John Elder

CHEMICAL AND PHYSICAL CHARACTERISTICS OF PRECIPITATION AT SELECTED SITES IN FLORIDA

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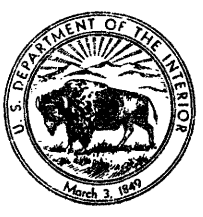

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CHEMICAL AND PHYSICAL CHARACTERISTICS OF PRECIPITATION AT SELECTED SITES IN FLORIDA

By G. A. Irwin and R. T. Kirkland

ABSTRACT

Infrequent sampling of precipitation in Florida has been conducted by the U.S. Geological Survey since 1965. A summary of the historical data from 24 sites throughout Florida indicate that the principal ionic composition of atmospheric precipitation samples is calcium sodium and bicarbonate chloride with an average specific conductance of 32 micromhos per centimeter at 25°C. Historically, much of the sampling focused on primary nutrients and selected trace elements. Historical data indicate that nitrogen and phosphorus concentrations averaged 1.1 and 0.1 milligrams per liter, respectively. The limited trace metal data indicate that motor-vehicle activity may have a significant impact on local precipitation quality. Lead, for example, was measured in concentrations of as much as 2,400 micrograms per liter in samples collected in a highly populated, commercial area in south Florida. Statistical testing indicated that most major inorganic constituents, primary nutrients, and trace metals were significantly different among the sampling sites. The pH data indicated a range of about 5.0 to 7.0, but only limited pH data were collected and analyzed at the historical sites in such a timely manner as to represent pH conditions of the atmospheric precipitation during active rainfall.

A critical review of the historical data suggested that while they may reflect local atmospheric quality conditions they likely do not define baseline conditions from a regional perspective. The application of these data was limited regarding regional extrapolation due to variations in sampling techniques, methods of sample preservation, sampling intervals, sample sizes, and periods of record.

INTRODUCTION

The chemistry of the atmosphere was largely a neglected topic until the last decade when concern about pollution produced a flurry of activity (Thrush, 1978). Perhaps the most widely publicized area of concern is acid rain. However, other environmental sectors such as aerosol propellants and toxic trace elements also are now recognized as potential hazards to atmospheric quality.

In response to concern about atmospheric pollution at the national level, a Work Group on Precipitation Quality was established by the (Federal) Interagency Advisory Committee on Water Data in September 1976, to determine the present status and future needs in the area of research and monitoring of precipitation (U.S. Department of the Interior, 1978). The work group concluded that one of the major gaps in the understanding of the hydrologic cycle is in the realm of precipitation chemistry. They further concluded that: (1) Long-term data on the quality of precipitation, with few exceptions, are not available in the United States; (2) data have been collected using a wide range of sampling techniques; (3) data have been generated using a wide range of analytical methods varying greatly in accuracy and precision; (4) data lack geographic coverage; and (5) sufficient data are not available nationwide for an analysis of either past trends in precipitation quality or for baseline evaluations.

With the national findings in mind, the purpose of this study was to summarize and evaluate specifically the historical quality of precipitation data collected in Florida by the U.S. Geological Survey. This report is intended to serve as a general reference for future quality of precipitation monitoring and project planning. This study and report was conducted in cooperation with the Florida Department of Environmental Regulation as part of the continuing statewide studies of environmental quality.

The scope of this project included: (1) A brief literature review of recent quality of precipitation studies; (2) complilation, technical review, summarization, and evaluation of the historical data collected by the Geological Survey on the quality of precipitation in Florida; (3) summarization of the history, purpose, and scope of most recent Geological Survey investigations conducted in Florida which focused at least in part on the quality of precipitation; (4) summarization of previous methods of collection, sample treatment, and analytical methods and procedures.

LITERATURE REVIEW

A brief review of the recent literature pertaining to the quality of precipitation indicates that much scientific effort is being directed toward the occurrence, processes, and environmental impacts of acid rain. Other areas of research include atmospheric deposition of toxic trace elements and nutrient materials. The effects of aerosol propellants on the composition of the atmosphere is another area which is currently receiving considerable attention.

It is evident in the literature that acidic rain resulting from increased world use of coal for energy production is causing worldwide concern. As summarized by Summers and Whelpdale (1976) it is predicted that the use of coal for generating electrical power in North America will result in an increase of nitrogen and sulfur emissions which will contribute to increased acidity of atmospheric precipitation. Wright and others (1976) report that acid precipitation occurs over large areas of Scandinavia, and is the result of emissions which originate in the industrialized areas of Great Britain and Central Europe. Henriksen and Wright (1977) report evidence which suggests that acidity of lakes and rivers in southern Scandinavia has increased over past decades, and is probably due to the deposition of acid precipitation which primarily originates from emissions, oxidation, and long-range transportation of sulfur and nitrogen oxides released from burning fossil fuels. Vermuelen (1978) reports that the chemical composition of precipitation in the Netherlands indicate that acids are present in larger quantities than should occur naturally. This increase in precipitation acidity is attributed to ever increasing emissions of sulfur and nitrogen oxides. Canadian researchers suggest that acid rain is likely to cause acidification of many lakes and streams in south-central Ontario because of their low buffering capacity (Dillon and others, 1978). In a study of six Swedish lakes, the reduction of decomposer activity by acidification has resulted in an interference with nutrient recycling resulting in a reduction of the species diversity of algal and zooplankton communities (Hendrey and others, 1976).

Environmental contamination from trace-element fallout is another area under study. Recent research indicates that precipitation is likely a significant source of many trace-inorganic constituents. Cambray and others (1975) estimated that the atmosphere is a significant source for certain heavy metals and trace elements found in both the North and Clyde Seas. Atmospheric precipitation which occurs over large areas of Scandinavia contains high concentrations of heavy metals such as copper, zinc, cadmium, and lead that mainly originate in the industrialized areas of Great Britain and central Europe (Wright and others, 1976). Atmospheric fallout was found to be a significant source of nickel and copper entering the watershed of a small Canadian lake (Beamish and Van Loon, 1977). Analysis of core samples of bottom

sediments from Woodhull Lake, Adirondack State Park, N.Y., indicated that atmospheric deposition of 44 metals has increased in recent time; similar results have been found in cores from Honnedaga Lake, N.Y., and Lake of the Clouds, Mount Washington, N.H. (Galloway and Likens, 1977). A recent study of urban California locations conducted by the Sanitary Engineering Research Laboratory of the University of California at Berkeley indicated that wet washout of lead from the atmosphere elevates the lead content of rainwater to a level about 0.05 milligrams per liter--the limit recommended for drinking water by the Safe Drinking Water Act (SERL news report in the Johnson Drillers Journal, 1979).

Recent studies have indicated that atmospheric precipitation also contributes synthetic organic substances to the Earth's surface. Wells and Johnstone (1978), for example, found measurable atmospheric input to the North Sea of 4 organochlorine groups (PCB, DDT, HCH, and dieldrin).

In addition to acids, trace elements, and organics, precipitation also contains significant quantities of major inorganic constituents. The literature is growing with evidence that rainfall contributes a large percentage of inorganic-chemical constituents which are common in natural surface and ground waters. For example, in a study of a peat catchment in mid-Wales, Cryer (1976) estimated that the magnesium, sodium, potassium, and chloride loads in bulk precipitation accounted for 51, 62, 63, and 56 percent respectively of the total loads discharged from the catchment. Jordan and Fisher (1977) reported that bulk precipitation is the principal source of minerals in the water of St. Thomas, V.I. Scandinavian researchers have observed that precipitation loading has increased the specific conductance and hardness of many Norwegian lakes, and atmospheric sulfate has replaced bicarbonate as the major anion (Wright and others, 1976).

Atmospheric loading of nutrients, primarily nitrogen and phosphorus, has been considered an integral component of eutrophication for some time. In his compilation of world literature, Vollenweider (1971) reported that the nitrogen salt content in various parts of the world varies between one and several milligrams per liter. Vollenweider further states that unlike nitrogen, little is known about phosphorus deposition from air. The phosphorus loading may be minimal under normal conditions, but the contribution of phosphorus from the air-to-land surfaces should no longer be disregarded when water eutrophication problems are considered.

The importance of the nutrient input from the atmosphere is further highlighted in a study of the eutrophication of selected lakes in Florida (Brezonik and others, 1969). Results of this investigation indicated that the precipitation falling directly on the surface of Anderson-Cue Lake is the most important natural source of nitrogen. The partial nutrient budget analysis of Anderson-Cue Lake for 1968

indicated that 44 kilograms or 26 percent of the nitrogen load to the lake was contributed by rainfall. During this same period the phosphorus input to the lake from rainfall was estimated at 2.67 kilograms or 20 percent of the partial phosphorus budget of 13.27 kilograms. In a similar study of the nutrient budget for Lake Mendota, Wis., it was estimated that the annual nitrogen and phosphorus load to the lake from rainfall was 17 and 2 percent, respectively, (Lee and others, 1966; Brezonik and Lee, 1968, in Brezonik and others, 1969). More recently, Kuntz (1978) reported that the atmosphere is a significant source of nitrogen for the Lake Erie Basin. Brakke (1977) in a study of Lake Sallie in Minnesota, observed an increase in primary production following rainfall events which were due to nutrient loading from dust contamination transported from a fertile-plains area west of the lake. In a study of stormwater quality of three land-use areas in Broward County, Fla., it was estimated that the atmospheric loads at one study site exceeded the stormwater (surface-water) runoff loads for both total nitrogen and phosphorus (Mattraw, 1978).

FACTORS CONTROLLING PRECIPITATION DATA COLLECTION AND ANALYSIS

The inorganic and organic material that falls to the Earth's surface is transported from the atmosphere by two basic pathways. The material is transported either by aqueous precipitation or by dry fallout. Materials associated with atmospheric dry fallout are in continuous circulation to and from the surface of the Earth. The materials associated with aqueous precipitation are present either in a dissolved or particulate state and are deposited during rainfall events. As summarized by Lewis and Grant (1978), from an analytical viewpoint, total dry and wet precipitation consists of three fractions: (1) Dissolved materials in aqueous precipitation; (2) the water-soluble component of dry precipitation; and (3) the water-insoluble component of either wet or dry precipitation.

Unlike many other facets of hydrologic data collection, there are no commonly accepted, time-tested methods and procedures for the sampling of precipitation quality data. The great disparity that exists in methods of collection often severely limits the utility of precipitation-quality data as an interpretive tool. Lewis and Grant (1978) suggest that the study of precipitation chemistry is obviously subject to a large number of methodological difficulties, some of which can be of sufficient importance to effect interpretation of mass balance data.

Lewis and Grant (1978) suggested seven basic causes of interpretational ambiguity of precipitation-quality data: (1) Dry-fallout leaching usually contributes a significant quantity of many dissolved substances contained in bulk precipitation--thus, variable leaching potential and leaching rates of dry fallout may complicate data analysis; (2) particle formation and chemical repartitioning in wet

precipitation samples can be caused by algal and bacterial growth. For example, biological growth may extract either the water-soluble component of dry precipitation or the dissolved materials in aqueous precipitation, thus repartitioning the material into the water-insoluble component which is often not analyzed for many chemical constituents; (3) sample collector height, texture, and surface composition can cause data variability. Samplers near the land surface, for example, will collect material of a very local origin which may greatly bias the data. Also, the surface texture and composition of the sampler may greatly control the amount of dry precipitation that is trapped (collected); (4) surface texture and composition of many sampler designs may often cause undersampling (underestimate); (5) local biota, such as birds, pollen, and flying insects can contaminate samples and greatly affect the reliability of the data if preventive steps are not taken during sample collection; (6) a very significant factor affecting the interpretation of precipitation-quality data is in the storage of samples. The composition of precipitation is very susceptible to chemical, physical, and biological change within the sample collector which can be a function of exposure time that a sample is stored in the collector; (7) often the water-insoluble chemical components of the particles are excluded from analysis and this fraction of precipitation may be a very significant input source. Another area which may cause interpretational ambiguity that was not specifically addressed in Lewis and Grant (1978) is variability in sampling procedures and analytical methods; sampling and analytical variability can be particularly troublesome in the interpretation of long-term data.

OVERVIEW OF HISTORICAL PRECIPITATION-QUALITY DATA COLLECTION IN FLORIDA

Precipitation monitoring conducted by the U.S. Geological Survey in Florida include data collection from 24 sites. Most of the historical sampling sites have been located in south Florida (fig. 1, table 1). Historical data coverage has included physical parameters (specific conductance, pH, color, and residues), major inorganic constituents (cations and anions), primary nutrients (nitrogen, phosphorus, and carbon), trace elements, pesticides, and tritium (isotopic hydrogen). Most of the past monitoring of atmosphere quality focused on the collection of bulk precipitation samples (wet and dry fallout). Samples collected only during rainfall events comprise a small percentage of the data on the quality of precipitation in Florida.

