SOUTHWEST FLORIDA REGIONAL
PLANNING COUNCIL
Citizens Participation Program
2121 W. First Street
Fort Myers, Florida 33901
(813) 334-7382, Ext. 34

section 208

WATER QUALITY MANAGEMENT PROGRAM

FINAL WATER QUALITY REPORT FOR THE CHARLOTTE HARBOR STUDY AREA

Southwest Florida Regional Planning Council

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CHARLOTTE HARBOR STUDY AREA

Prepared For:

Southwest Florida Regional Planning Council

Prepared By:

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.
and
Mr. Larry Hawkins
Jones, Edmunds and Associates
(Former Division Manager with
ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.)

Submitted By:

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.

P. O. Box 13454, University Station
Gainesville, Florida 32604

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INTRODUCTION

This document is a final technical report covering the latter stages of water quality analysis work performed as part of the Southwest Florida Section 208 Program. It has been written and produced to provide technical information for a variety of intended uses. First, it is intended to document technical services performed; second, it communicates to other members of the 208 project team the pollutant loads and water quality projections it contains so that subsequent technical planning may be accomplished using the data provided; third, it is intended to inform area advisory groups of water quality analysis results in order for them to provide needed input to the planning process; and fourth, it should be suitable to be included in selected portions of the initial 208 Water Quality Management Plan for the Southwest Florida Region.

In 1975 the water quality management planning process began for the southwest Florida region. Staff members of the Southwest Florida Regional Planning Council initiated Section 208 efforts for the six-county designated planning area. Receiving water bodies in Sarasota, Charlotte, Glades, Hendry, Lee, and Collier counties were soon to become objects of a comprehensive process dedicated to improving and preserving good water quality. The focus of this effort was to achieve 1983 water quality goals wherein waters could sustain aquatic life and safely support human body contact.

By mid-year 1975 the 208 project staff had organized the planning region into four hydrologic basin areas: Coastal Sarasota, Charlotte Harbor, Caloosahatchee River, and Big Cypress Basins. Advisory groups were chartered from each of the basins and asked to provide input to the planning process. After deliberation, each of these groups formulated statements of water quality concerns and needs for their respective areas.

In late fall of 1975 the Council staff completed a consultant selection process, choosing two water quality-oriented firms to provide technical expertise to the 208 program. Environmental Science and Engineering, Inc., was selected to provide services in the fields of water quality and environmental impact assessments. Post, Buckley, Schuh, and Jernigan, Inc., was selected to provide services in the area of waste controls engineering and financial and institutional management.

During the first half of 1976, the consultants and staff worked together to develop and draft a detailed Plan of Study (POS). The purpose of this POS was to serve as a comprehensive work plan and guide for the remainder of the program. Developing the POS involved a series of activities. Among these were:

1. Collection of all available water quality and related data;
2. Cataloging and assessing this data;
3. Detailed specification of water quality throughout the region as given by existing data;
4. Identification of existing and potential sources of water pollution;

5. Presentation of data gathering results to basin advisory groups;
6. Ranking of region water pollution problems;
7. Selection of problems to be addressed during the initial planning process;
8. Specification of activities, time frames, and budgets required to address the selected problems; and
9. Securing state and federal agency approval to commence work according to the proposed POS developed.

Florida Department of Environmental Regulation and U.S. Environmental Protection Agency approvals were forthcoming, and the initial water quality management planning process began.

The POS, as developed, focused on performing a group of case studies which would provide needed management planning information relevant to the entire region. Among the case studies selected were the Phillippi Creek, Charlotte Harbor, Caloosahatchee River, and Big Cypress Area Case Studies. The details of each of these are presented in this document and will not be discussed in this introduction. Included here are general comments pertinent to all the studies.

The planned work efforts in each of the case studies were similar. In the sections and subsections of this document are major portions of the case study results. The composition of this document reflects the overall work program of the case study, therefore an overview of the work effort is given by this introduction to this document.

Several sections are included which serve as a recount of much of the initial planning process.

The first section presents a description of the case study area. This description summarizes the results of the early POS development phase of the program. However, some more recently gathered information is included.

Although the POS included designs of water quality sampling programs, an early portion of subsequent work was the refinement of those designs. The second section summarizes the water quality sampling programs instituted.

The third and fourth sections present results of sampling efforts. Section 3.0 details findings of background and intensive sampling programs, while Section 4.0 contains storm event sampling results.

A significant effort has been made reducing and evaluating the water quality data gathered during sampling. The resulting information was then used to project future pollutant loading to the major waterways in the case study area. In Section 5.0 explanations of this loading forecasting process are given. Section 6.0 contains the results of the application, of these processes. Projections of water quality from point and nonpoint sources of pollution are made for 5-year increments for the next 20 years.

The seventh section is devoted to presentation of results from biologically-oriented, diurnal sampling. This effort was carried out as a parallel to the other sampling efforts, the results of which are discussed in Sections 3.0 and 4.0.

In Section 8.0 water quality management planning goals are discussed for the study area. Included are explanations of general 208 goals and objectives and relevancy of the specific goals of the case study to general program goals.

The concluding section presents the principal results of the water quality portion of the 208 program. Specification of maximum permissable pollutant loads is made, and corresponding requirements for cutbacks in projected pollutant loads to meet the maximums are given. Also included are suggestions for further planning work, which may be incorporated into the continuing planning process.

Not every significant aspect of the work efforts performed is included in this document. To include all would require a much larger document. What is included is an overview of the entire planning process along with elaboration on the latter stages of work during which the important water quality projections were made. Earlier work is thoroughly documented in interim documents which have been submitted to the 208 project staff. Included among these are several reports delivered during the development of the POS, a detailed sampling program design document, an interim report on region water quality, and a comprehensive presentation of technical procedures to be used in making waste load projections. Also, supporting data of various types are presented in appendices to this report, which have been produced as separate volumes.

1.0 DESCRIPTION OF STUDY AREA

1.1 Water Resources

1.1.1 Physical Description of Study Area

Charlotte Harbor, 60 miles south of Tampa Bay and about 140 miles northwest of Miami, on the Gulf coast of Florida, is one of the largest and perhaps least contaminated of the estuarine systems in the state.

The Charlotte Harbor system, a complex drowned estuary, is enclosed by a series of barrier islands, and includes the harbor itself, Pine Island Sound, Gasparilla Sound, Matlacha Pass, and San Carlos Bay. Of the five principal passes from the Gulf of Mexico into Charlotte Harbor, the deep water channel at Boca Grande is the largest and most important.

The Charlotte Harbor estuary is about 35 miles long and 30 miles wide at its southern extremes and has more than 200 miles of shoreline, not including small mangrove islands, with over 280 square miles of water area.

Huang and Goodell (1967) classified the Charlotte Harbor system into four zones:

1. Broad, shallow estuaries with central deep narrow channels connected to the tidal channels of the harbor;
2. Zero to six feet deep shallow lagoons, sounds, and sand and grass flats which contain many keys and small islands;
3. Slopes adjacent to the channels whose depth varies from six to twelve feet or more; and
4. Channels deeper than twelve feet.

The average depth is ten to twelve feet. Boca Grande, with a maximum depth of fifty-one feet, is the deepest channel in the harbor.

An estimated rise in mean sea level of 10 feet over the past 4,000 years has given Charlotte Harbor its present shape and depth.

The land adjacent to Charlotte Harbor has a surface geology almost entirely consisting of post-Eocene rocks which are primarily limestones and dolomites with minor amounts of quartz sand, clay, and phosphate.

Depths of as much as ten feet of unconsolidated sediments of recent age consisting of fine quartz sand have been found throughout most of the estuary. Coarse, shelly sands are found only in passes and channels, and silts and clays are deposited in areas near the mouths of major streams. The major tributary rivers have a very flat grade near their mouths and, consequently, do not contribute large sediment loads to the estuary during nonflood-stage periods. Only minor erosion and deposition had occurred in the harbor system during the 100-year period up to 1967.

Sources of municipal water supply are the Hawthorne-Tampa aquifer in north Charlotte County and south Lee County; the Floridan Aquifer in the islands of Charlotte Harbor; and shallow sand aquifers, including pleistocene sand-and-shell aquifer, Tamiami formation, and nonartesian aquifers in the remainder of Charlotte and Lee counties.

All but the extreme northeast tip of Charlotte County within the Peace River drainage basin lies in an area of artesian flow from the Floridan Aquifer.

Shell Creek supplies all of Punta Gorda's water at an average rate of pumping of 1.82 mgd[1]; the Myakka-Hatchee River serves as the supply source of North Port Charlotte at an average use of 0.25 mgd; Port Charlotte receives 92 percent of its 1.46 mgd water supply from the Fordham Waterway. Arcadia receives its water supply from the Peace River.

1.1.2 Hydrographic Description

Charlotte Harbor tides are of a mixed diurnal and semidiurnal type with a maximum amplitude of 3 feet or less under normal weather conditions. The U.S. Coast and Geodetic Survey Tide Tables give the mean diurnal spring tidal range as 1.9 feet at Punta Gorda. The tidal rise in Boca Grande is less than in the San Carlos entrance, which it lags by 15 minutes.

Flood and ebb currents for all major inlets in the Charlotte Harbor estuary except at San Carlos Pass are in an east-west direction. In Boca Grande Pass the maximum flood current is 1.8 knots at 55 degrees, the maximum ebb current is 2.2 knots at 250 degrees, and the median tidal range is 1.7 feet. Slightly higher ebb than flood velocities are observed because the freshwater discharge of the tributary rivers exceeds the tidal inflow of water.

Tidal currents in the inlets and passes, especially ebb currents, are strong during normal tidal conditions; however, current velocities of 2.4 to 3.0 knots may be reached during abnormal wind conditions, and considerably increased velocities dangerous to life and property, would be caused during major storms.

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[1]U.S.G.S. Water Resources Data from Florida Water Year 1975.

Gunter and Hall (1965) recorded saltwater wedges well upstream in the Myakka and Peace rivers during periods of low streamflow and high tide. However, fresh water from the rivers causes a reduction in surface salinity throughout the estuary when conditions are reversed.

Mean annual values of hydrographic data include:

	Temperature (°C)	Salinity (o/oo)	pH	O_2 (mg/l)	Inorganic PO_4 (mg/l)
Charlotte Harbor (mouth)	27	34	8.2	---	0.5
Peace River (mouth)	23	18	7.5	4.0	21.2
Myakka River (mouth)	23	15	7.5	3.2	4.0

During most of the year the harbor has a net longshore drift in a southerly direction; however, in the summer when mean wind direction is southwest, the longshore drift is northward. The tides which enter and leave Boca Grande Pass and San Carlos Bay entrance, the two main inlets, are primarily responsible for circulation in the harbor.

The agricultural drainage canal system in the interior of Charlotte County has been randomly developed, but the canals created for residential areas have been planned for flood control, stormwater management, and waterfront living. The annual runoff of the Peace and Myakka rivers is shown:

Stream Gage	Drainage Area (mi^2)	Runoff Minimum (in.)	Maximum (in.)	Average (in.)
Peace River at Arcadia	1,367	3.91	25.55	11.87
Myakka River at Sarasota	229	4.23	33.42	15.18

Two distinct types of flooding occur in Charlotte and Lee counties: freshwater flooding caused by rainfall; and saltwater or tidal flooding caused by abnormal rising of water surface of saltwater bodies. Reduced discharge capacity of sluggish coastal streams caused by abnormal tides due to hurricane winds aggravate the flood problem.

The greatest flood of record resulting from rainfall inundated 350 square miles to a depth of one foot for five days in October, 1924. The greatest tidal flood of record, which occurred in October, 1921, during the most severe hurricane experienced in the area, left high water marks of 11 feet at Punta Rassa, 8 feet at Punta Gorda, and 9 feet at Fort Myers; and it completely covered the coastal islands. A recurrence of the tidal floods would not necessarily be disastrous, but if the tidal flood of record (October, 1921) had happened in 1968, it was estimated to have had a potential destructive cost of $25 to $30 million.

In a letter from the Secretary of the Army to Congress dated November 22, 1967, it was recommended that federal improvements for hurricane tidal flood protection not be authorized. Although the project was economically justified, the local parties interested were unable to support the proposed improvements.

During periods of extended rainfall, flooding along the Myakka occurs. A canal has been constructed to divert flood flow to the Gulf of Mexico near Venice, but a salinity control structure within the canal was not constructed.

1.1.3 Identification of Principal Tributaries

The Myakka and Peace rivers are the two largest tributaries flowing into Charlotte Harbor. The Peace and Myakka rivers are inundated by salt water during high tide and, consequently, exhibit estuarine characteristics many miles upstream from their mouths.

The Peace River, one of Charlotte County's major sources of fresh water and its largest river, flows at an estimated average rate of 2,270 cfs into the northeast corner of Charlotte Harbor. The Peace River coastal area extends from the middle of Pine Island northward to Osprey. The beginning of the Peace River is at the junction of Peace Creek and Saddle Creek Canal at an elevation of about 110 feet, one mile east of Bartow. The combined length of the Peace River and Peace Creek is 98 miles from source to mouth; from Bartow to Arcadia it is 60 miles in length.

The Peace River has a width which varies from 60 to 200 feet, but in the swamp found in the northern section the water is 900 to 1,500 feet across. The maximum depth in the Peace River is 20 feet at Arcadia with the average depth generally ranging from 3 to 8 feet.

The Peace River watershed above the U.S.G.S. gaging station at Arcadia contains 1,367 square miles. The drainage area at the mouth of the Peace River is 2,400 square miles. Periodic zero flow conditions occur in all surface streams in Charlotte County except the Peace River.

Chief occupations in the Peace River basin are related to phosphate rock mining, agriculture, and processing of crops. On June 13, 1952, the Florida State Board of Health determined that the volume of phosphate containing effluent from industry above Fort Meade composed 60 percent of the volume of the flow in Peace River at Fort Meade. Inorganic P and PO_4 was responsible for most of the total phosphorus content of the streams. The average fluoride and mineral content at Arcadia for the water year ending September 30, 1964, was about 2 ppm and 160 ppm, respectively.

The drainage area of the Myakka River is about 850 square miles. The stream has a length of about 45 miles. The Myakka has a very winding channel and a low gradient throughout most of its length. In its lower portion, water reaches the Myakka by overland sheet flow during high runoff periods, but in the upper reaches the channels have been cut deep enough to receive groundwater discharge. The Myakka River flow has been observed to range from 0 to 5,800 cfs with an annual average of about 960 cfs.

1.1.4 Applicable Classifications

Segment classifications for the Charlotte Harbor and tributary sampling stations are listed as follows. Sources of segment classification criteria are discussed in introductory sections dealing with water quality criteria.

Station Number	Name	Classification
H-T1	Coral Creek	Class III, Marine
H-T2	Lower and mid-Myakka	Class III, Marine
H-T3	Big Slough	Class I, Fresh water
H-T4	Upper Myakka	Class I, Fresh water
H-T5	Charlotte Harbor	Class II, Marine
H-T6	Little Alligator Creek	Class III, Fresh water
H-T7	Sam Knight Creek	Class III, Fresh water
H-T8	Alligator Creek	Class III, Fresh water
H-T9	Bear Branch	Class III, Fresh water
H-T10	Peace River	Class III, Marine
H-T11	Shell-Myrtle Creek	Class I, Fresh water
H-T12	Peace River	Class I, Fresh water
H-B1	Charlotte Harbor	Class II, Marine
H-B2	Charlotte Harbor	Class II, Marine
H-B3	Charlotte Harbor	Class II, Marine
H-B4	Charlotte Harbor	Class II, Marine
H-B5	Charlotte Harbor	Class II, Marine
H-B6	Charlotte Harbor	Class II, Marine
H-B7	Charlotte Harbor	Class II, Marine
H-B8	Charlotte Harbor	Class II, Marine
H-B9	Charlotte Harbor	Class II, Marine
H-B10	Charlotte Harbor	Class II, Marine
H-B11	Charlotte Harbor	Class II, Marine
H-B12	Charlotte Harbor	Class II, Marine
H-B13	Charlotte Harbor	Class II, Marine
H-B14	Charlotte Harbor	Class II, Marine
H-B15	Charlotte Harbor	Class II, Marine
H-B16	Charlotte Harbor	Class II, Marine
H-B17	Charlotte Harbor	Class II, Marine
H-B18	Gulf of Mexico	Class II, Marine

1.2 Topography of Watersheds

Of a total of about 1,275 square miles in Charlotte and Lee counties, 345 square miles is water area under the jurisdiction of the Southwest Florida Water Management District. Half of the total area is located in the coastal section and this is divided about equally into water areas and low-lying land areas.

In the coastal section of Charlotte and Lee counties the land is up to 7 or 8 feet above mean sea level, with some spots as high as 11 feet. On

Useppa Island one mound is 27 feet high. Much of the land on the islands and along the mainland shore is five feet or less in elevation. The average slope of the ground surface is about two feet per mile in the coastal areas.

The interior section of the area has few developed drainage patterns; those that exist are largely indeterminate and subject to change. With an average elevation of 30 feet rising to as high as 70 feet in the northeast corner of the region, most of the topography is relatively flat and featureless with sheet flow drainage or drainage through manmade canals. The interior areas generally have slopes less than two feet per mile and contain many ponds and several large swamps.

The Peace River basin terrain has sand ridges, pine flatwoods, lake chains, swamps, strip-mined lands, and urbanized areas.

1.3 Soil Types of Watersheds

The soils adjacent to Charlotte Harbor are mainly histosole, black, acidic, and highly humic. Most of the associations of soils within Charlotte County and Lee County consist of poorly drained, sandy soils.

A summary of the limitations on land use due to soil types in Charlotte and Lee counties is presented in Table 2.1-1. These ratings were obtained from General Soil Association Maps prepared by the Bureau of Comprehensive Planning, Division of State Planning of the Florida Department of Administration. Most of the land in these two counties is severely limited for

Table 2.1-1. Summary of Land Use Limitations Due to Soil Associations Present.

Kind of Limitation for:	% of Total County Land Area — Charlotte County: Slight	Moderate	Severe	Very Severe	Lee County: Slight	Moderate	Severe	Very Severe
Sanitary Facilities								
Septic·tank absorption fields	----	----	86.0	14.0	----	----	84.0	16.0
Sewage lagoons	----	8.5	77.0	14.5	----	----	84.0	16.0
Sanitary landfill - trench type	----	----	85.5	14.5	----	----	84.0	16.0
Community Development								
Shallow excavations	----	----	85.5	14.5	----	----	84.0	16.0
Dwellings	----	35.5	50.0	14.5	----	44.5	39.5	16.0
Light industry	----	35.5	50.0	14.5	----	44.5	39.5	16.0
Local roads and streets	2.0	33.5	50.0	14.5	2.5	42.0	39.5	16.0
Water Management								
Embankments, dikes, and levees	8.5	----	77.0	----	----	----	84.0	3.5
Excavated ponds, aquifer fed	20.5	79.5	----	----	25.5	74.5	----	----
Recreation								
Camp and picnic areas	----	33.5	52.0	14.5	----	42.0	42.0	16.0
Playgrounds	----	1.5	84.0	14.5	----	15.5	68.5	16.0
Paths and trails	----	1.5	84.0	14.5	----	42.0	42.0	16.0

NOTE: When sum of percentages of a use do not total 100 percent, one or more of soil associations has not been classified or assessed for specific uses.

the construction of sanitary facilities. Approximately 65 percent of the land has severe to very severe limitations for community development.

Most of the soils with "very severe" limitations are freshwater marsh, swamp and tidal marsh, and swamp-dune associations which are found in inland swampy areas or along the coastal areas.

1.4 Predominant Land Uses in Watersheds

Charlotte County, located about 85 miles south of Tampa Bay, has an area of 832 square miles, 129 square miles of this is water under the jurisdiction of the Southwest Florida Water Management District. Lee County, south of Charlotte County, has a land area of 786 square miles of which about one-third is farmland.

Most of the inhabitants in the coastal areas reside in the larger municipalities of Port Charlotte and Punta Gorda in Charlotte County and North Fort Myers and Cape Coral in north Lee County as well as in smaller communities of Lemon Bay, El Jobean, Boca Grande, Captiva, Bokeelia, Pine Island, St. James City, Sanibel, and Punta Rassa.

In 1968, the Corps of Engineers conducted a flood hazard study which estimated the value of the approximately 60 square miles of urban development at $250,000,000 for residential property and $310,000,000 for business property.

Sport and commercial fishing, water recreation, shellfishing, and a large tourist trade are the economic mainstays of the Charlotte Harbor area.

Interior development is sparse and consists of small scattered farms devoted to citrus, truck crops, flowers, and dairy cattle. The main sources of income in Lee County are tourist trade, agriculture, and commercial fishing.

The Florida Board of Conservation projected an urban land area for Charlotte County in the year 2015 which is seven times that of 1963. Population projections for this same period show a 14-fold increase. From 1960 to 1963, Charlotte County experienced a 49 percent growth.

Land acreage estimates for 1976 in the Charlotte Harbor study are listed below by county:

	Sarasota	Charlotte	Lee
Residential	2,932	12,817	230
Commercial	32	1,205	8
Institutions-Parks	40	105	---
Other Urban	363	2,509	32
Pasture	31,447	39,905	960
Cropland	670	2,905	---
Golf Courses	360	522	110
Citrus	200	8,503	---
Open & Other	18,769	34,405	333

1.5 Significant Meteorological and Climatologic Features

The Charlotte Harbor estuary is located in a humid subtropical climate. An average of 100 thunderstorms may be expected annually and 38 hurricanes have been recorded in the 70 years preceding 1975. Two severe storms created tidal surges 9 to 14 feet above normal.

During July and August, average maximum and minimum air temperatures for the area were 90 ^{O}F and 75 ^{O}F, respectively. Winter average air temperatures, taken during January and February, were 77 ^{O}F maximum and 55 ^{O}F minimum. Daily variations of temperature in the summer are negligible. However, winter cold fronts may cause rapid temperature drops and abnormal cool weather for several days.

The annual average temperature at Fort Myers is 73.4 ^{O}F; the minimum monthly average is 63.8 ^{O}F in January, and the maximum monthly average is 81.5 ^{O}F in August.

The average annual rainfall for the 50-year period of 1915-1964 at Punta Gorda was 51.1 inches. About 60 percent of the total annual rainfall occurs in the June-October rainy season, primarily as scattered heavy showers during local thunderstorms. Occurrence of showers is about every other day in June and September, but more frequently in July and August.

Rainfall as much as eight inches in one day and twenty-five inches in thirty days is common during the wet season. The highest one-day rainfall recorded in Charlotte and North Lee counties was 11.70 inches on October 21, 1924; and the highest monthly total rainfall was 26.91 inches in June, 1912.

Rainfall from hurricanes of tropical storms which occur during the rainy season may cause localized or widespread flooding, depending on the antecedent saturation of the ground. Although wet to flood conditions often exist for 30 or more days during the rainy season, maximum flooding is generally caused by heavy rainfall concentrated during a two-day period or less when the ground is fully saturated.

Rainfall gaging stations in the Charlotte Harbor area are located at Myakka River State Park, Punta Gorda, Fort Myers, and Arcadia.

According to records of the U.S. Naval Weather Service, the most frequent (58.2 percent) wind speeds are between 7 and 16 knots. The most frequent (28 percent) wind is from the east; and, consequently, the highest percentage (31.5 percent) of waves are from the east.

Waves between 1 and 2 feet high have the highest frequency of occurrence (32.5 percent) with 67.5 percent of all waves having a period of less than 6 seconds.

1.6 Water Quality as Indicated by Available Data

In general, relatively little historical, long-term data exists to provide a reliable general assessment of the water quality of the Charlotte Harbor system. A number of excellent studies conducted on the system generally agree that the Harbor is a nitrogen-limited system and that the primary source of phosphorus is the Peace River. In addition, most investigators as well as existing data, tend to verify that the greatest potential for water quality degradation of the system is future urban development and subsequent stresses to the system from point and nonpoint sources, random land-use modification and shoreline alternation.

The difficulty with a majority of stored computerized data is that there is little information as to methodologies, purpose or origination of the data. Therefore, reliability of conclusions based on such data must be questioned. Stored data examined generally indicate problems in dissolved oxygen, heavy metals, bacteria and nutrients within most of the tributary systems. It is very difficult to assess the duration, frequency or severity of such problems from existing data sources. In some cases, for example, it cannot be determined from the stored data whether heavy metal analysis was taken from water column or sediment samples, or the number of samples analyzed to establish the existence of the problem.

Although historical data from diverse sources and locations within the system is extremely valuable in determining the potential for water quality problems in the estuary system, details regarding the sources and conditions under which the determinations were made prevent accurate determination of point or nonpoint sources.

1.7 Reasons for Selection as a Study Area

The Charlotte Harbor estuary system represents a major resource and one of the more significant and complex surface water systems within the planning region, and is also one of the largest estuarine environments in the State of Florida. The system is fed by three major tributaries, the Peace, Myakka, and Caloosahatchee rivers. Existing water quality data indicates that the general quality is good within the system. Recent studies show high concentrations of dissolved phosphorus within the system and localized heavy metals problems within the tributaries.

Potential and existing sources of degradation are many and complex. Land uses surrounding the estuary are diverse. Hydrographic modification, urbanization, rangeland, wetlands and point sources are among the notable potential problems. In addition, rapid future growth projections and changing land use as well as widespread urbanization are serious threats to the water quality of the system. A summary of land use projections provided by the SWFRPC for county areas within the Charlotte Harbor study area is presented in Table 2.1-2.

As a result of future growth, the Charlotte Harbor system is highly susceptible to water quality problems caused by shoreline and watershed alteration, and agricultural, industrial and urban development. A review of the historical data available for the system implied early stages of water quality impacts which may be primarily derived as nonpoint source problems. Data indicated heavy metal concentrations probably originating from agricultural activities. Other water quality parameters indicated urban runoff as potential sources. In addition, other diffuse pollutant sources or quality problems to the Harbor such as hydrographic modification for agricultural drainage, upstream phosphate mining, devegetation or modification of shorelines among others were indicated.

A general lack of historical water quality data for the entire Harbor system and its tributaries with which to understand the existing conditions, potential problems, and probable sources was a primary justification for the study. Considering the magnitude and value of this resource in the area, and projections for future growth and land-use change, protection of the

Table 2.1-2. Charlotte Harbor Study Area.

Year	Residential	Commercial	Institutions, Parks	Other Urban	Pasture	Cropland	Golf Courses	Citrus	Open and Other
Sarasota County--Acreages									
1976	2932	32	40	363	31,447	670	360	200	18,769
Δ1978	+45	+14	+6	+3	---	---	---	---	?
Δ1983	+440	+89	+37	+22	---	---	+155	---	?
Δ1988	+375	+122	+50	+29	---	---	---	---	?
Δ1993	+1025	+167	+68	+39	---	---	---	---	?
Δ1998	+1360	+260	+107	+61	---	---	---	---	?
Charlotte County--Acreages									
1976	12817	1205	105	2509	39,905	2905	522	8503	34,405
Δ1978	+359	+23	+18	+0	?	---	---	---	?
Δ1983	+3169	+106	+20	+60	?	---	+160	---	?
Δ1988	+4518	+170	+38	+143	?	---	+20	---	?
Δ1993	+4522	+155	+50	+129	?	---	+140	-20	?
Δ1998	+4010	+178	+120	+143	?	---	+130	---	?
Lee County--Acreages									
1976	20 + 210	8	---	32	960	0	110	---	333
Δ1978	+10	---	---	---	---	---	---	---	-10
Δ1983	+50	---	---	---	---	---	---	---	-30
Δ1988	+52	+7	---	---	---	---	---	---	---
Δ1993	+50	---	+10	---	---	---	---	---	-20
Δ1998	+50	---	---	---	---	---	---	---	

resource through a comprehensive 208 water quality management program is considered necessary.

2.0 DESCRIPTION OF SAMPLING PROGRAM INCLUDING BASIS FOR DESIGN

2.1 Original Program

2.1.1 Harbor and Tributary Background Sampling

The estuarine system is of great significance as a natural resource and the existing and potential water quality degradation sources are complex. The water quality program was designed to characterize primary sources of pollutants contributed by principal tributaries and inflow sources, and the baseline water quality of the system. The objective of the study was to determine, to a degree, the spatial and temporal distribution of contaminants introduced to the estuary. In other words, overall water quality resulting from contaminant inflow was evaluated. This was accomplished by monitoring pollutant loads to the harbor from the major contributing sources. Variation of water quality within the harbor was studied by establishing and monitoring a network of sampling sets.

The purposes of the water quality data collection program were to determine (1) the baseline water quality of the Charlotte Harbor Estuary system within the described boundary limits (depicted on base map), and (2) loadings on the system imposed by major tributary sources and certain land-use categories (storm sampling).

To accomplish these objectives, an extensive background sampling program was conducted. Background sampling stations included stations situated throughout the harbor and stations located on major harbor tributaries.

Harbor baseline stations are denoted by the letter "B" on Figure 2.1-1. There are a total of eighteen harbor baseline sites, H-B1 through H-B18; however, after the first sampling round, H-B12 in Turtle Bay was abandoned due to inaccessibility. The baseline stations have been strategically located to represent most all regions of the harbor in order to define possible zones of polluted waters. Tributary sample station locations are designated by the letter "T" in Figure 2.1-1. The twelve tributary sites, H-T1 through H-T12, are situated on the following water bodies:

H-T1	Coral Creek
H-T2	Myakka River, lower portion
H-T3	Big Slough
H-T4	Myakka River, upper portion
H-T5	Little Alligator Creek, lower portion
H-T6	Little Alligator Creek, upper portion
H-T7	Sam Knight Creek
H-T8	Alligator Creek
H-T9	Bear Branch
H-T10	Peace River, lower portion
H-T11	Shell Creek
H-T12	Peace River, upper portion

Analysis of samples collected at these points of influx to the harbor included the parameters listed as follows and analyzed results are depicted in Tables 2.3-1 through 2.3-15 in Section 3.2.

pH	NO_2 - NO_3 as N
Dissolved oxygen	NH_3 as N
Alkalinity	Arsenic, mercury, manganese
Color	Organochlorine pesticides

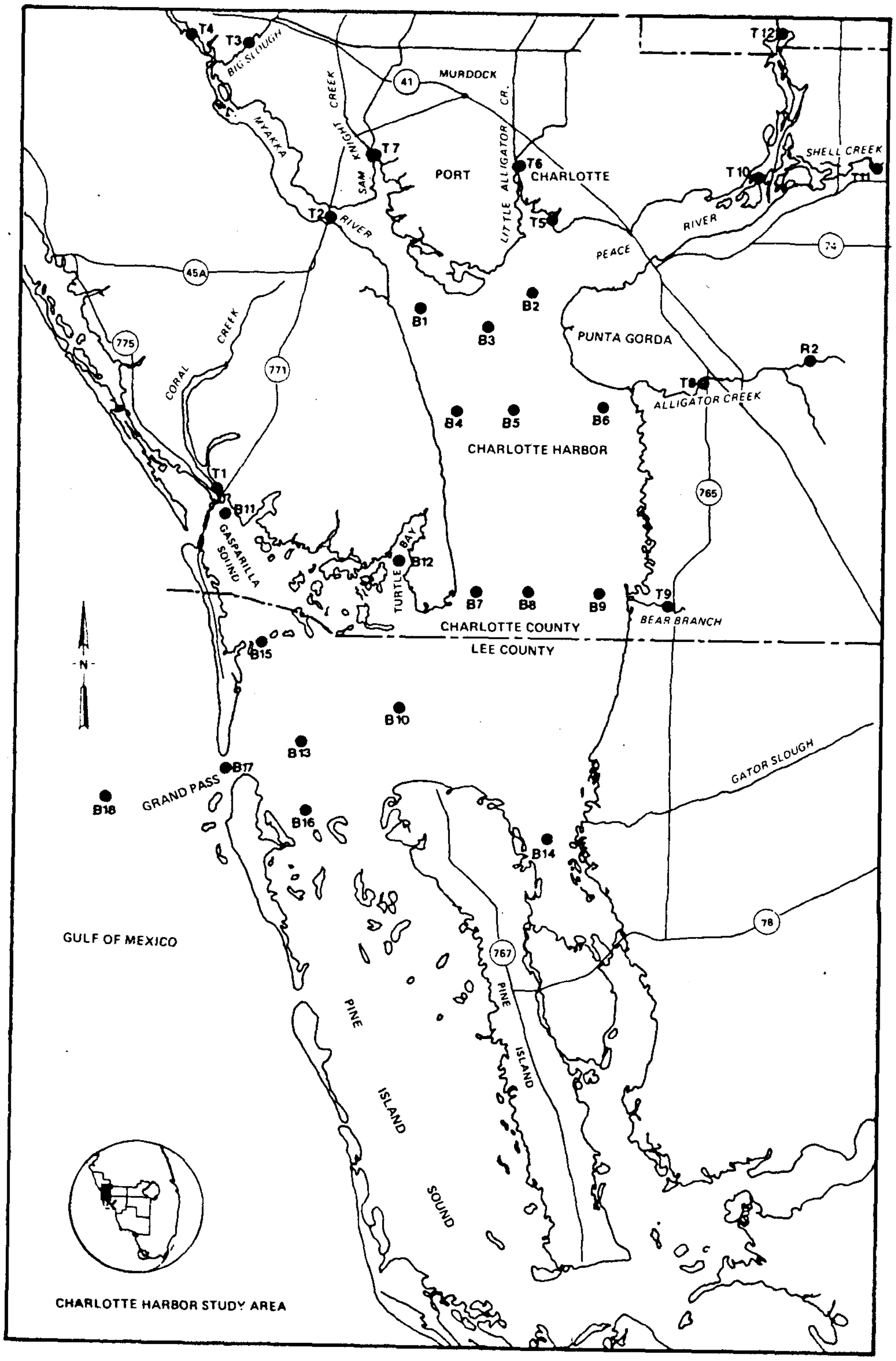


FIGURE 2.1-1
SAMPLING STATION LOCATIONS, CHARLOTTE HARBOR STUDY AREA

Turbidity

Total solids

Fecal coliform

Fecal streptococci

Total Phosphate

Dissolved orthophosphate

NO_2 - NO_3 as N

NH_3 as N

Arsenic, mercury, manganese

Organophosphate

Total organic carbon

Oil and grease

Hydrogen sulfide

Sulfate

Lead

Copper

Fluoride

Organochlorine pesticides

2.1.2 Storm Event Sampling--Original Program

Storm event sampling has been included in the Charlotte Harbor Case Study. The purpose of this sampling has been to determine pollutant loading rates from specific types of land use. These land uses are indicated in Table 2.2-1. The information obtained from the storm sampling is useful in two ways. First, it provides needed pollutant loading data for the types of land uses in the Charlotte Harbor area; and second, it provides data for comparison and use with data for similar types of land uses gathered elsewhere in the region. One site, H-R2, which drains open, undeveloped lands, is suitable for such comparison. The other sites involve canal-type development which has not been studied in other locations.

The sites selected drain relatively small watersheds of one predominant land use, as shown in Table 2.2-1. Locations of these sites are shown in Figure 2.2-1. (The "H" prefix has been omitted.)

These sites include those selected as part of the original and revised sampling programs. Original sites H-R1 and H-R2 will be discussed in this subsection, and the other sites will be discussed in a later subsection. The two original sites were selected in order to permit comparison of pollutant loads of developed versus undeveloped lands.

Table 2.2-1 Dominant Land Uses--Storm Event Sampling Sites, Charlotte Harbor Study Area

Sampling Site	Watercourse	Dominant Land Use
H-R1	Man-made canal	Residential (single- and multi-family)
H-R2	Alligator Creek	Open, undeveloped
H-R3	Man-made canal	Residential canal development with sanitary sewers
H-R4	Man-made canal	Residential canal development, as yet unpopulated
H-R5	Man-made canal	Residential canal development without sanitary sewers

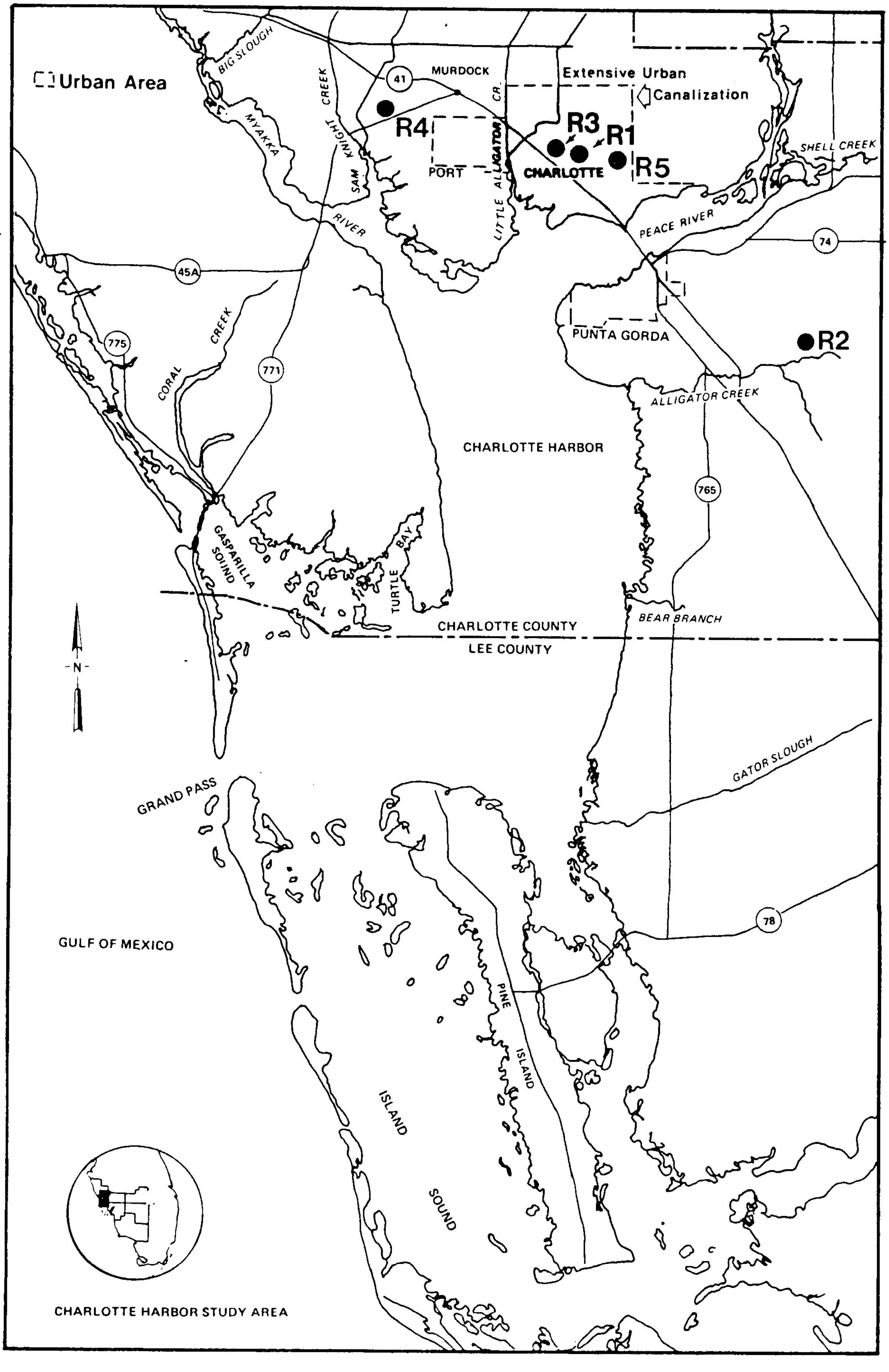


FIGURE 2.2-1
STORM EVENT SAMPLING SITE LOCATIONS, CHARLOTTE HARBOR STUDY AREA

Sampling of two storm events was planned for each site so that different rainfall amounts, storm intensities, and antecedent conditions (e.g., number of dry days preceding) could be observed, if possible. Sampling was scheduled for late summer, 1976. Wet season conditions caused by frequent correctional rainfall were expected during this period.

Also, statistical quality or reliability of the resulting data could be expected to improve by sampling two events. Samples were scheduled to be taken at various times throughout the occurrence of runoff, so that indications of pollutant loading with time could be obtained.

The planned constituents to be sampled at each site were selected carefully because of very limited program funds. The following groups of constituents were included in the analysis schedule for sites H-R1 and H-R2.

Physical Constituents--Temperature, dissolved oxygen, pH, color, turbidity, solids, conductivity.

Chemical Constituents--Alkalinity, phosphorus, nitrogen, organic carbon, fluoride.

Microbiologic Constituents--Fecal coliforms, fecal streptococci, biochemical oxygen demand.

Metals Constituents--Arsenic, mercury, lead, manganese, copper.

2.2 Modified Program

The sampling program as originally planned was implemented in the spring of 1977. An assessment of the accumulated data (Interim Report) indicated that some shifts and revisions of sampling stations could be made in the interest of economy and the ability to seek additional information. The data through May, 1977, representing nine months of sampling indicated that there were no severe problems in Charlotte Harbor that warranted the continuation of some stations within the harbor. Beginning February, only midwater harbor stations H-B1, 2, 3, 8, 10, and 17 were sampled for full constituent analysis. Bacteriological analysis was continued for all harbor stations.

The rather persistent high levels of some constituents within tributary systems, and additional information received during the program concerning bacteria levels and potential sources, warranted the establishment of some additional stations.

In order to more properly assess the water quality problems in the tributary systems, it was recommended that a sampling program be initiated to determine the character and sources of poor water quality within the major tributary systems. It was anticipated that this would be accomplished by the addition of sampling stations to augment existing tributary sampling. Stations were added to primarily characterize changing land-use areas along a given tributary in an attempt to characterize the quality of nonpoint sources within the system. The adjusted sampling program began in March and continued through June, 1977.

The first objective of the tributary sampling program was to determine specific water quality associated with varied land-use characteristics along a given tributary, or within a known problem area. The sampling stations were designed to assess quality of waters from upland, open space, or wetland sources prior to passing through urban or residential areas, and upon entering the harbor system after passage through developed areas. In other words, determine the "before and after" quality as impacted by developed or urban residential areas. Several stations were also added in areas of known water quality problems to further assess the sources. The stations were located at points on conveyance waterway systems within the Port Charlotte, Harbor Heights, and North Port areas.

New Tributary Sample Locations

H-T13	Big Slough Canal at North Port prior to entry to Cocoplum Waterway, approximately 1.5 miles north of U.S. 41.

H-T14	Unnamed stream to the north of Cocoplum Waterway in the headwater of Sam Knight Creek.
H-T15	Cocoplum Waterway quality sample approximately center of water at bridge crossing near BM-16.
H-T16	At conveyance waterway to the north prior to entering Cocoplum Waterway.
H-T17	At canal crossing (above weir structure) at U.S. 41 in Port Charlotte.
H-T18	At bridge crossing on canal waterway prior to entering Alligator Bay.
H-T19	At headwater of major canal conveyance in East Port Charlotte.
H-T20	At weir structure (same canal as HT-19) off U.S. 41.
H-T21	Salt creek above Harbor Inn off the Peace River.
H-T22	At entry of north-south canal west of Harbor Heights.
H-T23	Channelized stream at Shell Point at Harbor Heights.

It was intended for these stations to verify and, hopefully, yield some insight as to the possible sources of some pollutants seen primarily within the Little Alligator Creek, Sam Knight Creek, Cocoplum Waterway, and Peace River systems.

2.2.2 Storm Event Sampling--Modified Program

Storm event sampling in late summer of 1976 was restricted due to lack of rainfall; one storm at H-R1 was the only event sampled. Therefore, additional sampling was planned for the early summer of 1977. The purposes of this additional effort are the same as those discussed in Section 2.1.2.

Table 2.1-1 lists the sites selected and the principal land uses in the small watersheds. Figure 2.2-1 shows the locations of sampling stations.

As was the case with the selection of H-R1 and H-R2, additional sampling sites were selected such that pollutant loading from specific land uses might be developed. Considering all of the sites chosen, several opportunities for comparison were foreseen.

Because the H-R2 basin is relatively undeveloped, comparing it with any of the other sites indicates the effects of development on nonpoint pollutant loads. By contrasting data from H-R4 (as yet unpopulated, developed area) with data from H-R3 and H-R5 (populated areas), the influences of population can be studied. Finally, comparison of the H-R3 and H-R5 basins, with and without sanitary sewers, respectively, allows consideration of nonpoint loads from septic tank areas. Sampling of two storm events was planned for each site, H-R3, H-R4, and H-R5.

Samples were scheduled to be taken at various times throughout the occurrence of runoff for each storm. This was done to help define times of peak loading as stormwater moved toward receiving water bodies.

At sites H-R3, H-R4, and H-R5, the following analyses were scheduled:

Physical Constituents--solids.

Chemical Constituents--phosphorus and nitrogen.

Metals Constituents--lead and mercury.

This limited group was selected because earlier sampling indicated that emphasis should be placed on these substances.

2.2.3 Intensive Sampling

Intensive sampling was included as part of the Charlotte Harbor Case Study modified sampling program. The purpose of this sampling was to study the water quality characteristics of the harbor during a short time period. Monthly sampling, which was incorporated into the case study program, was not suitable to detect short-term changes in harbor water quality. The variety of potential pollution sources and the lack of knowledge about harbor circulation and mixing underscored the need to perform the intensive survey. Circulation studies, which were originally planned, were not performed because the level of effort planned was later judged inadequate, and more effort could not be supported financially.

Six stations in the harbor were located along a line reaching from mid-channel near the Peace River mouth to mid-harbor near Grand Pass. A station was also placed at the mouth of the Myakka River. Figure 2.2-2 shows station locations.

Sampling was planned at each station on alternate days over a two-week period. Early June was selected as the time for the two-week effort, because it marked the beginning of the wet season in the region. Early wet season marks the greatest increase of inflows to the harbor. Therefore, short-term changes in water quality, especially due to river and runoff inflows, are more likely to occur than at times of steadier conditions.

The constituents selected for analysis were limited to those deemed essential to the loads allocation process. These constituents are:

Physical Constituents--solids.

Chemical Constituents--nitrogen and phosphorus.

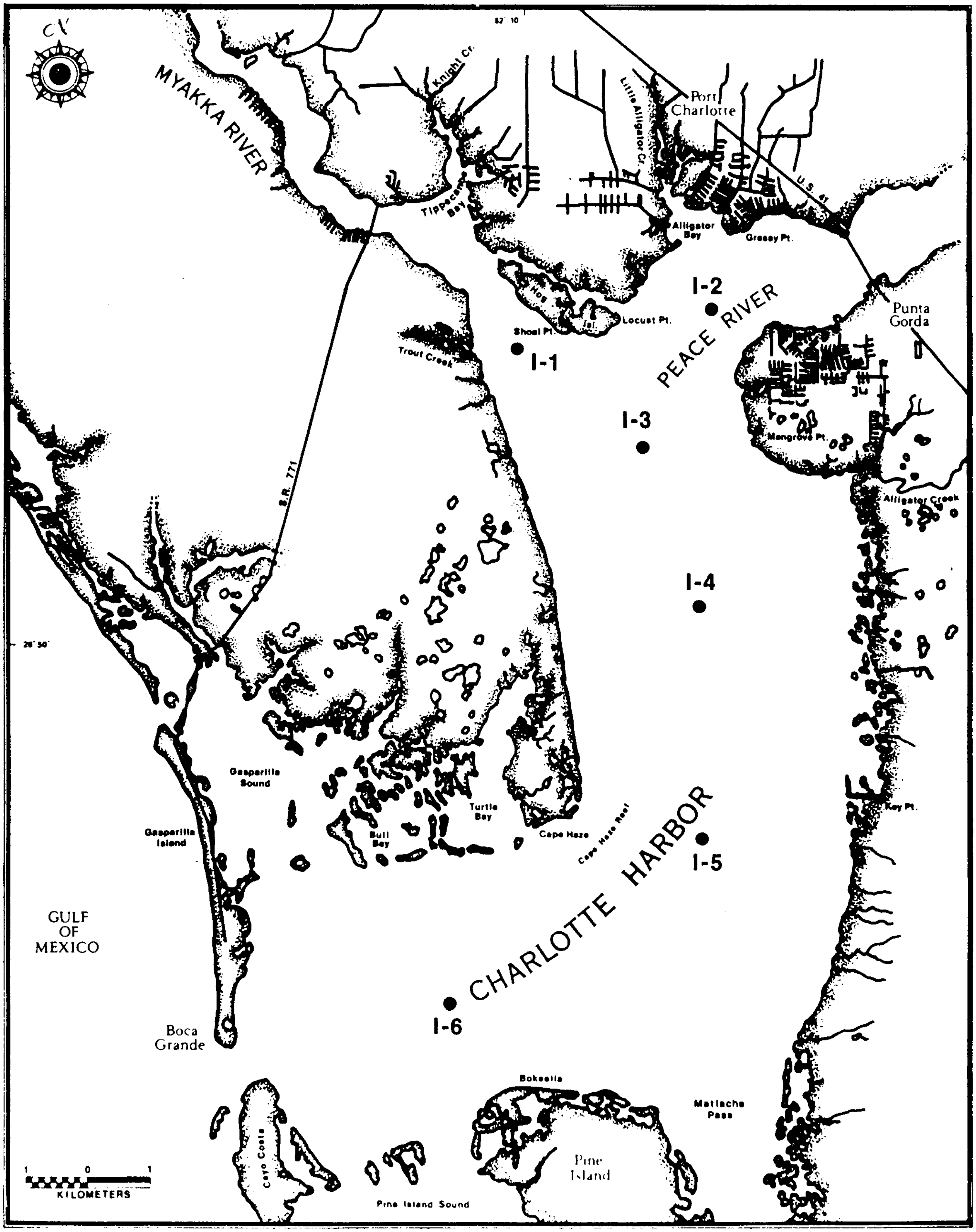


FIGURE 2.2-2
INTENSIVE SAMPLING STATION LOCATIONS ,
CHARLOTTE HARBOR STUDY AREA

2.3 Productivity Sampling

2.3.1 Biological Information in a Water Quality Program

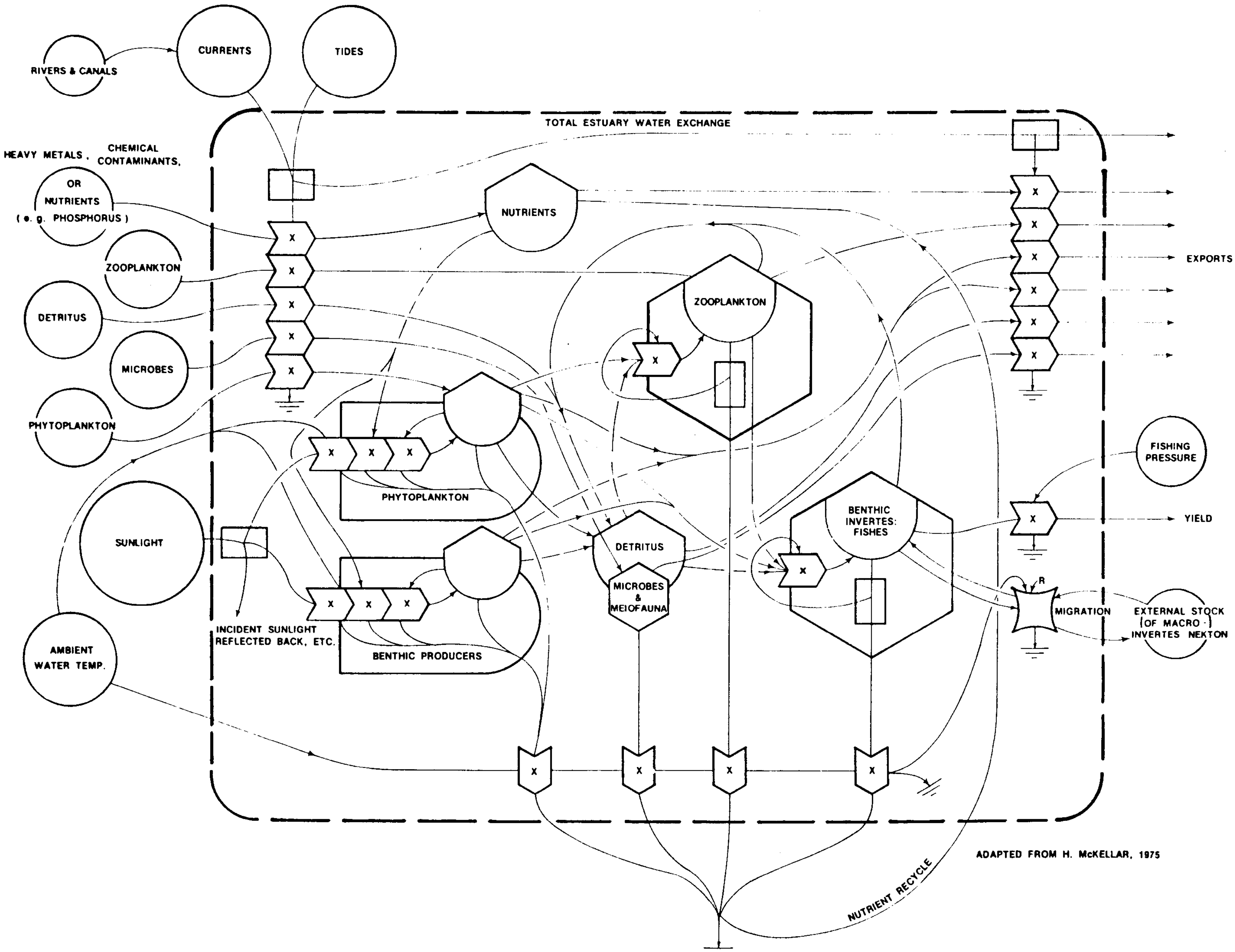
Water quality in an estuary is a function of chemical, physical, and biological processes of man and nature. Water quality programs often concentrate on chemical and physical measures of these processes because sampling techniques are established and well-defined, laboratory analyses are routine, and the results are easily compared with a rapidly growing data base throughout the county. Biological parameters tend to be more elusive; data is usually more difficult to gather, is subject to less strict interpretation, and does not readily lend itself to guideline-type standardization. However, these factors do not make biological information any less important or accurate as an indication of water quality and estuarine health. Water quality programs which incorporate measures of all processes ongoing in an estuary best lend themselves to the understanding and protection of estuarine health, and subsequently the prediction of an estuary's ability to maintain clean waters. In this spirit, the Southwest Florida Regional Planning Council (SWFRPC) incorporated biological investigation into the 208 Water Quality Planning Program.

