Data for and Adjusted Regional Regression Models of Volume and Quality of Urban Storm-Water Runoff in Boise and Garden City, Idaho, 1993–94

By L.C. Kjelstrom

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U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Gordon P. Eaton, Director

For additional information write to:

District Chief
U.S. Geological Survey
230 Collins Road
Boise, ID 83702-4520

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CONVERSION FACTORS AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To obtain
acre	0.4047	square hectometers
cubic foot (ft^3)	0.02832	cubic meter
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
pound (lb)	0.4536	kilogram
square mile (mi^2)	2.590	square kilometer

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C) as follows:

$$°C = (°F - 32)/1.8$$

Abbreviated water-quality units:

mg/L	milligrams per liter
µg/L	micrograms per liter
µS/cm	microsiemens per centimeter at 25 degrees Celsius
col/100 mL	colonies per 100 milliliters

ABBREVIATIONS

ADJ	Indicates estimate derived from regional regression equation has been adjusted on the basis of local data.
ADP	Antecedent dry period. Interval between storm having 0.10 inches or more of precipitation and next storm when samples collected, in hours.
BCF	Bias correction factor included in the detransformed regression model to provide a consistent estimator of the mean response.
BOD	Biochemical oxygen demand during 5 days of incubation in storm-runoff load, in pounds, or in storm-runoff mean concentration, in micrograms per liter.
CD	Total recoverable cadmium in storm-runoff load, in pounds, or in storm-runoff mean concentration, in micrograms per liter.
COD	Chemical oxygen demand in storm-runoff load or mean seasonal or mean annual load, in pounds, or in storm-runoff mean concentration, in micrograms per liter.
CU	Total recoverable copper in storm-runoff load or mean seasonal or mean annual load, in pounds, or in storm-runoff mean concentration, in micrograms per liter.
DA	Total contributing drainage area, in square miles.
DP	Dissolved phosphorus in storm-runoff load or mean seasonal or mean annual load, in pounds, or in storm-runoff mean concentration, in micrograms per liter.
DRN	Duration of each storm, in minutes, for storm-runoff load and mean concentration models, and in hours for mean seasonal or mean annual load models.
DS	Dissolved solids in storm-runoff load or mean seasonal or mean annual load, in pounds, or in storm-runoff concentrations, in milligrams per liter.
IA	Impervious area, as a percentage of total contributing drainage area.
INT	Maximum 24-hour precipitation intensity that has a 2-year recurrence interval, in inches.
LOC	Indicates estimate is derived from regression equation developed from local data.
LUC	Commercial land use, as a percentage of total contributing drainage area.
LUI	Industrial land use, as a percentage of total contributing drainage area.
LUN	Nonurban land use, as a percentage of total contributing drainage area.
LUR	Residential land use, as a percentage of total contributing drainage area.
MAR	Mean annual rainfall, in inches.
MHP	Maximum precipitation for 1 hour during a storm, in inches per hour.
MNL	Mean annual nitrogen load in precipitation, in pounds of nitrogen per acre.
PB	Total recoverable lead in storm-runoff load or mean seasonal or mean annual load, in pounds, or in storm-runoff mean concentration, in micrograms per liter.
REG	Indicates estimate is derived from regional regression equation.
RV	Runoff volume, in cubic feet.
SS	Suspended solids in storm-runoff load or mean seasonal or mean annual load, in pounds, or in storm-runoff mean concentration, in micrograms per liter.
TKN	Total ammonia plus organic nitrogen as nitrogen in storm-runoff load or mean seasonal or mean annual load, in pounds, or in storm-runoff mean concentration, in micrograms per liter.
TN	Total nitrogen in storm-runoff load or mean seasonal or mean annual load, in pounds, or in storm-runoff mean concentration, in micrograms per liter.
TP	Total phosphorus in storm-runoff load or mean seasonal or mean annual load, in pounds, or in storm-runoff mean concentration, in micrograms per liter.
TRN	Total storm rainfall, in inches.
ZN	Total recoverable zinc in storm-runoff load or mean seasonal or mean annual load, in pounds, or in storm-runoff mean concentration, in micrograms per liter.

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By L.C. Kjelstrom

Abstract

The U.S. Environmental Protection Agency requires information on the volume and quality of urban storm-water runoff to apply for a permit to discharge this water into the Boise River under the National Pollutant Discharge Elimination System Program. Concentrations of selected chemical constituents in storm runoff were determined from samples collected at four storm-sewer outfalls in Boise from October 1993 through June 1994 and at one outfall in Garden City from September through October 1994. Samples were analyzed for specific conductance, pH, alkalinity, water temperature, oxygen demand, fecal indicator bacteria, major ions, dissolved and suspended solids, nutrients, trace elements, and numerous organic compounds. The measurement of storm-runoff volume and mean concentrations of constituents were used to estimate storm-runoff loads.

Previously developed U.S. Geological Survey regional regression models of runoff and 11 chemical constituents were evaluated to assess their suitability for use in urban areas in Boise and Garden City. Data collected in the study area were used to develop adjusted regional models of storm-runoff volumes and mean concentrations and loads of chemical oxygen demand, dissolved and suspended solids, total nitrogen and total ammonia plus organic nitrogen as nitrogen, total and dissolved phosphorus, and total recoverable cadmium, copper, lead, and zinc. Explanatory variables used in these models were drainage area, impervious area, land-use information, and precipitation data. Mean annual runoff volume and loads at the five outfalls were estimated from 904 individual storms during 1976 through 1993. Two methods were used to compute individual storm loads. The first method used adjusted regional models of storm loads and the second used adjusted regional models for mean concentration and runoff volume. For large storms, the first method seemed to produce excessively high loads for some constituents and the second method provided more reliable results for all constituents except suspended solids. The first method provided more reliable results for large storms for suspended solids.

INTRODUCTION

Populations in Boise, Garden City, and Ada County, Idaho, have increased rapidly from 1989 to 1994. As urbanization has progressed, residential areas in the city have been replaced by businesses, parking lots, and shopping centers; rural areas in the county have been developed into residential subdivisions and commercial and industrial facilities. A storm-sewer system that collects storm-water runoff and conveys it to the Boise River was built to protect urbanized areas from flooding.

Because storm runoff can wash contaminants, which accumulate during dry periods, into receiving waters, the Clean Water Act of 1987 directed the U.S. Environmental Protection Agency (USEPA) to establish regulations governing storm runoff under the National Pollutant Discharge Elimination System (NPDES) Program. As part of these regulations developed by USEPA, managers of municipal storm-sewer systems that serve urban populations of more than 100,000 must apply for NPDES permits. Because of the variable nature of storm runoff and its effects on receiving waters, site-specific permitting was required.

Part 1 of the permit application initiates the process through which municipalities begin to identify sources of pollutants to the municipal storm-sewer system and propose strategies to characterize storm runoff (USEPA, 1991). In 1993, the City of Boise and Ada County Highway District (ACHD) completed part 1 of the permit application, which included submission of a proposed monitoring program to characterize urban storm runoff from basins with selected land uses. Part 2 of the permit application required implementation of this monitoring program, including collection and analysis of data to identify the volume and quality of storm runoff that reaches the Boise River.

In 1993, ACHD, the City of Boise, Idaho Transportation Department (ITD), Ada County Drainage District No. 3 (DD#3), Boise State University (BSU), and U.S. Geological Survey (USGS) began a cooperative program to assess the volume and quality of storm runoff in Boise and Garden City to fulfill the objectives of part 2 of the permit application. Water managers, policy makers, and the public are interested in this study because it provides data and models that can be used to evaluate the effectiveness of water-quality management programs developed by the City of Boise, Garden City, and Ada County. The models make it possible to predict the probable effects of changes in land- and water-management practices on the storm-sewer system and on water quality of discharge to the Boise River. Results of this study also may be of interest to other communities in similar geohydrologic settings.

Purpose and Scope

This report presents data that describe the volume and quality of storm runoff sampled at storm-sewer outfalls and associated data from five urban drainage basins in Boise and Garden City. Regional regression models were evaluated and adjusted using sample data and can be used to estimate (1) storm-runoff volumes, (2) mean concentrations of selected chemical constituents, and (3) individual storm and annual storm loads of selected chemical constituents from drainage basins in the Boise area where water volume and quality data are unavailable.

Description of Study Area

Ada County, the most densely populated county in the State, covers an area of 1,052 mi^2 in southwestern Idaho. Boise, the largest city in the State, is in the northeastern part of Ada County. Garden City is incorporated mostly on the south side of the Boise River northwest of Boise. The Boise Chamber of Commerce estimated that the population of Boise on July 1, 1993, was nearly 142,000 and that population in Ada County (231,000) would increase about 3.5 percent per year from 1990 to 2000. In 1993, Garden City had a population of about 7,000. The Boise River flows through Boise and Garden City for about 9 mi (fig. 1).

Boise and surrounding urban communities are expanding into agricultural and desert lands. Irrigation and drainage canals that once served farmlands are sometimes used for drainage of the expanded urban areas. As a result of this and a variety of other flood control facilities, the storm-sewer drainage system is complex.

The storm-sewer drainage system includes central collection areas from which water drains to irrigation canals or ponds or is discharged directly to the Boise River, and onsite collection areas from which water is allowed to seep to the ground-water system. The City of Boise manages the storm-sewer system and creeks that drain the Boise foothills; ACHD manages all drainage facilities within the public streets and rights of way; ITD manages drainage facilities along State highways; DD#3 manages drainage facilities within Boise; BSU manages the drainage system for the university's property; and other irrigation and drainage districts manage their separate drainage facilities.

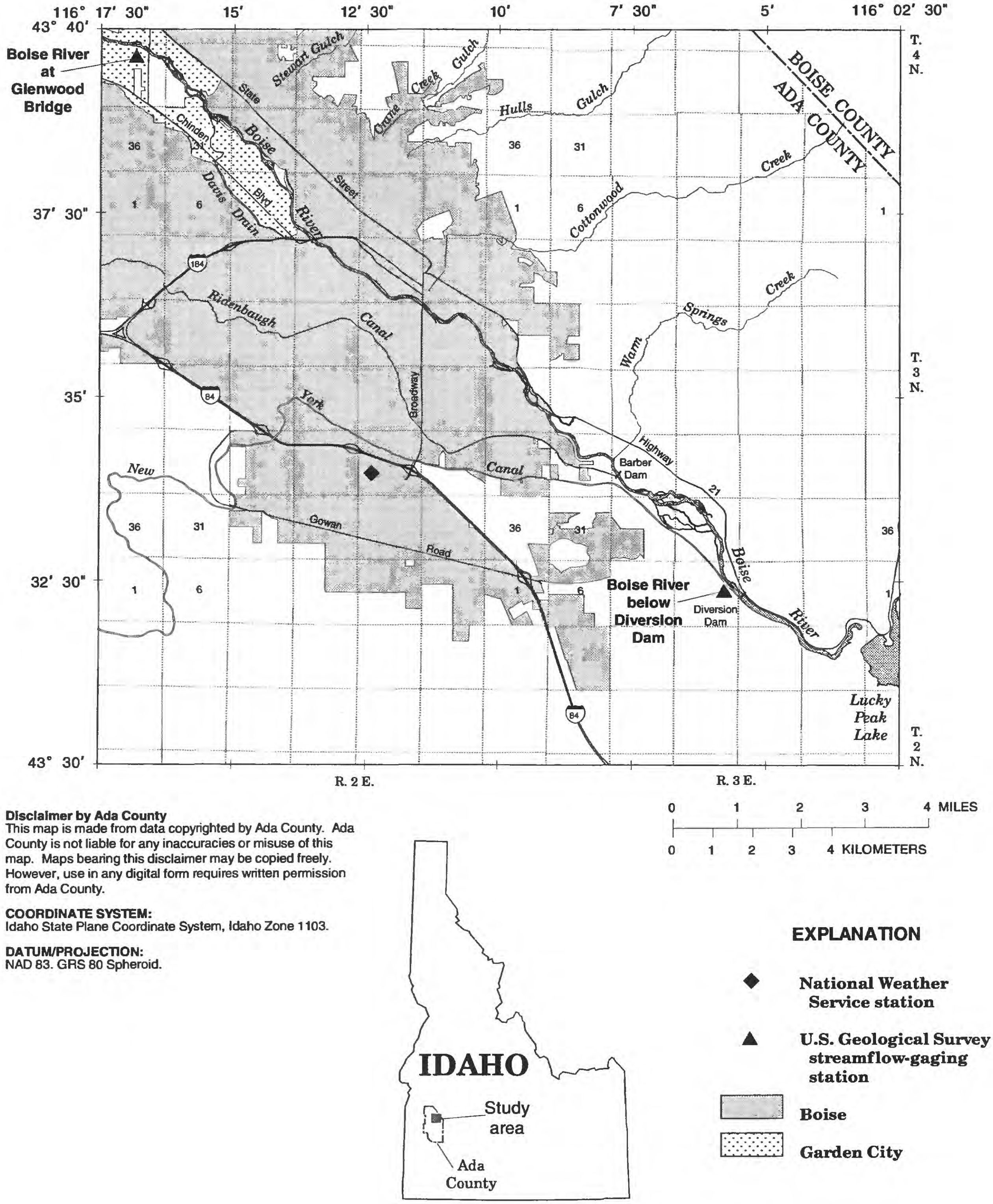


Figure 1. Locations of study area and weather and streamflow-gaging stations.

Table 1. Monthly and annual mean precipitation at Boise, Idaho, during 1951–93 and 1976–93
(Data from National Weather Service)

Period of analysis	Mean precipitation, in inches												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1951–93	1.33	1.18	1.26	1.25	1.27	0.92	0.31	0.35	0.58	0.79	1.33	1.31	11.88
1976–93	1.18	1.15	1.54	1.40	1.30	.77	.47	.41	.89	.64	1.40	1.19	12.34

CLIMATE

Climate in the study area is controlled largely by the general atmospheric circulation over the northern Pacific Ocean. During the summer, dry, subtropical air from the Gulf of Mexico and Pacific Ocean circulates northward and causes high temperatures and moderate rainfall in the study area; most rainfall is produced by sporadic thunderstorms caused by orographic uplift. During the fall and winter, air movement from the Pacific Ocean produces frontal systems that are the dominant source of precipitation. During the spring (generally from March through May), a combination of thunderstorms and frontal systems produces about 30 percent of the annual precipitation. Because of Boise's location east of several significant mountain ranges, rainfall totals are low.

Mean annual precipitation recorded by the National Weather Service during 1951–93 at the airport in southern Boise was about 11.9 in. (table 1); however, the foothills in northeastern Boise normally received greater amounts. Data from the hourly rain gage at the Boise airport were used to develop storm statistics. A storm was defined as having at least 0.05 in. of precipitation and a 6-hour interval of no precipitation prior to the next storm. Although mean precipitation during 1976–93 was slightly greater than during 1951–93, the former period was used for an analysis of storms for this study (table 2). A mean of 50 storms per year, a mean precipitation of 0.23 in. per storm, and a mean storm duration of about 8.2 hours (table 2) were determined from an analysis of 904 storms from 1976 through 1993. During these years, 39 percent of the storms had 0.20 in. or more of precipitation and produced about 66 percent of the total precipitation. Annual mean precipitation from storms was 11.4 in., or about 92 percent of the total precipitation.

Further storm analysis was done by classifying storms from November through February as winter storms, from March through May as spring storms, and from June through October as dry-period storms (monthly mean precipitation was less than 1 in. for those months from 1951 to 1993) (table 1). Spring and dry-period storms having greater than 0.5 in. of precipitation produced larger percentages of total precipitation within those time periods than winter storms (table 2). However, the number of storms having greater than 0.5 in. of precipitation was about equal for each of the three seasonal periods. During the winter period, storms having less than 0.20 in. of precipitation had a larger percentage of precipitation than storms during the spring or dry periods. However, the spring and dry periods seem to receive more of their precipitation from storms having greater than 0.50 in. of precipitation.

SURFACE-WATER HYDROLOGY

Streamflow in the Boise River is controlled by releases from Lucky Peak Lake (fig. 1) and two upstream reservoirs. Storage is used for irrigation, hydroelectric energy, flood control, and recreation. From Lucky Peak Lake to the streamflow-gaging station Boise River at Glenwood Bridge, 10 canals and several small laterals divert water from the Boise River. The two largest canals, New York and Ridenbaugh, divert water from Diversion and Barber Dams. Irrigators downstream from Boise depend on return flows from upstream irrigators to supply much of their water needs. During the winter, flow in the Boise River downstream from Diversion Dam usually is maintained at 150 ft^3/s or more and, if possible, floodflows are limited to 6,500 ft^3/s. Flows are less than 100 ft^3/s during some winters when stored water is not available for release and, occasionally, floodflows exceed 6,500 ft^3/s when storage space is not available.

