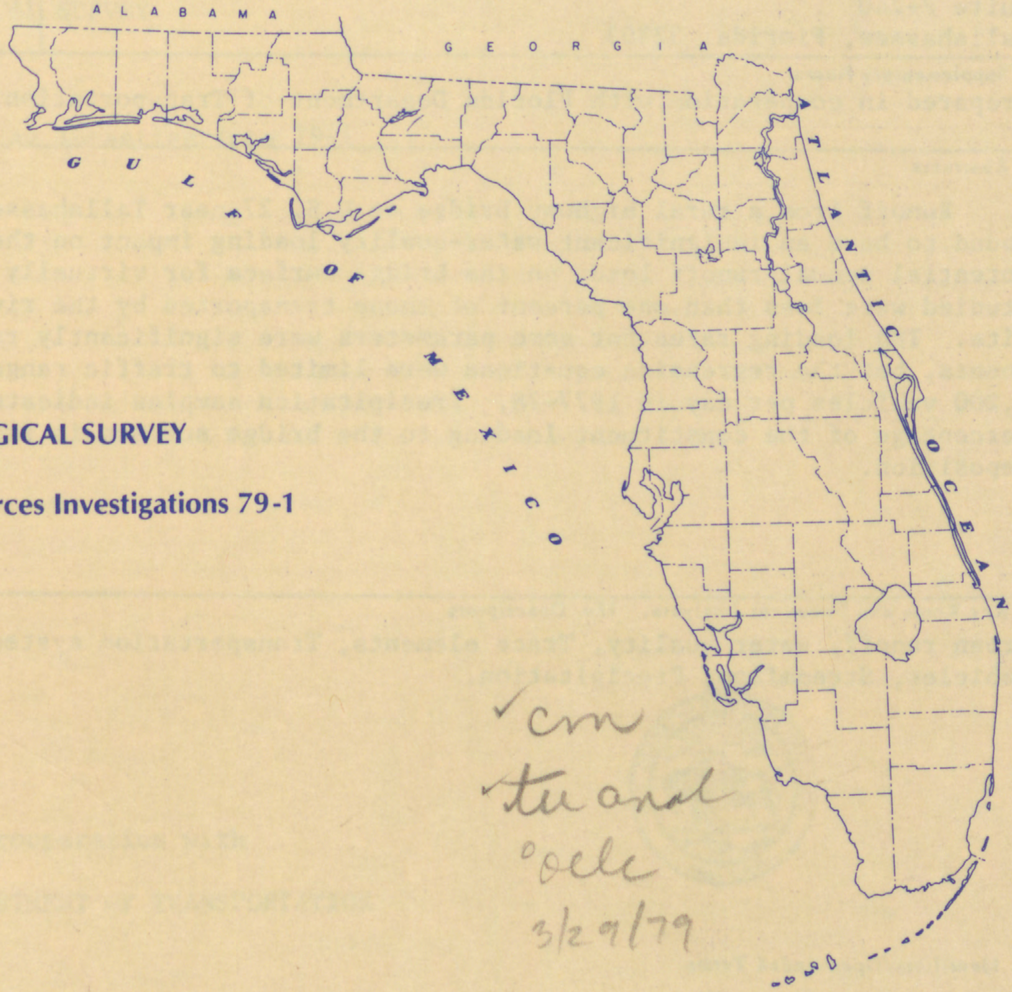
(200)
WRi
No. 79-1

WATER-QUALITY ASSESSMENT OF RUNOFF FROM A RURAL HIGHWAY BRIDGE NEAR TALLAHASSEE, FLORIDA



U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 79-1

3/29/79

Prepared in cooperation with
FLORIDA DEPARTMENT OF TRANSPORTATION

WRI 79-1 WATER-QUALITY ASSESSMENT OF RUNOFF FROM A RURAL HIGHWAY BRIDGE NEAR TALLAHASSEE, FLORIDA WRI 79-1

BIBLIOGRAPHIC DATA SHEET

1. Report No.	2.	3. Recipient's Accession No.

4. Title and Subtitle
WATER-QUALITY ASSESSMENT OF RUNOFF FROM A RURAL HIGHWAY BRIDGE NEAR TALLAHASSEE, FLORIDA

5. Report Date
January 1979

6.

7. Author(s)
G. A. Irwin and G. T. Losey

8. Performing Organization Rept. No. USGS/WRI 79-1

9. Performing Organization Name and Address
U. S. Geological Survey, Water Resources Division
325 John Knox Road
Suite F-240
Tallahassee, Florida 32303

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address
U. S. Geological Survey, Water Resources Division
325 John Knox Road
Suite F-240
Tallahassee, Florida 32303

13. Type of Report & Period Covered

14.

15. Supplementary Notes
Prepared in cooperation with Florida Department of Transportation.

16. Abstracts

Runoff from a rural highway bridge on U.S. 27 near Tallahassee, Florida, was found to have an insignificant water-quality loading impact on the Ochlockonee River. Potential annual-runoff loads on the bridge surface for virtually all constituents studied were less than one percent of those transported by the river at the study site. The loading rates for some parameters were significantly related to traffic counts, but the regression equations were limited to traffic ranges between 3,800 to 4,200 vehicles per day in 1977-78. Precipitation samples indicated that a significant percentage of the constituent loading to the bridge surface is from atmospheric deposition.

17. Key Words and Document Analysis. 17a. Descriptors
Urban runoff, Water quality, Trace elements, Transportation systems, Automative vehicles, Streamflow, Precipitation.

17b. Identifiers/Open-Ended Terms

Florida, Leon County, Gadsden County, Ochlockonee River, U.S. Highway 27.

17c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
No restriction on distribution.	UNCLASSIFIED	34
	20. Security Class (This Page)	22. Price
	UNCLASSIFIED	

WATER-QUALITY ASSESSMENT OF RUNOFF FROM A RURAL HIGHWAY BRIDGE NEAR TALLAHASSEE, FLORIDA

By G. A. Irwin and G. T. Losey

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 79-1

Prepared in cooperation with

FLORIDA DEPARTMENT OF TRANSPORTATION

1978

Dr
MPV
FO

UNITED STATES DEPARTMENT OF THE INTERIOR

CECIL D. ANDRUS, Secretary

GEOLOGICAL SURVEY

H. William Menard, Director

For additional information write to:

U.S. Geological Survey
325 John Knox Road
Suite F-240
Tallahassee, Florida 32303

CONTENTS

ILLUSTRATIONS

TABLES

For readers who may prefer to use metric (SI) units rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Inch-pound unit	By	To obtain metric (SI) unit
gallon (gal)	3.785	liter (L)
inch (in.)	2.540x10	millimeter (mm)
cubic foot per second (ft^3/s)	2.832×10^{-2}	cubic meter per second (m^3/s)
pound (lb)	4.535	kilogram (kg)
square foot (ft^2)	9.290×10^{-2}	square meter (m^2)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
ton (short)	0.907	megagram (Mg)

WATER-QUALITY ASSESSMENT OF RUNOFF FROM A RURAL HIGHWAY BRIDGE NEAR TALLAHASSEE, FLORIDA

By G. A. Irwin and G. T. Losey

ABSTRACT

Runoff from a rural highway bridge on U.S. 27 near Tallahassee, Florida, was found to have a small water-quality loading impact on the Ochlockonee River. Potential annual-runoff loads on the bridge surface for virtually all constituents studied were far less than 1 percent of those transported by the river at the study site. The loading rates for some parameters were significantly related to traffic counts, but the regression equations were limited to traffic ranges between 3,800 to 4,200 vehicles per day in 1977-78. Precipitation samples indicated that a significant percentage of the constituent loading to the bridge surface is from atmospheric deposition.

INTRODUCTION

The adverse impact on the hydrologic environment caused by chemical contaminants which accompany urbanization has caused national and worldwide concern. Within the last decade extensive research has revealed that urban runoff may cause a variety of severe water-quality problems. In particular, roadways have been shown to be a significant urban loading source for many undesirable chemical and physical constituents.