2.3.2 Sampling Design

The value of biological information in water quality planning was approached on the basis of: (1) overall measures of productivity, biomass, and diversity as indicators of estuarine health; (2) potential incorporation of selected biological measurements into water quality monitoring programs; and (3) use of simplified ecosystems diagrams for estimating waste load allocations and evaluating impacts of contributing systems on receiving bays.

The water column of an estuary is only one of its vital components. Others include the benthic communities, the sediments, the contributing systems (rivers, tidal creeks, surrounding mangrove forests, etc.) and the receiving systems. All these exist and operate in a dynamic system of flows, forcing functions, and storages. A model involves a synthesis of information which provides a way of monitoring, organizing, and visualizing this system.

Figure 2.2-3 presents an energy circuit model of an estuarine ecosystem and its relationships to major external driving forces. (The symbols of the energy circuit language are explained in an appendix to this report.) This model represents the major components and processes thought to exist in the Charlotte Harbor estuary. Five major compartments of energy storage are represented in this model: (1) the primary producers, composed of phytoplankton and benthic flora; (2) organic detritus with its associated microbial community; (3) zooplankton; (4) an aggregated compartment of benthic invertebrates and fish; and (5) a storage of limiting nutrients such as phosphorus. This storage can also represent accumulation of heavy metals or chemical contaminants as well. The natural driving forces are solar radiation, local



ADAPTED FROM H. McKELLAR, 1975

FIGURE 2.2-3
AN ENERGY CIRCUIT MODEL OF AN ESTUARINE BAY ECOSYSTEM

and coastal currents, tides, external stocks of organisms and detritus, and ambient water temperature. Man's influence is shown in this system by imposing fishing pressure and by the addition of heavy metals, chemical contaminants, nutrients, organic loads, or microbes.

The value and role of models of this type in a water quality planning program include the following:

1. They force the scientist to state his assumptions explicitly;
2. They organize information and data about the system under investigation. Developed as part of the plan of study, models aid in determining the relative importance of storages and processes and in identifying potential data gaps. This insight is useful in prioritizing data gathering activities before going into the field.
3. Models serve as impact summaries. Lines from the outside forcing functions show causal actions that pass through main productive plant components to consumers. These lines allow the investigator to follow the impact of changing a forcing function along a given pathway through the various components. Secondary, tertiary, and so-called "hidden" impacts are not as easily overlooked.
4. Qualitative energy diagrams can be made quantitative by adding data gathered throughout the field activity so that

relative magnitudes of flows can be seen. The quantification gives a basis for estimating properties of systems response such as turnover times (the ratio of a storage to a flow in or out of it). Turnover times are useful for assessing the ability of the estuary to maintain clean waters.

5. Evaluated models can be simulated to show the consequence of changes in the estuary over time. The predictive ability of a model is essential to good long-term water quality planning.

Evaluation of the pathways, storages (state variables), and forcing functions (driving forces) shown graphically in Figure 2.2-3 was the basis for sampling design in Charlotte Harbor. Some data existed in the literature, additional data were forthcoming from other Southwest Florida 208 sampling activities. Those components for which no data existed were selected for measurement.

Field sampling and literature search results were summarized in the evaluated ecosystem diagram of the estuarine area. This diagram served as the basis for order-of-magnitude quantification of roles that the estuary plays for the surrounding area. Some specific roles addressed included: (1) organic waste assimilation and nutrient regeneration, (2) nutrient scrubbing and trapping, and (3) fisheries and related production.

2.3.3 Charlotte Harbor Sampling Stations

Diurnal estuarine sampling took place during June, 1977, on a one-time basis. The dry-to-wet transition period was selected as a most probable time of high nutrient loading into the estuarine bay area assuming a potential "first-flush" phenomenon as the wet season began. Sample sites are given in Figure 1.1-2.

Sampling was conducted over a 24-hour period at 11 stations in Charlotte Harbor. Some parameters such as turbidity were also measured at selected tides in Alligator Bay. Primarily for logistic reasons the harbor was divided into a north section and a south section. The southern portion (Stations 9 through 13, Figure 2.2-4) was sampled from June 18 through 21, 1977. The northern portion (Stations 1 through 6, including Alligator Bay, Figure 2.2-4) was sampled June 21 through 23, 1977. Stations 1 and 2 straddled the Peace River and were situated nearest the developed areas of the harbor. They were subject to large freshwater flows from the Peace River. Station 3 was located at the mouth of the Myakka River. Station 4 was the deepest station in the northern harbor, located centrally due west of Mangrove Point. Station 5, located near the outflow of Alligator Creek, was selected to represent the eastern shore of the harbor. Station 6 represented the western shore of the harbor. The coastal area near Station 6 was undeveloped mangrove area. Collectively, these stations represent a

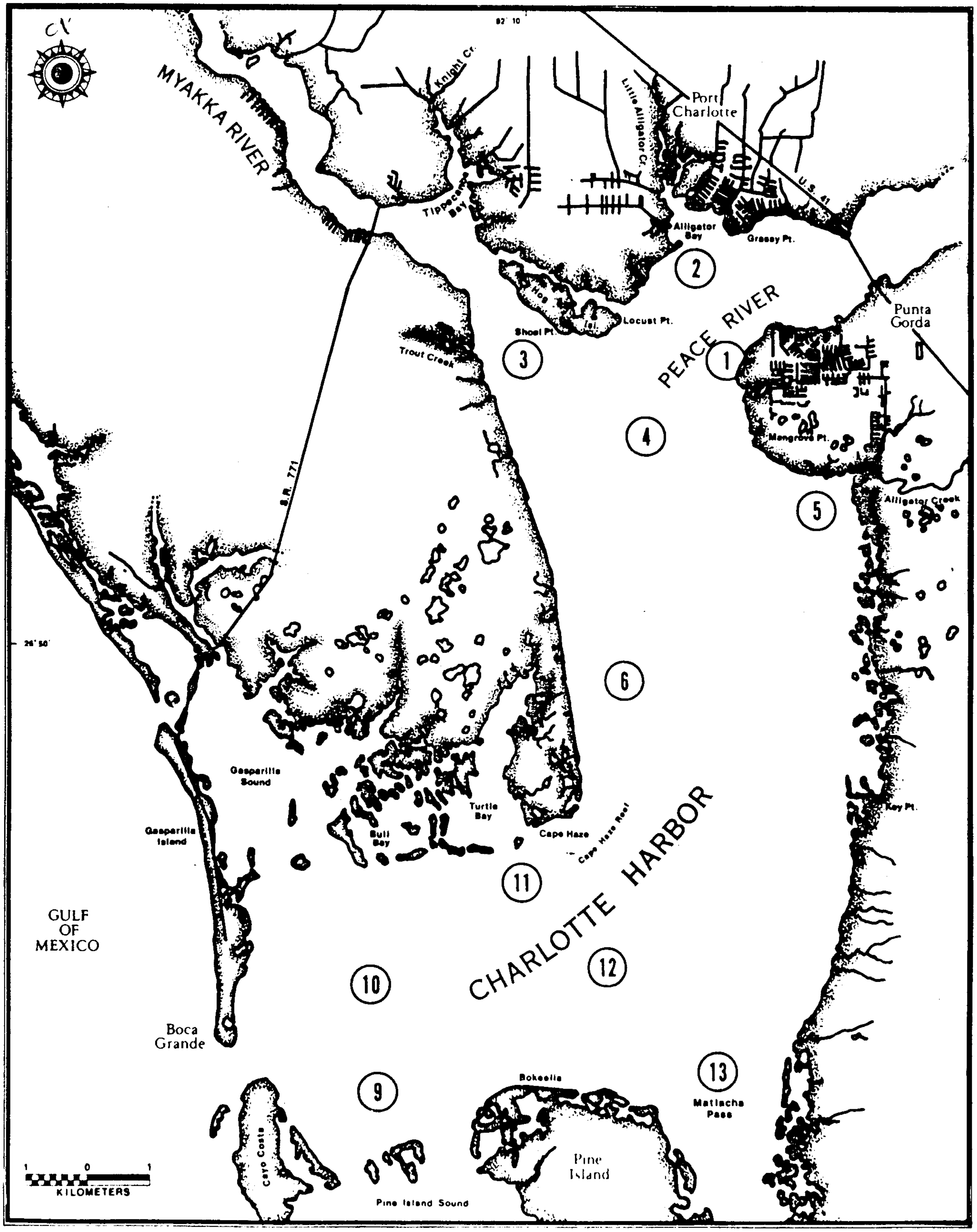


FIGURE 2.2-4
PRODUCTIVITY SAMPLING STATIONS LOCATION: CHARLOTTE HARBOR STUDY AREA

relatively deep (for Florida estuaries), mostly undeveloped, coastal estuary which receives large freshwater flows from the Peace and Myakka Rivers.

Stations in the southern part of the harbor were situated south of the Cape Haze Reef. Station 9 was located over a grass bed at the northern boundary of Pine Island Sound and Charlotte Harbor. The deepest of all stations sampled, Station 10, was situated north of the radar reflectors inside Boca Grande Pass. This station also was subject to strong currents. Station 11 was located near Cape Haze, an undeveloped mangrove estuarine area. Station 12 was a deep station in the center of the harbor south of the red flashing channel marker, and Station 13 was situated at the northern end of Matlache Pass. The southern portion of the harbor is also undeveloped and represents a large, deep coastal estuary. Charlotte Harbor could be subject to potential oil spills by oil barges travelling to Boca Grande. Due to its large area (42 square miles), developmental impacts may tend to be localized. The estuarine area serves primarily as a fishing and recreation area.

Free-water diurnal oxygen measurements in an estuarine area of such depth and size are subject to greater variations due to advection of water masses (horizontal differences in water masses) as well as vertical stratification. The magnitude and complexity of Charlotte Harbor suggest that the productivity results presented herein provide a minimum amount of information needed to manage a coastal area such as this one.

2.3.4 Sampling Parameters and Measurements

The productivity sampling scheduled for the Charlotte Harbor case study include several types of biological and physical measurements. Data from these measurements were then to be reduced and analyzed so that productivity parameters could be calculated. The types of data collected during the sampling effort are given below:

Total community metabolism--using diurnal oxygen measurements;

Plankton metabolism--using light and dark bottle oxygen measurements;

Planktonic and benthic community structure--using phytoplankton, zooplankton, and benthos samples collected during the study, and subsequently analyzed for taxonomic composition, abundance, and biomass;

Chlorophyll concentrations--using chlorophyll samples collected during the study as estimates of phytoplankton biomass;

Related physical measurements--including oxygen diffusion, water current velocities, wind velocities, water depths, solar insolation, light penetration, water and air temperatures, and salinity.

3.0 DISCUSSION OF BASELINE SAMPLING RESULTS--SPECIFICATION OF EXISTING WATER QUALITY

3.1 Chemical, Physical, and Bacteriological Constituents

Water quality data for the Charlotte Harbor and tributary stations has been resolved for tabular comparison of maximum and minimum concentrations at sampling stations and mean values for the number of samples analyzed (Tables 2.3-1 through 2.3-15).

Charlotte Harbor and tributary samples were analyzed for "BHC," Lindane, Heptachlor, Aldrin, Heptachlor Epoxide, Dieldren, Endrin, and DDT/DDD derivatives and component compounds. These pesticides are not presented in the data tables. "BHC" is the most persistent of all pesticides, appearing in significant concentrations in all tributary stations and all but three harbor stations. Lindane and heptachlor appear in the north harbor at the Myakka River and on the western side of the central harbor, lower Coral Creek, Grande Pass, one southern harbor station, and in the upper reaches of the Peace and Myakka river systems. Aldrin appears in Big Slough and Little Alligator Creek. Dieldrin concentrations were detected in northern harbor stations, upper Gasparilla Sound, and all tributaries except Big Slough, Little Alligator Creek, and Alligator Creek. Concentrations of other pesticides examined were not detected in any samples.

3.2 Vertical Profiles of Three Physical Constituents

Estuaries are frequently classified by the freshwater-saltwater balance and may be typed as well-stratified, partially stratified, mixed, or well-mixed. In deeper estuaries, saltwaters intrude inland on the bottom during a tidal excursion. The saline water exchanges or mixes with the

Table 2.3-1. Water Quality Data Maximum and Minimum Concentrations with Mean Values for Period Sampled at Stations H-T1 and H-T2.

Factor	Station No. H-T1			Station No. H-T2		
	Mean	Range	No. of Samples	Mean	Range	No. of Samples
BOD, mg/l	1.7	3.2-1.2	6	2.4	4.1-1.2	7
TOC, mg/l	5.7	12.3-.5	10	10.3	20.4-.5	10
ALK, mg/l	161	280-114	7	106	210-56	7
COLOR, cpu	27	95-5	10	68	241-1	10
TS, mg/l	38,700	47,000-27,000	10	17,250	33,600-2,930	10
SS, mg/l	48	110-5	10	30	66-5	10
COND, μmho/cm	53,300	98,500-39,700	7	24,100	43,200-4,000	6
pH	7.9	8.1-7.6	8	7.7	8.0-7.1	8
F-DO, ppm	5.5	7.3-2.4	4	6.7	7.1-5.7	4
SAL, ppt	24		1	14		1
$O-PO_4$	.041	.076-.002	10	.141	.268-.057	10
TP, mg/l	.23	.46-.09	10	.30	.53-.12	10
TKN, mg/l	1.13	2.33-.60	10	1.48	2.34-.84	10
NO_2/NO_3, mg/l	.020	.046-.004	10	.022	.062-.004	10
NH_3, mg/l	.15	.33-.02	10	.14	.56-.03	10
FC, /100 ml	57	400-1	8	14	36-4	7
FS, /100 ml	102	560-4	8	47	239-1	8
AS, μg/l	18	20-10	6	18	20-10	6
PB, μg/l	2.1	3-2	9	2.5	3.4-2	9
CU, μg/l	5.3	17.6-2	6	4.5	14-2	6
F, mg/l	.86	1.0-.76	7	.69	.88-.52	7
HG, μg/l	8.1	28.8-.3	9	4.1	8.6-.24	9
O & G, mg/l*	<5			8.9		

*All O & G (oil and grease) values dated August 1, 1977.

Table 2.3-2. Water Quality Data Maximum and Minimum Concentrations with Mean Values for Period Sampled at Stations H-T3 and H-T4.

Factor	Station No. H-T3			Station No. H-T4		
	Mean	Range	No. of Samples	Mean	Range	No. of Samples
BOD, mg/l	1.8	2.7-1.0	6	1.9	2.4-1.0	6
TOC, mg/l	15.9	24.7-7.4	9	17.1	26.8-9.9	10
ALK, mg/l	127	220-92	6	63	90-32	7
COLOR, cpu	129	229-45	10	160	305-40	10
TS, mg/l	4,510	23,100-316	9	4,400	23,700-380	10
SS, mg/l	9	35-1	9	11	40-1	10
COND, μmho/cm	2,750	7,500-320	6	2,600	8,500-400	7
pH	7.7	8.3-6.9	7	7.4	7.9-7.0	8
F-DO, ppm	5.9	7.6-4.8	5	5.8	7.1-5.1	5
SAL, ppt	1		2	1		2
O-PO_4	.105	.142-.055	10	.097	.193-.028	10
TP, mg/l	.28	68-.13	10	.45	.91-.09	10
TKN, mg/l	1.77	3.46-1.18	10	1.59	2.34-1.20	9
NO_2/NO_3, mg/l	.023	.070-.004	10	.049	.101-.009	10
NH_3, mg/l	.16	.40-.02	10	.17	.51-.03	10
FC, /100 ml	99	600-1	7	68	500-1	10
FS, /100 ml	124	420-30	8	121	540-11	8
AS, μg/l	18	20-10	6	33	80-20	5
PB, μg/l	2.1	3-2	9	2.2	3-2	9
CU, μg/l	4.5	13.8-2	6	2.8	4.3-2	6
F, mg/l	.42	.72-.24	6	.30	.50-.17	6
HG, μg/l	8.6	32.2-.2	9	6.5	17.6-.8	9
O & G, mg/l*	<5					

*All O & G (oil and grease) values dated August 1, 1977.

Table 2.3-3. Water Quality Data Maximum and Minimum Concentrations with Mean Values for Period Sampled at Stations H-T5 and H-T6.

Factor	Station No. H-T5			Station No. H-T6		
	Mean	Range	No. of Samples	Mean	Range	No. of Samples
BOD, mg/l	2.7	4.4-1.0	6	4.2	9,6-1.4	6
TOC, mg/l	6.6	13.4-1.0	9	9.1	18.6-.5	10
ALK, mg/l	104	156-81	6	117	140-98	7
COLOR, cpu	48	107-10	10	39	83-5	10
TS, mg/l	25,100	33,200-16,500	9	22,000	32,600-10,000	10
SS, mg/l	35	85-8	9	30	77-5	10
COND, μmho/cm	30,500	55,600-22,000	6	24,000	33,100-14,000	7
pH	7.7	7.9-7.4	7	7.8	8.2-7.6	8
F-DO, ppm	7.6	11.0-5.4	9	8.0	9.8-6.6	4
SAL, ppt	18.8	23-11	6	19		1
O-PO_4	.256	.399-.032	9	.264	.426-.183	10
TP, mg/l	.51	.85-.31	9	.46	.80-.23	10
TKN, mg/l	1.65	2.48-.90	9	1.46	2.06-.84	10
NO_2/NO_3, mg/l	.014	.039-.002	10	.014	.050-.002	10
NH_3, mg/l	.28	.99-.03	9	.14	.26-.03	10
FC, /100 ml	18	120-1	8	14	36-1	8
FS, /100 ml	50	260-1	9	49	225-3	9
AS, μg/l	18	20-10	5	20	33-10	6
PB, μg/l	2.3	3.3-2	9	2.2	3-2	7
CU, μg/l	4.7	16.3-2	6	8.0	15.9-2	6
F, mg/l	.76	1.0-.60	6	.76	1.0-.56	6
HG, μg/l	4.1	19.2-.2	9	2.3	6.1-.3	7
O & G, mg/l*	---			<5		

*All O & G (oil and grease) values dated August 1, 1977.

Table 2.3-4. Water Quality Data Maximum and Minimum Concentrations with Mean Values for Period Sampled at Stations H-T7 and H-T8.

Factor	Station No. H-T7			Station No. H-T8		
	Mean	Range	No. of Samples	Mean	Range	No. of Samples
BOD, mg/l	2.0	4.4-1.0	7	2.1	2.6-1.0	7
TOC, mg/l	10.2	19.8-1.1	9	8.2	12.5-.5	10
ALK, mg/l	151	244-105	6	124	150-48	7
COLOR, cpu	68	141-21	10	53	112-15	10
TS, mg/l	16,300	32,400-688	10	11,600	22,800-912	10
SS, mg/l	25	48-1	10	24	55-3	10
COND, μmho/cm	14,800	27,600-760	7	11,700	23,700-870	7
pH	7.9	8.0-7.7		7.7	7.9-6.9	8
F-DO, ppm	6.4	7.8-5.0	4	6.3	7.8-4.5	5
SAL, ppt	12		1	5	10-1	2
O-PO_4	.073	.147-.025	10	.107	.187-.057	10
TP, mg/l	.42	1.51-.06	10	.34	.64-.14	10
TKN, mg/l	1.50	2.15-.89	10	1.24	2.15-.53	10
NO_2/NO_3, mg/l	.021	.114-.002	10	.028	.058-.004	10
NH_3, mg/l	.19	.59-.03	10	.18	.50-.02	10
FC, /100 ml	127	760-4	8	153	1,000-4	8
FS, /100 ml	68	236-4	8	226	800-18	9
AS, μg/l	18	20-10	6	18	20-10	6
PB, μg/l	2.3	4.1-2	9	2.7	4.7-2	9
CU, μg/l	2.8	4-2	6	2.7	3.7-2	6
F, mg/l	.60	.95-.24	7	.50	.80-.13	7
HG, μg/l	2.9	6.9-.2	8	5.7	13.3-.2	9
O & G, mg/l*	<5			<5		

*All O & G (oil and grease) values dated August 1, 1977.

Table 2.3-5. Water Quality Data Maximum and Minimum Concentrations with Mean Values for Period Sampled at Stations H-T9 and H-T10.

Factor	Station No. H-T9			Station No. H-T10		
	Mean	Range	No. of Samples	Mean	Range	No. of Samples
BOD, mg/l	2.2	4.5-1.2	6	1.6	2.5-1.0	6
TOC, mg/l	6.9	12.7-.5	9	12.6	19.9-3.3	9
ALK, mg/l	133	180-110	5	69	101-48	6
COLOR, cpu	33	57-15	9	97	264-18	9
TS, mg/l	26,300	38,500-10,000	9	6,900	20,100-1,300	9
SS, mg/l	35	58-9	9	16	31-4	9
COND, μmho/cm	29,700	37,000-13,000	6	6,450	12,000-1,200	6
pH	7.8	8.0-7.5	7	7.6	7.9-7.5	7
F-DO, ppm	7.1	12.0-4.2	8	8.0	16.0-5.2	8
SAL, ppt	21.5	28-6	6	4.4	7-1	5
O-PO_4	.083	.100-.022	9	1.347	2.150-.555	9
TP, mg/l	.23	.47-.10	9	1.69	2.40-.82	9
TKN, mg/l	1.23	1.59-.89	9	1.57	2.03-1.18	9
NO_2/NO_3, mg/l	.026	.075-.002	9	.233	.330-.004	9
NH_3, mg/l	.15	.28-.01	9	.13	.31-.01	9
FC, /100 ml	59	300-1	7	48	200-4	8
FS, /100 ml	57	380-1	9	60	180-4	9
AS, μg/l	18	20-10	5	18	20-10	5
PB, μg/l	2.2	3-2	9	2.3	4.1-2	9
CU, μg/l	4.7	15.9-2	6	4.6	15.5-2	6
F, mg/l	.75	.99-.51	6	.82	1.3-.48	6
HG, μg/l	2.2	5.6-.2	9	5.7	22.8-.4	9
O & G, mg/l*	---			---		

*All O & G (oil and grease) values dated August 1, 1977.

Table 2.3-6. Water Quality Data Maximum and Minimum Concentrations with Mean Values for Period Sampled at Stations H-T11 and H-T12.

Factor	Station No. H-T11			Station No. H-T12		
	Mean	Range	No. of Samples	Mean	Range	No. of Samples
BOD, mg/l	1.8	2.3-1.0	7	1.4	1.8-1.0	7
TOC, mg/l	11.1	15.7-3.2	9	13.8	23.1-.5	10
ALK, mg/l	81	95-64	6	39	56-35	7
COLOR, cpu	108	211-5	10	139	328-22	10
TS, mg/l	2,960	10,300-352	10	380	1,150-195	10
SS, mg/l	8	20-1	10	6.5	18-1	10
COND, μmho/cm	5,200	18,500-365	6	690	1,220-170	7
pH	7.7	8.4-6.9	7	7.5	8.3-6.9	7
F-DO, ppm	7.1	8.3-4.9	5	7.5	11.8-4.8	5
SAL, ppt	1	1-1	2	1	1-1	2
$O\text{-}PO_4$	.275	.749-.102	10	1.184	2.796-.009	10
TP, mg/l	.83	2.23-.15	10	2.00	3.10-.54	10
TKN, mg/l	2.09	4.82-.61	9	1.32	1.69-.67	10
NO_2/NO_3, mg/l	.035	.089-.004	9	.567	1.180-.004	10
NH_3, mg/l	.12	.28-.03		.33	2.3-.01	10
FC, /100 ml	35	120-1	7	135	1,000-1	8
FS, /100 ml	102	440-10	9	124	476-15	9
AS, μg/l	24	57-10	6	18	20-10	6
PB, μg/l	2.2	3-2	9	2.1	3-2	9
CU, μg/l	2.6	3.3-2	6	4.9	17.6-2	6
F, mg/l	.34	.60-.18	7	.87	1.15-.47	7
HG, μg/l	3.8	10.8-.2	9	2.3	6.4-.2	9
O & G, mg/l*	7.1			7.4		

*All O & G (oil and grease) values dated August 1, 1977.

Table 2.3-7. Water Quality Data Maximum and Minimum Concentrations with Mean Values for Period Sampled at Stations H-B1 and H-B2.

Factor	Station No. H-B1			Station No. H-B2		
	Mean	Range	No. of Samples	Mean	Range	No. of Samples
BOD, mg/l	3.3	11.3-1.0	7	4.8	11.9-1.1	7
TOC, mg/l	8.8	23.0-1.0	10	8.1	14.8-1.0	10
ALK, mg/l	97.3	110-64	7	109.9	198-80	7
COLOR, cpu	74.7	217-15	10	53.9	130-5.0	10
TS, mg/l	20,694	39,000-7,540	10	27,089	30,000-16,900	9
SS, mg/l	40.3	130-5	10	42.3	140-6	10
COND, μmho/cm	29,600	45,000-11,000	7	29,240	37,800-23,000	7
pH	7.80	8.0-7.7	8	7.72	7.9-7.2	8
F-DO, ppm	8.49	10.2-6.9	10	8.74	12.5-6.8	10
SAL, ppt	23.0	29-14	9	22.0	29-15	9
$O-PO_4$	.160	.289-.002	10	.230	.397-.069	10
TP, mg/l	.42	1.13-.21	10	.43	.68-.36	10
TKN, mg/l	1.30	2.60-.74	10	1.42	3.15-.97	10
NO_2/NO_3, mg/l	.014	.042-.002	10	.017	.056-.002	10
NH_3, mg/l	.15	.42-.01	10	.13	.25-.03	10
FC, /100 ml	4.4	10-1	8	3.8	10-1	9
FS, /100 ml	14.5	96-1.0	6	4.1	10-1	8
AS, μg/l	18.3	20-10	10	18.3	20-10	6
PB, μg/l	2.4	4.1-2.0	7	2.1	3.0-2.0	9
CU, μg/l	4.1	15.3-2.0	7	2.3	3.6-2.0	7
F, mg/l	.74	1.0-.58	10	.78	.89-.62	5
HG, μg/l	4.1	13.2-.08		1.8	9.6-1.0	4
O & G, mg/l*	<5			<5		

*All O & G (oil and grease) values dated August 1, 1977.

Table 2.3-8. Water Quality Data Maximum and Minimum Concentrations with Mean Values for Period Sampled at Stations H-B3 and H-B4.

Factor	Station No. H-B3			Station No. H-B4		
	Mean	Range	No. of Samples	Mean	Range	No. of Samples
BOD, mg/l	4.4	12.0-1.0	7	1.9	3.8-1.1	7
TOC, mg/l	7.1	13.4-1.0	10	8.7	15.3-.80	7
ALK, mg/l	97.3	108-76	7	101.0	110-80	6
COLOR, cpu	45.7	135-5.0	10	57.3	89-31	7
TS, mg/l	27,070	32,000-15,000	10	24,693	30,950-14,700	7
SS, mg/l	39.6	91-5	10	19.1	64-6	7
COND, μmho/cm	30,060	40,900-20,000	7	29,700	38,600-19,000	7
pH	7.75	7.9-7.5	8	7.76	7.9-7.5	7
F-DO, ppm	9.22	11.8-6.9	10	8.36	10.2-6.8	7
SAL, ppt	22.9	27-15	9	20.8	25-16	6
$O-PO_4$	.170	.327-.072	10	.180	.254-.079	7
TP, mg/l	.43	1.05-.22	10	.29	.44-.18	7
TKN, mg/l	1.29	1.79-.81	10	1.17	1.56-.42	7
NO_2/NO_3, mg/l	.014	.044-.002	10	.022	.057-.002	7
NH_3, mg/l	.14	.28-.01	10	.20	.42-.10	7
FC, /100 ml	6.0	24-1	9	4.9	10-1	7
FS, /100 ml	16.0	100-1	8	5.8	10-1	5
AS, μg/l	18.3	20-10	6	18.4	20.3-10	6
PB, μg/l	2.1	3.0-2.0	10	2.4	4.1-2.0	7
CU, μg/l	4.3	14.4-2.0	7	4.6	17.4-2.0	7
F, mg/l	.77	1.0-.64	7	.68	1.0-.20	7
HG, μg/l	3.7	8.8-.26	10	7.9	42.49-.20	7
O & G, mg/l*	<5			<5		

*All O & G (oil and grease) values dated August 1, 1977.

Table 2.3-9. Water Quality Data Maximum and Minimum Concentrations with Mean Values for Period Sampled at Stations H-B5 and H-B6.

Factor	Station No. H-B5			Station No. H-B6		
	Mean	Range	No. of Samples	Mean	Range	No. of Samples
BOD, mg/l	1.56	3.8-1.0	7	2.0	4.0-1.00	7
TOC, mg/l	9.1	18.7-2.0	7	5.5	11.7-.50	7
ALK, mg/l	102.6	115-88	7	104.6	120-84	7
COLOR, cpu	45.3	89-26	7	38.7	72-2	7
TS, mg/l	27,286	33,300-19,000	7	28,328	33,200-25,000	7
SS, mg/l	35.4	120-6	7	26.4	48-7	7
COND, μmho/cm	312,30	37,800-21,000	7	33,000	40,800-24,500	7
pH	7.90	8.0-7.8	7	7.80	8.0-7.6	7
F-DO, ppm	8.60	11.0-7.2	7	7.93	10.2-5.8	7
SAL, ppt	23.2	27-19	6	24.0	27-20	6
$O-PO_4$	.130	.281-.070	7	.140	.259-.069	7
TP, mg/l	.36	.88-.12	7	.36	.67-.08	7
TKN, mg/l	1.33	1.69-.81	7	1.14	1.72-.72	7
NO_2/NO_3, mg/l	.014	.051-.002	7	.010	.019-.002	7
NH_3, mg/l	.26	1.0-.07	7	.34	1.18-.11	7
FC, /100 ml	5.0	10-1	6	5.0	10-1	6
FS, /100 ml	5.8	10-1	5	5.5	10-1	5
AS, μg/l	18.5	21-10	6	18.3	20-10	6
PB, μg/l	2.3	4.1-2.0	7	2.2	3.3-2.0	7
CU, μg/l	14.4	74.6-2.0	7	5.2	16.7-2.0	7
F, mg/l	.78	1.0-.62	7	.79	1.0-.62	7
HG, μg/l	2.5	5.3-.20	7	3.5	15.2-.20	7
O & G, mg/l*	<5			6.2		

*All O & G (oil and grease) values dated August 1, 1977.

Table 2.3-10. Water Quality Data Maximum and Minimum Concentrations with Mean Values for Period Sampled at Stations H-B7 and H-B8.

Factor	Station No. H-B7			Station No. H-B8		
	Mean	Range	No. of Samples	Mean	Range	No. of Samples
BOD, mg/l	1.7	2.9-1.0	7	1.5	2.0-1.0	7
TOC, mg/l	7.5	14.5-.70	7	6.1	13.7-.1	10
ALK, mg/l	102.7	115-90	7	103	120-84	7
COLOR, cpu	39.1	78-2	7	28	72-8	10
TS, mg/l	25,054	33,200-2,380	7	32,400	41,700-20,500	10
SS, mg/l	30.3	66-12	7	44	100-10	10
COND, μmho/cm	33,660	42,800-28,000	7	36,100	42,700-26,000	7
pH	7.90	8.1-7.6	7	8.0	8.1-7.8	8
F-DO, ppm	8.19	9.9-5.9	7	8.3	11.0-6.2	10
SAL, ppt	23.5	29-19	6	26	30-22	9
$O-PO_4$	.140	.210-.071	7	.098	.190-.014	10
TP, mg/l	.36	.78-.19	7	.26	.61-.09	10
TKN, mg/l	1.28	1.86-.74	7	1.0	1.79-.39	10
NO_2/NO_3, mg/l	.015	.050-.002	7	.023	.101-.003	10
NH_3, mg/l	.18	.33-.07	7	.15	.38-.01	10
FC, /100 ml	5.0	10-1	6	10	46-1	8
FS, /100 ml	5.8	10-1	5	30	100-1	8
AS, μg/l	18.5	20-10	6	18	20-10	6
PB, μg/l	2.1	2.5-2.0	7	2	3-2	10
CU, μg/l	2.3	2.9-2.0	7	2.5	3.6-2	7
F, mg/l	.80	1.0-.50	7	2.0	5.6-.2	10
HG, μg/l	3.4	13.2-.20	7	.80	1.0-.67	7
O & G, mg/l*	<5			<5		

*All O & G (oil and grease) values dated August 1, 1977.

Table 2.3-11. Water Quality Data Maximum and Minimum Concentrations with Mean Values for Period Sampled at Stations H-B9 and H-B10.

Factor	Station No. H-B9			Station No. H-B10		
	Mean	Range	No. of Samples	Mean	Range	No. of Samples
BOD, mg/l	1.6	2.6-1.0	7	2.3	7.7-1.0	7
TOC, mg/l	8.4	12.8-3.0	7	7.5	14.8-1.0	8
ALK, mg/l	119	250-72	7	105	120-83	7
COLOR, cpu	29	48-17	7	23	42-1	8
TS, mg/l	29,200	34,600-10,000	7	35,200	39,600-28,800	8
SS, mg/l	44	92-11	7	54	140-5	8
COND, μmho/cm	36,500	42,000-31,000	6	41,800	46,000-39,000	7
pH	7.7	8.0-6.4	7	7.7	8.0-6.5	7
F-DO, ppm	7.6	9.9-4.6	7	8.2	10.2-5.9	8
SAL, ppt	26	29-23	5	30	33-26	7
$O-PO_4$	.095	.150-.050	7	.073	.123-.032	8
TP, mg/l	.20	.32-.09	7	.34	1.2-.07	8
TKN, mg/l	1.25	2.69-.52	7	1.15	2.8-.43	8
NO_2/NO_3, mg/l	.017	.031-.004	8	.030	.068-.002	8
NH_3, mg/l	.17	.29-.07	7	.16	.31-.03	8
FC, /100 ml	5	10-1	6	3.5	10-1	6
FS, /100 ml	6	10-3	5	5	10-1	6
AS, μg/l	18	20-10	6	18	20-10	6
PB, μg/l	2	2.5-2	7	2	4.1-2	8
CU, μg/l	2.5	3.3-2	7	2.1	2.4-2	6
F, mg/l	3.8	10.8-.21	7	1.6	5.0-.24	8
HG, μg/l	.73	1.0-.14	8	.83	1.0-.61	7
O & G, mg/l*	<5			<5		

*All O & G (oil and grease) values dated August 1, 1977.

Table 2.3-12. Water Quality Data Maximum and Minimum Concentrations with Mean Values for Period Sampled at Stations H-B11 and H-B12.

Factor	Station No. H-B11			Station No. H-B12		
	Mean	Range	No. of Samples	Mean	Range	No. of Samples
BOD, mg/l	3.8	8.1-1.0	7	3.1	3.3-2.9	2
TOC, mg/l	6.6	13.0-.5	7	6.7	8.6-4.9	2
ALK, mg/l	119	135-107	7	110	120-100	2
COLOR, cpu	14	31-5	7	29	37-21	2
TS, mg/l	38,500	40,600-33,800	7	29,300	32,600-26,000	2
SS, mg/l	48	85-11	7	26	31-21	2
COND, μmho/cm	44,300	51,000-41,000	7	40,000	46,000-34,000	2
pH	8.0	8.4-7.8	7	8.0	8.1-7.8	2
F-DO, ppm	8.3	10.6-6.5	6	8.4		
SAL, ppt	31	34-29	6	26		
O-PO_4	.094	.448-.014	7	.170	183-158	2
TP, mg/l	.33	.97-.12	7	.46	.72-.21	2
TKN, mg/l	.99	1.38-.58	7	1.87	2.27-1.46	2
NO_2/NO_3, mg/l	.005	.011-.002	7	.005	.006-.003	2
NH_3, mg/l	.16	.25-.08	7	.34	35-33	2
FC, /100 ml	4	10-1	5	10		
FS, /100 ml	6	10-1	5	7	10-4	2
AS, μg/l	18	20-10	6	20	20-20	2
PB, μg/l	2	3.3-2	7	2	2-2	2
CU, μg/l	4.8	18-2	6	2.3	2.5-2	2
F, mg/l	3.0	12-2	7	2.2	4.15-.25	2
HG, μg/l	.83	.92-.76	7	.77	83-70	2
O & G, mg/l*	<5			<5		

*All O & G (oil and grease) values dated August 1, 1977.

Table 2.3-13. Water Quality Data Maximum and Minimum Concentrations with Mean Values for Period Sampled at Stations H-B13 and H-B14.

Factor	Station No. H- B13			Station No. H- B14		
	Mean	Range	No. of Samples	Mean	Range	No. of Samples
BOD, mg/l	1.6	4.2-1.0	7	2.2	3.4-1.0	7
TOC, mg/l	6.2	12.6-.50	9	6.9	14.6-.50	7
ALK, mg/l	115	165-86	7	136	260-107	7
COLOR, cpu	14	31-2	9	36	54-1	7
TS, mg/l	37,300	41,200-29,800	9	31,200	36,000-25,100	7
SS, mg/l	43	68-11	9	30	66-9	7
COND, μmho/cm	43,900	49,000-41,000	7	36,700	43,000-28,700	5
pH	8.0	8.1-7.8	8	7.9	8.0-7.7	7
F-DO, ppm	8.4	11.2-5.5	7	7.7	9.9-5.3	7
SAL, ppt	30	33-27	8	26	29-22	5
$O-PO_4$	.051	.107-.007	9	.043	.058-.028	7
TP, mg/l	.24	.51-.05	9	.28	.52-.09	
TKN, mg/l	.85	1.04-.26	9	1.17	1.73-.68	7
NO_2/NO_3, mg/l	.014	.049-.004	9	.007	.021-.002	7
NH_3, mg/l	.17	.34-.03	9	.21	.36-.09	7
FC, /100 ml	3.5	10-1	5	4	10-1	5
FS, /100 ml	20	100-1	9	7		5
AS, μg/l	18	20-10	6	19	26-10	6
PB, μg/l	2	2.5-2	8	2	3.3-2	7
CU, μg/l	7.1	17.4-2	6	6.4	16.7-2	7
F, mg/l	3.0	8.3-.2	8	1.2	2.8-.4	5
HG, μg/l	.88	1.0-.75	6	.78	1.0-.68	7
O & G, mg/l*	<5			<5		

*All O & G (oil and grease) values dated August 1, 1977.

Table 2.3-14. Water Quality Data Maximum and Minimum Concentrations with Mean Values for Period Sampled at Stations H-B15 and H-B16.

Factor	Station No. H-B15			Station No. H-B16		
	Mean	Range	No. of Samples	Mean	Range	No. of Samples
BOD, mg/l	2.0	3.6-1.0	7	2.2	6.3-1.0	7
TOC, mg/l	7.0	12.2-.50	7	7.5	14.8-.50	7
ALK, mg/l	134	260-107	7	133	255-105	7
COLOR, cpu	35	165-1	7	18	37-1	7
TS, mg/l	35,700	41,000-32,000	7	36,000	39,600-33,200	7
SS, mg/l	36	88-2	7	36	72-11	7
COND, μmho/cm	42,900	48,000-38,500	7	44,000	51,000-39,500	7
pH	8.0	8.2-7.8	7	8.0	8.2-7.8	7
F-DO, ppm	8.0	9.3-6.5	7	7.6	8.8-5.8	7
SAL, ppt	30	33-25	6	30	32-28	6
O-PO_4	.058	.103-.018	7	.050	.077-.026	7
TP, mg/l	.24	.43-.09	7	.17	.29-.06	7
TKN, mg/l	1.06	1.50-.46	7	1.51	2.23-.43	7
NO_2/NO_3, mg/l	.007	.017-.002	7	.013	.041-.002	7
NH_3, mg/l	.18	.39-.09	7	.22	.38-.12	7
FC, /100 ml	4	10-1	5	4	10-1	5
FS, /100 ml	6	10-1	5	11	26-4	5
AS, μg/l	24	57-10	6	18	20-10	6
PB, μg/l	3	6.4-2	7	2	2-2	7
CU, μg/l	6.2	27.1-2	7	2.6	3.8-2	7
F, mg/l	3.2	13.6-.21	5	2.8	9.5-.24	7
HG, μg/l	.90	1.2-.74		.89	1.2-.67	7
O & G, mg/l*	<5			<5		

*All O & G (oil and grease) values dated August 1, 1977.

Table 2.3-15. Water Quality Data Maximum and Minimum Concentrations with Mean Values for Period Sampled at Stations H-B17 and H-B18.

Factor	Station No. H-B17			Station No. H-B18		
	Mean	Range	No. of Samples	Mean	Range	No. of Samples
BOD, mg/l	1.6	3.8-1.0	7	2.4	5.8-1.0	6
TOC, mg/l	3.8	10.5-.50	10	5.0	12.6-.50	6
ALK, mg/l	115	135-102	7	106	116-86	6
COLOR, cpu	21	49-5	10	28	72-8	6
TS, mg/l	39,800	60,400-33,100	10	38,100	42,600-32,800	6
SS, mg/l	56	220-10	10	37	80-5	6
COND, μmho/cm	44,600	53,000-40,500	7	43,800	46,300-38,000	6
pH	8.0	8.2-7.8	8	7.7	8.1-6.6	6
F-DO, ppm	7.8	9.8-5.2	9	7.5	9.2-5.1	6
SAL, ppt	30	33-28	9	32	33-30	5
O-PO_4	.033	.097-.005	10	.040	.090-.016	6
TP, mg/l	.20	.49-.09	10	.24	.49-.09	6
TKN, mg/l	.85	1.12-.44	10	1.04	2.47-.50	6
NO_2/NO_3, mg/l	.019	.048-.004	10	.011	.021-.002	
NH_3, mg/l	.12	.25-.01	10	.12	.17-.07	
FC, /100 ml	3	10-1	6	4	10-1	5
FS, /100 ml	22	100-1	8	5	10-1	4
AS, μg/l	18	20-10	6	18	20-10	5
PB, μg/l	2.1	3-2	9	7	25.2-2	5
CU, μg/l	4.6	16.9-2		6.0	16.5-2.7	5
F, mg/l	5.2	26-.2	9	4.6	16.6-.2	5
HG, μg/l	.77	1.0-.25	7	.84	1.0-.72	6
O & G, mg/l*	<5			---		

*All O & G (oil and grease) values dated August 1, 1977.

seaward-flowing surface fresh water generating a horizontal salinity gradient increasing seaward. The volume of seawater available for exchange is largely dependent upon the volume flow of surface fresh water. When surface runoff flow is high, the saline wedge volume is larger and intrudes further inland promoting a greater exchange. Well-mixed estuaries are typically large and shallow. They are subject to small tidal ranges and have substantial freshwater flow volumes. Saline gradients generally increase seaward due to the rapid mixing of waters. An estuary system may exhibit a large salinity variance of fresh to brackish to saline waters. It is this wide range of salinity conditions which accommodate the abundance and variety of aquatic life within an unaltered estuarine system.

The Charlotte Harbor system, comparing width to depth, is a shallow estuarine system which exhibits varied degrees of stratification and mixing seasonally. Generally, during low flow periods, the system is well mixed and wind is probably the dominant mixing mechanism. During these low flow periods, the Harbor predominantly exhibits a horizontal salinity gradient increasing toward the Gulf.

The greatest vertical stratification within the system generally occurs during the wet season when freshwater flow to the system is greatest. During dry season-low flow periods the Harbor appears to be well mixed vertically, showing little gradient in salinity from top to bottom except during periods of high tides, when saline wedges may intrude well upstream. Typically, in broad shallow estuaries such as Charlotte Harbor, wind becomes the dominant mixing mechanism in the absence of substantial tidal dynamics and inflow conditions. Mixing within the estuary at times of high prevailing winds often becomes so rapid that water short-term column inversions occur and suspension of bottom sediments in some mid-water areas is rather common.

Tidal intrusion of saline waters has been seen well upstream into the Peace and Myakka rivers. The condition is variable dependent upon flow and tide conditions. As may be expected in any estuarine system, dissolved oxygen (DO) levels decrease with low flow-high temperature conditions. Although critically low DO or temperature conditions were not experienced during the sampling periods in the Harbor, it is generally agreed that the most severe DO condition may exist during extreme low flow periods prior to the onset of the wet season. It is noteworthy that even during dry season periods, aeration of the water column may occur in the Harbor during periods of high prevailing winds in some mid-water areas thereby inducing overtures and upwellings. Temperature, dissolved oxygen, and salinity profile data are presented in the data appendix.

3.3 Comments Regarding Extent to Which Sampling Satisfied Basis for Inclusion

In general, the sampling program for the Charlotte Harbor area satisfied the primary objectives of establishing surface water quality of the system and the major tributary source waters. The modifications to the sampling program in the spring of 1977 also contributed significantly to an assessment of upland drainage system water quality as a source to the estuary system. Although the data accumulated for the system is descriptive of the system for the sampling year, it is unfortunate that the program, unavoidably, was conducted during a period of below-average rainfall for the area. Hydrographic flow data is not yet available from which to properly evaluate the impact of the drought on the sampling program. It is probable that many water quality parameters within the Harbor are affected as a condition of flow rather than concentration such as phosphorus and nitrogen.

3.4 Water Quality Based on All Available Data

Tables 2.3-16 through 2.3-45 present maxima, minima, and mean values of water quality constituents for each of the Charlotte Harbor and tributary stations. The water quality is presented graphically so that a rapid assessment of the range of concentration and average concentrations of parameters for the sampling period can be made. These values are plotted against water quality criteria in order to assess the severity, duration, and magnitude of those parameters in violation of criteria.

Table 2.3-16. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-T1.

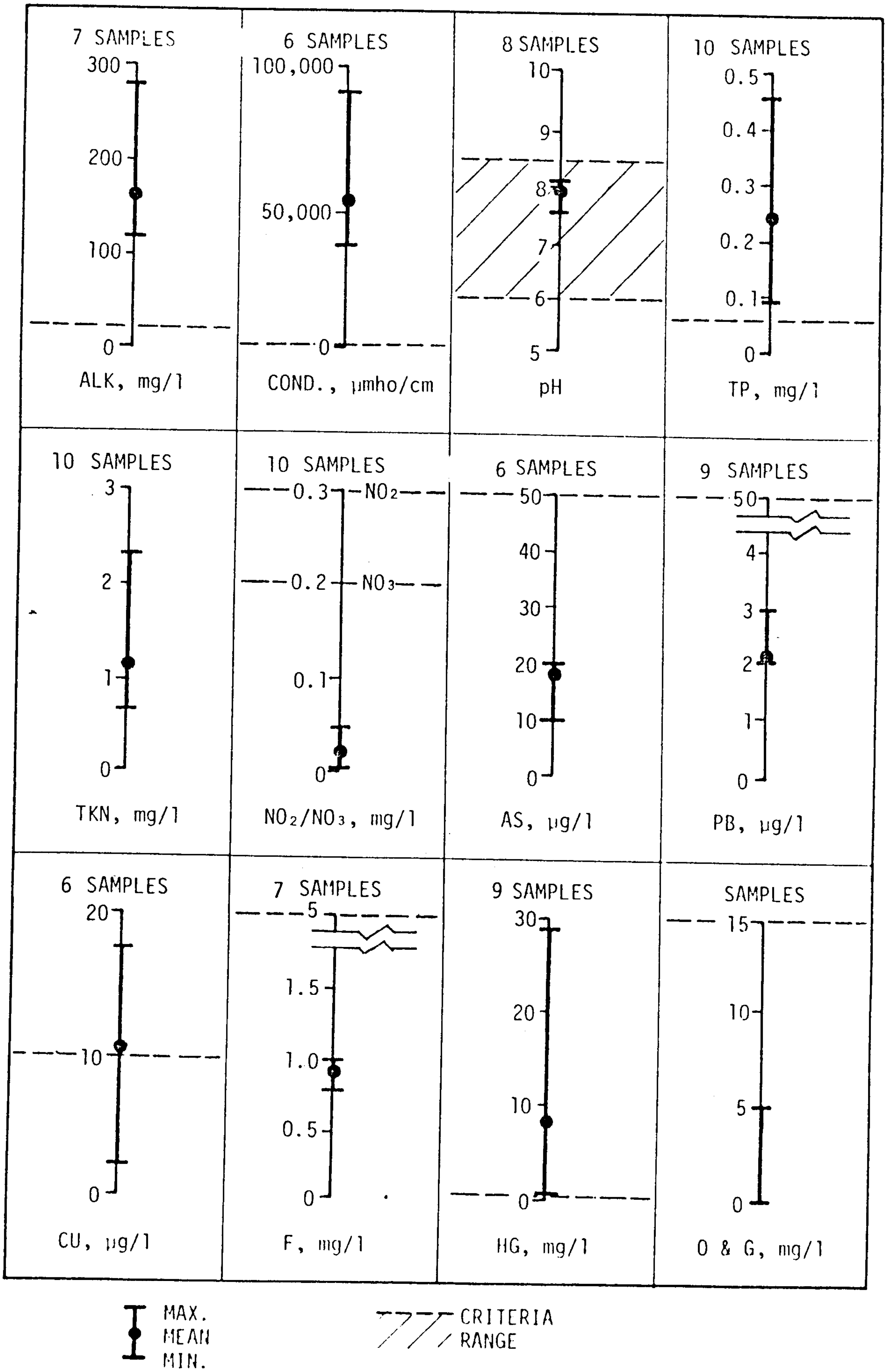


Table 2.3-17 Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-T2.