Table 2. Analysis of precipitation and storms at Boise, Idaho, 1976–93 (Data from National Weather Service)

[Storms have at least 0.05 inches of precipitation and a 6-hour interval of no precipitation prior to the next storm]

Period of analysis	Mean precipitation, in inchea			Mean duration of storm, in hours	Mean number of storms per year
	Per storm	Per year from storms	Total per year		
Annual	0.23	11.4	12.3	8.2	50
Nov. – Feb.	.20	4.5	4.9	9.2	22
Mar. – May	.25	4.0	4.2	8.2	16
June – Oct.	.25	2.9	3.2	6.4	12

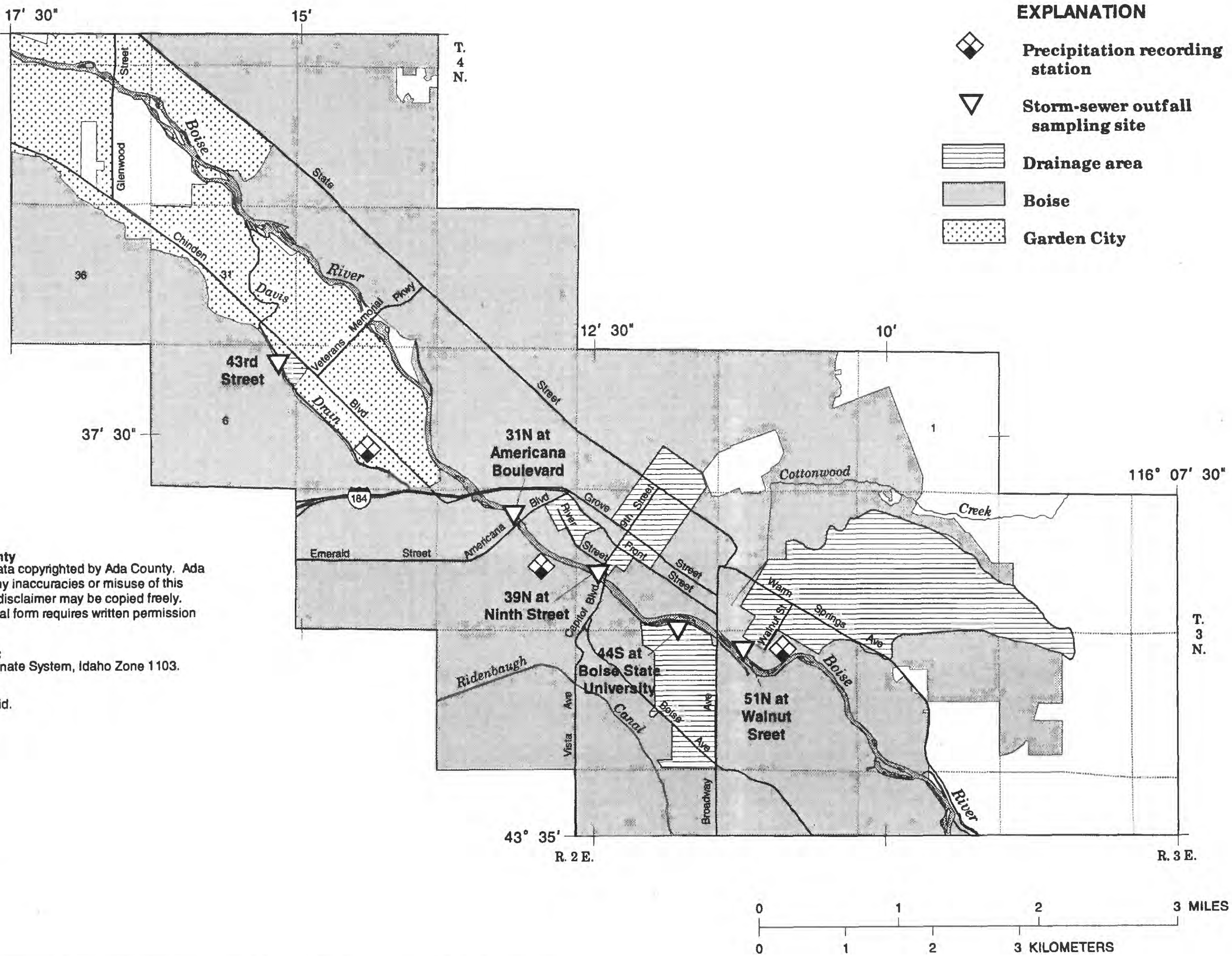
Period of analysis	Percentage of storms within specified range of precipitation				
	From 0.05 to 0.09 inchea	From 0.10 to 0.19 inches	From 0.20 to 0.29 inches	From 0.30 to 0.50 inches	Greater than 0.50 inches
Annual	29	33	15	14	9
Nov. – Feb.	33	33	13	15	6
Mar. – May	27	32	17	14	10
June – Oct.	26	32	17	13	12

Period of analysia	Percentage of total precipitation for specified range of storm precipitation				
	From 0.05 to 0.09 inches	From 0.10 to 0.19 inches	From 0.20 to 0.29 inches	From 0.30 to 0.50 inches	Greater than 0.50 inches
Annual	8	19	15	22	28
Nov. – Feb.	11	21	14	26	19
Mar. – May	7	17	16	20	34
June – Oct.	6	17	15	19	34

Estimated low flows, based on historical records of reservoir releases for Boise, are as follows: greater than 150 ft^3/s for 42 out of 50 years, between 80 and 150 ft^3/s for 6 out of 50 years, and less than 80 ft^3/s for 2 out of 50 years (Bureau of Reclamation, written commun., 1994).

Mean annual flow in the Boise River at Glenwood Bridge during water years 1982–92 was 1,176 ft^3/s. The highest flow was 9,840 ft^3/s and the lowest was 42 ft^3/s. A few times during the last 100 years, storm runoff from drainage basins in the Boise foothills has caused flooding in Boise. The highest recorded discharges from several of the Boise foothill drainages were caused by a cloudburst on August 20, 1959 (Thomas, 1963). The most recent flooding from the Boise foothills was caused by steady rain and melting snow during January 11–12, 1979 (Harper and Hubbard, 1980).

Most storm runoff from parts of Boise and Garden City is conveyed to the Boise River through a storm-sewer system that is separate from the waste-sewer system. The volume of storm runoff that reaches the Boise River is difficult to establish. Developers are required to provide storage and seepage systems adequate for storms with precipitation depths of a 50-year recurrence interval. Storm-sewer outfalls do not always empty directly to the Boise River. Many outfalls empty into irrigation canals and drains. The volume of storm runoff that reaches the Boise River by way of canals or drains may be depleted by seepage or diversion for irrigation, or may be augmented by water from other sources. Also, the design of the storm-sewer system can, in some cases, affect the monitoring of storm runoff. Retention ponds that temporarily store water and trash racks that prevent large pieces of debris from entering the storm sewers delay runoff to storm-sewer outfalls. In Garden City, 16 storm-sewer outfalls and numerous storage and seepage systems have been identified (Idaho Department of Health and Welfare, Division of Environmental Quality, written commun., 1994). Five of the 16 outfalls are part of the ACHD drainage system. Some of the storm sewers have been constructed with outfalls to Davis Drain, which empties into the Boise River (fig. 2).



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COORDINATE SYSTEM:
Idaho State Plane Coordinate System, Idaho Zone 1103.

DATUM/PROJECTION:
NAD 83. GRS 80 Spheroid.

Figure 2. Locations of storm-sewer outfalls in Boise and Garden City, Idaho.

The drainage area between the gaging stations Boise River below Diversion Dam (13203510) and Boise River at Glenwood Bridge (13206000) is about 120 mi^2, which includes the Boise foothills. Significant parts of this drainage area do not discharge storm runoff to the Boise River. The determination of drainage areas contributing to the storm-sewer system becomes complex because of the irrigation canal and drain systems, storage and seepage systems, and ground water discharging to the Boise River.

Previous Studies

Concern about the water-quality effects of storm water discharged to the Nation's waterways led to the development of the Nationwide Urban Runoff Program (NURP). NURP defines a water-quality "problem" as having three elements: (1) impairment or denial of beneficial uses, (2) water-quality criterion violation, and (3) local public perception (USEPA, 1983).

Studies conducted under the NURP determined that volumes of urban runoff and concentrations of contaminants were highly variable. NURP data showed that trace elements were the most prevalent pollutant in urban runoff (USEPA, 1983). For example, NURP data indicated that cadmium, copper, lead, and zinc exceeded State ambient water-quality standards for the South Platte River in the Denver area during nearly all storms. NURP monitoring detected 63 of 106 possible site-specific organic pollutants. However, few were at levels that would be expected to exceed available water-quality criteria for receiving water during storms. Coliform bacteria were present at high levels in urban runoff and were expected to exceed water-quality criteria for receiving water during storms. Nutrients generally were present in urban runoff but concentrations usually were less than concentrations in discharges from secondary treatment plants. Total suspended solids concentrations in urban runoff were usually higher than concentrations in treatment-plant discharges.

Contaminants in urbanized areas that are likely to be in storm runoff are primarily anthropogenic (human caused) and include organic debris, sediments, nutrients, petroleum-based products, and potentially toxic chemicals such as trace elements and pesticides. The Idaho Department of Health and Welfare (1992) indicated that sediment, organics, and oil and grease are pollutants of concern in Boise. Frenzel and Hansen (1988) reported that cadmium, chromium, hexavalent chromium, cyanide, lead, nickel, and silver concentrations in the Boise River were less than or near analytical detection levels and were less than chronic toxicity criteria when detectable. Concentrations of trace elements in bottom sediment from the Boise River generally were small. Results of chemical analyses of water samples collected from the Boise River between gaging stations near Diversion Dam and at Glenwood Bridge are shown in table 3. At the time the samples were collected, flow in the Boise River at the Glenwood Bridge gaging station was less than the median flow for the period of record and did not include storm runoff.

WATER-QUALITY STANDARDS AND CRITERIA

The State of Idaho develops or adopts water-quality standards that meet or exceed water-quality standards established by the Federal Government for protection of public health, aquatic life, and water used for recreation. USEPA reviews and approves State water-quality standards and may promulgate standards for a State to satisfy Clean Water Act requirements, such as the National Toxics Rule (USEPA, 1992c) that is in effect for Idaho.

Water-quality standards consist of three major components: (1) use designation; (2) criteria (a numerical value or narrative statement for a contaminant that identifies possible effects of the contaminant) that, if achieved, will protect the designated use; and (3) rules, regulations, methods, policies, and guidelines that will facilitate implementation. Designated uses for the Boise River are domestic and agricultural water supplies, cold water biota habitat, salmonid spawning, and recreation. Numeric and narrative criteria that protect these designated uses are

Table 3. Chemical analyses of water samples collected from the Boise River between Diversion Dam and Glenwood Bridge, Boise and Garden City, Idaho

[DD, Diversion Dam; GB, Glenwood Bridge; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter]

Water-quality constituent or characteristic	3-28-91		5-22-91		9-11-91	
	DD	GB	DD	GB	DD	GB
Discharge, in cubic feet per second	177	57	1,350	602	737	574
Specific conductance, in µS/cm	97	143	92	105	84	99
pH, in standard units	8.0	8.3	7.8	8.9	8.0	8.6
Alkalinity, total as $CaCO_3$, in mg/L	45	59	43	46	40	43
Temperature, water, in degrees Celsius	4.5	8.5	8.0	12.0	18.0	18.0
Dissolved oxygen, in mg/L	11.7	13.2	10.4	13.0	9.2	10.4
Calcium, dissolved, in mg/L	13	15	12	13	12	13
Magnesium, total, in mg/L	1.5	2.0	1.3	1.5	1.2	1.3
Sodium, dissolved, in mg/L	5.6	12	5.1	6.6	4.6	6.4
Potassium, dissolved, in mg/L	.7	1.3	.7	.9	.6	.8
Sulfate, dissolved, in mg/L	3.8	.4	3.3	4.3	3.1	4.3
Chloride, dissolved, in mg/L	.4	5.7	.2	1.2	.4	2.4
Dissolved solids, in mg/L	66	97	61	68	59	67
Suspended solids, in mg/L	3	7	3	11	4	6
Residue, volatile nonfilterable, in mg/L	78	88	52	71	46	65
Nitrogen, ammonia, total as N, in mg/L	.01	.3	.04	.02	.02	.01
Phosphorus, total as P, in mg/L	.02	.32	.01	.08	.03	.10

provided by Idaho's Water Quality Standards (conventional and general narrative and numeric criteria) and the National Toxics Rule (numeric criteria for 126 priority pollutants that, if not exceeded, will protect aquatic life and public health).

STORM-RUNOFF DATA

Storm-runoff samples from five drainage basins were collected at storm-sewer outfalls in Boise and Garden City. The samples were collected to describe the volume and chemical characteristics of storm runoff to the Boise River in Boise and Garden City. Constituent loads were estimated to help assess the degree of contamination received by the Boise River from nonpoint sources in the drainage basins.

Measurement Sites

Precipitation recording stations were established at two sites along the Boise River near the most upstream and downstream storm-sewer outfalls (fig. 2). Precipitation data also were available from a station operated by the City of Boise near the middle reach of the Boise River where the other three outfalls are located (fig. 2) and from the long-term station operated by the National Weather Service at the airport (fig. 1).

Weirs were constructed at storm-sewer outfalls in Boise to aid in the development of stage-discharge relations. Pressure transducers were installed to measure the stage of water. The stage of water above the weir generally was recorded at 15-minute intervals, which were adequate for the sampled storms. Discharge measurements were made during the sampling period, and at other times, to develop the stage-discharge relation at each storm-sewer outfall. An electromagnetic sensor for depth and velocity was installed in the sewer pipe to measure discharge at a site in Garden City. The storm-sewer outfalls used for sampling (fig. 2) and the primary land uses in their drainage basins were as follows:

51N at Walnut Street in Boise	Low-density residential
44S at Boise State University in Boise	High-density residential
39N at Ninth Street in Boise	Commercial
31N at Americana Boulevard in Boise	Commercial and residential
South end of 43rd Street in Garden City	Commercial

The drainage area, percentage of area covered by impervious surfaces, and percentage of selected land uses in the drainage basin (table 4) are needed to estimate constituent loads and can be used to help identify probable sources of contamination. This information was supplied by ACHD (written commun., 1993).

Table 4. Physical characteristics of storm-sewer outfalls in Boise and Garden City, Idaho

[—, not applicable. Data from Ada County Highway District (written commun., 1993)]

Storm-sewer outfall	Drainage area, in square miles	Impervious cover, in percentage of drainage area	Land use, in percentage of drainage area: Commercial	Residential	Nonurban
51N at Walnut Street	1.4	6	—	55	45
44S at Boise State University	.375	11	5	95	—
39N at Ninth Street	.328	35	85	15	—
31N at Americana Boulevard	.095	26	50	50	—
43rd Street in Garden City	.020	91	96	4	—

Rainfall and Runoff

Each of the four storm-sewer outfalls in Boise were sampled three times during October 1993 through June 1994. The outfall site in Garden City was not selected and instrumented until June 1994 and no storms occurred until September and October 1994. The date and time each storm began, duration of the storm, total rainfall, and number of hours between each storm and the previous storm having rainfall greater than 0.1 in. are listed in table 5. For each storm, precipitation on the drainage area was estimated from one or two of the recording stations.

Table 5. Rainfall and runoff data collected at storm-sewer outfalls in Boise and Garden City, Idaho

Storm-sewer outfall	Date rainfall began	Time rainfall began	Duration of rainfall, in hours	Total rainfall, in inches	Time from previous rainfall, in hours	Total runoff, in cubic feet	Duration of runoff, in hours
51N at Walnut Street	10- 7-93	1:30	4.5	0.08	1,239	2,710	6.8
	12-11-93	23:15	2.2	.17	95	11,300	20.2
	5-17-94	1:00	8.0	.20	216	10,400	12.2
44S at Boise State University	10- 7-93	1:30	4.5	.08	1,239	2,250	10.5
	12-11-93	23:15	2.2	.17	95	12,700	15.8
	4-23-94	17:00	12.0	.34	313	29,600	15.2
39N at Ninth Street	10- 7-93	1:30	4.5	.08	1,239	3,460	9.2
	12- 7-93	15:30	8.7	.14	130	5,250	16.2
	5- 4-94	6:00	3.0	.03	83	145	3.0
31N at Americana Boulevard	12- 7-93	15:30	8.7	.14	130	7,560	16.2
	4-23-94	17:00	12.0	.31	313	34,100	17.5
	6- 1-94	2:30	5.7	.20	117	14,000	14.2
43rd Street in Garden City	9-13-94	22:30	5.5	.09	2,509	537	.5
	10- 4-94	17:30	9.5	.23	493	4,450	1.5
	10-14-94	2:30	7.5	.26	73	4,910	3.5

Runoff data include the total volume of runoff and the duration of runoff. Storm-runoff sampling followed a dry-weather period of at least 72 hours. Sampling began when precipitation from the storm was expected to exceed 0.1 in.

Water-Quality Characteristics and Constituent Concentrations

The results of field determinations and lab analyses of samples collected from each of the storm-sewer outfalls are listed in tables 6–10 (back of report). Flow-weighted composite samples were collected at 15-minute intervals for 3 hours or for the duration of the storm if less than 3 hours. In addition, grab samples for analysis of selected constituents were collected at each outfall at the time of peak runoff. Samples for each constituent were collected as described by USEPA (1992a). Bacteria samples were collected at the beginning, middle, and end of the sampling period. Field determinations were made for specific conductance, pH, water temperature, and dissolved oxygen when grab samples were taken. Laboratory analyses were made for alkalinity, chemical oxygen demand, biochemical oxygen demand, fecal indicator bacteria, and concentrations of major ions, dissolved and suspended solids, nutrients, trace elements, and selected organic compounds. Samples also were analyzed for carbon, oil and grease, and many volatile, base/neutral, acid, and pesticide organic compounds. The variation of detection limits shown in tables 6–10 is directly related to the degree of dilution necessary to perform the analytical procedure.

Most samples were analyzed by the USGS National Water Quality Laboratory in Denver, Colo. Bacteria counts were made in the USGS laboratory in Boise. Biochemical oxygen demand samples were analyzed by the Boise City Public Works Central Laboratory. All samples were analyzed according to methods approved by the USEPA (1990).

Quality assurance of sample collection and analysis is essential to define the validity of analytical data. The USGS National Water Quality Laboratory analyzed field equipment blanks to assess possible sample contamination during field collection and processing, as well as possible laboratory contamination. The equipment blank was prepared by filling sample collection containers with reagent-grade distilled water in the field and processing the sample in the same manner as a storm-runoff sample. Equipment blanks were analyzed for oxygen demand, major ions, nutrients, trace elements, and selected volatile and organic compounds. No sample contamination was indicated in the field equipment blanks.