In recent years the rapid population growth in Florida has naturally resulted in an expansion of the State's transportation system. Presently, there are several thousand roadway bridges crossing Florida's myriad waterways. These structures range from large systems such as the Skyway Bridge crossing Tampa Bay or the Matthews Bridge in Jacksonville to small rural bridges. Traffic density per day on these bridges range from tens of thousands of vehicles to perhaps only a few hundred vehicles.

Roadway construction has long been recognized as a potential source of adverse environmental impact upon hydrologic systems and as such is closely monitored. Fortunately, much of the undesirable impact has been minimized through legislation and modern construction technology. In the past most attention has been focused on environmental preservation during active road and bridge construction. It was not until very recently, however, that any particular concern was given to the possible environmental impact of bridges after construction.

Recent studies have shown that roadways, including bridges, may act as depositories for significant quantities of toxic materials and these materials may be transported to receiving waters during storm runoff events. Because of the great number of bridges in Florida which pass directly over open waterways, State agencies have expressed some concern regarding the quality and quantity of material deposited on and subsequently transported from bridge surfaces to State waters.

PURPOSE AND SCOPE

The Florida Department of Transportation, having particular interest in the ecological impacts of roadways and bridges, and the U.S. Geological Survey, having similar interests, participated in a cooperative reconnaissance investigation to assess the chemical loading and potential water-quality impact of runoff from rural bridges. A rural site was selected because most of Florida's bridges are in rural areas and because very limited data are available in nonurbanized areas. Project planning was begun during spring 1977 and field data collection began in September 1977. The scope of the study included sampling and analyses of selected water-quality parameters in water washed from the bridge surface after selected antecedent dry periods and traffic counts. Samples of the river water, bottom material, and bulk precipitation were also collected for comparative purposes in an attempt to both regionalize and to estimate the overall environmental impact of bridge runoff on the river quality.

PREVIOUS STUDIES

Many materials common to the urban setting contribute substantially to water-quality degradation. For example, a study by Vitale and Sprey, 1974, reported that between 40 and 80 percent of the total annual load of oxygen-demanding materials entering receiving waters from a city is caused by sources other than the sewage-treatment plant. Further, during a single storm event about 94 to 99 percent of the total oxygen demand load is contributed by sewer overflows, storm sewers, and street runoff. Similarily, suspended sediments are attributable almost entirely to sewer overflow, storm sewers, and street runoff.

Vitale and Sprey, 1974, also reported that urban stormwater runoff is a significant source of nutrients, namely nitrogen and phosphorus. Urban runoff usually contributes less than 10 percent of the annual nutrient load as sewage contributes most of the nitrogen and phosphorus. However, nutrients in stormwater runoff dominate all other sources during a particular runoff event. Thus, stormwater is a very significant nutrient source with regard to a "shock loading" to an aquatic system.

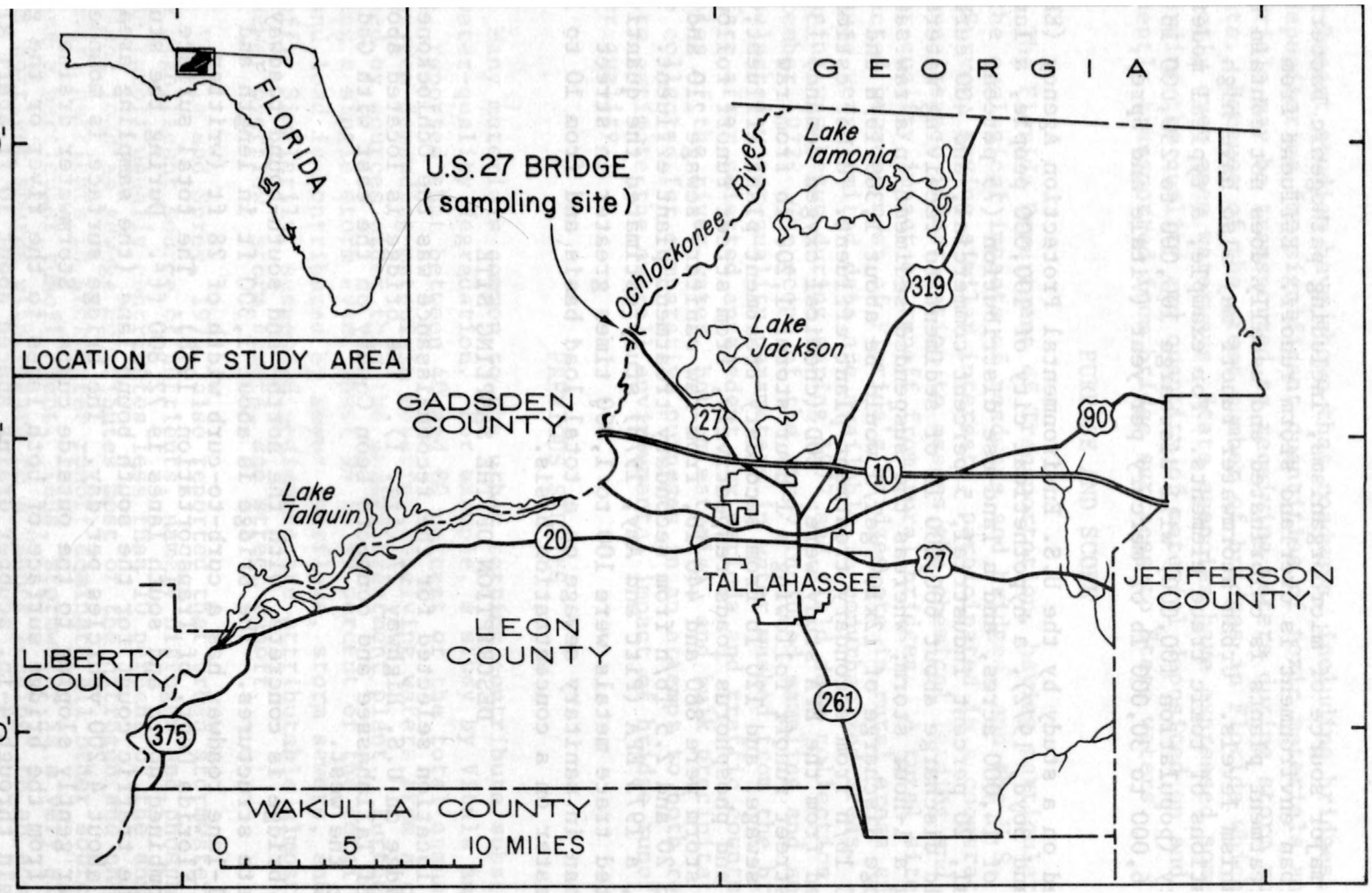
The major source of microorganisms, including pathogenic bacteria, in the urban environment is overland storm runoff. Effluent from sewage-treatment plants is chlorinated and usually does not contain high microorganism levels. Urban stormwater runoff may also have high concentrations of toxic trace elements. For example, a typical moderate sized city (population 100,000) will discharge 100,000 to 250,000 lb of lead and 6,000 to 30,000 lb of mercury per year (Vitale and Sprey, 1974).

Based on a study by the U.S. Environmental Protection Agency (EPA) (Sartor and Boyd, 1972), a hypothetical city of 100,000 people, a land-use area of 14,000 acres, and a land-use distribution (75 percent residental, 20 percent industrial, 5 percent commercial, and 400 curb mi), would discharge about 600,000 lb of sediment to receiving waters following a 1-hour storm; whereas the suspended sediment in a raw sanitary sewage discharge of 12×10^6 gal/d would be about 1,300 lb/h and about 130 lb/h from secondary treatment plant effluent. Other estimates determined from the EPA study were: COD (chemical oxygen demand) 13,000 lb from street runoff following a 1-hour storm, 1,200 lb from raw sanitary sewage, and 120 lb from secondary treatment plant effluent; nitrogen and phosphorus loads respectively, from street runoff following a 1-hour storm were 880 and 440 lb, from raw sanitary sewage 210 and 50 lb/h, and 20 and 2.5 lb/h from secondary treatment plant effluent. In addition, a 1973 EPA (Pitt and Amy, 1973) study estimated the quantity of selected trace metals were 100 to 1,000 times greater in street runoff than in sanitary sewage on a total load basis and from 10 to 100 times greater on a concentration basis.