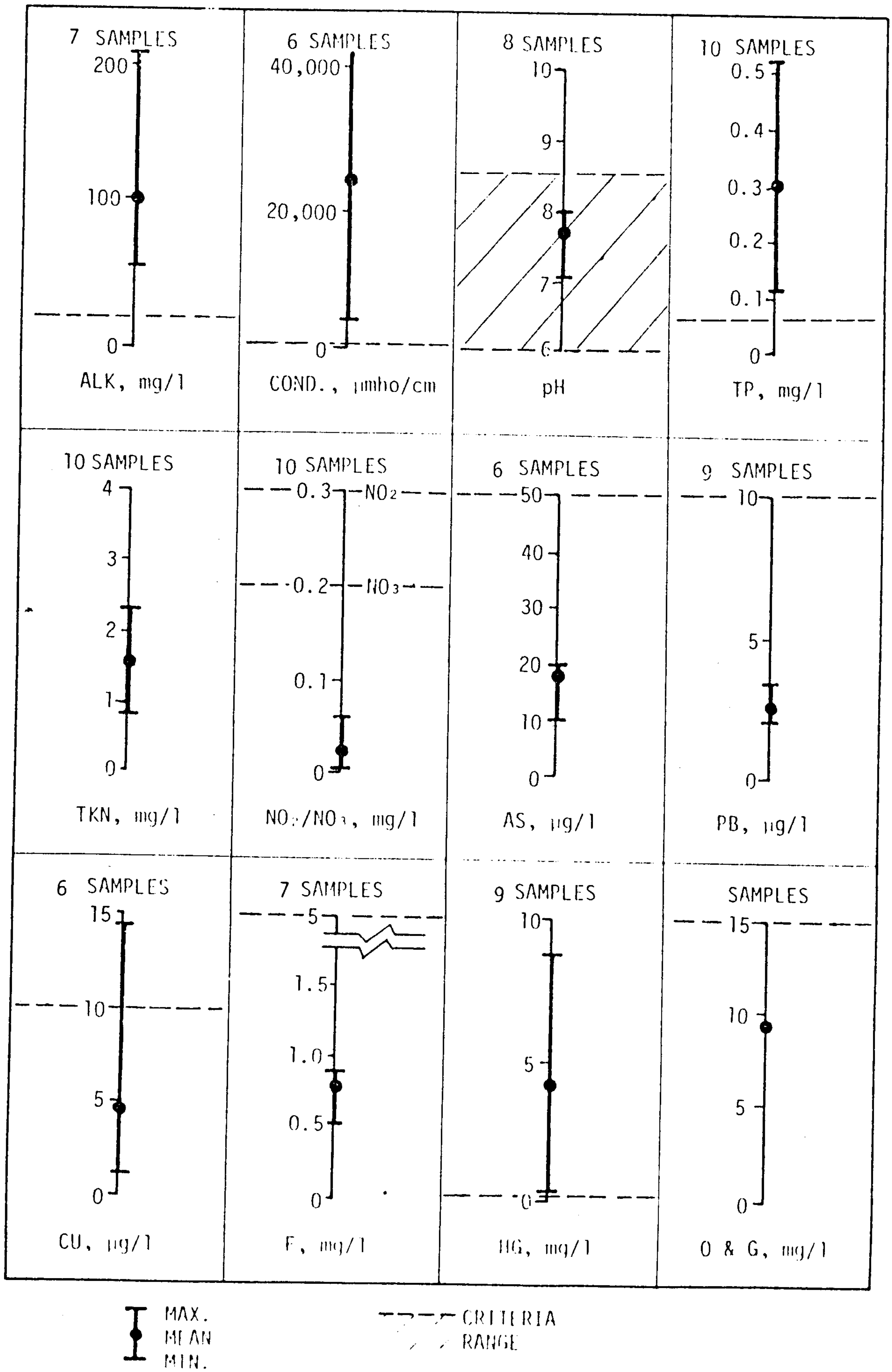


Table2.3-18. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-T3.

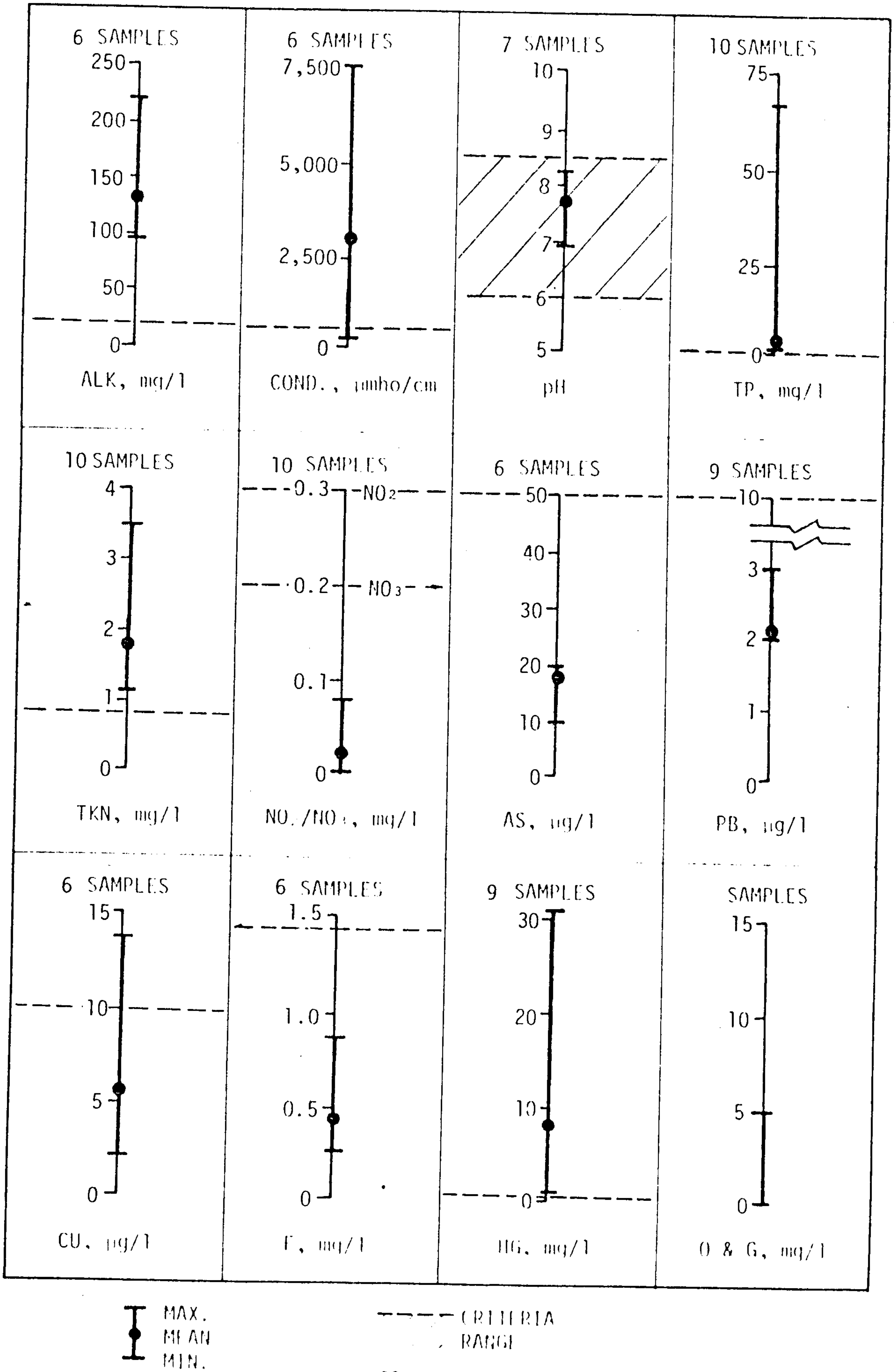


Table 2.3-19. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-T4.

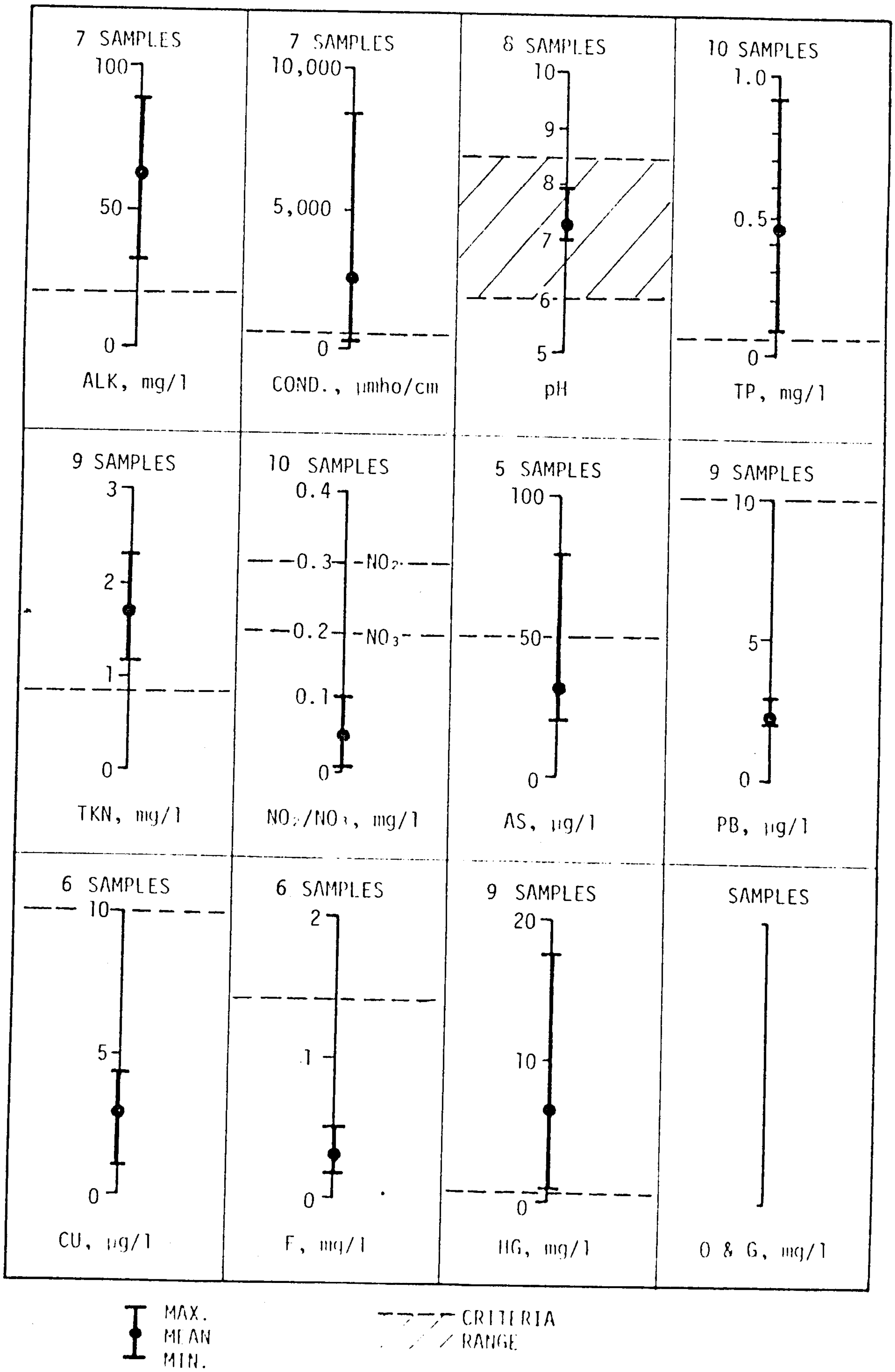


Table 2.3-20. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-T5.

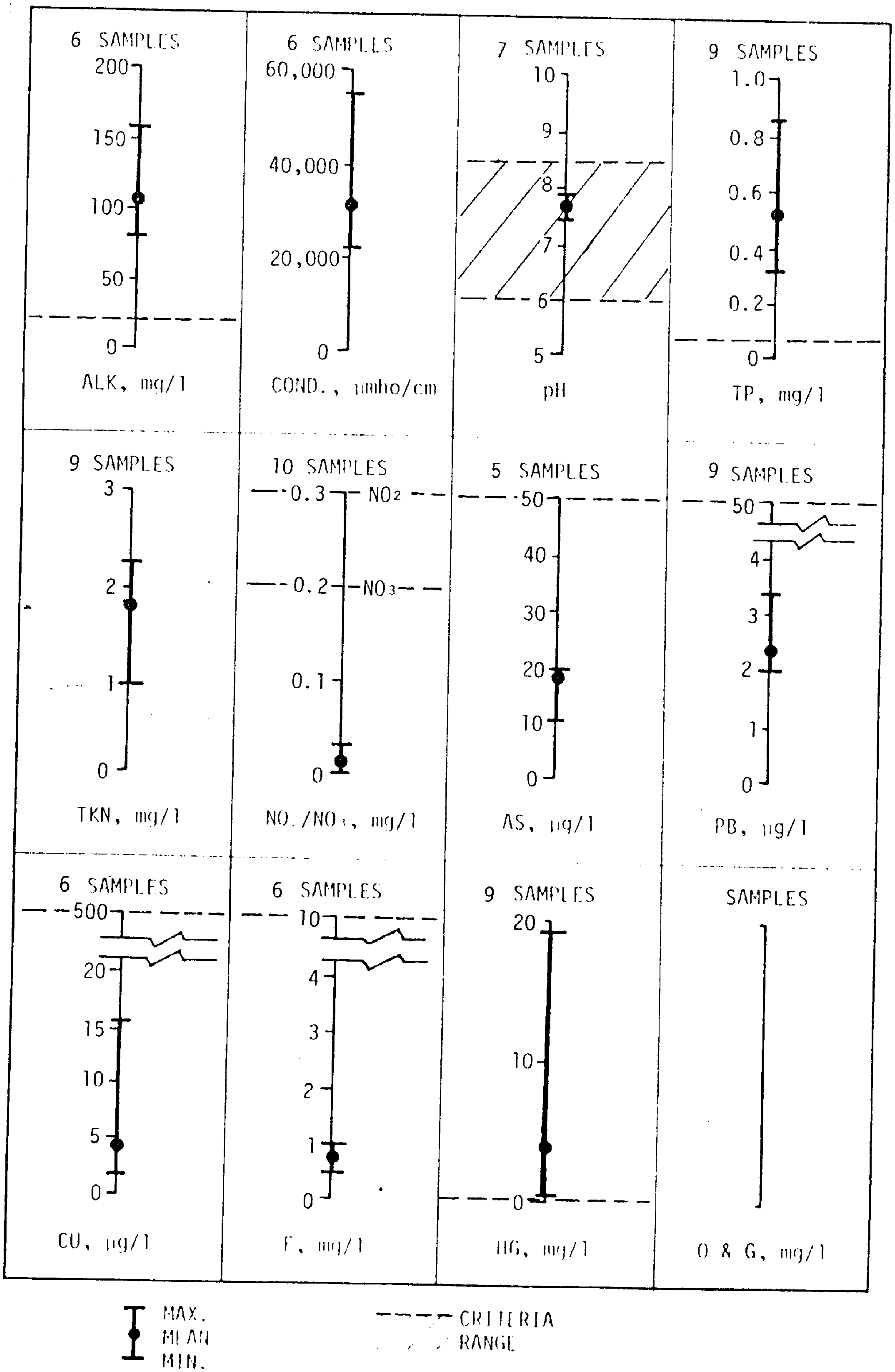


Table 2.3-21. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-16.

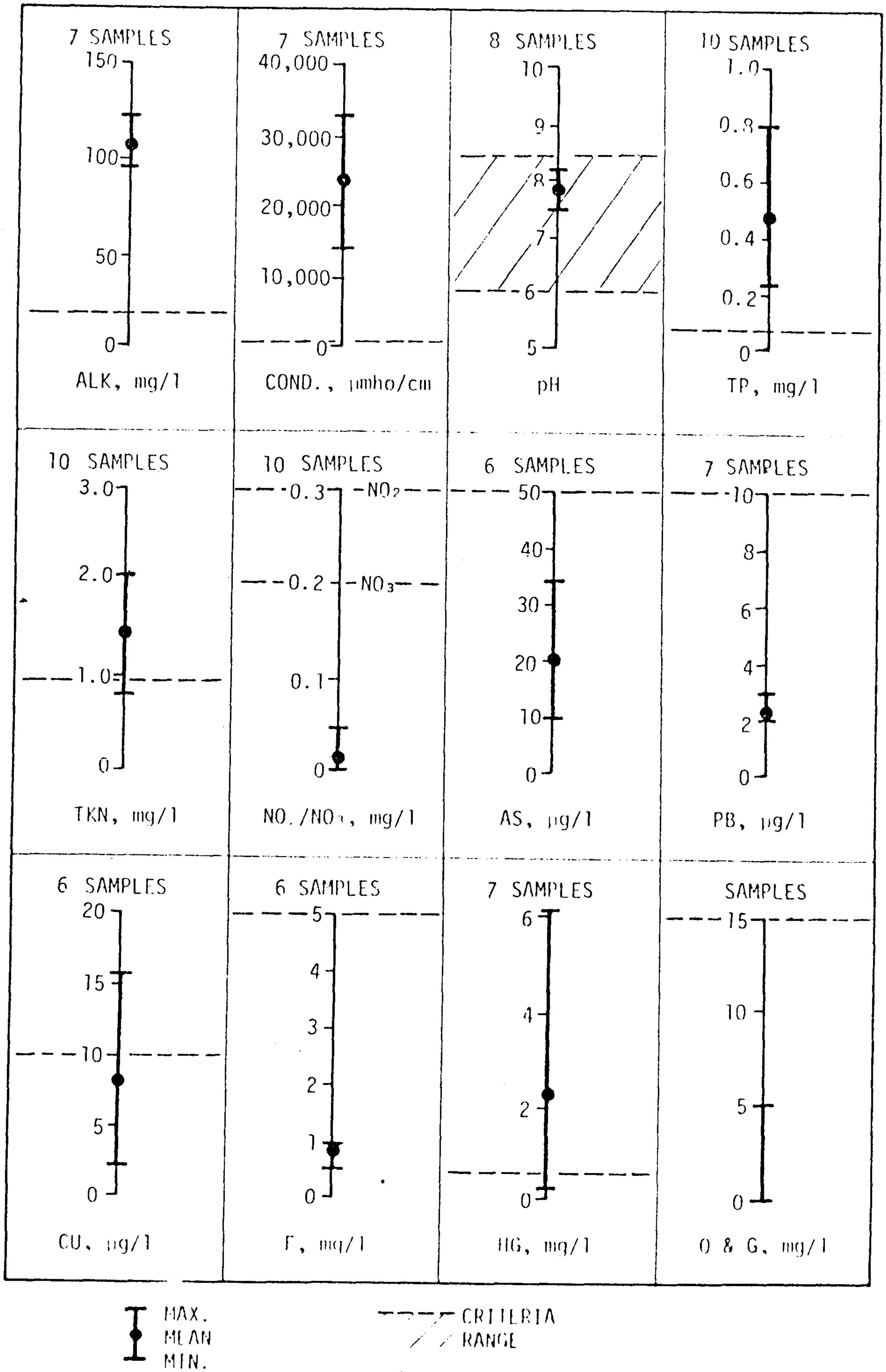


Table 2.3-22. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-17.

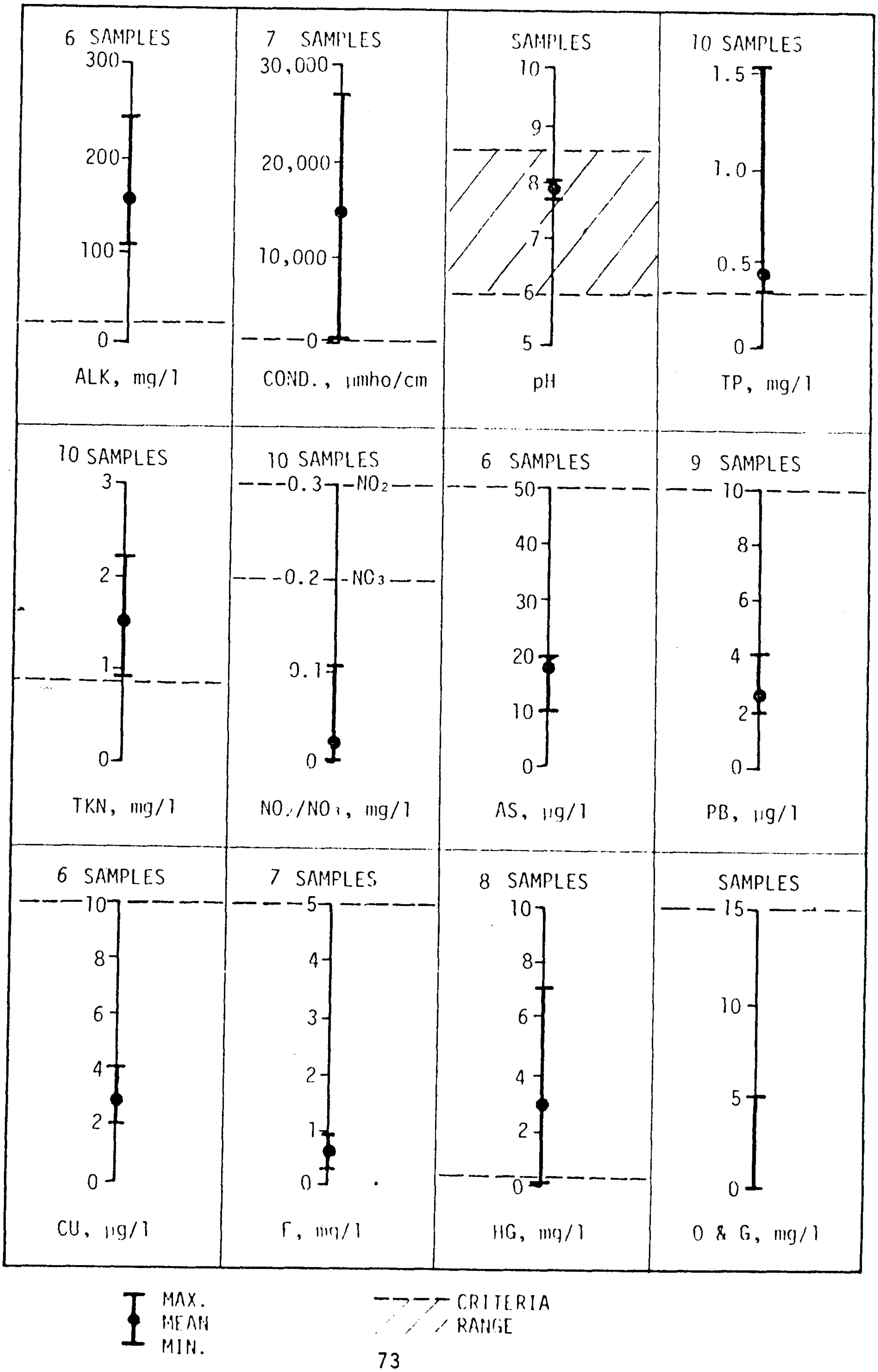


Table 2.3-23. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-T8.

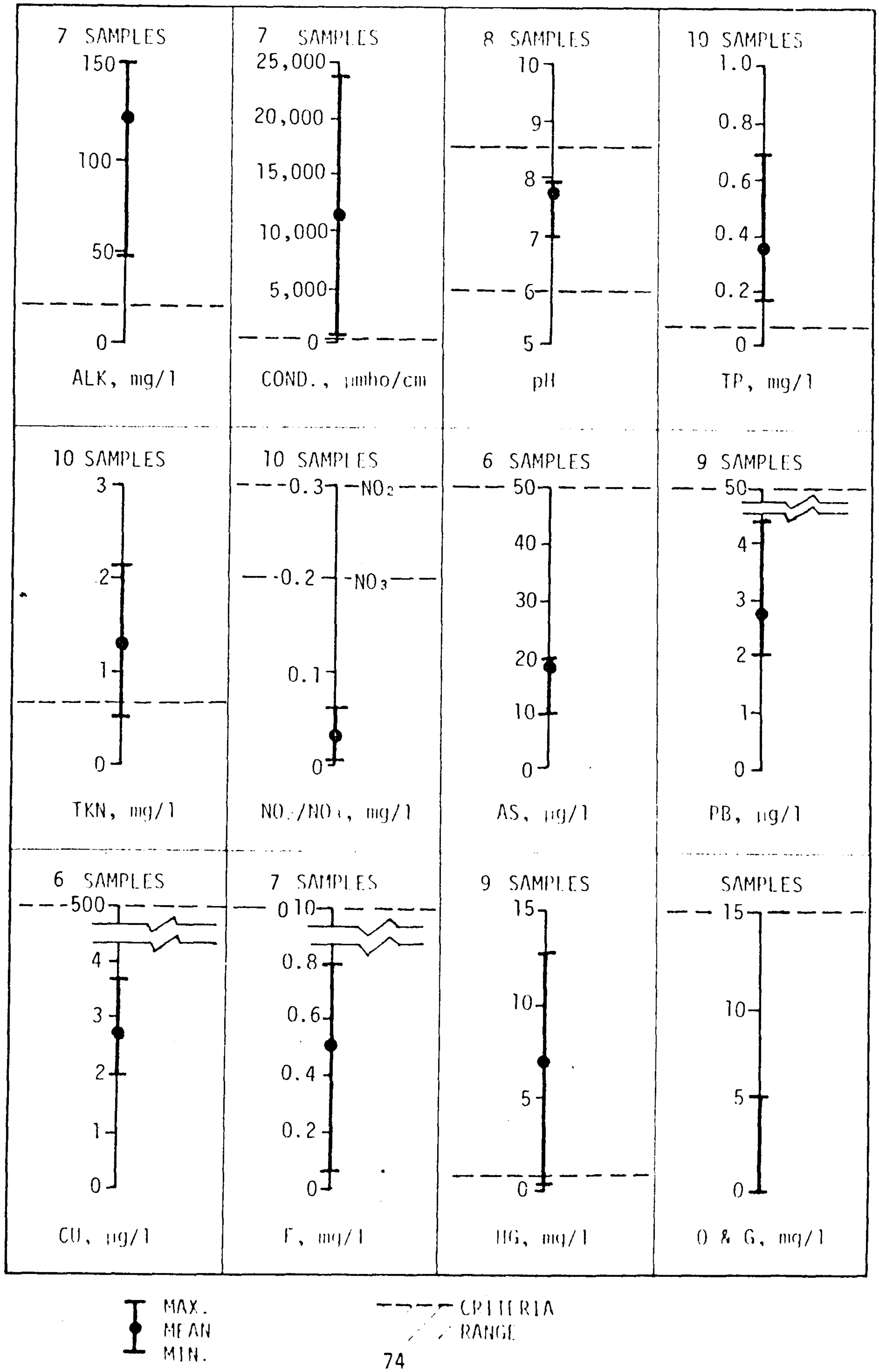


Table 2.3-24. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-T9.

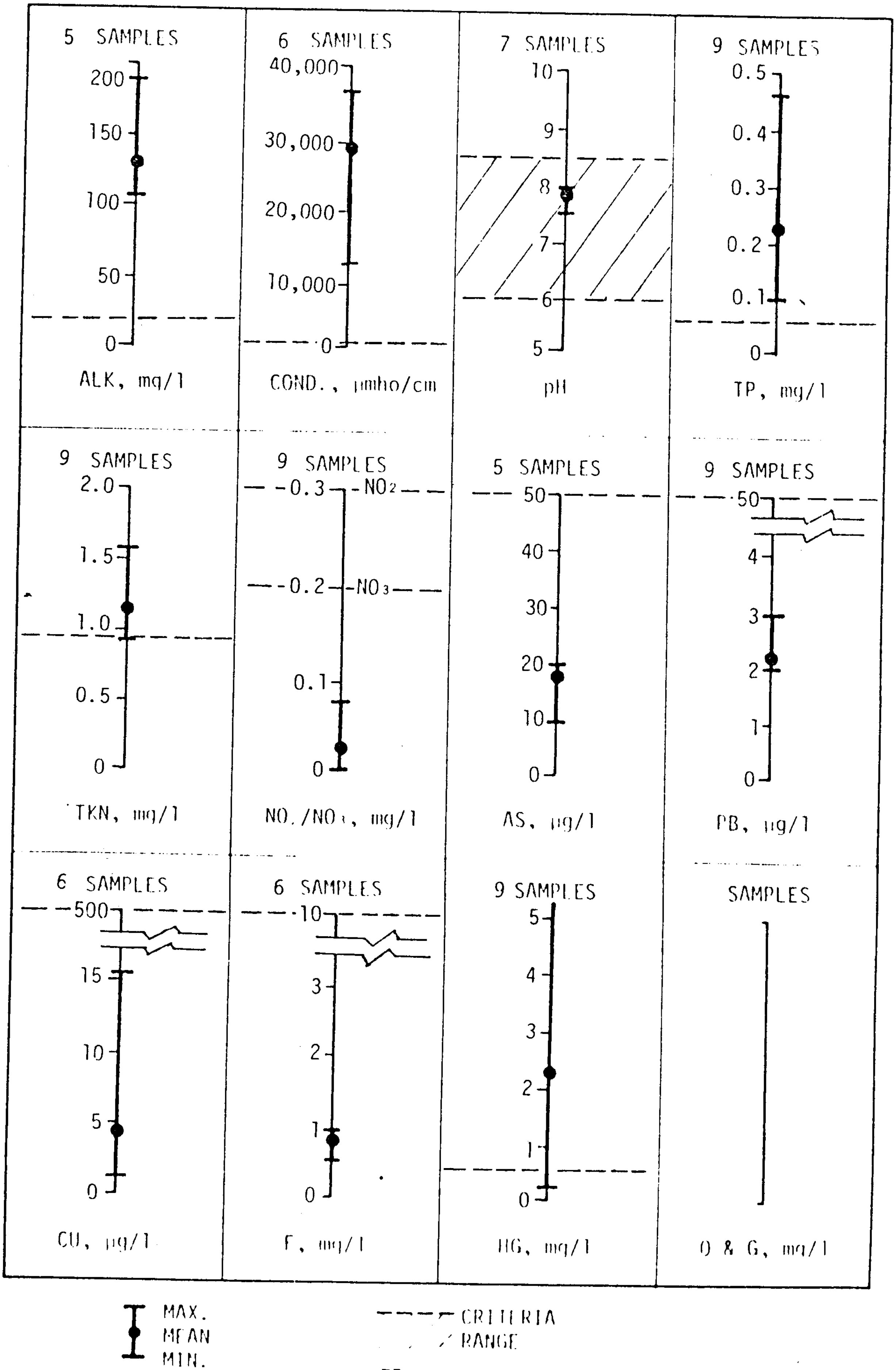


Table 2.3-25. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-T10.

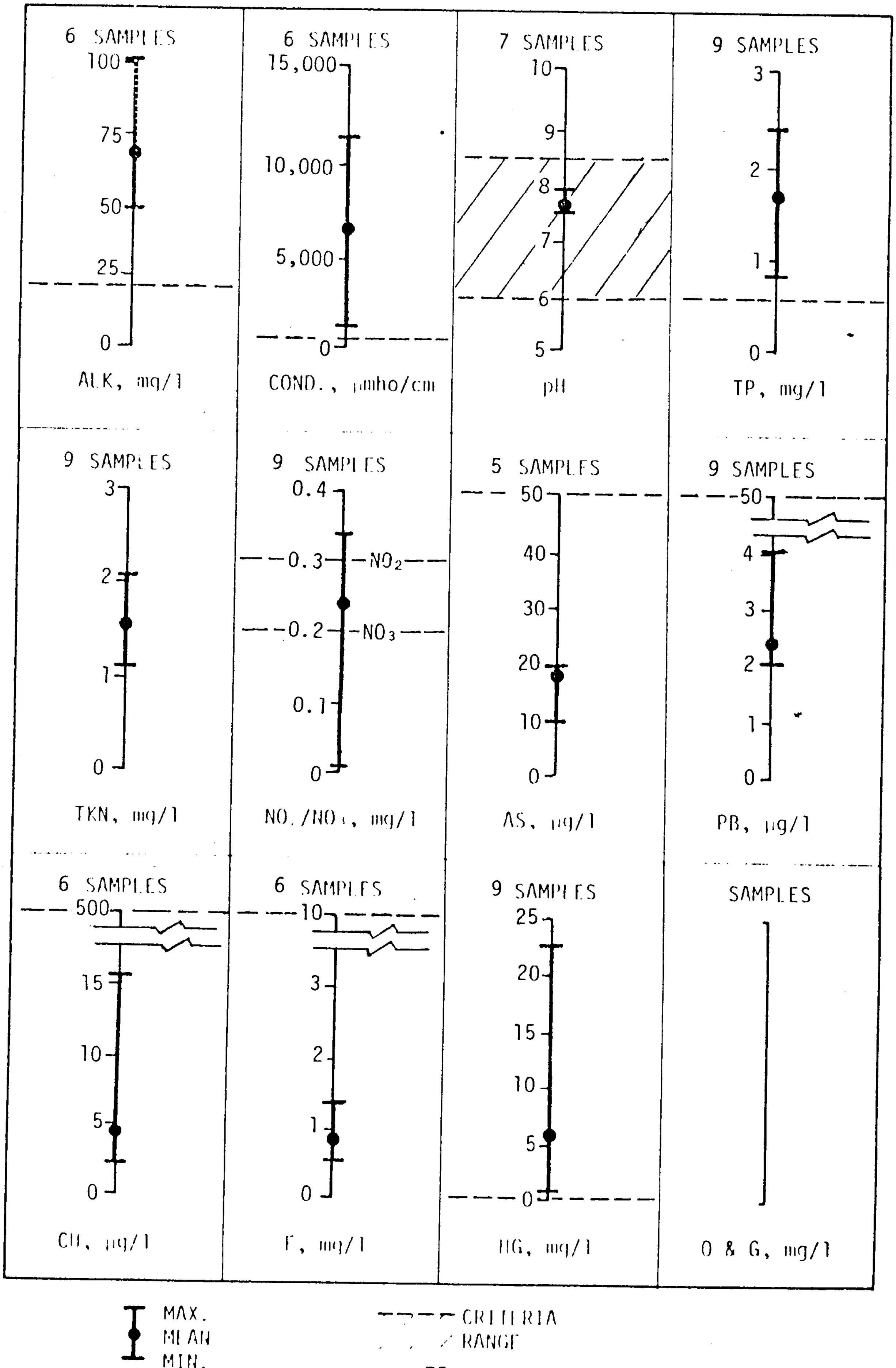


Table 2.3-26. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-T11.

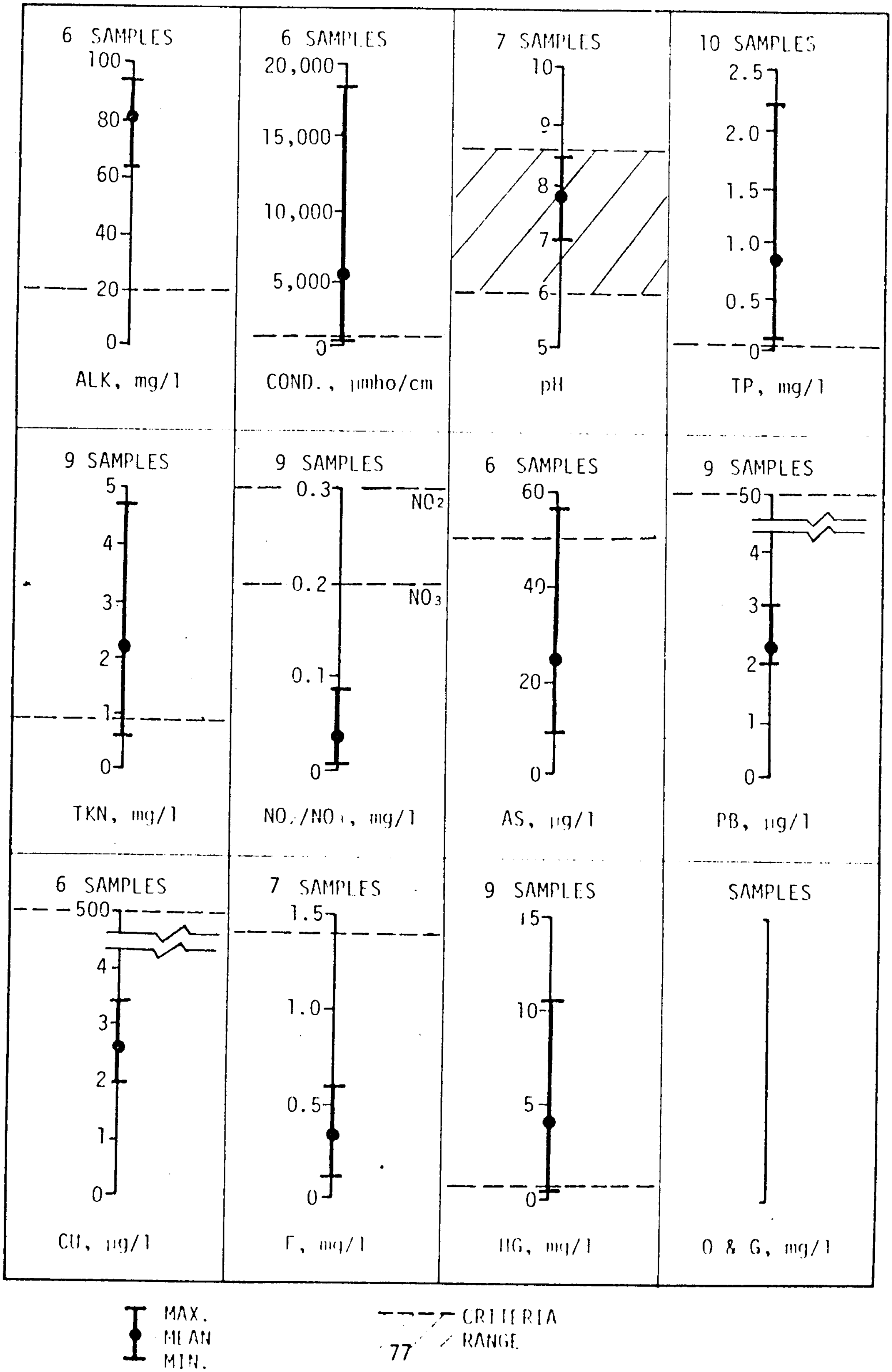


Table 2.3-27. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-T12.

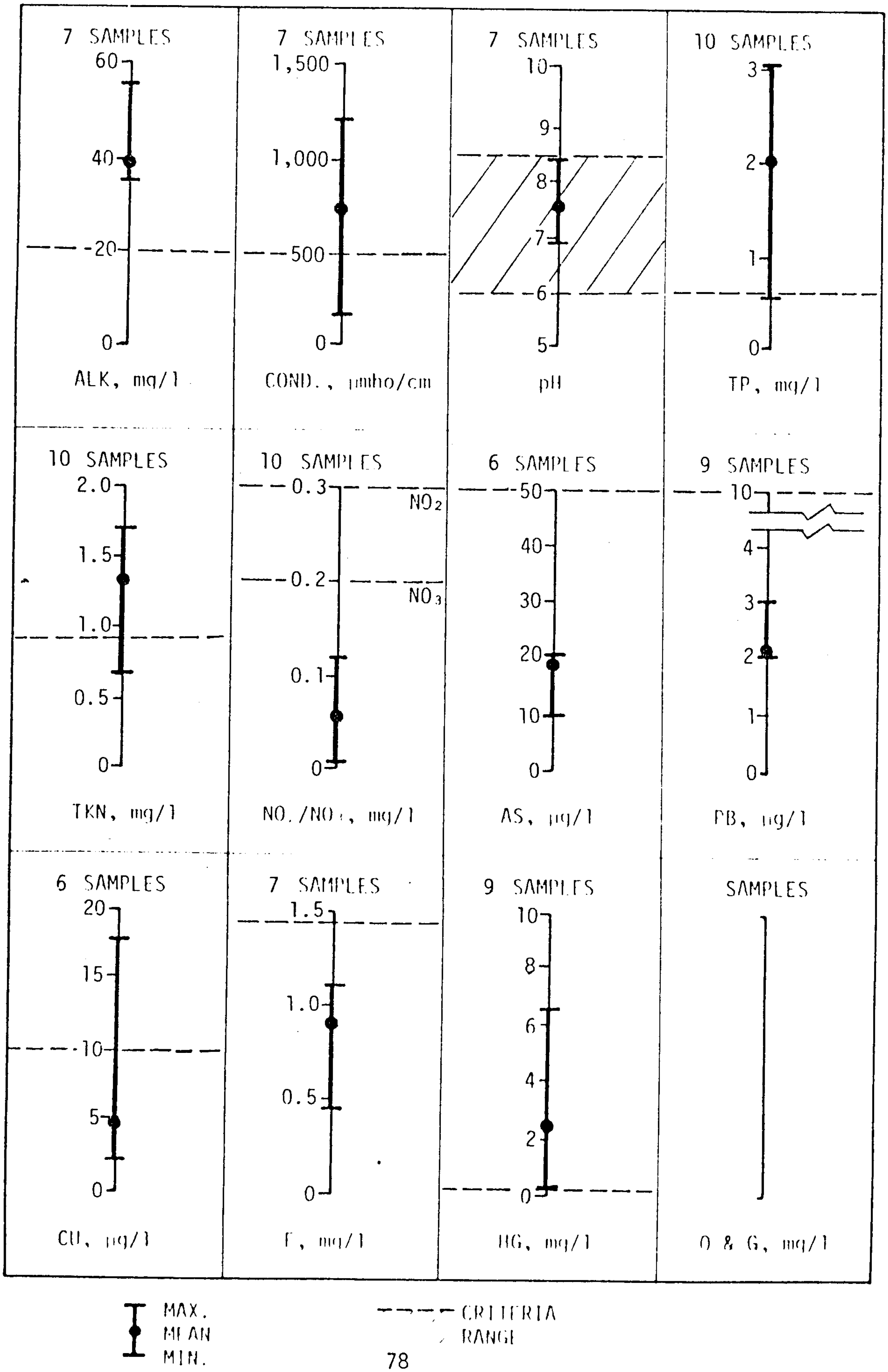


Table 2.3-28. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-B1.

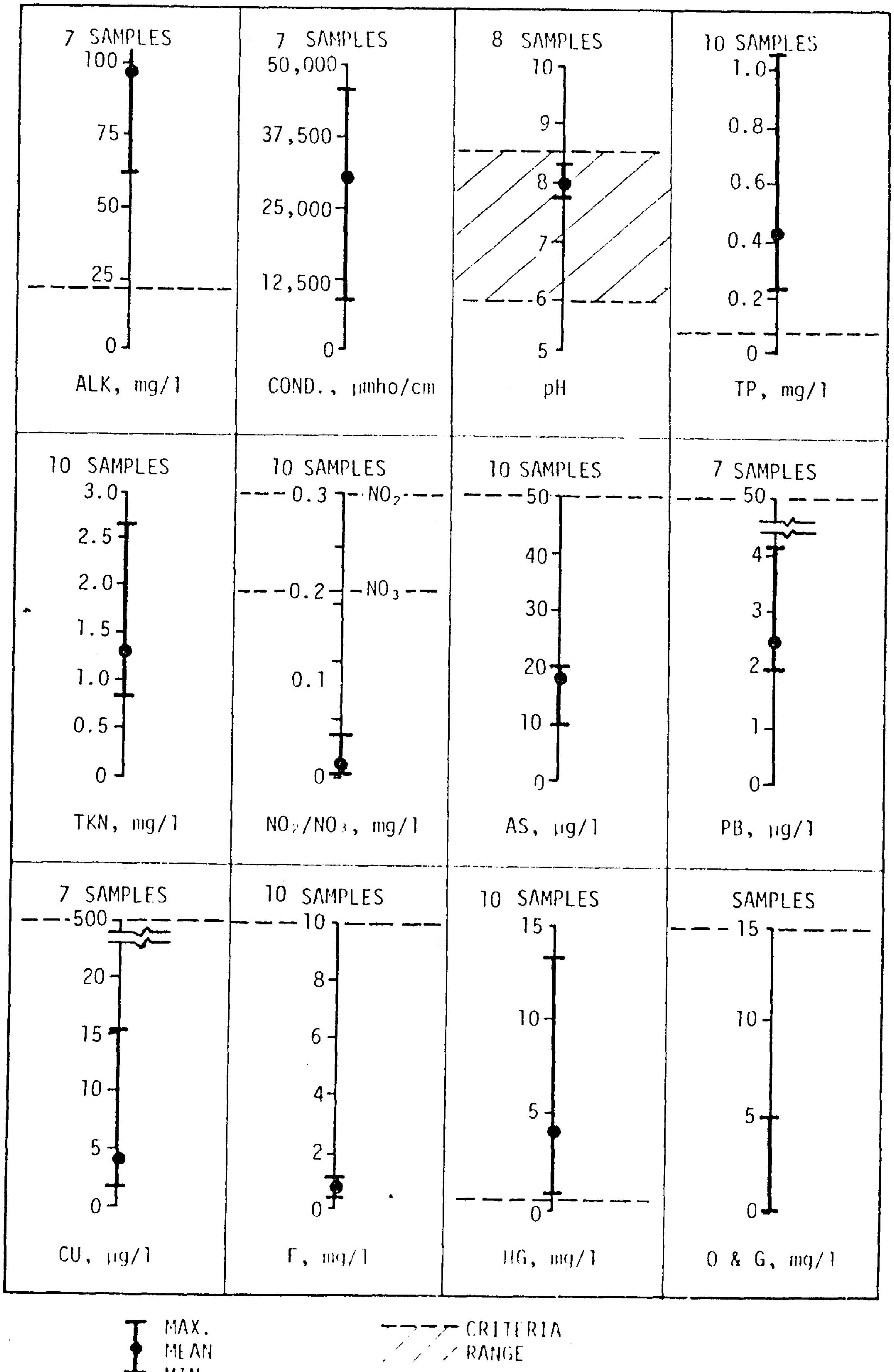


Table 2.3-29. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-B2.

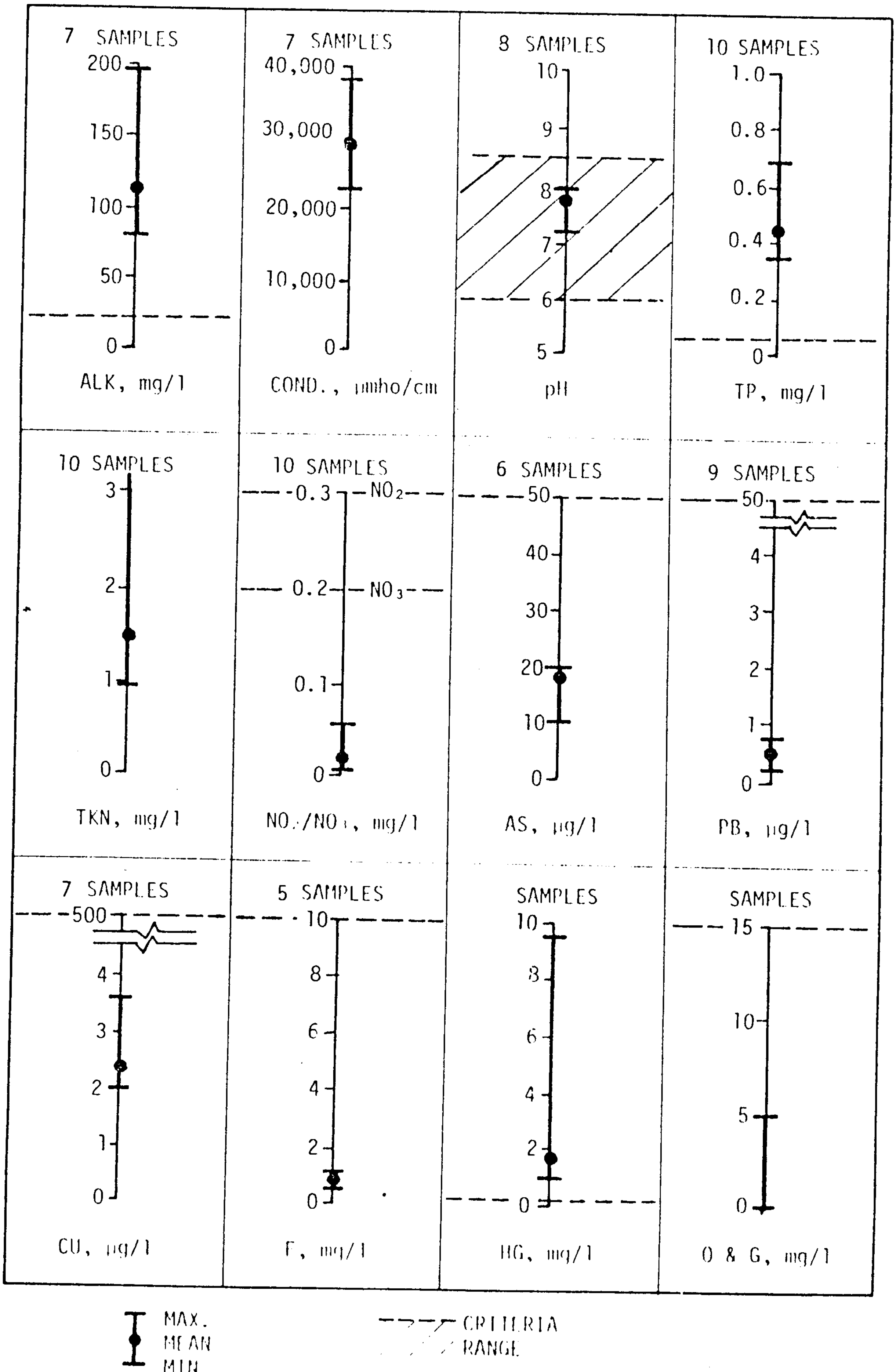


Table 2.3-30. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-B3.