Duplicate samples were collected during 3 of the 15 storm-water sampling events. The resulting differences in constituent concentrations in the duplicate samples were generally small. The two largest differences were for 31N outfall. On April 23, the original sample concentration of phenol was 10 μg/L and the duplicate sample concentration was 5 μg/L; on June 1, 1994, the original sample concentration for DDE was 0.12 μg/L and the duplicate sample concentration was 0.08 μg/L.

Constituent Loads

Total storm-runoff loads of selected constituents measured at the five storm-sewer outfalls are listed in table 11. Total storm-runoff loads were computed by multiplying the constituent concentrations by the measured storm-runoff volumes. Storm-runoff loads were computed for chemical oxygen demand, biochemical oxygen demand, dissolved solids, suspended solids, total nitrogen, total ammonia plus organic nitrogen as nitrogen, total phosphorus, dissolved phosphorus, and total recoverable cadmium, copper, lead, and zinc.

REGIONAL MODELS

Regression equations for regional models of urban basins drained by a storm-sewer system (Driver and Tasker, 1990) use storm rainfall, physical, land use, and climatic data to estimate the total volume and quality of storm runoff. The models were developed for three regions characterized by differences in the amount of mean annual precipitation. Models were developed with urban storm-runoff data to estimate runoff volume and mean concentrations and loads for 11 chemical constituents: chemical oxygen demand, dissolved solids, suspended solids, total nitrogen, total ammonia plus organic nitrogen as nitrogen, total phosphorus, dissolved phosphorus, and total recoverable cadmium, copper, lead, and zinc. No regional model was developed for biochemical oxygen demand. Regression models of storm-runoff loads were developed from a stepwise regression analysis of 13 candidate explanatory variables; the number of explanatory variables selected as significant for a particular model ranged from three to six (Driver and Tasker, 1990, table 1). Stepwise regression analysis models of mean concentrations were developed in a similar manner (Driver and Tasker, 1990, table 5). Regional models selected for use in the Boise area were developed with data from five metropolitan areas where mean annual precipitation is less than 20 in. The metropolitan area in that group nearest to the study area was Salt Lake City, Utah.

ADJUSTED REGIONAL MODELS

Storm-runoff volume and mean concentrations and loads of selected chemical constituents estimated from regional models were compared with measured data at five storm-sewer outfalls to the Boise River to evaluate the reliability of the estimates. It was concluded that results obtained from the regional models generally did not represent conditions in the study area after examining plots of observed and estimated values, evaluating root mean square errors, and determining that measurement sites were suitable and that storms monitored for this study constituted a valid sample of the historical record. This finding was not unexpected in that the regression equations for the regional models were developed with data from other cities and did not include data collected in the study area.

Hoos and Sisolak (1993) identified four procedures whereby regional models (Driver and Tasker, 1990) and data collected from a study area could be combined to develop adjusted regional models. The four procedures were (1) single-factor regression against the regional model prediction, (2) regression against model prediction, (3) regression against model prediction and additional local variables, and (4) a weighted combination of model prediction and a local regression prediction. The general form of the equation(s) associated with each procedure is:

Table 11. Storm-runoff volumes and loads of selected constituents measured at storm-sewer outfalls in Boise and Garden City, Idaho

[COD, chemical oxygen demand; BOD, biochemical oxygen demand; DS, dissolved solids; SS, suspended solids, TN, total nitrogen; TKN, total ammonia plus organic nitrogen as nitrogen; TP, total phosphorus; DP, dissolved phosphorus; CD, total recoverable cadmium; CU, total recoverable copper; PB, total recoverable lead; ZN, total recoverable zinc; —, no data]

Storm-sewer outfall	Beginning date of storm	Storm volume, in cubic feet	Storm load, in pounds											
			COD	BOD	DS	SS	TN	TKN	TP	DP	CD	CU	PB	ZN
51N at Walnut Street	10- 7-93	2,710	25	9.1	40	5.6	0.12	0.63	0.069	0.054	0.00017	0.00152	0.00051	0.0237
	12-11-93	11,300	55	13.4	196	52	.60	.90	.219	.127	.00071	.00353	.00776	.0776
	5-17-94	10,400	35	.44	118	9.7	.16	.78	.149	.123	.00065	.00325	.00065	.0325
44S at Boise State University	10- 7-93	2,250	48	16.9	24	2.8	.34	.90	.111	.100	.00014	.00436	.00225	.0436
	12-11-93	12,700	71	18.2	30	41	.41	1.19	.206	.127	.00079	.00634	.0174	.0793
	4-23-94	29,600	370	72.1	100	340	.91	6.47	.924	.573	.00185	.0314	.0980	.4806
39N at Ninth Street	10- 7-93	3,460	288	80.3	97	87	1.04	6.43	.937	.703	.00034	.0435	.0335	.4352
	12- 7-93	5,250	107	—	72	92	.29	1.98	.404	.240	.00051	.0263	.0112	.1328
	5- 4-94	145	1.8	.30	1.8	.5	.0076	.034	.0044	.0028	.000009	.00022	.00199	.0019
31N at Americana Boulevard	12- 7-93	7,560	72	—	70	73	.27	.93	.134	.058	.00045	.00851	.0224	.0896
	4-23-94	34,100	354	77.3	90	335	.84	5.16	2.10	.773	.00161	.0322	.0870	.4511
	6- 1-94	14,000	140	60.0	33	189	.51	3.06	.580	.230	.00087	.0122	.0370	.1400
43rd Street in Garden City	9-13-94	537	11	2.5	5.7	2.3	.32	.28	.026	.020	.000034	.00178	.00084	.0235
	10- 4-94	4,450	170	67	22	93	14.2	13.9	.333	.161	.000834	.0272	.0445	.200
	10-14-94	4,910	74	14	14	59	1.72	1.50	.166	.095	.000613	.0150	.0209	.0981

$$P_a = P_u (BCF), \tag{1}$$

$$P_a = B_o (P_u)^{X_0} (BCF), \tag{2}$$

$$P_a = B_o (P_u)^{X_0} (TRN)^{X_1} (DA)^{X_2} (EV)^{X_3} (EV)^{X_4} (EV)^{X_5} (BCF), \tag{3}$$

$$P_l = B_o (TRN)^{X_1} (DA)^{X_2} (EV)^{X_3} (EV)^{X_4} (EV)^{X_5} (BCF), \text{ and} \tag{4}$$

$$P_a = (P_u)^{w} (P_l)^{(1-w)} (BCF), \tag{5}$$

where

P_a = an adjusted response variable,

P_u = an unadjusted response variable from regional regression equation,

B_o = a calibration coefficient,

X_0, X_1, X_2, X_3, X_4, and X_5 = exponents determined from regression analysis,

EV = values of three selected explanatory variables,

P_l = a response variable from a local regression equation,

w = a weighting coefficient for the unadjusted response variable, and

BCF = the bias correction factor. The BCF is calculated for each adjustment procedure using a nonparametric method based on the average residuals in original units:

$$BCF = \frac{1}{n} \Sigma\, 10^{ei},$$

where

ei = the least-squares residual for observations *i* from the calibration data set, in log units; and

n = the number of observations.

Hoos and Sisolak (1993) described two sets of conditions under which this procedure is appropriate: (1) a small calibration data set (the local data set might consist of only 15 data pairs) argues against attempting to calibrate more than one coefficient, and (2) the relation between explanatory variables and the response variable appears to be adequately modeled by the regional model and the predicted values are biased in a consistent direction and by a constant factor.

Hoos and Sisolak (1993) also suggested a scheme to guide which adjustment procedure to use. When observed and estimated values were strongly correlated and related according to a consistent direction of bias, adjustment procedure 1 or 2 was used. When observed and predicted values were not strongly correlated or the direction of bias was not consistent, adjustment procedure 3 or 4 was used. The fit of the estimated mean concentration and load for the mean storm with collected data was considered when choosing which adjustment procedure to use. Another consideration was that signs of the coefficients were logical. Generally, standard errors were not considered when choosing the adjustment procedure.

REGRESSION EQUATIONS

Regression equations for regional models (Driver and Tasker, 1990) and local and adjusted regional models for individual storms are presented in the next three sections. Regression equations for local models were produced as an intermediate step when procedure 4 was used to develop adjusted regional models. Local models were developed from data collected exclusively in the study area. Regression equations for several local models produced increased coefficients of determination or decreased standard errors of estimate compared with those produced from regional or adjusted regional models. However, adjusted regional models were considered to provide a better representation of conditions in the study area, with one exception identified later, because improvements in coefficients of determination and standard errors of estimate were small and data sets used to develop local models were much smaller than data sets for regional models and, therefore, described less variability relative to data sets used to develop regional models. Regression equations should be used with caution because standard errors of estimate generally were large for both regional and adjusted regional models and the amount of data collected in the study area used to develop adjusted regional models was small.

Usually, more than one regression equation must be solved to obtain an adjusted regional model. The solution from one equation is used to obtain the solution to another regression equation in a sequential manner, depending on which of the four adjustment procedures was selected. Composite regression models were developed that combine the solution of a string of regression equations needed to obtain an adjusted regional model into a single regression equation that contains only one constant and exponents for the appropriate set of variables. Composite regression models, presented in a table in each of the next three sections, were provided to supplement the individual regression equations and to simplify the computation of estimated storm-runoff volume and mean concentrations and loads of selected chemical constituents.

Storm-Runoff Volume Models

$$RV_{REG} = 1{,}123{,}052\ (TRN)^{1.049}\ (DA)^{0.916}\ (IA+1)^{0.677}\ (MAR)^{-1.312}\ (1.299) \quad (6)$$

$$RV_{ADJ} = 0.0167\ (RV_{REG})^{1.333}, \quad (7)$$

where

RV = runoff volume,

$_{REG}$ = regional regression model, and

$_{ADJ}$ = adjusted regional regression model.

Procedure 2 was used to develop the adjusted regional model of storm-runoff volume. The log standard error of estimate was 0.316 for the regional model and 0.407 for the adjusted regional model. Procedure 2 was used because of a strong relation between the observed and predicted volumes. The adjusted coefficient of determination (R^2 value) was 0.70. A higher R^2 value (0.84) and a lower standard error (0.296) were indicated by procedure 3, but the suggested guide for choosing the adjustment procedure was followed. The constant and exponents for the composite regression model of the adjusted regional regression model for runoff volume are listed in table 12.

Table 12. Constant and exponents for a composite regression model of storm-runoff volume, Boise and Garden City, Idaho

[TRN, total storm rainfall; DA, total contributing drainage area; IA, impervious area; MAR, mean annual rainfall]

	Constant	TRN, in inches	DA, in square miles	IA+1, in percent	MAR, in inches
Storm runoff, in cubic feet..................	2,750,000	1.40	1.22	0.90	-1.75

Storm-Runoff Mean Concentration Models

Chemical oxygen demand

$$COD_{REG} = 5.035\ (TRN)^{-0.473}\ (DA)^{-0.027}\ (LUI+1)^{0.388}\ (LUC+1)^{0.012}\ (LUN+2)^{0.048}\ (MAR)^{0.855}\ (1.163) \quad (8)$$

$$COD_{LOC} = 33.8\ (TRN)^{-0.271}\ (DA)^{0.065}\ (IA)^{0.474}\ (LUC+1)^{0.081}\ (MHP)^{0.130}\ (1.142) \quad (9)$$

$$COD_{ADJ} = (COD_{REG})^{0.56}\ (COD_{LOC})^{0.44}\ (0.988), \quad (10)$$

where

REG = regional regression model,

LOC = local regression model, and

ADJ = adjusted regional regression model.

Dissolved solids

$$DS_{REG} = 0.333\ (TRN)^{-0.402}\ (DA)^{0.469}\ (IA+1)^{0.445}\ (MAR)^{1.497}\ (1.352) \quad (11)$$

$$DS_{ADJ} = (1.11)\ (DS_{REG}) \quad (12)$$

Suspended solids

$$SS_{REG} = 2{,}041\ (TRN)^{0.143}\ (DA)^{0.108}\ (DRN)^{-0.370}\ (1.543) \quad (13)$$

$$SS_{LOC} = 126\ (TRN)^{0.602}\ (DA)^{0.426}\ (IA+1)^{0.473}\ (LUC+1)^{0.444}\ (MHP)^{0.420}\ (1.092) \quad (14)$$

$$SS_{ADJ} = (SS_{REG})^{0.24}\ (SS_{LOC})^{0.76}\ (1.367) \quad (15)$$

Total nitrogen

$$TN_{REG} = 3.52\ (TRN)^{-0.285}\ (DA)^{0.033}\ (LUI{+}1)^{0.512}\ (LUC{+}1)^{0.017}\ (LUN{+}2)^{0.012}\ (MAR)^{-0.129}\ (1.096) \quad (16)$$

$$TN_{LOC} = 0.0513\ (TRN)^{0.370}\ (DA)^{0.355}\ (IA{+}1)^{1.016}\ (ADP)^{0.480}\ (LUC{+}1)^{0.021}\ (1.122) \quad (17)$$

$$TN_{ADJ} = (TN_{REG})^{0.65}\ (TN_{LOC})^{0.35}\ (1.156) \quad (18)$$

Total ammonia plus organic nitrogen as nitrogen

$$TKN_{REG} = 1.282\ (TRN)^{-0.449}\ (DA)^{0.022}\ (LUI{+}1)^{0.426}\ (LUC{+}1)^{0.016}\ (LUN{+}2)^{-0.012}\ (MNL)^{0.347}\ (1.167) \quad (19)$$

$$TKN_{LOC} = 0.0316\ (TRN)^{0.453}\ (DA)^{0.404}\ (IA{+}1)^{1.123}\ (ADP)^{0.506}\ (LUC{+}1)^{0.038}\ (1.132) \quad (20)$$

$$TKN_{ADJ} = (TKN_{REG})^{0.55}\ (TKN_{LOC})^{0.45}\ (1.072) \quad (21)$$

Total phosphorus

$$TP_{REG} = 0.085\ (TRN)^{-0.232}\ (DA)^{-0.012}\ (LUI{+}1)^{0.552}\ (LUC{+}1)^{-0.080}\ (LUN{+}2)^{0.038}\ (MAR)^{0.530}\ (1.261) \quad (22)$$

$$TP_{ADJ} = 1.47\ (TP_{REG}) \quad (23)$$

Dissolved phosphorus

$$DP_{REG} = 0.352\ (TRN)^{0.352}\ (DA)^{-0.294}\ (LUI{+}1)^{0.629}\ (LUC{+}1)^{-0.136}\ (LUN{+}2)^{-0.046}\ (MAR)^{-0.297}\ (1.266) \quad (24)$$

$$DP_{LOC} = 0.0107\ (TRN)^{0.403}\ (DA)^{0.615}\ (IA\ {+}1)^{0.650}\ (ADP)^{0.455}\ (LUC{+}1)^{0.257}\ (1.042) \quad (25)$$

$$DP_{ADJ} = (DS_{REG})^{0.23}\ (DS_{LOC})^{0.77}\ (1.129) \quad (26)$$

Total recoverable cadmium

$$CD_{REG} = 0.338\ (TRN)^{-0.256}\ (DA)^{0.025}\ (LUI{+}1)^{0.090}\ (LUC{+}1)^{0.033}\ (LUN{+}2)^{-0.110}\ (MAR)^{0.481}\ (1.166) \quad (27)$$

Total recoverable copper

$$CU_{REG} = 11.3\ (TRN)^{-0.327}\ (DA)^{0.066}\ (LUI{+}1)^{0.237}\ (LUC{+}1)^{0.048}\ (LUN{+}2)^{0.155}\ (INT)^{0.406}\ (1.297) \quad (28)$$

$$CU_{LOC} = 17.2\ (TRN)^{-0.109}\ (DA)^{-0.026}\ (LUC{+}1)^{0.292}\ (MHP)^{-0.016}\ (LUR)^{-0.274}\ (1.168) \quad (29)$$

$$CU_{ADJ} = (CU_{REG})^{0.46}\ (CU_{LOC})^{0.54}\ (1.603) \quad (30)$$

Total recoverable lead

$$PB_{REG} = 141\,(TRN)^{-0.347}\,(DA)^{0.145}\,(LUI+1)^{-0.109}\,(LUC+1)^{0.034}\,(LUN+2)^{-0.086}\,(MAR)^{0.460}\,(1.304) \qquad (31)$$

$$PB_{LOC} = 18.5\,(TRN)^{-0.67}\,(DA)^{-0.27}\,(LUC+1)^{0.36}\,(ADP)^{-0.070}\,(MHP)^{0.73}\,(1.306) \qquad (32)$$

Total recoverable zinc

$$ZN_{REG} = 199\,(TRN)^{-0.338}\,(DA)^{0.070}\,(LUC+1)^{-0.029}\,(LUR+1)^{0.114}\,(LUN+2)^{0.068}\,(MAR)^{-0.004}\,(1.242) \qquad (33)$$

$$ZN_{LOC} = 2.98\,(TRN)^{-0.034}\,(DA)^{0.303}\,(IA+1)^{1.094}\,(MHP)^{0.205}\,(ADP)^{0.343}\,(1.069) \qquad (34)$$

$$ZN_{ADJ} = (ZN_{REG})^{0.32}\,(ZN_{LOC})^{0.68}\,(1.501) \qquad (35)$$

Procedures 1 and 4 were used to develop adjusted regional models of selected chemical constituents (table 13). A local model was chosen to represent the load of lead because statistical measures of correlation and fit were much poorer for the regional and adjusted regional models. The log standard error of estimate ranged from 0.189 to 0.434 for regional models and from 0.163 to 0.360 for adjusted regional and local models. An adjusted regional model was not developed for cadmium because concentrations of cadmium in all storm-runoff samples collected in Boise were at or less than the detection limit of 1 µg/L. Constants and exponents for composite regression models of the adjusted regional regression models for the preceding constituents are listed in table 14.