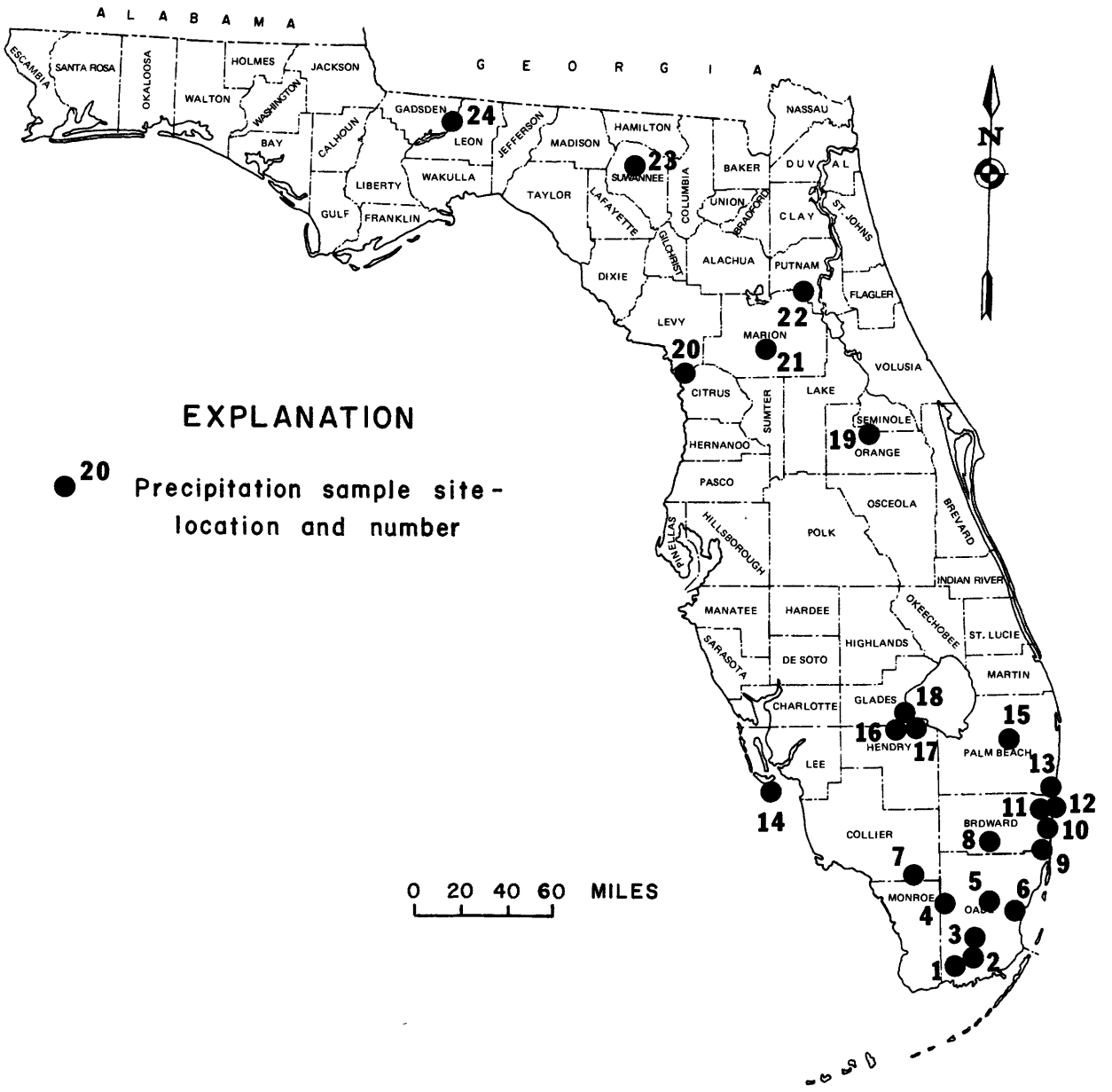

Figure 1.--Locations of precipitation sampling sites.

Table 1.--Summary of quality of precipitation monitoring in Florida

Site location number shown in figure 1	Station number	Site location	Number of samples[1/]	Period of record	Data collection
1	252323080405000	Everglades National Park Research Center near Florida City.	9	1978-79	Physical, inorganics, nutrients, trace metals, pesticides.
2	252350080383000	Campground near Florida City	20	1971-79	Pesticides.
3	253656080350302	Grossman Hammock near Goulds	12	1978-79	Physical, inorganics, nutrients, trace metals, pesticides.
4	254542080493001	40-mile Bend near Pinecrest	27	1978-79	Physical, inorganics, nutrients, trace metals, pesticides.
5	254555080284000	Tamiami Highway near Sweetwater	8	1978-79	Physical, inorganics, nutrients, trace metals, pesticides.
6	254031080191101(02)	U.S. Highway 1 at Kendall	23	1977-78	Physical, inorganics, trace metals, nutrients.
7	254500080573000	Loop Road near Ochopee	17	1973-75	Pesticides.
8	260340080263001	Pump Station-9 near Andytown	14	1973-75	Physical, inorganics, nutrients, trace metals.

[1/] Maximum number of samples and does not necessarily include all parameters shown.

Table 1.--Summary of quality of precipitation monitoring in Florida--Continued

Site location number shown in figure 1	Station number	Site location	Number of samples[1/]	Period of record	Data collection
9	260207080110600	45th Avenue at Hollywood	16	1973-75	Pesticides.
10	261002080070101	U.S. Highway 1 at Oakland Park	50	1975-77	Physical, inorganics, nutrients, trace metals.
11	261629080072401	Sample Road near Pompano Beach	54	1975-77	Physical, inorganics, nutrients, trace metals.
12	261615080055901	U.S. Highway 1 at Pompano Beach	3	1975	Physical, nutrients.
13	262145080052702	East Water Plant at Boca Raton	4	1975-79	Pesticides.
14	262552082034301	Sanibel Island	4	1977	Physical, inorganics, nutrients, trace metals.
15	264105080221501	Pump Station-5 near Loxahatchee	14	1973-75	Physical, inorganics, nutrients, trace metals, pesticides.
16	26471808118150	Ortona Locks near La Belle	5	1978-79	Physical, inorganics, nutrients, trace metals.

[1/] Maximum number of samples and does not necessarily include all parameters shown.

Table 1.--Summary of quality of precipitation monitoring in Florida--Continued

Site location number shown in figure 1	Station number	Site location	Number of samples[1/]	Period of record	Data collection
17	26502908105110	Rim Canal at Moore Haven	6	1978-79	Physical, inorganics, nutrients, trace metals.
18	265020081051500	Hurricane/Gate Structure 1 at Moore Haven.	11	1969	Physical, nutrients.
19	283824081221502	Lake Hope at Maitland	20	1972-79	Physical, inorganics, nutrients, trace metals.
20	290130082365100	Inglis Lock near Inglis	11	1975	Physical, nutrients.
21	291119082082100(01)	Federal Building at Ocala	227	1962-79	Physical, inorganic, tritium.
22	293245081433600	Buckman Lock near Palatka	11	1975	Physical, nutrients.
23	301735082581800	Live Oak	1	1979	Physical, nutrients.
24	303314084230304	U.S. Highway 27 North near Tallahassee.	5	1977-78	Physical, nutrients, trace metals.

[1/] Maximum number of samples and does not necessarily include all parameters shown.

Scope of Past Monitoring Programs

A brief summary of historical precipitation monitoring activities is given below:

(1) The longest continuous monitoring site is located in Ocala (site 21) where bulk samples for analysis of tritium have been collected and composited on a monthly basis since 1961. This station was established as part of a national network to monitor radioactive fallout following the resumption of nuclear weapons testing by the U.S.S.R. in late 1961 (L. B. Leopold, written commun., 1961). Additional samples from the Ocala site were collected and analyzed for major inorganic constituents during the 1965 calendar year. Samples of both bulk precipitation and wet fallout were collected in the 1965 sampling.

(2) In 1969, eleven monthly composite samples of precipitation on the southwestern edge of Lake Okeechobee (site 18) were collected. These samples were analyzed for nitrogen and phosphorus as part of a study of the chemical and biological conditions of the lake. The contribution of major nutrients by precipitation was found to be significant, at times exceeding the contribution of Lake Okeechobee's tributaries (Joyner, 1974).

(3) Also, in 1969 several bulk precipitation monitoring sites were established in the Everglades National Park and one in Hollywood, Fla. (sites 2, 7, 9). These stations began as part of a study to assess atmospheric loading of pesticides in wildlife-recreation water management areas. These data indicated that some traces of DDT, dieldrin, parathion, and lindane were present (Yates and others, 1970).

(4) In 1971, a cooperative study with the Florida Department of Transportation was begun for the purpose of evaluating the possible impacts of stormwater runoff from a major highway interchange at Maitland, Fla. (site 19). Composite samples of bulk precipitation were collected triannually from June 1972 through April 1979 for physical, inorganic, nutrient, and trace metal parameters. Data obtained from this study indicated significant quantities of certain trace metals were contributed by bulk precipitation.

(5) During the period 1972-75 several related investigations of the chemical and biological quality of water in the Everglades resulted in the establishment of three additional precipitation sampling sites in south Florida (sites 4, 8, 15). Among the conclusions drawn from these studies was that bulk precipitation was a major contributor of macronutrients to part of the Everglades. Also noted was that the concentrations of major nutrients varied seasonally, and that total nutrient loads were considerably higher than those found in the northeastern United States (Waller, 1975; Waller and Earle, 1975).

Sampling at rainfall site 4 was reactivated in 1977 in conjunction with the establishment of another site at the Everglades National Park Research Center (site 1). Data from these stations are used as baseline water quality data for the National Park.

(6) During the period 1975-77 four bulk precipitation sampling sites were established in Dade and Broward Counties as part of an urban runoff study (sites 6, 10, 11, 12). Data from the sites were used to assess runoff quality loading from a commercial parking lot (Miller and others, 1979), a major highway (Hardee and others, 1978), a single-family residential area (Mattraw and others, 1979), and a multiple-family residential complex.

(7) In 1975, bulk precipitation data from sites 20 and 22 were collected as part of an environmental impact study of the proposed Cross-Florida Barge Canal. Samples were composited monthly and analyzed for major nutrients. These data, as reported by Lamonds and Merritt (1976), indicated that average concentrations of nitrogen and phosphorus were found to be significant, with levels being slightly lower than those reported by Waller (1975), but slightly higher than those reported by Joyner (1974).

(8) In 1975, sampling of rainfall to monitor atmospheric pesticide contributions was begun at the East Water Plant in Boca Raton, Fla. (site 13). This sampling is a basic data effort and is continuing.

(9) A study to evaluate management of undeveloped wetlands on the eastern edge of the Everglades National Park in Dade County initiated the collection of bulk precipitation at two additional sites in 1978-79 (sites 3, 5). This investigation is designed to assess the effects of agricultural development of the area.

(10) Two sites (16 and 17) on the Caloosahatchee River west of Lake Okeechobee were established in 1978. Data from these bulk precipitation stations will be used in a 3-year investigation of the hydraulic inputs to the river and to provide additional base precipitation quality data in the area. Except for brief rainfall sampling on Sanibel Island in 1977, no rainfall quality data has been collected west of Lake Okeechobee since 1969 (Joyner, 1974).

(11) Water quality loading of the Ochlockonee River from a rural highway bridge near Tallahassee was the subject of an investigation in cooperation with the Florida Department of Transportation in 1977-78 (site 24). Bulk precipitation samples were collected to estimate

atmospheric loading rates. The study noted that nutrient concentrations were lower than those reported by Waller and Earle (1975) in south Florida and by Lamonds and Merritt (1976) in north-central Florida. Concentrations of selected trace elements were about the same as reported in the earlier studies with the exceptions of lead and zinc (Irwin and Losey, 1978).

(12) The quality of runoff into drainage wells was the subject of a recent reconnaissance in north Florida (site 23). A composite of four sites around Live Oak, Fla., was analyzed to estimate atmospheric contribution to runoff quality (Yurewicz, written commun., 1979).

METHODS AND PROCEDURES

Sample Collection and Preservation

The data included in this report reflect considerable variance in experimental design. Specifically, over the years, the techniques and approaches used for the collection of precipitation samples have not been uniform. For example, the techniques of sample collection have ranged in sophistication from elaborate automated-refrigerated devices to a single 5-gallon jug with a funnel attached. The period of sample collection is another area of high variability for the historical data. At some sites the collection interval for an individual sample was as much as 2 or 3 months; whereas, samples at other sites were collected during discrete storm events lasting perhaps only a few minutes. In addition, some sample compositing was done. For example, the sample collector was emptied perhaps weekly for a period of 2 or 3 months with the analysis being performed on the composite of weekly samples. Techniques of sample collection for specific sites are given in the data compilation beginning on page 29.

The historical data also reflect considerable variability in the techniques and procedures for sample preservation. Before 1970, chemical analysis for most parameters was performed on unfiltered, untreated water samples. Subsequent to that time water samples have been collected and preserved in a variety of ways. For the most part, techniques of sample collection and preservation are standarized as described in Brown and others (1970). Nutrient samples, however, have undergone a rather involved evolution of preservation techniques. Over the past two decades samples collected for nutrient analysis have varied in treatment including no preservation, chilled in ice, treated with chloroform, treated with chloroform and chilled, frozen, treated with sulfuric acid, treated with sulfuric acid and chilled, treated with mercuric chloride, and treated with mercuric chloride and chilled.

Analytical Methods

Most of the historical precipitation samples were analyzed in the District laboratory in Ocala, Fla. Prior to 1971, the analytical methods used for physical, inorganic, and nutrient parameters generally were those as described in Rainwater and Thatcher (1960), and Brown and others (1970). Exceptions were the methods used for calcium, magnesium, sodium, and potassium which were determined by atomic absorption spectrophotometry since about 1965 with methods being similar to those described in Fishman and Brown (1976).

Automated methods of analyses for major nutrients which are similar to those described by Skougstad and others (1979) have been used in the Ocala laboratory since 1969. Pesticides were determined using the methods described in Goerlitz and Brown (1972), and tritium methods are described in Thatcher and others (1977).

RESULTS

All data included in this compilation were subject to rigorous technical review and all results which indicated a high degree of contamination or had questionable documentation were omitted from this summary. Even so, the following presentation necessarily must be preceded with additional caveats. The data discussed in the following summary were collected by various sampling methods and field procedures; samples were collected at different times during a period from about 1965 to present; samples were analyzed using different analytical methods; and the number of samples collected among the sites varied considerably from perhaps one or two to over seventy. Unless indicated, all results included in this section are based on the analysis of wet and dry fallout (bulk precipitation) samples. A compilation of the data by individual sites is given in the data compilation section of this report beginning on page 29.

Major Inorganic Chemical Composition

Analyses of the major chemical composition of precipitation have been made over the years at about 10 sites throughout Florida. A graphical presentation of these analyses is given in figure 2.

Samples from site 3 (Grossman Hammock), site 4 (Pinecrest), and site 21 (Ocala) were predominantly calcium bicarbonate in water type. Site 14 (Sanibel Island) was a sodium chloride water type. The major ionic composition of the remaining six precipitation sampling sites was calcium-sodium and bicarbonate-chloride.

