RECONNAISSANCE OF TOXIC SUBSTANCES IN THE JORDAN RIVER, SALT LAKE COUNTY, UTAH

by Kendall R. Thompson

U.S. GEOLOGICAL SURVEY

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CONTENTS

ILLUSTRATION

TABLES

page VI follows

CONVERSION FACTORS

For readers who prefer to use metric units, conversion factors for inch-pound units used in this report are listed below:

Multiply inch-pound units	By	To obtain metric units
foot	0.3048	meter
foot per mile	0.1894	meter per kilometer
inch	25.40	millimeter
mile	1.609	kilometer
pound per day	0.4536	kilogram per day

Chemical concentration and water temperature are given only in metric units. Chemical concentration is given in milligrams per liter (mg/L) or micrograms per liter (ug/L). Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter of water). One thousand micrograms per liter is equivalent to 1 milligram per liter. For concentrations less than 7,000 mg/L, the numerical value is about the same as for concentrations in parts per million. Chemical concentrations in bottom materials is given in units of micrograms per gram (ug/g) or micrograms per kilogram (ug/kg). Both units express concentration on a weight per weight basis.

Water temperature is given in degrees Celsius (^{o}C), which can be converted to degrees Fahrenheit (^{o}F) by the following equation:

$$^{o}F = 1.8(^{o}C) + 32$$

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called mean sea level, is referred to as sea level in this report.

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ABSTRACT

A reconnaissance of toxic substances in the Jordan River, Salt Lake County, Utah, was made during July 1980 to October 1982 as part of a larger study of the river that included studies of sanitary quality, dissolved oxygen, and turbidity. Samples for toxic substances were collected at five sites on the Jordan River, at three major tributaries, and at six storm conduits.

The toxic substance that most frequently exceeded State standards was total mercury. About 78 percent of the 138 samples for total mercury exceeded the State standard of 0.05 microgram per liter. Other toxic substances that exceeded State standards were: Ammonia--18 percent of the samples analyzed, cadmium--9 percent, copper--9 percent, zinc--6 percent, and lead--2 percent. One sample for cyanide and one for iron also exceeded State standards.

The diversity of toxic substances with concentrations large enough to cause them to be problems increased from the upstream sampling site at the Jordan Narrows to the next two downstream sites at 9000 South and 5800 South Streets. Concentrations of trace elements in stream-bottom materials also increased in a downstream direction. Substantial increases first were observed at 5800 South Street, and they were sustained throughout the downstream study area.

Iron is transported in the greatest quantity of all the trace elements studied, with a mean load of 110 pounds per day. Notable loads of barium, boron, lead, and zinc also are transported by the river.

DDD, DDE, DDT, dieldrin, heptachlor, methoxychlor, PCB, and 2,4-D were detected in bottom materials; and DDE, Silvex, and 2,4-D were detected in water samples. Of 112 organic compounds in the Environmental Protection Agency's priority pollutant list, only chloroform was detected in the storm conduits that empty into the Jordan River. Several metals and phenol also were detected in the samples analyzed for priority pollutants.

INTRODUCTION

From July 1980 to October 1982 the U.S. Geological Survey, in cooperation with the Salt Lake County Division of Flood Control and Water Quality, made a study of the quality of the Jordan River, Salt Lake County, Utah. Prior to initiation of field work, Federal, State, and local agencies were asked by the U.S. Geological Survey to identify the most serious water-quality problems in the Jordan River. As a result of their responses, the study focused on the following subjects: toxic substances (this report), sanitary quality (Thompson, 1984), dissolved oxygen (Stephens, 1984), and turbidity (Weigel, 1984).

The objectives of the study on toxic substances were:

A. Identify selected toxic substances that exceed State standards in the Jordan River and major tributaries.

B. Quantify differences between the dissolved phase and suspended phase of selected toxic substances.

C. Determine selected pesticide concentrations in the Jordan River and major tributaries.

D. Determine concentrations of selected toxic substances in bottom materials of the Jordan River and major tributaries.

E. Identify selected toxic substances that may be transported to the Jordan River as a result of storm runoff from urban areas.

Hydrologic Setting

The Jordan River originates as outflow from Utah Lake; and it flows north approximately 55 miles before its waters eventually reach Farmington Bay, which is part of the Great Salt Lake--a terminal, saline lake. Two-thirds of the Jordan River basin is within Salt Lake County, and this study is limited to that area (fig. 1).

The Jordan River enters Salt Lake County at the Jordan Narrows, a gap in the Traverse Mountains about 10 miles downstream from Utah Lake (fig. 1). The discharge from Utah Lake is controlled by gates or by pumping. The altitude along the river decreases from about 4,470 feet at the Jordan Narrows to about 4,200 feet at the Great Salt Lake. The mean gradient of the Jordan River through Salt Lake County is 6 feet per mile. although the gradient from the Jordan Narrows to 4200 South Street is 11 feet per mile and from 4200 South Street to the river mouth only 1.9 feet per mile.