Table 13. Adjustment procedures and standard errors of estimate of mean concentrations of selected chemical constituents in storm runoff, Boise and Garden City, Idaho

Chemical constituent	Model adjustment procedure	Standard error of estimate (log)	
		Regional	Adjusted
Chemical oxygen demand	4	0.245	0.266
Dissolved solids	1	.322	.185
Suspended solids	4	.434	.243
Total nitrogen	4	.189	.320
Total ammonia plus organic nitrogen as nitrogen	4	.242	.297
Total phosphorus	1	.303	.360
Dissolved phosphorus	4	.300	.163
Total recoverable cadmium	(1)	.247	(2)
Total recoverable copper	4	.316	.344
Total recoverable lead	(1)	.331	.418
Total recoverable zinc	4	.308	.248

[1]Not adjusted.
[2]Used detection limit for loads.

Table 14. Constants and exponents for composite regression models of mean concentrations of selected chemical constituents in storm runoff in Boise and Garden City, Idaho

[COD; chemical oxygen demand; DS, dissolved solids; SS, suspended solids; TN, total nitrogen; TKN, total ammonia plus organic nitrogen as nitrogen; TP, total phosphorus; DP, dissolved phosphorus; CU, total recoverable copper; PB, total recoverable lead; ZN, total recoverable zinc; TRN, total storm rainfall; DA, total contributing drainage area; IA, impervious area; LUI, industrial land use; LUC, commercial land use; LUN, nonurban land use; LUR, residential land use; DRN, duration of storm; ADP, antecedent dry period; MAR, mean annual rainfall; INT, maximum 24-hour precipitation intensity; MNL, mean annual nitrogen load in precipitation; MHP, maximum precipitation for 1 hour during a storm; —, variable not used]

Chemical constituent	Constant	TRN, in inches	DA, in square miles	IA+1, in percent	LUI+1, in percent	LUC+1, in percent	LUN+2, in percent	LUR+1, in percemt	DRN, in minutes	ADP, in hours	MAR, in inches	INT, in inches	MNL, in pounds of nitrogen per acre	MHP, in inches per hour
COD	13.3	-0.38	0.013	0.21	0.22	0.043	0.027	—	—	—	0.48	—	—	0.057
DS	.500	-.40	.47	.44	—	—	—	—	—	—	1.50	—	—	—
SS	399	.49	.35	.36	—	.34	—	—	-0.089	—	—	—	—	.32
TN	1.02	-.055	.14	.36	.33	.018	.008	—	—	0.17	-.084	—	—	—
TKN	.299	-.043	.19	.50	.23	.026	-.007	—	—	.23	—	—	0.19	—
TP	.158	-.23	-.012	—	.55	-.080	.038	—	—	—	.53	—	—	—
DP	.0294	.39	.41	.50	.14	.17	-.011	—	—	.35	-.068	—	—	—
CU	27.9	-.21	.016	—	.11	.18	.071	-0.15	—	—	—	0.19	—	-.009
PB	24.1	-.67	-.27	—	—	.36	—	—	—	-.070	—	—	—	.73
ZN	19.3	-.13	.23	.74	—	-.009	.022	.036	—	.23	-.001	—	—	.14

Storm-Runoff Load Models

Chemical oxygen demand

$$COD_{REG} = 7{,}111\ (TRN)^{0.671}\ (DA)^{0.617}\ (LUI{+}1)^{0.415}\ (LUC{+}1)^{0.267}\ (LUN{+}2)^{-0.156}\ (MAR)^{-0.633}\ (1.704) \quad (36)$$

$$COD_{ADJ} = 0.0757\ (COD_{REG})^{1.214}\ (TRN)^{0.658}\ (DA)^{-0.176}\ (LUR{+}1)^{-0.003}\ (DRN)^{0.326}\ (MHP)^{0.381}\ (1.321), \quad (37)$$

where

$_{REG}$ = regional regression model, and

$_{ADJ}$ = adjusted regional regression model.

Dissolved solids

$$DS_{REG} = 54.8\ (TRN)^{0.585}\ (DA)^{1.356}\ (IA{+}1)^{1.383}\ (MAR)^{-0.718}\ (1.239) \quad (38)$$

$$DS_{LOC} = 51.1\ (TRN)^{1.584}\ (DA)^{0.947}\ (IA{+}1)^{0.625}\ (ADP)^{0.201}\ (DRN)^{0.192}\ (1.241) \quad (39)$$

$$DS_{ADJ} = (DS_{REG})^{0.59}\ (DS_{LOC})^{0.41}\ (1.472), \quad (40)$$

where

$_{LOC}$ = local regression model.

Suspended solids

$$SS_{REG} = 1{,}518\ (TRN)^{1.211}\ (DA)^{0.735}\ (DRN)^{-0.463}\ (2.112) \quad (41)$$

$$SS_{LOC} = 52{,}710\ (TRN)^{2.672}\ (DA)^{0.927}\ (LUC+1)^{0.849}\ (MHP)^{0.705}\ (DRN)^{-0.209}\ (1.213) \quad (42)$$

$$SS_{ADJ} = (SS_{REG})^{0.26}\ (SS_{LOC})^{0.74}\ (0.859) \quad (43)$$

Total nitrogen

$$TN_{REG} = 1{,}132\ (TRN)^{0.798}\ (DA)^{0.960}\ (LUI+1)^{0.462}\ (LUC+1)^{0.260}\ (LUN+2)^{-0.194}\ (MAR)^{-0.951}\ (1.139) \quad (44)$$

$$TN_{LOC} = 1.312\ (TRN)^{2.08}\ (DA)^{0.13}\ (AI+1)^{0.45}\ (ADP)^{0.48}\ (LUR)^{-0.29}\ (1.364) \quad (45)$$

Total ammonia plus organic nitrogen as nitrogen

$$TKN_{REG} = 18.9\ (TRN)^{0.670}\ (DA)^{0.831}\ (LUI+1)^{0.378}\ (LUC+1)^{0.258}\ (LUN+2)^{-0.219}\ (MNL)^{1.350}\ (1.206) \quad (46)$$

$$TKN_{ADJ} = 35.4\ (TKN_{REG})^{0.327}\ (TRN)^{2.618}\ (DA)^{0.441}\ (LUC+1)^{0.599}\ (ADP)^{0.708}\ (DRN)^{-0.658}\ (1.241) \quad (47)$$

Total phosphorus

$$TP_{REG} = 262\ (TRN)^{0.828}\ (DA)^{0.645}\ (LUI+1)^{0.583}\ (LUC+1)^{0.181}\ (LUN+2)^{-0.235}\ (MAR)^{-1.376}\ (1.548) \quad (48)$$

$$TP_{LOC} = 111.5\ (TRN)^{3.344}\ (DA)^{1.163}\ (LUC+1)^{0.963}\ (ADP)^{0.681}\ (DRN)^{-0.814}\ (1.095) \quad (49)$$

$$TP_{REG} = (TP_{REG})^{0.25}\ (TP_{LOC})^{0.75}\ (1.831) \quad (50)$$

Dissolved phosphorus

$$DP_{REG} = 588\ (TRN)^{0.808}\ (DA)^{0.726}\ (LUI+1)^{0.642}\ (LUC+1)^{0.096}\ (LUN+2)^{-0.238}\ (MAR)^{-1.899}\ (1.407) \quad (51)$$

$$DP_{REG} = 17.8\ (DP_{REG})^{0.544}\ (TRN)^{2.681}\ (DA)^{0.755}\ (LUC+1)^{0.761}\ (ADP)^{0.760}\ (DRN)^{-0.824}\ (1.084) \quad (52)$$

Total recoverable cadmium

$$CD_{REG} = 0.039\ (TRN)^{0.845}\ (DA)^{0.753}\ (LUI+1)^{0.138}\ (LUC+1)^{0.248}\ (LUN+2)^{-0.374}\ (1.244) \quad (53)$$

$$CD_{ADJ} = 0.282\ (CD_{REG}) \quad (54)$$

Total recoverable copper

$$CU_{REG} = 0.141\ (TRN)^{0.807}\ (DA)^{0.590}\ (LUI+1)^{0.424}\ (LUC+1)^{0.274}\ (LUN+2)^{0.061}\ (INT)^{0.928}\ (1.502) \quad (55)$$

$$CU_{ADJ} = 0.419\ (CU_{REG}) \quad (56)$$

Total recoverable lead

$$PB_{REG} = 478\ (TRN)^{0.764}\ (DA)^{0.918}\ (LUI+1)^{-0.161}\ (LUC+1)^{0.276}\ (LUN+2)^{-0.282}\ (MAR)^{-1.829}\ (1.588) \quad (57)$$

$$PB_{LOC} = 9.42\ (TRN)^{2.11}\ (DA)^{0.50}\ (LUC+1)^{0.67}\ (ADP)^{0.14}\ (DRN)^{-0.86}\ (1.650) \quad (58)$$

Total recoverable zinc

$$ZN_{REG} = 224\ (TRN)^{0.745}\ (DA)^{0.792}\ (LUC+1)^{0.172}\ (LUR+1)^{-0.195}\ (LUN+2)^{-0.142}\ (MAR)^{-1.355}\ (1.444) \quad (59)$$

$$ZN_{LOC} = 0.3377\ (TRN)^{1.70}\ (DA)^{0.54}\ (LUC+1)^{0.33}\ (ADP)^{0.47}\ (DRN)^{-0.18}\ (1.425) \quad (60)$$

Procedures 1, 3, and 4 were used to develop adjusted regional and local model loads of selected chemical constituents (table 15). Local models were chosen to represent the load of total nitrogen, lead, and zinc because statistical measures of correlation and fit were much poorer for the regional and adjusted regional models. The log standard error of estimate ranged from 0.230 to 0.589 for regional models and from 0.244 to 0.600 for adjusted regional and local models. An adjusted regional model of cadmium load was developed on the basis of a detection limit of 1 µg/L; concentrations in 2 of the 15 samples were greater than 1 µg/L. Constants and exponents for the composite regression models of the adjusted regional regression models for the preceding constituents are listed in table 16.

Table 15. Adjustment procedures and standard errors of estimate of loads of selected chemical constituents in storm runoff, Boise and Garden City, Idaho

Chemical constituent	Model adjustment procedure	Standard error of estimate (log)	
		Regional	Adjusted
Chemical oxygen demand	3	0.324	0.402
Dissolved solids	4	.285	.370
Suspended solids	4	.589	.406
Total nitrogen	[1]	.230	.440
Total ammonia plus organic nitrogen as nitrogen	3	.277	.379
Total phosphorus	4	.427	.321
Dissolved phosphorus	3	.363	.244
Total recoverable cadmium	1	.311	.526
Total recoverable copper	1	.388	.600
Total recoverable lead	[1]	.455	.561
Total recoverable zinc	[1]	.407	.467

[1] Used local model.

Table 16. Constants and exponents for composite regression models of loads of selected chemical constituents in storm runoff, Boise and Garden City, Idaho

[COD; chemical oxygen demand; DS, dissolved solids; SS, suspended solids; TN, total nitrogen; TKN, total ammonia plus organic nitrogen as nitrogen; TP, total phosphorus; DP, dissolved phosphorus; CD, total recoverable cadmium; CU, total recoverable copper; PB, total recoverable lead; ZN, total recoverable zinc; TRN, total storm rainfall; DA, total contributing drainage area; IA, impervious area; LUI, industrial land use; LUC, commercial land use; LUN, nonurban land use; LUR, residential land use; INT, maximum 24-hour precipitation intensity; DRN, duration of storm; ADP, antecedent dry period; MAR, mean annual rainfall; MHP, maximum precipitation for 1 hour during a storm; MNL, mean annual nitrogen load in precipitation; —, variable not used]

Chemical constituent	Constant	TRN, in inches	DA, in square miles	IA+1, in percent	LUI+1, in percent	LUC+1, in percent	LUN+2, in percent	LUR+1 in percent	INT, in inches	DRN, in minutes	ADP, in hours	MAR, in inches	MHP, in inches per hour	MNL, in pounds of nitrogen per acre
COD	6,540	1.47	0.57	—	0.50	0.32	-0.19	-0.003	—	0.33	—	-0.77	0.38	—
DS	97.2	.99	1.19	1.07	—	—	—	—	—	.079	0.082	-.42	—	—
SS	25,200	2.29	.88	—	—	.63	—	—	—	-.28	—	—	.52	—
TN	1.79	2.08	.13	.45	—	—	—	-.29	—	—	.48	—	—	—
TKN	122	2.84	.71	—	.12	.68	-.072	—	—	-.66	.71	—	—	0.44
TP	302	2.71	1.03	—	.15	.77	-.059	—	—	-.61	.51	-.34	—	—
DP	744	3.12	1.15	—	.35	.81	-.13	—	—	-.82	.76	-1.03	—	—
CD	.0137	.84	.75	—	.14	.25	-.37	—	—	—	—	—	—	—
CU	.0887	.81	.59	—	.42	.27	.061	—	0.93	—	—	—	—	—
PB	15.5	2.11	.50	—	—	.67	—	—	—	-.86	.14	—	—	—
ZN	.481	1.70	.54	—	—	.33	—	—	—	-.18	.47	—	—	—

MEAN ANNUAL RUNOFF VOLUME AND LOAD ESTIMATES

Mean annual runoff volumes and loads for the five storm-sewer outfalls were estimated by computing runoff volume and loads for the 904 individual storms during 1976 through 1993. The model in table 12 was used to compute runoff volumes. Storm loads were computed by two methods. First, storm loads were computed by using the models in table 16 and the resulting mean annual loads are given in table 17. Upon examination of individual storm loads, a few of the larger storms seemed to produce excessively high loads for some constituents (other constituents could have excessively low loads). Because the models in table 16 may not apply to a few of the larger storms from 1976 through 1993, a second method was used to compute storm loads. For the second method, storm loads were determined by computing mean concentrations of constituents from models in table 14 and runoff volume from the model in table 12. The resulting mean annual loads using the second method are given in table 18. Storm load estimates using the second method generally would apply to large storms, because the mean concentration of most constituents generally would decrease as runoff increased and the exponents for total storm rainfall (TRN) in table 14 are negative for all constituents except suspended solids. The negative exponents would decrease mean

Table 17. Mean annual loads of selected chemical constituents in storm runoff and runoff volumes measured at storm-sewer outfalls in Boise and Garden City, Idaho, computed from adjusted regional regression load models

[COD, chemical oxygen demand; DS, dissolved solids; SS, suspended solids, TN, total nitrogen; TKN, total ammonia plus organic nitrogen as nitrogen; TP, total phosphorus; DP, dissolved phosphorus; CD, total recoverable cadmium; CU, total recoverable copper; PB, total recoverable lead; ZN, total recoverable zinc; MARV, mean annual runoff volume, in cubic feet]

Storm-sewer outfall	Mean annual load, in pounds											
	COD	DS	SS	TN	TKN	TP	DP	CD	CU	PB	ZN	MARV
51N at Walnut Street	16,800	4,110	10,600	70	516	131	49	0.058	2.3	0.63	10	2,400,000
44S at Boise State University	25,500	1,520	10,300	65	545	162	69	.11	1.4	1.1	9.0	782,000
39N at Ninth Street	55,800	4,210	48,600	176	3,030	1,090	509	.19	2.7	5.0	20	1,790,000
31N at Americana Boulevard	23,200	708	11,800	94	882	204	80	.067	1.1	2.3	8.7	304,000
43rd Street in Garden City	11,800	412	4,500	261	452	67	22	.024	.54	1.6	4.6	137,000

Table 18. Mean annual loads of selected chemical constituents in storm runoff, Boise and Garden City, Idaho, computed from adjusted regional regression mean concentration and runoff volume models

[COD, chemical oxygen demand; DS, dissolved solids; SS, suspended solids; TN, total nitrogen; TKN, total ammonia plus organic nitrogen as nitrogen; TP, total phosphorus; DP, dissolved phosphorus; CU, total recoverable copper; PB, total recoverable lead; ZN, total recoverable zinc]

Storm-sewer outfall	Mean annual load, in pounds									
	COD	DS	SS	TN	TKN	TP	DP	CU	PB	ZN
51N at Walnut Street	35,600	12,600	29,500	602	396	126	42	3.9	0.95	38
44S at Boise State University	4,380	2,800	13,500	199	204	32	14	1.3	.84	13
39N at Ninth Street	15,900	9,750	108,000	696	858	59	85	6.1	5.2	59
31N at Americana Boulevard	2,460	816	9,000	89	97	11	6.9	1.4	1.03	6.4
43rd Street in Garden City	1,440	303	4,540	106	42	4.6	3.4	.54	.89	4.6

Table 19. Mean annual loads of selected chemical constituents in storm runoff, Boise and Garden City, Idaho, computed from national regression models

[COD, chemical oxygen demand; DS, dissolved solids; SS, suspended solids; TN, total nitrogen; TKN, total ammonia plus organic nitrogen as nitrogen; TP, total phosphorus; DP, dissolved phosphorus; CU, total recoverable copper; PB, total recoverable lead; ZN, total recoverable zinc]

Storm-sewer outfall	Mean annual load, in pounds									
	COD	DS	SS	TN	TKN	TP	DP	CU	PB	ZN
51N at Walnut Street	219,000	1,550,000	106,000	3,630	745	557	142	176	206	443
44S at Boise State University	16,600	54,500	13,100	452	96	36	23	16	18	33
39N at Ninth Street	18,300	43,200	11,400	196	44	30	20	13	23	41
31N at Americana Boulevard	4,850	9,160	4,310	177	39	8.4	8.5	4.4	6.1	10
43rd Street in Garden City	4,820	3,450	2,340	85	20	3.8	5.0	2.2	8.4	14

concentrations as the amount of rainfall increased. Therefore, the method used in table 18 to estimate mean annual loads provides more reliable results for large storms for all constituents except suspended solids. The method in table 17 may be used to estimate suspended solids for large storms.