Based on these limited data, the major ionic composition of precipitation appears variable within the State. For example, of the five sites located in Broward and Dade Counties, two sites had calcium bicarbonate type waters, one site had a sodium-calcium bicarbonate

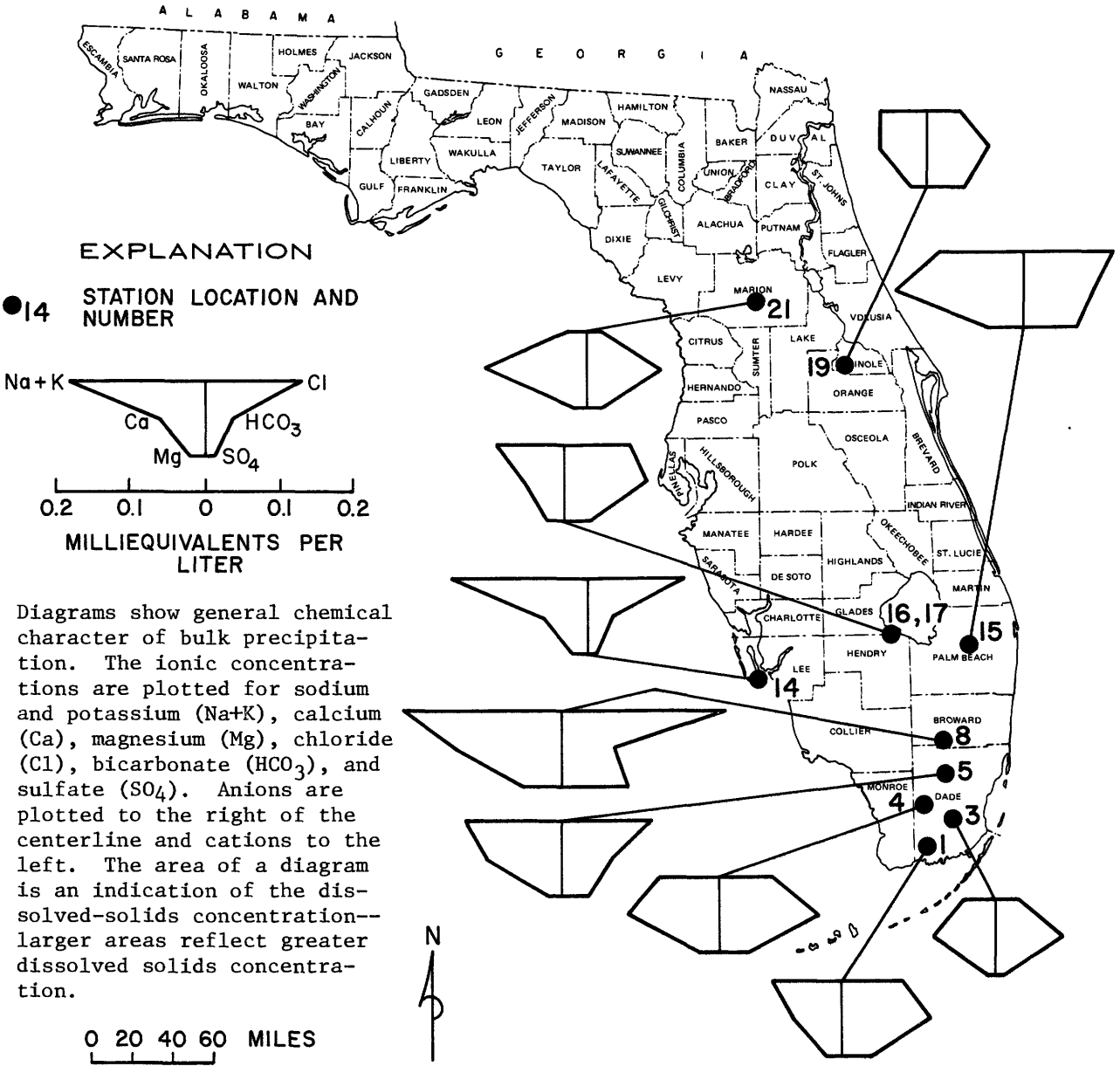

Figure 2.--Average chemical composition of precipitation samples at selected sites.

water type, and two sites had sodium-calcium chloride type waters. Further, sites 19 and 21, the two most northern sites had calcium-sodium and calcium bicarbonate water types respectively. The absence of any regional water-type pattern is likely due in part to local contamination from windblown soils and other particulate material. Site 14, located on Sanibel Island, was predominantly sodium chloride undoubtedly reflecting marine influence.

Specific Conductance

Mean values and respective confidence intervals of specific conductance for 16 precipitation sampling sites throughout Florida are presented in figure 3. The average specific conductance among the sites is 32 µmho with individual site means ranging from 20 µmho at site 21 (Ocala) to 66 µmho at site 8 (Andytown). Fifteen of the sites had mean specific conductances between 20 and 41 µmho, and eight sites had mean specific conductances between 20 and 30 µmhos.

The variance in specific conductance within most sites was quite large as indicated by the rather wide confidence intervals. For most of the sites the standard deviation approximated the mean value. Although the within variance for individual sampling sites was rather high, the mean conductances were significantly different among the sites at the 95-percent probability level.

Selected Major Chemical Constituents

Mean concentrations and confidence intervals of calcium, sodium, and chloride for selected precipitation sampling sites are presented in figure 4. Based on these samplings, the statewide mean concentrations of calcium, sodium, and chloride were 2.1, 1.7, and 3.2 mg/L, respectively. Calcium ranged from a mean of 1.1 mg/L at site 19 (Maitland) to 3.4 mg/L at site 15 (Loxahatchee). Sodium ranged from 0.5 mg/L at site 21 (Ocala) to 4.4 mg/L at site 8 (Andytown), and chloride ranged from 1.1 mg/L at site 3 (Grossman Hammock) to 7.9 mg/L at site 8 (Andytown).

Statewide, the variance of sodium was greater than for calcium. The standard deviation for sodium among the sites was 1.3 mg/L which approximated the statewide sodium mean of 1.7 mg/L; whereas, the standard deviation for calcium among the sites was 0.8 mg/L with a statewide mean of 2.1 mg/L. Chloride was also somewhat variable having a statewide standard deviation of 2.0 mg/L with a mean of 3.2 mg/L.

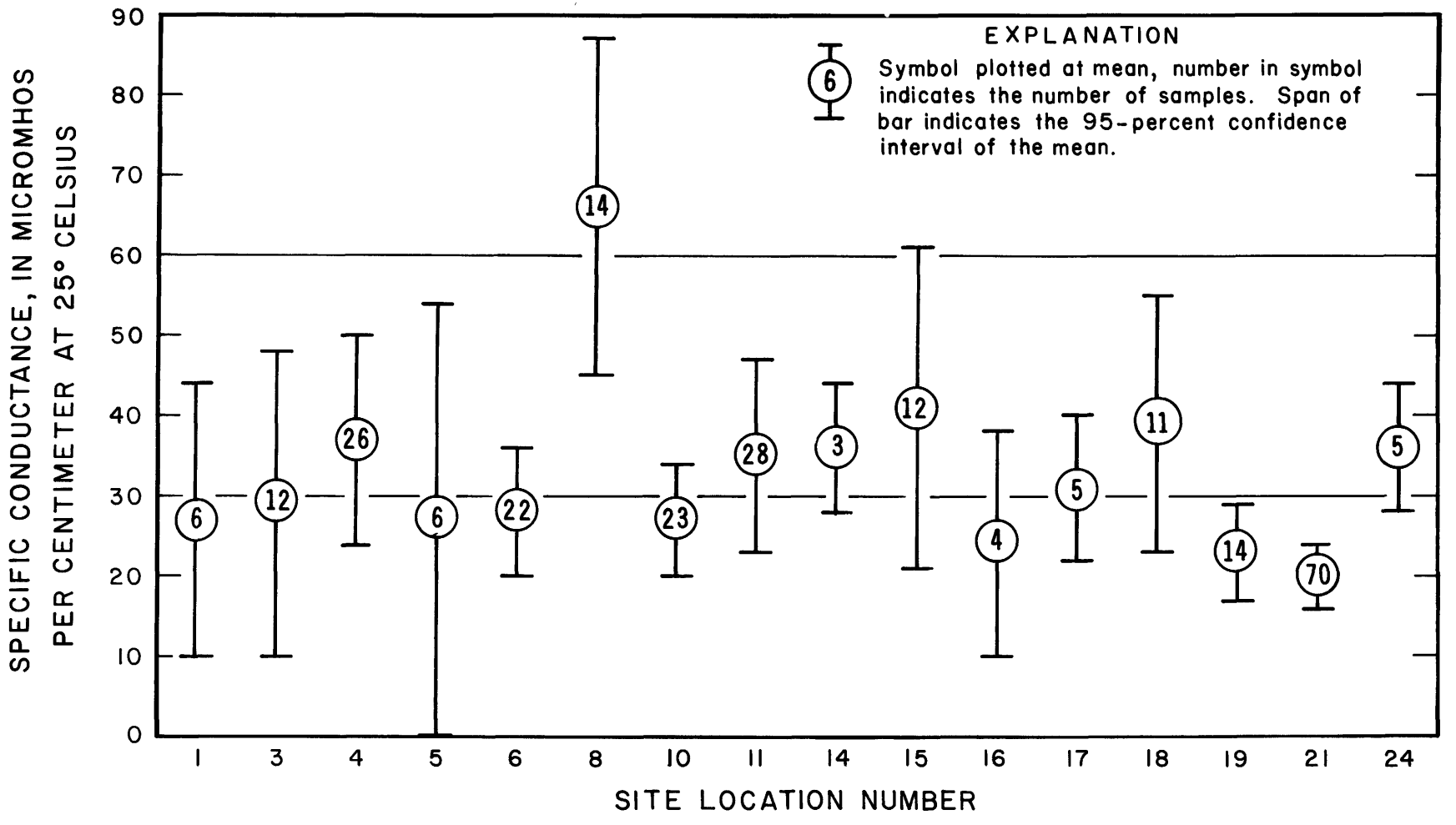

Figure 3.--Distribution of mean specific conductance at selected precipitation sampling sites.

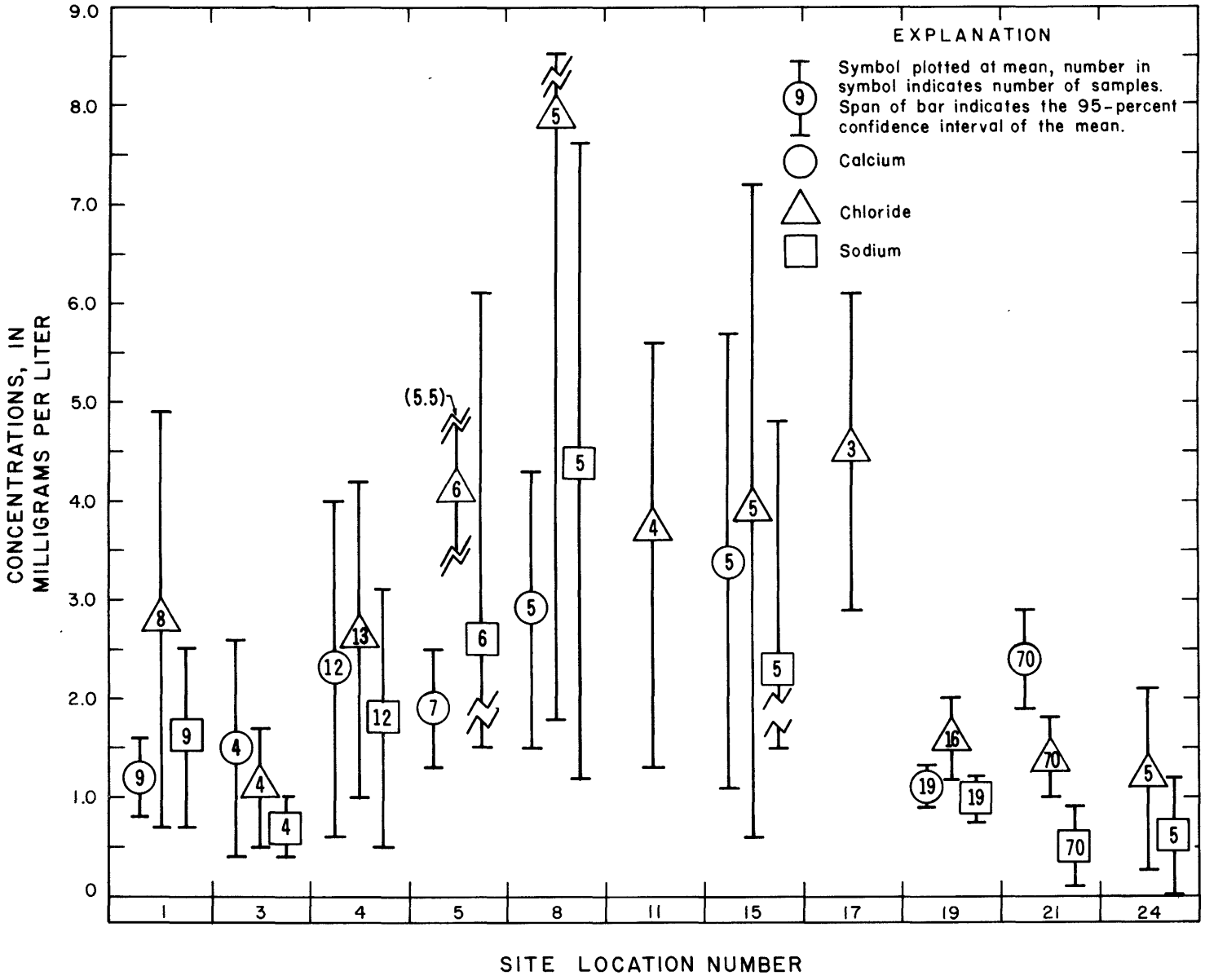

Figure 4.--Distribution of mean calcium, sodium, and chloride concentrations at selected precipitation sampling sites.

pH

The pH of precipitation samples collected at 12 sites ranged from 4.7 to 8.8 or about 4 pH units. With few exceptions, the data reflect pH levels after a considerable period of sample exposure, and thus the pH values are only approximate. The bulk and wet precipitation samples collected at Ocala (site 21) were analyzed soon after rainfall events ranged between 5.0 and 7.0 and perhaps reflected timely local atmospheric pH levels.

Selected Primary Nutrients

Nitrogen

The mean concentrations and data variability of total nitrogen at 16-precipitation sampling sites are portrayed in figure 5. Mean concentrations of total nitrogen ranged from a minimum of 0.50 mg/L at site 24 (Tallahassee) to a maximum of 2.4 mg/L at site 8 (Andytown). About half of the sites had mean concentrations of less than 1 mg/L. Statewide, the variance among the sites was not excessive in that the standard deviation was 0.52 mg/L with a 16-site mean of 1.1 mg/L. However, a statistical test of the means indicated that there was a significant difference among the sites at the 95-percent probability level.

Phosphorus

Total phosphorus ranged from 0.03 mg/L at sites 10, 20, and 24 to 0.30 mg/L at site 3 (fig. 6). Statewide, the mean phosphorus concentration among the sites was 0.10 mg/L, and was somewhat variable with a standard deviation of 0.08 mg/L. Mean phosphorus concentrations among the sites were significantly different at the 95-percent probability level. In addition to the among site concentration differences, there were noticeable within site concentration differences as can be seen by the rather wide confidence intervals. For example, at sites 1 and 3 the standard deviations exceeded the sample mean concentrations.