DESCRIPTION OF THE SAMPLING SITE

The location selected for the reconnaissance was the Ochlockonee River Bridge on U.S. Highway 27 (fig. 1). The bridge is located about 7 mi west of Tallahassee and connects Leon County on the east with Gadsden County on the west.

The bridge is concrete, with the north- and south-bound roadways on separate structures. The bridge is about 1,300 ft in length and each dual-lane roadway has a curb-to-curb width of 28 ft (written commun., Florida Dept. of Transportation, 1978). The total surface area of the combined north and south lanes is 72,800 ft^2. During the study period the traffic count for the south bound lane (the sampling area) averaged about 4,200 vehicles per day. The bridge surface is mounded in the center gently sloping to the outside curbs. Stormwater drains directly from the bridge surface of both lanes to the river or the grassy flood plain through 4-in. scupper drains spaced about 10 ft apart along the curbs.


GEORGIA
FLORIDA
LOCATION OF STUDY AREA
U.S. 27 BRIDGE
(sampling site)
Ochlockonee River
Lake Iamonia
Lake Jackson
Lake Talquin
GADSDEN COUNTY
LEON COUNTY
JEFFERSON COUNTY
LIBERTY COUNTY
WAKULLA COUNTY
TALLAHASSEE
30°40'
30°30'
30°20'
319
27
90
10
20
27
261
375
0 5 10 MILES

At the sampling site the Ochlockonee River, which heads in Georgia, is about 68 mi in length above the gage and has a drainage area of 1,140 mi^2. The 50-year average river discharge at the bridge is 1,028 ft^3/s based on data obtained at the Geological Survey gaging station (02329000) located on the downstream side of the bridge. The site is also a water quality sampling station in the National Stream Quality Accounting Network (NASQAN) of the U.S. Geological Survey.

DESCRIPTION OF VARIABLES

Previous investigations, Sartor and Boyd, 1972, Shaheen, 1975, and Lager and others, 1977, have identified seven general categories of chemical substances that are usually associated with street surface contamination: (1) suspended solids, (2) oxygen-demanding material, (3) primary nutrients, (4) bacteria, (5) trace metals, (6) pesticides, and (7) petroleum products. The material deposited at any given street location, however, will be a composite of several factors. The actual composition is a function of such factors as land use, geographical locale, season, weather, traffic volume, and local public work practices (Sartor and Boyd, 1972).

Suspended Solids

Samples for suspended solids and turbidity were collected during the study and are a measure of the particulate matter found on road surfaces. These solids generally consist of inert minerals of various types and primarily reflect the components of paving compounds and local soil types. If in sufficient quantities, the solids discharged from roads will have a direct pollutional impact of reduced water clarity and physical damage or burial of aquatic organisms. In addition, solids can have an indirect pollutional impact by acting as a mobile substrate on which toxic materials may sorb and may be biochemically released into the aquatic environment at some later time.

Oxygen Demand

One of the most adverse impacts that a material can have on a receiving water is to depress the dissolved-oxygen level. Oxygen-demanding materials can deplete the concentration of oxygen resulting in highly undesirable conditions such as fish kills, odor, and anaerobic bacterial slime growths. Specific analyses made during this study to estimate the potential oxygen demand were biochemical oxygen demand (BOD) and chemical oxygen demand (COD).

Primary Nutrients

There are numerous essential plant nutrients, but during this study the nutrient sampling focused mainly on carbon, nitrogen, and phosphorus. Samples were collected for total concentrations of ammonia, nitrite, nitrate, organic nitrogen, phosphorus, and organic carbon.

Bacteria

Indicator bacteria, namely fecal coliform and fecal streptococcus, were not determined routinely during the study. Fecal bacteria were not considered a significant pollutional factor at this particular site because the site is mainly affected by traffic, local soil types, and bulk precipitation. However, a limited sampling for the indicator bacteria was made during the latter phase of the study.

Trace Elements

Samples were collected for total metals including chromium, copper, lead, mercury, nickel, and zinc. These metals have been reported to be traffic related and known to be toxic to organisms in the aquatic environment.

Pesticides

Pesticides were not monitored during the study because pesticide use is not widespread in this area nor are they directly related to traffic.

Petroleum Products

Analyses for the presence of oil and grease were made as a general indicator of vehicular leakage of fuel, lubricants, hydraulic fluids, and coolants.

Major Inorganic Constituents

Analyses of specific conductance, sodium, and chloride were made in order to determine the general inorganic composition of the runoff water. Chloride is also a general indicator of roadway abrasion. (Shaheen, 1975).

METHODS AND PROCEDURES

Analytical Methods

Water samples collected during the investigation were analyzed by the U.S. Geological Survey Central Laboratory in Doraville, Georgia, and by the District Water Quality Service Unit in Ocala, Florida.

Nitrogen compounds, phosphorus, BOD, COD, total organic carbon, turbidity, and suspended solids were analyzed in the Ocala laboratory. Total chromium, total copper, total lead, total mercury, total nickel, total zinc, and oil and grease were analyzed in the Doraville laboratory. Determinations of water temperature, pH, specific conductance, and bacteria were performed in the field at the time of sampling. The analytical methods used are those prescribed by Brown, Skougstad, and Fishman, 1970, Goerlitz and Brown, 1972, and Fishman and Brown, 1976.

Procedures for Sample Collection

The method used to estimate the quality and quantity of the traffic related deposition on the bridge surface was to sample simulated storm runoff from a known area of the bridge as a function of a known antecedent dry period and traffic count. Thus, constituent loads deposited on the bridge surface could be evaluated as a function of both exposure time and number of vehicles.

Prior to each test period (interval of deposition) the outside south bound lane was blocked to traffic and the bridge surface was throughly washed using a Florida Department of Transportation water truck. Analyses of the wash water are given in table 1. This was done to clear out the scupper drains and rinse the bridge surface of any accumulated deposition. After the south lane was thoroughly cleaned, traffic counters were set, and the lane was reopened to traffic. After about 7 days of exposure or about 25,000 to 30,000 vehicles, the outside south bound lane was blocked to traffic and sample collection was conducted. If a precipitation event in excess of a few hundredths of an in. occurred during a test period the bridge was rewashed, traffic counters reset, and the test period was started again. The testing period was restarted because the amount of deposited material which may have been removed by the precipitation-runoff event during the test interval was unknown.

The simulated bridge runoff samples were collected at the scupper drains which are located about 10 ft apart at the curb along the downstream side of the south bound lane. The scupper sampling points were selected to represent different parts of the bridge and were located near the gaging station about 200 ft from the south end of the bridge (site 1), about midspan (site 2), and about 10 feet from the north end of the bridge (site 3).

A 2- by 14-ft area of the bridge surface was sampled at each site during each of the simulated runoff sampling events. This 28-ft^2 area enclosed a 2-ft section of bridge surface from the center line to the curb. These 28-ft^2 areas were delineated using a 2- by 14-ft wooden frame constructed of 2- by 4-in. dimension stock placed on the bridge surface and sealed to prevent leakage using neoprene rubber stripping and plastic tape. A 4-in. PVC (polyvinyl chloride) sampling pipe was attached to the scupper drain contained within the sampling area. The PVC sampling pipe was reduced and divided by two 1/2 in. garden hose outlets with control valves on each outlet. These hoses were placed into 5-gal polyethylene jugs for sample collection with no loss of sample.