Runoff volumes computed from 904 individual storms during 1976 through 1993 were grouped by season. Thirty-six percent of the runoff occurred during the winter season; 38 percent occurred during the spring season; and 26 percent occurred during the dry season. Loads computed for each of the storms also were grouped seasonally. Percentages for seasonal loads for most constituents generally were similar to the percentages for seasonal runoff volumes.

Results from national models (table 19) for estimating mean annual loads (Driver and Tasker, 1990, table 10) generally did not correspond with estimates in tables 17 and 18 for the five outfalls. Larger data bases than those from the five outfalls would be necessary to further define differences in mean annual load models.

SUMMARY

The City of Boise and much of Ada County are parts of a rapidly growing urban area. Water-quality management of runoff through the storm-sewer system from urban drainage basins requires city engineers, planners, and designers to estimate storm-runoff volume and mean concentration and load of chemical constituents to assess current and potential effects of storm runoff on water quality of the Boise River.

The need for information about the volume and quality of storm runoff resulted in the development of the Nationwide Urban Runoff Program. Data collection and analyses described in this report are part of an effort by the Ada County Highway District, City of Boise, Idaho Transportation Department, Ada County Drainage District

No. 3, and Boise State University to comply with a series of regulations (National Pollutant Discharge Elimination System) that are used to control pollutant discharge to the Nation's waterways. This information is required when applying for a permit from the U.S. Environmental Protection Agency to discharge urban storm runoff to the Boise River.

Storm-runoff samples were collected at four storm-sewer outfalls to the Boise River in Boise and one outfall in Garden City using guidelines established by the U.S. Environmental Protection Agency. Data in Boise were collected three times at each site from October 1993 to June 1994. Data in Garden City were collected three times during September and October 1994. Samples were analyzed for specific conductance, pH, alkalinity, water temperature, oxygen demand, fecal indicator bacteria, major ions, dissolved and suspended solids, nutrients, trace elements, and numerous organic compounds.

Regional regression models were developed to estimate runoff volume and mean concentration and load of selected chemical constituents as part of the Nationwide Urban Runoff Program. Models are presented for the estimation of storm-runoff volume and mean concentrations and loads of chemical oxygen demand, dissolved and suspended solids, total nitrogen, total ammonia plus organic nitrogen as nitrogen, total and dissolved phosphorus, and total recoverable cadmium, copper, lead, and zinc.

Storm-runoff volume and mean concentrations and loads of chemical constituents estimated from regional models were compared with measured data from five storm-sewer outfalls in Boise and Garden City to assess the suitability of the models for the Boise area. Comparisons indicated that regional models generally did not represent conditions in the study area. A scheme was followed to guide in the selection of one of four procedures to adjust each regional model. Adjusted regional models were developed for runoff volume and mean concentrations and loads for 11 selected chemical constituents. Models should be used with caution because the data bases used to develop the regional and adjusted regional models were small and the standard errors of estimate were high.

Adjusted regional models were used to compute runoff volumes and loads from the 904 individual storms during 1976 through 1993 to estimate mean annual runoff volume and loads for 11 selected chemical constituents at the five outfalls. Two methods were used to compute individual storm loads. The first method, using adjusted regional regression models for constituent load, seemed to produce excessively high loads for large storms for some constituents. The second method, using adjusted regional regression models for mean concentration and runoff volume, generally would apply to large storms because mean concentrations decrease as the amount of rainfall increases. The second method provided more reliable results for large storms for all constituents except suspended solids. The first method provided more reliable results for large storms for suspended solids.

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TABLES 6–10

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Table 6. Chemical analyses of storm-runoff samples collected at 51N outfall at Walnut Street during October 1993 through May 1994, Boise, Idaho

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; col/100 mL, colonies per 100 milliliters; K, nonideal colony count; —, no data; >, greater than; <, less than]

Water-quality constituent or characteristic	Beginning date of storm 10-7-93	12-11-93	5-17-94
Discharge, volume, in cubic feet	2,710	11,300	10,400
Specific conductance, in µS/cm	292	384	316
pH, in standard units	7.1	7.6	7.3
Alkalinity, total as $CaCO_3$, in mg/L	68	78	80
Hardness, total as $CaCO_3$, in mg/L	100	120	91
Temperature, water, in degrees Celsius	16.0	6.0	11.5
DISSOLVED OXYGEN AND OXYGEN DEMAND			
Dissolved oxygen, in mg/L	—	—	8.3
Chemical oxygen demand, in mg/L	150	78	54
Biochemical oxygen demand, 5-day, in mg/L	54	19	13
FECAL INDICATOR BACTERIA			
Fecal coliform, in col/100 mL: Beginning	K633	K667	4,200
Fecal coliform, in col/100 mL: Middle	K1,500	K470	2,500
Fecal coliform, in col/100 mL: End	K1,200	K267	K1,000
Fecal streptococci, in col/100 mL: Beginning	K1,600	16,600	10,900
Fecal streptococci, in col/100 mL: Middle	>10,000	K3,600	18,000
Fecal streptococci, in col/100 mL: End	K3,000	4,000	23,000
MAJOR IONS			
Calcium, dissolved, in mg/L	31	37	29
Magnesium, total, in mg/L	5.7	6.7	4.5
Sodium, dissolved, in mg/L	28	48	29
Potassium, dissolved, in mg/L	4.8	4.5	2.9
Sulfate, dissolved, in mg/L	63	99	58
Chloride, dissolved, in mg/L	<.1	18	8.1
DISSOLVED AND SUSPENDED SOLIDS			
Dissolved solids, in mg/L	178	264	178
Suspended solids, in mg/L	33	74	15
Residue, volatile nonfilterable, in mg/L	250	304	206
NUTRIENTS			
Nitrate, total as N, in mg/L	.64	.82	.20
Nitrite, total as N, in mg/L	.07	.03	.02
Nitrogen, ammonia, total as N, in mg/L	1.2	.28	.36
Nitrogen, organic plus ammonia as N, total, in mg/L	3.7	1.3	1.2
Nitrogen, total organic as N, in mg/L	2.5	1	.84
Phosphorus, total as P, in mg/L	.41	.31	.23
Phosphorus, dissolved as P, in mg/L	.32	.18	.19
TRACE ELEMENTS			
Antimony, total as Sb, in µg/L	<10	<10	<10
Arsenic, total as As, in µg/L	10	7	5
Beryllium, total as Be, in µg/L	<10	<10	<10
Cadmium, total as Cd, in µg/L	<1	<1	<1
Chromium, total as Cr, in µg/L	<1	3	<1
Copper, total as Cu, in µg/L	9	5	5
Lead, total as Pb, in µg/L	3	11	2
Mercury, total as Hg, in µg/L	<.1	<.1	<.1
Nickel, total as Ni, in µg/L	5	4	<1
Selenium, total as Se, in µg/L	<1	<1	<1
Silver, total as Ag, in µg/L	<.5	<.5	<.5
Thallium, dissolved, in µg/L	<5	<20	<5
Zinc, total as Zn, in µg/L	140	110	60
Cyanide, dissolved as CN, in mg/L	<.01	<.01	<.01
ORGANIC COMPOUNDS			
Carbon, organic, total as C, in mg/L	46	17	12
Oil and grease, total recoverable, in mg/L	<1	<1	<1
VOLATILE ORGANIC COMPOUNDS			
Acrolein, total, in µg/L	<20	<100	<20
Acrylonitrile, total, in µg/L	<20	<100	<20
Benzene, total, in µg/L	<5	<1	<.2
Bromobenzene, total, in µg/L	<5	<1	<.2
Bromoform, total, in µg/L	<5	<1	<.2
Carbon tetrachloride, total, in µg/L	<5	<1	<.2
VOLATILE ORGANIC COMPOUNDS—Continued			
Chlorobenzene, total, in µg/L	<5	<1	<0.2
Chlorodibromomethane, total, in µg/L	<5	<1	<.2
Chloroethane, total, in µg/L	<5	<1	<.2
Chloroform, total, in µg/L	<5	<1	<.2
Cis-1,2-dichloroethene, total, in µg/L	<5	<1	<.2
Cis-1,3-dichloropropene, total, in µg/L	<5	<1	<.2
Dibromochloropropane, total recoverable, in µg/L	<25	<5	<1
Dibromomethane, total recoverable, in µg/L	<5	<1	<.2
Dichlorobromomethane, total, in µg/L	<5	<1	<.2
Dichlorodifluoromethane, total, in µg/L	<5	<1	<.2
Ethylbenzene, total, in µg/L	<5	<1	<.2
Methylbromide, total, in µg/L	<5	<1	<.2
Methylchloride, total, in µg/L	<5	<1	<.2
Methylene chloride, total, in µg/L	<5	<1	<.4
N-butylbenzene, total recoverable, in µg/L	<5	<1	<.2
O-chlorotoluene, total, in µg/L	<5	<1	<.2
P-isopropyltoluene, total recoverable, in µg/L	<5	<1	<.2
Sec-butylbenzene, total recoverable, in µg/L	<5	<1	<.2
Styrene, total, in µg/L	<5	<1	<.2
Tert-butylbenzene, total recoverable, in µg/L	<5	<1	<.2
Tetrachloroethylene, total, in µg/L	<5	<1	<.2
Toluene, total, in µg/L	<5	<1	<.2
Trans-1,3-dichloropropene, total, in µg/L	<5	<1	<.2
Trichloroethylene, total, in µg/L	<5	<1	<.2
Trichlorofluoromethane, total, in µg/L	<5	<1	<.2
Vinyl chloride, total, in µg/L	<5	<1	<.2
Xylene, total recoverable, in µg/L	<5	<1	<.2
1,1,1,2-Tetrachloroethane, total, in µg/L	<5	<1	<.2
1,1,1-Trichloroethane, total, in µg/L	<5	<1	<.2
1,1,2,2-Tetrachloroethane, total, in µg/L	<5	<1	<.2
1,1-Dichloroethane, total, in µg/L	<5	<1	<.2
1,1-Dichloroethylene, total, in µg/L	<5	<1	<.2
1,1-Dichloropropene, total, in µg/L	<5	<1	<.2
1,2,3-Trichlorobenzene, total recoverable, in µg/L	<5	<1	<.2
1,2,3-Trichloropropane, total, in µg/L	<5	<1	<.2
1,2-Dibromoethane, total, in µg/L	<5	<1	<.2
1,2-Dichloroethane, total, in µg/L	<5	<1	<.2
1,2-Dichloropropane, total, in µg/L	<5	<1	<.2
1,2-Transdichloroethene, total, in µg/L	<5	<1	<.2
1,3-Dichloropropane, total, in µg/L	<5	<1	<.2
2,2-Dichloropropane, total, in µg/L	<5	<1	<.2
2-Chloroethylvinylether, total, in µg/L	<1	<5	<1
BASE/NEUTRAL ORGANIC COMPOUNDS			
Acenaphthene, total, in µg/L	<5	<5	<5
Acenaphthylene, total, in µg/L	<5	<5	<5
Anthracene, total, in µg/L	<5	<5	<5
Benzidine, total, in µg/L	<40	<40	<40
Benzo(a)anthracene, 1,2-benzanthracene, total, in µg/L	<10	<10	<10
Benzo(a)pyrene, total, in µg/L	<10	<10	<10
Benzo(b)fluoranthene, total, in µg/L	<10	<10	<10
Benzo(ghi)perylene 1,12-benzoperylene, total, in µg/L	<10	<10	<10
Benzo(k)fluoranthene, total, in µg/L	<10	<10	<10
Bis(2-chloroethoxy)methane, total, in µg/L	<5	<5	<5
Bis(2-chloroethyl)ether, total, in µg/L	<5	<5	<5
Bis(2-chloroisopropyl)ether, total, in µg/L	<5	<5	<5
Bis(2-ethylhexyl)phthalate, total, in µg/L	<5	<5	<5
Chrysene, total, in µg/L	<10	<10	<10
Di-n-butyl phthalate, total, in µg/L	<5	<5	<5
Diethyl phthalate, total, in µg/L	<5	<5	<5
Dimethyl phthalate, total, in µg/L	<5	<5	<5
Dinoctyl phthalate, total, in µg/L	<10	<10	<10

Table 6. Chemical analyses of storm-runoff samples collected at 51N outfall at Walnut Street during October 1993 through May 1994, Boise, Idaho—Continued

Water-quality constituent or characteristic	Beginning date of storm		
	10-7-93	12-11-93	5-17-94
BASE/NEUTRAL ORGANIC COMPOUNDS—Continued			
Fluoranthene, total, in µg/L	<5	<5	<5
Fluorene, total, in µg/L	<5	<5	<5
Hexachlorobenzene, total, in µg/L	<5	<5	<5
Hexachlorobutadiene, total, in µg/L	<5	<5	<5
Hexachlorocyclopentadiene, total, in µg/L	<5	<5	<5
Hexachloroethane, total, in µg/L	<5	<5	<5
Indeno(1,2,3-cd)pyrene, total, in µg/L	<10	<10	<10
Isophorone, total, in µg/L	<5	<5	<5
Isopropylbenzene, total recoverable, in µg/L	<5	<1	<.2
N-butylbenzyl phthalate, total, in µg/L	<5	<5	<5
N-nitrosodi-n-propylamine, total, in µg/L	<5	<5	<5
N-nitrosodimethylamine, total, in µg/L	<5	<5	<5
N-nitrosodiphenylamine, total, in µg/L	<5	<5	<5
N-propylbenzene, total recoverable, in µg/L	<5	<1	<.2
Naphthalene, total, in µg/L	<5	<5	<5
Nitrobenzene, total, in µg/L	<5	<5	<5
Phenanthrene, total, in µg/L	<5	<5	<5
Pyrene, total, in µg/L	<5	<5	<5
1,2,4-Trichlorobenzene, total, in µg/L	<5	<5	<5
1,2,5,6-Dibenzanthracene, total, in µg/L	<10	<10	<10
1,2-Diphenylhydrazine, total recoverable, in µg/L	<5	<5	<5
1,3-Dichlorobenzene, total, in µg/L	<5	<5	<5
1,4-Dichlorobenzene, total, in µg/L	<5	<5	<5
2,4-Dinitrotoluene, total, in µg/L	<5	<5	<5
2,6-Dinitrotoluene, total, in µg/L	<5	<5	<5
2-Chloronaphthalene, total, in µg/L	<5	<5	<5
3,3'-Dichlorobenzidine, total, in µg/L	<20	<20	<20
4-Bromophenylphenylether, total, in µg/L	<5	<5	<5
4-Chlorophenylphenylether, total, in µg/L	<5	<5	<5
ACID ORGANIC COMPOUNDS			
Parachlorometacresol, total, in µg/L	<30	<30	<30
Pentachlorophenol, total, in µg/L	<30	<30	<30

Water-quality constituent or characteristic	Beginning date of storm		
	10-7-93	12-11-93	5-17-94
ACID ORGANIC COMPOUNDS—Continued			
Phenol, total, in µg/L	8	5	<1
Parachlorometa cresol, total, in µg/L	<30	<30	<30
2,4,6-Trichlorophenol, total, in µg/L	<20	<20	<20
2,4,Dimethylphenol, total, in µg/L	<5	<5	<5
2,4-Dichlorophenol, total, in µg/L	<5	<5	<5
2,4-Dinitrophenol, total, in µg/L	<20	<20	<20
2-Chlorophenol, total, in µg/L	<5	<5	<5
2-Nitrophenol, total, in µg/L	<5	<5	<5
4,6-Dinitroorthocresol, total, in µg/L	<30	<30	<30
4-Nitrophenol, total, in µg/L	<30	<30	<30
PESTICIDE ORGANIC COMPOUNDS			
Aldrin, total, in µg/L	<.04	<.04	<.04
Aroclor 1016 PCB, total, in µg/L	<.1	<.1	<.1
Aroclor 1221 PCB, total, in µg/L	<1	<1	<1
Aroclor 1232 PCB, total, in µg/L	<.1	<.1	<.1
Aroclor 1242 PCB, total, in µg/L	<.1	<.1	<.1
Aroclor 1248 PCB, total, in µg/L	<.1	<.1	<.1
Aroclor 1254 PCB, total, in µg/L	<.1	<.1	<.1
Aroclor 1260 PCB, total, in µg/L	<.1	<.1	<.1
Chlordane, total, in µg/L	<.1	<.1	<.1
DDD, total, in µg/L	<.1	<.1	<.1
DDE, total, in µg/L	<.04	<.04	<.04
DDT, total, in µg/L	<.1	<.1	<.1
Dieldrin, total, in µg/L	<.02	<.02	<.02
Endosulfan, total, in µg/L	<.1	<.1	<.1
Endrin, total, in µg/L	<.06	<.06	<.06
Heptachlor epoxide, total, in µg/L	<.8	<.8	<.8
Heptachlor, total, in µg/L	<.03	<.03	<.03
Lindane, total, in µg/L	<.03	<.03	<.03
Toxaphene, total, in µg/L	<2	<2	<2

Table 7. Chemical analyses of storm-runoff samples collected at 44S outfall at Boise State University during October 1993 through April 1994, Boise, Idaho

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; col/100 mL, colonies per 100 milliliters; K, nonideal colony count; —, no data; >, greater than; <, less than]