Selected Trace Metals

A summary of selected trace metal data for 8 precipitation sites is given in table 2. Although the sample numbers and areal coverage are somewhat limited, the data do indicate that there are concentration differences within the State. Of the four metals given in table 2, iron and lead are the most variable, both within and among sites. Mean concentrations of iron ranged from 40 µg/L at site 15 (Loxahatchee) to 340 µg/L at site 10 (Oakland Park). Lead means ranged from 7 µg/L at site 4 (Pinecrest) to 440 µg/L at site 10 (Oakland Park). Concentrations of both iron and lead indicated significant differences among sites at the 95-percent probability level. Within-site sample variance for iron was also quite evident as the standard deviations were of the

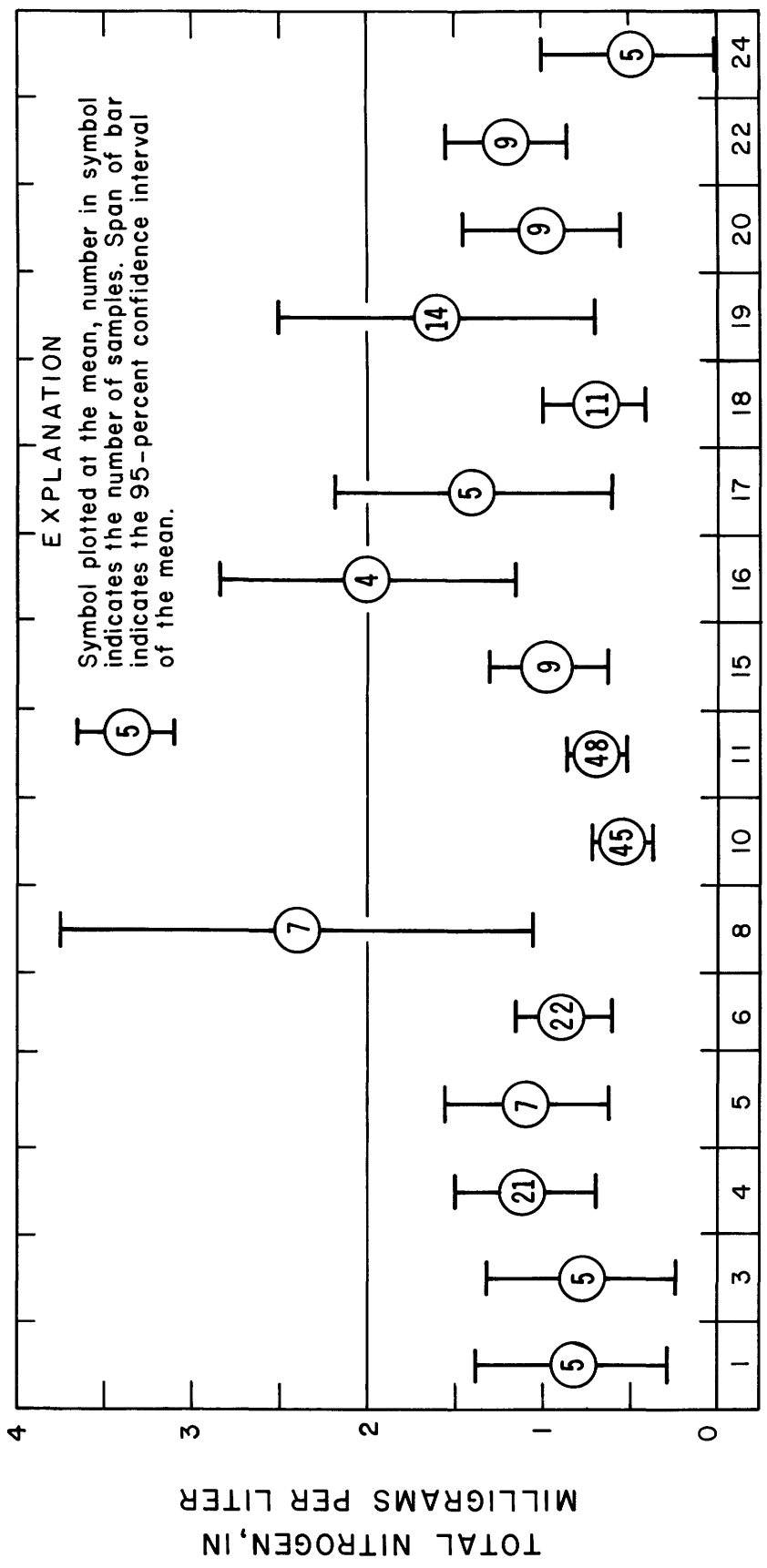

Figure 5.--Distribution of mean total nitrogen concentrations at selected precipitation sites.

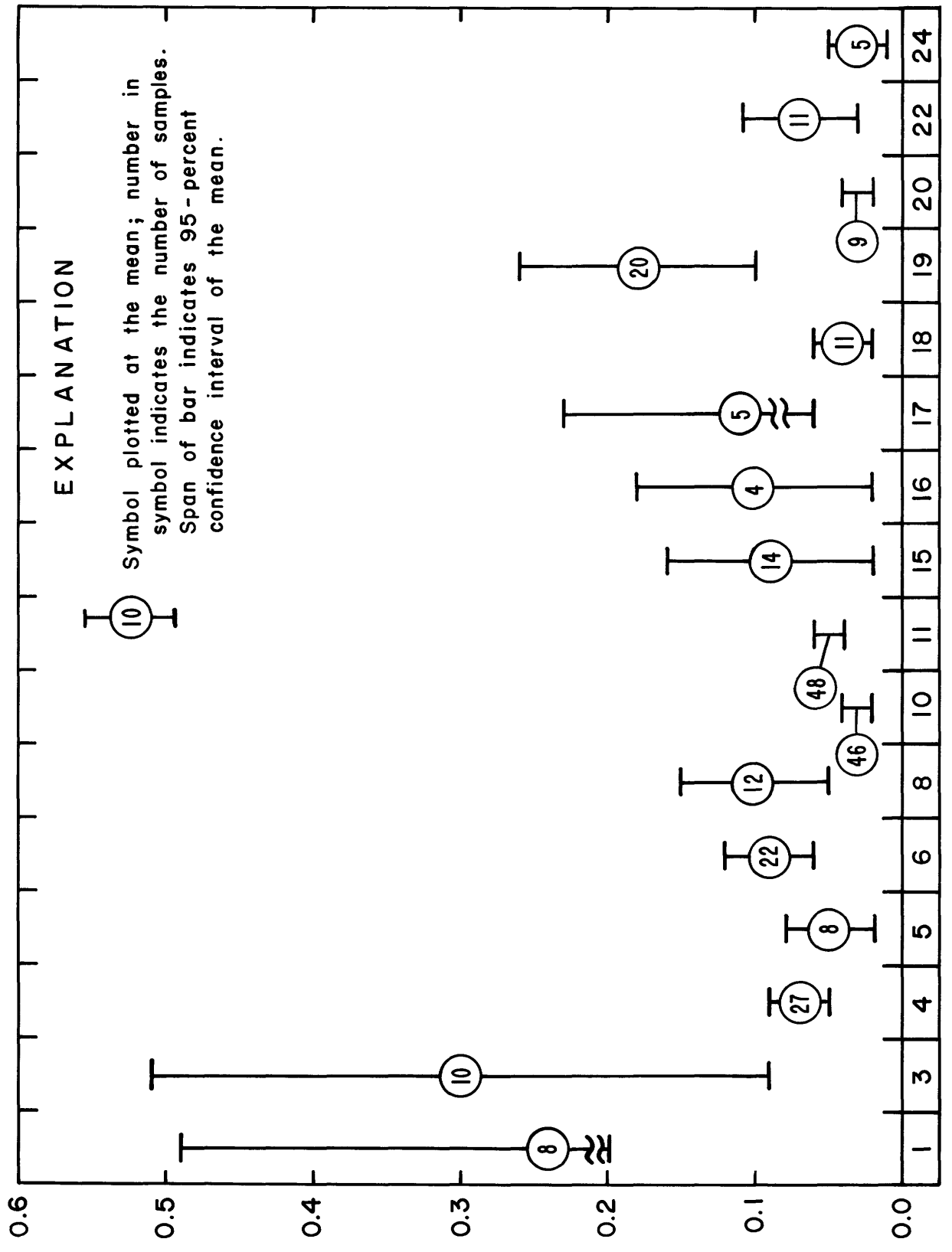

Figure 6.--Distribution of mean total phosphorus concentrations at selected precipitation sites.

Table 2.--Summary of selected trace element data for selected precipitation sampling sites

[Total concentration in micrograms per liter]

Site location	Site location number shown in figure 1	Number of samples	Mean	Standard deviation	95-percent confidence limits
		Copper			
40-Mile Bend near Pinecrest	4	5	2	2	2
U.S. Highway 1 near Kendall	6	25	5	3	1
Pump station-9 near Andytown	8	5	6	4	5
U.S. Highway 1 at Oakland Park	10	49	10	18	5
Sample Road at Pompano Beach	11	54	4	4	1
Pump station-5 near Loxahatchee	15	5	4	4	5
Lake Hope at Maitland	19	15	9	7	4
U.S. Highway 27 near Tallahassee	24	5	4	2	2
		Zinc			
40-Mile Bend near Pinecrest	4	6	75	68	68
U.S. Highway 1 near Kendall	6	25	30	20	8
Pump station-9 near Andytown	8	5	90	50	57
U.S. Highway 1 at Oakland Park	10	50	180	170	47
Sample Road at Pompano Beach	11	54	80	50	13
Pump station-5 near Loxahatchee	15	5	130	70	80
Lake Hope at Maitland	19	14	50	40	23
U.S. Highway 27 near Tallahassee	24	5	10	10	11

Table 2.--Summary of selected trace element data for selected precipitation sampling sites--Continued

[Total concentration in micrograms per liter]

Site location	Site location number shown in figure 1	Number of samples	Mean	Standard deviation	95-percent confidence limits
		Iron			
40-Mile Bend near Pinecrest	4	5	50	65	75
U.S. Highway 1 near Kendall	6	25	171	131	54
Pump station-9 near Andytown	8	5	150	160	180
U.S. Highway 1 at Oakland Park	10	48	340	330	93
Sample Road at Pompano Beach	11	53	90	70	19
Pump station-5 near Loxahatchee	15	5	40	40	46
Lake Hope at Maitland	19	16	50	130	64
U.S. Highway 27 near Tallahassee	24	----------	----------	----------	----------
		Lead			
40-Mile Bend near Pinecrest	4	6	7	5	5
U.S. Highway 1 near Kendall	6	25	25	15	6
Pump station-9 near Andytown	8	5	24	7	8
U.S. Highway 1 at Oakland Park	10	50	440	460	130
Sample Road at Pompano Beach	11	54	100	69	18
Pump station-5 near Loxahatchee	15	5	15	10	12
Lake Hope at Maitland	19	15	19	23	13
U.S. Highway 27 near Tallahassee	24	5	46	18	21

same magnitude as the respective mean concentrations for most sites. Lead also was variable, but standard deviations approximated means at only about half the sites.

Total zinc ranged from a maximum mean of 180 µg/L at site 10 (Oakland Park) to a minimum mean of 10 µg/L at site 24 (Tallahassee). Mean concentrations of zinc among the sites were found to be significantly different at the 95-percent probability level. Within site concentration variance of zinc at individual sites was also high as most sites had standard deviations approximating respective mean concentrations. Concentrations of copper were generally lower than for iron, lead, and zinc, ranging from a mean of 2 µg/L at site 4 (Pinecrest) to 10 µg/L at site 10 (Oakland Park). When tested, the copper concentrations among sites were found not to be significantly different at the 95-percent probability level. Copper was, however, quite variable within sites with the standard deviations approximating respective means at all sites.

DISCUSSION

The primary objective in collecting much of the past data was to estimate atmospheric input of selected chemical and physical parameters to a particular hydrologic system such as a lake or river basin. Most of the past samplings have perhaps been adequate for such purposes. Few of the sampling programs, however, were so designed as to delve greatly into the processes controlling the quality of precipitation.

The most apparent deficiency in much of the historical information pertains to data transferability. Specifically, does the sample represent the area in question or a very limited microcosm? For example, during this present endeavor some consideration was given to regionalizing statewide conditions for selected parameters using the existing data. However, this attempt was abandoned because the historical data herewith are very limited in sample size and were not collected randomly. Most sampling sites were located with the objective of measuring some local phenomena, and thus very likely do not portray regional conditions. For example, the lead concentrations at sites 10 (Oakland Park) and site 11 (Pompano Beach) and to a lesser degree those at site 24 (Tallahassee) were likely influenced greatly by very local activities. These three sites were in part established to estimate localized impacts resulting from the emission from motor vehicles. While the data indicate significant levels of lead, the data represent only an extremely localized condition.

A second area which complicates the regionalization of much of the historical data is that the samples included both the dry and wet fallout (bulk precipitation) and were collected under relatively uncontrolled conditions. As a result, samples at the time of retrieval commonly contained obvious quantities of debris of local origin such as soil particles and partly decomposed organic matter. For any given

sample, data very likely reflect several local conditions such as those discussed in an early section of this report. Further, the historical samples were collected over a considerable time interval and thus likely reflect to some degree such processes as leaching, particle formation, chemical repartitioning, and biochemical activity. Consideration of the above data generally precludes its use for estimating regional phenomena.

While the interpretational value of the historical data is somewhat limited, this situation is not particularly unique to Florida. As pointed out by the Federal Interagency Work Group on Precipitation Quality in 1978, the data base throughout the country is also quite restricted. Until such time when sampling and network design are more throughly researched and standardized, the utility of much of the atmospheric-quality data will be highly restricted. However, with sagacious application, the historical data can serve as estimates for baseline orders of magnitude.

SUMMARY

Based on data collected infrequently since about 1965, the major ionic composition of precipitation is predominantly calcium-sodium and bicarbonate-chloride. The statewide average specific conductance based on 16 sites is 32 µmho and ranged from 20 µmho at Ocala (site 21) to 66 µmho at Andytown (site 8). Fifteen of the sites had specific conductance between 20 and 41 µmho. Specific conductance values among the sites were significantly different at the 95-percent probability level.

Mean concentrations of nitrogen and phosphorus statewide were 1.1 mg/L and 0.1 mg/L respectively. While both nitrogen and phosphorus exhibited some within site variance, they were found to be significantly different among the sites at the 95-percent probability level. Historical trace element data were quite limited, but those available suggested significant differences among sites in addition to a rather high variance within individual sites. Additionally, notable concentrations of lead and iron, attributable to motor vehicle activity, were detected in precipitation samples collected in south Florida.

This report and data supplement present the majority of data on the quality of precipitation which have been collected by the Geological Survey in Florida and should be useful as a starting point for future studies of the quality of precipitation. However, the data mainly reflect the composite quality of wet and dry fallout for selected sites and for selected periods and are generally not adequate to describe with high confidence past or present baseline conditions of the precipitation quality in Florida.