Table 1.--Analyses of wash water and water used for simulated runoff

[Concentrations in milligrams per liter, except as indicated]

Parameter	Deionized water: Number of samples	Deionized water: Range	Truck wash water: Number of samples	Truck wash water: Range
Specific conductance (umho/cm at 25°C)	2	1-2	--	--
Sodium (Na)	2	0	1	2.7
Chloride (Cl)	2	0	1	5.2
Suspended solids	1	0	1	5
Turbidity (JTU)	2	1	1	1
Oil and grease	1	0	1	0
Ammonia, total as N	2	0.00-.01	1	0.00
Nitrite, total as N	2	.00	1	.00
Nitrate, total as N	2	.00	1	.37
Organic nitrogen, total as N	2	.00	1	.00
Nitrogen, total as N	2	.00	1	.37
Phosphorus, total as P	2	.01	1	.04
Total organic carbon	1	0	1	2.0
Biochemical oxygen demand (BOD)	2	.3-.4	1	.2
Total chromium (Cr)[1]	2	<10-20	1	10
Total copper (Cu)[1]	3	2-6	1	6
Total lead (Pb)[1]	3	7-11	1	15
Total mercury (Hg)[1]	2	<.5	1	<.5
Total nickel (Ni)[1]	3	7-10	1	5
Total zinc (Zn)[1]	2	10-20	1	70

[1] Concentrations in micrograms per liter.

Once the 2- by 14-ft frame and scupper sampling apparatus were in place, the bridge surface inside the frame was washed with 10 gal of deionized water. Ten gallons added to the 28-ft^2 bridge surface is equivalent to 0.57 in. of runoff. The deionized wash water was then agitated across the sampling section with a stiff bristle push broom through the scupper into the collection container. Analyses of the deionized wash water are given in table 1. Pumps were initially used at a few sites. They were found to be generally unsatisfactory with regard to volume rate and agitation when compared to the push broom. The broom-sweeping method of sampling has been widely used by the EPA for similar studies. At least by visual inspection the push broom agitation removed essentially all deposited material from the sample area.

All the wash water (10 gal) from each sampling was collected with the exception of minor leakage from the frame. The two 5-gal jugs used to collect the wash water were filled simultaneously to assure that a representative sample was collected. One of the 5-gal sample containers was well mixed and transferred into a churn sample splitter for subsampling. The remaining 5-gal jug was used as a reserve sample and after subsampling was completed the excess sample was discarded.

After the three 28-ft bridge sections were sampled, the equipment was removed from the bridge and the entire bridge surface was washed using the tank truck. Approximately 5,000 gal of wash water were applied to the entire bridge surface of the south bound lane. While the scuppers were draining this wash water, a composite sample of the river water was collected. River samples were also collected before and after the truck wash. This sampling was conducted in the attempt to estimate the impact of bridge deposition on the quality of the river. Water samples collected in the river were depth integrated and composited from sampling sites immediately downstream of the scupper sampling sites 1, 2, and 3. About five verticals were sampled.

Bulk precipitation samples were collected in a 5-gal polyethylene bottle attached to a 3-ft^2 plastic funnel apparatus. Precipitation data were collected to estimate atmospheric loading rates. The sampler was located on a knoll about 3,000 ft south of the bridge, 450 ft east of Highway 27.

Bottom material samples were collected using a Ponar[1/] grab sampler. Samples were taken at approximately mid-stream sites 200 ft upstream of the bridge and 30, 200, and 1,200 ft downstream of the bridge.

1/ Any use of trade names and trademarks in this publication is for descriptive purposes only and does not constitute endorsement by the U.S. Geological Survey.

Water Sample Preservation

Water samples for the determination of BOD, total concentrations of ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, organic nitrogen, and phosphorus were collected in polyethylene bottles and chilled to 4°C. Samples for COD analyses were collected in polyethlene bottles and acidified with sulfuric acid to a pH of less than 2. Total organic carbon samples were collected in glass vials and chilled to 4°C. Water samples for total chromium, copper, lead, mercury, nickel, sodium, and zinc were collected in acid-washed polyethylene bottles and acidified with concentrated nitric acid to a pH of less than 2. Suspended sediment, turbidity, chloride, specific conductance, pH, and bacteria samples were not treated. Oil and grease samples were collected in pretreated glass bottles and acidified with 2.5 mL (milliliters) of sulfuric acid per 500 mL of sample. Bottom material samples were not treated.

Water samples were shipped to the Doraville and Ocala laboratories for analyses, usually on the day of collection.

Frequency of Sample Collection

The sampling program began during October 1977 and continued periodically until March 1978. Five simulated bridge runoff events were sampled. Three river samplings were conducted before, during, and after runoff. Five bulk precipitation samples were collected during the investigation. One sampling of the bottom material was made on April 6, 1978.

RESULTS

Runoff from U.S. Highway 27-Ochlockonee River Bridge

The analytical results of the deionized wash-water bridge runoff samples are summarized in table 2. (Note: The deionized water used to wash the bridge surface contained detectable traces of ammonia, phosphorus, chromium, copper, lead, nickel, zinc, and biochemical oxygen demand--see table 1). Most of the parameter concentrations in the wash water bridge runoff were quite variable among the three sites. However, when concentrations were statistically evaluated most were not found significantly different at the 5 percent probability level. Thus, for the summary, the data from sites 1, 2, and 3 were combined.

The specific conductance of the bridge runoff samples ranged from 8 to 64 micromhos and averaged 28 micromhos. Suspended solids concentrations averaged 99 mg/L (milligrams per liter) with an average turbidity of 40 JTU (Jackson turbidity units). The average total organic carbon concentration was 6.0 mg/L. The organic material present on the bridge surface had a slight oxygen demand. The average BOD was 3.7 mg/L and two samples had concentrations of 8.0 mg/L. One set of samples,

Table 2.--Summary of selected chemical and physical runoff data, using deionized water, collected at U.S. Highway 27-Ochlockonee River Bridge scupper drain sampling sites 1-3 from October 1977 through March 1978

[Concentrations in milligrams per liter, except as indicated]

Parameter	Number of samples	Mean	Standard deviation	Range
Specific conductance (umho/cm at 25°C)	15	28	16	8-64
Sodium (Na)	15	0.3	0.1	0.2-.4
Chloride (Cl)	15	.5	.2	.2-.9
Suspended solids	12	99	73	21-278
Turbidity (JTU)	15	40	30	4-100
Oil and grease	15	.7	.9	.0-3.0
Ammonia, total as N	15	.04	.03	.00-.11
Nitrite, total as N	15	.02	.01	.00-.03
Nitrate, total as N	15	.07	.02	.04-.12
Organic nitrogen, total as N	15	1.1	.85	.06-3.4
Nitrogen, total as N	15	1.2	.87	.12-3.5
Phosphorus, total as P	15	.15	.10	.01-.30
Total organic carbon	15	6.0	5.5	.0-23
Biochemical oxygen demand (BOD)	15	3.7	2.2	.6-8.0
Total chromium (Cr)[1]	15	([2])		< 10-30
Total copper (Cu)[1]	15	32	51	6-210
Total lead (Pb)[1]	15	210	170	16-620
Total mercury (Hg)[1]	15	([2])	--	< .5-.5
Total nickel (Ni)[1]	15	8	3	3-14
Total zinc (Zn)[1]	15	130	90	20-340
Chemical oxygen demand (COD)	3	51	--	36-64

1 Concentrations in micrograms per liter.
2 Some concentrations were below the analytical detection limit.

collected March 1978, was analyzed for COD; the average COD concentration was 51 mg/L and ranged from 36 to 64 mg/L.

Total nitrogen averaged 1.2 mg/L and ranged in concentration from 0.12 to 3.5 mg/L. Organic nitrogen was the dominant form averaging 92 percent of the total nitrogen. Oil and grease averaged 0.7 mg/L and ranged in concentration from 0.0 to 3.0 mg/L. While it was the intent to use the oil and grease data to estimate the general magnitude of petroleum products, it was ascertained that the occurrence of natural plant oils and animal fats also indicate positive results using the Freon extraction method (written commun., D. E. Erdmann and A. C. Watterson, March 28, 1978). Thus, in this report the oil and grease data do not indicate solely the presence of commerical petroleum products.

During March 1978 water samples were collected for fecal coliform bacteria at each of the scupper-drain sites. Small populations of coliform bacteria were detected at two sites with a maximum of 33 colonies per 100 mL at site 1.