Water-quality constituent or characteristic	Beginning date of storm 10-7-93	12-11-93	4-23-94
Discharge, volume, in cubic feet	2,250	12,700	29,600
Specific conductance, in µS/cm	303	67	114
pH, in standard units	6.7	7.3	7.4
Alkalinity, total as $CaCO_3$, in mg/L	57	19	26
Hardness, total as $CaCO_3$, in mg/L	100	16	38
Temperature, water, in degrees Celsius	18.0	5.0	13.0
DISSOLVED OXYGEN AND OXYGEN COMMAND			
Dissolved oxygen, in mg/L	—	—	8.8
Chemical oxygen demand, in mg/L	340	90	200
Biochemical oxygen demand, 5-day, in mg/L	120	23	39
FECAL INDICATOR BACTERIA			
Fecal coliform, in col/100 mL: Beginning	K1,600	K1,000	K267
Fecal coliform, in col/100 mL: Middle	K2,500	K200	13,000
Fecal coliform, in col/100 mL: End	>6,000	K600	2,300
Fecal streptococci, in col/100 mL: Beginning	K1,300	4.800	K733
Fecal streptococci, in col/100 mL: Middle	K7,200	K4,600	>20,000
Fecal streptococci, in col/100 mL: End	K8,300	5,800	15,400
MAJOR IONS			
Calcium, dissolved, in mg/L	32	5.2	13
Magnesium, total, in mg/L	5	.75	1.4
Sodium, dissolved, in mg/L	16	4.6	4.6
Potassium, dissolved, in mg/L	7.2	3.4	3.4
Sulfate, dissolved, in mg/L	24	5.4	6.6
Chloride, dissolved, in mg/L	14	3.6	5.8
DISSOLVED AND SUSPENDED SOLIDS			
Dissolved solids, in mg/L	146	37	54
Suspended solids, in mg/L	20	52	184
Residue, volatile nonfilterable, in mg/L	264	56	96
NUTRIENTS			
Nitrate, total as N, in mg/L	2.26	.48	.44
Nitrite, total as N, in mg/L	.14	.04	.05
Nitrogen, ammonia, total as N, in mg/L	2.6	.61	1.1
Nitrogen, organic plus ammonia as N, total, in mg/L	6.4	1.5	3.5
Nitrogen, total organic as N, in mg/L	3.8	.89	2.4
Phosphorus, total as P, in mg/L	.79	.26	.5
Phosphorus, dissolved as P, in mg/L	.71	.16	.31
TRACE ELEMENTS			
Antimony, total as Sb, in µg/L	<10	<10	<20
Arsenic, total as As, in µg/L	9	2	10
Beryllium, total as Be, in µg/L	<10	<10	<10
Cadmium, total as Cd, in µg/L	<1	<1	<1
Chromium, total as Cr, in µg/L	6	6	10
Copper, total as Cu, in µg/L	31	8	17
Lead, total as Pb, in µg/L	16	22	53
Mercury, total as Hg, in µg/L	<.1	.2	<.1
Nickel, total as Ni, in µg/L	7	3	6
Selenium, total as Se, in µg/L	<1	<1	<1
Silver, total as Ag, in µg/L	<.5	<.5	<.5
Thallium, dissolved, in µg/L	<5	<10	<5
Zinc, total as Zn, in µg/L	310	100	260
Cyanide, dissolved as CN, in mg/L	<.01	.01	<.01
ORGANIC COMPOUNDS			
Carbon, organic, total as C, in mg/L	110	22	53
Oil and grease, total recoverable, in mg/L	5	2	3
VOLATILE ORGANIC COMPOUNDS			
Acrolein, total, in µg/L	<500	<200	<20
Acrylonitrile, total, in µg/L	<500	<200	<20
Benzene, total, in µg/L	<5	<2	<.2
Bromobenzene, total, in µg/L	<5	<2	<.2
Bromoform, total, in µg/L	<5	<2	<.2
VOLATILE ORGANIC COMPOUNDS—Continued			
Carbon tetrachloride, total, in µg/L	<5	<2	<0.2
Chlorobenzene, total, in µg/L	<5	<2	<.2
Chlorodibromomethane, total, in µg/L	<5	<2	<.2
Chloroethane, total, in µg/L	<5	<.2	<.2
Chloroform, total, in µg/L	<5	<2	<.2
Cis-1,2-dichloroethene, total, in µg/L	<5	<1	<.2
Cis-1,3-dichloropropene, total, in µg/L	<5	<1	<.2
Dibromochloropropane, total recoverable, in µg/L	<25	<5	<1
Dibromomethane, total recoverable, in µg/L	<5	1	<.2
Dichlorobromomethane, total, in µg/L	<5	<1	<.2
Dichlorodifluoromethane, total, in µg/L	<5	<1	<.2
Ethylbenzene, total, in µg/L	<5	<1	<.2
Methylbromide, total, in µg/L	<5	<1	<.2
Methylchloride, total, in µg/L	<5	<.2	<.2
Methylene chloride, total, in µg/L	<5	<2	<.2
N-butylbenzene, total recoverable, in µg/L	<5	<2	<.2
O-chlorotoluene, total, in µg/L	<5	<2	<.2
P-isopropyltoluene, total recoverable, in µg/L	<5	<2	<.2
Sec-butylbenzene, total recoverable, in µg/L	<5	<2	<.2
Styrene, total, in µg/L	<5	<2	<.2
Tert-butylbenzene, total recoverable, in µg/L	<5	<2	<.2
Tetrachloroethylene, total, in µg/L	<5	<2	<.2
Toluene, total, in µg/L	<5	<2	.4
Trans-1,3-dichloropropene, total, in µg/L	<5	<2	<.2
Trichloroethylene, total, in µg/L	<5	<2	<.2
Trichlorofluoromethane, total, in µg/L	<5	<.2	<.2
Vinyl chloride, total, in µg/L	<5	<.2	<.2
Xylene, total recoverable, in µg/L	<5	<2	<.2
1,1,1,2-Tetrachloroethane, total, in µg/L	<5	<2	<.2
1,1,1-Trichloroethane, total, in µg/L	<5	<2	<.2
1,1,2,2-Tetrachloroethane, total, in µg/L	<5	<2	<.2
1,1-Dichloroethane, total, in µg/L	<5	<2	<.2
1,1-Dichloroethylene, total, in µg/L	<5	<2	<.2
1,1-Dichloropropene, total, in µg/L	<5	<2	<.2
1,2,3-Trichlorobenzene, total recoverable, in µg/L	<5	<2	<.2
1,2,3-Trichloropropane, total, in µg/L	<5	<2	<.2
1,2-Dibromoethane, total, in µg/L	<5	<2	<.2
1,2-Dichloroethane, total, in µg/L	<5	<2	<.2
1,2-Dichloropropane, total, in µg/L	<5	<2	<.2
1,2-Transdichloroethene, total, in µg/L	<5	<2	<.2
1,3-Dichloropropane, total, in µg/L	<5	<2	<.2
2,2-Dichloropropane, total, in µg/L	<5	<2	<.2
2-Chloroethylvinylether, total, in µg/L	<25	<10	<1
BASE/NEUTRAL ORGANIC COMPOUNDS			
Acenaphthene, total, in µg/L	<5	<5	<5
Acenaphthylene, total, in µg/L	<5	<5	<5
Anthracene, total, in µg/L	<5	<5	<5
Benzidine, total, in µg/L	<40	<40	<40
Benzo(a)anthracene, 1,2-benzanthracene, total, in µg/L	<10	<10	<10
Benzo(a)pyrene, total, in µg/L	<10	<10	<10
Benzo(b)fluoranthene, total, in µg/L	<10	<10	<10
Benzo(ghi)perylene 1,12-benzoperylene, total, in µg/L	<10	<10	<10
Benzo(k)fluoranthene, total, in µg/L	<10	<10	<10
Bis(2-chloroethoxy)methane, total, in µg/L	<5	<5	<5
Bis(2-chloroethyl)ether, total, in µg/L	<5	<5	<5
Bis(2-chloroisopropyl)ether, total, in µg/L	<5	<5	<5
Bis(2-ethylhexyl)phthalate, total, in µg/L	<5	5	10
Chrysene, total, in µg/L	<10	<10	<10

Table 7. Chemical analyses of storm-runoff samples collected at 44S outfall at Boise State University during October 1993 through April 1994, Boise, Idaho—Continued

Water-quality constituent or characteristic	Beginning date of storm		
	10-7-93	12-11-93	4-23-94
BASE/NEUTRAL ORGANIC COMPOUNDS—Continued			
Di-n-butyl phthalate, total, in µg/L	<5	<5	<5
Diethyl phthalate, total, in µg/L	<5	<5	<5
Dimethyl phthalate, total, in µg/L	<5	<5	<5
Dinoctyl phthalate, total, in µg/L	<10	<10	<10
Fluoranthene, total, in µg/L	<5	<5	<5
Fluorene, total, in µg/L	<5	<5	<5
Hexachlorobenzene, total, in µg/L	<5	<5	<5
Hexachlorobutadiene, total, in µg/L	<5	<2	<5
Hexachlorocyclopentadiene, total, in µg/L	<5	<5	<5
Hexachloroethane, total, in µg/L	<5	<5	<5
Indeno(1,2,3-cd)pyrene, total, in µg/L	<10	<10	<10
Isophorone, total, in µg/L	<5	<5	<5
Isopropylbenzene, total recoverable, in µg/L	<5	<2	<.2
N-butylbenzyl phthalate, total, in µg/L	<5	<5	<5
N-nitrosodi-n-propylamine, total, in µg/L	<5	<5	<5
N-nitrosodimethylamine, total, in µg/L	<5	<5	<5
N-nitrosodiphenylamine, total, in µg/L	<5	<5	<5
N-propylbenzene, total recoverable, in µg/L	<5	<2	<.2
Naphthalene, total, in µg/L	<5	<2	<5
Nitrobenzene, total, in µg/L	<5	<5	<5
Phenanthrene, total, in µg/L	<5	<5	<5
Pyrene, total, in µg/L	<5	<5	<5
1,2,4-Trichlorobenzene, total, in µg/L	<5	<2	<5
1,2,5,6-Dibenzanthracene, total, in µg/L	<10	<10	<10
1,2-Diphenylhydrazine, total recoverable, in µg/L	<5	<5	<5
1,3-Dichlorobenzene, total, in µg/L	<5	<2	<5
1,4-Dichlorobenzene, total, in µg/L	<5	<2	<5
2,4-Dinitrotoluene, total, in µg/L	<5	<5	<5
2,6-Dinitrotoluene, total, in µg/L	<5	<5	<5
2-Chloronaphthalene, total, in µg/L	<5	<5	<5
3,3'-Dichlorobenzidine, total, in µg/L	<20	<20	<20
4-Bromophenylphenylether, total, in µg/L	<5	<5	<5
4-Chlorophenylphenylether, total, in µg/L	<5	<5	<5

Water-quality constituent or characteristic	Beginning date of storm		
	10-7-93	12-11-93	4-23-94
ACID ORGANIC COMPOUNDS			
Parachlorometacresol, total, in µg/L	<30	<30	<30
Pentachlorophenol, total, in µg/L	<30	<30	<30
Phenol, total, in µg/L	23	12	4
2,4,6-Trichlorophenol, total, in µg/L	<20	<20	<20
2,4,Dimethylphenol, total, in µg/L	<5	<5	<5
2,4-Dichlorophenol, total, in µg/L	<5	<5	<5
2,4-Dinitrophenol, total, in µg/L	<20	<20	<20
2-Chlorophenol, total, in µg/L	<5	<5	<5
2-Nitrophenol, total, in µg/L	<5	<5	<5
4,6-Dinitroorthocresol, total, in µg/L	<30	<30	<30
4-Nitrophenol, total, in µg/L	<30	<30	<30
PESTICIDE ORGANIC COMPOUNDS			
Aldrin, total, in µg/L	<.04	<.04	<.04
Aroclor 1016 PCB, total, in µg/L	<.1	<.1	<.1
Aroclor 1221 PCB, total, in µg/L	<1	<1	<1
Aroclor 1232 PCB, total, in µg/L	<.1	<.1	<.1
Aroclor 1242 PCB, total, in µg/L	<.1	<.1	<.1
Aroclor 1248 PCB, total, in µg/L	<.1	<.1	<.1
Aroclor 1254 PCB, total, in µg/L	<.1	<.1	<.1
Aroclor 1260 PCB, total, in µg/L	<.1	<.1	<.1
Chlordane, total, in µg/L	<.1	<.1	.1
DDD, total, in µg/L	<.1	<.1	<.1
DDE, total, in µg/L	<.04	<.04	<.04
DDT, total, in µg/L	<.1	<.1	.1
Dieldrin, total, in µg/L	<.02	<.02	<.02
Endosulfan, total, in µg/L	<.1	<.1	<.1
Endrin, total, in µg/L	<.06	<.06	<.06
Heptachlor epoxide, total, in µg/L	<.8	<.8	<.8
Heptachlor, total, in µg/L	<.03	<.03	<.03
Lindane, total, in µg/L	<.03	<.03	<.03
Toxaphene, total, in µg/L	<2	<2	<2

Table 8. Chemical analyses of storm-runoff samples collected at 39N outfall at Ninth Street during October 1993 through May 1994, Boise, Idaho

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; col/100 mL, colonies per 100 milliliters; K, nonideal colony count; —, no data; >, greater than; <, less than]

Water-quality constituent or characteristic	Beginning date of storm		
	10-7-93	12-7-93	5-4-94
Discharge, volume, in cubic feet	3,460	5,250	145
Specific conductance, in µS/cm	368	233	330
pH, in standard units	7.1	7.3	7.4
Alkalinity, total as $CaCO_3$, in mg/L	76	33	85
Hardness, total as $CaCO_3$, in mg/L	130	34	64
Temperature, water, in degrees Celsius	19.0	7.5	16
DISSOLVED OXYGEN AND OXYGEN DEMAND			
Dissolved oxygen, in mg/L	—	—	6.4
Chemical oxygen demand, in mg/L	860	210	200
Biochemical oxygen demand, 5-day, in mg/L	240	235	33
FECAL INDICATOR BACTERIA			
Fecal coliform, in col/100 mL: Beginning	>6,000	K1,100	3,500
Fecal coliform, in col/100 mL: Middle	K6,100	K930	5,000
Fecal coliform, in col/100 mL: End	>6,000	2,000	2,800
Fecal streptococci, in col/100 mL: Beginning	>10,000	K45,000	>20,000
Fecal streptococci, in col/100 mL: Middle	K6,700	K31,000	>20,000
Fecal streptococci, in col/100 mL: End	K3,500	K33,800	>20,000
MAJOR IONS			
Calcium, dissolved, in mg/L	42	10	22
Magnesium, total, in mg/L	5.0	2.1	2.2
Sodium, dissolved, in mg/L	42	35	50
Potassium, dissolved, in mg/L	11	4.5	6.2
Sulfate, dissolved, in mg/L	76	8.2	55
Chloride, dissolved, in mg/L	19	48	11
DISSOLVED AND SUSPENDED SOLIDS			
Dissolved solids, in mg/L	265	131	202
Suspended solids, in mg/L	260	180	56
Residue, volatile nonfilterable, in mg/L	632	183	301
NUTRIENTS			
Nitrate, total as N, in mg/L	2.87	.44	.69
Nitrite, total as N, in mg/L	.23	.12	.15
Nitrogen, ammonia, total as N, in mg/L	8.2	.87	.88
Nitrogen, organic plus ammonia as N, total, in mg/L	19	3.9	3.7
Nitrogen, total organic as N, in mg/L	11	3.0	2.8
Phosphorus, total as P, in mg/L	2.8	.79	.490
Phosphorus, dissolved as P, in mg/L	2.1	.47	.310
TRACE ELEMENTS			
Antimony, total as Sb, in µg/L	<10	<20	<10
Arsenic, total as As, in µg/L	10	5	6
Beryllium, total as Be, in µg/L	<10	<10	<10
Cadmium, total as Cd, in µg/L	<1	1	<1
Chromium, total as Cr, in µg/L	16	15	4
Copper, total as Cu, in µg/L	130	32	24
Lead, total as Pb, in µg/L	100	74	15
Mercury, total as Hg, in µg/L	.1	<.1	<.1
Nickel, total as Ni, in µg/L	20	8	5
Selenium, total as Se, in µg/L	<1	<1	<1
Silver, total as Ag, in µg/L	<.5	<.5	<.5
Thallium, dissolved, in µg/L	<5	<10	<5
Zinc, total as Zn, in µg/L	1,300	260	210
Cyanide, dissolved as CN, in mg/L	.015	<.010	<.010
ORGANIC COMPOUNDS			
Carbon, organic, total as C, in mg/L	330	55	65
Oil and grease, total recoverable, in mg/L	1	2	1
VOLATILE ORGANIC COMPOUNDS			
Acrolein, total, in µg/L	<100	<200	<500
Acrylonitrile, total, in µg/L	<100	<200	<500
Benzene, total, in µg/L	<1	<2	<5
Bromobenzene, total, in µg/L	<1	<2	<5
Bromoform, total, in µg/L	<1	<2	<5
Carbon tetrachloride, total, in µg/L	<1	<2	<5
VOLATILE ORGANIC COMPOUNDS—Continued			
Chlorobenzene, total, in µg/L	<1	<2	<5
Chlorodibromomethane, total, in µg/L	<1	<2	<5
Chloroethane, total, in µg/L	<1	<2	<5
Chloroform, total, in µg/L	<1	<2	<5
Cis-1,2-dichloroethene, total, in µg/L	<1	<2	<5
Cis-1,3-dichloropropene, total, in µg/L	<1	<2	<5
Dibromochloropropane, total recoverable, in µg/L	<5	<10	<25
Dibromomethane, total recoverable, in µg/L	<1	<2	<5
Dichlorobromomethane, total, in µg/L	<1	<2	<5
Dichlorodifluoromethane, total, in µg/L	<1	<2	<5
Ethylbenzene, total, in µg/L	<1	<2	<5
Methylbromide, total, in µg/L	<1	<2	<5
Methylchloride, total, in µg/L	<1	<2	<5
Methylene chloride, total, in µg/L	1	<2	<5
N-butylbenzene, total recoverable, in µg/L	<1	<2	<5
O-chlorotoluene, total, in µg/L	<1	<2	<5
P-isopropyltoluene, total recoverable, in µg/L	<1	<2	<5
Sec-butylbenzene, total recoverable, in µg/L	<1	<2	<5
Styrene, total, in µg/L	<1	<2	<5
Tert-butylbenzene, total recoverable, in µg/L	<1	<2	<5
Tetrachloroethylene, total, in µg/L	<1	<2	<5
Toluene, total, in µg/L	<1	<2	<5
Trans-1,3-dichloropropene, total, in µg/L	<1	<2	<5
Trichloroethylene, total, in µg/L	<1	<2	<5
Trichlorofluoromethane, total, in µg/L	<1	<2	<5
Vinyl chloride, total, in µg/L	<1	<2	<5
Xylene, total recoverable, in µg/L	<1	<2	<5
1,1,1,2-Tetrachloroethane, total, in µg/L	<1	<2	<5.
1,1,1-Trichloroethane, total, in µg/L	<1	<2	<5
1,1,2,2-Tetrachloroethane, total, in µg/L	<1	<2	<5
1,1-Dichloroethane, total, in µg/L	<1	<2	<5
1,1-Dichloroethylene, total, in µg/L	<1	<2	<5
1,1-Dichloropropene, total, in µg/L	<1	<2	<5
1,2,3-Trichlorobenzene, total recoverable, in µg/L	<1	<2	<5
1,2,3-Trichloropropane, total, in µg/L	<1	<2	<5
1,2-Dibromoethane, total, in µg/L	<1	<2	<5
1,2-Dichloroethane, total, in µg/L	<1	<2	<5
1,2-Dichloropropane, total, in µg/L	<1	<2	<5
1,2-Transdichloroethene, total, in µg/L	<1	<2	<5
1,3-Dichloropropane, total, in µg/L	<1	<2	<5
2,2-Dichloropropane, total, in µg/L	<1	<2	<5
2-Chloroethylvinylether, total, in µg/L	<5	<10	<25
BASE/NEUTRAL ORGANIC COMPOUNDS			
Acenaphthene, total, in µg/L	<5	<5	<5
Acenaphthylene, total, in µg/L	<5	<5	<5
Anthracene, total, in µg/L	<5	<5	<5
Benzidine, total, in µg/L	<40	<40	<40
Benzo(a)anthracene, 1,2-benzanthracene, total, in µg/L	<10	<10	<10
Benzo(a)pyrene, total, in µg/L	<10	<10	<10
Benzo(b)fluoranthene, total, in µg/L	<10	<10	<10
Benzo(ghi)perylene 1,12-benzoperylene, total, in µg/L	<10	<10	<10
Benzo(k)fluoranthene, total, in µg/L	<10	<10	<10
Bis(2-chloroethoxy)methane, total, in µg/L	<5	<5	<5
Bis(2-chloroethyl)ether, total, in µg/L	<5	<5	<5
Bis(2-chloroisopropyl)ether, total, in µg/L	<5	<5	<5
Bis(2-ethylhexyl)phthalate, total, in µg/L	6	22	15
Chrysene, total, in µg/L	<10	<10	<10
Di-n-butyl phthalate, total, in µg/L	<5	<5	<5
Diethyl phthalate, total, in µg/L	<5	<5	<5
Dimethyl phthalate, total, in µg/L	<5	<5	<5