To reiterate, findings of the Federal Work Group on Precipitation Quality, other studies, and this brief compilation strongly suggest that standardization of analytical methods, sampling techniques, and network design are required to obtain meaningful regional monitoring of precipitation quality.

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DATA COMPILATION

PRECIPITATION AT EVERGLADES NATIONAL PARK RESEARCH CENTER
NEAR FLORIDA CITY, FLORIDA

STATION NUMBER: 252323080405000 SITE LOCATION NUMBER: 1
PERIOD OF RECORD: March 1978-January 1979
TYPE OF SAMPLE COLLECTOR: Glass funnels mounted on portable refrigerator containing glass bottles.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation analyzed monthly.

Parameter	Number of samples	Mean	Standard deviation	Range
Major inorganic constituents and related characteristics (Dissolved concentrations in milligrams per liter, except as indicated)				
Calcium (Ca)	9	1.2	0.6	0.4-2.1
Magnesium (Mg)	9	.2	.1	.1-0.4
Sodium (Na)	9	1.6	1.2	.4-4.3
Potassium (K)	9	.7	.7	.2-2.5
Bicarbonate (HCO_3)	8	7	7	0-22
Carbonate (CO_3)	8	0	0	0
Sulfate (SO_4)	7	1.8	1.5	.0-3.9
Chloride (Cl)	8	2.8	2.6	.4-8.4
Fluoride (F)	9	.1	.1	.0-.2
Silica (SiO_2)	9	.2	.3	.0-.9
Hardness ($CaCO_3$)	9	3.7	1.7	1-7
Noncarbonate hardness	8	1	1	0-3
Specific conductance (µmho/cm at 25°C)	6	27	17	9-47
pH (units)	9	-	-	6.1-7.4
Solids (residue at 180°C)	8	14	11	7-40
Color (Pt-Co units)	9	11	19	0-60
Turbidity (JTU)	1		-	1
Turbidity (NTU)	12	3	3	1-10
Primary nutrients and related characteristics (Total concentrations in milligrams per liter, except as indicated)				
Ammonia as N	6	0.48	0.33	0.04-.89
Nitrite as N	12	.02	.02	.00-.07
Nitrate as N	12	.16	.14	.00-.47
Organic nitrogen as N	7	.26	.21	.02-.64
Nitrogen as N	5	.84	.47	.23-1.35
Phosphorus, ortho as P	8	.20	.25	0-.66
Phosphorus, as P	8	.24	.31	0-.75
Carbon, organic as C	8	3.3	1.3	1-5.1

PRECIPITATION AT EVERGLADES NATIONAL PARK RESEARCH CENTER
NEAR FLORIDA CITY, FLORIDA--Continued

STATION NUMBER: 252323080405000 SITE LOCATION NUMBER: 1
PERIOD OF RECORD: March 1978-January 1979
TYPE OF SAMPLE COLLECTOR: Glass funnels mounted on portable refrigerator containing glass bottles.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation analyzed monthly.

Parameter	Number of samples	Mean	Standard deviation	Range
Selected trace elements (Total concentrations in micrograms per liter, except as indicated)				
Arsenic (As)	2	0	-	0
Cadmimum (Cd)	2	0	-	0
Chromium (Cr)	2	10	-	10
Copper (Cu)	1	-	-	-1
Iron (Fe)	1	-	-	10
Lead (Pb)	1	-	-	4
Manganese (Mn)	1	-	-	10
Mercury (Hg)	2	-	-	.5
Nickel (Ni)	1	-	-	8
Strontium (Sr)	9	46	52	10-180
Zinc (Zn)	2	15	-	10-20
Selected pesticide and industrial compounds (Total concentrations in micrograms per liter, except as indicated)				
PCB	1	-	-	0.1

PRECIPITATION AT CAMPGROUND NEAR FLORIDA CITY, FLORIDA

STATION NUMBER: 252350080383000 SITE LOCATION NUMBER: 2
PERIOD OF RECORD: June 1971-May 1975
TYPE OF SAMPLE COLLECTOR: Galvanized funnel and teflon bottle.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation.

Parameter	Number of samples	Mean	Standard deviation	Range
Selected pesticide and industrial compounds (Total concentrations in micrograms per liter, except as indicated)				
Chlordane	19	0.06	0.14	0.00-.40
Diazinon	18	.26	.70	.00-2.9
Dieldrin	20	.01	.01	.00-.05
DDE	20	.00	.01	.00-.04
DDT	20	.02	.04	.00-.17
Lindane	20	.01	.01	.00-.05
Malathion	18	.47	.97	.00-3.4
Methyl Parathion	18	.01	.04	.00-.14
Parathion	18	.06	.12	.00-.42

PRECIPITATION AT GROSSMAN HAMMOCK NEAR GOULDS, FLORIDA

STATION NUMBER: 253656080350302 SITE LOCATION NUMBER: 3
PERIOD OF RECORD: April 1978-March 1979
TYPE OF SAMPLE COLLECTOR: Glass funnels mounted on portable refrigerator containing glass bottles.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation analyzed monthly.

Parameter	Number of samples	Mean	Standard deviation	Range
Major inorganic constituents and related characteristics (Dissolved concentrations in milligrams per liter, except as indicated)				
Calcium (Ca)	4	1.5	0.8	0.9-2.6
Magnesium (Mg)	4	.1	.1	.1-0.2
Sodium (Na)	4	.7	.2	.5-0.9
Potassium (K)	5	.6	.4	.2-1.2
Bicarbonate (HCO_3)	3	5.7	3.8	3.0-10
Carbonate (CO_3)	3	0	0	0
Sulfate (SO_4)	5	.6	.6	.0-1.4
Chloride (Cl)	4	1.1	.4	.6-1.4
Fluoride (F)	4	.1	.1	.0-.1
Silica (SiO_2)	4	.3	.5	.0-1.0
Hardness ($CaCO_3$)	4	4.2	1.9	3-7
Noncarbonate hardness	3	1	1	0-2
Specific conductance (µmho/cm at 25°C)	12	29	30	9-98
pH (units)	11	-	-	5.2-6.7
Solids (residue at 180°C)	4	9	5	5-14
Color (Pt-Co units)	4	5	6	0-10
Turbidity (NTU)	10	3	2	1-8
Primary nutrients and related characteristics (Total concentrations in milligrams per liter, except as indicated)				
Ammonia as N	7	0.38	0.34	0.07-.97
Nitrite as N	9	.02	.02	0-.05
Nitrate as N	10	.26	.12	.10-.46
Organic nitrogen as N	7	.60	.46	.16-1.3
Nitrogen as N	5	.78	.48	.34-1.52
Phosphorus, ortho as P	10	.26	.27	.01-.69
Phosphorus, as P	10	.30	.30	.02-.76
Carbon, organic as C	8	5.0	3.2	0-8.3

PRECIPITATION AT GROSSMAN HAMMOCK NEAR GOULDS, FLORIDA--Continued

STATION NUMBER: 253656080350302 SITE LOCATION NUMBER: 3
PERIOD OF RECORD: April 1978-March 1979
TYPE OF SAMPLE COLLECTOR: Glass funnels mounted on portable refrigerator containing glass bottles.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation analyzed monthly.

Parameter	Number of samples	Mean	Standard deviation	Range
Selected trace elements (Total concentrations in micrograms per liter, except as indicated)				
Arsenic (As)	2	0	-	0-1
Cadmimum (Cd)	2	3	-	1-5
Chromium (Cr.)	2	10	-	10
Copper (Cu)	2	2	-	2-3
Iron (Fe)	2	35	-	20-50
Lead (Pb)	2	21	-	0-42
Manganese (Mn)	2	5	-	0-10
Mercury (Hg)	2	1.2	-	.5-2.0
Nickel (Ni)	2	5	-	2-8
Strontium (Sr)	4	25	-	10-40
Zinc (Zn)	2	20	-	20
Selected pesticide and industrial compounds (Total concentrations in micrograms per liter, except as indicated)				
PCB	1	0.2	-	0.2

PRECIPITATION AT 40-MILE BEND NEAR PINECREST, FLORIDA

STATION NUMBER: 254542080493001 SITE LOCATION NUMBER: 4
PERIOD OF RECORD: July 1973-March 1979
TYPE OF SAMPLE COLLECTOR: Glass funnels mounted on portable refrigerator containing glass and plastic bottles.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation refrigerated.

Parameter	Number of samples	Mean	Standard deviation	Range
Major inorganic constituents and related characteristics (Dissolved concentrations in milligrams per liter, except as indicated)				
Calcium (Ca)	12	2.3	2.7	0.5-9.3
Magnesium (Mg)	12	.4	.6	.0-2.0
Sodium (Na)	12	1.8	2.1	.2-6.7
Potassium (K)	12	.2	.2	.1-.7
Bicarbonate (HCO_3)	12	8	10	0-38
Carbonate (CO_3)	10	0	0	0
Sulfate (SO_4)	10	1.8	1.2	.0-3.1
Chloride (Cl)	13	2.6	2.6	.2-8.4
Fluoride (F)	12	.1	.1	.0-.1
Silica (SiO_2)	11	.8	.9	0-2.3
Hardness ($CaCO_3$)	12	8	9	1-30
Noncarbonate hardness	11	2	5	0-17
Specific conductance (µmho/cm at 25°C)	26	37	31	5-104
pH (units)	15	-	-	5.5-8.7
Solids (residue at 180°C)	10	20	18	4-53
Color (Pt-Co units)	14	4	3	0-10
Turbidity (JTU)	14	4	1	2-6
Turbidity (NTU)	12	1	1	0-3
Primary nutrients and related characteristics (Total concentrations in milligrams per liter, except as indicated)				
Ammonia as N	25	0.34	0.27	0-.92
Nitrite as N	27	.02	.02	0.00-.11
Nitrate as N	26	.34	.24	.10-1.0
Organic nitrogen as N	25	.62	.52	.03-1.7
Nitrogen as N	21	1.1	.68	.22-2.64
Phosphorus, ortho as P	27	.05	.04	.00-.16
Phosphorus, as P	27	.07	.06	.01-.19
Carbon, organic as C	25	2.4	2.1	0-8

PRECIPITATION AT 40-MILE BEND NEAR PINECREST, FLORIDA--Continued

STATION NUMBER: 254542080493001 SITE LOCATION NUMBER: 4
PERIOD OF RECORD: July 1973-March 1979
TYPE OF SAMPLE COLLECTOR: Glass funnels mounted on portable refrigerator containing glass and plastic bottles.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation refrigerated.

Parameter	Number of samples	Mean	Standard deviation	Range
Selected trace elements (Total concentrations in micrograms per liter, except as indicated)				
Arsenic (As)	6	2	3	0-7
Cadmimum (Cd)	6	27	24	0-62
Chromium (Cr)	6	10	10	0-10
Cobalt (Co)	4	2	1	0-3
Copper (Cu)	5	2	2	0-6
Iron (Fe)	5	50	65	0-150
Lead (Pb)	6	7	5	0-15
Manganese (Mn)	5	4	5	0-10
Mercury (Hg)	6	.2	.2	0-.5
Nickel (Ni)	5	16	18	0-36
Strontium (Sr)	12	49	59	0-180
Zinc (Zn)	6	75	68	10-180
Selected pesticide and industrial compounds (Total concentrations in micrograms per liter, except as indicated)				
Malathion	5	0.01	0.02	0.00-.04
Diazinon	5	.00	.00	.00-.01

PRECIPITATION AT TAMIAMI HIGHWAY NEAR SWEETWATER, FLORIDA

STATION NUMBER: 254555080284000 SITE LOCATION NUMBER: 5
PERIOD OF RECORD: May 1978-January 1979
TYPE OF SAMPLE COLLECTOR: Glass funnels mounted on portable refrigerator containing glass bottles.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation, refrigerated.

Parameter	Number of samples	Mean	Standard deviation	Range
Major inorganic constituents and related characteristics (Dissolved concentrations in milligrams per liter, except as indicated)				
Calcium (Ca)	7	1.9	0.7	0.9-3.1
Magnesium (Mg)	6	.3	.3	.1-.9
Sodium (Na)	6	2.6	3.5	.3-9.6
Potassium (K)	6	.4	.3	.2-.9
Bicarbonate (HCO_3)	5	4.4	3.8	1-11
Carbonate (CO_3)	5	0	0	0
Sulfate (SO_4)	5	2.1	2.4	.5-6.2
Chloride (Cl)	6	4.1	5.5	1.1-15
Fluoride (F)	6	.1	.1	.0-.1
Silica (SiO_2)	6	.4	.4	.0-1.0
Hardness ($CaCO_3$)	6	6	2.8	3-11
Noncarbonate hardness	5	2.4	1.5	0-4
Specific conductance (µmho/cm at 25°C)	6	27	27	13-82
pH (units)	7	-	-	6.2-8.2
Solids (residue at 180°C)	5	11	3	8-17
Color (Pt-Co units)	5	1	2	0-5
Turbidity (NTU)	8	1.5	1	1-2
Primary nutrients and related characteristics (Total concentrations in milligrams per liter, except as indicated)				
Ammonia as N	8	0.34	0.29	0.1-.98
Nitrite as N	8	.02	.02	.01-.07
Nitrate as N	7	.33	.11	.18-.50
Organic nitrogen as N	8	.51	.30	.20-1.0
Nitrogen as N	7	1.1	.52	.62-2.1
Phosphorus, ortho as P	8	.03	.02	.01-.08
Phosphorus, as P	8	.05	.04	.02-.12
Carbon, organic as C	6	2.2	1.9	0-4.0

PRECIPITATION AT TAMIAMI HIGHWAY NEAR SWEETWATER, FLORIDA--Continued

STATION NUMBER: 254555080284000 SITE LOCATION NUMBER: 5
PERIOD OF RECORD: May 1978-January 1979
TYPE OF SAMPLE COLLECTOR: Glass funnels mounted on portable refrigerator containing glass bottles.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation, refrigerated.