Of the trace metals analyzed, lead and zinc were detected in the highest concentrations averaging 210 and 130 ug/L (micrograms per liter) (table 2). One sample had a copper concentration of 210 ug/L, but the average copper concentration was only 32 ug/L. By contrast, average chromium and nickel concentrations were very low with respective maximum concentrations of 30 and 14 ug/L, and mercury was virtually undetected.

Estimated Accumulation Rates of Selected Chemical and Physical Parameters Per Curb Mile for U.S. Highway 27-Ochlockonee River Bridge and Major U.S. City Streets

The loading rates of selected parameters were computed from data collected at the Ochlockonee River Bridge and compared with similar data collected by Sartor and Boyd, 1972, and Pitt and Amy, 1973. The comparisons are summarized in table 3.

It is interesting to note that for most parameters the loading rates in pounds per day for the Ochlockonee River Bridge site are about the same as the lower range concentrations reported in the study of major U.S. cities (Sartor and Boyd, 1972) as shown below:

Parameter	Ochlockonee River Bridge (lb/mi)/d	Major U.S. cities (lb/mi)/d	
Total nitrogen	0.081	0.073	Baltimore, Md; Tulsa, Okla.
Total phosphorus	.010	.018	Phoenix, Ariz.
BOD	.249	.33	Phoenix, Ariz.
Total lead	.014	.012	Seattle, Wash.
Total copper	.0024	.0036	Tulsa, Okla.

[In pounds per curb mile per day]

Parameter	U.S. Highway 27, Florida		10 Major U.S. city streets[1]		San Francisco Bay Area, California[2]		
					City streets	Rural roads	Highways
	Mean	Range	Mean	Range	Mean	Mean	Mean
Biochemical oxygen demand (BOD)	0.249	0.151-.446	2.1	0.33-12	2.6	0.48	3.0
Total nitrogen	.081	.019-.132	.30	.073-1.4	.48	.16	.84
Total phosphorus	.010	.002-.017	.090	.018-.76	.22	.60	.26
Suspended solids	6.5	4.0-11.5	400	30-2,700	--	--	--
Total chromium	<.0008	<.0008-.0012	.018	.0001-.055	.046	.068	.24
Total copper	.0024	.0008-.0060	.086	.0003-.590	.026	.012	.052
Total lead	.0142	.0038-.0282	.220	.0033-1.5	.332	.020	.630
Total mercury	<.0001	<.0001-.0001	.0065	.0007-.021	--	--	--
Total nickel	.0005	.0002-.0006	.0078	.0012-.032	.008	.032	.140
Total zinc	.0090	.0068-.012	.3000	.0047-2.1	.082	.022	.250

The results of the current study and the results of a street runoff study by Pitt and Amy, 1973, in the San Francisco Bay area, California, also indicated a similarity in the magnitudes of loading rates for some parameters. For example, the maximum loading rates for BOD, nitrogen, copper, lead, and zinc from the Ochlockonee River Bridge site are of about the same magnitude as were the average loading rates for rural roads in the San Francisco Bay area.

The average loading rates reported for most parameters in both the 1972 and 1973 studies were generally higher than those found for the Ochlockonee River Bridge. For the Sartor and Boyd (1972) study, the streets sampled were located in densely urbanized areas having high traffic volumes. As for the Pitt and Amy (1973) study, the street surface exposure time was not accurately documented and the experimental design was not highly controlled with regard to time; thus, the accuracy of study results cannot be precisely assessed. However, the data are felt to be adequate for a general comparison with the current study.

The most noticeable contrast between the Ochlockonee River bridge study and the study conducted by Sartor and Boyd (1972), was in the loading rates of suspended solids. The average loading rate of 6.5 (lb/mi)/d for the Ochlockonee River Bridge was significantly lower than the 400 (lb/mi)/d average loading rate found during the study of major U.S. cities (Sartor and Boyd, 1972). In reviewing the suspended solids data from the 1972 study; however, it was determined that the average suspended solids loading rate was greatly influenced by the very high loading rate of 2,700 (lb/mi)/d for Milwaukee, Wisconsin. By deleting the Milwaukee loading rate from the statistic, the average loading rate for the remaining nine cities became 142 (lb/mi)/d. Thus, the average suspended solids loading rate for the Ochlockonee River site was about 5 percent of that found for the average for the major cities. The average loading rates for all the bridge site parameters ranged from 3 to 27 percent of the average loading rates for the 10 major U.S. cities.

Regression Analysis of Parameter Loading Rates and Vehicular Volume

In the attempt to determine if significant correlations existed between the concentrations of individual sampling events and traffic volumes a series of regression analyses were made. Traffic volume was designated as the independent variable and the parameter concentration as the dependent variable. Results of these regression analyses, namely the regression correlation coefficient and the percentage of explained variance, are given in figure 2.

The explained variance, as shown in figure 2, is the percentage of concentration variance (dependent variable) that is accounted for by the variation in traffic volume (independent variable). The percentage of explained variance is the square of the correlation coefficient.

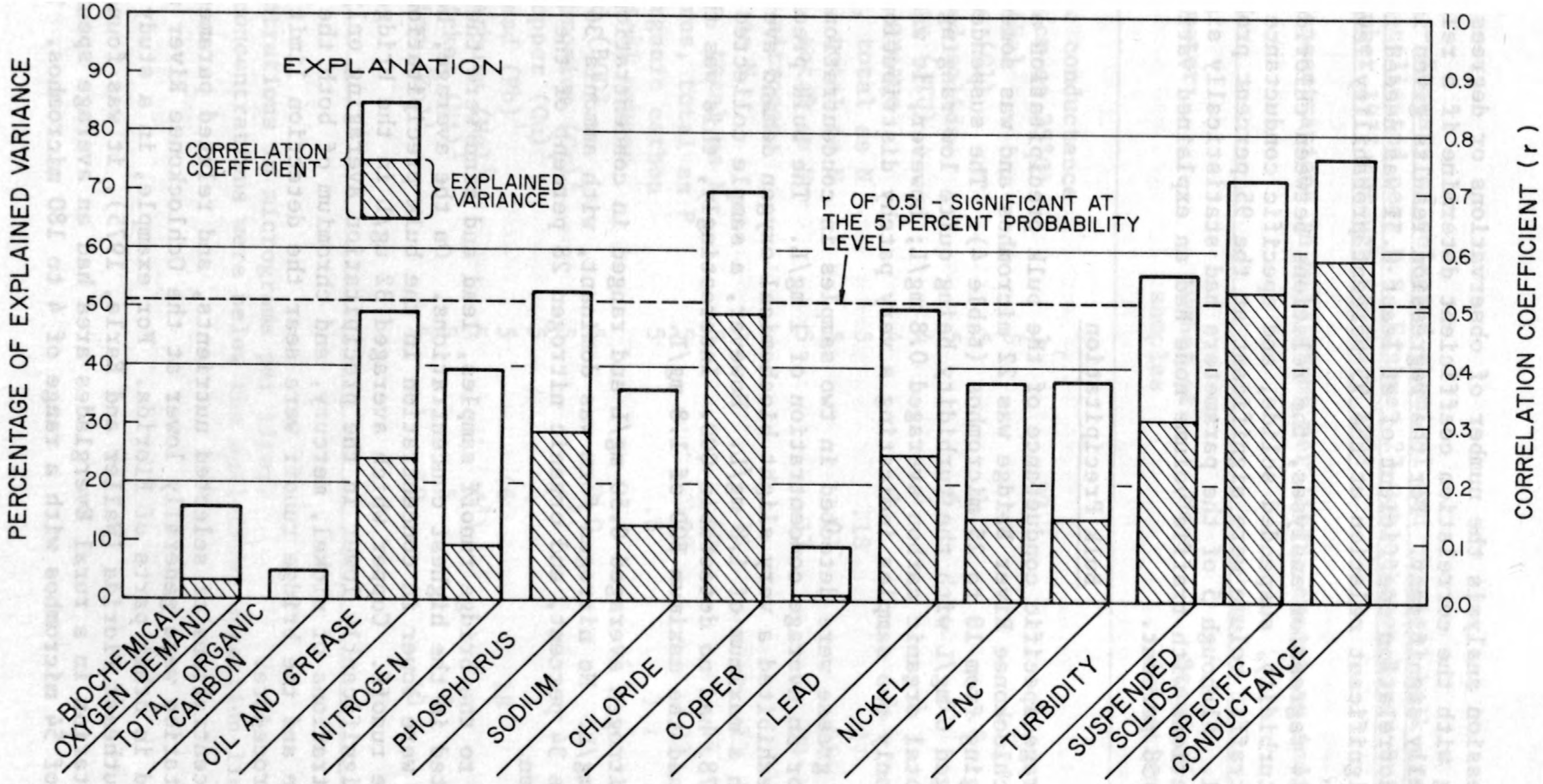


Figure 2.--Percentage of explained variances and correlation coefficients for loads of selected parameters on the bridge surface as a function of traffic volume.