Table 8. Chemical analyses of storm-runoff samples collected at 39N outfall at Ninth Street during October 1993 through May 1994, Boise, Idaho—Continued

Water-quality constituent or characteristic	Beginning date of storm 10-7-93	12-7-93	5-4-94
BASE/NEUTRAL ORGANIC COMPOUNDS—Continued			
Dinoctyl phthalate, total, in µg/L	<10	<10	<10
Fluoranthene, total, in µg/L	<5	<5	<5
Fluorene, total, in µg/L	<5	<5	<5
Hexachlorobenzene, total, in µg/L	<5	<5	<5
Hexachlorobutadiene, total, in µg/L	<5	<5	<5
Hexachlorocyclopentadiene, total, in µg/L	<5	<5	<5
Hexachloroethane, total, in µg/L	<5	<5	<5
Indeno(1,2,3-cd)pyrene, total, in µg/L	<10	<10	<10
Isophorone, total, in µg/L	<5	<5	<5
Isopropylbenzene, total recoverable, in µg/L	<1	<2	<5
N-butylbenzyl phthalate, total, in µg/L	<5	<5	<5
N-nitrosodi-n-propylamine, total, in µg/L	<5	<5	<5
N-nitrosodimethylamine, total, in µg/L	<5	<5	<5
N-nitrosodiphenylamine, total, in µg/L	<5	<5	<5
N-propylbenzene, total recoverable, in µg/L	<1	<2	<5
Naphthalene, total, in µg/L	<5	<5	<5
Nitrobenzene, total, in µg/L	<5	<5	<5
Phenanthrene, total, in µg/L	<5	<5	<5
Pyrene, total, in µg/L	<5	<5	<5
1,2,4-Trichlorobenzene, total, in µg/L	<5	<5	<5
1,2,5,6-Dibenzanthracene, total, in µg/L	<10	<10	<10
1,2-Diphenylhydrazine, total recoverable, in µg/L	<5	<5	<5
1,3-Dichlorobenzene, total, in µg/L	<5	<5	<5
1,4-Dichlorobenzene, total, in µg/L	<5	<5	<5
2,4-Dinitrotoluene, total, in µg/L	<5	<5	<5
2,6-Dinitrotoluene, total, in µg/L	<5	<5	<5
2-Chloronaphthalene, total, in µg/L	<5	<5	<5
3,3'-Dichlorobenzidine, total, in µg/L	<20	<20	<20
4-Bromophenylphenylether, total, in µg/L	<5	<5	<5
4-Chlorophenylphenylether, total, in µg/L	<5	<5	<5
ACID ORGANIC COMPOUNDS			
Parachlorometacresol, total, in µg/L	<30	<30	<30
Pentachlorophenol, total, in µg/L	<30	<30	<30
Phenol, total, in µg/L	23	21	5
2,4,6-Trichlorophenol, total, in µg/L	<20	<20	<20
2,4,Dimethylphenol, total, in µg/L	<5	<5	<5
2,4-Dichlorophenol, total, in µg/L	<5	<5	<5
2,4-Dinitrophenol, total, in µg/L	<20	<20	<20
2-Chlorophenol, total, in µg/L	<5	<5	<5
2-Nitrophenol, total, in µg/L	<5	<5	<5
4,6-Dinitroorthocresol, total, in µg/L	<30	<30	<30
4-Nitrophenol, total, in µg/L	<30	<30	<30
PESTICIDE ORGANIC COMPOUNDS			
Aldrin, total, in µg/L	<.04	<.04	<.04
Aroclor 1016 PCB, total, in µg/L	<.1	<.1	<.1
Aroclor 1221 PCB, total, in µg/L	<1	<1	<1
Aroclor 1232 PCB, total, in µg/L	<.1	<.1	<.1
Aroclor 1242 PCB, total, in µg/L	<.1	<.1	<.1
Aroclor 1248 PCB, total, in µg/L	<.1	<.1	<.1
Aroclor 1254 PCB, total, in µg/L	<.1	<.1	<.1
Aroclor 1260 PCB, total, in µg/L	<.1	<.1	<.1
Chlordane, total, in µg/L	<.1	<.1	<.1
DDD, total, in µg/L	<.1	<.1	<.1
DDE, total, in µg/L	<.04	<.04	<.04
DDT, total, in µg/L	<.1	<.1	<.1
Dieldrin, total, in µg/L	<.02	<.02	<.02
Endosulfan, total, in µg/L	<.1	<.1	<.1
Endrin, total, in µg/L	<.06	<.06	<.06
Heptachlor epoxide, total, in µg/L	<.8	<.8	<.8
Heptachlor, total, in µg/L	<.03	<.03	<.03
Lindane, total, in µg/L	<.03	<.03	<.03
Toxaphene, total, in µg/L	<2	<2	<2

Table 9. Chemical analyses of storm-runoff samples collected at 31N outfall at Americana Boulevard during December 1993 through June 1994, Boise, Idaho

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; col/100 mL, colonies per 100 milliliters; K, nonideal colony count; —, no data; >, greater than; <, less than]

Water-quality constituent or characteristic	Beginning date of storm 12-7-93	4-23-94	6-1-94
Discharge, volume, in cubic feet	7,560	34,100	9,580
Specific conductance, in µS/cm	325	98	78
pH, in standard units	8.0	7.1	7.5
Alkalinity, total as $CaCO_3$, in mg/L	34	25	24
Hardness, total as $CaCO_3$, in mg/L	60	36	19
Temperature, water, in degrees Celsius	6.5	13.5	16
DISSOLVED OXYGEN AND OXYGEN DEMAND			
Dissolved oxygen, in mg/L	—	—	8.3
Chemical oxygen demand, in mg/L	160	220	160
Biochemical oxygen demand, 5-day, in mg/L	—	48	64
FECAL INDICATOR BACTERIA			
Fecal coliform, in col/100 mL: Beginning	1,000	<1	1,100
Fecal coliform, in col/100 mL: Middle	K800	4,000	2,400
Fecal coliform, in col/100 mL: End	933	K2,000	3,000
Fecal streptococci, in col/100 mL: Beginning	6,800	K1,300	K18,000
Fecal streptococci, in col/100 mL: Middle	600	>20,000	K24,000
Fecal streptococci, in col/10 mL: End	3,200	14,000	K27,400
MAJOR IONS			
Calcium, dissolved, in mg/L	15	12	6.4
Magnesium, total, in mg/L	5.5	1.5	.75
Sodium, dissolved, in mg/L	35	8.5	3.4
Potassium, dissolved, in mg/L	3.5	3.8	3.8
Sulfate, dissolved, in mg/L	11	7.8	3.4
Chloride, dissolved, in mg/L	63	3.7	1.8
DISSOLVED AND SUSPENDED SOLIDS			
Dissolved solids, in mg/L	157	56	38
Suspended solids, in mg/L	164	208	216
Residue, volatile nonfilterable, in mg/L	194	105	69
NUTRIENTS			
Nitrate, total as N, in mg/L	.5	.47	.53
Nitrite, total as N, in mg/L	.10	.05	.05
Nitrogen, ammonia, total as N, in mg/L	.77	1.2	.96
Nitrogen, organic plus ammonia as N, total, in mg/L	2.1	3.2	3.5
Nitrogen, total organic as N, in mg/L	1.3	2.0	2.5
Phosphorus, total as P, in mg/L	.30	1.3	.66
Phosphorus, dissolved as P, in mg/L	.13	.48	.26
TRACE ELEMENTS			
Antimony, total as Sb, in µg/L	<20	<10	<10
Arsenic, total as As, in µg/L	6	9	7
Beryllium, total as Be, in µg/L	<10	<10	<10
Cadmium, total as Cd, in µg/L	1	1	<1
Chromium, total as Cr, in µg/L	9	9.1	7.1
Copper, total as Cu, in µg/L	19	20	14
Lead, total as Pb, in µg/L	50	54	42
Mercury, total as Hg, in µg/L	<.1	.1	.1
Nickel, total as Ni, in µg/L	7	6	5
Selenium, total as Se, in µg/L	<1	<1	<1
Silver, total as Ag, in µg/L	<.5	<.5	<.5
Thallium, dissolved, in µg/L	<10	<5	<5
Zinc, total as Zn, in µg/L	200	280	160
Cyanide, dissolved as CN, in mg/L	<.01	<.01	<.01
ORGANIC COMPOUNDS			
Carbon, organic, total as C, in mg/L	23	48	46
Oil and grease, total recoverable, in mg/L	2	2	2
VOLATILE ORGANIC COMPOUNDS			
Acrolein, total, in µg/L	<200	<20	<500
Acrylonitrile, total, in µg/L	<200	<20	<500
Benzene, total, in µg/L	<2	<.2	<5
Bromobenzene, total, in µg/L	<2	<.2	<5
Bromoform, total, in µg/L	<2	<.2	<5
Carbon tetrachloride, total, in µg/L	<2	<.2	<5

Water-quality constituent or characteristic	Beginning date of storm 12-7-93	4-23-94	6-1-94
VOLATILE ORGANIC COMPOUNDS—Continued			
Chlorobenzene, total, in µg/L	<2.0	<0.2	<5
Chlorodibromomethane, total, in µg/L	<2	<.2	<5
Chloroethane, total, in µg/L	<2	<.2	<5
Chloroform, total, in µg/L	<2	<.2	<5
Cis-1,2-dichloroethene, total, in µg/L	<2	<.2	<5
Cis-1,3-dichloropropene, total, in µg/L	<2	<.2	<5
Dibromochloropropane, total recoverable, in µg/L	<10	<1	<25
Dibromomethane, total recoverable, in µg/L	<2	<.2	<5
Dichlorobromomethane, total, in µg/L	<2	<.2	<5
Dichlorodifluoromethane, total, in µg/L	<2	<.2	<5
Ethylbenzene, total, in µg/L	<2	<.2	<5
Methylbromide, total, in µg/L	<2	<.2	<5
Methylchloride, total, in µg/L	<2	<.2	<5
Methylene chloride, total, in µg/L	<2	<.2	<5
N-butylbenzene, total recoverable, in µg/L	<2	<.2	<5
O-chlorotoluene, total, in µg/L	<2	<.2	<5
P-isopropyltoluene, total recoverable, in µg/L	<2	<.2	<5
Sec-butylbenzene, total recoverable, in µg/L	<2	<.2	<5
Styrene, total, in µg/L	<2	<.2	<5
Tert-butylbenzene, total recoverable, in µg/L	<2	<.2	<5
Tetrachloroethylene, total, in µg/L	<2	<.2	<5
Toluene, total, in µg/L	<2	1.2	4.8
Trans-1,3-dichloropropene, total, in µg/L	<2	<.2	<5
Trichloroethylene, total, in µg/L	<2	<.2	<5
Trichlorofluoromethane, total, in µg/L	<2	<.2	<5
Vinyl chloride, total, in µg/L	<2	<.2	<5
Xylene, total recoverable, in µg/L	<2	<.2	<5
1,1,1,2-Tetrachloroethane, total, in µg/L	<2	<.2	<5
1,1,1-Trichloroethane, total, in µg/L	<2	<.2	<5
1,2-Dichloroethane, total, in µg/L	<2	<.2	<5
1,2-Dichloropropane, total, in µg/L	<2	<.2	<5
1,2-Transdichloroethene, total, in µg/L	<2	<.2	<5
1,3-Dichloropropane, total, in µg/L	<2	<.2	<5
2,2-Dichloropropane, total, in µg/L	<2	<.2	<5
2-Chloroethylvinylether, total, in µg/L	<10	<1	<25
1,1,2,2-Tetrachloroethane, total, in µg/L	<2	<.2	<5
1,1-Dichloropropene, total, in µg/L	<2	<.2	<5
1,1-Dichloroethane, total, in µg/L	<2	<.2	<5
1,1-Dichloroethylene, total, in µg/L	<2	<.2	<5
1,2,3-Trichlorobenzene, total recoverable, in µg/L	<2	<.2	<5
1,2,3-Trichloropropane, total, in µg/L	<2	<.2	<5
1,2-Dibromoethane, total, in µg/L	<2	<.2	<5
BASE/NEUTRAL ORGANIC COMPOUNDS			
Acenaphthene, total, in µg/L	<5	<5	<5
Acenaphthylene, total, in µg/L	<5	<5	<5
Anthracene, total, in µg/L	<5	<5	<5
Benzidine, total, in µg/L	<40	<40	<40
Benzo(a)anthracene, 1,2-benzanthracene, total, in µg/L	<10	<10	<10
Benzo(a)pyrene, total, in µg/L	<10	<10	<10
Benzo(b)fluoranthene, total, in µg/L	<10	<10	<10
Benzo(ghi)perylene 1,12-benzoperylene, total, in µg/L	<10	<10	<10
Benzo(k)fluoranthene, total, in µg/L	<10	<10	<10
Bis(2-chloroethoxy)methane, total, in µg/L	<5.0	<5.0	<5.0
Bis(2-chloroethyl)ether, total, in µg/L	<5.0	<5.0	<5.0
Bis(2-chloroisopropyl)ether, total, in µg/L	<5.0	<5.0	<5.0
Bis(2-ethylhexyl)phthalate, total, in µg/L	18	11	<5.0
Chrysene, total, in µg/L	<10	<10	<10
Di-n-butyl phthalate, total, in µg/L	<5.0	<5.0	<5.0
Diethyl phthalate, total, in µg/L	<5.0	<5.0	<5.0

Table 9. Chemical analyses of storm-runoff samples collected at 31N outfall at Americana Boulevard during December 1993 through June 1994, Boise, Idaho—Continued