Parameter	Number of samples	Mean	Standard deviation	Range
Selected trace elements (Total concentrations in micrograms per liter, except as indicated)				
Arsenic (As)	2	0	-	0
Cadmimum (Cd)	2	1	-	0-1
Chromium (Cr)	2	10	-	10
Copper (Cu)	1	-	-	2
Iron (Fe)	1	-	-	10
Lead (Pb)	2	24	-	6-43
Manganese (Mn)	1	-	-	0
Mercury (Hg)	2	.5	-	.5
Nickel (Ni)	1	-	-	6
Strontium (Sr)	6	32	17	10-50
Zinc (Zn)	2	10	-	10
Selected pesticide and industrial compounds (Total concentrations in micrograms per liter, except as indicated)				

Not detected

PRECIPITATION AT U.S. HIGHWAY 1 AT KENDALL, FLORIDA

STATION NUMBER: 254031080191101 SITE LOCATION NUMBER: 6
PERIOD OF RECORD: June 1977-May 1978
TYPE OF SAMPLE COLLECTOR: Two plastic funnels connected to plastic sample bottles in large refrigerator.
SAMPLE COLLECTION AND PROCESSING: Automated sampling of bulk precipitation samples collected after each storm.

Parameter	Number of samples	Mean	Standard deviation	Range
Major inorganic constituents and related characteristics (Dissolved concentrations in milligrams per liter, except as indicated)				
Potassium (K)	20	0.4	0.1	0.2-0.7
Specific conductance (μmho/cm at 25°C)	22	28	19	6-62
Color (Pt-Co units)	21	6	5	0-20
Turbidity (JTU)	16	4	2	2-7
Turbidity (NTU)	7	5	2	3-8
Primary nutrients and related characteristics (Total concentrations in milligrams per liter, except as indicated)				
Ammonia as N	22	0.33	0.25	0.02-.98
Nitrite as N	23	.01	.01	.00-.02
Nitrate as N	23	.20	.15	.02-.47
Organic nitrogen as N	21	.4	.37	.00-1.2
Nitrogen as N	22	.88	.65	.04-2.0
Phosphorus, ortho as P	22	.04	.05	0-.21
Phosphorus, as P	22	.09	.08	.01-.31
Carbon, organic as C	21	4.4	3.9	0-12
Chemical oxygen demand (COD) (high level)	22	16	16	0-58

PRECIPITATION AT U.S. HIGHWAY 1 AT KENDALL, FLORIDA--Continued

STATION NUMBER: 254031080191101 SITE LOCATION NUMBER: 6
PERIOD OF RECORD: June 1977-May 1978
TYPE OF SAMPLE COLLECTOR: Two plastic funnels connected to plastic sample bottles in large refrigerator.
SAMPLE COLLECTION AND PROCESSING: Automated sampling of bulk precipitation samples collected after each storm.

Parameter	Number of samples	Mean	Standard deviation	Range
Selected trace elements (Total concentrations in micrograms per liter, except as indicated)				
Arsenic (As)	1	-	-	0
Cadmimum (Cd)	25	1	1	0-4
Chromium (Cr)	25	10	<10	10-20
Copper (Cu)	25	5	3	0-8
Iron (Fe)	25	171	131	40-590
Lead (Pb)	25	25	15	2-58
Zinc (Zn)	25	30	20	0-110

PRECIPITATION AT U.S. HIGHWAY 1 AT KENDALL, FLORIDA

STATION NUMBER: 254031080191102 SITE LOCATION NUMBER: 6
PERIOD OF RECORD: April 1977-June 1978
TYPE OF SAMPLE COLLECTOR: Plastic funnel connected to plastic sample bottle in large refrigerator.
SAMPLE COLLECTION AND PROCESSING: Automated sampling of wet precipitation. Samples collected after each storm.

Parameter	Number of samples	Mean	Standard deviation	Range
Major inorganic constituents and related characteristics (Dissolved concentrations in milligrams per liter, except as indicated)				
Potassium (K)	10	0.2	0.2	0.1-0.6
Specific conductance (μmho/cm at 25°C)	11	20	11	4-38
Color (Pt-Co units)	11	8	5	5-20
Turbidity (JTU)	6	2	1	2-3
Turbidity (NTU)	6	3	1	1-4
Primary nutrients and related characteristics (Total concentrations in milligrams per liter, except as indicated)				
Ammonia as N	12	0.29	0.21	0.02-.76
Nitrite as N	12	.01	.01	.00-.02
Nitrate as N	12	.15	.12	.01-.39
Organic nitrogen as N	12	.12	.12	.00-.39
Nitrogen as N	12	.57	.41	.03-1.6
Phosphorus, ortho as P	12	.01	.02	.00-.06
Phosphorus, as P	12	.02	.03	.00-.10
Carbon, organic as C	8	2.6	2	0-5.0
Chemical oxygen demand (COD) (high level)	11	12	13	1-40

PRECIPITATION AT U.S. HIGHWAY 1 AT KENDALL, FLORIDA--Continued

STATION NUMBER: 254031080191102 SITE LOCATION NUMBER: 6
PERIOD OF RECORD: April 1977-June 1978
TYPE OF SAMPLE COLLECTOR: Plastic funnel connected to plastic sample bottle in large refrigerator.
SAMPLE COLLECTION AND PROCESSING: Automated sampling of wet precipitation. Samples collected after each storm.

Parameter	Number of samples	Mean	Standard deviation	Range
Selected trace elements (Total concentrations in micrograms per liter, except as indicated)				
Cadmimum (Cd)	12	2	3	0-10
Chromium (Cr)	11	10	<10	10-30
Copper (Cu)	12	6	3	2-15
Iron (Fe)	12	84	96	0-310
Lead (Pb)	12	21	11	9-47
Zinc (Zn)	10	30	30	10-100

PRECIPITATION AT LOOP ROAD NEAR OCHOPEE, FLORIDA

STATION NUMBER: 254500080573000 SITE LOCATION NUMBER: 7
PERIOD OF RECORD: August 1973-May 1975
TYPE OF SAMPLE COLLECTOR: Galvanized funnel and teflon bottles.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation.

Parameter	Number of samples	Mean	Standard deviation	Range
Selected pesticide and industrial compounds (Total concentrations in micrograms per liter, except as indicated)				
Chlordane	17	0.01	0.02	0.00-.10
Diazinon	17	.01	.01	.00-.04
Dieldrin	17	.00	.00	.00-.01
DDT	17	.00	.01	.00-.03
Ethion	13	.00	.01	.00-.04
Lindane	17	.00	.00	.00-.01
Malathion	17	.00	.02	.00-.07
Parathion	17	.00	.01	.00-.04

PRECIPITATION AT PUMP STATION-9 NEAR ANDYTOWN, FLORIDA

STATION NUMBER: 260340080263001 SITE LOCATION NUMBER: 8
PERIOD OF RECORD: July 1973-May 1975
TYPE OF SAMPLE COLLECTOR: Glass funnels mounted on portable refrigerator containing glass and plastic bottles.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation, refrigerated.

Parameter	Number of samples	Mean	Standard deviation	Range
Major inorganic constituents and related characteristics (Dissolved concentrations in milligrams per liter, except as indicated)				
Calcium (Ca)	5	2.9	1.2	1.0-4.1
Magnesium (Mg)	5	.6	.2	.3-.8
Sodium (Na)	5	4.4	2.8	1.0-7.3
Potassium (K)	5	.6	.6	.0-1.5
Bicarbonate (HCO_3)	5	4	4	0-8
Carbonate (CO_3)	3	-	-	0
Sulfate (SO_4)	5	4.3	2.5	1.4-7.9
Chloride (Cl)	5	7.9	5.3	2.5-15
Fluoride (F)	5	.1	.1	.0-.1
Silica (SiO_2)	6	.2	.2	.0-.6
Hardness ($CaCO_3$)	5	9	4	4-14
Noncarbonate hardness	5	7	6	0-14
Specific conductance (µmho/cm at 25°C)	14	66	37	19-134
pH (units)	4	-	-	4.7-6.6
Solids (residue at 180°C)	5	36	14	19-56
Color (Pt-Co units)	6	4	2	0-7
Turbidity (JTU)	13	4	3	1-10
Primary nutrients and related characteristics (Total concentrations in milligrams per liter, except as indicated)				
Ammonia as N	11	0.99	0.67	0.08-1.9
Nitrite as N	11	.04	.04	.01-.12
Nitrate as N	13	.64	.46	.13-1.8
Organic nitrogen as N	12	.89	.57	.13-2.0
Nitrogen as N	7	2.4	1.5	1.1-5.2
Phosphorus, ortho as P	12	.07	.08	.01-.27
Phosphorus, as P	12	.10	.08	.02-.31
Carbon, organic as C	12	3.0	2.4	.5-8.5

PRECIPITATION AT PUMP STATION-9 NEAR ANDYTOWN, FLORIDA--Continued

STATION NUMBER: 260340080263001 SITE LOCATION NUMBER: 8
PERIOD OF RECORD: July 1973-May 1975
TYPE OF SAMPLE COLLECTOR: Glass funnels mounted on portable refrigerator containing glass and plastic bottles.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation, refrigerated.

Parameter	Number of samples	Mean	Standard deviation	Range
Selected trace elements (Total concentrations in micrograms per liter, except as indicated)				
Arsenic (As)	5	3	4	0-8
Cadmimum (Cd)	5	34	23	5-58
Chromium (Cr)	5	4	5	0-10
Cobalt (Co)	5	3	3	0-8
Copper (Cu)	5	6	4	1-13
Iron (Fe)	5	150	160	40-400
Lead (Pb)	5	24	7	14-32
Manganese (Mn)	5	12	18	0-40
Mercury (Hg)	5	.1	.2	.0-.4
Nickel (Ni)	5	20	27	63
Strontium (Sr)	5	60	30	0-80
Zinc (Zn)	5	90	50	40-170
Selected pesticide and industrial compounds (Total concentrations in micrograms per liter, except as indicated)				
Chlordane	4	0.02	0.05	0.00-.10
Dieldrin	4	.01	.01	.00-.01
Malathion	4	.14	.24	.00-.50
Diazinon	4	.01	.01	.00-.02
Methyl Parathion	3	.01	.01	.00-.02

PRECIPITATION AT 45TH AVENUE AT HOLLYWOOD, FLORIDA

STATION NUMBER: 260207080110600 SITE LOCATION NUMBER: 9
PERIOD OF RECORD: January 1973-May 1975
TYPE OF SAMPLE COLLECTOR: Galvanized funnel and teflon bottle.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation.

Parameter	Number of samples	Mean	Standard deviation	Range
Selected pesticide and industrial compounds (Total concentrations in micrograms per liter, except as indicated)				
Aldrin	16	0.00	0.00	0.00-.01
Chlordane	15	.05	.05	.00-.10
DDT	16	.00	.00	.00-.01
Diazinon	16	.04	.06	.00-.21
Dieldrin	16	.00	.01	.00-.01
Lindane	16	.00	.00	.00-.01
Malathion	16	.04	.06	.00-.18
Methyl Parathion	16	.02	.05	.00-.18
Parathion	16	.01	.03	.00-.14
PCB	16	.01	.03	.00-.10

PRECIPITATION AT U.S. HIGHWAY 1 AT OAKLAND PARK, FLORIDA

STATION NUMBER: 261002080070101 SITE LOCATION NUMBER: 10
PERIOD OF RECORD: January 1976-July 1977
TYPE OF SAMPLE COLLECTOR: Two plastic funnels connected to plastic sample bottle in large refrigerator.
SAMPLE COLLECTION AND PROCESSING: Automated sampling of bulk precipitation samples collected after each storm.

Parameter	Number of samples	Mean	Standard deviation	Range
Major inorganic constituents and related characteristics (Dissolved concentrations in milligrams per liter, except as indicated)				
Sodium (Na)	1	-	-	10
Potassium (K)	23	0.3	0.3	.1-1.4
Chloride (Cl)	2	12	-	5-19
Specific conductance (μmho/cm at 25°C)	23	27	16	5-69
Color (Pt-Co units)	46	7	8	0-50
Turbidity (NTU)	46	6	3	0-20
Primary nutrients and related characteristics (Total concentrations in milligrams per liter, except as indicated)				
Ammonia as N	46	0.06	0.06	0.00-.28
Nitrite as N	46	.01	.01	.00-.10
Nitrate as N	46	.20	.16	.00-.83
Organic nitrogen as N	46	.27	.42	.00-2.7
Nitrogen as N	45	.55	.59	.05-3.9
Phosphorus, ortho as P	46	.01	.02	.00-.12
Phosphorus, as P	46	.03	.04	.00-.24
Carbon, organic as C	44	4.5	3.7	0-22
Chemical oxygen demand (COD) (high level)	23	37	37	4-130
Chemical oxygen demand (COD) (low level)	20	39	21	6-81

PRECIPITATION AT U.S. HIGHWAY 1 AT OAKLAND PARK, FLORIDA--Continued

STATION NUMBER: 261002080070101 SITE LOCATION NUMBER: 10
PERIOD OF RECORD: January 1976-July 1977
TYPE OF SAMPLE COLLECTOR: Two plastic funnels connected to plastic sample bottle in large refrigerator.
SAMPLE COLLECTION AND PROCESSING: Automated sampling of bulk precipitation samples collected after each storm.

Parameter	Number of samples	Mean	Standard deviation	Range
Selected trace elements (Total concentrations in micrograms per liter, except as indicated)				
Arsenic (As)	3	0	0	0
Cadmimum (Cd)	49	1	1	0-6
Chromium (Cr)	48	20	20	0-90
Copper (Cu)	49	10	18	0-120
Iron (Fe)	48	340	330	0-1,800
Lead (Pb)	50	440	460	10-2,400
Zinc (Zn)	50	180	170	10-1,000

PRECIPITATION AT SAMPLE ROAD NEAR POMPANO BEACH, FLORIDA

STATION NUMBER: 261629080072401 SITE LOCATION NUMBER: 11
PERIOD OF RECORD: October 1975-June 1977
TYPE OF SAMPLE COLLECTOR: Two plastic funnels connected to plastic bottles in large refrigerator.
SAMPLE COLLECTION AND PROCESSING: Automated sampling of bulk precipitation. Samples collected after each storm.

Parameter	Number of samples	Mean	Standard deviation	Range
Major inorganic constituents and related characteristics (Dissolved concentrations in milligrams per liter, except as indicated)				
Sodium (Na)	1	-	-	3.9
Potassium (K)	25	.4	.5	.1-1.8
Bicarbonate (HCO_3)	1	-	-	18
Chloride (Cl)	4	3.7	1.7	2.0-6.0
Specific conductance (µmho/cm at 25°C)	28	35	32	6-160
pH (units)	1			6.2
Color (Pt-Co units)	49	9	10	0-54
Turbidity (JTU)	51	5	2	1-10
Primary nutrients and related characteristics (Total concentrations in milligrams per liter, except as indicated)				
Ammonia as N	48	0.14	0.14	0.01-.56
Nitrite as N	51	.01	.01	.00-.08
Nitrate as N	51	.23	.20	.00-1.1
Organic nitrogen as N	48	.36	.39	0-1.6
Nitrogen as N	48	.70	.57	.05-2.6
Phosphorus, ortho as P	48	.02	.04	0-.22
Phosphorus, as P	48	.05	.05	0-.24
Carbon, organic as C	49	4.0	3.6	.0-17
Chemical oxygen demand (COD) (high level)	34	21	23	0-85
Chemical oxygen demand (COD) (low level)	17	22	13	4-49

PRECIPITATION AT SAMPLE ROAD NEAR POMPANO BEACH, FLORIDA--Continued

STATION NUMBER: 261629080072401 SITE LOCATION NUMBER: 11
PERIOD OF RECORD: October 1975-June 1977
TYPE OF SAMPLE COLLECTOR: Two plastic funnels connected to plastic bottles in large refrigerator.
SAMPLE COLLECTION AND PROCESSING: Automated sampling of bulk precipitation. Samples collected after each storm.