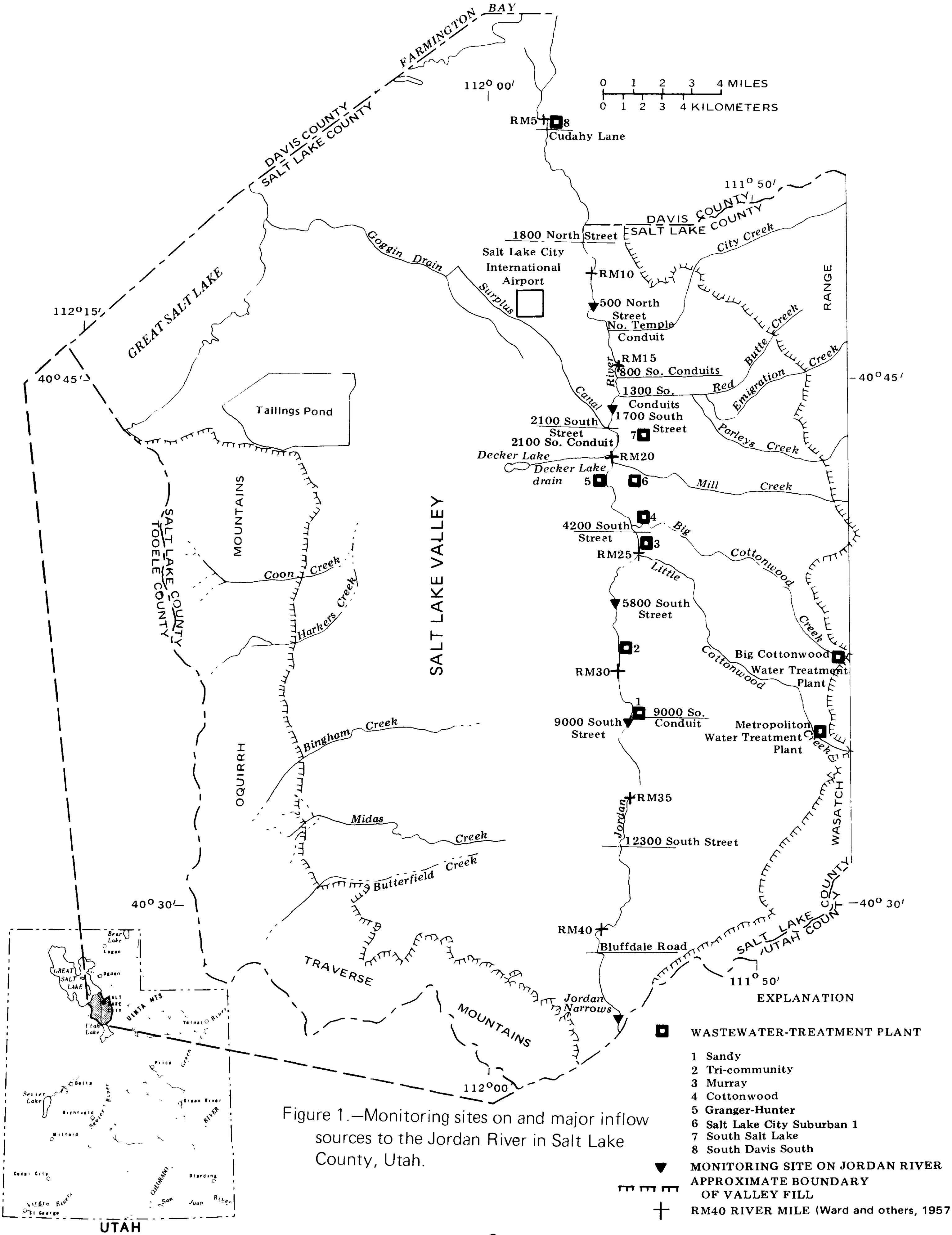

Figure 1.—Monitoring sites on and major inflow sources to the Jordan River in Salt Lake County, Utah.

Salt Lake County consists of a central lowland, known as the Salt Lake Valley, which includes a large urban area. The valley is bordered by mountains on three sides (fig. 1). The Wasatch Range to the east rises to more than 11,000 feet, the Oquirrh Mountains to the west rise to more than 9,000 feet, and the Traverse Mountains to the south rise to more than 6,000 feet. The population of Salt Lake County was estimated to be 641,000 as of July 1981 (Marvin Levy, Utah State Health Department, Bureau of Statistical Services, oral commun., 1982), which is about 42 percent of Utah's population. The Jordan River is the primary receiving water for the discharge from this urban area, which includes seven municipal wastewater-treatment plants in Salt Lake County and one plant in Davis County to the north.