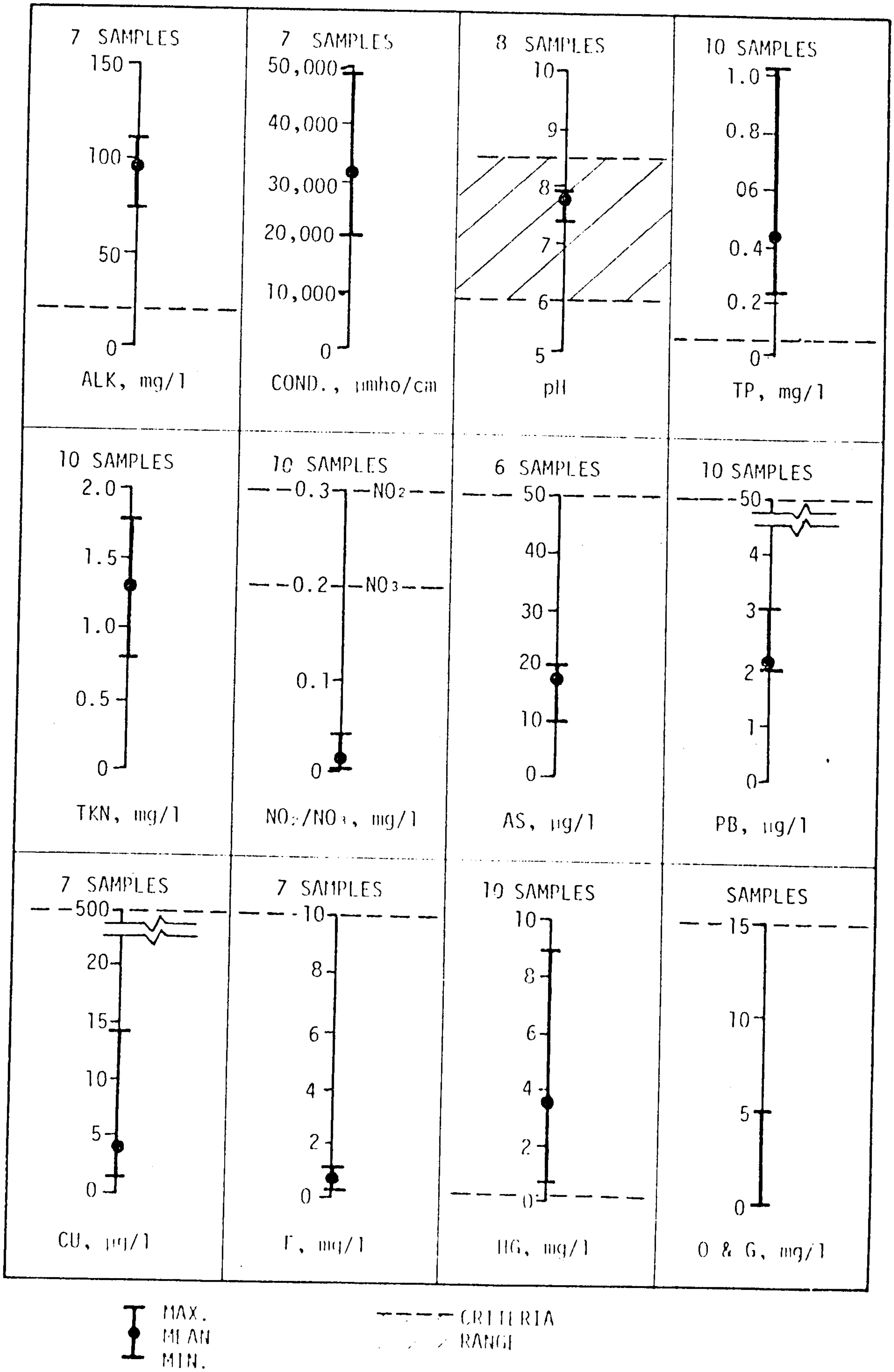


Table 2.3-31. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-B4.

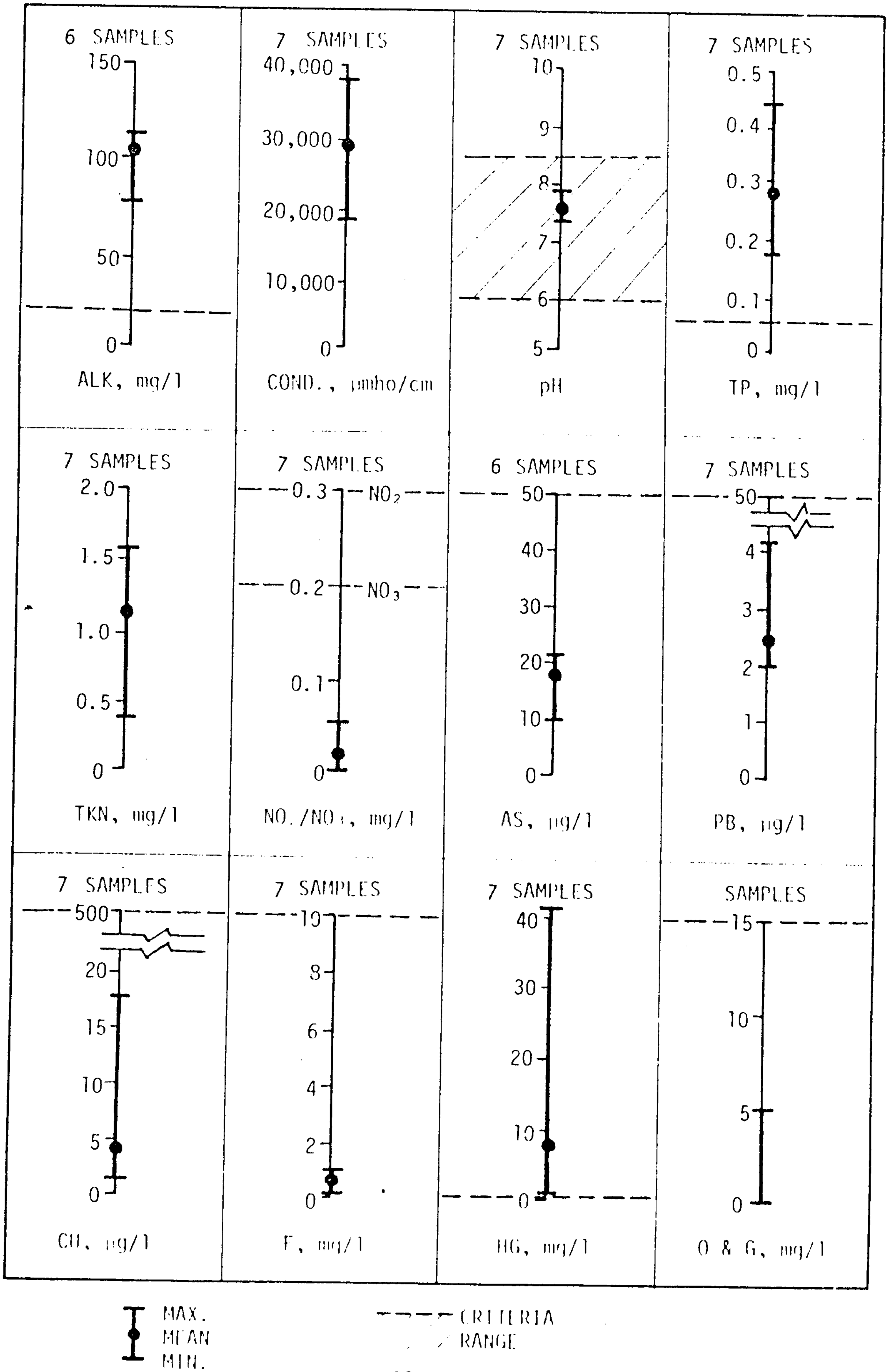


Table 2.3-32. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-B5.

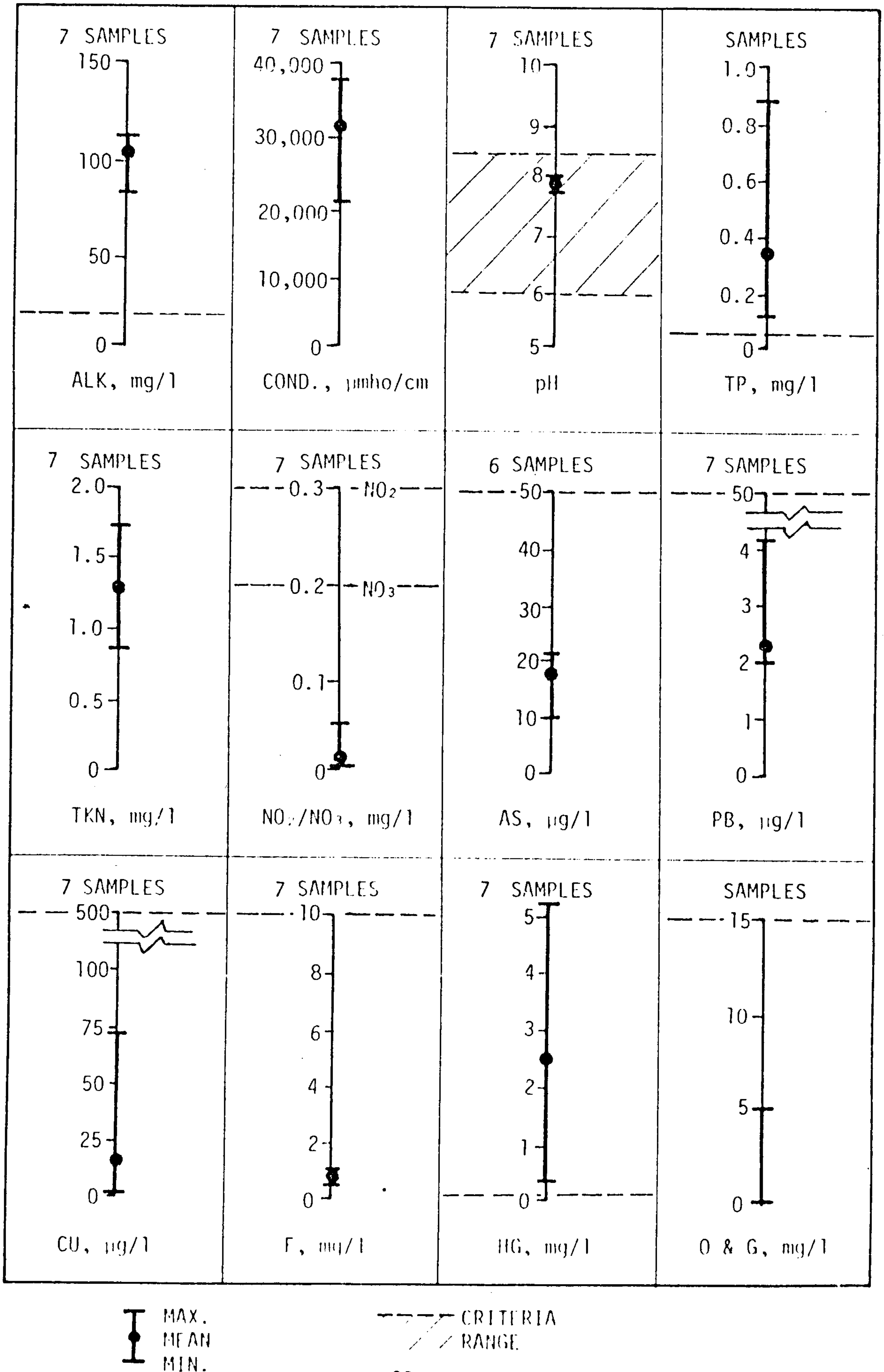


Table 2.3-33. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-B6.

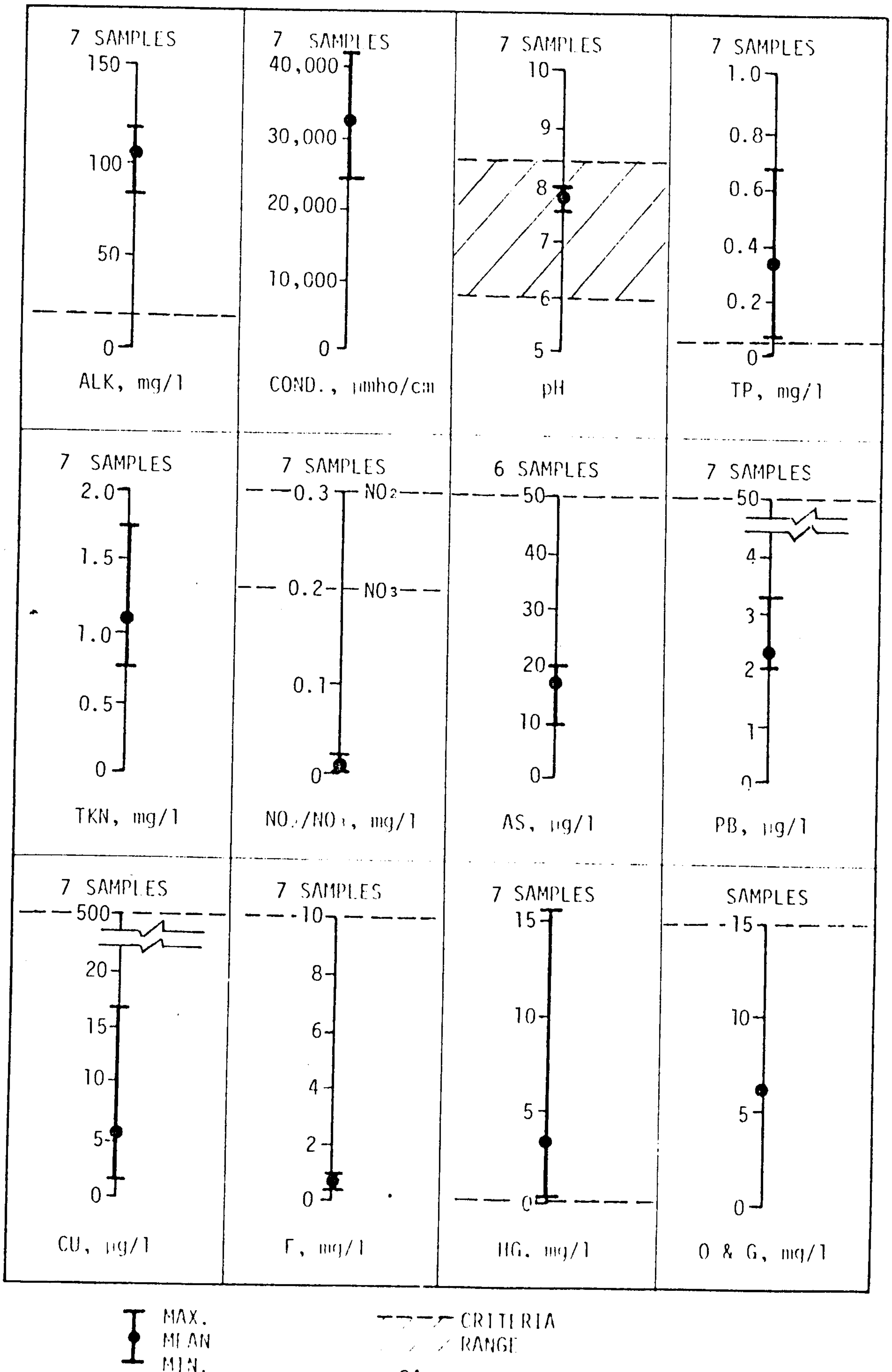


Table 2.3-34. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-B7.

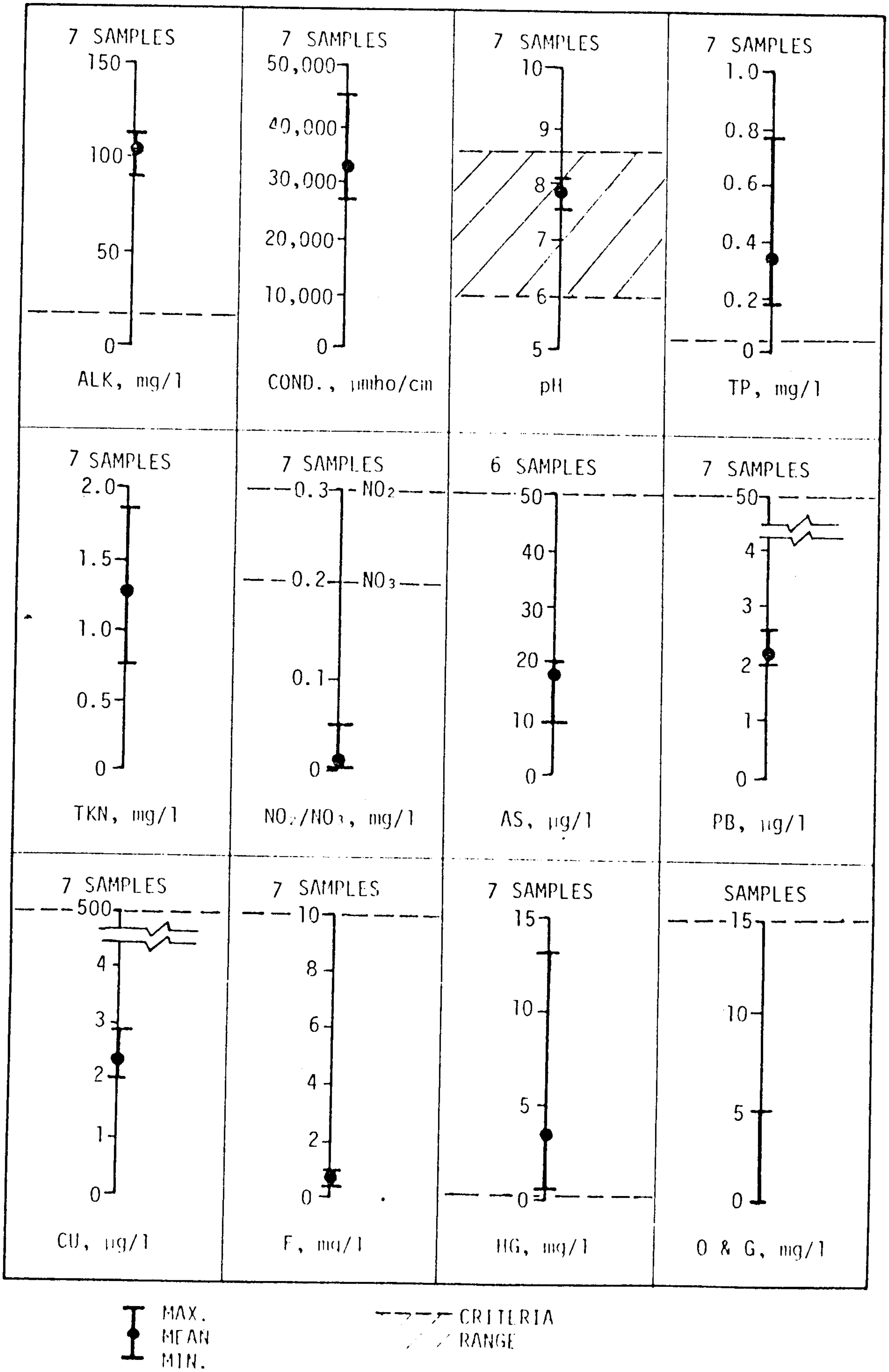


Table 2.3-35. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-B8.

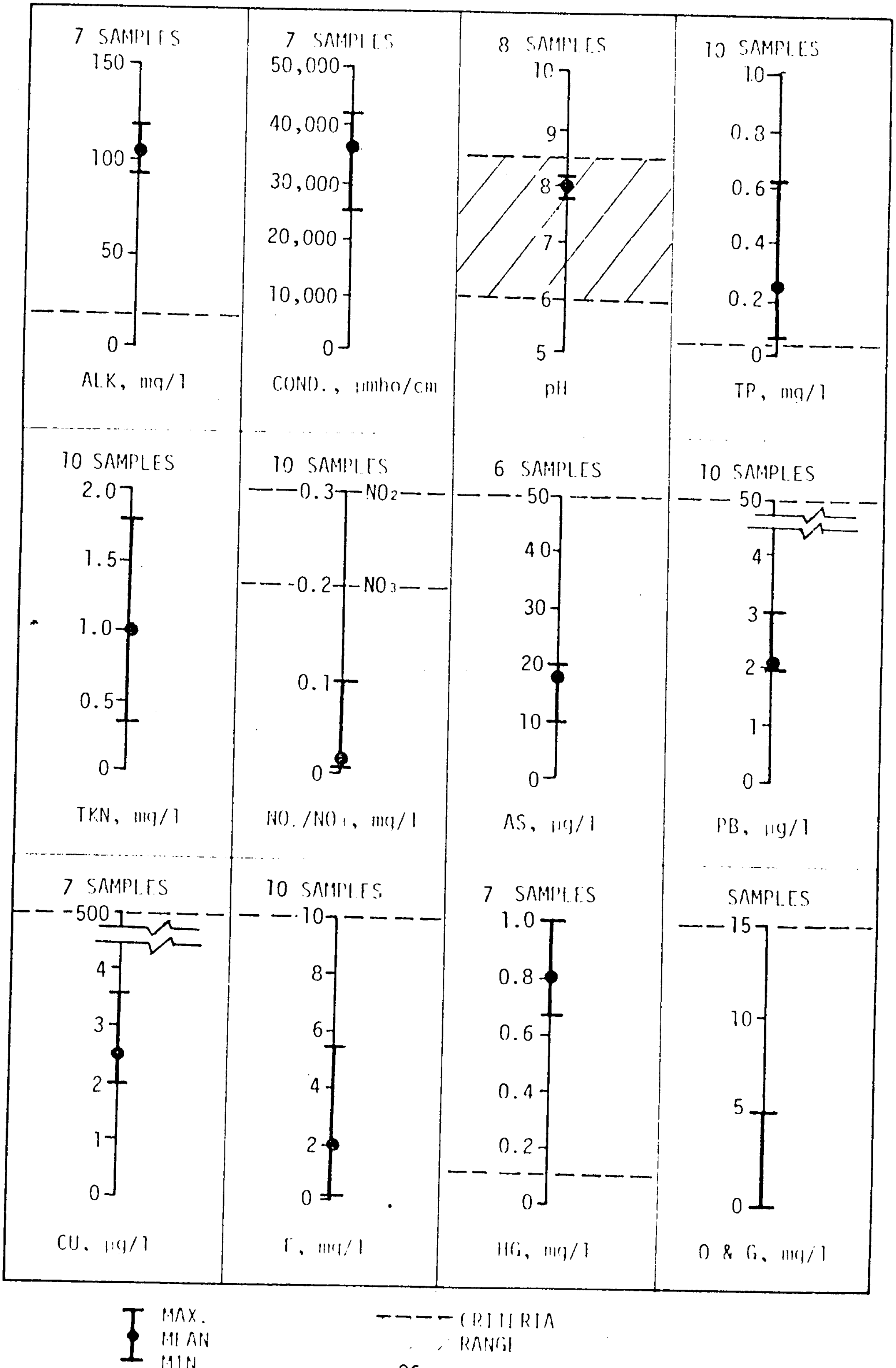


Table 2.3-36. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-B9.

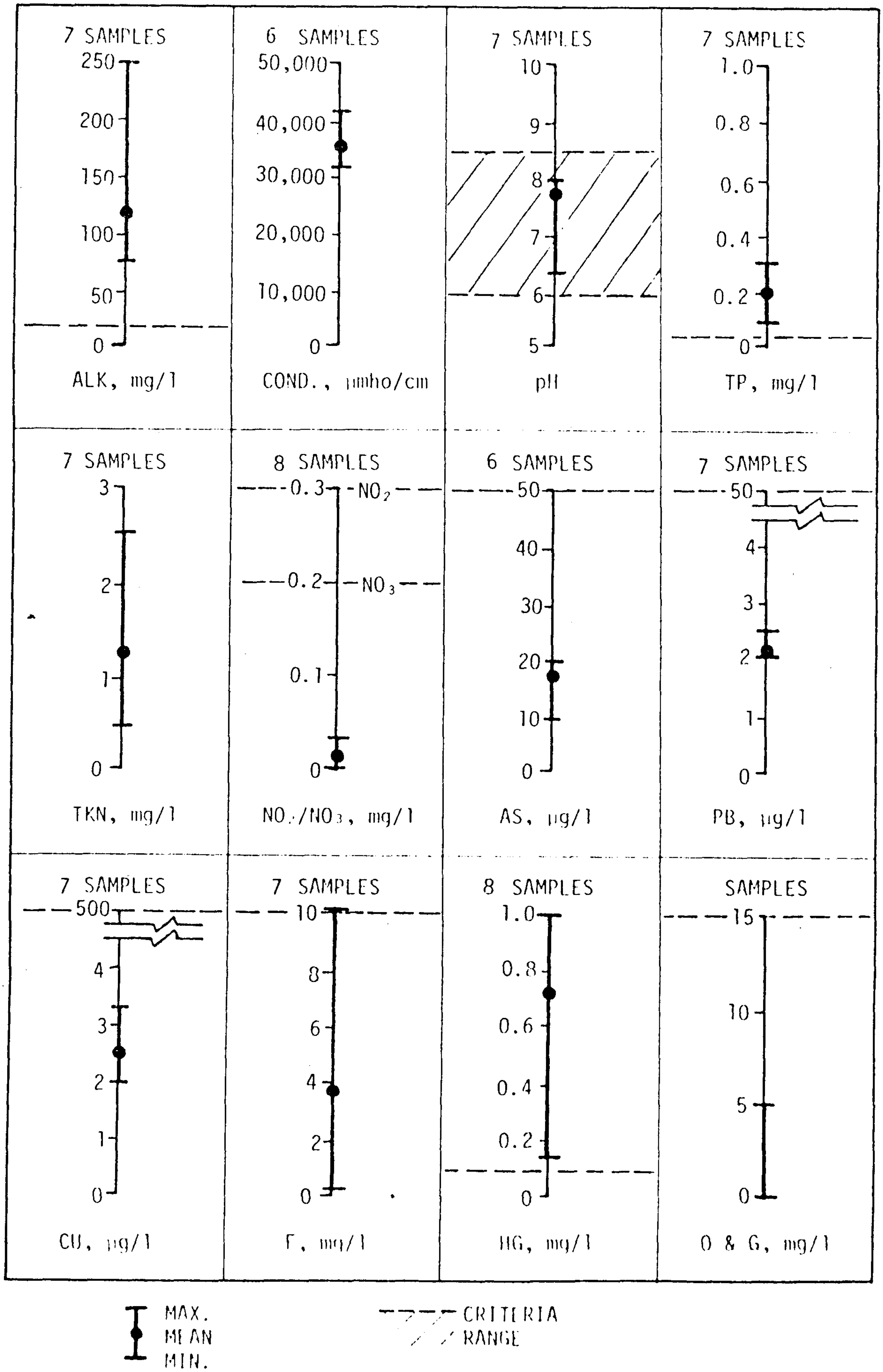


Table 2.3-37. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-B10.

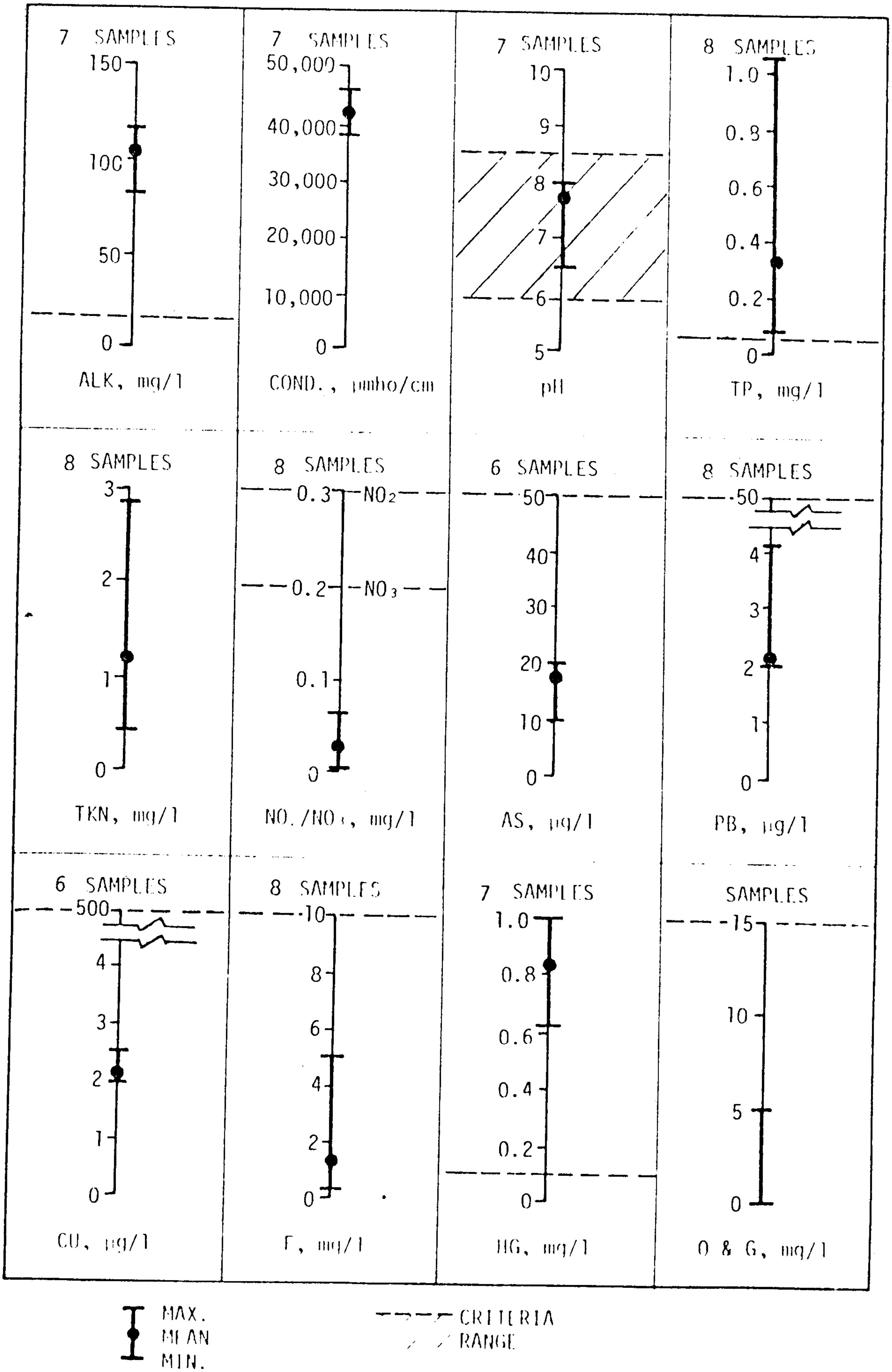


Table 2.3-38. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-BII.

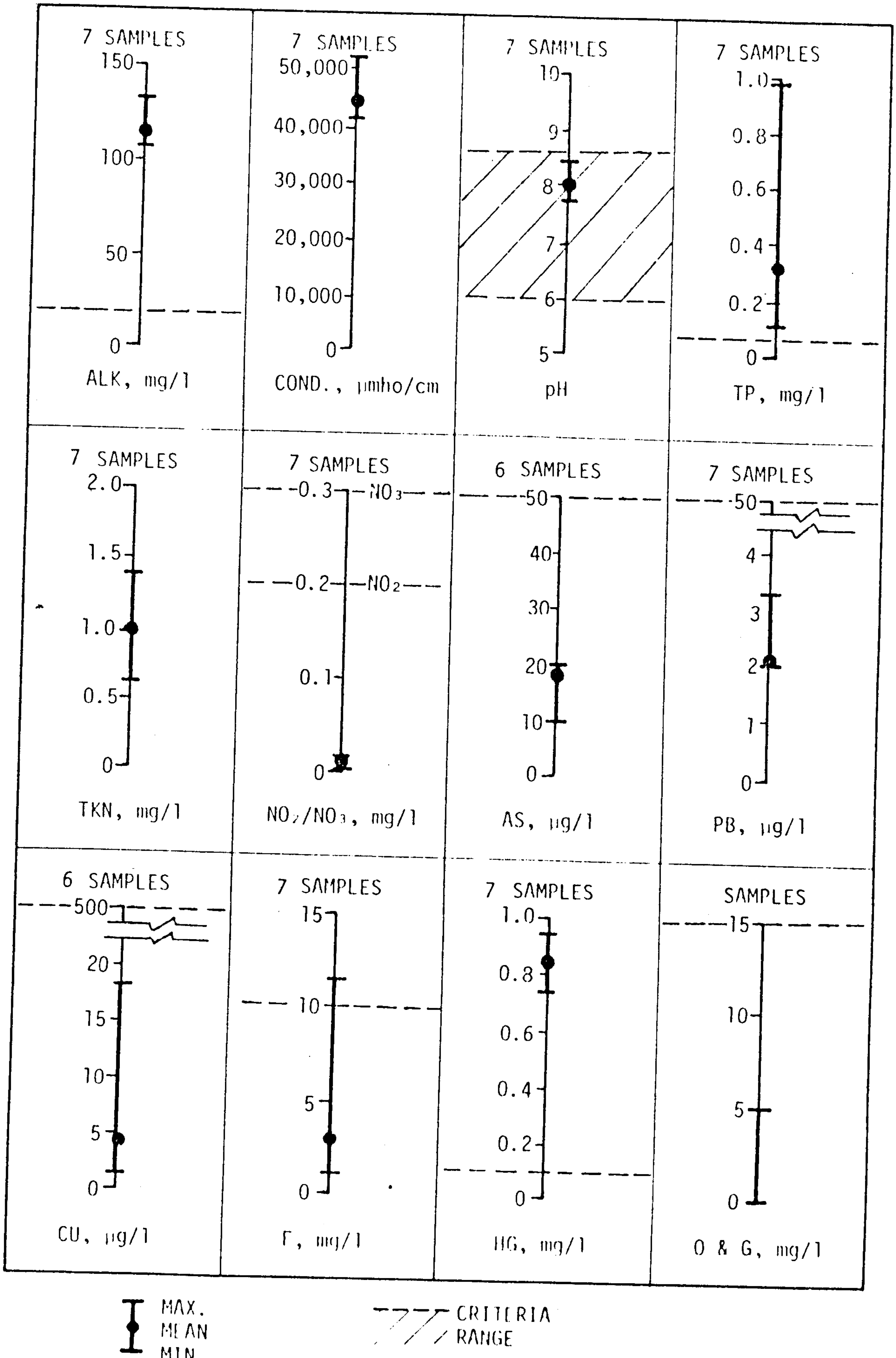


Table 2.3-39. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-B12.

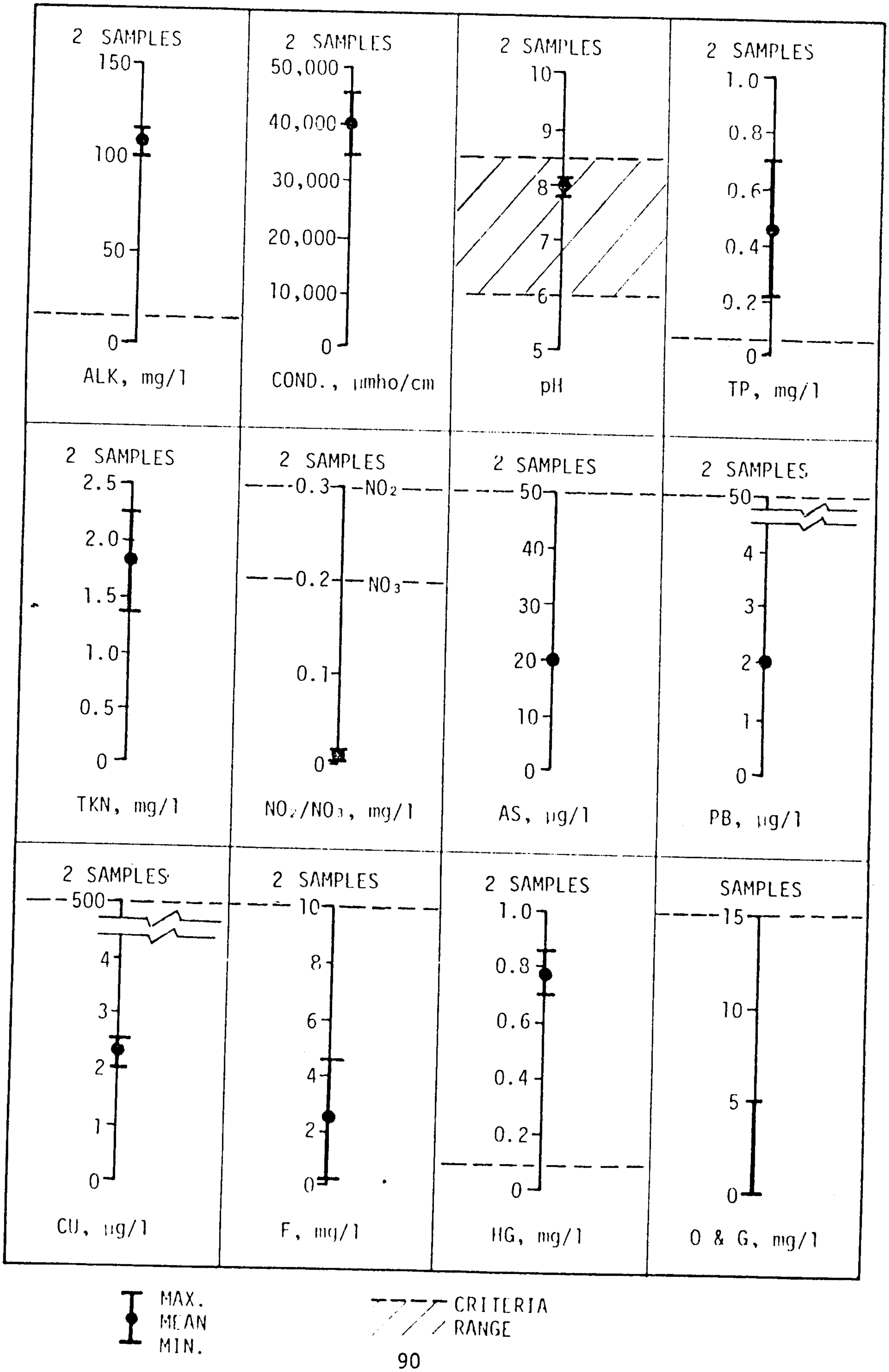


Table 2.3-40. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-B13.

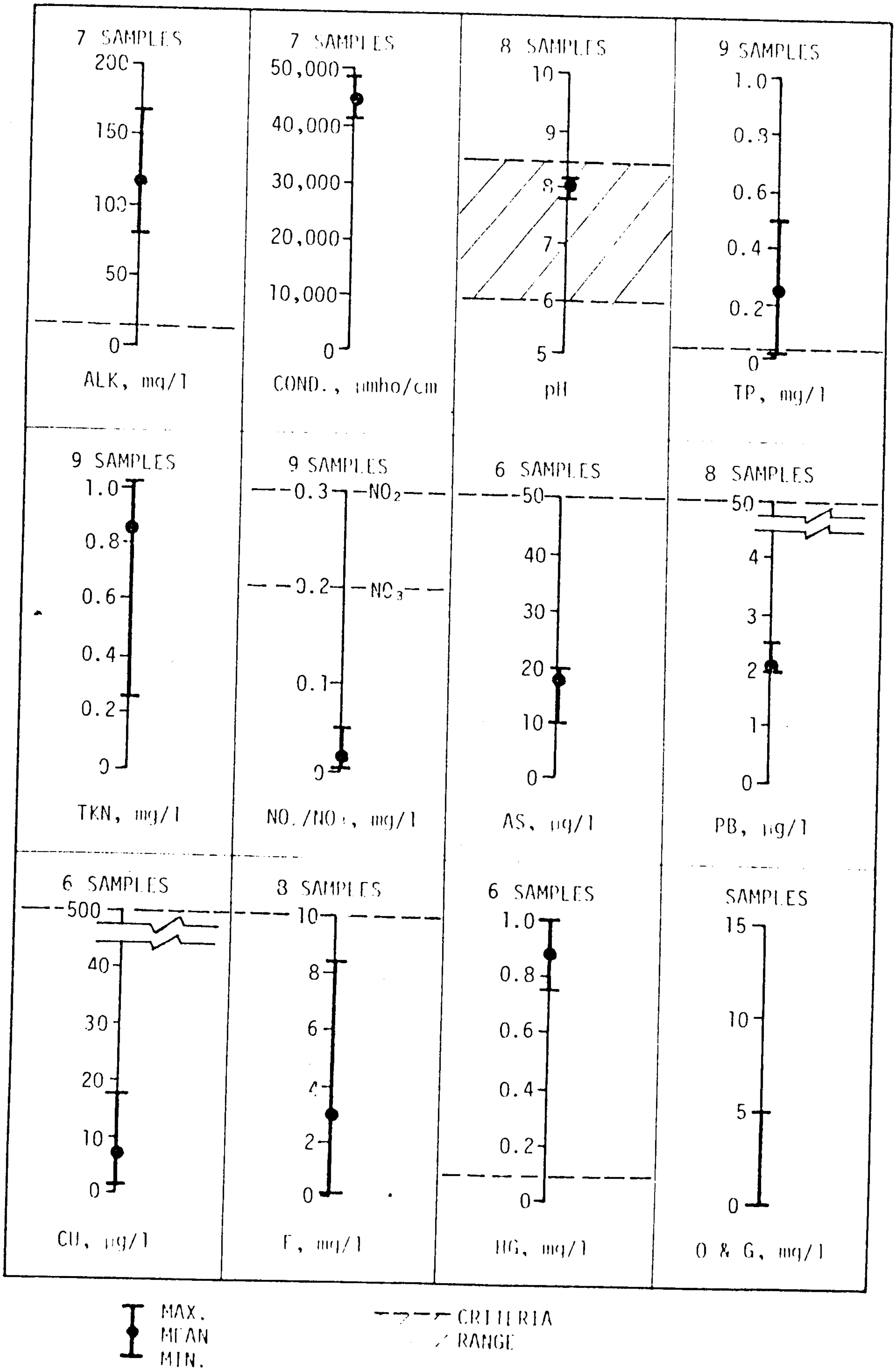


Table 2.3-41. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-B14.

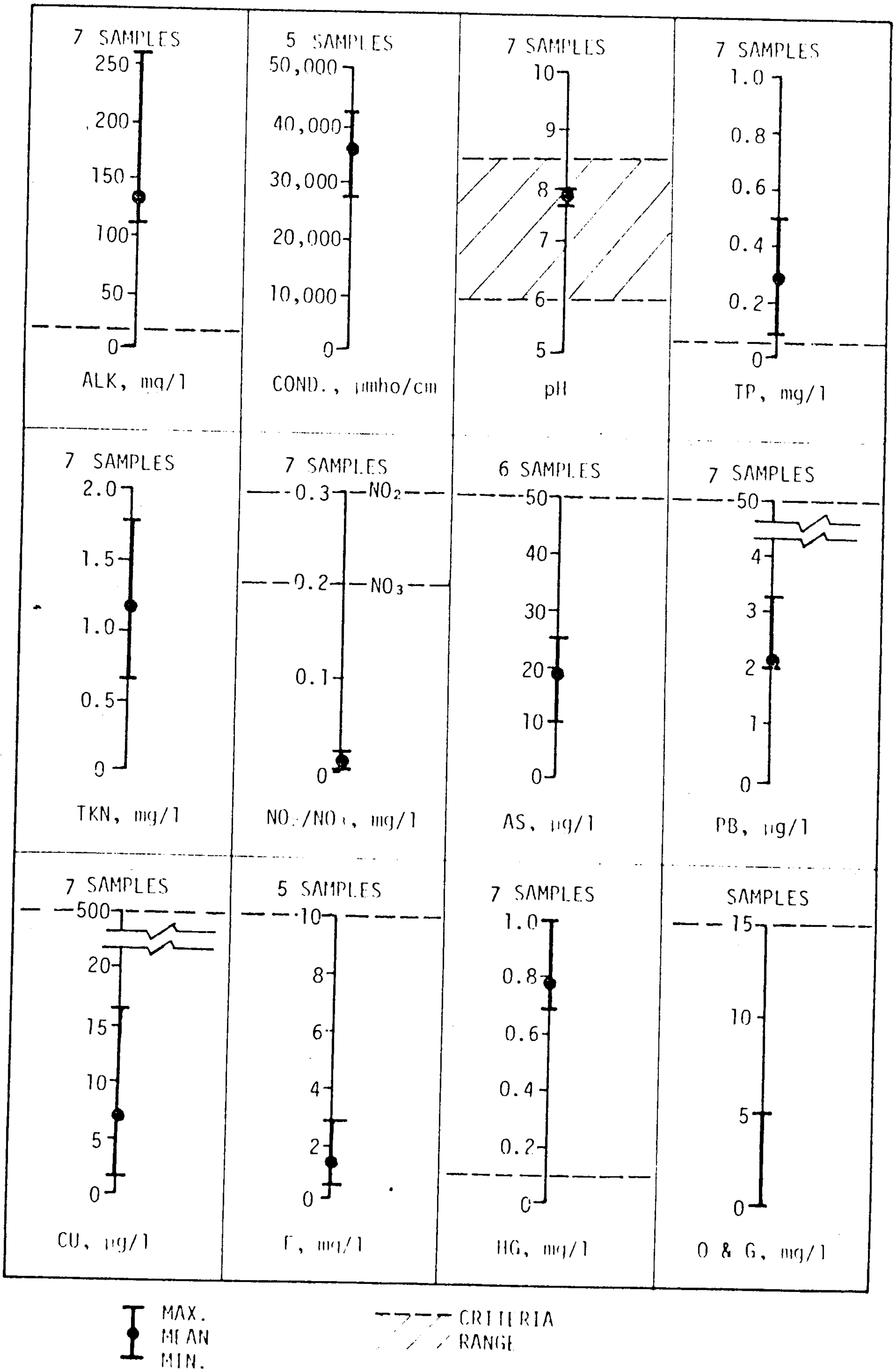


Table 2.3-42. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-B15.

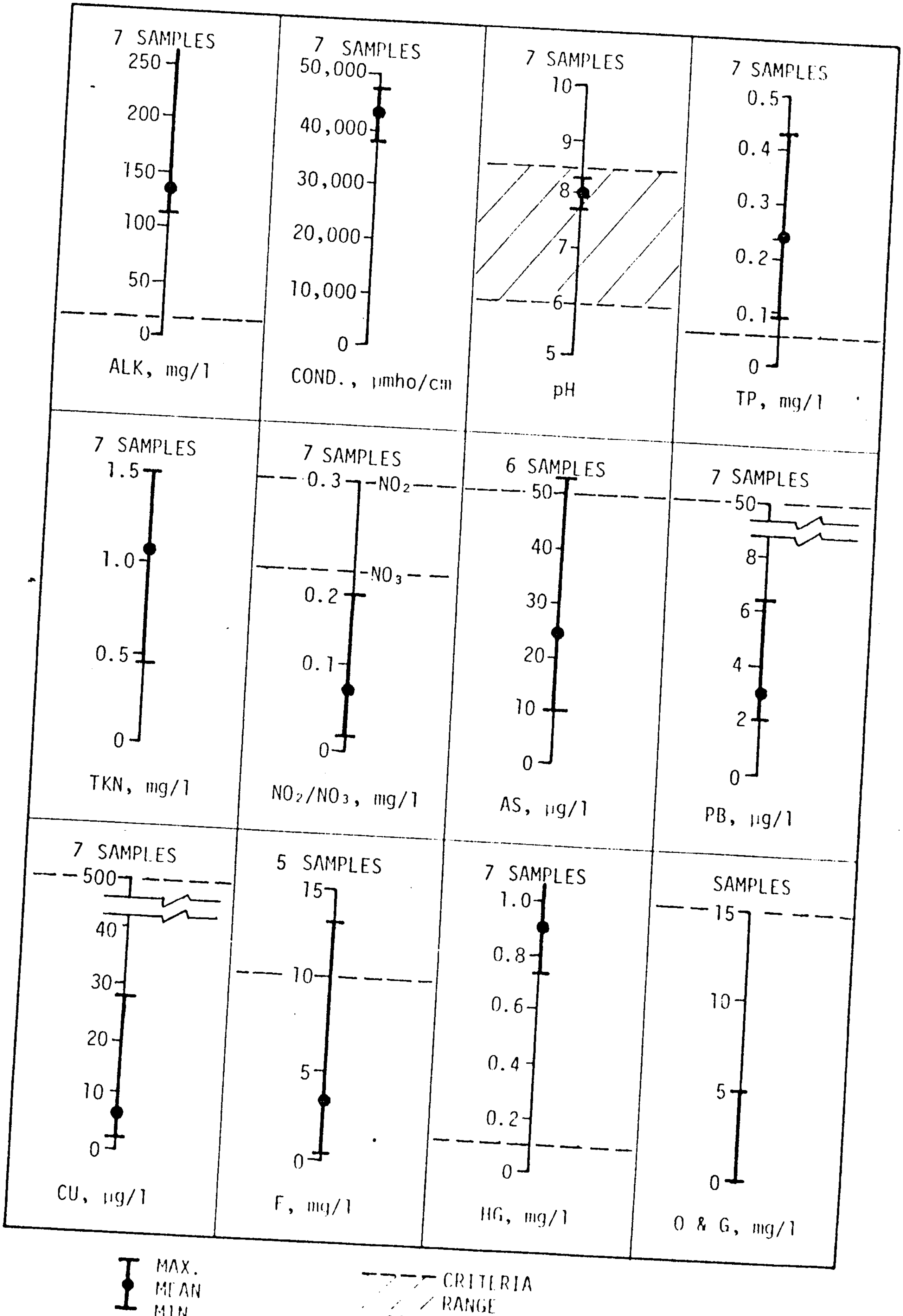


Table 2.3-43. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-B16.