Water-quality constituent or characteristic	Beginning date of storm		
	12-7-93	4-23-94	6-1-94
BASE/NEUTRAL ORGANIC COMPOUNDS—Continued			
Dimethyl phthalate, total, in µg/L	<5.0	<5.0	<5.0
Dinoctyl phthalate, total, in µg/L	<10	<10	<10
Fluoranthene, total, in µg/L	<5.0	<5.0	<5.0
Fluorene, total, in µg/L	<5.0	<5.0	<5.0
Hexachlorobenzene, total, in µg/L	<5.0	<5.0	<5.0
Hexachlorobutadiene, total, in µg/L	<5.0	<5.0	<5.0
Hexachlorocyclopentadiene, total, in µg/L	<5.0	<5.0	<5.0
Hexachloroethane, total, in µg/L	<5.0	<5.0	<5.0
Indeno(1,2,3-cd)pyrene, total, in µg/L	<10	<10	<10
Isophorone, total, in µg/L	<5.0	<5.0	<5.0
Isopropylbenzene, total recoverable, in µg/L	<2.0	<.2	<5.0
N-butylbenzyl phthalate, total, in µg/L	<5.0	<5.0	<5.0
N-nitrosodi-n-propylamine, total, in µg/L	<5.0	<5.0	<5.0
N-nitrosodimethylamine, total, in µg/L	<5.0	<5.0	<5.0
N-nitrosodiphenylamine, total, in µg/L	<5.0	<5.0	<5.0
N-propylbenzene, total recoverable, in µg/L	<2.0	<.2	<5.0
Naphthalene, total, in µg/L	<5.0	<5.0	<5.0
Nitrobenzene, total, in µg/L	<5.0	<5.0	<5.0
Hexachlorobenzene, total, in µg/L	<5.0	<5.0	<5.0
Hexachlorobutadiene, total, in µg/L	<5.0	<5.0	<5.0
Hexachlorocyclopentadiene, total, in µg/L	<5.0	<5.0	<5.0
Hexachloroethane, total, in µg/L	<5.0	<5.0	<5.0
Phenanthrene, total, in µg/L	<5.0	<5.0	<5.0
Pyrene, total, in µg/L	<5.0	<5.0	<5.0
1,2,4-Trichlorobenzene, total, in µg/L	<5.0	<5.0	<5.0
1,2,5,6-Dibenzanthracene, total, in µg/L	<10	<10	<10
1,2-Diphenylhydrazine, total recoverable, in µg/L	<5.0	<5.0	<5.0
1,3-Dichlorobenzene, total, in µg/L	<5.0	<5.0	<5.0
1,4-Dichlorobenzene, total in µg/L	<5.0	<5.0	<5.0
2,4-Dinitrotoluene, total, in µg/L	<5.0	<5.0	<5.0
2,6-Dinitrotoluene, total, in µg/L	<5.0	<5.0	<5.0
2-Chloronaphthalene, total, in µg/L	<5.0	<5.0	<5.0
3,3'-Dichlorobenzidine, total, in µg/L	<20	<20	<20
BASE/NEUTRAL ORGANIC COMPOUNDS—Continued			
4-Bromophenylphenylether, total, in µg/L	<5.0	<5.0	<5.0
4-Chlorophenylphenylether, total, in µg/L	<5.0	<5.0	<5.0
ACID ORGANIC COMPOUNDS			
Parachlorometacresol, total, in µg/L	<30	<30	<30
Pentachlorophenol, total, in µg/L	<30	<30	<30
Phenol, total, in µg/L	29	10	13
2,4,6-Trichlorophenol, total, in µg/L	<20	<20	<20
2,4,Dimethylphenol, total, in µg/L	<5.0	<5.0	<5.0
2,4-Dichlorophenol, total, in µg/L	<5.0	<5.0	<5.0
2,4-Dinitrophenol, total, in µg/L	<20	<20	<20
2-Chlorophenol, total, in µg/L	<5.0	<5.0	<5.0
2-Nitrophenol, total, in µg/L	<5.0	<5.0	<5.0
4,6-Dinitroorthocresol, total, in µg/L	<30	<30	<30
4-Nitrophenol, total, in µg/L	<30	<30	<30
PESTICIDE ORGANIC COMPOUNDS			
Aldrin, total, in µg/L	<.04	<.04	<.04
Aroclor 1016 PCB, total, in µg/L	<.1	<.1	<.1
Aroclor 1221 PCB, total, in µg/L	<1.0	<1.0	<1.0
Aroclor 1232 PCB, total, in µg/L	<.1	<.1	<.1
Aroclor 1242 PCB, total, in µg/L	<.1	<.1	<.1
Aroclor 1248 PCB, total, in µg/L	<.1	<.1	<.1
Aroclor 1254 PCB, total, in µg/L	<.1	<.01	<.1
Aroclor 1260 PCB, total, in µg/L	<.1	<.1	<.1
Chlordane, total, in µg/L	<.1	<.1	<.1
DDD, total, in µg/L	<.1	<.1	<.1
DDE, total, in µg/L	<.04	<.04	.12
DDT, total, in µg/L	<.1	.1	.2
Dieldrin, total, in µg/L	<.02	<.02	<.02
Endosulfan, total, in µg/L	<.1	<.1	<.1
Endrin, total, in µg/L	<.06	<.06	<.06
Heptachlor epoxide, total, in µg/L	<.8	<.8	<.8
Heptachlor, total, in µg/L	<.03	<.03	<.03
Lindane, total, in µg/L	<.03	<.03	<.03
Toxaphene, total, in µg/L	<2	<2	<2

Table 10. Chemical analyses of storm-runoff samples collected at storm-sewer outfall at 43rd Street during September and October 1994, Garden City, Idaho

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; col/100 mL, colonies per 100 milliliters; K, nonideal colony count; —, no data; >, greater than; <, less than]

Water-quality constituent or characteristic	Beginning date of storm		
	9-13-94	10-4-94	10-14-94
Discharge, volume, in cubic feet	537	4,450	4,910
Specific conductance, in µS/cm	330	62	58
pH, in standard units	7.1	7.4	7.8
Alkalinity, total as $CaCO_3$, in mg/L	84	19	19
Hardness, total as $CaCO_3$, in mg/L	100	38	28
Temperature, water, in degrees Celsius	17.4	12.7	11.8
DISSOLVED OXYGEN AND OXYGEN DEMAND			
Dissolved oxygen, in mg/L	—	8.5	9.9
Chemical oxygen demand, in mg/L	340	610	240
Biochemical oxygen demand, 5-day, in mg/L	76	242	47
FECAL INDICATOR BACTERIA			
Fecal coliform, in col/100 mL: Beginning	3,300	31,000	1,700
Fecal coliform, in col/100 mL: Middle	2,400	32,000	5,600
Fecal coliform, in col/100 mL: End	2,900	10,200	7,800
Fecal streptococci, in col/100 mL: Beginning	15,000	48.000	7,700
Fecal streptococci, in col/100 mL: Middle	17,000	10,000	78,000
Fecal streptococci, in col/10 mL: End	20,300	6,200	42,000
MAJOR IONS			
Calcium, dissolved, in mg/L	35	13	9.5
Magnesium, total, in mg/L	3.8	1.4	1.0
Sodium, dissolved, in mg/L	16	8.1	5.1
Potassium, dissolved, in mg/L	5.0	4.0	2.1
Sulfate, dissolved, in mg/L	29	20	7.6
Chloride, dissolved, in mg/L	6.4	4.7	3.4
DISSOLVED AND SUSPENDED SOLIDS			
Dissolved solids, in mg/L	68	336	194
Suspended solids, in mg/L	156	79	46
Residue, volatile nonfilterable, in mg/L	286	205	73
NUTRIENTS			
Nitrate, total as N, in mg/L	1.34	1.18	.65
Nitrite, total as N, in mg/L	.06	.12	.06
Nitrogen, ammonia, total as N, in mg/L	3.4	7.7	1.9
Nitrogen, organic plus ammonia as N, total, in mg/L	8.1	50	4.9
Nitrogen, total organic as N, in mg/L	4.7	42	3.0
Phosphorus, total as P, in mg/L	.79	1.2	.54
Phosphorus, dissolved as P, in mg/L	.61	.58	.31
TRACE ELEMENTS			
Antimony, total as Sb, in µg/L	<10	<20	<10
Arsenic, total as As, in µg/L	5	8	2
Beryllium, total as Be, in µg/L	<10	<10	<10
Cadmium, total as Cd, in µg/L	1	3	2
Chromium, total as Cr, in µg/L	8.6	34	16
Copper, total as Cu, in µg/L	53	98	49
Lead, total as Pb, in µg/L	25	160	68
Mercury, total as Hg, in µg/L	<.1	<.1	<.1
Nickel, total as Ni, in µg/L	14	16	9
Selenium, total as Se, in µg/L	<1	<1	<1
Silver, total as Ag, in µg/L	<.5	<.5	<.5
Thallium, dissolved, in µg/L	<5	<5	<10
Zinc, total as Zn, in µg/L	700	720	320
Cyanide, dissolved as CN, in mg/L	<.01	<.01	<.01
ORGANIC COMPOUNDS			
Carbon, organic, total as C, in mg/L	100	170	38
Oil and grease, total recoverable, in mg/L	3	4	>1
VOLATILE ORGANIC COMPOUNDS			
Acrolein, total, in µg/L	<200	<80	<2,000
Acrylonitrile, total, in µg/L	<200	<32	<2,000
Benzene, total, in µg/L	<2	<8	<2
Bromobenzene, total, in µg/L	<2	<8	<2
Bromoform, total, in µg/L	<2	<8	<2
Carbon tetrachloride, total, in µg/L	<2	<8	<2
VOLATILE ORGANIC COMPOUNDS—Continued			
Chlorobenzene, total, in µg/L	<2	<8	<2
Chlorodibromomethane, total, in µg/L	<2	<8	<2
Chloroethane, total, in µg/L	<2	<8	<2
Chloroform, total, in µg/L	<2	<8	<2
Cis-1,2-dichloroethene, total, in µg/L	<2	<8	<2
Cis-1,3-dichloropropene, total, in µg/L	<2	<8	<2
Dibromochloropropane, total recoverable, in µg/L	<10	<40	<10
Dibromomethane, total recoverable, in µg/L	<2	<8	<2
Dichlorobromomethane, total, in µg/L	<2	<8	<2
Dichlorodifluoromethane, total, in µg/L	<2	<8	<2
Ethylbenzene, total, in µg/L	<2	<8	<2
Methylbromide, total, in µg/L	<2	<8	<2
Methylchloride, total, in µg/L	<2	<8	<2
Methylene chloride, total, in µg/L	<2	<8	<2
N-butylbenzene, total recoverable, in µg/L	<2	<8	<2
O-chlorotoluene, total, in µg/L	<2	<8	<2
P-isopropyltoluene, total recoverable, in µg/L	<2	<8	<2
Sec-butylbenzene, total recoverable, in µg/L	<2	<8	<2
Styrene, total, in µg/L	<2	<8	<2
Tert-butylbenzene, total recoverable, in µg/L	<2	<8	<2
Tetrachloroethylene, total, in µg/L	<2	<8	<2
Toluene, total, in µg/L	<2	<8	1.1
Trans-1,3-dichloropropene, total, in µg/L	<2	<8	<2
Trichloroethylene, total, in µg/L	<2	<8	<.1
Trichlorofluoromethane, total, in µg/L	<2	<8	<2
Vinyl chloride, total, in µg/L	<2	<8	<2
Xylene, total recoverable, in µg/L	<2	<8	<2
1,1,1,2-Tetrachloroethane, total, in µg/L	<2	<8	<2
1,1,1-Trichloroethane, total, in µg/L	<2	<8	<2
1,1,2,2-Tetrachloroethane, total, in µg/L	<2	<8	<2
1,1-Dichloropropene, total, in µg/L	<2	<8	<2
1,1-Dichloroethane, total, in µg/L	<2	<8	<2
1,1-Dichloroethylene, total, in µg/L	<2	<8	<2
1,2,3-Trichlorobenzene, total recoverable, in µg/L	<2	<8	<2
1,2,3-Trichloropropane, total, in µg/L	<2	<8	<2
1,2-Dibromoethane, total, in µg/L	<2	<8	<2
1,2-Dichloroethane, total, in µg/L	<2	<8	<2
1,2-Dichloropropane, total, in µg/L	<2	<8	<2
1,2-Transdichloroethene, total, in µg/L	<2	<8	<2
1,3-Dichloropropane, total, in µg/L	<2	<8	<2
2,2-Dichloropropane, total, in µg/L	<2	<8	<2
2-Chloroethylvinylether, total, in µg/L	<10	<40	<10
BASE/NEUTRAL ORGANIC COMPOUNDS			
Acenaphthene, total, in µg/L	<5	<5	<5
Acenaphthylene, total, in µg/L	<5	<5	<5
Anthracene, total, in µg/L	<5	<5	<5
Benzidine, total, in µg/L	<40	<40	<40
Benzo(a)anthracene, 1,2-benzanthracene, total, in µg/L	<10	<10	<10
Benzo(a)pyrene, total, in µg/L	<10	<10	<10
Benzo(b)fluoranthene, total, in µg/L	<10	<10	<10
Benzo(ghi)perylene 1,12-benzoperylene, total, in µg/L	<10	<10	<10
Benzo(k)fluoranthene, total, in µg/L	<10	<10	<10
Bis(2-chloroethoxy)methane, total, in µg/L	<5	<5	<5
Bis(2-chloroethyl)ether, total, in µg/L	<5	<5	<5
Bis(2-chloroisopropyl)ether, total, in µg/L	<5	<5	<5
Bis(2-ethylhexyl)phthalate, total, in µg/L	<5	<5	<5
Chrysene, total, in µg/L	<10	<10	<10
Di-n-butyl phthalate, total, in µg/L	<5	<5	<5
Diethyl phthalate, total, in µg/L	<5	<5	<5

Table 10. Chemical analyses of storm-runoff samples collected at storm-sewer outfall at 43rd Street during September and October 1994, Garden City, Idaho—Continued

Water-quality constituent or characteristic	Beginning date of storm		
	9-13-94	10-4-94	10-14-94
BASE/NEUTRAL ORGANIC COMPOUNDS—Continued			
Dimethyl phthalate, total, in µg/L	<5	<5	<5
Dinoctyl phthalate, total, in µg/L	13	34	<10
Fluoranthene, total, in µg/L	<5	<5	<5
Fluorene, total, in µg/L	<5	<5	<5
Hexachlorobenzene, total, in µg/L	<5	<5	<5
Hexachlorobutadiene, total, in µg/L	<5	<5	<5
Hexachlorocyclopentadiene, total, in µg/L	<5	<5	<5
Hexachloroethane, total, in µg/L	<5	<5	<5
Indeno(1,2,3-cd)pyrene, total, in µg/L	<10	<10	<10
Isophorone, total, in µg/L	<5	<5	<5
Isopropylbenzene, total recoverable, in µg/L	<2	<8	<5
N-butylbenzyl phthalate, total, in µg/L	<5	<5	<5
N-nitrosodi-n-propylamine, total, in µg/L	<5	<5	<5
N-nitrosodimethylamine, total, in µg/L	<5	<5	<5
N-nitrosodiphenylamine, total, in µg/L	<5	<5	<5
N-propylbenzene, total recoverable, in µg/L	<2	<8	<2
Naphthalene, total, in µg/L	<5	<5	<5
Nitrobenzene, total, in µg/L	<5	<5	<5
Phenanthrene, total, in µg/L	<5	<5	<5
Pyrene, total, in µg/L	<5	<5	<5
1,2,4-Trichlorobenzene, total, in µg/L	<5	<5	<5
1,2,5,6-Dibenzanthracene, total, in µg/L	<10	<10	<10
1,2-Diphenylhydrazine, total recoverable, in µg/L	<5	<5	<5
1,3-Dichlorobenzene, total, in µg/L	<5	<5	<5
1,4-Dichlorobenzene, total in µg/L	<5	<5	<5
2,4-Dinitrotoluene, total, in µg/L	<5	<5	<5
2,6-Dinitrotoluene, total, in µg/L	<5	<5	<5
2-Chloronaphthalene, total, in µg/L	<5	<5	<5
3,3'-Dichlorobenzidine, total, in µg/L	<20	<20	<20
4-Bromophenylphenylether, total, in µg/L	<5	<5	<5
4-Chlorophenylphenylether, total, in µg/L	<5	<5	<5
ACID ORGANIC COMPOUNDS			
Parachlorometacresol, total, in µg/L	<30	<30	<30
Pentachlorophenol, total, in µg/L	<30	<30	<30
Phenol, total, in µg/L	<5	<5	13
2,4,6-Trichlorophenol, total, in µg/L	<20	<20	<20
2,4,Dimethylphenol, total, in µg/L	<5	<5	<5
2,4-Dichlorophenol, total, in µg/L	<5	<5	<5
2,4-Dinitrophenol, total, in µg/L	<20	<20	<20
2-Chlorophenol, total, in µg/L	<5	<5	<5
2-Nitrophenol, total, in µg/L	<5	<5	<5
4,6-Dinitroorthocresol, total, in µg/L	<30	<30	<30
4-Nitrophenol, total, in µg/L	<30	<30	<30
PESTICIDE ORGANIC COMPOUNDS			
Aldrin, total, in µg/L	<.04	<.04	<.04
Aroclor 1016 PCB, total, in µg/L	<.1	<.1	<.1
Aroclor 1221 PCB, total, in µg/L	<1	<1	<1.0
Aroclor 1232 PCB, total, in µg/L	<.1	<.1	<.1
Aroclor 1242 PCB, total, in µg/L	<.1	<.1	<.1
Aroclor 1248 PCB, total, in µg/L	<.1	<.1	<.1
Aroclor 1254 PCB, total, in µg/L	<.1	<.1	<.1
Aroclor 1260 PCB, total, in µg/L	<.1	<.1	<.1
Chlordane, total, in µg/L	<.1	<.1	<.1
DDD, total, in µg/L	<.1	<.1	<.1
DDE, total, in µg/L	<.04	<.04	.12
DDT, total, in µg/L	<.1	.1	.2
Dieldrin, total, in µg/L	<.02	<.02	<.02
Endosulfan, total, in µg/L	<.1	<.1	<.1
Endrin, total, in µg/L	<.06	<.06	<.06
Heptachlor epoxide, total, in µg/L	<.8	<.8	<.8
Heptachlor, total, in µg/L	<.03	<.03	<.03
Lindane, total, in µg/L	<.03	<.03	<.03
Toxaphene, total, in µg/L	<2	<2	<2