Parameter	Number of samples	Mean	Standard deviation	Range
Selected trace elements (Total concentrations in micrograms per liter, except as indicated)				
Arsenic (As)	2	0	0	0
Cadmimum (Cd)	53	<1	1	0-2
Chromium (Cr)	54	10	10	10-40
Copper (Cu)	54	4	4	0-22
Iron (Fe)	53	90	70	0-280
Lead (Pb)	54	100	69	9-310
Zinc (Zn)	54	80	50	0-200

PRECIPITATION AT U.S. HIGHWAY 1 AT POMPANO BEACH, FLORIDA

STATION NUMBER: 261615080055401 SITE LOCATION NUMBER: 12
PERIOD OF RECORD: August-September 1975
TYPE OF SAMPLE COLLECTOR: Two plastic funnels connected to plastic bottles in large refrigerator.
SAMPLE COLLECTION AND PROCESSING: Automated sampling of bulk precipitation. Samples collected after each storm.

Parameter	Number of samples	Mean	Standard deviation	Range
Major inorganic constituents and related characteristics (Dissolved concentrations in milligrams per liter, except as indicated)				
Color (Pt-Co units)	3	7	3	5-10
Turbidity (JTU)	3	5	2	4-7
Primary nutrients and related characteristics (Total concentrations in milligrams per liter, except as indicated)				
Ammonia as N	3	0.02	0.02	0.01-.04
Nitrite as N	3	.01	.01	.00-.01
Nitrate as N	3	.33	.35	.12-.73
Organic nitrogen as N	3	.12	.03	.09-.15
Nitrogen as N	3	.48	.31	.29-.84
Phosphorus, ortho as P	3	.02	.02	.01-.03
Phosphorus, as P	3	.03	.02	.01-.05
Carbon, organic as C	3	2.0	1.0	1.0-3.0
Chemical oxygen demand (COD) (high level)	3	14	11	4-25
Selected trace elements (Total concentrations in micrograms per liter, except as indicated)				
Cadmimum (Cd)	2	0	0	0
Chromium (Cr)	2	10	-	10
Copper (Cu)	2	2	-	2-3
Iron (Fe)	2	220	-	140-310
Lead (Pb)	2	44	-	35-540
Zinc (Zn)	2	80	-	80-90

PRECIPITATION AT EAST WATER PLANT AT BOCA RATON, FLORIDA

STATION NUMBER: 262145080052702 SITE LOCATION NUMBER: 13
PERIOD OF RECORD: September 1975-July 1978
TYPE OF SAMPLE COLLECTOR: Plastic funnel and bottles.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation composited for annual analysis of pesticide.

Parameter	Number of samples	Mean	Standard deviation	Range
Selected pesticide and industrial compounds (Total concentrations in micrograms per liter, except as indicated)				
Diazinon	4	0.04	0.06	0.00-.12
Malathion	4	.08	.12	.00-.25
PCB	4	.07	.15	.00-.30

PRECIPITATION AT SANIBEL ISLAND, FLORIDA

STATION NUMBER: 262552082034301 SITE LOCATION NUMBER: 14
PERIOD OF RECORD: June-September 1977
TYPE OF SAMPLE COLLECTOR: Plastic funnel and bottle.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation. Samples not refrigerated.

Parameter	Number of samples	Mean	Standard deviation	Range
Major inorganic constituents and related characteristics (Dissolved concentrations in milligrams per liter, except as indicated)				
Calcium (Ca)	2	1.1	-	0.8-1.4
Magnesium (Mg)	2	.2	-	.2-.3
Sodium (Na)	2	3.6	-	2.8-4.5
Potassium (K)	2	.8	-	.3-1.2
Bicarbonate (HCO_3)	2	2	-	0-6
Carbonate (CO_3)	2	0		0
Sulfate (SO_4)	1	-	-	.4
Chloride (Cl)	2	4.5	-	2.9-3.6
Silica (SiO_2)	2	1.0	-	.3-1.7
Hardness ($CaCO_3$)	2	4	-	3-4
Noncarbonate hardness	2	2	-	0-3
Specific conductance (µmho/cm at 25°C)	3	36	4	32-39
pH (units)	4	-	-	5.6-7.5
Color (Pt-Co units)	1	5	-	5
Turbidity (JTU)	1	3	-	3
Primary nutrients and related characteristics (Total concentrations in milligrams per liter, except as indicated)				
Ammonia as N	2	0.26	0.12	0.17-.34
Nitrite as N	2	.01	.00	.01
Nitrate as N	2	.11	.01	.10-.11
Organic nitrogen as N	1	.14	-	.14
Nitrogen as N	1	.42	-	.42
Phosphorus, ortho as P	2	.22	.14	.12-.32
Phosphorus, as P	2	.22	.14	.12-.32

STATION NUMBER: 262552082034301 SITE LOCATION NUMBER: 14
PERIOD OF RECORD: June-September 1977
TYPE OF SAMPLE COLLECTOR: Plastic funnel and bottle.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation. Samples not refrigerated.

Parameter	Number of samples	Mean	Standard deviation	Range
Selected trace elements (Total concentrations in micrograms per liter, except as indicated)				
Iron (Fe)	1	-	-	10
Strontium (Sr)	1	-	-	150

PRECIPITATION AT PUMP STATION-5 NEAR LOXAHATCHEE, FLORIDA

STATION NUMBER: 264105080221501 SITE LOCATION NUMBER: 15
PERIOD OF RECORD: April 1973-May 1975
TYPE OF SAMPLE COLLECTOR: Glass funnels mounted on portable refrigerator containing glass and plastic bottles.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation, refrigerated.

Parameter	Number of samples	Mean	Standard deviation	Range
Major inorganic constituents and related characteristics (Dissolved concentrations in milligrams per liter, except as indicated)				
Calcium (Ca)	5	3.4	2.0	1.0-5.8
Magnesium (Mg)	5	.6	.5	.0-1.4
Sodium (Na)	5	2.3	2.2	.8-6.1
Potassium (K)	5	.4	.3	.1-.9
Bicarbonate (HCO_3)	5	5.6	4.2	3.0-13
Carbonate (CO_3)	3	0	0	0
Sulfate (SO_4)	5	3.2	2.6	.9-7.6
Chloride (Cl)	5	3.9	2.9	1.6-8.5
Fluoride (F)	5	.1	.1	.0-.2
Silica (SiO_2)	6	.1	.1	.0-.3
Hardness ($CaCO_3$)	5	11	6	5-20
Noncarbonate hardness	5	6	2	3-9
Specific conductance (µmho/cm at 25°C)	12	41	31	12-97
pH (units)	4	-	-	5.6-6.4
Solids (residue at 180°C)	5	32	20	13-61
Color (Pt-Co units)	6	6	7	1-20
Turbidity (JTU)	14	3	1	1-5
Primary nutrients and related characteristics (Total concentrations in milligrams per liter, except as indicated)				
Ammonia as N	12	0.32	0.24	0.05-.75
Nitrite as N	14	.03	.03	.01-.09
Nitrate as N	11	.31	.10	.15-.48
Organic nitrogen as N	14	.45	.41	.08-1.4
Nitrogen as N	9	.97	.45	.43-1.7
Phosphorus, ortho as P	14	.07	.12	.00-.39
Phosphorus, as P	14	.09	.13	.01-.39
Carbon, organic as C	13	2.2	2.5	.00-8.5

PRECIPITATION AT PUMP STATION-5 NEAR LOXAHATCHEE, FLORIDA--Continued

STATION NUMBER: 264105080221501 SITE LOCATION NUMBER: 15
PERIOD OF RECORD: April 1973-May 1975
TYPE OF SAMPLE COLLECTOR: Glass funnels mounted on portable refrigerator containing glass and plastic bottles.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation, refrigerated.

Parameter	Number of samples	Mean	Standard deviation	Range
Selected trace elements (Total concentrations in micrograms per liter, except as indicated)				
Arsenic (As)	5	3	3	0-7
Cadmimum (Cd)	5	4	3	1-8
Chromium (Cr)	5	<10	<10	0-10
Cobalt (Co)	5	4	4	0-8
Copper (Cu)	4	4	0	10
Iron (Fe)	5	40	40	0-100
Lead (Pb)	5	15	10	2-29
Manganese (Mn)	5	0	0	0
Mercury (Hg)	5	.2	.4	.0-.9
Nickel (Ni)	5	19	21	0-44
Strontium (Sr)	5	22	16	0-40
Zinc (Zn)	5	130	70	60-230
Selected pesticide and industrial compounds (Total concentrations in micrograms per liter, except as indicated)				
Chlordane	4	0.08	0.10	0.00-.20
Dieldrin	4	.01	.01	.00-.02
Malathion	3	.11	.11	.00-.22
Methyl Parathion	3	.01	.02	.00-.03

PRECIPITATION AT ORTONA LOCKS NEAR LA BELLE, FLORIDA

STATION NUMBER: 264718081181504 SITE LOCATION NUMBER: 16
PERIOD OF RECORD: November 1978-February 1979
TYPE OF SAMPLE COLLECTOR: Glass funnels mounted on portable refrigerator containing glass bottles.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation, refrigerated.

Parameter	Number of samples	Mean	Standard deviation	Range
Major inorganic constituents and related characteristics (Dissolved concentrations in milligrams per liter, except as indicated)				
Calcium (Ca)	1	-	-	0.9
Magnesium (Mg)	1	-	-	.2
Sodium (Na)	1	-	-	1.5
Potassium (K)	1	-	-	1.2
Bicarbonate (HCO_3)	1	-	-	9.0
Carbonate (CO_3)	1	-	-	0
Sulfate (SO_4)	1	-	-	1.5
Chloride (Cl)	2	1.6	-	.5-2.8
Fluoride (F)	1	-	-	.0
Silica (SiO_2)	1	-	-	.1
Hardness ($CaCO_3$)	1	-	-	3
Noncarbonate hardness	1	-	-	0
Specific conductance (µmho/cm at 25°C)	4	24	10	16-34
pH (units)	5	-	-	7.3-7.7
Solids (residue at 180°C)	1	-	-	15
Color (Pt-Co units)	1	-	-	0
Turbidity (NTU)	4	2	1	1-3
Primary nutrients and related characteristics (Total concentrations in milligrams per liter, except as indicated)				
Ammonia as N	4	0.22	0.19	0.02-.45
Nitrite as N	4	.01	.01	.00-.01
Nitrate as N	4	.14	.04	.10-.17
Organic nitrogen as N	4	1.6	.48	1.1-2.2
Nitrogen as N	4	2.0	.61	1.4-2.6
Phosphorus, ortho as P	4	.09	.06	.02-.16
Phosphorus, as P	4	.10	.06	.03-.17
Carbon, organic as C	2	1.5		.0-3.0

PRECIPITATION AT ORTONA LOCKS NEAR LA BELLE, FLORIDA--Continued

STATION NUMBER: 264718081181504 SITE LOCATION NUMBER: 16
PERIOD OF RECORD: November 1978-February 1979
TYPE OF SAMPLE COLLECTOR: Glass funnels mounted on portable refrigerator containing glass bottles.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation, refrigerated.

Parameter	Number of samples	Mean	Standard deviation	Range
Selected trace elements (Total concentrations in micrograms per liter, except as indicated)				
Aluminum (Al)	1	-	-	0
Arsenic (As)	1	-	-	0
Copper (Cu)	1	-	-	1
Iron (Fe)	1	-	-	60
Lead (Pb)	1	-	-	100
Manganese (Mn)	1	-	-	0
Nickel (Ni)	1	-	-	3
Strontium (Sr)	1	-	-	50
Zinc (Zn)	1	-	-	30

PRECIPITATION AT RIM CANAL AT MOORE HAVEN, FLORIDA

STATION NUMBER: 265029081051101 SITE LOCATION NUMBER: 17
PERIOD OF RECORD: October 1978 - March 1979
TYPE OF SAMPLE COLLECTOR: Glass funnels mounted on portable refrigerator containing glass bottles.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation, refrigerated.

Parameter	Number of samples	Mean	Standard deviation	Range
Major inorganic constituents and related characteristics (Dissolved concentrations in milligrams per liter, except as indicated)				
Calcium (Ca)	1	-	-	1.0
Magnesium (Mg)	1	-	-	.3
Sodium (Na)	1	-	-	1.9
Potassium (K)	1	-	-	.2
Bicarbonate (HCO_3)	1	-	-	4
Carbonate (CO_3)	1	-	-	0
Sulfate (SO_4)	1	-	-	1.5
Chloride (Cl)	3	4.5	0.9	3.5-5.0
Fluoride (F)	1	-	-	.0
Silica (SiO_2)	1	-	-	.0
Hardness ($CaCO_3$)	1	-	-	4
Noncarbonate hardness	1	-	-	1
Specific conductance (µmho/cm at 25°C)	5	31	8.5	24-45
pH (units)	6	-	-	7.3-8.8
Solids (residue at 180°C)	1	-	-	10
Color (Pt-Co units)	1	-	-	0
Turbidity (NTU)	5	1	1	1-2
Primary nutrients and related characteristics (Total concentrations in milligrams per liter, except as indicated)				
Ammonia as N	5	0.32	0.29	0.14-.84
Nitrite as N	5	.02	.01	.01-.04
Nitrate as N	5	.27	.12	.12-.38
Organic nitrogen as N	5	.84	.52	.12-1.4
Nitrogen as N	5	1.4	.69	.69-2.4
Phosphorus, ortho as P	5	.06	.07	.02-.19
Phosphorus, as P	5	.11	.11	.04-.30
Carbon, organic as C	3	2.8	4.5	.0-8.0

PRECIPITATION AT RIM CANAL AT MOORE HAVEN, FLORIDA--Continued

STATION NUMBER: 265029081051101 SITE LOCATION NUMBER: 17
PERIOD OF RECORD: October 1978 - March 1979
TYPE OF SAMPLE COLLECTOR: Glass funnels mounted on portable refrigerator containing glass bottles.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation, refrigerated.