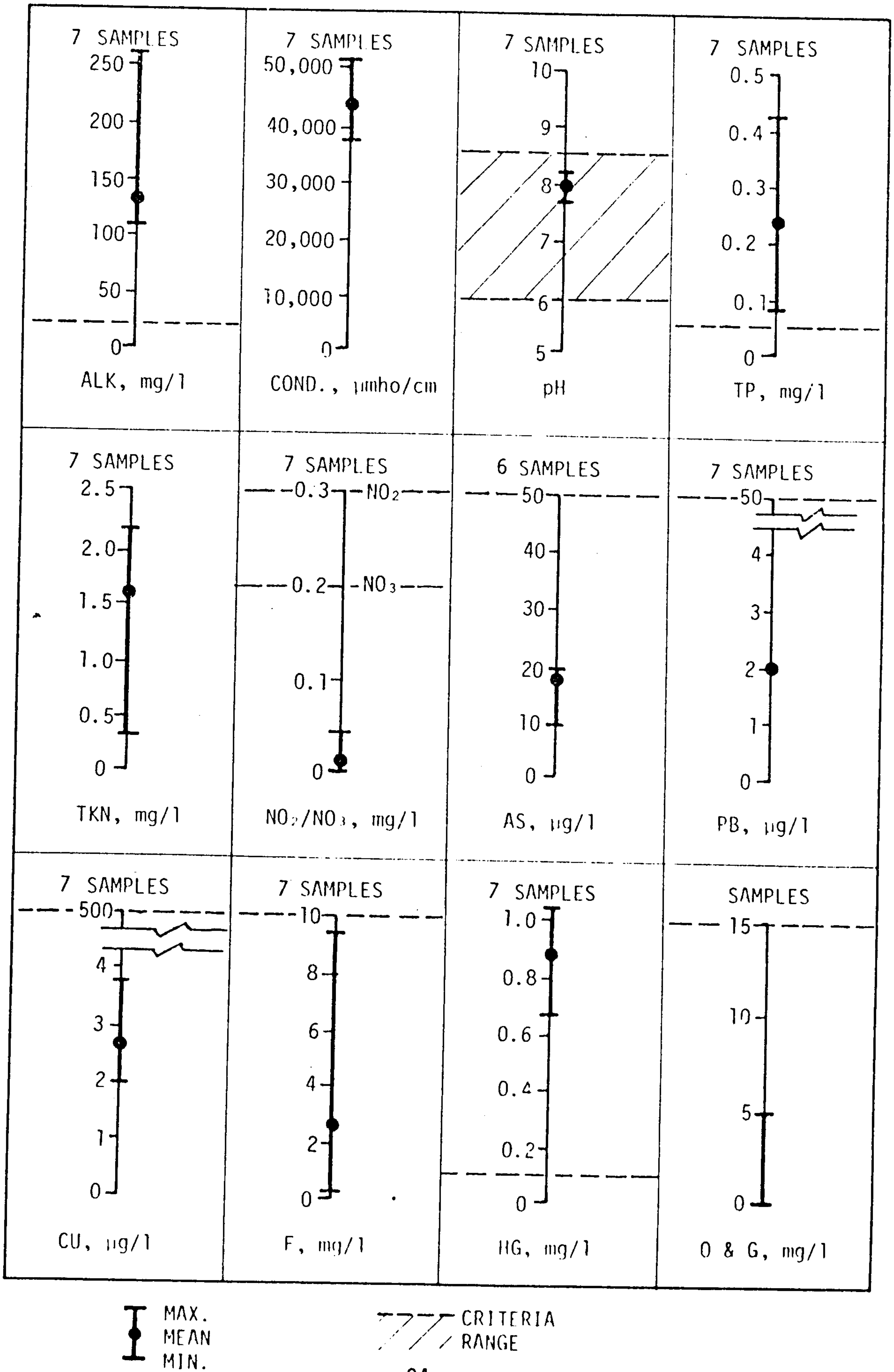


Table 2.3-44. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-B17.

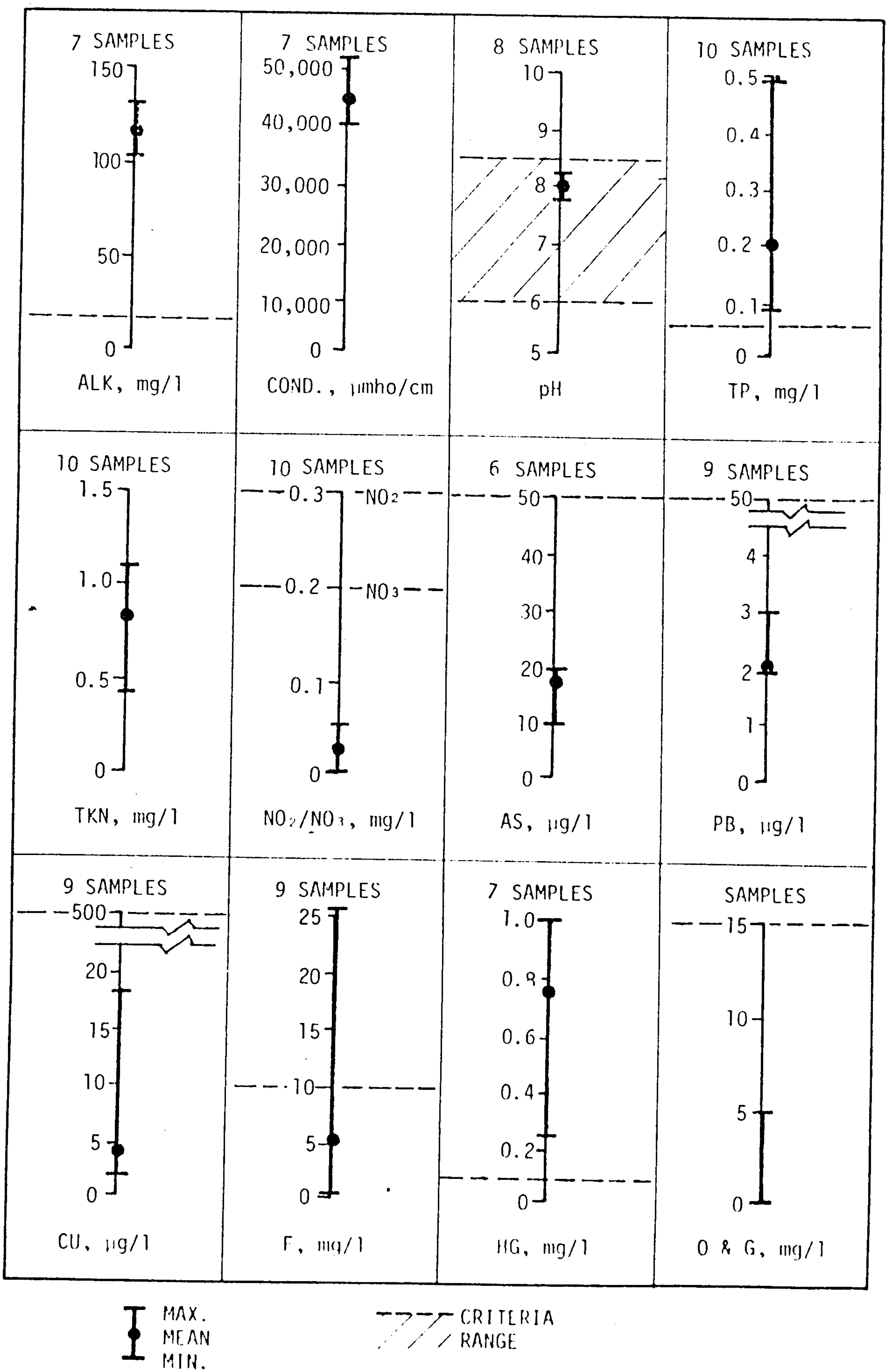
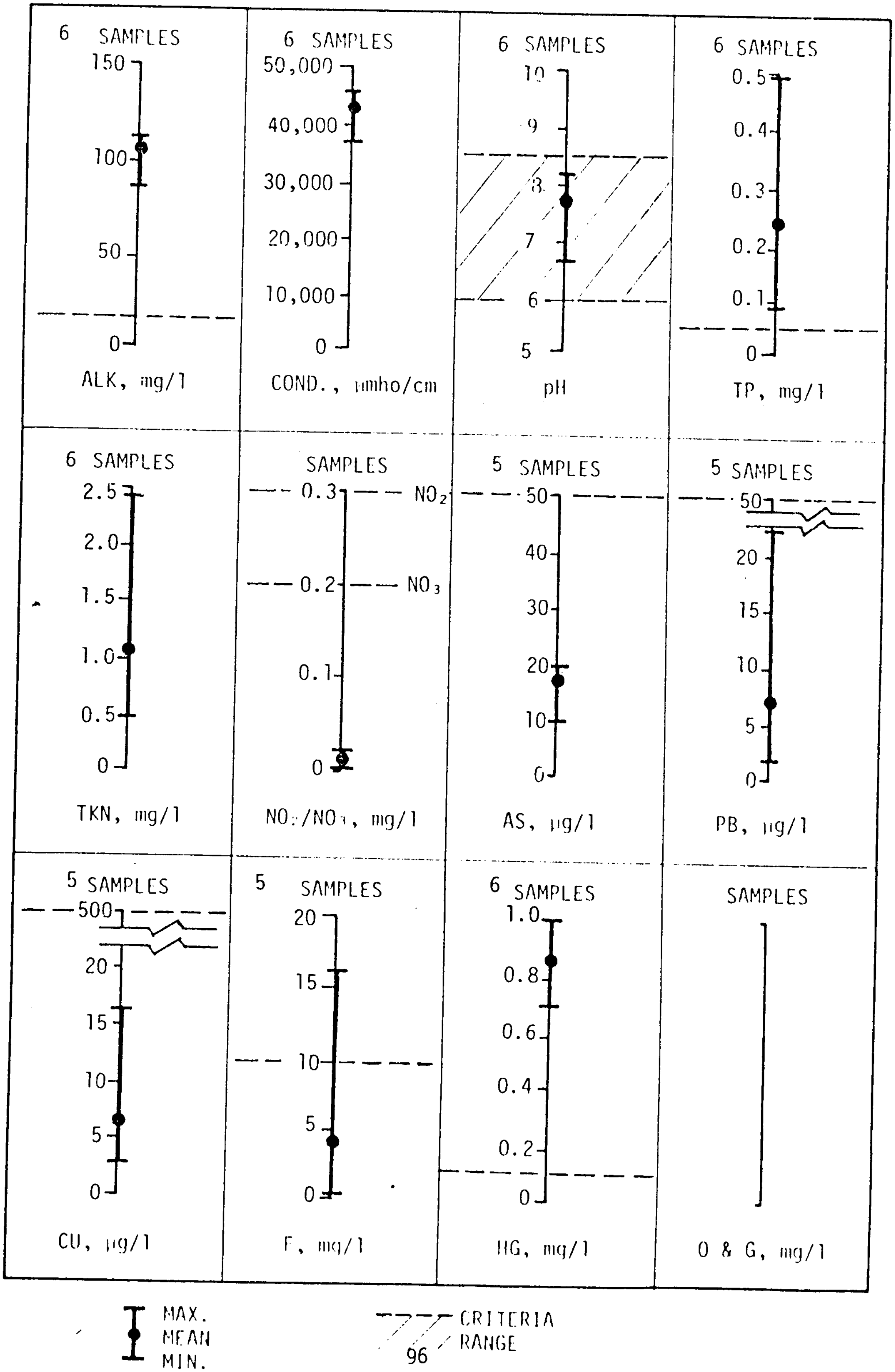


Table 2.3-45. Maximum and Minimum Concentrations and Mean Values Compared to Segment Water Quality Criteria for Station H-B18.



3.5 Intensive Sampling

Intensive sampling was performed in Charlotte Harbor during June, 1977. Six harbor stations were sampled on alternate days until eight samples were collected.

The sampling results are presented in Figures 2.3-1 and 2.3-2. In Figure 2.3-1 nitrogen concentrations for each sampling round are plotted against longitudinal distance in the harbor. The results of the first round, #1, are shown in the bottom plot, with the results of the final round, #8, shown in the top plot. A similar presentation of total phosphorus concentrations is given in Figure 2.3-2.

The concentration scales are identical for each plot on the same figure in order to facilitate comparisons of sampling rounds. The plots graphically point out two key intensive sampling results. First, the variation along the harbor of constituent concentration generally decreases toward the Gulf of Mexico. This result is compatible with overall background sampling results. Second, the levels of these constituents do not change noticeably during short time intervals, under the conditions existing during this sampling effort.

Conditions during sampling were drier than anticipated. Coincident storm sampling efforts verified virtually no runoff from upland canals to the harbor during intensive sampling. Several large rainfalls

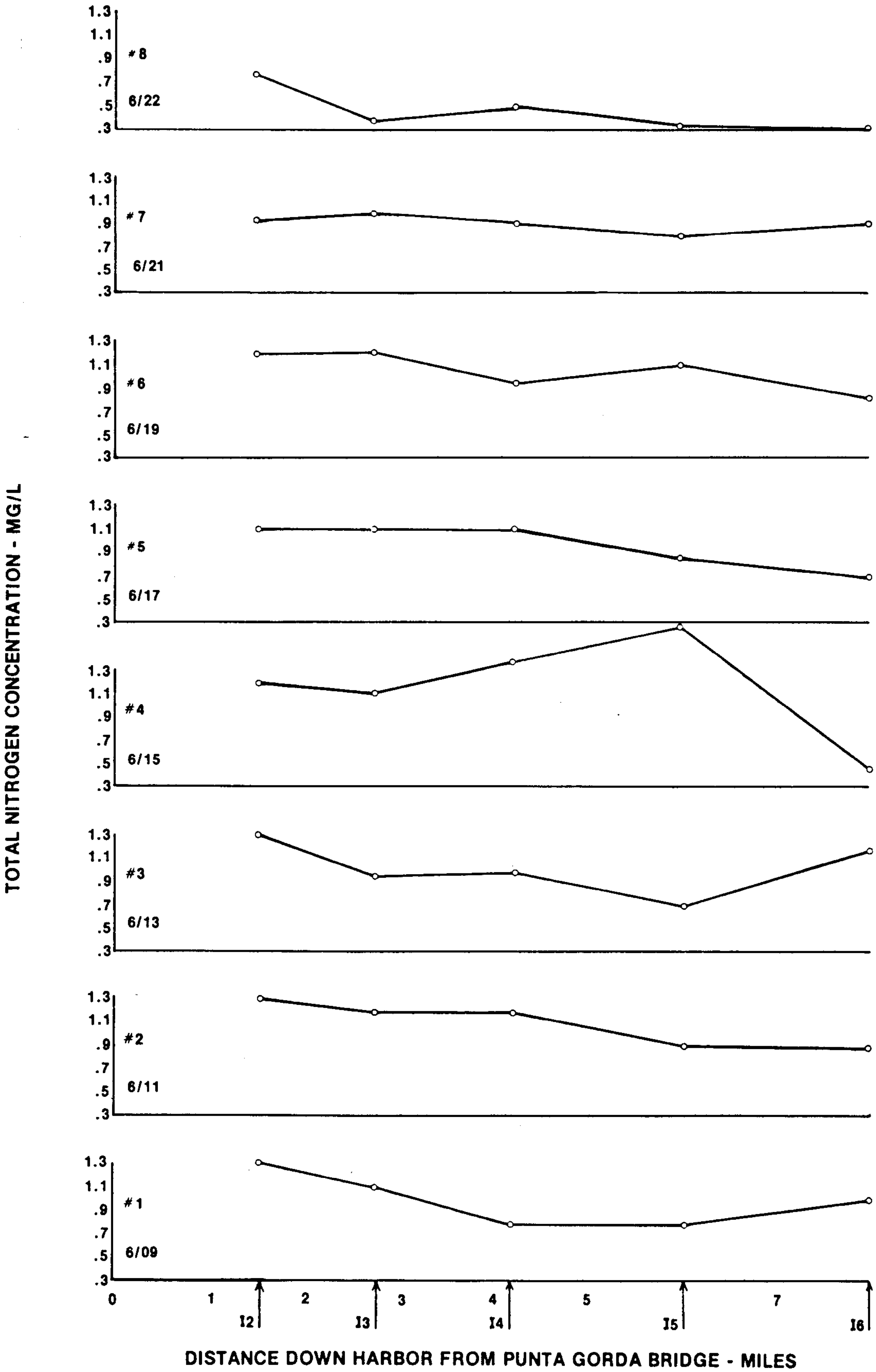


FIGURE 2.3-1
WATER QUALITY VERSUS HARBOR LOCATION, INTENSIVE SURVEY, CHARLOTTE HARBOR STUDY AREA

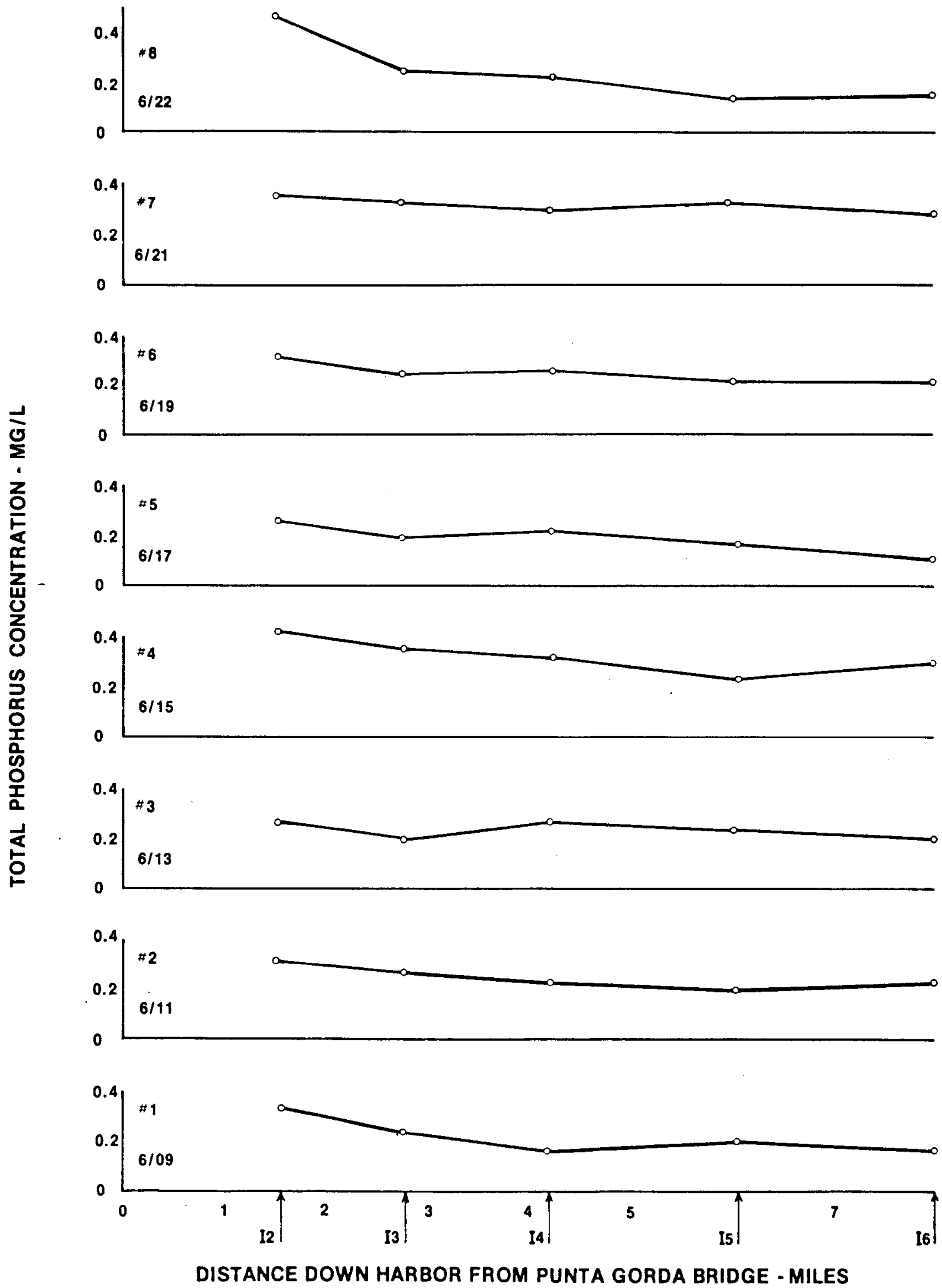
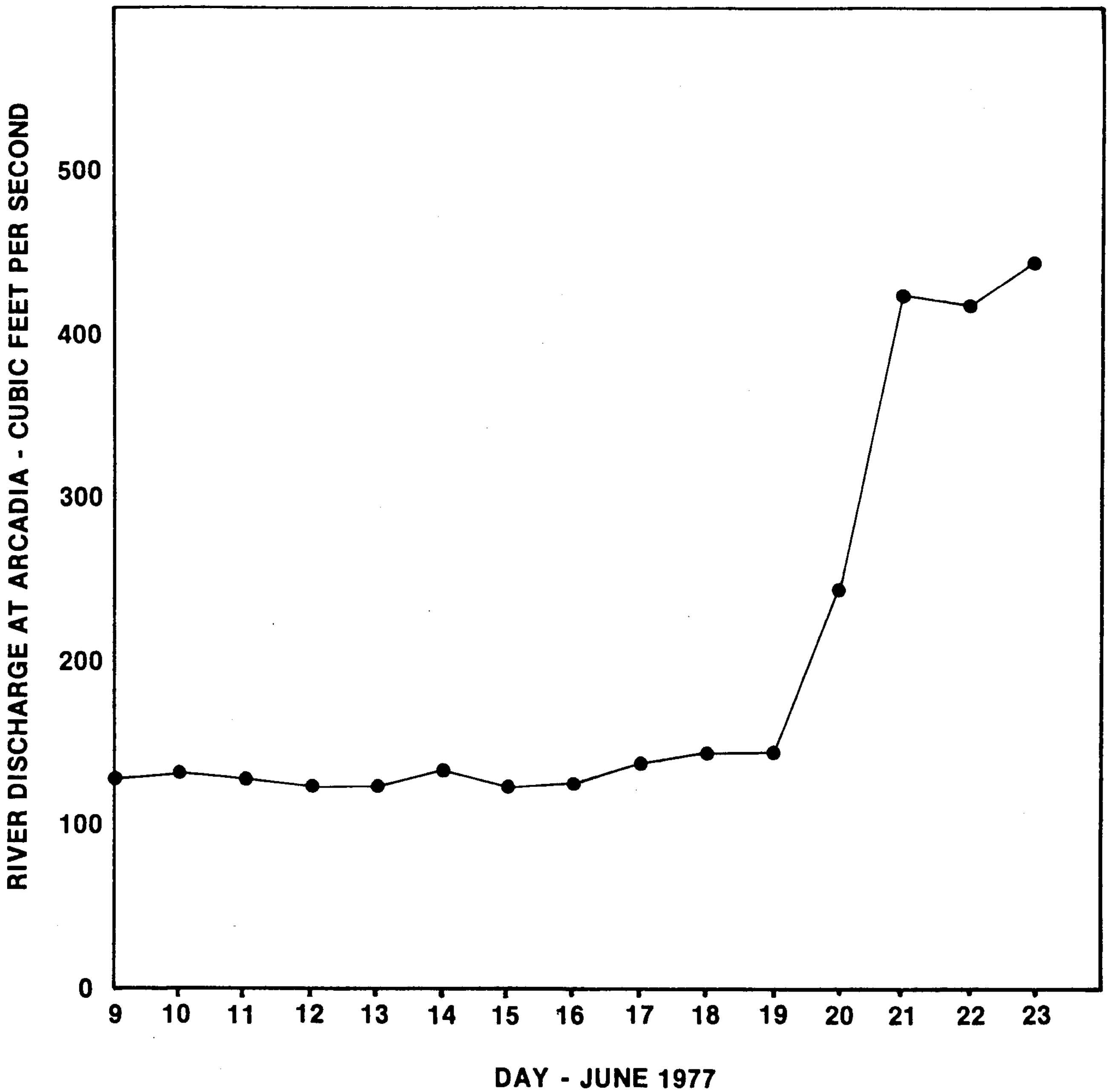


FIGURE 2.3-2
WATER QUALITY VERSUS HARBOR LOCATION, INTENSIVE SURVEY, CHARLOTTE HARBOR STUDY AREA

occurred, yet canal levels were so low that water levels, although rising, did not rise enough to produce much discharge to the harbor. Peace River flows are also important to harbor nutrient loads. Daily river flows during sampling are shown in Figure 2.3-3.

As can be seen in the graph, river discharge increased during the intensive survey. Flows as recorded at Arcadia increased about 500 percent in a single day. One of the reasons for performing intensive sampling during early June was to experience changing river discharge. Because the marked increase in flow occurred near the end of the scheduled sampling, its effects were not detected completely. Had the same increase happened near the ninth or eleventh month, there would have been better opportunity to detect influences of changing flow. No significant water quality changes are noticeabale in the graphs of Figures 2.3-1 and 2.3-2. However, both nitrogen and phosphorus levels slightly decrease on June 22 (Round #8). No water quality data for river water during June is available, so further comment of short-term impact of the flow increase is not possible.

Intensive sampling occurred under a specific, limited set of hydrologic and meteorologic circumstances. Therefore, the results obtained are not general; however, within this limitation, a summary can be made. The results obtained indicate that harbor water quality changes slowly relative to daily time frames. Therefore, monthly sampling, as



SOURCE : USGS PRELIMINARY DATA

FIGURE 2.3 - 3
PEACE RIVER DISCHARGE AT ARCADIA DURING INTENSIVE SAMPLING

performed in part of this case study, is probably adequate to characterize harbor-scale water quality. Smaller-scale water quality issues may have to be studied using daily or more frequent sampling.

4.0 DISCUSSION OF STORM EVENT SAMPLING RESULTS

4.1 Introduction

The subsections which follow present a summary of storm event sampling results for the Charlotte Harbor Case Study.

The watersheds in the study area were sampled during runoff from rainfall events. These watersheds represent open, canal residential populated, and canal residential unpopulated land uses, respectively.

Sampling took place in September and October, 1976, and in June, 1977. During the 1976 sampling, lighter than average rainfall took place, and this affected the program results. Out of four planned storm events at two sites, only one event was sampled. No events were sampled at the site representing canal-type development (H-R1). For this reason additional sampling was planned for 1977, but the constituent analyses performed on the additional samples were few because of limited program funds. In all, one storm at each of three sites, H-R2, H-R3, and H-R4, was sampled.

The purposes of the storm event sampling were only partially fulfilled, because all planned storms were not encountered and constituent analyses were limited. Also, the 1977 sampling results have restricted usefulness because very little runoff from the canals occurred during sampling. In 1977, ample rain fell on the small basins, contrary to the circumstances during 1976 sampling. However, because water levels in the canals were below overflow level when the sampling effort began, the rainfall runoff mostly caused water level rises. Only after several small rainfalls did the canals begin to overflow, and then outflow amounts were very small.

This lack of canal outflow caused a slight modification of the sampling procedure. Samples were taken at previously designated points, but sampling times were arbitrarily adjusted to span several days. Collection times were lengthened to account for the large storage capacity of the canals relative to the amount of outflow observed.

To the extent possible, the results of the sampling have been used to develop region-specific nonpoint pollutant loading data. Results have also been compared against literature values for comparable land uses. The details of the use of these data are given in other sections.

Selected graphs accompany the commentary for each land use category. Graphs are grouped at the close of each land use subsection. Different plots show flow, pollutant concentration, and pollutant loads versus time during runoff. Additional graphs present hydrographs which show flow or discharge in cubic feet per second (cfs) versus time in minutes from start of runoff. Pollutographs indicate pollutant concentration, in milligrams per liter (mg/l), versus time from runoff start.

Loadograph plots of pollutant (substance) load, in pounds per minute, versus time are given. Using more precise terms, these loadographs show, not substance load, but loading rate versus time. By plotting loading rate versus time, the total pollutant load is represented by the area on the graph under the curve.

Graphs are not included for all constituents, just as the commentary does not address every constituent analyzed. Only significant aspects of the laboratory analysis and only representative graphs are included. The number of plots has been limited to improve document format. Selected graphs show the plots of the constituents incorporated into the waste loads projections--total nitrogen (TN) and total phosphorus (TP), plus the metals constituent--lead (PB).

In some cases, water quality data are reported as below detection limits for the analysis methods used. In these instances, it is proper to report the value of constituent concentration as lower than a certain value, the detection limit, rather than to report a zero value. In the graphs in this section, these values have been denoted with circled data points.

This section presents summaries of the water quality constituent and flow data gathered during the storm event sampling efforts. Each land use is considered separately, and key points regarding the sampling results are noted. The commentaries are generally qualitative in content. Emphasis has not been placed on repeating numbers; instead, explanations of pollutant levels relative to water quality criteria are used. In addition, the times during the runoff occurrence that notable phenomena, e.g., discernable peaks of pollutant concentration occurring early, or late, or at mid-times, are pointed out.

4.2 Open Land Site--Station H-R2

Site H-R2 is located on the north fork of Alligator Creek at the Jones Loop Road bridge crossing. The drainage basin is approximately 3 square miles in area. It consists of open space, woodlands, and some pasture area. Portions of the watershed have been influenced by preliminary development activities. Some surface drainage ditches have been dug and roadways cleared; however, there has been no paving, and only two or three residences exist in the basin. Because of flat topography, most drainage occurs as a result of percolation to the shallow water table and then by interflow to grassy ditches. Surface drainage is routed via these ditches to larger ditches, which are also grassy, and ultimately to the creek.

One storm was encountered at H-R2 in September, 1976. More than 1 inch of rain fell, and no other events occurred during the three-day sampling period. The hydrograph for this event is shown in Figure 2.4-1. Runoff varied from base flow conditions of about 2 cubic feet per second (cfs) to a peak of about 10 cfs which occurred a day after the rain fell. After another day, flow had decreased but remained above base flow.

Selected comments regarding the results of analysis performed on samples taken at H-R2 are as follows:

1. Suspended solids levels are extremely low.
2. Color levels significantly peak at the time of maximum flow.

3. Fecal coliform values vary from extremely low to moderately high. Fecal strept values do not seem to depend on flow. Ratios suggest animal sources.
4. Nutrients are present in high concentrations; however, phosphorus excesses are more pronounced. Increases in phosphorus and nitrogen occur with flow. Pollutographs and loadographs for total nitrogen and phosphorus are presented in Figures 2.4-2 through 2.4-5. While the concentrations vary irregularly, the loads show pronounced peaks which correspond with the peak flow at about 1,500 minutes.
5. Mercury levels are usually low. A single severe exceeding of acceptable levels occurs, and it happens near the beginning of the runoff. No other metals excesses are noted. For comparison purposes, the pollutograph and loadograph for lead are shown in Figures 2.4-6 and 2.4-7, respectively. Both levels and loads are very low. The small load peak occurs prior to peak flow.
6. Fluoride levels are low.

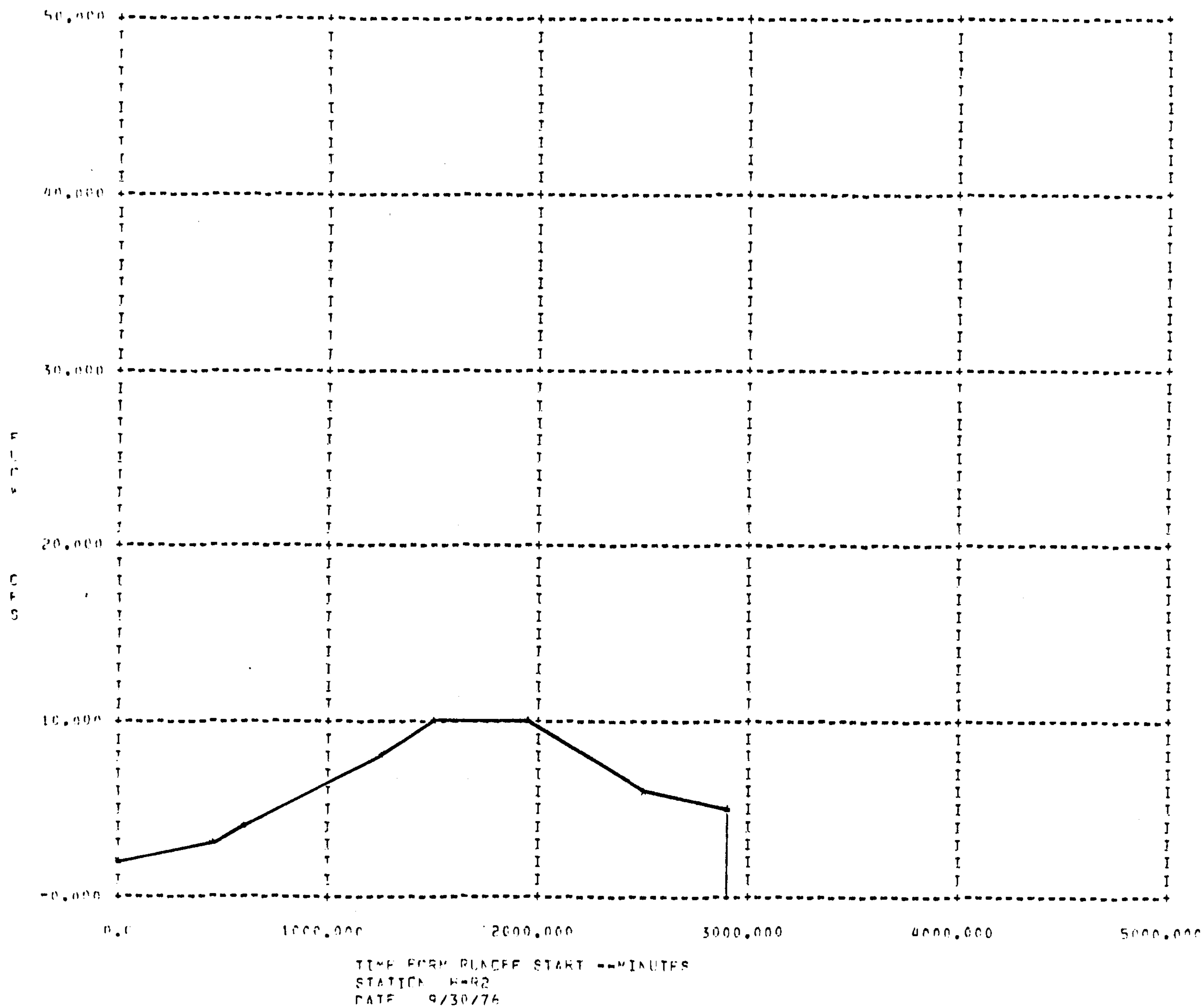


FIGURE 2.4-1 HYDROGRAPH AT H-R2

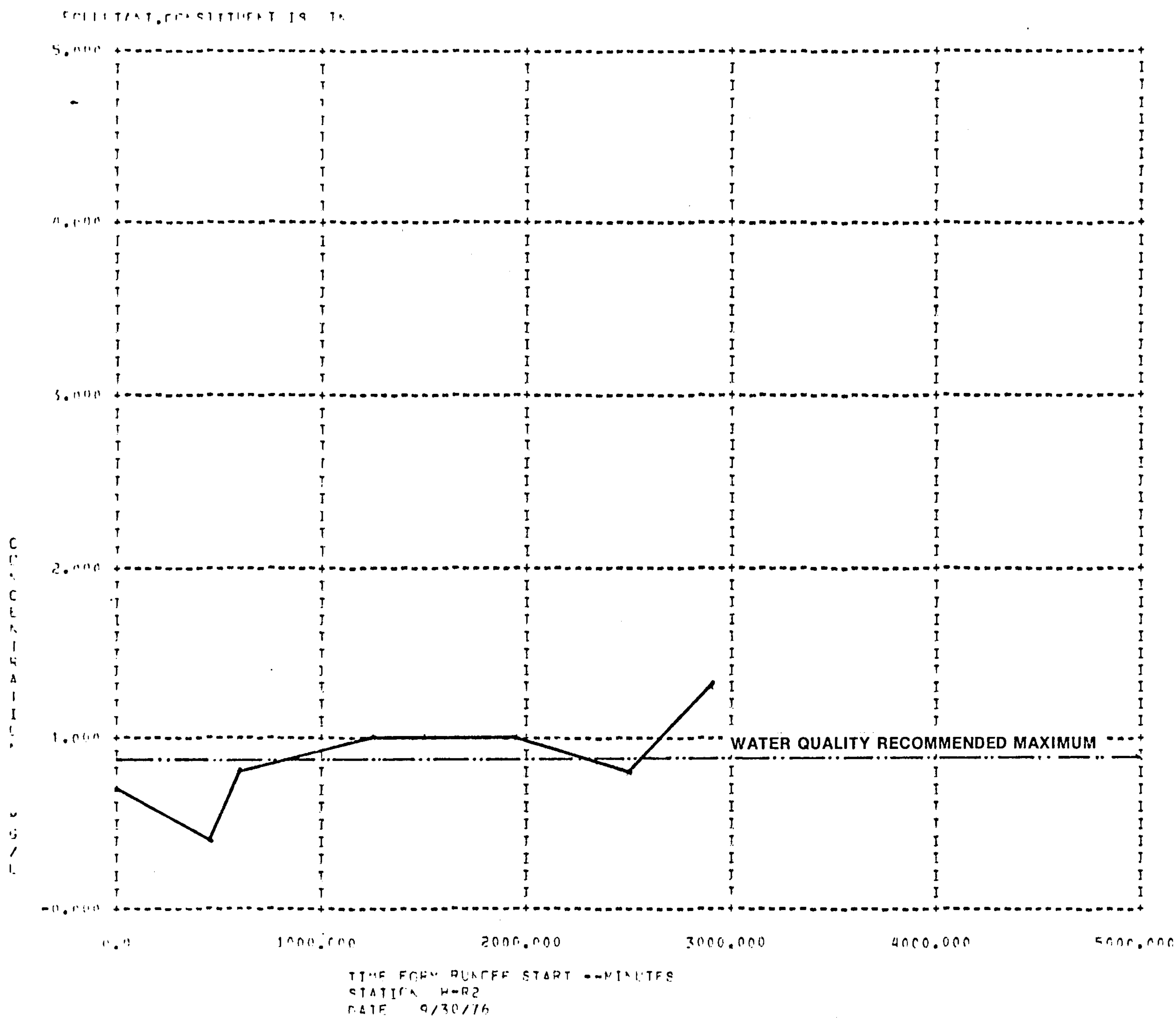


FIGURE 2.4-2 TOTAL NITROGEN POLLUTOGRAPH AT H-R2

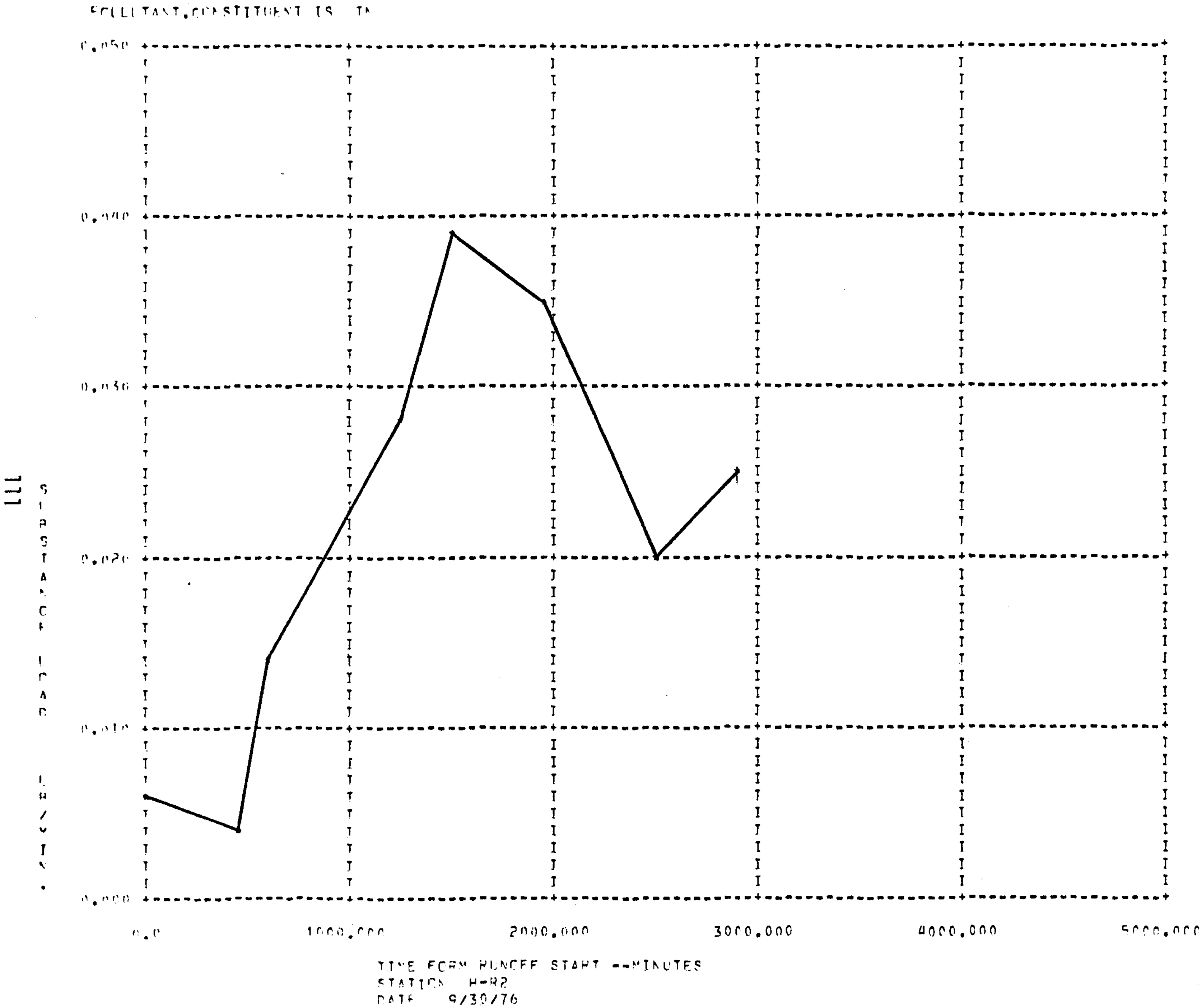


FIGURE 2.4-3 TOTAL NITROGEN LOADAGRAPH AT H-R2

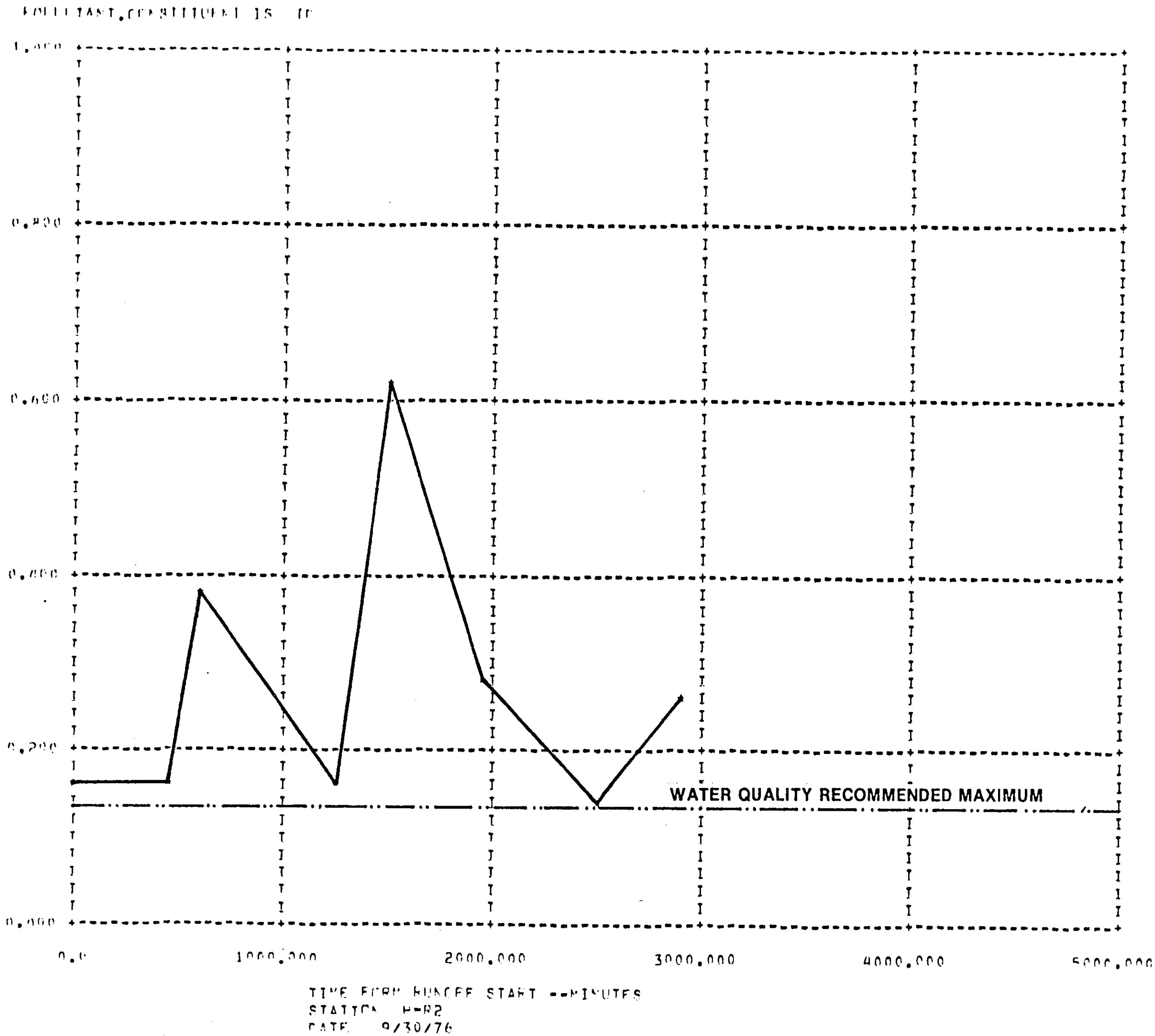


FIGURE 2.4-4 TOTAL PHOSPHORUS POLLUTOGRAPH AT H-R2

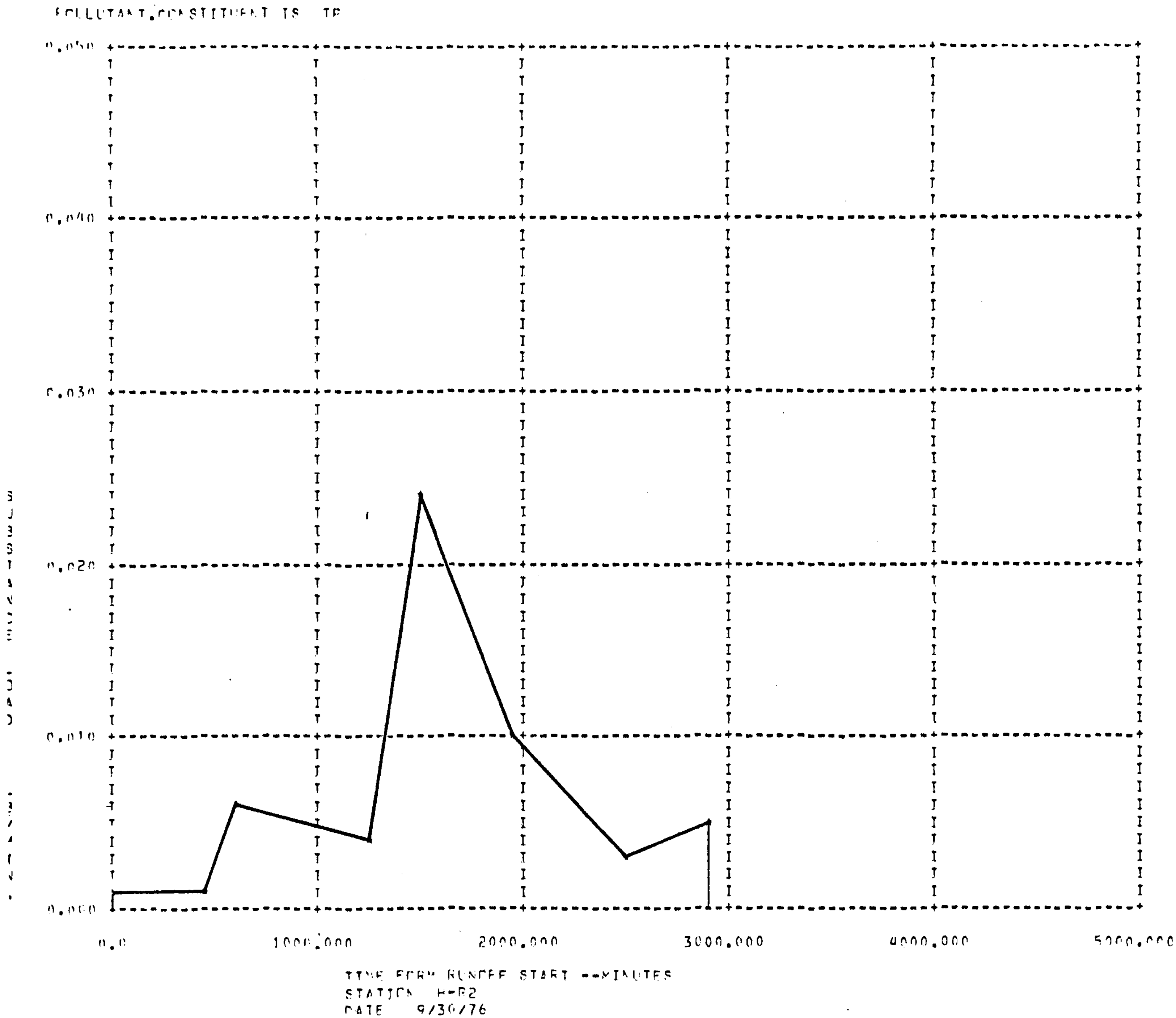


FIGURE 2.4-5 TOTAL PHOSPHORUS LOADOGRAPH AT H-R2

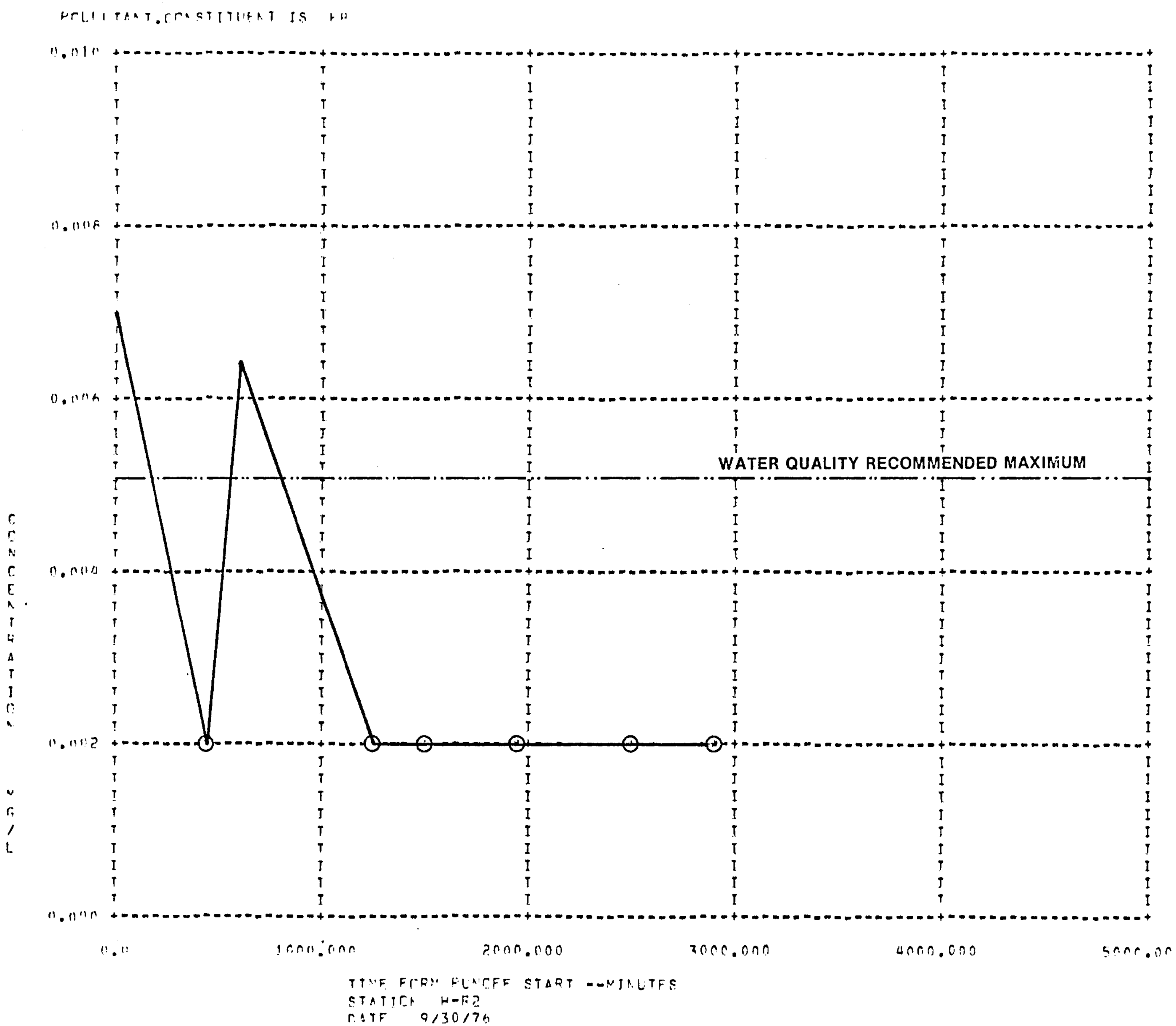


FIGURE 2.4-6 LEAD POLLUTOGRAPH AT H-R2

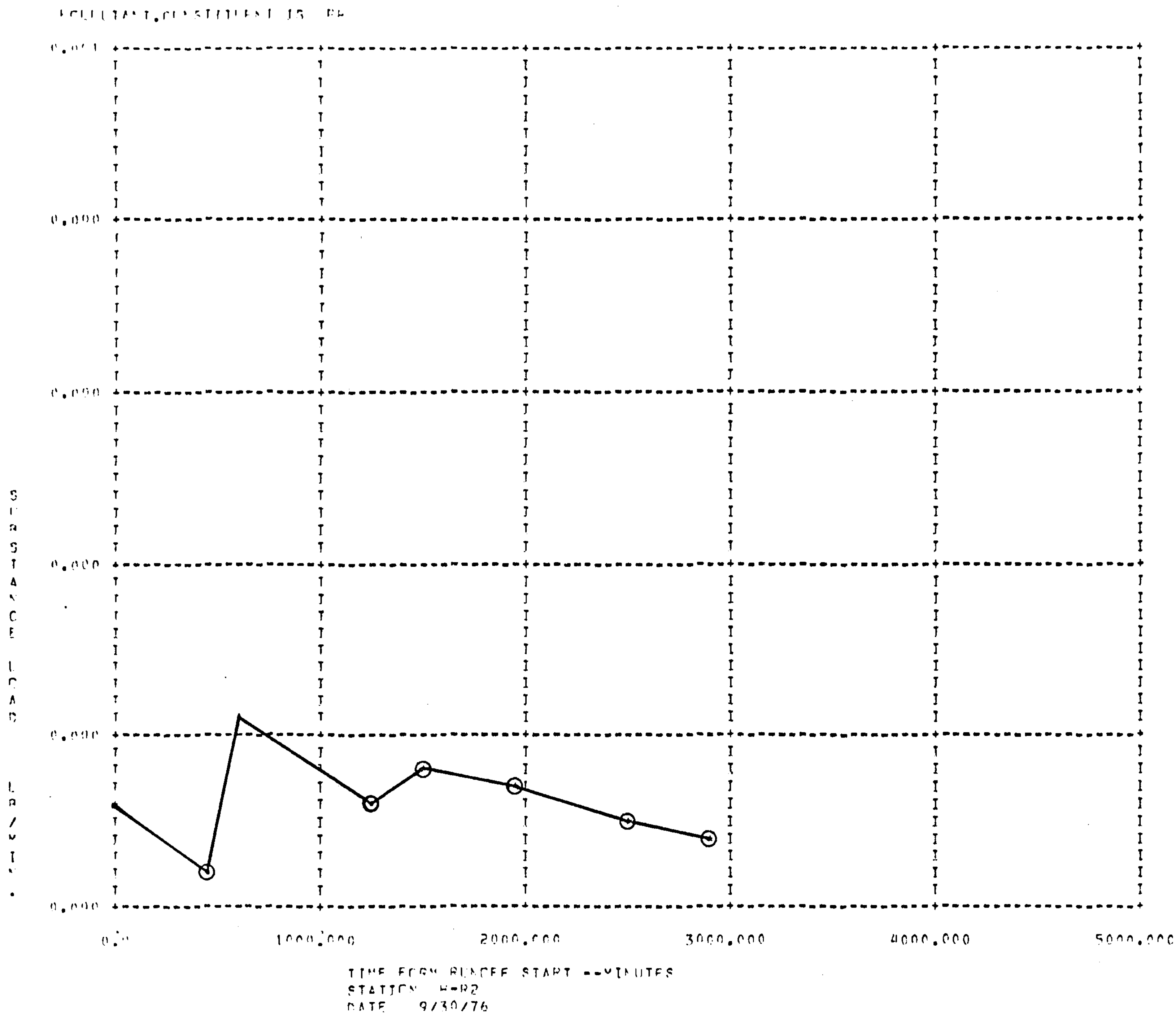


FIGURE 2.4-7 LEAD LOADOGRAPH AT H-R2

4.3 Residential Canal Development--Stations H-R3 and H-R4

Storm event sites H-R3 and H-R4 are in the Port Charlotte area. H-R3 is located near U.S. Highway 41 and Olean Boulevard at an outflow culvert from a canal surrounded by single- and multi-family residences. H-R4 is located near Florida Highway 771 near Collinswood Street on an outflow stream from a canal in an unpopulated, but developed area. The watershed has been cleared, paved roadways laid, and of course, canals dug; however, no houses have yet been built.