In regression analysis the number of observations or degrees of freedom along with the correlation coefficient determine if a relation is statistically significant. For the regression results given in figure 2, a correlation coefficient of at least 0.51 was needed to indicate a significant relation at the 95 percent probability level.

Of the 14 regression analyses, the relations between chloride, phosphorus, turbidity, suspended solids, and specific conductance as a function of traffic volume were significant at the 95 percent probability level. Although 5 of the parameters had statistically significant relations with traffic volume none had an explained variance greater than 58 percent.

Bulk Precipitation

The average specific conductance of the bulk precipitation at U.S. Highway 27-Ochlockonee River Bridge was 22 micromhos and was somewhat variable ranging from 18 to 25 micromhos (table 4). The suspended solids averaged 6 mg/L with the turbidity being quite low ranging from 1 to 7 JTU. Total organic carbon averaged 0.8 mg/L; however, it was detected in only two samples indicating a very patchy distribution.

Oil and grease were detected in two samples in concentrations of 1 and 3 mg/L for an average concentration of 1 mg/L. The bulk precipitation also exhibited a very slight biochemical oxygen demand averaging 1.0 mg/L with a maximum of 1.8 mg/L. However, a sample collected on March 21, 1978, had no detectable COD. Interestingly, this was the same sample that had the maximum BOD of 1.8 mg/L.

Total nitrogen averaged 0.50 mg/L and ranged in concentration from 0.15 to 1.2 mg/L. No nitrogen form was dominant, with ammonia 36 percent, nitrate 34 percent, and organic nitrogen 28 percent of the average total nitrogen.

Similar to the bridge runoff samples, lead and zinc were the trace metals detected in the highest concentrations. On the average, however, these metals were lower in concentration in the bulk precipitation than in the bridge runoff. Copper which averaged 32 ug/L in the bridge runoff was significantly lower in the precipitation averaging only 4 ug/L. Concentrations of nickel, mercury, and chromium of both the bulk precipitation and the bridge runoff were near the detection limit of the analytical procedure.

The concentrations of selected nutrients, and related parameters in bulk precipitation were generally lower at the Ochlockonee River site than reported in other parts of Florida. For example, in a study conducted in southeast Florida (Waller and Earle, 1975), it was found that bulk precipitation in a rural Everglades area had an average specific conductance of 54 micromhos with a range of 4 to 180 micromhos. The

Table 4.--Summary of selected chemical and physical bulk precipitation data collected near U.S. Highway 27-Ochlockonee River Bridge from December 1977 through February 1978

[Concentrations in milligrams per liter, except as indicated]

Parameter	Number of samples	Mean	Standard deviation	Range
Specific conductance (umho/cm at 25°C)	3	22	4	18-25
Sodium (Na)	5	.6	.5	.1-1.2
Chloride (Cl)	5	1.2	.8	.1-2.1
Suspended solids	5	6	6	0-16
Turbidity (JTU)	4	4	3	1-7
Oil and grease	4	1	1.4	0-3
Ammonia, total as N	5	.18	.27	.02-.66
Nitrite, total as N	5	.01	.01	.00-.01
Nitrate, total as N	5	.17	.09	.06-.31
Organic nitrogen, total as N	5	.14	.15	.00-.31
Nitrogen, total as N	5	.50	.44	.15-1.2
Phosphorus, total as P	5	.03	.02	.01-.05
Total organic carbon	5	.8	1.1	.00-2.0
Biochemical oxygen demand (BOD)	5	1.0	.5	.4-1.8
Total chromium (Cr)[1]	5	([2])	--	< 10-10
Total copper (Cu)[1]	5	4	2	1-6
Total lead (Pb)[1]	5	46	18	27-74
Total mercury (Hg)[1]	5	([2])	--	< .5-.5
Total nickel (Ni)[1]	5	5	3	2-10
Total zinc (Zn)[1]	5	10	10	10-30

[1] Concentrations in micrograms per liter.
[2] Some concentrations were below the analytical detection limit.

specific conductance at the Everglades site, on the average, was two times the conductance observed for the bulk precipitation at the Ochlockonee River site. Total nitrogen at the Everglades site averaged 1.79 mg/L and total phosphorus averaged 0.07 mg/L. For bulk precipitation in north-central Florida, Lamonds and Merritt (1976) reported an average total nitrogen of 0.91 mg/L and phosphorus of 0.05 mg/L. On the average, bulk precipitation nitrogen was four times greater at the Everglades site and two times greater in central Florida than at the Ochlockonee River site. Similarly, total phosphorus was about two times higher at the Everglades site and in central Florida than at the Ochlockonee River site. The average total organic carbon at the Everglades site was 3.1 mg/L ranging from 0.0 to 7.5 mg/L and averaged about four times that observed during the current study.

Bulk precipitation concentrations of selected trace elements between the southeastern Everglades site and the Ochlockonee River site did not indicate any real difference as did the above mentioned parameters. Chromium, copper, and mercury concentrations were about the same between the sites. At the Everglades site, chromium averaged 10 ug/L ranging from 0 to 10 ug/L, copper averaged 3 ug/L ranging from 0 to 6 ug/L, and mercury averaged 0.1 ug/L ranging from 0.0 to 0.2 ug/L. However, lead averaged 11 ug/L at the Everglades site, but averaged 46 ug/L or four times greater at the Ochlockonee River site. Yet zinc at the Everglades site averaged 99 ug/L or 10 times greater than at the Ochlockonee River site. The higher lead concentration at the Ochlockonee River site can perhaps be attributed to vehicular emissions from the nearby highway, but the reason for the contrast in the zinc concentrations between the sites is not obvious.

Ochlockonee River

Results of analyses of the Ochlockonee River near Havana (U.S. Highway 27-Ochlockonee River Bridge) are summarized in table 5. This summary includes both the data collected specifically for this study and as part of the National Stream Quality Accounting Network (NASQAN) program.

The Ochlockonee River is sodium chloride in water type with an average specific conductance of 215 micromhos and dissolved solids of 107 mg/L. The concentration of suspended solids averaged 12 mg/L, and were not highly variable, ranging only from 5 to 20 mg/L. The river is somewhat turbid averaging 13 JTU with a maximum turbidity of 40 JTU.

Total organic carbon averaged 8.8 mg/L and ranged from 5.0 to 13 mg/L. The average oil and grease concentration of the Ochlockonee River was 0.3 mg/L; however, of the 9 samples collected only 2 had detectable concentrations. The BOD in the river was quite low averaging 0.8 and ranging from 0.2 to 1.2 mg/L.