Parameter	Number of samples	Mean	Standard deviation	Range
Selected trace elements (Total concentrations in micrograms per liter, except as indicated)				
Aluminum (Al)	1	-	-	30
Arsenic (As)	1	-	-	1
Copper (Cu)	1	-	-	1
Iron (Fe)	1	-	-	80
Lead (Pb)	1	-	-	240
Manganese (Mn)	1	-	-	10
Mercury (Hg)	1	-	-	.5
Nickel (Ni)	1	-	-	4
Strontium (Sr)	1	-	-	60
Zinc (Zn)	1	-	-	10

PRECIPITATION AT HURRICANE GATE STRUCTURE-1 AT MOORE HAVEN, FLORIDA

STATION NUMBER: 265020081051500 SITE LOCATION NUMBER: 18
PERIOD OF RECORD: January-December 1969
TYPE OF SAMPLE COLLECTOR: Plastic bottle and funnel.
SAMPLE COLLECTION AND PROCESSING: Composite and single event samples. Sample refrigerated between collection periods.

Parameter	Number of samples	Mean	Standard deviation	Range
Major inorganic constituents and related characteristics (Dissolved concentrations in milligrams per liter, except as indicated)				
Specific conductance (µmho/cm at 25°C)	11	39	24	17-80
Primary nutrients and related characteristics (Total concentrations in milligrams per liter, except as indicated)				
Ammonia as N	11	0.25	0.31	0.00-.85
Nitrite as N	11	.00	.00	.00
Nitrate as N	11	.09	.09	.0-.3
Organic nitrogen as N	11	.37	.14	.20-.58
Nitrogen as N	11	.71	.42	.25-1.6
Phosphorus, ortho as P	11	.02	.03	.00-.11
Phosphorus, as P	11	.04	.04	.01-.13

PRECIPITATION AT LAKE HOPE AT MAITLAND, FLORIDA

STATION NUMBER: 283824081221502 SITE LOCATION NUMBER: 19
PERIOD OF RECORD: July 1972-September 1978
TYPE OF SAMPLE COLLECTOR: Plastic funnel and bottle.
SAMPLE COLLECTION AND PROCESSING: Composited into refrigerated bottle weekly, analyzed triannually.

Parameter	Number of samples	Mean	Standard deviation	Range
Major inorganic constituents and related characteristics (Dissolved concentrations in milligrams per liter, except as indicated)				
Calcium (Ca)	19	1.1	0.5	0.1-1.8
Magnesium (Mg)	19	.3	.4	.0-1.9
Sodium (Na)	19	1.0	.5	.3-1.9
Potassium (K)	19	.5	.4	.1-1.5
Bicarbonate (HCO_3)	16	5	5	0-14
Carbonate (CO_3)	14	0	0	0
Sulfate (SO_4)	16	2.6	.9	1.3-4.1
Chloride (Cl)	16	1.6	.8	.6-2.7
Fluoride (F)	19	.1	.1	.0-.2
Silica (SiO_2)	18	.1	.1	0-.6
Hardness ($CaCO_3$)	19	4	2	1-11
Noncarbonate hardness	16	1	2	0-9
Specific conductance (µmho/cm at 25°C)	14	23	11	13-58
pH (units)	11	-	-	5.0-7.5
Solids (residue at 180°C)	19	13	6	3-21
Color (Pt-Co units)	19	3	3	0-10
Turbidity (JTU)	17	3	1	1-5
Turbidity (NTU)	3	1	1	1-2

PRECIPITATION AT LAKE HOPE AT MAITLAND, FLORIDA--Continued

STATION NUMBER: 283824081221502 SITE LOCATION NUMBER: 19
PERIOD OF RECORD: July 1972-September 1978
TYPE OF SAMPLE COLLECTOR: Plastic funnel and bottle.
SAMPLE COLLECTION AND PROCESSING: Composited into refrigerated bottle weekly, analyzed triannually.

Parameter	Number of samples	Mean	Standard deviation	Range
Primary nutrients and related characteristics (Total concentrations in milligrams per liter, except as indicated)				
Ammonia as N	20	0.78	0.70	0.02-3.3
Nitrite as N	20	.02	.03	.00-.13
Nitrate as N	20	.29	.25	.00-1.2
Organic nitrogen as N	20	.48	.47	.08-2.2
Nitrogen as N	14	1.6	1.6	.19-6.8
Phosphorus, ortho as P	20	.15	.18	.00-.79
Phosphorus, as P	20	.18	.19	.01-.89
Carbon, organic as C	9	4.0	6.1	1.0-20
Chemical oxygen demand (COD) (high level)	6	8	6	2-19
Chemical oxygen demand (COD) (low level)	2	10	-	4-15
Selected trace elements (Total concentrations in micrograms per liter, except as indicated)				
Aluminum (Al)	16	40	50	0-220
Arsenic (As)	15	0	1	0-2
Cadmimum (Cd)	1	-	-	0
Copper (Cu)	15	9	7	2-29
Iron (Fe)	16	50	120	0-500
Lead (Pb)	15	19	23	2-92
Manganese (Mn)	15	5.3	7.4	0-20
Mercury (Hg)	14	.2	.2	0.0-.5
Nickel (Ni)	16	7	9	0-34
Strontium (Sr)	13	44	33	0-110
Zinc (Zn)	14	50	40	10-150

PRECIPITATION AT INGLIS LOCK NEAR INGLIS, FLORIDA

STATION NUMBER: 290130082365100 SITE LOCATION NUMBER: 20
PERIOD OF RECORD: January-November 1975
TYPE OF SAMPLE COLLECTOR: Plastic funnel and bottle.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation, composited monthly.

Parameter	Number of samples	Mean	Standard deviation	Range
Major inorganic constituents and related characteristics (Dissolved concentrations in milligrams per liter, except as indicated)				
Chloride (Cl)	1	-	-	2
Hardness ($CaCO_3$)	1	-	-	9
Specific conductance (µmho/cm at 25°C)	1	-	-	29
Color (Pt-Co units)	1	-	-	5
Turbidity (JTU)	10	3	2	1-7
Primary nutrients and related characteristics (Total concentrations in milligrams per liter, except as indicated)				
Ammonia as N	10	0.39	0.27	0.14-.99
Nitrite as N	11	.01	.00	.00-.01
Nitrate as N	11	.27	.14	.10-.49
Organic nitrogen as N	9	.32	.24	0-.88
Nitrogen as N	9	1.0	.60	.25-2.29
Phosphorus, ortho as P	10	.03	.04	.01-.16
Phosphorus, as P	9	.03	.01	.01-.05
Carbon, organic as C	2	2.5	2.1	1.0-4.0

PRECIPITATION AT FEDERAL BUILDING AT OCALA, FLORIDA

STATION NUMBER: 291119082082100 SITE LOCATION NUMBER: 21
PERIOD OF RECORD: January-December 1965, (Tritium July 1962-Nov 1977).
TYPE OF SAMPLE COLLECTOR: 2x5 foot fiberglass sheet funneled into a plastic bottle.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation collected after each event.

Parameter	Number of samples	Mean	Standard deviation	Range
Major inorganic constituents and related characteristics (Dissolved concentrations in milligrams per liter, except as indicated)				
Calcium (Ca)	70	2.4	2.2	0.5-11
Magnesium (Mg)	70	.1	.12	0-.7
Sodium (Na)	70	.5	.7	0-4.7
Potassium (K)	70	.1	.2	0-1.3
Bicarbonate (HCO_3)	69	6.1	5.2	1-27
Carbonate (CO_3)	69	0	0	0
Sulfate (SO_4)	70	1.2	1.7	0-9.2
Chloride (Cl)	70	.9	1.7	0-9.6
Fluoride (F)	70	.1	.1	.0-.3
Silica (SiO_2)	69	.3	.4	0-1.8
Hardness ($CaCO_3$)	70	6.3	5.7	1-30
Noncarbonate hardness	70	1.2	2.0	0-10
Specific conductance (µmho/cm at 25°C)	70	20	16	1-90
pH (units)	75	-	-	5.0-7.0
Solids (residue at 180°C)	71	9	8	3-47
Primary nutrients and related characteristics (Total concentrations in milligrams per liter, except as indicated)				
Nitrate as N	73	0.11	0.11	0-.50
Phosphorus, ortho as P	27	.06	.05	0-.16
Tritium, picocuries per liter	152	360	589	19-3,830
Selected trace elements (Total concentrations in micrograms per liter, except as indicated)				
Iron (Fe)	75	9	30	0-170

PRECIPITATION AT FEDERAL BUILDING AT OCALA, FLORIDA

STATION NUMBER: 291119082082101 SITE LOCATION NUMBER: 21
PERIOD OF RECORD: February-November 1965
TYPE OF SAMPLE COLLECTOR: 2x5 foot friberglass sheet, covered except for storm event. Funneled into plastic bottle.
SAMPLE COLLECTION AND PROCESSING: Wet precipitation, collected after each event.

Parameter	Number of samples	Mean	Standard deviation	Range
Major inorganic constituents and related characteristics (Dissolved concentrations in milligrams per liter, except as indicated)				
Calcium (Ca)	9	0.9	0.5	0.4-1.8
Magnesium (Mg)	9	.1	.1	0-.2
Sodium (Na)	9	.3	.21	.1-.8
Potassium (K)	9	.1	.05	0-.1
Bicarbonate (HCO_3)	9	3.7	1.7	1-6
Carbonate (CO_3)	9	0	0	0
Sulfate (SO_4)	9	.5	.8	0-2.4
Chloride (Cl)	9	.3	.4	0-1.0
Fluoride (F)	9	.1	.1	.0-.3
Silica (SiO_2)	9	.1	.3	0-1.0
Hardness ($CaCO_3$)	9	2.6	1.5	1-5
Noncarbonate hardness	9	0	0	0
Specific conductance (µmho/cm at 25°C)	9	11	6.1	4-24
pH (units)	12	-	-	5.6-6.7
Solids Sum	12	11	11	2-30
Primary nutrients and related characteristics (Total concentrations in milligrams per liter, except as indicated)				
Nitrate as N	12	0.16	0.26	0.00-.84
Phosphorus, ortho as P	4	.08	.10	.00-.21

PRECIPITATION AT BUCKMAN LOCK NEAR PALATKA, FLORIDA

STATION NUMBER: 293245081433600 SITE LOCATION NUMBER: 22
PERIOD OF RECORD: January-November 1975
TYPE OF SAMPLE COLLECTOR: Plastic funnel and bottle.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation, composited monthly.

Parameter	Number of samples	Mean	Standard deviation	Range
Major inorganic constituents and related characteristics (Dissolved concentrations in milligrams per liter, except as indicated)				
Chloride (Cl)	1	-	-	0.9
Hardness ($CaCO_3$)	1	-	-	42
Specific conductance (μmho/cm at 25°C)	1	-	-	21
Color (Pt-Co units)	1	-	-	5
Turbidity (JTU)	9	3	1	2-4
Primary nutrients and related characteristics (Total concentrations in milligrams per liter, except as indicated)				
Ammonia as N	10	0.48	0.28	0.18-1.1
Nitrite as N	11	.01	.01	.00-.02
Nitrate as N	10	.26	.13	.14-.59
Organic nitrogen as N	9	.44	.26	.01-.77
Nitrogen as N	9	1.2	.47	.34-1.88
Phosphorus, ortho as P	11	.06	.05	.00-.18
Phosphorus, as P	11	.07	.07	.01-.24
Carbon, organic as C	1	-	-	1.0

PRECIPITATION AT LIVE OAK, FLORIDA

STATION NUMBER: 301735082581800 SITE LOCATION NUMBER: 23
PERIOD OF RECORD: April 1975
TYPE OF SAMPLE COLLECTOR: Plastic bottle and funnel
SAMPLE COLLECTION AND PROCESSING: Composite of four samples of a single storm. Analyzed in USGS Mobile Laboratory within hours of collection.

Parameter	Number of samples	Mean	Standard deviation	Range
Major inorganic constituents and related characteristics (Dissolved concentrations in milligrams per liter, except as indicated)				
Chloride (Cl)	1	-	-	0.2
Specific conductance (µmho/cm at 25°C)	1	-	-	5
pH (units)	1	-	-	5.4
Color (Pt-Co units)	1	-	-	0
Turbidity (NTU)	1	-	-	1
Primary nutrients and related characteristics (Total concentrations in milligrams per liter, except as indicated)				
Ammonia as N	1	-	-	0.06
Nitrite as N	1	-	-	.01
Nitrate as N	1	-	-	.03
Organic nitrogen as N	1	-	-	.06
Nitrogen as N	1	-	-	.16
Phosphorus, ortho as P	1	-	-	.01
Phosphorus, as P	1	-	-	.01
Carbon, organic as C	1	-	-	2.3
Chemical oxygen demand (COD) (high level)	1	-	-	40

PRECIPITATION AT U.S. HIGHWAY 27 NORTH NEAR TALLAHASSEE, FLORIDA

STATION NUMBER: 303314084230304 SITE LOCATION NUMBER: 24
PERIOD OF RECORD: December 1977-March 1978
TYPE OF SAMPLE COLLECTOR: Plastic funnel and bottle.
SAMPLE COLLECTION AND PROCESSING: Bulk precipitation collected monthly.

Parameter	Number of samples	Mean	Standard deviation	Range
Major inorganic constituents and related characteristics (Dissolved concentrations in milligrams per liter, except as indicated)				
Sodium (Na)	5	0.6	0.5	0.1-1.2
Chloride (Cl)	5	1.2	.8	.1-2.1
Specific conductance (µmho/cm at 25°C)	5	22	4	18-25
Primary nutrients and related characteristics (Total concentrations in milligrams per liter, except as indicated)				
Ammonia as N	5	0.18	0.27	0.02-.66
Nitrite as N	5	.01	.01	.00-.01
Nitrate as N	5	.17	.09	.06-.31
Organic nitrogen as N	5	.14	.15	.00-.31
Nitrogen as N	5	.50	.44	.15-1.2
Phosphorus, as P	5	.03	.02	.01-.05
Carbon, organic as C	5	.8	1.1	.0-2.0
Selected trace elements (Total concentrations in micrograms per liter, except as indicated)				
Chromium (Cr)	5	<10	<10	<10-10
Copper (Cu)	5	4	2	1-6
Lead (Pb)	5	46	18	27-74
Mercury (Hg)	5	<.5	<.5	<.5-.5
Nickel (Ni)	5	5	3	2-10
Zinc (Zn)	5	10	10	10-30

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