At H-R3, seven rainfalls took place dropping a total of 2.8 inches at the sampling site. A total of 3.62 inches were recorded at another place in the basin. As a result, water levels rose continually during an eight-day sampling span. The overall rise was about 9 inches, producing a trace of canal outflow at the highest water levels. No hydrograph exists for H-R3 due to the meager outflow. The basin area is about 300 acres. The approximate 3 inches of rain falling over the 300 acres totals about 25 million gallons of water, of which only a trace ran out of the basin.

At H-R4, minimal discharge occurred throughout an eight-day sampling period. Figure 2.4-8 shows the hydrograph during sampling. A small weir was constructed to help gage the very small flow, which varied from less than 0.018 cubic feet per second (cfs) to a maximum of about 0.066 cfs. Average discharge rate during the period was approximately 0.046 cfs, which equals a total discharge of about 240,000 gallons of water. Rainfalls occurred on six days during sampling and varied in amounts on different days and at different locations in the watershed. More than two inches of rain (2.075 inches) were recorded at the sampling site, and nearly one inch (0.875 inch and 0.955 inch) was recorded at each of the other rain gages. The watershed area is slightly greater than 1,500 acres. If an average of 1.5 inches of rain fell over the 1,500 acres, a total of about 61 million gallons of water would be collected. As noted above, only about one-quarter million gallons flowed out of the canal. At both sites, much more rain fell than ran out of the watershed. Most of this water was stored in the canals and nearby ground.

Very limited constituent analyses were performed on samples taken at H-R3 and H-R4. Pertinent results are as follows:

(1) Suspended solids levels are not excessive at either site. H-R3 levels are several times the levels at H-R4.

(2) Mercury levels are higher than receiving water quality standards. Lead levels are very low.

(3) Nutrient levels are high at H-R3. Most phosphorus is in suspended form at both sites. Total nitrogen is about three times higher at H-R3 than at H-R4. Because ammonia nitrogen occurs at both sites, most of the higher nitrogen at H-R3 is organic in nature. Nitrite plus nitrate levels are generally low. Figures 2.4-9 and 2.4-10 show H-R3 pollutographs for nitrogen and phosphorus, respectively. Figures 2.4-11 and 2.4-12 are pollutographs at H-R4. Because of meager flows, loadographs are not included.

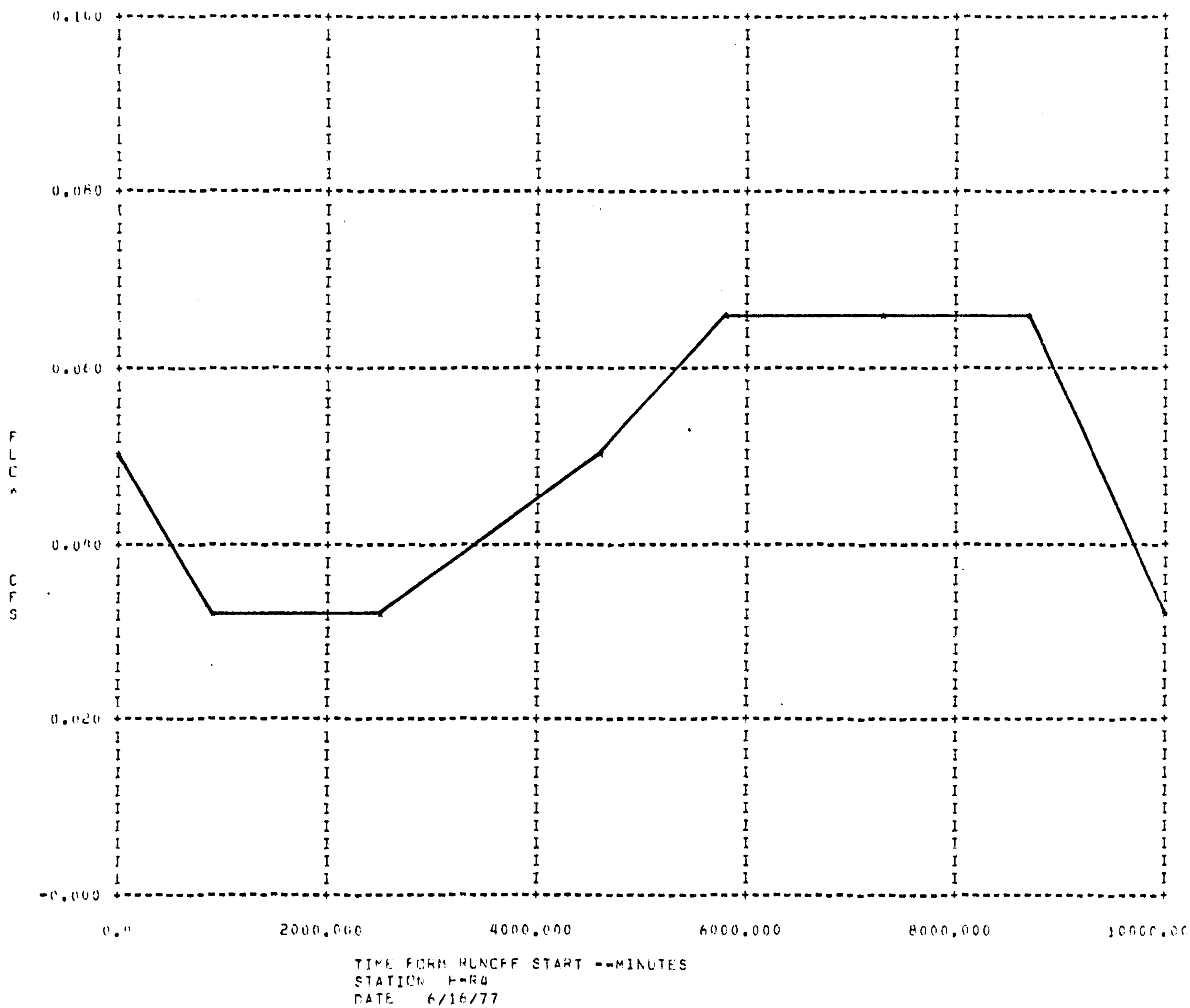


FIGURE 2.4-8 HYDROGRAPH AT H-R4

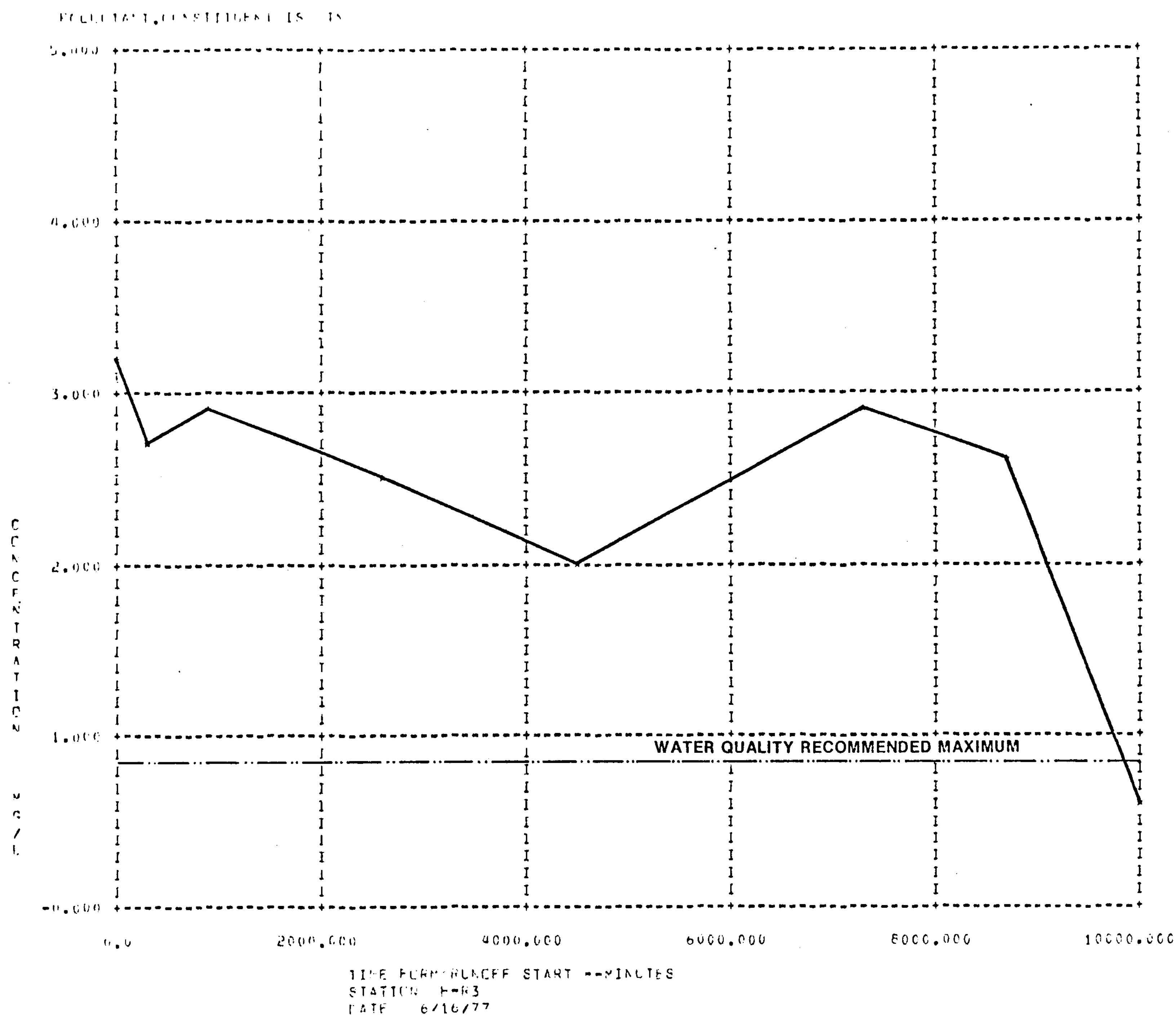


FIGURE 2.4-9 TOTAL NITROGEN POLLOTOGRAPH AT H-R3

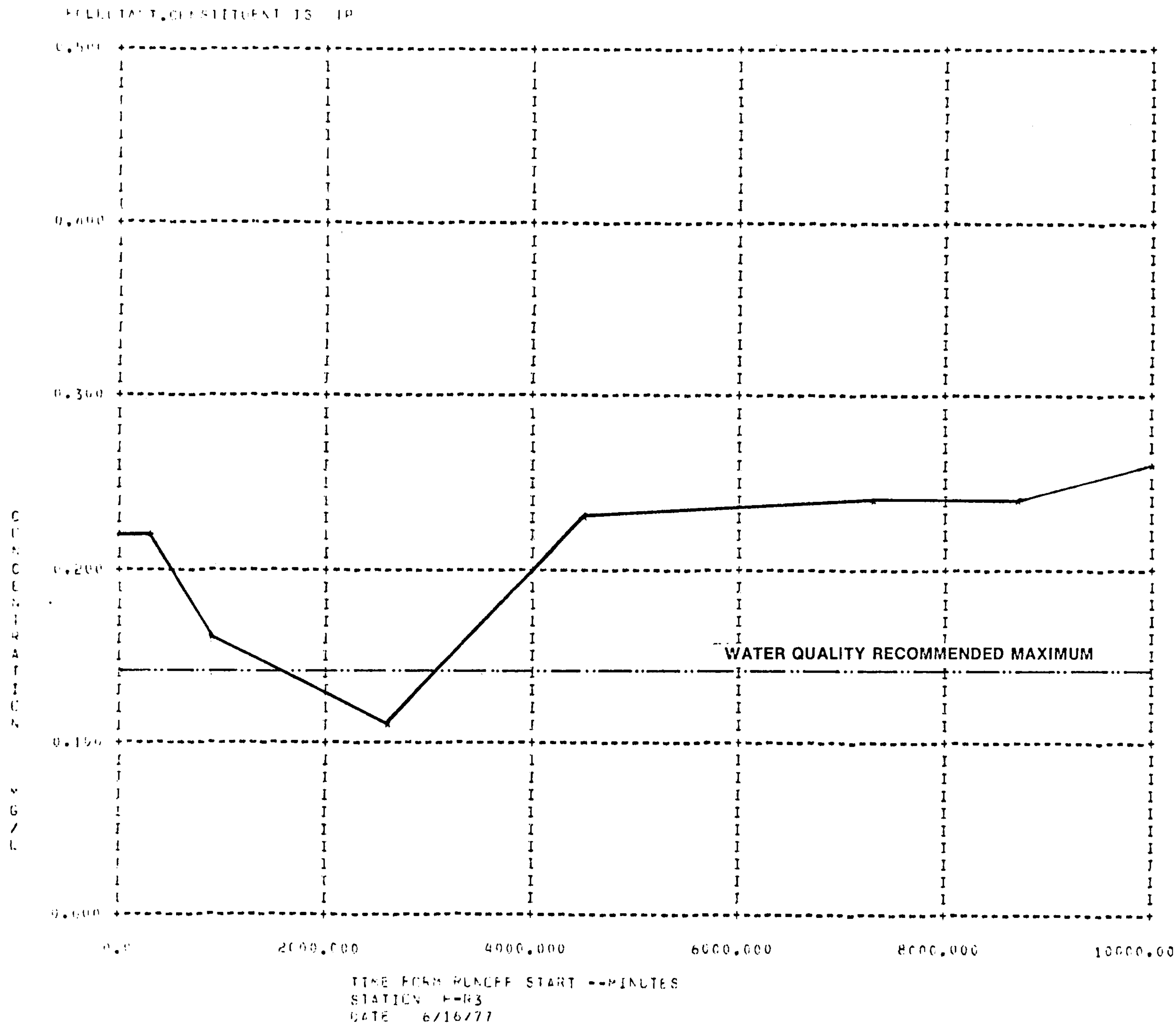


FIGURE 2.4-10 TOTAL PHOSPHORUS POLLUTOGRAPH AT H-R4

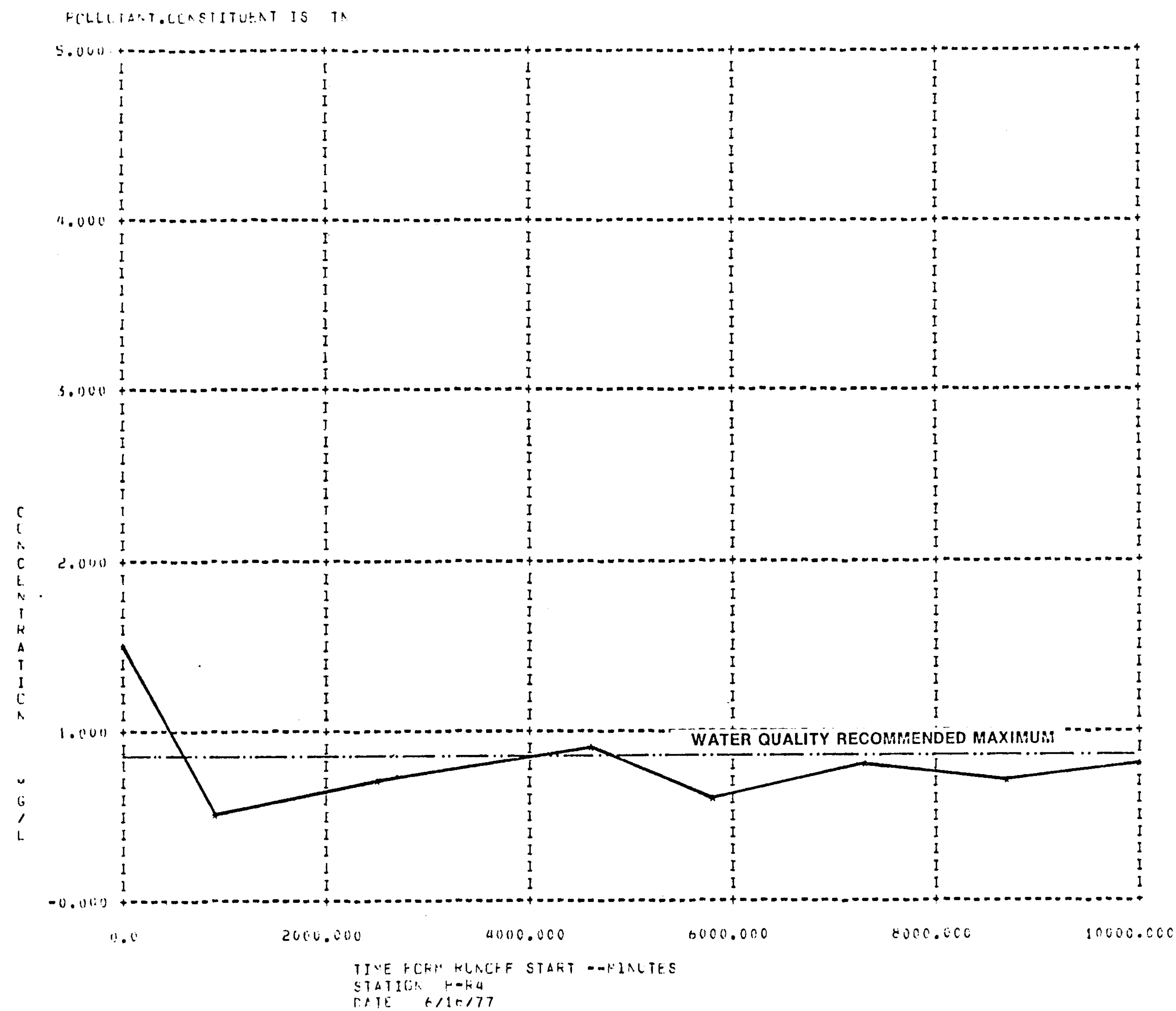


FIGURE 2.4-11 TOTAL NITROGEN POLLUTOGRAPH AT H-R4

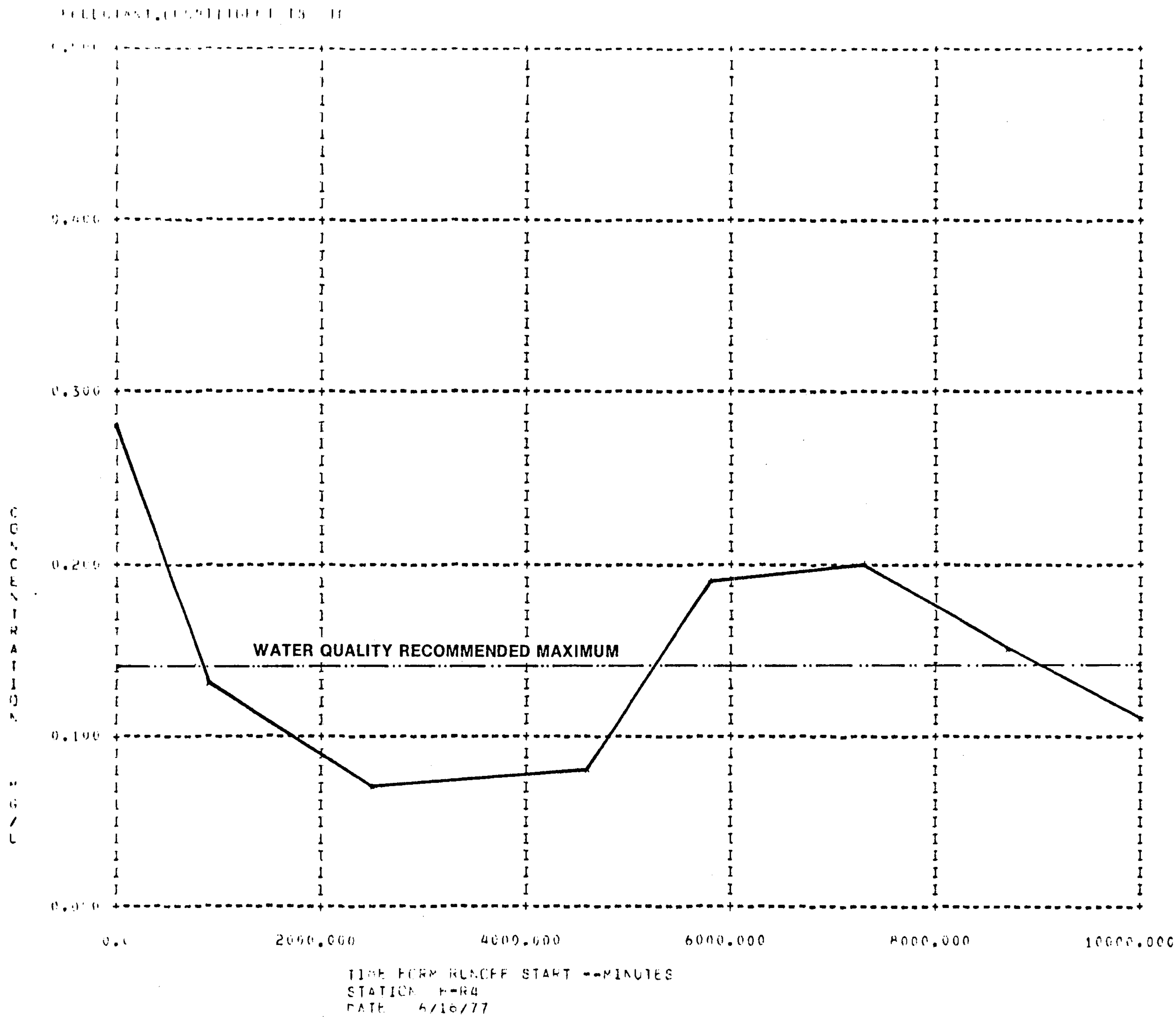


FIGURE 2.4-12 TOTAL PHOSPHORUS POLLUTOGRAPH AT H-R4

4.4 Summary

The primary purpose of storm event sampling has been to acquire pollutant loading quantification according to specific land uses. The results of such analysis are discussed in other sections; however, some general comments of a qualitative nature can be presented here.

At H-R2, the suspended solids concentrations are unusually low. No other storm event sampled indicates such low values. A possible explanation is that the basin is very grassy and that the flat topography of the basin causes water to drain very slowly. The color of water increases directly with flow, which tends to indicate a different regime of water occurring during runoff. Fecal strept/fecal coliform ratios are high, which suggests no pollution from human wastes. Phosphorus and oxidized nitrogen values clearly peak at the same time, which suggests that both come from the same source.

Limited data at H-R3 and H-R4 preclude a detailed discussion here. Nutrient data seem to reveal the effects of population on nonpoint loads. Higher levels in populated areas are pronounced. Furthermore, the high total nitrogen is mostly organic nitrogen at H-R3, the populated area. Low ammonia levels suggest low fecal pollution, which may be expected since the area is served by sanitary sewers. Perhaps high organic levels are due to grass cuttings being washed into and disposed of into the canal. Another possibility is that lawn fertilization by homeowners enriches the canal via runoff to such a level that aquatic plants are overabundant. In either case, the presence of people is noticeable in comparing water qualities of the two canals.

Limited data at H-R3 and H-R4 also restrict comparison between open land versus canaled, residential areas. Lead levels are low everywhere, and are not noticeably different at any of the sites. Neither urban versus nonurban nor populated versus nonpopulated differences are shown by the data. The urban canaled areas differ from other urban areas by not revealing high, or at least higher than nonurban, lead levels.

Total nitrogen levels are significantly higher in the populated watershed than in either of the other two basins. Again, lawn fertilizing may be a cause. The relative portion of total nitrogen attributable to ammonia nitrogen is much higher in the open area. Perhaps fecal matter from previous pastureland use is the reason.

5.0 ESTIMATION OF POLLUTANT LOADINGS FOR PRESENT AND FUTURE CONDITIONS

5.1 Analysis Techniques for Calculations and Projection of Nonpoint Source Loads

Data at H-R2 were the only data from this case study suitable for loading analysis, because insufficient runoff occurred at H-R3 and H-R4. The H-R2 data described in the preceding section were analyzed to determine the volume of runoff and total mass of pollutant substance carried by the runoff waters. Total nitrogen (TN) and total phosphorus (TP) were the substances considered for the storm event, because these were the only pollutants considered in the loads allocation process.

After reconstructing the runoff hydrograph for the storm event, the volume of runoff was determined by computing the area under the hydrograph. The total volume of runoff resulting from this storm event was calculated as 1,130,000 cubic feet.

The mass of pollutants for the storm event was determined by multiplying the measured instantaneous flow by the instantaneous pollutant concentration to generate a loadograph. The area under the curve of this plot represents pollutant mass or load resulting from the storm event. This mass was calculated to be 67 pounds of nitrogen and 21 pounds of phosphorus.

Also the flow-weighted concentration of each pollutant was calculated. The flow-weighted concentration is derived from the total runoff volume and the corresponding runoff pollutant load, dividing load by volume and the corresponding runoff pollutant load. Dividing load by volume and correcting for proper units yields the following values: 0.94 mg/l nitrogen and 0.30 mg/l phosphorus. These levels compare well with literature values for similar land uses, and indicate high nitrogen and very high phosphorus content in runoff waters.

Sufficient data were not available to determine site specific nonpoint pollutant loading factors from different land uses in this case study area. The differences between canal-type urban areas and those without canals could not be studied conclusively, because good pollutant loading data for the canaled areas were not available. Therefore, the site specific relationships derived between runoff flow-weighted pollutant concentration and percent imperviousness in the Phillippi Creek case study were also used in this case study.

In the Phillippi Creek study, the procedures for estimating present and future nonpoint waste loads involved: (1) developing relationships between storm event water quality of runoff for TN and TP, and the land use characteristics of sampled watersheds; (2) verifying the validity of these relationships by comparing the calculated pollutant loads with the available instream water quality data; and (3) applying the selected relationships to estimate present and future nonpoint waste loads for several subwatersheds within the case study area.

The land use characteristics of each subwatershed were expressed in terms of gross population density and composite percent imperviousness. These parameters were derived from the land use and population data of each sampled subwatershed.

In order to relate the nonpoint pollutant loads to the land use characteristics, the flow-weighted concentration of each pollutant was plotted against the gross population density as well as against the percent imperviousness. Plots of flow-weighted concentrations versus percent showed a better fit than the corresponding plots against population density. Based on these plots the following regression equations were developed. They mathematically relate the concentrations of substance in runoff water from a watershed to the percent imperviousness (% Imp) of the watershed.

The relationships derived in the Phillippi Creek case study are as follows:

$$TN = (0.010)(\%\ Imp) + 1.757$$

$$TP = (-0.003)(\%\ Imp) + 0.605$$

where: TN = total nitrogen concentration (mg/l)

TP = total phosphorus concentration (mg/l)

% Imp = composite percent imperviousness for the watershed

The assigned values of percent imperviousness for the Charlotte Harbor land use categories shown in Table 2.5-1 were area-weighted to determine the composite percent imperviousnesses for the watersheds. Note that the percent imperviousness for canal type residential development is 50 percent while that for typical residential development is 40 percent. This is because in the Port Charlotte area examined, the houses are spaced closer together than in other areas compared. Also, the land surface area in the vicinity is reduced because substantial surface area is taken up by canals. The water surface is not counted in the percent imperviousness area computations.

Knowing the percent imperviousness for the watershed, the flow-weighted concentrations of total nitrogen and total phosphorus were computed using the equations given above. Figure 2.5-1 was used to determine

Table 2.5-1. Imperviousness Factors According to Land Use, Charlotte Harbor

Land Use	% Imperviousness
Residential	40
Residential (Canal Type)	50
Commercial	80
Open and Other Urban	15
Cropland	0
Pastureland	0
Other Nonurban	0

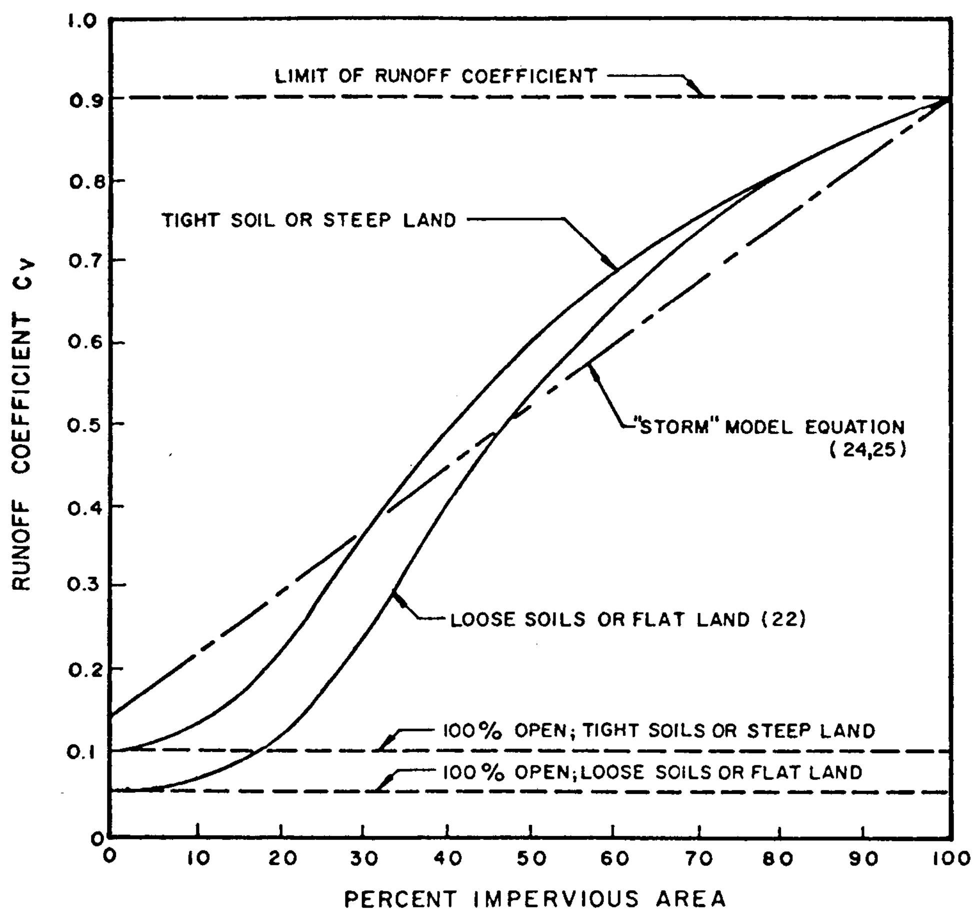


FIGURE 2.5-1

PERCENT IMPERVIOUSNESS VS· RUNOFF COEFFICIENT

the runoff coefficients for the watersheds, knowing the percent imperviousness.

Knowing the runoff coefficient, the volume of runoff was computed by month by using the following formula:

$$V_m = C_v R_m A$$

where V_m = monthly volume of runoff for month m;

C_v = runoff coefficient;

R_m = monthly rainfall; and

A = area of watershed

The nonpoint pollutant loads were calculated by month by multiplying the monthly runoff volumes by the mean pollutant concentrations. For example, for month 1, the mass or load of nitrogen would be pounds TN = $V_1 \cdot TN$.

5.2 Nonpoint Pollutant Loads

For the purpose of calculating nonpoint pollutant loads, the study area was divided into nine subwatersheds. The delineation of these subwatersheds is shown in Figure 2.5-2 and was based on the segmentation of Charlotte Harbor. The segmentation of the harbor was done for water quality modeling purposes and is discussed in Subsection 6.0.

Nonpoint pollutant loads were calculated for Subwatersheds 1 through 7 in the Charlotte Harbor basin using techniques described in the preceding subsection. Pollutant loads for Subwatersheds 8 and 9 will be discussed in Subsection 5.5.

The percent imperviousnesses were computed for Subwatersheds 1 through 7 for years 1976, 1978, 1983, 1988, 1993, and 1998 based on the land use data presented in Tables 2.5-2 through 2.5-8. The percent imperviousness for each subwatershed is shown in Table 2.5-9.

Knowing the percent imperviousness for each subwatershed, the mean pollutant concentrations were determined using equations presented in the preceding subsection.

The runoff coefficients for each subwatershed were determined using Figure 2.5-1, knowing the percent imperviousness for each subwatershed.

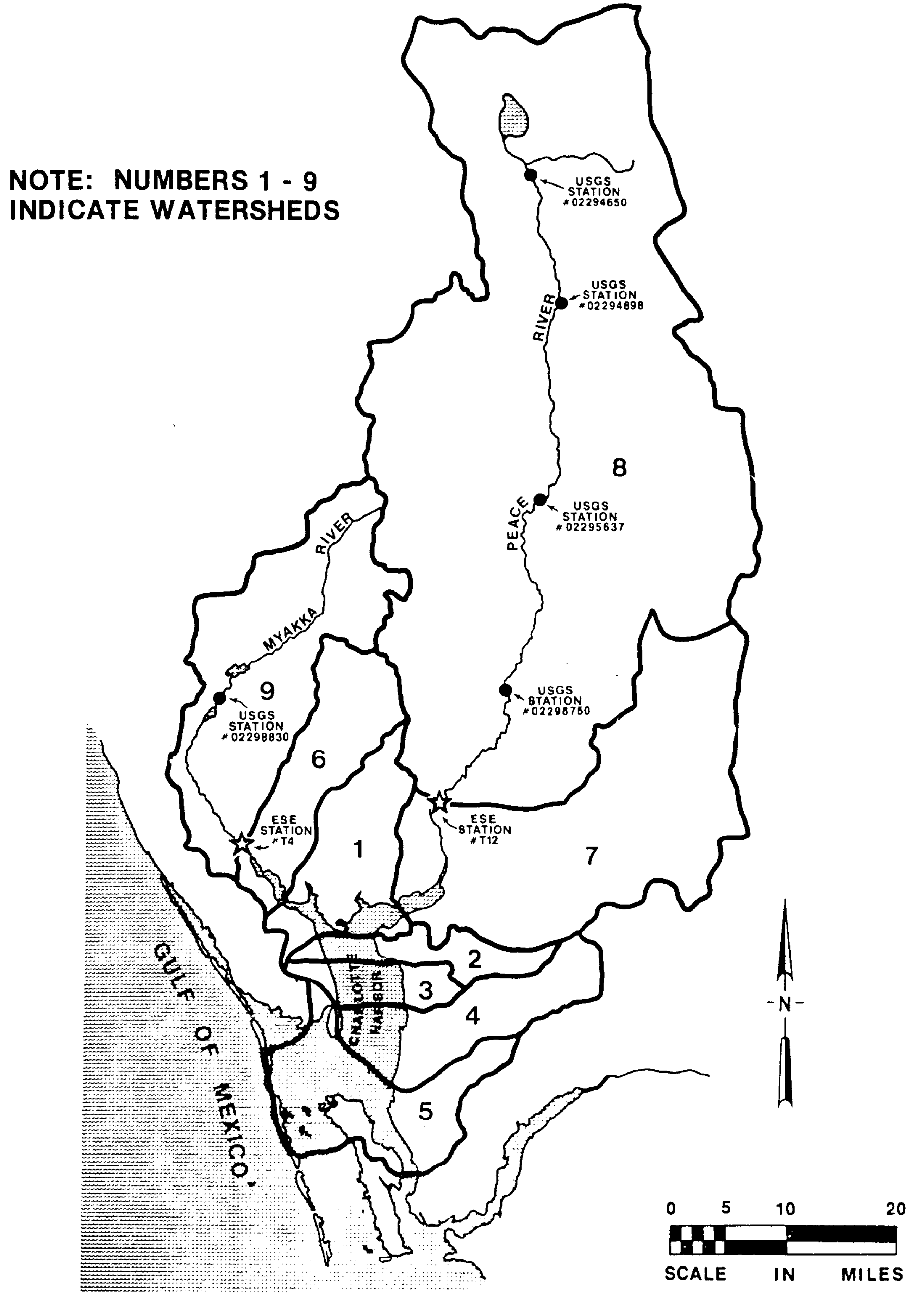


FIGURE 2.5-2
WATERSHED DELINEATION, CHARLOTTE HARBOR STUDY AREA

Table 2.5-2. Charlotte Harbor Study Area, Land Use Acreages, Subwatershed 1

Land Use	Area (acres)					
	1976	1978	1983	1988	1993	1998
Residential	7,783	7,975	8,089	11,481	14,175	16,140
Residential (Canal Type)	3,478	3,478	4,236	5,992	6,047	6,047
Commercial	1,543	1,552	1,601	1,667	1,743	1,804
Open and Other Urban	22,634	22,461	21,579	17,502	15,202	13,352
Cropland	328	328	328	328	328	328
Pastureland	1,554	1,554	1,580	1,570	1,558	1,549
Other Nonurban	48,652	48,624	48,559	47,432	46,919	46,752
Total	85,972	85,972	85,972	85,972	85,972	85,972

Table 2.5-3. Charlotte Harbor Study Area, Land Use Acreages, Subwatershed 2

Land Use	Area (acres)					
	1976	1978	1983	1988	1993	1998
Residential	616	603	1,582	2,275	2,418	3,769
Residential (Canal Type)	767	858	1,625	1,625	1,774	1,774
Commercial	198	209	250	266	293	353
Open and Other Urban	5,489	5,402	4,010	3,641	3,641	2,729
Cropland	613	613	613	613	613	613
Pastureland	2,462	2,459	2,459	2,469	2,469	2,405
Other Nonurban	23,455	23,455	23,061	22,711	22,392	21,957
Total	33,600	33,600	33,600	33,600	33,600	33,600

Table 2.5-4. Charlotte Harbor Study Area, Land Use Acreages, Subwatershed 3

Land Use	Area (acres)					
	1976	1978	1983	1988	1993	1998
Residential	499	499	648	648	1,236	2,568
Residential (Canal Type)						
Commercial	93	93	106	120	128	137
Open and Other Urban	3,359	3,359	3,209	3,209	2,918	2,186
Cropland	456	456	456	456	431	431
Pastureland	1,487	1,487	1,487	1,487	1,487	1,413
Other Nonurban	11,693	11,693	11,681	11,667	11,387	10,852
Total	17,587	17,587	17,587	17,587	17,587	17,587

Table 2.5-5. Charlotte Harbor Study Area, Land Use Acreages, Subwatershed 4

Land Use	Area (acres)					
	1976	1978	1983	1988	1993	1998
Residential	219	219	779	779	1,077	1,314
Residential (Canal Type)						
Commercial	192	192	192	192	192	192
Open and Other Urban	2,458	2,458	1,899	1,899	1,602	1,365
Cropland	62	62	62	62	62	62
Pastureland	2,613	2,613	2,613	2,613	2,613	2,613
Other Nonurban	36,574	36,574	36,574	36,574	36,574	36,574
Total	42,120	42,120	42,120	42,120	42,120	42,119

Table 2.5-6. Charlotte Harbor Study Area, Land Use Acreages, Subwatershed 5

Land Use	Area (acres)					
	1976	1978	1983	1988	1993	1998
Residential	17	29	72	124	176	208
Residential (Canal Type)	179	179	179	179	179	179
Commercial	42	42	42	50	50	50
Open and Other Urban	230	218	175	175	137	137
Cropland						
Pastureland						
Other Nonurban	5,760	5,760	5,760	5,700	5,686	5,654
Total	6,228	6,228	6,228	6,228	6,228	6,228

Table 2.5-7. Charlotte Harbor Study Area, Land Use Acreages, Subwatershed 6

Land Use	Area (acres)					
	1976	1978	1983	1988	1993	1998
Residential	1,235	1,272	1,813	2,361	3,394	4,605
Residential (Canal Type)	539	539	539	539	539	539
Commercial	107	132	264	394	557	710
Open and Other Urban	10,257	10,227	10,123	10,072	9,997	9,790
Cropland	817	817	817	817	817	817
Pastureland	21,310	21,310	21,325	21,332	21,371	21,403
Other Nonurban	58,243	58,211	57,627	56,993	55,833	54,644
Total	92,508	92,508	92,508	92,508	92,508	92,508

Table 2.5-8. Charlotte Harbor Study Area, Land Use Acreages, Subwatershed 7

Land Use	Area (acres)					
	1976	1978	1983	1988	1993	1998
Residential	2,697	2,737	3,336	4,157	4,561	5,423
Residential (Canal Type)	307	307	307	307	368	827
Commercial	1,240	1,240	1,257	1,341	1,366	1,384
Open and Other Urban	7,130	7,114	6,515	5,907	5,891	4,699
Cropland	27,588	27,588	27,588	27,588	27,580	27,580
Pastureland	65,745	65,745	65,847	65,739	65,640	65,647
Other Nonurban	207,640	207,617	207,500	207,311	206,944	206,790
Total	312,350	312,350	312,350	312,350	312,350	312,350

Table 2.5-9. Charlotte Harbor Study Area, Subwatershed Percent Imperviousness

Year	Subwatershed Composite Percent Imperviousness						
	1	2	3	4	5	6	7
1977	11.0	4.8	4.4	1.5	2.6	2.6	1.1
1978	11.1	4.9	4.4	1.5	2.7	2.6	1.1
1983	11.5	6.7	4.7	1.8	2.9	2.9	1.1
1988	13.4	7.4	4.8	1.8	3.3	3.3	1.2
1993	14.4	7.8	5.9	2.0	3.5	3.9	1.3
1998	15.0	9.2	8.3	2.1	3.7	4.5	1.4

The monthly runoff volumes were computed using the runoff coefficients and the monthly rainfall as described in the preceding subsection.

Nonpoint loads were computed for each subwatershed on a monthly basis by multiplying the mean pollutant concentrations by the monthly runoff volumes. The 1976 monthly rainfalls were used to calculate the existing nonpoint loads, and the long-term average monthly rainfalls were used to calculate the projected loads.

Tables 2.5-10 through 2.5-13 present the seasonal nonpoint loads, or more properly, loading factors on a per-acre basis for Subwatersheds 1 through 7. Wet season extends from June through September and dry season extends from October through May. The existing nonpoint loads for Subwatershed 1 are the highest and the loads for Subwatersheds 2 and 3 are higher than those for the remaining subwatersheds. The loads for Subwatersheds 1, 2, and 3 are the highest because these areas are more developed than the other subwatersheds with correspondingly higher percent imperviousnesses and runoff coefficients.

The per-acre basis used in Tables 2.5-10 through 2.5-13 permits comparisons to be made regarding the relative pollutant contributions of a unit of land surface area. Total loads would then be given by multiplying these values by the number of acres within each subwatershed.

Table 2.5-10. Charlotte Harbor Study Area, Nonpoint Loads (Loading Factors) for Total Nitrogen and Total Phosphorus

Watershed 1				Watershed 2			
		Nonpoint Load (lb/acre/seas)				Nonpoint Load (lb/acre/seas)	
Year	Season	TN	TP	Year	Season	TN	TP
1977	Wet	0.705	0.216	1977	Wet	0.486	0.159
	Dry	0.434	0.133		Dry	0.299	0.098
1978	Wet	0.923	0.282	1978	Wet	0.637	0.208
	Dry	0.527	0.161		Dry	0.363	0.119
1983	Wet	0.936	0.286	1983	Wet	0.755	0.242
	Dry	0.534	0.163		Dry	0.431	0.138
1988	Wet	1.01	0.302	1988	Wet	0.780	0.249
	Dry	0.577	0.172		Dry	0.446	0.142
1993	Wet	1.08	0.319	1993	Wet	0.796	0.253
	Dry	0.616	0.182		Dry	0.455	0.144
1998	Wet	1.15	0.337	1998	Wet	0.826	0.260
	Dry	0.657	0.193		Dry	0.472	0.149

Table 2.5-11. Charlotte Harbor Study Area, Nonpoint Loads (Loading Factors) for Total Nitrogen and Total Phosphorus

Watershed 3				Watershed 4			
		Nonpoint Load (lb/acre/seas)				Nonpoint Load (lb/acre/seas)	
Year	Season	TN	TP	Year	Season	TN	TP
1977	Wet	0.475	0.156	1977	Wet	0.457	0.155
	Dry	0.292	0.096		Dry	0.281	0.096
1978	Wet	0.621	0.205	1978	Wet	0.598	0.203
	Dry	0.355	0.117		Dry	0.342	0.116
1983	Wet	0.632	0.208	1983	Wet	0.598	0.203
	Dry	0.362	0.119		Dry	0.342	0.116
1988	Wet	0.636	0.208	1988	Wet	0.598	0.203
	Dry	0.363	0.119		Dry	0.342	0.116
1993	Wet	0.677	0.219	1993	Wet	0.602	0.203
	Dry	0.386	0.125		Dry	0.344	0.116
1998	Wet	0.810	0.257	1998	Wet	0.602	0.203
	Dry	0.462	0.146		Dry	0.344	0.116

Table 2.5-12. Charlotte Harbor Study Area, Nonpoint Loads (Loading Factors) for Total Nitrogen and Total Phosphorus

Watershed 5				Watershed 6			
		Nonpoint Load (lb/acre/seas)				Nonpoint Load (lb/acre/seas)	
Year	Season	TN	TP	Year	Season	TN	TP
1977	Wet	0.460	0.154	1977	Wet	0.460	0.154
	Dry	0.283	0.095		Dry	0.283	0.095
1978	Wet	0.602	0.202	1978	Wet	0.598	0.202
	Dry	0.344	0.115		Dry	0.342	0.115
1983	Wet	0.603	0.202	1983	Wet	0.605	0.202
	Dry	0.344	0.155		Dry	0.346	0.115
1988	Wet	0.604	0.202	1988	Wet	0.605	0.201
	Dry	0.344	0.155		Dry	0.346	0.115
1993	Wet	0.604	0.202	1993	Wet	0.609	0.201
	Dry	0.344	0.155		Dry	0.348	0.115
1998	Wet	0.605	0.201	1998	Wet	0.621	0.204
	Dry	0.345	0.115		Dry	0.354	0.117

Table 2.5-13. Charlotte Harbor Study Area, Nonpoint Loads (Loading Factors) for Total Nitrogen and Total Phosphorus

Watershed 7

Year	Season	Nonpoint Load (lb/acre/seas) TN	TP
1977	Wet	0.458	0.156
	Dry	0.282	0.096
1978	Wet	0.599	0.204
	Dry	0.342	0.116
1983	Wet	0.599	0.204
	Dry	0.342	0.116
1988	Wet	0.599	0.204
	Dry	0.342	0.116
1993	Wet	0.599	0.204
	Dry	0.342	0.116
1998	Wet	0.599	0.204
	Dry	0.342	0.116

By considering pollutant loading on the per-acre basis, better insight is gained into the relative effects of changing land use or changing pollutant loading. This information provides needed input to the planning process by helping to identify not only subwatersheds contributing heavy loads, but trends in land use changes contributing heavy loads.