Table 5.--Summary of selected chemical and physical data collected at the Ochlockonee River near Havana (02329000) from October 1976 through December 1977

[Concentrations in milligrams per liter, except as indicated]

Parameter	Number of samples	Mean	Standard deviation	Range
Specific conductance (umho/cm at 25°C)	21	215	156	37-600
Dissolved solids, residue at 180°C	13	107	82	44-331
Sodium (Na)	22	27	26	3.2-90
Chloride (Cl)	22	40	40	5.2-140
Suspended solids	13	12	5	5-20
Turbidity (JTU)	22	13	8	3-40
Oil and grease	9	.3	.7	0-2
Ammonia, total as N	22	.07	.04	.03-.15
Nitrite plus nitrate, total as N	22	.57	.27	.04-1.1
Organic nitrogen, total as N	22	.41	.08	.29-.60
Nitrogen, total as N	22	1.1	.26	.61-1.79
Phosphorus, total as P	22	.30	.14	.08-.46
Total organic carbon	14	8.8	2.8	5.0-13
Biochemical oxygen demand (BOD)	9	.8	.3	.2-1.2
Total chromium (Cr)[1]	13	([2])	--	< 10-20
Total copper (Cu)[1]	13	10	14	1-47
Total lead (Pb)[1]	15	20	23	3-90
Total mercury (Hg)[1]	15	([2])	--	0-.5
Total nickel (Ni)[1]	9	4	3	1-8
Total zinc (Zn)[1]	13	30	50	0-180

[1] Concentrations in micrograms per liter.

[2] Some concentrations were below the analytical detection limit.

Total nitrogen averaged 1.1 mg/L ranging from 0.61 to 1.79 mg/L. On the average, nitrate and nitrite combined accounted for about 55 percent of the average nitrogen in the river.

The average concentrations of copper, lead, nickel, and zinc were lower in the river than in the bridge runoff with little difference between concentrations of chromium and mercury. The concentrations of chromium, mercury, and nickel were about the same magnitude in the river and in bulk precipitation. Copper and zinc in the river on the average was slightly higher and lead somewhat lower than in the bulk precipitation.

Results of three special river surveys which included sample collection before, during, and after the entire bridge surface was washed using the tank truck did not indicate any measurable river quality change for those parameters monitored. The changes which did occur were little more than expected analytical variance.

River Sediments

A brief survey of the trace metal concentration and distribution in midchannel river sediment near the Ochlockonee River Bridge was made in April 1978, and the results are given in table 6. Sediments, because of their sorptive capacity, may serve as an integrator (collector) for many chemical substances. The level of such parameters as trace metals that are associated with bottom sediments gives a general indication of the long-term impact or chronic effect that the aquatic system may be experiencing. That is, the concentration of parameters may be low at any given time, but through sorption or assimilation the parameters may accumulate in the bottom sediments or in living organisms to undesirable levels.

Lead was the only trace metal detected in concentrations greater than 10 ug/g (microgram per gram). The maximum lead concentration was 50 ug/g detected 30 ft downstream from the Ochlockonee River Bridge. A lead concentration of 30 ug/g was detected in the river bottom sediment 200 feet upstream and <10 ug/g was detected in the bottom sediment 200 ft downstream from the bridge.

Estimated Annual Loads for Selected Chemical and Physical Parameters for the Bridge Surface, Bulk Precipitation, and Ochlockonee River

The annual loading rates for selected parameters on the Ochlockonee River Bridge surface, in bulk precipitation to the bridge surface, and in the Ochlockonee River are given in table 7.

Table 6.--Results of selected trace metal analyses of bottom sediment in the Ochlockonee River near bridge on U.S. Highway 27, April 6, 1978

[Total concentrations in micrograms per gram]

Station	Chromium	Copper	Lead	Mercury	Nickel	Zinc
Upstream (200 ft) from bridge	< 10	< 10	30	0.0	< 10	< 10
Downstream (30 ft) from bridge	< 10	< 10	50	.0	< 10	< 10
Downstream (200 ft) from bridge	< 10	< 10	< 10	.0	10	< 10
Downstream (1,200 ft) from bridge	< 10	< 10	20	.0	< 10	< 10

Table 7.Estimated loads of selected chemical and physical parameters in bridge surface bulk precipitation, in bridge surface runoff, and in the Ochlockonee River

[Total loads in pounds per year]

Parameter	Bridge surface runoff	Bulk precipitation	Ochlockonee River
Dissolved solids	220	280	215,000,000
Sodium (Na)	2.9	14.3	54,700,000
Chloride (Cl)	6.9	26	81,000,000
Suspended solids	1,210	138	24,300,000
Oil and grease	9.1	17.9	608,000
Nitrogen (N)	14.6	11.3	2,030,000
Phosphorus (P)	1.8	.58	608,000
Organic carbon	78.8	17.9	17,800,000
Biochemical oxygen demand (BOD)	45.6	21.5	1,620,000
Chromium (Cr)	< .15	< .20	< 24,000
Copper (Cu)	.44	.08	20,300
Lead (Pb)	2.60	1.04	40,500
Mercury (Hg)	< .01	< .01	< 1,000
Nickel (Ni)	.11	.11	8,100
Zinc (Zn)	1.60	.32	60,800

The estimated annual loads for the bridge surface (measured by sampling bridge runoff) were computed by extrapolating to the entire bridge surface the loading rates measured for the individual 28-ft^2 sampling areas. As both the load and the exposure time in days for the sampling areas were known, the annual loading rates were therefore computed by simple ratio.

The annual loads to the bridge surface from bulk precipitation were estimated by computing the loading rates for the individual sampling event (usually about 1 week) and extrapolating this loading rate to an annual figure. These loading rates to the bridge surface for all the individual sampling events were extrapolated to an annual loading rate by solving a simple ratio of known precipitation and loads per event as a function of the annual precipitation. During the investigation a total of 5.25 in. of rainfall was sampled. The annual loads given in table 7 are averages of five precipitation events. To make these computations, the average precipitation was assumed to be 59.2 in. and the precipitation on the bridge was assumed to be uniform. Both assumptions are speculative. The 59.2 in. of precipitation used for the computation was based on the long-term averages at the weather stations located at Quincy and Tallahassee. Precipitation data that were used to compute the loading rates for the individual sampling events during the study were from short-term gages located on the Ochlockonee River Bridge and at the Leon County Airport.

The annual loads for the Ochlockonee River were estimated using both the data collected during this study and from the historical U.S. Geological Survey water-quality file. The discharge data for the computations are from the Ochlockonee River gaging station (02329000) located at the bridge. Annual loads were based on average figures for both concentration and discharge. The discharge used for the computations was 1,028 ft^3/s which is the 50-year average.

The estimated annual loads for most parameters, both to the bridge surface through bulk precipitation and on the bridge surface (estimated by the amount washed from the bridge surface), were of the same general magnitude. Interestingly, for the parameters generally associated with particulate matter, the loading rates for the bridge surface were generally greater than the rates for bulk precipitation. The most noticeable was in suspended solids which was estimated at about 138 lb/yr (pounds per year) in the bulk precipitation and 1,210 lb/yr on the bridge surface. The total organic carbon loading rate was also greater on the bridge surface being about four times that of the bulk precipitation. The annual load of total phosphorus was three times and BOD was two times greater on the bridge surface than in the bulk precipitation. Little difference was indicated between the bridge and bulk precipitation loading rates for chromium, mercury, and nickel. However, the annual loading rates of copper, lead, and zinc on the bridge surface ranged from three to six times that estimated to have been contributed to the bridge surface through bulk precipitation.

Sodium, chloride, and dissolved solids (estimated from specific conductance) annual loading rates were estimated to have been greater in the bulk precipitation than in the bridge surface annual accumulation. The estimated total dissolved solids loading rate for the bulk precipitation was 280 lb/yr or about 1.3 times the 220 lb/yr for the bridge surface. Sodium and chloride annual loading rates were about four to five times greater in the bulk precipitation than for the bridge surface accumulation.

The annual loading rates for the above parameters for the Ochlockonee River are also given in table 6. The estimated annual load contribution of the bridge surface and bulk precipitation to the bridge becomes generally insignificant when compared with the annual loads contributed by the 1,140-mi^2 drainage basin of the river.

DISCUSSION

While this investigation had certain constraints, such as limited areal coverage and artifically simulated bridge runoff, results did indicate the water-quality impact of runoff from this large rural-highway bridge into the Ochlockonee River is small. It was estimated for example, the total annual inorganic dissolved material load from U.S. Highway 27-Ochlockonee River Bridge was 0.0001 percent of the annual dissolved solids load of the Ochlockonee River at the study site. Similarly, the annual suspended solids load of the bridge was 0.005 percent of the annual river load. Lead had an estimated annual bridge surface loading rate of 2.6 lb or 0.006 percent of the 40,500 lb annual load estimated for the Ochlockonee River.