The estimated existing loads are not directly comparable to the projected loads, because actual 1976 monthly rainfalls were used to compute the existing loads and the long term average monthly rainfalls were used to compute the projected loads. The 1976 rainfall was less than the long term average rainfall, so even if no significant changes in land use occurred throughout the planning period, an increase in nonpoint pollutant loads is forecast due to the higher values of rainfall used. Therefore, estimated loads for years 1978, 1983, 1988, 1993, and 1998 were compared to determine the change in load due to land use changes.

The predicted nonpoint loads for 1978 are approximately the same as those for 1976, since no significant changes in land use were projected to occur in this period.

The loads for all of the subwatersheds are predicted to increase by 1998 because of projected development. The loads predicted for 1998 for Subwatershed 1 are the highest, followed by those for Subwatersheds 2 and 3, followed by those for Subwatershed 6. The predicted loads for the remaining subwatersheds, 4, 5, and 7, are the lowest and are approximately the same. By examining Table 2.5-10, for example, the projected per-acre loading for total nitrogen (TN) increases from 0.923 pounds per acre per wet season, to 1.15 pounds per acre per wet season over the 20 years from 1978 to 1998. An approximate 25 percent increase in loads will occur if no control measures are taken. Similar occurrences are estimated throughout the case study area, as indicated repeatedly in Tables 2.5-10 through 2.5-13.

5.3 Analysis Techniques for Calculation and Projection of Point Source Loads

The 201 Facility Plans for the Charlotte County area provided discharge and water quality data for the point source dischargers. These data were used to compute existing monthly point loads.

5.4 Point Source Pollutant Loads

Two point sources discharge into Charlotte Harbor--the Punta Gorda Wastewater Treatment Plant and the Mary Lu Trailer Court Facility. Gulf Shore Seafood discharges seafood washing water to the harbor. However, this fact is not considered significant and was not included in the loads analysis. Both of these point sources are located in Subwatershed 7. The Punta Gorda Plant provides secondary treatment and the Mary Lu Trailer Court facility provides advanced wastewater treatment. Existing mean monthly discharges, nitrogen and phosphorus concentrations, and loads for the Punta Gorda Plant are presented in Table 2.5-14.

Monthly data were not available for the Mary Lu Trailer Park facility, but the average annual daily flow was converted to a monthly flow. This mean monthly flow was assumed constant over the entire year. The average monthly concentration levels recommended for advance treated wastewaters were used because effluent nutrient concentration data were also lacking. These concentrations for nitrogen and phosphorus are 5 mg/l and 2 mg/l, respectively. Loads of nitrogen and phosphorus were calculated using the mean monthly discharges and the above concentrations and are presented in Table 2.5-15.

The loads for both of these point sources were assumed constant through 1983. After 1983, the point sources were projected to cease discharge

Table 2.5-14 Point Source Loads--Punta Gorda Wastewater Treatment Plant (1976)

Month	Mean Monthly Discharge (MG)	Mean Monthly Concentration (mg/l)		Mean Monthly Load (lb)	
		TN	TP	TN	TP
January	22.72	14.60	0.41	2,766	78
February	21.00	15.91	0.20	2,786	35
March	20.99	17.35	0.28	3,037	49
April	15.69	15.70	0.21	2,054	27
May	17.67	4.47	0.32	659	47
June	22.02	3.54	0.46	650	84
July	19.96	4.89	0.23	814	38
August	21.98	6.43	0.67	1,179	123
September	24.72	8.11	0.85	1,672	175
October	23.06	6.98	0.53	1,342	102
November	22.05	6.74	0.55	1,239	101
December	25.20	10.35	0.66	2,175	139

Table 2.5-15 Point Source Loads--Mary Lu Trailer Court Facility (1976)

Mean Monthly Discharge (MG)	Mean Monthly Concentration (mg/l)		Mean Monthly Load (lb)	
	TN	TP	TN	TP
0.012	5	2	5	2

to surface waters. Therefore no loading of the harbor via surface waters is anticipated. Loading of the harbor via groundwater movement has not been considered.

5.5 Total Pollutant Loads

Total pollutant loads for Subwatersheds 1 through 7 were determined by summing the point and nonpoint loads for each subwatershed. Nonpoint loads for each subwatershed are obtained by multiplying the annual pollutant load per acre (dry season plus wet season) by respective total area.

Subwatersheds 8 and 9 are the Peace and Myakka River watersheds, respectively (see Figure 2.5-2). These two subwatersheds extend out of the planning region, and available land use data for these areas were reviewed. Data did not meet detail requirements for nonpoint load analysis techniques. However, the land use for both subwatersheds is predominantly rural and available information regarding changes in land use projected throughout the planning period indicated only slight changes. Therefore, total pollutant loads emanating from these subwatersheds were computed by multiplying mean monthly in-stream pollutant concentrations by mean monthly stream discharges. These loads were assumed constant throughout the planning period.

Since no discharge data were available for the Peace and Myakka Rivers at the terminal points of the subwatersheds, estimates of the discharges for the two rivers had to be made. Discharge data were collected by the U.S. Geological Survey at stations upstream of the terminal points on both rivers (see Figure 2.5-2). Discharge data collected at U.S.G.S. Station 02296750 on the Peace River near Arcadia were developed into mean monthly discharges per unit area, and the same was done for U.S.G.S. Station 02298830 on the Myakka River at the state park. Flows for the entire basin were determined by extrapolating the discharges per unit area over the total watershed area.

Background water quality data collected at the terminal points of Subwatersheds 8 and 9 were used to develop mean monthly nitrogen and phosphorus concentrations at these points. These water quality sampling stations are shown in Figure 2.5-2.

Mean monthly loads were then calculated for Subwatersheds 8 and 9 using the mean monthly discharge and concentration data. The existing loads were computed using 1976 flow and water quality data, and the loads for the remainder of the planning period were computed using long-term average data. Long-term concentrations were computed from water quality records for the U.S.G.S. stations on the Peace and Myakka Rivers, as noted earlier.

The existing and 1998 total nitrogen and phosphorus loads for Subwatersheds 1 through 9 are presented in Tables 2.5-16 and 2.5-17, respectively. As shown in Table 2.5-16, the existing and 1998 total nitrogen loads estimated for Subwatersheds 8 and 9 are so much higher than those estimated for the remaining subwatersheds that they, in effect, overshadow the other loads. The same case is true for the total phosphorus loads, as shown in Table 2.5-17.

Table 2.5-16 Charlotte Harbor Total Nitrogen Loads

Subwater-shed	1976 Annual Pollutant Loads (lb/yr)			1998 Annual Pollutant Loads (lb/yr)		
	Point	Nonpoint	Total	Point	Nonpoint	Total
1	0	92,411	92,411	0	155,390	155,390
2	0	26,396	26,396	0	43,610	43,610
3	0	13,490	13,490	0	22,359	22,359
4	0	31,112	31,112	0	39,833	39,833
5	0	4,627	4,627	0	4,627	4,627
6	0	44,294	44,294	0	68,570	68,570
7	20,433	230,900	251,333	0	230,900	230,900
8 (Peace River)	--	--	3,121,103	--	--	5,930,400
9 (Myakka River)	--	--	731,263	--	--	861,470

Table 2.5-17 Charlotte Harbor Total Phosphorus Loads

Subwatershed	1976 Annual Pollutant Loads (lb/yr)			1998 Annual Pollutant Loads (lb/yr)		
	Point	Nonpoint	Total	Point	Nonpoint	Total
1	0	28,177	28,177	0	45,370	45,370
2	0	8,631	8,631	0	13,730	13,730
3	0	4,442	4,442	0	7,094	7,094
4	0	10,559	10,559	0	13,433	13,433
5	0	1,554	1,554	0	1,554	1,554
6	0	14,599	14,599	0	21,953	21,953
7	1,022	78,568	79,590	0	78,568	78,568
8 (Peace River)	--	--	2,820,696	--	--	7,014,700
9 (Myakka River)	--	--	347,786	--	--	947,300

6.0 PREDICTIONS OF WATER QUALITY ASSUMING NO NONPOINT SOURCE CONTROLS

The analysis of water quality in an estuary is quite complicated because it is subjected to freshwater inflow as well as astronomical tides. Materials that are discharged at one point in the system affect water quality in both the upstream and downstream direction because of tidal reversals. The classical method of incorporating this mixing transport in estuaries is through the use of dispersion coefficients, normally designated E. In practice, the dispersion coefficient is an estimator of the net rate at which the pollutant mass is transported from regions of higher concentrations to regions of lower concentrations.

Water quality is also subject to physical, chemical, and biological activity which alters the concentration of constituents when introduced into the water. Water acts as a reactive system which may increase or decrease the concentration of substances introduced into the system. The rate at which the substance concentration varies is estimated by using reaction rate coefficients, otherwise known as "K" factors. Figure 2.6-1 is a curve which represents a reactive system where substance concentration is plotted versus distance along the estuary. Point "O" indicates the point at which the substance is introduced into the system. The direction of flow in the estuary is indicated as left to right. A high reaction rate, or "K" factor, would cause the substance

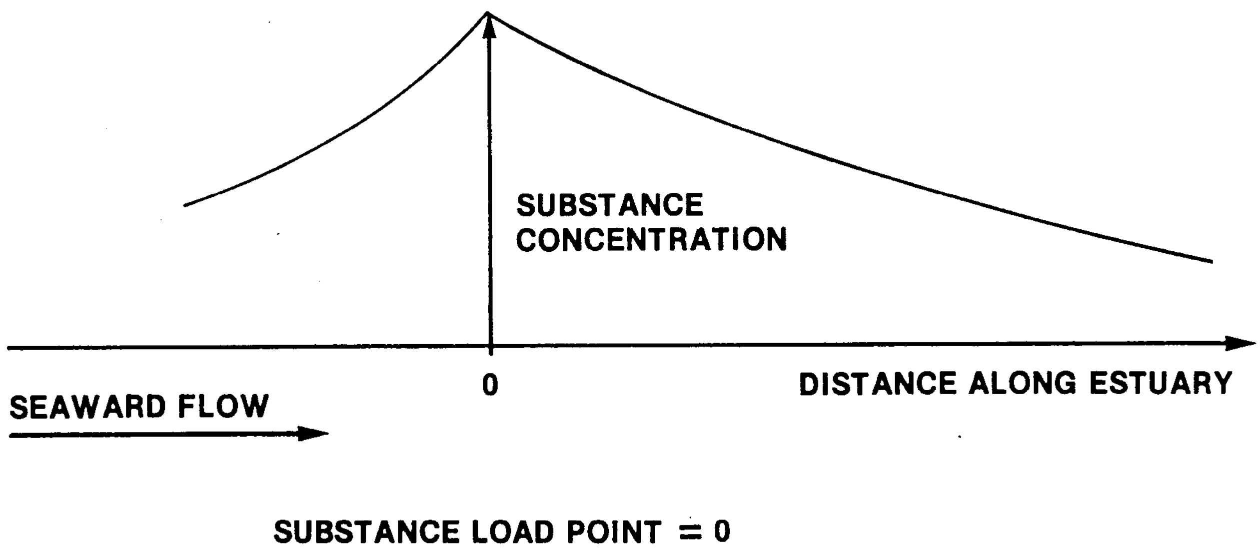


FIGURE 2.6 - 1
SUBSTANCE CONCENTRATION VS. DISTANCE ALONG ESTUARY - REACTIVE SYSTEM APPROACH

concentration on either side of the substance load point, "O", to drop off more markedly, resulting in lower concentration levels nearer "O."

Nitrogen and phosphorus were the constituents considered in the water quality analysis for Charlotte Harbor. The harbor was simplified to a one-dimensional system where water quality was estimated along a single line routed from the Peace River area, down mid-harbor, and through Grand Pass. The harbor, on this one-dimensional line, was divided into six segments, as shown in Figure 2.6-2. This segmentation distributes the pollutant loads along the harbor, which is more realistic than imposing one large load. The point and nonpoint pollution loads for each subwatershed were summed and treated as a single point load in that segment. Figure 2.6-3 shows the location of the loads by subwatershed relative to the harbor segments. As shown in Figure 2.6-3, the total loads for Subwatersheds 1, 6, 7, 8, and 9 are imposed on Segment 1; the total loads for Subwatershed 2 are imposed on Segment 2; the total loads for Subwatershed 3 are imposed on Segment 3; one-half the total load for Subwatershed 4 is imposed on Segment 4; one-half the total load for Subwatershed 4 is imposed on Segment 5; and finally, the total loads for Subwatershed 5 are imposed on Segment 6.

The average water quality (i.e., nitrogen and phosphorus concentrations) was computed for 1976. The reaction rates for nitrogen and phosphorus were adjusted to match the computed water quality with

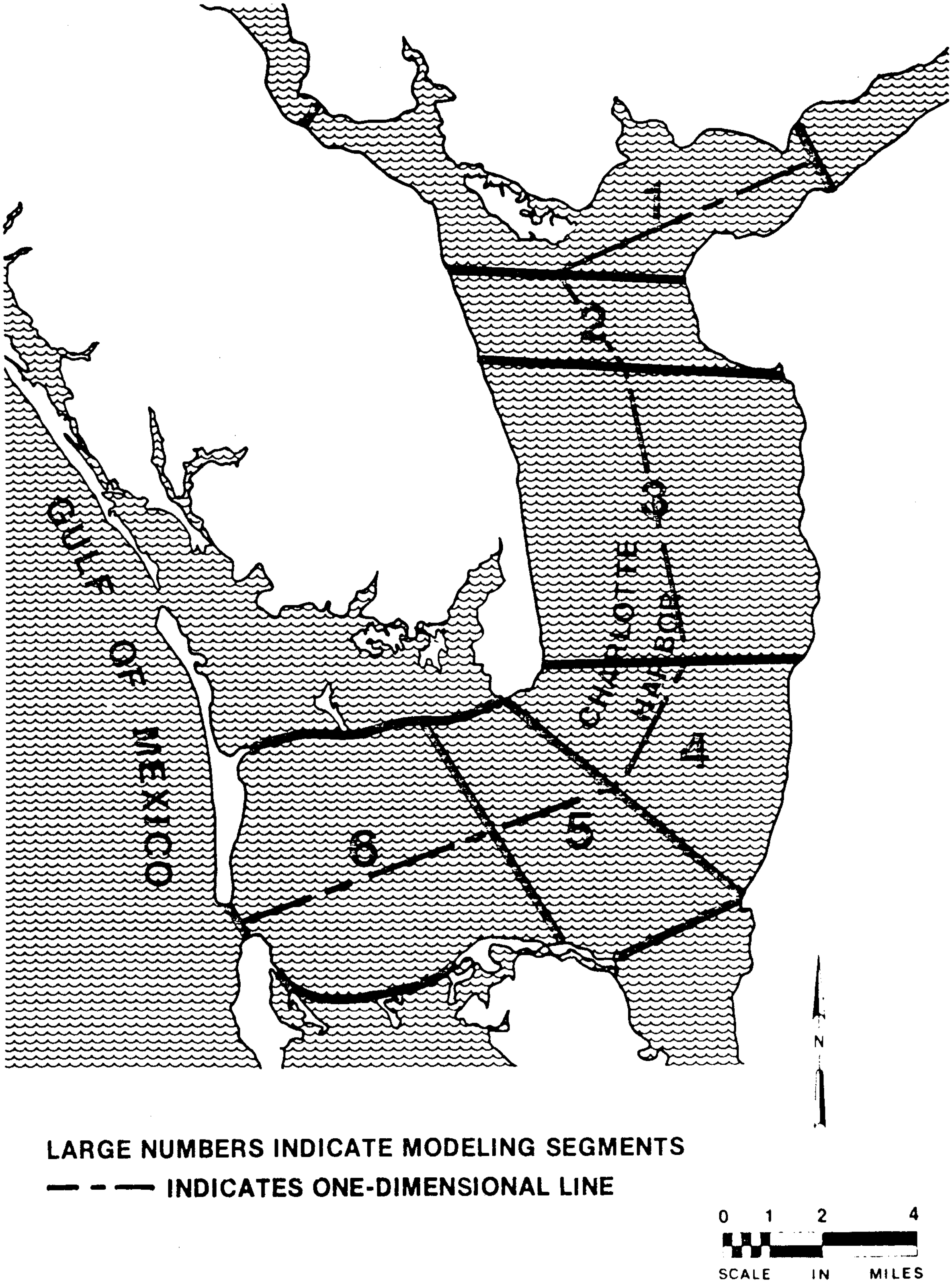


FIGURE 2.6-2
CHARLOTTE HARBOR SEGMENTATION

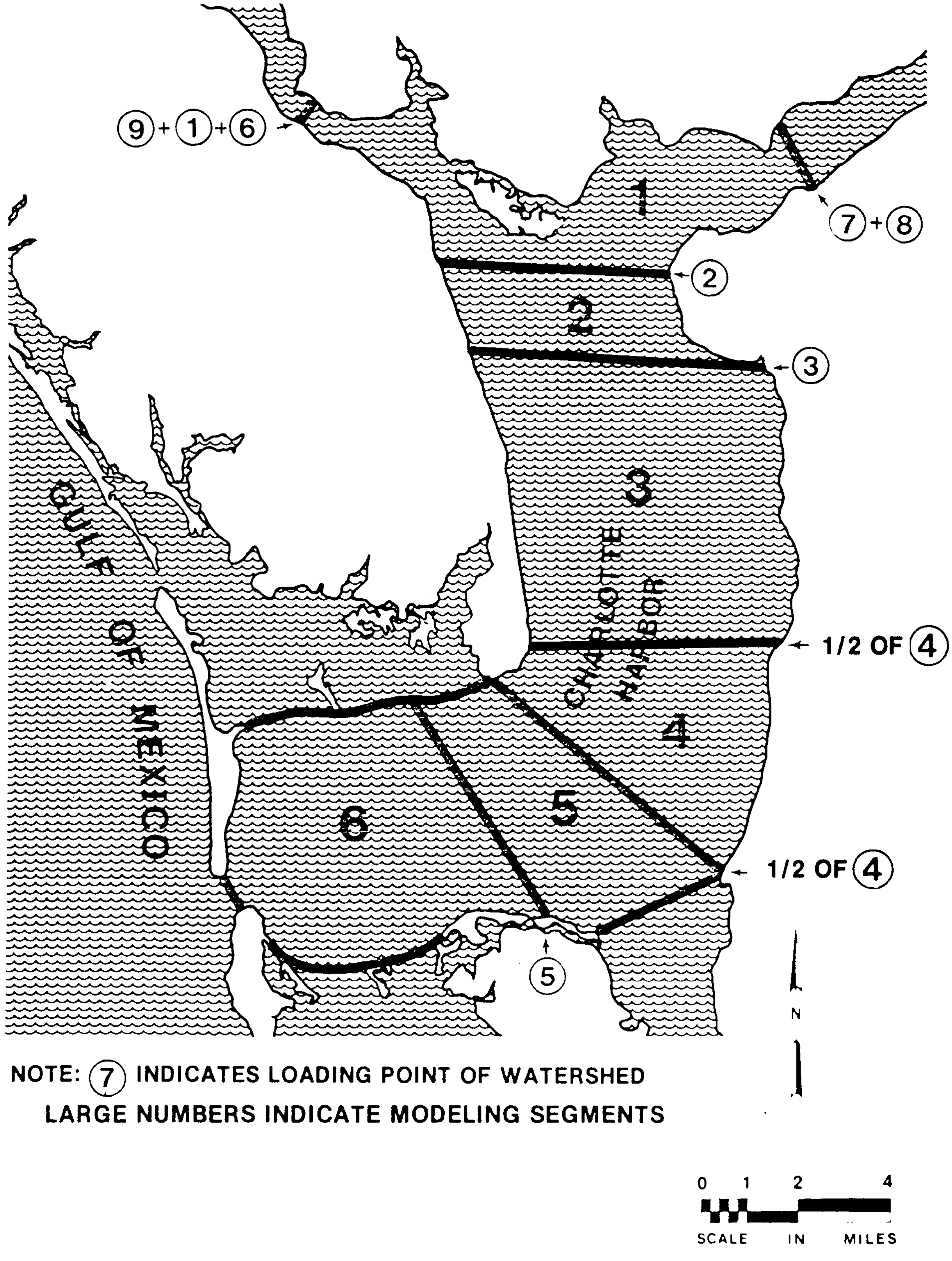


FIGURE 2.6-3
CHARLOTTE HARBOR POLLUTANT
LOADING POINTS

observed water quality. The computed nitrogen and phosphorus concentrations are compared with the observed concentrations on a monthly basis in Table 2.6-1. No observed water quality data were available for the month of May. Considering the simplistic analytic technique used to compute the water quality, Table 2.6-1 shows relatively good agreement between computed and observed water quality.

Table 2.6-1. Charlotte Harbor Water Quality Analysis Calibration

Segment	Total Nitrogen (mg/l)		Total Phosphorus (mg/l)	
	Computed	Observed	Computed	Observed
January				
1	1.13	1.01	0.61	0.61
2	1.06	0.82	0.52	0.22
3	0.96	0.69	0.40	0.14
4	0.85	0.61	0.29	0.11
5	0.79	0.51	0.24	0.09
6	0.81	0.48	0.23	0.10
February				
1	0.99	1.07	0.76	0.52
2	0.92	0.86	0.64	0.23
3	0.82	0.76	0.49	0.15
4	0.71	0.74	0.34	0.17
5	0.66	0.76	0.28	0.27
6	0.66	0.91	0.25	0.30
March				
1	0.60	1.07	0.34	0.68
2	0.55	0.71	0.28	0.31
3	0.48	0.70	0.20	0.25
4	0.40	0.64	0.13	0.20
5	0.36	0.68	0.10	0.16
6	0.34	0.75	0.08	0.12
May				
1	1.39	1.44	0.55	0.65
2	1.32	1.20	0.47	0.38
3	1.20	1.20	0.37	0.37
4	1.07	1.19	0.27	0.36
5	1.00	1.17	0.23	0.35
6	1.03	1.08	0.21	0.30
June				
1	1.87	1.15	0.82	0.34
2	1.75	0.98	0.70	0.26
3	1.57	--	0.54	--
4	1.38	0.88	0.39	0.22
5	1.28	0.79	0.32	0.21
6	1.39	--	0.36	--

Table 2.6-1. Charlotte Harbor Water Quality Analysis Calibration (Continued, Page 2 of 3)

Segment	Total Nitrogen (mg/l)		Total Phosphorus (mg/l)	
	Computed	Observed	Computed	Observed
July				
1	1.27	1.32	0.71	0.71
2	1.20	1.03	0.61	0.72
3	1.09	0.92	0.48	0.52
4	0.98	1.00	0.36	0.50
5	0.92	2.13	0.31	0.54
6	1.00	1.42	0.35	0.56
August				
1	1.89	1.65	0.82	0.75
2	1.76	1.28	0.69	0.53
3	1.58	1.47	0.54	0.33
4	1.38	1.67	0.38	0.23
5	1.28	1.00	0.32	0.44
6	1.39	0.95	0.35	0.37
September				
1	2.15	2.24	0.51	0.58
2	1.94	1.45	0.40	0.37
3	1.65	1.33	0.29	0.30
4	1.35	1.21	0.18	0.32
5	1.20	1.22	0.14	0.20
6	1.26	1.28	0.13	0.13
October				
1	1.75	1.24	0.51	0.52
2	1.64	1.37	0.43	0.35
3	1.48	1.19	0.34	0.29
4	1.31	1.11	0.24	0.23
5	1.22	0.84	0.20	0.19
6	1.25	0.91	0.19	0.24
November				
1	1.92	1.97	0.53	0.32
2	1.80	1.75	0.45	0.33
3	1.63	1.37	0.36	0.31
4	1.44	1.07	0.26	0.21
5	1.34	1.22	0.21	0.13
6	1.38	0.98	0.20	0.11

Table 2.6-1. Charlotte Harbor Water Quality Analysis Calibration (Continued, Page 3 of 3)

Segment	Total Nitrogen (mg/l)		Total Phosphorus (mg/l)	
	Computed	Observed	Computed	Observed
December				
1	1.21	1.61	0.75	0.61
2	1.14	1.33	0.64	0.28
3	1.03	1.60	0.50	0.26
4	0.92	1.88	0.37	0.31
5	0.86	1.76	0.30	0.39
6	0.88	1.50	0.29	0.24

6.1 1978, 1983, 1988, 1993, 1998 Projections

Once the analysis technique calibration was completed, the harbor water quality was projected under future conditions using the reaction rates selected during calibration.

The recommended pollutant concentrations for Charlotte Harbor are as follows:

TN = 0.87 mg/l

TP = 0.14 mg/l

The criteria used in setting these limits are discussed in Subsection 9.2.

As shown by the observed water quality in Table 2.6-1, excesses in nutrient levels for existing conditions occur for both nitrogen and phosphorus. These violations are more pronounced in the wet season (June through September) and in the most upstream segments of the harbor.

Table 2.6-2 presents the existing and projected water quality for the month of August. Water quality violations are the worst during August when considering the nitrogen and phosphorus concentration excesses. No changes in water quality are projected to occur from 1978 through 1998 due to insignificant changes in the total pollutant loads entering the harbor. However, the projected water quality is worse than that

Table 2.6-2. Charlotte Harbor Water Quality for August, Existing and Projected

Segment	1976 TN (mg/l)	1976 TP (mg/l)	1978 - 1998 TN (mg/l)	1978 - 1998 TP (mg/l)
1	1.89	0.82	2.08	1.73
2	1.76	0.69	1.99	1.52
3	1.58	0.54	1.84	1.23
4	1.38	0.38	1.68	0.95
5	1.28	0.32	1.60	0.83
6	1.39	0.35	1.72	0.96

existing since the projected pollutant loads are considerably higher than the existing loads. The primary reason for this increase in projected pollutant loads is that they were computed using long-term average monthly rainfalls, and the 1976 average monthly rainfalls, which were much lower than the long-term average monthly rainfalls, and were used to compute the existing loads.

7.0 RESULTS OF PRODUCTIVITY STUDY

7.1 Field Measurements

7.1.1 Total Community Metabolism

Tables 2.7-1 and 2.7-2 give productivity results for each station. Station locations are shown in Figure 2.1-2. Stations in the northern harbor were numbered 1 through 6, those in the southern portion 9 through 13. There were no station numbers 7 and 8. Productivity calculations were made for three different data sets. Calculations were based on surface data, bottom data, and combined surface and bottom data. The extent to which the surface and bottom rates are similar is an indication of thorough mixing in the water column. Combined surface and bottom data is often most desirable; however, some significant differences between combined data set results and separate surface and bottom results were noted for Stations 10 and 11. This difference appears to be attributable to depth. Plankton metabolism data (Table 2.7-6) indicate that total community metabolism (TCM) results from combined data underestimated community metabolism. It is hypothesized that this may be due to the fact that the metabolic rate of change on the bottom in a deeper estuary such as Charlotte Harbor is primarily a respiratory rate, while the surface rate is generally a production rate. Rate of change in the production direction is calculated as plus, while that in the respiration direction is calculated as minus. When the data is combined, the different rates somewhat cancel each other out. This would account for a lower combined rate than those measured separately.

Table 2.7-1. Productivity Summary for Charlotte Harbor North, June 18, 19, and 20, 1977

Station No.	Process	Surface Data $g/m^2 \cdot day$	Bottom Data $g/m^2 \cdot day$	Surface and Bottom Data Combined $g/m^2 \cdot day$
1	NR	4.16	6.27	3.73
	DR	6.07	5.75	6.42
	NDP	3.35	2.05	2.75
	TCM	13.58	14.07	12.90
2	NR	3.41	4.69	3.91
	DR	5.27	8.98	7.10
	NDP	2.33	5.47	3.50
	TCM	11.01	19.14	14.51
3	NR	3.09	4.12	3.36
	DR	2.67	3.06	1.64
	NDP	2.59	2.15	2.02
	TCM	8.35	9.33	7.02
4	NR	9.75	6.83	7.02
	DR	7.88	10.94	9.38
	NDP	9.79	8.80	8.20
	TCM	27.42	26.57	24.60
5	NR	4.71	2.09	3.73
	DR	9.16	5.48	5.00
	NDP	5.28	2.68	3.25
	TCM	19.15	10.25	11.98

(Continued)

Table 2.7-1. Productivity Summary for Charlotte Harbor North, June 18, 19, and 20, 1977 (Continued, page 2 of 2).

Station No.	Process	Surface Data $g/m^2 \cdot day$	Bottom Data $g/m^2 \cdot day$	Surface and Bottom Data Combined $g/m^2 \cdot day$
6	NR	5.53	2.16	3.89
	DR	5.90	2.02	3.44
	NDP	7.52	3.01	4.64
	TCM	18.95	7.19	11.97
$\bar{x}$	$\overline{TCM}$	16.41	14.43	13.83
S.E.*		+ 2.25	3.18	+ 2.38

* S.E., one standard error about the mean, $\bar{x}$.
NR, nighttime respiration.
DR, daytime respiration.
NDP, net daytime production.
TCM, total community metabolism = NDP + NR + DR.

Table 2.7-2. Productivity Summary for Charlotte Harbor South, June 18, 19, and 20, 1977

Station No.	Process	Surface Data $g/m^2 \cdot day$	Bottom Data $g/m^2 \cdot day$	Surface and Bottom Data Combined $g/m^2 \cdot day$
9	NR	5.54	5.55	3.36
	DR	2.47	8.16	4.39
	NDP	5.39	5.52	5.22
	TCM	13.40	19.23	12.97
10	NR	4.83	6.46	2.00
	DR	4.54	6.77	2.22
	NDP	3.98	1.90	1.29
	TCM	13.35	15.33	5.51
11	NR	2.73	6.12	1.84
	DR	4.14	6.15	0.97
	NDP	3.75	4.34	2.61
	TCM	10.62	16.61	5.42
12	NR	4.23	3.71	3.75
	DR	4.44	2.32	2.77
	NDP	0.67	1.59	1.41
	TCM	9.34	7.62	7.93
13	NR	3.89	9.78	3.69
	DR	7.36	9.01	6.23
	NDP	2.08	6.52	4.73
	TCM	13.33	25.31	14.65
$\bar{x}$	TCM	12.01	16.82	9.30
S.E.*		$\pm$0.85	$\pm$2.87	$\pm$1.91

* S.E., one standard error about the mean, $\bar{x}$.
NR, nighttime respiration.
DR, daytime respiration.
NDP, net daytime production.
TCM, total community metabolism = NDP + NR + DR.

The differences in results among the data sets suggest metabolic stratification in Charlotte Harbor, and indicate that water quality monitoring of diurnal oxygen should be done at least for surface and bottom. The fact that the water column does not mix sufficiently to only take surface measurements is significant. Monitoring only at the surface in the harbor would underestimate total metabolism at most stations. The data also suggest that separate metabolic rates for surface and bottom be calculated and then averaged to derive a total for the water column, rather than averaging concentration data over the column, and from the averaged data, determine a metabolic rate of change.

The data presented in Tables 2.7-1 and 2.7-2 are within ranges reported for Gulf Coast estuaries (Odum and Wilson, 1962) and are generally higher than those reported for estuarine bays near Crystal River, Florida (Smith, et al., 1974). Total community metabolism (TCM) values between 10 and 20 grams per square meter per day ($g/m^2/day$) are considered moderate to high for shallow Florida Gulf Coast estuaries. Similarity of data (mean values, $\bar{X}$) suggests that metabolic histories (biological activity and components) of the stations are generally alike. Differences in means were noted between combined surface and bottom data for Charlotte Harbor North (Stations 1-6) and Charlotte Harbor South (Stations 9-13). No major trends were apparent from station to station.

7.1.2 Oxygen Diffusion and Other Physical Parameters

Oxygen diffusion in grams of oxygen per square meter per hour (g O_2/m^2/hr) was calculated as a linear function of the dissolved oxygen concentration deficit from saturation. The formula, D=KS, where S was the percent dissolved oxygen deficit and K was the oxygen diffusion coefficient (reaeration coefficient) in g O_2/m^2/hr at 100 percent saturation deficit. Odum and Wilson (1962) gave relationships of reaeration coefficients with water depth and wind velocity for Texas bays, and McKellar (1975) gave data on Florida. Physical data collected during field sampling are given in Table 2.7-3. Water current velocities in the north portion of Charlotte Harbor were about half those measured in the southern portion (0.10 m/sec versus 0.19 m/sec). Mean wind velocities were higher in the south than in the north (7.4 mph versus 5.0 mph), and water depths were slightly greater in the south (3.7 m in southern portion, 3.3 m in northern portion). Based on these physical factor differences, a reaeration coefficient of 0.5 g O_2/m^2/hr was used to correct oxygen diurnal curves to reflect only biological changes for stations in the northern harbor (Stations 1 through 6). A coefficient of 1.0 g O_2/m^2/hr was used to correct the stations in the south (Stations 9 through 13). Diffusion rates may vary throughout a given day, and application of a constant rate may introduce some error into productivity calculations.

Table 2.7-3 Mean Wind and Water Current Velocities, Water Depths, Temperatures and Salinities for Charlotte Harbor During Diurnal Measurements, June 18-23, 1977

Station No.	Wind Velocity mph	Water Depth meters	Temperature °C	Salinities o/oo	Water Current Velocities m/sec	
					Flooding Tide	Ebbing Tide
1	6.9 ± 1.6	3.1 ± 0.1	29.7 ± 0.2	27.2 ± 0.7	--	0.12
2	5.1 ± 1.1	2.6 ± 0.2	29.9 ± 0.2	26.4 ± 0.6	--	0.10
3	5.1 ± 1.0	2.1 ± 0.1	29.8 ± 0.2	27.2 ± 0.6	--	0.10
4	4.3 ± 1.3	6.1 ± 0.1	29.5 ± 0.1	27.8 ± 0.5	--	0.15
5	4.6 ± 1.7	2.8 ± 0.1	29.9 ± 0.2	28.0 ± 0.6	--	0.08
6	3.9 ± 1.6	3.1 ± 0.1	29.5 ± 0.2	28.2 ± 0.4	--	0.08
9	6.6 ± 1.4	2.7 ± 0.1	30.5 ± 0.3	33.8 ± 0.6	0.11	0.12
10	7.2 ± 0.9	6.2 ± 0.2	29.9 ± 0.3	34.1 ± 0.6	0.24	0.27
11	7.4 ± 0.9	3.0 ± 0.1	30.2 ± 0.2	33.1 ± 0.7	0.26	0.19
12	8.1 ± 0.6	3.6 ± 0.1	30.1 ± 0.2	34.1 ± 0.6	0.22	0.25
13	7.7 ± 0.6	3.0 ± 0.1	30.3 ± 0.1	33.2 ± 0.7	0.15	0.11
$\bar{x}$*	6.1	3.5	29.9	30.3	0.20	0.14
S.E. †	±0.5	±0.4	±0.1	±1.0	±0.03	±0.04

* Mean, $\bar{x}$, of all observations for the period.
† S.E. = one standard error about the mean, $\bar{x}$.

Light penetration into the water column is given in Table 2.7-4 as a function of light extinction coefficients measured by two methods as noted in the table. On the average, secchi disc measurements gave higher extinction values than did photometer values. This may be a function of light scatter at the surface or of the nature of the particulate material in the water. Higher extinction coefficients in the northern harbor ($\bar{X}$=0.7, photometer) indicate higher turbidities there than in the southern portion ($\bar{X}$=0.4, photometer). Extinction coefficients less than 1.0 indicate clear water relative to Florida Gulf Coast estuaries for this period of the year. The average coefficient of extinction for the harbor was 0.6 ± 0.1 (photometer data) per meter of water depth. This value indicates that about 12 percent of the light at the surface reaches the average depth during photometer measurements of 3.5 meters.

Photosynthetic efficiency may be calculated to provide indications of productivity relative to sunlight. Results presented in Table 2.7-5 do not show any definite relationship between lower photosynthetic efficiencies (lower productivity) for those stations with higher K values (turbidities). The efficiencies are generally within the ranges found for the Phillippi Creek and Big Cypress Basin estuaries sampled as part of the 208 program, and reported elsewhere.

Table 2.7-4. Light Extinction Coefficients from Submarine Photometer and Secchi Disc Data for Charlotte Harbor, June 18-23, 1977

Station No.	Secchi Disc		Submarine Photometer	
	K, Meters^{-1}	Water Depth, d,* Meters	K, Meters^{-1}	Water Depth, d,** Meters
1	0.8±0.1	3.0±0.1	0.5	2.8
2	1.1±0.1	2.8±0.2	1.1	2.2
3	1.1±0.1	2.2±0.1	0.7	2.0
4	1.0±0.2	6.2±0.1	0.6	6.0
5	0.9±0.2	2.9±0.1	0.6	2.5
6	1.0±0.2	3.1±0.1	0.8	2.9
Alligator Bay	1.8	1.2	1.4	1.5
9	0.7±0.1	3.0±0.1	0.5	3.0
10	0.5±0.3	6.5±0.1	0.6	7.0
11	0.9±0.2	3.1±0.2	0.4	3.5
12	0.6±0.1	4.0±0.1	0.4	4.0
13	VOB	3.1±0.1	0.3	3.0
$\bar{X}$	0.9	3.4	0.6	3.4
S.E.	±0.1	±0.4	±0.1	±0.5

* Mean water column depths during secchi disc measurements.
** Water column depths during submarine photometer measurements.
VOB, secchi disc visible on bottom.
S.E., one standard error about the mean, $\bar{X}$.

Table 2.7-5. Comparison of Solar Insolation, Light Penetration, and Photosynthetic Efficiencies, Charlotte Harbor, June 18-23, 1977

Station No.	Solar Insolation Kcal/m^2/day	Turbidity Indicator K,* Meters^{-1}	GPP		Photosynthetic Efficiency (GPP/Insolation x 100)
			g O_2/m^2/day	Kcal/m^2/day †	
1	5561	0.5	9.17	36.68	0.7
2	5561	1.1	10.60	42.40	0.8
3	5561	0.7	3.66	14.64	0.3
4	5561	0.6	17.58	70.32	1.2
5	5561	0.6	8.25	33.00	0.6
6	5561	0.8	8.08	32.32	0.6
9	5327	0.5	9.61	38.44	0.7
10	5327	0.6	8.57	34.28	0.6
11	5327	0.4	8.74	34.97	0.6
12	5327	0.4	4.18	16.72	0.3
13	5327	0.3	10.96	43.84	0.8

* K = extinction coefficient, Table 2.7-4, m^{-1} (per meter of water depth).

† assuming g O_2 = g org matter and Kcal/g org matter = 4.

GPP = gross primary production = net daytime production (NDP) + daytime respiration (DR).

7.1.3 Plankton Metabolism

Levels of plankton metabolism measured in Charlotte Harbor in June are presented in Table 2.7-6. These levels are similar to those reported previously for Florida's west coast estuaries. Areal rates of planktonic gross primary production ranged from a low of 2.64 g O_2/m^2/day to 7.68 g O_2/m^2/day with a mean of 5.00 g O_2/m^2/day for the six stations sampled. Net plankton production for Charlotte Harbor averaged 3.24 g O_2/m^2/day and ranged from 1.03 to 4.85 g O_2/m^2/day. Planktonic respiratory rates of from 0.12 to 2.83 g O_2/m^2/day were measured averaging 1.76 g O_2/m^2/day.

On a volumetric (cubic meter) basis, greatest metabolic activity was measured at Station 2, located near Punta Gorda at the mouth of the Peace River. Lowest levels of production, both gross and net, were found at Station 5. Plankton respiration was greatest at Station 5 and lowest at Station 12.

The P/R ratio (P gross 24/R24) is a useful index in characterizing a system, in this case the plankton community, as a net producer (autotrophic) or consumer (heterotrophic) of organic matter. Autotrophic

Table 2.7-6. Estimated Levels of Plankton Metabolism (g O_2/m^2/day)* in Charlotte Harbor, June 1977.

Date	Station No.	Pnet 24 g O_2/m^2/day	R24 g O_2/m^2/day	Pgross 24 g O_2/m^2/day	Pgross24/R24	Mean Depth m
North Charlotte Harbor						
June 21 and 22	2	2.96	1.46	4.42	3.03	2.59
June 21 and 22	4	4.59	2.64	7.22	2.74	6.14
June 21 and 22	5	1.03	1.61	2.64	1.64	2.78
June 21 and 22	6	3.00	1.39	4.39	3.17	3.06
South Charlotte Harbor						
June 18 and 19	10	4.85	2.83	7.68	2.71	6.57
June 18 and 19	12	3.00	0.62	3.62	5.83	3.47

systems exhibit P/R ratios greater than one, while heterotrophic systems have ratios of less than one. P/R ratios indicate that, in June, the plankton community of Charlotte Harbor was a net producer of organic matter. Ratios ranged from a low of 1.64 at Station 5 to 5.83 at Station 12 and averaged 3.19.

7.1.4 Phytoplankton Measurements

Phytoplankton concentrations, volumetrically estimated biomass, and species diversities measured in June in Charlotte Harbor are presented in Tables 2.7-7, 2.7-8, and 2.7-9, respectively. Measurements were made on surface samples taken at high and low tide from each of the eleven biological stations.

Phytoplankton abundance was low over the study area averaging 363 cells/ml. Densities ranged from 23 to 2,910 cells/ml. Highest numbers were found at Station 4. Biomass (wet weight) as estimated by cell volume measurements exhibited a wide range, from 0.157 to 79.288 mg/l. Extremely high biomass values were found at Station 4 at high tide, at Station 6, and at Station 9 at low tide. The overall mean for volumetrically determined biomass, skewed by these high values, was 8.417 mg/l. Species diversities for the plankton community of Charlotte Harbor ranged from 0.40 to 2.96 with a mean of 2.02. No apparent trends in phytoplankton abundance, biomass, or diversity were noted.

Table 2.7-7. Estimated Concentrations of Phytoplankton in Samples Taken at High and Low Tides in Charlotte Harbor; June 18 to 20, 1977.

Station	Concentration (cells/ml)		
	High	Low	Mean
1	42	300	171
2	52	94	73
3	43	23	33
4	405	2,910	1,658
5	90	37	64
6	456	579	518
North Harbor Mean	181	657	420
Standard Deviation	194	1,124	633
9	177	76	127
10	363	450	407
11	613	734	674
12	43	32	38
13	110	343	227
South Harbor Mean	261	327	295
Standard Deviation	230	288	253
OVERALL Mean	218	507	363
Standard Deviation	204	833	479

Table 2.7-8. Phytoplankton Biomass* in Samples Taken at High and Low Tides in Charlotte Harbor; June 18 to 20, 1977.

Station	Volumetrically Determined Biomass (mg/l)		
	High	Low	Mean
1	1.614	7.876	4.745
2	0.772	4.915	2.844
3	3.132	1.523	2.328
4	79.288	1.4093	40.349
5	2.429	0.411	1.420
6	29.103	15.714	22.409
North Harbor Mean	19.390	5.308	12.349
Standard Deviation	31.294	5.806	15.382
9	0.256	13.146	6.701
10	2.999	0.610	1.805
11	6.446	3.494	4.970
12	0.709	2.215	1.462
13	6.956	0.157	3.557
South Harbor Mean	3.473	3.924	3.699
Standard Deviation	3.130	5.323	2.193
OVERALL Mean	12.155	3.924	8.417
Standard Deviation	23.721	5.323	12.151

* wet weight as estimated by cell volume measurements

Table 2.7-9. Diversity of Phytoplankton Species Collected in High and Low Tide Samples in Charlotte Harbor; June 18 to 20, 1977.

Station	Shannon-Weaver Diversity		
	High	Low	Mean
1	2.91	2.29	2.60
2	2.45	2.64	2.55
3	1.99	2.58	2.29
4	1.53	0.40	0.97
5	2.71	1.91	2.31
6	1.26	0.66	0.96
North Harbor Mean	2.14	1.75	1.95
Standard Deviation	0.66	0.98	0.77
9	2.96	2.34	2.65
10	1.69	0.52	1.11
11	2.70	2.35	2.53
12	2.66	2.83	2.75
13	2.15	0.83	1.49
South Harbor Mean	2.43	1.77	2.11
Standard Deviation	0.51	1.03	0.75
OVERALL Mean	2.27	1.76	2.02
Standard Deviation	0.59	0.95	0.73

The class composition of the phytoplankton of Charlotte Harbor is presented in Table 2.7-10. Bacillariophyceae (diatoms) numerically dominated the phytoplankton assemblage. This is typical of coastal and estuarine phytoplankton communities. Cyanophyceae (blue-green algae), while only observed in three samples, were the most abundant class at Station 10 near the harbor mouth. Dinophyceae (dinoflagellates), Cryptomonadaceae, and microflagellates were distributed throughout the study area.

The species distribution of the phytoplankton can be seen in Table 2.7-10. No clear-cut species dominance was observed. Nitzschia delicatula, a diatom, was the most abundant species encountered in samples. The diatoms Cylindrothem closterium and Thalamosira pseudonana were also common though never numerous.

7.1.5 Zooplankton Measurements

Surface net tows (153u mesh) for zooplankton collection were made along north-south transects at each of the 11 biological sampling stations in Charlotte Harbor. Zooplankton concentrations, dry weights and ash-free dry weights, and diversities are presented in Table 2.7-11.

Quantitative data indicates that Charlotte Harbor supports a large zooplankton population. Zooplankton concentrations over the harbor ranged from 29,905 to 282,227 individuals/m^3 and averaged 98,068

Table 2.7-10. Percent Composition, By Class, of Phytoplankton Counted in Samples Collected in Charlotte Harbor; June 18 to 20, 1977. (Bac. = Bacillariophyceae, Dino. = Dinophyceae, Crypt. = Cryptomonadaceae, Cyan. = Cyanophyceae, Eug. = Euglenophyceae, Micro. = Microflagellates).

Station	Tide	Bac.	Dino.	Crypt.	Cyan.	Micro.
1	H	80.4		19.6		
	L	93.5	0.6	5.8		
2	H	91.7	6.7	1.7		
	L	93.3		6.7		
3	H	97.3		2.8		
	L	100.0				
4	H	99.6				0.4
	L	100.0				
5	H	77.5	13.7	2.5		6.3
	L	100.0				
6	H	99.7		0.3		
	L	99.6		0.4		
North Harbor Mean		94.4	1.8	3.3		0.6
9	H	89.4			10.6	
	L	100.0				
10	H	32.6	0.5		66.9	
	L	7.0			93.0	
11	H	100.0				
	L	98.6				1.4
12	H	100.0				
	L	80.9		8.5		10.6
13	H	100.0				
	L	98.4		1.6		
South Harbor Mean		80.7	0.1	1.0	17.1	1.2
OVERALL Mean		88.2	1.0	2.3	7.8	0.9

Table 2.7-11. Zooplankton Concentrations, Dry Weights, Ash-free Dry Weights, and Diversities, Charlotte Harbor, June 18-20, 1977.

Tow	Concentration (individuals/m^3)	Dry Weight (mg/m^3)	Ash-free Dry Weight (mg/m^3)	Shannon-Weaver Diversity
1	253,361	431.4	339.8	2.85
2	282,227	333.5	259.5	2.69
3	80,159	157.9	126.6	2.79
4	74,970	129.1	110.2	2.98
5	83,905	102.1	76.8	2.11
6	57,373	148.7	120.9	2.78
North Harbor Mean	138,666	217.1	172.3	2.70
Standard Deviation	100,849	133.1	103.3	0.30
9	40,955	115.2	101.4	3.32
10	35,594	157.9	143.3	3.65
11	99,803	394.7	303.9	3.17
12	40,500	77.2	74.9	3.34
13	29,905	237.0	185.3	3.12
South Harbor Mean	49,351	196.4	161.8	3.32
Standard Deviation	28,555	125.8	89.8	0.21
Overall Mean	98,068	207.7	167.5	2.98
Standard Deviation	87,103	123.7	92.7	0.41

individuals/m^3. Densities were highest in the north harbor, particularly at the mouth of the Peace River (Stations 1 and 2). Previous estuarine studies have noted an inverse relationship between zooplankton concentration and salinity. Such a trend appears to exist in Charlotte Harbor, though confirmation would require a more extensive sampling program. Biomass values were also high. Dry weights ranged from 77.2 to 431.4 mg/m^3 and averaged 207.7 mg/m^3. Ash-free dry weights averaged 167.5 mg/m^3, ranging from 74.9 to 339.8 mg/m^3.

Taxonomic data indicate that the study area supports a diverse assemblage of zooplankton. Highest diversities were found in the south harbor. Values over the harbor ranged from 2.11 to 3.65 with a mean of 3.32.

Copepods constituted a dominant fraction of the zooplankton numerically. Copepods typically dominate coastal and estuarine zooplankton communities. The most numerous copepods were the calanoids *Paracalanus* sp. and *Acartia tonsa*. Though less abundant the cyclopoid *Orthona* sp., the harpacticord *Euterpina acutifrons* and nauplii (juvenile stages) also comprise a significant fraction of the copepods counted. Also common was the cladoceran *Evadne tergestina*.

The term "microplankton" refers to organisms which are only temporarily members of the plankton community, usually larval forms. Microplankton accounted for a large fraction of the zooplankton enumerated. Gastropod (snail), Pelycypod (bivalve), and barnacle nauplii were abundant. Decapod zoea (larval crabs, snails) were also present in most samples, these being most numerous in south Charlotte Harbor. Fish eggs were observed in samples taken at the mouth of the Peace River. A taxonomic listing of zooplankton collected is presented in Tables 2.7-12 and 2.7-13.

7.1.6 Benthic Invertebrates

Presented in Table 2.7-14 is a summary, by station, of abundance, dry weight biomass, and diversity of benthic macroinvertebrates collected in Charlotte Harbor.

In abundance benthic invertebrates ranged from 400 to 6,822 individuals/m^2 with a mean density for the harbor of 1,598 individuals/m^2. Macroinvertebrate biomass at the sampling stations fluctuated widely from 0.389 to 22.053 g/m^2, averaging 3.79 g/m^2. These values fall within the range of values previously reported for estuarine waters.

Diversities calculated for macroinvertebrate taxa ranged from 0.88 to 3.72 and averaged 2.54. Values for this index were highest at Stations 10 and 11 and lowest at Station 9. Polychaeta and Pelecypoda (bivalves) were the numerically dominant classes of benthic macroinvertebrates in

Table 2.7-12. Zooplankton Taxon Abundance (individual/m^3); Charlotte Harbor Study Area; June 18-20, 1977

	Station					
	1	2	3	4	5	6
PROTISTA						
Ciliophora						
Tintinnoidea						
miscellaneous unidentified			296	252		282
COELENTERATA-CNIDARIA						
Hydrozoa						
miscellaneous Medusae			198			751
ANNEDLIDA						
Polychaeta						
miscellaneous unidentified				126		
ARTHROPODA						
Crustacea						
Copepoda						
Calanoida						
Acartia tonsa	27928	30958	16506	1890	9021	2441
Labidocera aestiva	252			252		657
Paracalanus spp.	41514	80098	17989	12222	5335	6949
Pseudodiaptomus coronatus	5787	7535	1977		291	188
miscellaneous unidentified			198			
Cyclopoida						
Oithona spp.	7296	6880	3855	7812	3686	4507
miscellaneous unidentified				126	97	
Harpacticoid						
Euterpina acutifrons	252	2293	593	4788	873	2911
miscellaneous unidentified			99	126		
Copepod nauplii	5284	1966	1977	1386	776	845
Cladocera						
Evadne tergestina	49565	41114	4151	28224	4559	3380
Penilia avirostris			99			
miscellaneous unidentified				504		282
Isopoda			99			
CHAETOGNATHA						
Sagitta sp.		491	99		97	

(continued)

Table 2.7-12 Zooplankton Taxon Abundance (individual/m^3); Charlotte Harbor Study Area; June 18-20, 1977 (Continued, page 2 of 2).

	Station 1	2	3	4	5	6
CHORDATA						
Urochordata						
Appendicularia						
Oikopleura sp.	1761	3440	1285	1260	776	845
Cephalochordata						
Amphioxus sp.	252		99	126		
LARVAL FORMS						
Polychaete	503		99	378		282
Cirriped nauplii	3522	1802	1186	4410	5238	27794
Cirriped cyprids	1510	6716	1878	126	97	188
Decapod zoea		164			291	563
Decapod mysids			99	126		94
Gastropod	41011	37346	26094	5418	51216	2723
Pelecypod	64661	59623	1285	2016	1358	563
Vertebrata fish eggs	755	1310				
Vertebrata fish larvae					194	
Miscellaneous Unidentified	1510	491		3403		1127
TOTAL	253361	282227	80159	74970	83905	57373

Table 2.7-13. Zooplankton Taxon Abundance (individual/m^3); Charlotte Harbor Study Area; June 18-20, 1977

	Station				
	9	10	11	12	13
PROTISTA					
Ciliophora					
Tintinnoidea					
miscellaneous unidentified		137	186		
COELENTERATA-CNIDARIA					
Hydrozoa					
miscellaneous Medusae		274	186	68	
ANNEDLIDA					
Polychaeta					
miscellaneous unidentified					57
ARTHROPODA					
Crustacea					
Copepoda					
Calanoida					
Acartia tonsa	5819	4518	28675	3848	2296
Labidocera aestiva	549	411	931	68	
Paracalanus spp.	5819	3286	13034	7628	5223
Pseudodiaptomus coronatus	439	274	372	473	
miscellaneous unidentified		548	186		
Cyclopoida					
Corycaeus spp.	110	137	186	68	
Oithona spp.	6039	8625	6889	7290	9299
miscellaneous unidentified		274			
Harpacticoid					
Euterpina acutifrons	4063	3286	13406	5400	57
miscellaneous unidentified		137	1676		
Copepod nauplii	1867	1232	7820	3173	574
Cladocera					
Evadne tergestina	439	411	559	608	287
Penilia avirostris	110	3696			
miscellaneous unidentified	110		559	675	57
Isopoda			372		
CHAETOGNATHA					
Sagitta sp.	1098	1369	745	135	230

(continued)

Table 2.7-13. Zooplankton Taxon Abundance (individual/m^3); Charlotte Harbor Study Area; June 18-20, 1977 (Continued, page 2 of 2).

	Station				
	9	10	11	12	13
MOLLUSCA					
CHORDATA					
Urochordata					
Appendicularia					
Oikopleura sp.	659	2190	2421	878	2755
Cephalochordata					
Amphioxus sp.		137		68	1148
LARVAL FORMS					
Polychaete	110		372	203	115
Cirriped nauplii	220	1095	2234	1350	1665
Cirriped cyprids				68	
Decapod zoea	769	274	2793	203	861
Decapod mysids	549	1095	2793	338	57
Gastropod	9004	1369	8751	3375	1492
Pelecypod	2965	685	4469	4590	517
Miscellaneous Unidentified	220	137	186		3214
TOTAL	40955	35594	99803	40500	29905

Table 2.7-14 Abundance, Biomass (dry weight), and Diversity of Benthic Macroinvertebrates Collected by Ponar Grabs at Stations in Charlotte Harbor, June 18-20, 1977

Station	Abundance (individuals/m2)	Dry Weight (g/m2)	Shannon-Weaver Diversity
1	2,289	4.791	2.65
2	711	0.589	2.67
3	400	22.053	2.25
4	844	0.624	1.54
5	489	0.480	3.27
6	1,022	2.733	1.96
North Harbor Mean	959	5.21	2.39
Standard Deviation	690	8.42	0.61
9	1,244	0.389	0.88
10	578	0.713	3.72
11	1,378	0.887	3.65
12	6,822	2.491	2.82
13	1,800	5.886	2.52
South Harbor Mean	2,364	2.07	2.72
Standard Deviation	2,530	2.28	1.15
Overall Mean	1,598	3.79	2.54
Standard Deviation	1,827	6.34	0.86

north Charlotte Harbor, while Brachiopoda and Crustacea were the principal contributors to biomass. Crustaceae (primarily amphipods) were the most numerous benthic invertebrates in the south harbor. Also abundant were polychaetes and bivalves. Polychaetes overwhelmingly dominated macroinvertebrate biomass in south Charlotte Harbor.

7.1.7 Photosynthetic Pigments

Levels of chlorophyll a measured in surface samples taken at high and low tide in Charlotte Harbor are presented in Table 2.7-15. Levels appear to reflect the mixing of gulf and estuarine waters. Chlorophyll a concentrations are greater than those generally cited for the Gulf of Mexico but relatively low for estuarine waters. Concentrations were lowest in south Charlotte Harbor and were highest near the mouth of the Peace River. Mean values, by station, ranged from a low of 0.60 mg/m Station 12) to a high of 3.96 mg/m^3 (Station 4). The overall mean chlorophyll a concentration measured was 2.01 mg/m^3.

Chlorophyll a is used as an estimator of phytoplankton biomass. Values determined for this parameter in Charlotte Harbor corroborate results obtained through microscopic examination which indicate that the harbor supported a low density phytoplankton population at the time of study.

Table 2.7-15 Mean Concentrations of Chlorophyll *a** Measured in Samples Taken at High and Low Tides in Charlotte Harbor; June 18 to 20, 1977.

Station	Chlorophyll a (mg/m^3)		
	High	Low	Mean
1	2.75	2.75	2.75
2	2.09	4.67	3.38
3	1.75	2.50	2.13
4	3.09	4.84	3.96
5	1.42	1.67	1.55
6	2.25	1.50	1.88
North Harbor Mean	2.23	2.99	2.61
Standard Deviation	0.62	1.45	0.93
9	1.20	1.40	1.30
10	1.20	1.20	1.20
11	1.74	0.93	1.34
12	0.73	0.47	0.60
13	1.80	2.34	2.07
South Harbor Mean	1.33	1.27	1.30
Standard Deviation	0.44	0.69	0.52
OVERALL Mean	1.82	2.21	2.01
Standard Deviation	0.70	1.43	1.00

* corrected for phaeopigments

7.2 Systems Comparison

Systems diagrams are used as a basis for summary, and the diagram (Figure 2.7-1) represents a comprehensive look at the Charlotte Harbor estuarine area. Selected data from the diagram are given in Table 2.7-16. Evaluation of the diagram was based on best known available data and is intended to represent the transition (dry to wet) period of the year. Some data, however, were only available in annual averages. General highlights of the evaluation include the following:

1. The bay is a net exporter of benthic invertebrates and fish, exporting up to 7 percent of its gross primary production along this pathway.
2. Benthic invertebrates and fish feed at both producer levels, but the largest amount is grazed at the phytoplankton level.
3. Net nutrient removal does not occur in the Charlotte Harbor estuarine area. Total phosphorus inputs to the area would have to be reduced by about 5 percent to bring the bay to the null point. To bring the bay to a nutrient scrubbing capacity similar to natural estuarine areas (such as Chokoloskee Bay in the Ten Thousand Islands), total phosphorus input would have to be reduced 11 percent.

Balance of organic inputs and outputs is an essential assumption for the use of models of this type for estimating organic loads into an estuary. Projected theoretical loading alternatives were made based on a steady-

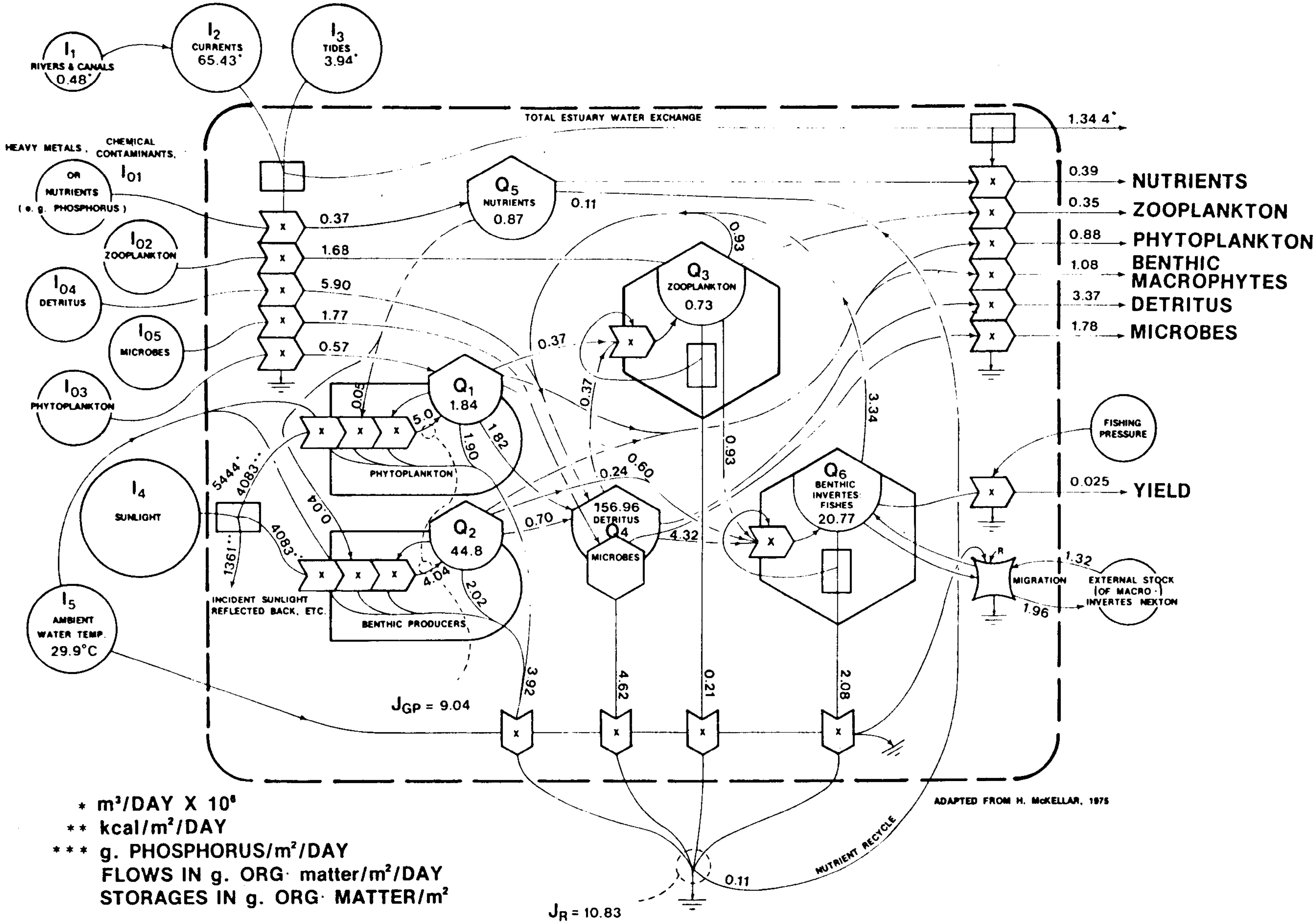


FIGURE 2.7-1 EVALUATED ECOSYSTEM MODEL FOR CHARLOTTE HARBOR

Table 2-7.16 Summary of Results of System Analysis Based on the Evaluated Diagram for Estuarine Area, June, 1977.

Net Daytime Production $g/m^2/day$	Nighttime Respiration $g/m^2/day$	P/R*	Metabolic Turnover of State Variables**, Days				
			Phytoplankton	Benthic Producers	Zooplankton	Detritus	Fish†
4.13	4.98	0.83	1.0	22.2	3.5	34.0	10

Physical Turnover of Bay, ***days	Turnover of Components Due to Combined Physical and Biological Processes, ****days						Organic Input $g/m^2/day$
	Nutrients TP	Phytoplankton	Benthic Producers	Zooplankton	Detritus	Fish	
2.1	1.8	0.3	11.1	0.3	25.3	10.2	11.24

Organic Output $g/m^2/day$	Percent Organic Matter Removed	Organic Matter Removed Per Bay (lbs/day x 10^5)	Organic Input (Loading) Alternatives Percent of Total Input	
			Case I††	Case II†††
9.42	16	1.65	6%	3%

(Continued)

Table 2.7-16. Summary of Results of System Analysis Based on the Evaluated Diagram for Charlotte Harbor Estuarine Area, June, 1977.

FOOTNOTES

* P/R is the ratio of gross primary production (J_{GP}) to total respiration (J_R). May indicate present tendency for accumulation of organic matter.

** Metabolic turnover is determined by dividing daily respiration (J_{Ri}) of a specific component into its standing stock (Qi). Turnover due to organism respiration.

† Values in this column were set equal to 10 as a basic assumption for evaluation purposes.

*** Turnover of bay due to advective and tidal water exchange; water exchange in and out of a given bay with a certain volume.

**** Turnover of each component calculated as a ratio of throughput (inputs or outputs) to content (standing stock).

†† Case I: Percent or organic input estimated to bring bay to the point of null fish production. This value should be considered theoretical.

††† Case II: Percent of organic input estimated to sustain fish production at 50 percent of its present rate. This value is the estimated percent additional organic load the bay could sustain with a resultant 50 percent reduction in fish production. This value should be considered theoretical.

state organic balance and the following corollary assumptions.

1. Net fish production is considered a high management priority for estuaries;
2. Inbalances in the organic budget of an estuary are most likely compensated for by in- or out-migration of benthic invertebrates or fish as the most mobile of estuarine state variables; and
3. Increased organic loads into an estuary attract or encourage increased microbial populations which demand even more organic material [often measured as Biological Oxygen Demand (BOD)].

Ecosystem demand on benthic invertebrates and fish stocks to balance the detrital pool were considered proportional to the net difference in migration. The difference between where an estuary is now (in net fish production or consumption) and where it would be at the null point (no net loss or gain) is the order-of-magnitude change in organic loading that may serve to guide a management decision. For example, in the Charlotte Harbor estuarine area, organic loading into the bay could be increased 6 percent (0.64 $g/m^2/day$) before fish production capability may be lost (see Table 2.7-15). These projections should be considered as estimates, but serve as an example in which the evaluated ecosystem model may be used as a basis for wasteload allocation.

7.3 Discussion

Biological information as part of the case study has been directed toward (1) overall measures of productivity, biomass, and diversity, as indicators of estuarine health, (2) use of simplified ecosystems diagrams for calculating waste load allocations, and (3) appropriateness of biological information to a water quality monitoring program. Discussion of these three types of information is presented in the following paragraphs.

7.3.1 Estuarine Health

Total community metabolism in the Charlotte Harbor estuarine area ranged from 7.0 to 24.6 g O_2/m^2/day. These values are moderate to high for a semi-tropical estuary, and generally indicate a viable biological system. Total community metabolism exceeded total respiration at all stations (P/R ratio 1.28) which suggests the estuary is serving a productive role. The planktonic community primary production ranged from 2.6 to 7.7 O_2/m^2/day. This data suggests an active plankton population as well.

Phytoplankton diversities were moderate ($\overline{x}$ = 2.02, Shannon-Weaver)as were zooplankton ($\overline{x}$ = 2.98), and benthic macroinvertebrate diversities ($\overline{x}$ = 2.54). None of these diversity values are indicative of stresses acting on component biotic subsystems.

Moderate chlorophyll a concentration throughout the study area during the sampling period further suggest that the bay is healthy. Species abundance data for the plankton and benthic subsystems do not indicate any unusually high levels of species which are often associated with the presence of sewage or other waste discharges.

Physical measurements related to biological parameters measured further indicate that this estuarine area is functioning within ranges typical of an area of this type. Water temperature during the measurements was 30°C. Light penetration in the water column was reduced to less than 12 percent of the surface level; a turbidity level common in detrital based estuaries. Turbidities were higher in the northern harbor than in the southern harbor. Photosynthetic efficiencies of incoming sunlight to gross primary production were generally less than 1 percent; ranging from 0.3 to 1.2 percent. These efficiencies are not considered unusual.

7.3.2 Ecosystem Diagrams for Overview and Wasteload Allocation

Evaluation of the ecosystem model establishes the estuary as a detrital based one. This means the largest energy flows occur through the detrital system-- the detrital system being the basis of the food chain and the nutrient regeneration capability. The plankton component accounts for a large fraction of total community metabolism. Nutrient and organic loading into estuaries are sometimes reflected in shifts from benthic production to plankton production, highlighted in some instances by plankton "blooms."

The Charlotte Harbor estuary is currently removing an estimated 1.8 g organic matter/m^2/day with subsequent nutrient regeneration. This represents 16 percent of the organic load the bay receives from internal production and external sources. It is estimated that organic loads could be increased by 6 percent before net fish production capability would be lost.

As a nutrient trap (phosphorus) the estuary is a net loser. It is estimated that total phosphorus inputs would have to be reduced by about 5 percent to bring the bay to the null point. To bring the bay to a nutrient scrubbing capacity similar to natural estuarine areas (such as Chokoloskee Bay) with similar turnover times, 11 percent of the total phosphorus input would have to be reduced.

Charlotte Harbor is a viable, productive estuarine area. It is actively processing organic matter and shows a net organic reduction from inputs to outputs, which suggest nutrient regeneration capabilities are still intact. It is a net fish production area of 0.64 $g/m^2/day$. The area does not exhibit nutrient scrubbing capability based on this analysis.

7.3.3 Biological Information and Water Quality

Biological information is essential to a water quality program. Total community metabolism as an indicator of estuarine health is a good overall indicator, however plankton metabolism measurements should accompany total community measurements to show benthic or planktonic dominance. High total community productivities can occur in sewage treatment polishing ponds, so it is important to establish component productivities to determine if what is being produced is desirable. Data indicate that free-water diurnal measurements in this area need be made for both surface and bottom due to the depths of the water column.

Diurnal productivities should be monitored quarterly to establish seasonal trends. Total organic carbon, total phosphorus, and total nitrogen levels should be monitored seasonally as well. Data reduction procedures for diurnal oxygen procedures are available in a USGS Aquatic Sampling Handbook. Chlorophyll data should also be monitored seasonally and possibly more frequently during periods when phytoplankton blooms would be expected to occur (late spring to early fall). Data for chlorophyll, zooplankton, and phytoplankton sample collection indicate no significant difference in levels between high and low tides. Model evaluation and analysis suggest that chlorophyll data is preferential over phytoplankton biovolume data as a basis for estimating phytoplankton biomass.

8.0 DISCUSSION OF AREA WATER QUALITY GOALS AND OBJECTIVES

8.1 Section 303 a), b), and c); and 40 CFR 130.17(C) Requirements

The general requirements of PL 92-500, Section 303, and 40 CFR 130.17 have been addressed in introductory sections of this report.

8.2 Study Area Water Resource Management Objectives

It is generally recognized that water quality is a primary consideration in the ecologic and economic health of an estuary system. Sources of water quality degradation include a variety of point and nonpoint sources that accompany development of shoreline areas, and activities in upland drainage basins and watersheds that affect the quality of inflowing waters to the estuarine system. There are types of development activities in estuarine areas that have equal or greater consequential impacts to the ecology of the system than water quality degradation alone. These activities include dredge and fill, channelization and drainage projects, canal development, diversion or change in freshwater flows and random development of coastal wetlands. The impacts resulting from these activities may be widespread, cumulative, long-term, and extremely difficult to correct or even irreversible. Those activities which may significantly alter the circulation of the system or upset the cycle or quantity of freshwater flows to the estuary have great potential for serious, long-term ecologic consequences.

In keeping with the intent of PL 92-500 and the 208 program to maintain swimmable, fishable waters, a water quality management program resulting from implementation of Section 208 should consider the varied complexities and relationships between water use, flood control and drainage projects, development impacts, point and nonpoint discharges, and the carrying capacity of the estuarine system.

This assessment of management objectives is intended to review existing and potential sources of water quality degradation, environmental considerations and possible management objectives associated with the Charlotte Harbor estuary system. The information contained has been derived from evaluations of past and recent water quality data, a review of literature on Florida estuary studies, personal communications with state and local agencies, and recent surveys conducted within the Harbor and its tributaries. Detailed analysis of water quality and other physical data are not presented here, but have been discussed in other sections of this report.

Relative to other west coast estuaries the Charlotte Harbor system has not yet seen extensive dense development of the shoreline areas. This is not to say that the Harbor has not yet been affected; it is a matter of degree. Charlotte Harbor is vulnerable to every potential impact associated with industrial, agricultural, and urban development. The Charlotte Harbor estuary system is somewhat unique in that there is opportunity to implement an estuary management program oriented as a problem prevention and planning program rather than a "clean-up" force.

A program for water quality and estuarine management should recognize the problems specific to Charlotte Harbor as well as those problems generally common to Florida estuary systems.

8.2.1 Hydrologic Modification

Estuarine ecosystems include upland watersheds, drainage basins, and freshwater wetlands which represent the source of fresh water to the estuary system. These upland drainage basins, in a natural state, serve to store and regulate the release of waters accumulated from seasonal rainfall. Stored waters are released ultimately to the estuary through surface and subsurface flows. During transit these waters are cleaned naturally through filtration and other mechanisms which partially remove sediments, nutrients, some chemicals and bacteria, and release good quality fresh water to the estuary. Equally important, the natural hydrology of these systems release water to the estuary at intervals and volumes which would normally avoid impacts to the system arising from sharp salinity changes.

The rhythmic release of fresh water from upland drainage is the primary mechanism responsible for the salinity and circulation patterns, flushing capacity, and the transport of nutrients necessary to the high productivity of the estuary system. The salinity gradients within the estuary are typically low inland at the freshwater tributary sources and increase in concentration seaward approaching the salinity of seawater. Aquatic species (both plant and animal) within the estuary vary in their ability to tolerate changes in salinity while others are tolerant to only a very narrow salinity range. Further, the ability of some species to reproduce is dependent upon the level of salinity within the system, and some require different salinity ranges during their growth period. Aquatic species within an estuary are generally present because of their suitability to the natural salinity regime within that system.

Considering it is the inflow of fresh water to the estuary system that generates the broad range of salinity gradients, establishes the circulation pattern, promotes flushing, and carries to the estuary much of the nutrient budget necessary for this highly productive system, it would seem imperative that freshwater flow to the system be maintained as closely as possible to natural rates. Alterations to the flow regime within upland drainage basins or tributaries such as agricultural drainage, channelization, canal construction, and water diversion or withdrawal projects have great potential for changing the freshwater flow regime to the estuary and, therefore, possible severe impacts to the estuarine ecosystem. Such alterations may cause an increase or decrease in freshwater inflow, a change in the cyclicity of the runoff, change the location of the discharge, or any combination of the above. Reductions of freshwater inflow have the greatest potential for serious impacts to the system. Reduced freshwater volumes available for dilution of saline waters would alter or decrease brackish areas of the system and hence the suitability of the habitat for salinity-sensitive aquatic species. In addition, the ability of the system to dilute, flush, and treat wastes will be seriously impaired, and this very important source of nutrients to the system would be diminished.

- Extensive hydrologic modification has occurred to the north and in the Port Charlotte area. Upland channelization for improvement of agricultural and pasturelands has diverted flows to the south through an intricate system of interceptor canals and waterways which ultimately flow to Charlotte Harbor. Most upland drainage is directed to the harbor primarily through Big Slough, Tippecanoe Bay, and Little Alligator Creek. Other significant constructed drainage systems exist along the eastern shoreline directing flows to the harbor through Alligator Creek, Gator Slough, and Bear Branch. These drainage systems exhibit a variety of flow control structures and salinity barriers. It has been estimated that more than 11,000 acres of coastal and submerged land have been modified for channels, spoil islands, developments, and drainage projects.

Unfortunately, a historical data base may not exist from which the long-term biologic or hydrologic impacts of such freshwater flow alterations might be determined. A review of historical rain and flow data for Peace and Myakka gage stations indicate that average flow volumes may be on the decrease.

The historical mean annual precipitation for the Ft. Myers area for the years 1933 to 1961 is 53.73 inches. For the period 1933 to 1976 the average is 53.17 inches, a one percent decrease from the 1933 to 1976 base. For the period 1961 to 1972 the average is 52.09 inches, a three percent decline from the 1933 to 1961 base.

The historical mean annual runoff for the Peace River at Arcadia for the period April 1931 to September 1961 was 13.04 inches. For the period 1931 to 1976 the mean annual runoff was 11.79 inches, a ten percent decrease. For the period 1961 to 1976 the mean annual runoff was 9.29 inches, a 28 percent decrease from the 1931 to 1961 base.

In the Myakka River, near Sarasota, the mean annual runoff for the period 1936 to 1961 was 15.71 inches. From 1936 to 1976 the runoff averaged 15.06 inches, a 4 percent decrease. For the period 1961 to 1976 the mean annual runoff was 13.98 inches, an 11 percent decline from the 1936 to 1961 base.

From the above data it appears that although the long-term mean annual rainfall remained essentially constant from 1961 to 1976, the long-term mean annual runoff for the Peace and Myakka rivers has been decreasing. Without more detailed analysis it is difficult to say why this trend is occurring. A number of theories may be advanced: (1) Increased development has changed the hydrologic character of the watershed. Drawdown of the water table may be decreasing groundwater flow contributed to the stream or may cause flow from the stream to enter the groundwater regime. (2) Channelization and construction of drainage canals is diverting stormwater from natural drainage paths which normally would contribute to streamflow. (3) Increased usage of surface water by upstream municipalities and industries, or irrigation for agriculture has decreased flow in the stream.

It is acknowledged that a direct correlation cannot be made between precipitation at Ft. Myers and streamflow in the Peace River at Arcadia and in the Myakka River near Sarasota. Rather, an assumption is made that if Ft. Myers has a relatively "dry" or "wet" year, then the surrounding area would be likely to experience a similar amount of precipitation. This comparison of precipitation and rainfall is intended to show any trends in streamflow which may ultimately affect the quantity of tributary discharge to Charlotte Harbor. A more detailed analysis should be made using precipitation data from rainfall gages at Arcadia, Punta Gorda, and Myakka River State Park.

Impacts resulting from hydrologic modification and alteration of freshwater flows to estuaries are well documented through several case studies. A recent study of Rookery Bay, Florida, for example, noted that drainage alterations of seasonal freshwater discharges resulted in abrupt salinity changes, turbidity increases, large increases in BOD and total phosphates, decreased DO, and marked increases in coliform bacteria counts. The Fahka Union Canal system seasonally discharges freshwater through Fahka Union Bay from a large channelization system so rapidly that the ability of the extensive mangrove system to assimilate nutrients for release during periods of low discharge has been upset creating an imbalance within the ecosystem.

The extreme importance of maintaining the cycle and volumes of freshwater flows to an estuary as a management objective, has been adequately demonstrated in the literature. Hydrologic modification to the Charlotte Harbor system has been extensive although the long-term impacts may not yet be realized.

8.2.2 Stormwater Runoff and Land Drainage

As previously discussed, the estuarine system includes upland drainage areas or watersheds which are directly linked to the estuary through flows of runoff waters. The estuary is a focal point that tends to concentrate runoff waters from upland watersheds. Consequently, activities wtihin these watersheds which degrade the quality, change the volume, or alter the timing or rate of delivery of runoff waters to the estuary have potential for negative impacts to the system. The character and volume of contaminants carried by nonpoint sources of runoff are diverse and are dependent upon a variety of land use and watershed characteristics. The most prominent nonpoint pollution problems arise from the flow of toxic substances, nutrients, metals, bacteria and sediments to the estuary. The character of these loads and their possible sources within the Charlotte Harbor area are discussed elsewhere.

An apparent problem within the Charlotte Harbor system having a potential for serious impact is the rate and volume of storm runoff waters delivered to the estuary system. This problem is primarily one of decreasing or increasing flows to the estuary and changing the timing or cycling of flows to the estuary. The impounding of freshwater flow and the diversion of water for agricultural, industrial, or consumptive uses tends to reduce the volume of freshwater flow to the estuary. The magnitude of this reduction is dependent upon seasonal fluctuation in terms of rainfall and agricultural-industrial uses. Any reduction in flow reduces the volume of fresh water available for dilution of saline waters within the estuary, and hence reduces the size of the biologically rich brackish zone. Although the average annual volume of flow may be maintained through flow regulation, changes in the cycle of these freshwater flows alter the migration, breeding and feeding habits of salinity-sensitive organisms within the estuary. This, of course, directly influences the availability of commercially important fish and shellfish. Conversely, freshwater flows to the estuary may be increased due to urbanization, channelization, devegetation, and construction of storm drainage systems. Increased flow volumes are equally disruptive to the salinity patterns of the estuary.

The extensive channelization to the north of Charlotte Harbor for the purposes of agricultural and urban drainage has been generally described. A serious potential problem exists in the future development of vast areas between and adjacent to the Peace and Myakka rivers. Generally, this includes an area from Harbor Heights west to North Port, and from Port Charlotte north to the Sarasota county line. This entire area has been pre-developed for future urbanization. A massive system of interceptor waterways and drainage channels has preceded this future development.

Urban stormwater drainage systems within these "pre-developed" areas consist of graded swales drained directly to interceptor canals which ultimately flow to Charlotte Harbor through Alligator Bay, Tippecanoe Bay or the Big Slough waterway.

The potential impact of the substantial increase in impervious surface area resulting from future development and the subsequent rapid runoff of storm waters is an important issue to the future water quality and general health of the Charlotte Harbor system.

Existing drainage systems are constructed to rapidly convey stormwaters away from urbanized areas, and subsequently, have a potential for causing flow surges to receiving waters. While the canal systems and interceptor waterways through which these waters are directed, will provide some storage and retention, the usefulness and efficiency of stormwater interceptor canals as wastewater treatment systems is not yet proven. The pollutant loads associated with urban stormwater flows have been substantially documented in the literature. The future potential impacts from the stormwater systems appear then to be surges of contaminant-loaded stormwater to the harbor and alterations of the flow regime due to either increased runoff flows as a result of urbanization or an upset of the flow cycle due to hydraulic modifications.

Urban canal developments within the tidal zone have somewhat different runoff problems from canal systems above salinity barriers. The primary difference is that runoff water in the tidal areas does not benefit from any degree of possible pre-treatment or flow regulation from retention or storage within canal systems prior to entering the receiving waters. Runoff from roads, bridges, lawns, and finger-fill housing areas is more or less directed to the tidal canals. In many areas the canals are the direct receptor systems for stormwater runoff. A variety of runoff flow problems in the tidal canal areas exist as direct road drainage, sheet flow from lawns graded to the canals over sloped lawns, or storm drainage systems directed to the canals. The primary problem within these areas is that the stormwater flows are rather direct and have accelerated such that there is little or no natural treatment benefit or stabilization of flows through vegetated areas or soil infiltration.

It is apparent that stormwater runoff problems in the Charlotte Harbor area could only be expected to become more severe with increased urbanization and development, and management of these nonpoint sources is necessary.

8.2.3 Coliform Bacteria

Coliform bacteria levels in natural waters are the general criteria by which health officials determine the health hazard of waters for contact recreation or shellfishing. In recent years, the Charlotte Harbor area has seen numerous closings in the north harbor and river areas adjacent to urban development. Recent literature investigating bacteria in stormwaters indicates that coliform bacteria levels in urban runoff waters alone may be sufficiently high to cause violations of health standards. Additional sources of coliform bacteria (other than treatment facilities) in Florida estuaries include feedlots, grazing areas, and septic fields. In the Charlotte Harbor area, urban runoff and septic systems appear to be the most severe sources within developed drainage areas.

Septic tank systems become serious potential sources of water pollution when they are placed near water bodies, particularly in tidally influenced and high water table areas. Septic drain fields near water bodies may become saturated due to high rainfall, rising water table or tide forces. Any one of these conditions or combination of influences may cause flushing of the drain fields into nearby surface waters. Drain fields that operate poorly may also cause tanks to overflow during high rainfall or rising water table, causing surface runoff or overflow pipe discharges of septic wastes to coastal waters. Coliform bacteria levels tend to decrease with increased salinity levels. The downstream decrease in coliform levels is readily seen as salinity concentrations increase seaward in most estuarine systems. During periods of high freshwater flow, however, coliform contaminated waters may persist and become rather widespread as has been seen in Rookery Bay; and beach and shellfishing area closings are a result.

Septic field absorption efficiency is primarily a function of soil suitability and the distance to the water body. If these conditions are not sufficient for primary treatment of liquid wastes the seepage reaches surface water in a poorly treated condition. These septic field pollutants include bacteria and nutrients. Septic contamination can also be a substantial source of nitrogen. In a nitrogen-limited estuary such as Charlotte Harbor, this potential problem becomes acute. Setback distances from shorelines may be adequate for attenuation of bacteria while inadequate for removal of dissolved nitrates.

The potential problems of septic fields have been seen in other nearby Florida coastal waters such as Lemon Bay, Phillipi Creek, Rookery Bay, and Hillsborough Bay. Typically, these systems experience marked increases in coliform bacteria and nutrients during periods of high freshwater flow. While there are many possible sources of these contaminants, fecal coliform-fecal strept ratios indicate human waste sources and septic tank systems are highly suspect.

The Charlotte Harbor sampling program showed rather persistent, although varied, violation levels of fecal coliforms in most tributary areas that were heavily developed. During the sampling program, beach closings were seen at Harbor Heights and several sections of the lower Peace River along the west shoreline. Spot sampling in tidal creeks along the shore and in some developed interior canals showed violation levels of coliform bacteria. Bank seepage at the shoreline adjacent to septic tank fields was seen in several areas. Further, intermittent flows from drain pipes through bulkhead walls were observed. Personal communication with local area residents indicate these may be direct flows of raw untreated sewage into tidal creeks and overflow of septic fields is not uncommon. Interviews with shoreline residents and local government officials verify that tests conducted in some homes revealed that wastes flowed to surface waters through drain systems (or possibly septic overflow drains) in bulkhead walls and poured into canal waters in less than 30 minutes. Some residents along canals and tidal creeks complain of strong septic odors during periods of extreme low tides.

The problem of septic tank contamination in Charlotte Harbor waters is not well documented. The frequency of beach and shellfish area closings does, however, indicate the potential seriousness of bacterial pollution, and septic systems are a prime suspect. The evidence at least warrants consideration for engineering evaluation of sanitary wastewater management alternatives.

8.2.4 Nutrient Management

Charlotte Harbor waters are relatively rich in nutrients necessary for biological productivity compared to most natural coastal waters. The Peace River, which flows through phosphate-bearing formations (Bone Valley and Hawthorn), is the primary source of phosphorus to the system. A previous study of nutrient contributions to the Charlotte Harbor system indicates that the Peace River contributes 90 percent of the total phosphorus inflow to the harbor. Further, the rate of inflow of nutrients to the harbor system appears to be dependent upon flow volume rather than concentration.

Concentrations of nitrogen and phosphorus are highest in the upper reaches of the rivers and decrease proportionally as river waters dilute seaward with higher salinity waters. Data taken during the 208 sampling program tend to verify previous studies concluding that Charlotte Harbor is a nitrogen-limited system. The relatively low level of nitrogen is the primary factor which limits increased primary productivity within the system.

Charlotte Harbor is typical of a naturally rich estuarine system highly productive biologically because abundant food is produced for growth of organisms. This level of productivity is dependent upon the nutrient budget and nutrient stores within the sediments of the estuary and peripheral tidal marshes and mangrove areas. These nutrient storage areas maintain a state of balance or equilibrium with estuarine waters. In terms of the nutrient budget within Charlotte Harbor, the most serious nonpoint pollution problems may be those which contribute excess phosphorus and, particularly, nitrogen to the system. Additions of nitrate and ammonia stimulate growth significantly. Apparently insignificant increases in productivity as a result of small additions of nutrients may have cumulative effects on the already highly productive system. Productivity surges tax the oxygen balance within the system, and during periods of low flow during the summer, prolonged dissolved oxygen depletion can result in fish and shellfish kills.

An assessment of the natural nutrient budget and sources to the Charlotte Harbor system would prove to be a very important management tool. Future impacts may be prevented if the nutrient budget were understood. Presently, other key sources of nutrients to the system are primarily derived from raw and treated sanitary wastes, agricultural activities within the watersheds including land treatment of fertilizers and soil erosion, urban runoff, and certain sources of groundwater nutrients as infiltration to surface water systems.

While many of these nonpoint sources of nutrients may be managed in the future, a critical and rather persistent problem arises in the deregulation of the natural nutrient budgets of the system by artificial drainage systems, and destruction of tidal wetlands and mangrove systems critical to natural nutrient control within the system. Intertidal wetlands and mangrove systems provide a buffer zone between upland nutrient runoff and the harbor. These areas store, absorb, convert, and regulate upland nutrient additions to the harbor. Intertidal areas within Charlotte Harbor are declining due to drainage, dredge and fill, and subsequent development. Channelization and drainage projects virtually eliminate the buffer effect of tidal zone vegetation because runoff waters are routed directly to Charlotte Harbor.

The future preservation of water quality in Charlotte Harbor may be highly dependent upon management of excessive nutrient additions to the system. Since Charlotte Harbor is a nitrogen-limited system, it could be expected that serious impacts would result from future nitrogen additions.

8.3 Water Quality Management Criteria Recommendations

8.3.1 Hydrographic Modification

In view of the potential impacts to the water quality and ecosystem within Charlotte Harbor as a result of future hydrologic modification, possible engineering and management priorities should be considered. A hydrologic evaluation (including a water budget) of the Charlotte Harbor estuary system and tributaries would provide necessary background data to assess the impacts of future projects having potential for alteration of the hydrology of the harbor or tributary system.

Engineering and management objectives may include:

1. Preservation of natural land drainage systems within basins and watersheds.
2. Nonstructural alternatives to channelization for agricultural drainage projects.
3. Engineering alternatives for the preservation of the natural freshwater flow regime to Charlotte Harbor.
4. Management of construction within submerged areas, and coastal zones.
5. Management of construction which alters quality or quantity of runoff waters to Charlotte Harbor.
6. Management of dredge and fill projects.

8.3.2 Stormwater Runoff and Land Drainage

The primary problems associated with stormwater runoff flow and land drainage systems include water quality degradation, increase or decrease in flow volume, flow surges, and upset of natural freshwater flow periods to the Charlotte Harbor estuary.

Management criteria may include:

1. An evaluation of the freshwater budget to Charlotte including

an assessment of the impacts of present stormwater and upland drainage systems on the freshwater flow budget.

2. Management of the construction of stormwater runoff drainage systems.
3. Nonstructural and structural stormwater runoff control and pretreatment engineering alternatives which might include:
   a. flow regulation through vegetated drainage swales;
   b. on-site retention within swale systems or retention ponds;
   c. preservation of vegetative buffers along drainage paths;
   d. preservation of vegetative buffers along water courses to Charlotte Harbor;
   e. evaluation of the effectiveness of porous paving materials;
   f. development of an areawide management policy for stormwater runoff control which may include flow regulation, nonstructural treatment alternatives, and practices for reducing pollutant loads in stormwater runoff; and
   g. investigations of the potential for beneficial use of excessive runoff volumes and nutrient-rich or polluted runoff waters (diversion for irrigation or land treatment, for example).

8.3.3 Coliform Bacteria

The widespread use of septic tank systems in shoreline development raises great potential for pollution of Charlotte Harbor waters by coliform and pathogen bacteria and nutrients, particularly nitrates.

Management objectives may include:

1. Evaluation of soils in shoreline areas and their suitability for septic tank systems.

2. Establishment of adequate setback lines for septic systems from high water lines in shoreline areas.
3. Establishment of water table and soils criteria for shoreline septic system construction.
4. Engineering evaluation of other treatment alternatives for shoreline developments.
5. Evaluation of present septic tank construction practice and inspection requirements. Other construction practices such as seepage pits and overflow pipes to surface waters should be reviewed.

8.3.4 Nutrient Management

Future water quality impacts to Charlotte Harbor may be minimized through management of point and nonpoint nutrient sources and, particularly, management of nitrogen. Management and engineering alternatives would include control of nonpoint sources such as urban runoff, agricultural sources including land treatment of fertilizers and erosion, diffuse sources of septic infiltration of nitrate, and management of drainage, devegetation, and dredge and fill projects.

Management criteria may include:

1. Determination of the natural nutrient budget and nitrogen-phosphorus ratio for Charlotte Harbor.
2. Evaluations of existing sources and sinks of nutrients within the estuarine system.
3. Evaluation of waste load allocations for nutrients within the system and:

a. determine inputs from point and nonpoint waste treatment sources;

b. assess the existing and potential effects of diffuse septic tank infiltration of nitrates to the system;

c. estimate combined effects of septic tank sources and other poorly treated waste sources of nitrogen to the system; and

d. estimate the magnitude of these source problems to be nutrient load allocations.

4. Determination of nonstructural engineering alternatives for management of nonpoint nutrient sources from agricultural activities such as: soil erosion; land treatment of fertilizers; cropping practices; drainage practices; grazing and pasture drainage; and feedlot drainage.

5. Estimation of nutrient contributions from runoff for various land use categories within the Charlotte Harbor estuary system, and evaluate structural and nonstructural control alternatives for excess nutrients from those categories.

6. Determination of engineering and management control alternatives for dredge and fill, channelization and drainage, devegetation and destruction of intertidal zones as alterations to the natural nutrient budget control within the Charlotte Harbor system.

9.0 DISCUSSION OF DEFICIENCIES IN WATER QUALITY

9.1 Present Conditions

Water quality within Charlotte Harbor is generally good. Quality deficiencies exist primarily for nutrients, bacteria, the presence of pesticides, and some heavy metals. The presence of these constituents and the level of their concentration are highly variable, depending upon tidal and flow conditions, precipitation, and other seasonal influences. The magnitude and persistence of parameters compared to established criteria may be evaluated in Tables 2.3-16 through 2.3-45. Section 3.4.

9.1.1 Nutrients

High levels of phosphorus in Charlotte Harbor contributed primarily by the Peace River system coupled with substantial supporting data that the Charlotte Harbor system is nitrogen-limited, present a sensitive situation with regard to future nutrient additions. Recent studies suggest that nitrogen may be the limiting nutrient in estuaries.

Modification to natural nutrient budgets and nutrient additions caused by basin modifications and runoff are historically among the most serious problems which impact estuaries. Future additions of nutrients from any source, particularly nitrogen, should be closely managed.

9.1.2 Pesticides

Charlotte Harbor and tributary samples were analyzed for "BHC," Lindane, Heptachlor, Aldrin, Heptachlor Epoxide, Dieldren, Endrin, and DDT/DDD derivatives and component compounds. The presence of any of these pesticides in natural waters should be considered significant. "BHC" is the most persistent of all pesticides, appearing in significant concentrations in all tributary stations and all but three harbor stations. Lindane and Heptachlor appear in the north harbor at the Myakka River and on the western side of the central harbor, lower Coral Creek, Grande Pass, one southern harbor station, and in the upper reaches of the Peace and Myakka river systems. Aldrin appears in Big Slough and Little Alligator Creek. Dieldrin concentrations were detected in northern harbor stations, upper Gasparilla Sound, and all tributaries except Big Slough, Little Alligator Creek, and Alligator Creek. Concentrations of other pesticides examined were not detected in any samples. "BHC," Dieldrin, Lindane, Heptachlor, and Aldrin were present in that order of frequency and concentration.

9.1.3 Bacteria

Coliform bacteria concentrations above recommended health criteria are rather persistent in some tributary waters and within canal systems exposed to septic infiltration and direct runoff. Numerous closings of waters due to bacterial pollution have occurred in numerous areas in the Peace and Myakka rivers. High coliform counts are seen periodically throughout the Harbor system during periods of high flow. The data is indicative of a potentially severe future problem with poorly treated sanitary wastes entering the system.

9.1.4 Hydrographic Modification

Construction of channelization projects and residential artificial canal systems present a potential water quality hazard to the Charlotte Harbor estuary in the form of introduction of poor quality waters to the system. This problem has been discussed at length in other sections of this report, and other outputs of the 208 program. It is not necessary to elaborate further on the mechanics of the problems other than to iterate that it is an existing deficiency in the quality of Charlotte Harbor waters.

9.1.5 Heavy Metals

Heavy metals such as mercury and copper show high concentrations in tributaries and the Harbor, apparently as the rate of stormwater runoff increases within the system. Mercury shows rather high persistency at nearly all sampling stations for a given month during the rainy season. Levels of mercury may be examined in the comparative tables in Section 3.4.

Because of its persistence in the environment, instances of high levels of mercury, well above the yearly average, should not be taken lightly. These appearances are probably due to first flush effects of treated agricultural lands and domestic lawn treatment. Mercury levels should be monitored and remedial management instituted should the problem become more severe.

9.2 Maximum Allowable Loads

Maximum allowable loads of total nitrogen (TN) and total phosphorus (TP) that should be discharged to Charlotte Harbor were derived by first establishing the water quality criteria to be maintained in the harbor. These water quality criteria were established in terms of acceptable chlorophyll a levels in the harbor and then translated into allowable TN and TP concentrations. The acceptable chlorophyll a level was set at 15 micrograms per liter (ug/l). The following relationships, developed by the Florida DER for the Caloosahatchee estuary, were then applied to derive the nutrient levels needed to maintain desired chlorophyll a levels:

Chl a = 70.2 Limit NP - 47

Chl a = 329 TP - 31

where:

Limit NP = minimum of TN, or (10) TP

TN = total nitrogen concentration (mg/l)

TP = total phosphorus concentration (mg/l)

Chl a = chlorophyll a concentration (ug/l)

Using the above relationships, allowable TN and TP levels necessary to limit chlorophyll a to 15 ug/l are as follows:

TN = 0.87 mg/l

TP = 0.14 mg/l

The relationships used in the Caloosahatchee River were adopted because they represent the most recent work of this type available. Future studies will probably indicate any changes necessary for application specifically to Charlotte Harbor.

The available water quality data as well as the results of the water quality modeling effort described in Section 6.0 indicated that critical water quality conditions in the harbor, in terms of nutrients, occur during the month of August. Further, the data on the existing and projected waste loads indicated maximum input of nutrients into Segment 1, the northernmost portion of the harbor. Further, hydrodynamics of the harbor is such that, under the present and future land use conditions, maximum pollutant concentrations occur in Segment 1. Hydrodynamics, as used here, refers to the water movement using the simplified one-dimensional description of the harbor adopted for this study. Consequently, if the water quality criteria for TN and TP is met in Segment 1 during August, it will be met throughout the harbor during the year. Using this rationale, the allowable loads for Segment 1 during the month of August are those that determine maximum allowable loads. For 1976 and 1978 through 1998, the maximum allowable loads for TN and TP are listed below:

Maximum Allowable Load Pounds per Month

	TN	TP
1976	410,688	105,173
1978 through 1998	722,311	146,693

9.3 Necessary Reductions in Present and Future Projected Loads

Existing and projected wasteloads of TN and TP to Segment 1 were compared with the maximum allowable loads for this segment derived in the previous section. Thus, the percent reductions in TN and TP needed to maintain water quality criteria were determined. These load reductions to Segment 1 during the month of August are as follows:

	Percent Reduction in Segment 1	
	TN	TP
1976	54	83
1978 through 1998	58	92

The input to Segment 1 is comprised of Peace and Myakka Rivers, point sources, and the nonpoint loads from Watersheds 1, 6, and 7. Consequently, the controls are needed only on these sources.

9.4 Water Quality Standards Revisions Recommendations

Revisions to or additions of water quality standards for stream or surface water segments that are part of a complex estuarine system such as Charlotte Harbor should consider those water quality parameters and problems unique to estuaries. Establishment of water quality parameter criteria for estuaries is of little use unless the various complex relationships between chemical constituents, carrying capacity, and general health of the system are understood.

Criteria for nutrient levels specifically for the Charlotte Harbor system should be established with due consideration to the high phosphorus loadings within the system and the nitrogen-limiting relationship which appears to be a natural state. Conductivity and salinity criteria, perhaps on an annual average basis, should be considered which would realistically monitor the problems of freshwater flow deregulation of the natural system.

Pesticide, herbicide, and toxic substance criteria should be evaluated in consideration of the productivity of the system, time of maximum juvenile populations, and indigenous species unique to the Charlotte Harbor area.

9.5 Future Study Recommendations

One of the greatest potential impacts to water quality of an estuary system lies in the possibility of modification of the natural salinity patterns or regimen within the system. Salinity changes occur typically through abrupt or long-term alterations in the freshwater inflow to the system, channelization which diverts or restricts entry of saline waters, or dredge and fill activities which alter the hydrography of the estuary basin.

Historically, it has been alteration of estuary salinity that has ultimately had the greatest consequential impact on man's use of the system for recreation, fish and shellfish harvesting, or other beneficial uses.

A priority future study should be oriented toward an understanding of optimal salinity conditions, circulation and mixing, and minimum-maximum freshwater inflow budgets of the system. The hydrography of Charlotte Harbor is poorly understood, and must be defined if the quality of the system is to be preserved. Of nearly equal importance would be the establishment of a mathematical predictive model which simulates optimal salinity and hydrographic conditions as a management tool by which the impacts of projects which impinge upon the system may be determined.