In the attempt to quantify the dynamics of bridge surface deposition, regression analyses of parameter concentrations on the bridge surface and traffic counts were made. The concentrations of chloride, phosphorus, suspended solids, specific conductance, and turbidity as a function of traffic volume were statistically significant at the 95 percent probability level. It must be noted, however, the equations were developed using a rather limited range in traffic counts (26,600-29,600). Whether these particular regressions would define the loading relations during dry periods when the bridge surface is exposed to higher or lower volumes of traffic than were observed during this study is unknown. It is likely that the loading to the bridge surface is continuous, but the slope of the regression may change. This is because material is continuously being removed from the bridge by wind turbulence caused by the high-speed traffic. Traffic-related wind removal of bridge surface material through the scuppers was observed during the study. It is not known if the removal by vehicular turbulence is a constant or if it varies as a function of the amount of deposited material. However, the data collected during this study indicate a direct and linear relation existed between the loading of some parameters and traffic counts at a reasonably high statistical level. It is likely the relation between the entire range of traffic which may be expected over the bridge during dry periods and parameter loading is not defined by a single linear relation, but rather a series of equations or a curvilinear relation.

An additional factor must be recognized regarding the actual bridge surface loading to the Ochlockonee River. The area of bridge surface from which runoff actually has direct contact with the river must be taken into account when considering the overall loading impact. The estimated bridge loads that have been discussed in this report are based on the entire bridge surface which is about 1,300 ft long with both the north and south bound lanes being about 28 ft wide for a total area of about 72,800 ft^2. However, while the bridge is 1,300 ft long, for a great percentage of the time the river channel is only about 150-200 ft wide and much of the bridge structure overlies densely vegetated flood plain. Thus runoff from only about 10,000 ft^2 of the bridge surface has direct contact with the river, except during periods of high flow. Runoff from perhaps 85 percent of the bridge surface is to the vegetated flood plain during much of the time.

Atmospheric loading must also be considered when estimating the total water-quality impact of the bridge runoff. The total load to the bridge and subsequent runoff to the river is affected by both the load of materials which is transported to the bridge surface by vehicular activity and by the load which is carried to the bridge surface through precipitation. Interestingly, during this study the annual load estimates for most parameters contributed by bulk precipitation to the bridge surface were of the same general magnitude as were the annual bridge surface loads (estimated by sampling the bridge runoff after antecedent dry periods).

While the precipitation and bridge accumulation data were collected somewhat independently, these loading sources are interrelated. As a sizeable rainfall event would tend to wash accumulated material from the bridge surface it was necessary to make the bridge runoff surveys during periods of no rainfall. This is because a primary objective of this study was to determine if relations existed with parameter loads, traffic counts, and days of exposure. However, even with this precaution of sampling only during periods of no rainfall, the bridge surface accumulation loads very likely reflect atmospheric influence.

The annual loads computed for the bridge surface accumulation (measured by sampling bridge runoff) probably reflect some particulate atmospheric dry fallout in addition to the material carried to the bridge surface by vehicular activity. Even during periods of no precipitation, it is likely that material is continuously deposited upon the bridge surface. The material which is washed from the bridge after an antecedent dry period is therefore a combination of both material deposited from the atmosphere and material deposited by vehicles.

During this study no sophisticated sampling was conducted in the attempt to differentiate between the loads to the bridge from dry fallout and rainfall. Atmospheric loads were estimated from the samples collected in the precipitation sampler and thus would include both rainfall and particulate material or the bulk precipitation load. Of the estimated 138 lb of suspended solids in the bulk precipitation, it could be concluded that most of the load was probably the result of a continuous deposition caused by atmospheric changes in wind currents, direction, and velocity during non-rainfall periods. However, because much of the suspended solid material was rather fine it may be possible that some of the material remains in atmospheric suspension until a rainfall event which then causes a change in the colloidal chemistry of the particulate material which results in coagulation and deposition.

Regression analyses of concentration as a function of rainfall per event were made and while none of the relations were highly significant it was interesting to note that all the relations were indirect. This suggests that most of the materials are deposited from the atmosphere during dry periods and simply diluted during rainfall events. It is possible however, that a significant quantity of bulk material is flushed from the atmosphere and deposited during the initial part of a rainfall event and may be somewhat independent of the total quantity of rainfall for that particular rainfall event.

Atmospheric sources of contamination appear to be a significant portion of stormwater runoff. For example, the annual bulk precipitation suspended solids load was 138 lb or 11 percent of the 1,210 lb estimated for the bridge surface accumulation (note: the annual bridge surface load reflects some atmospheric dry fallout). The bulk precipitation BOD was 47 percent and lead was 40 percent of that for the bridge surface. For selected dissolved constituents such as chloride, sodium, and dissolved solids, the annual loads in the bulk precipitation were estimated to be higher than those estimated for the bridge surface accumulation. This can be explained by the fact that these parameters are for the most part dissolved in rainfall and rapidly drain from the bridge with little deposition.

In overview, the bulk precipitation load to the bridge and its subsequent water-quality impact on the Ochlockonee River is small. Yet, the bulk precipitation load over the entire drainage basin is very significant.

SUMMARY

The data collected during this study indicate there is a measurable loading of some undesirable chemical and physical parameters to the Ochlockonee River Bridge. The loading mechanism seems to be related to vehicular activity and atmospheric bulk precipitation. However, the annual loads estimated to originate from the bridge surface are much less than 0.005 percent of the annual loads in the river for most parameters. In addition computed parameter loads per curb mile for the Ochlockonee River Bridge were lower on the average than similar parameter loads found in an EPA study of streets of 10 major cities in the United States.

REFERENCES

Brown, Eugene, Skougstad, M. W., and Fishman, M. J., 1970, Methods for collection and analysis of water samples for dissolved minerals and gases: U.S. Geological Survey Techniques Water-Resources Investigations, book 5, chapter A1, 160 p.

Fishman, M. J., and Brown, Eugene, 1976, Selected methods of the U.S. Geological Survey for the analysis of waste water: U.S. Geological Survey open-file report, 87 p.

Goerlitz, D. F., and Brown, Eugene, 1972, Methods for analysis of organic substances in water: U.S. Geological Survey Techniques Water-Resources Investigations, book 5, chapter A3, 40 p.

Lager, J. A., Smith, W. G., Lynord, W. G., Finn, R. M., and Finneimore, E. J., 1977, Urban stormwater management and technology: Update and users guide, Metcalf & Eddy Inc., Palo Alto, Calif., U.S. Environmental Protection Agency report EPA-600/8-77-014, September 1977, 313 p.

Lamonds, A. G., and Merritt, M. L., 1976, Proposed cross-Florida barge canal: Water-quality aspects: U.S. Geological Survey Water-Resources Investigations 76-23, 189 p.

Pitt, R. E., and Amy, Gary, 1973, Toxic material analysis of street surface contaminants: U.S. Environmental Protection Agency report EPA-R2-73-283, August 1973, 133 p.

Sartor, J. D., and Boyd, G. B., 1972, Water pollution aspects of street surface contaminants: U.S. Environmental Protection Agency report EPA-R2-72-081, November 1972, 236 p.

Shaheen, D. G., 1975, Contributions of urban roadway usage to water pollution: U.S. Environmental Protection Agency report EPA-600-2-75-004, March 1975, 228 p.

Vitale, A. M., and Sprey, P. M., 1974, Total urban water pollution loads: The impact of storm water: Environmental Control, Inc., Rockville, Ma.; available only from U.S. Department Commerce, National Technical Information Service, Springfield, VA 22151, as report PB-231 730, 183 p.

Waller, B. G., and Earle, J. E., 1975, Chemical and biological quality of water in part of the Everglades, southeastern Florida: U.S. Geological Survey Water-Resources Investigations 56-75, 157 p.

D STATES DEPARTMENT OF THE INTERIOR
GICAL SURVEY
ohn Knox Rd--Suite F240
hassee, Florida 32303