The major tributaries to the Jordan River in Salt Lake County originate in the Wasatch Range. Little Cottonwood Creek empties into the river at about 4900 South Street, Big Cottonwood Creek at about 4200 South Street, and Mill Creek at about 3000 South Street. Parleys, Emigration, and Red Butte Creeks are diverted into a storm conduit, which empties into the river at about 1300 South Street. City Creek is diverted into a storm conduit which empties into the river at North Temple Street. Streams on the west side of Salt Lake County typically are diverted by canals or run dry before reaching the river.

During the irrigation season, large quantities of water are diverted from the Jordan River at or near the Jordan Narrows and channeled northward through seven major canals. The major canals east of the Jordan River, which interchange water with tributaries from the Wasatch Range, terminate in smaller canals. Return flows to the Jordan River usually are through streams or storm conduits. Return flows from the canals west of the Jordan River typically reach the river less directly through nonpoint-source runoff. The only major diversion north of 9000 South Street is the Surplus Canal at 2100 South Street, a flood-control structure that allows excess water to flow directly to Great Salt Lake.

The climate ranges from semiarid in parts of the Salt Lake Valley to humid in higher parts of the Wasatch Range. Precipitation during 1981 near the Salt Lake International Airport was 16.59 inches, which is 1.42 inches greater than the 1928-81 average at this site (National Oceanic and Atmospheric Administration, 1981, p. 4). Precipitation in the valley is generally slight and infrequent during the irrigation season.

Previous Studies

The Salt Lake County Soil Conservation District (1981) discussed several toxic substances in a report on water quality of agricultural-nonpoint sources. Several pesticides and herbicides were sampled, but no significant problems were found in their study area.

Way (1977) discussed ammonia, chlorine, and other constituents that affect the Jordan River fishery and safe and projected constituent concentrations. Way (1977, p. 15) recommended that ammonia removal or reduction in concentration (90-percent nitrification) be integrated into future wastewater-treatment processes and that an additional study be made of chlorine in the Jordan River.

Hydroscience, Inc. (1976) discussed ammonia nitrogen, additional nitrogen and phosphorus compounds, dissolved solids, carbonaceous-biochemical-oxygen demand, and coliform bacteria. The report also states that agricultural return loads contribute significantly to all water-quality constituents investigated except ammonia nitrogen.

Templeton, Linke, and Alsup, and Engineering-Science, Inc. (1974) present a short discussion of toxicity in the Jordan River, and they also report some analytical results. Coburn (1972, p. xi) found that pesticide pollution was increasing south of Salt Lake City. He reported pesticide concentrations that indicate significant use of o ,p-DDT and dieldrin.

Sampling Sites

Water-quality samples and discharge measurements were obtained at five sites on the Jordan River during this study. These sites were at the Jordan Narrows (U.S. Geological Survey station 10167001), 9000 South Street (10167230), 5800 South Street (10167300), 1700 South Street (10171000), and 500 North Street (10172550) (fig. 1). The five sites generally were sampled monthly and before and during selected rainstorms.

Three major tributaries to the Jordan River also were sampled near their mouths: Little Cottonwood, Big Cottonwood, and Mill Creeks. In addition, six storm conduits were sampled before and during selected rainstorms: 1300 South Street Conduit--South and North Conduits; 800 South Street Conduit--South, Middle, and North Conduits; and North Temple Conduit.

Methods

Data for this report were collected using standard methods of the U.S. Geological Survey (Skougstad and others, 1979; and U.S. Geological Survey, 1977). Water samples were collected using depth-integrating samplers modified for collection of trace metals. The equal-width-increment technique was used to sample the river cross section. Water samples collected during storm runoff from urban areas were composited using a discharge-weighting technique determined from the storm hydrograph at individual sampling sites. Samples for priority pollutants were collected in specially-treated glassware to avoid contact with plastics or metals. Streambed material was sampled with a U.S.BMH-60 bed-material sampler modified for sampling trace metals. In this report a constituent that can pass through a 0.45-micron filter is considered to be dissolved. The dissolved plus the suspended concentration is equal to the total concentration of a constituent. Total recoverable refers to an analytically-determined concentration that may not represent 100 percent of the actual concentration. All analytical work was done by the U.S. Geological

Survey except that samples collected for analysis of priority pollutants were analyzed at the Utah Biomedical Test Laboratories in Salt Lake City, Utah, and the same samples were analyzed for additional trace elements by Versar Inc., Springfield, Va.

State Stream-Use Classes and Associated Standards for Toxic Substances

Toxic substances are a widely diversified group of elements and compounds. Many of the constituents referred to in this report as "toxic substances" may occur naturally and may, in some instances, be beneficial in small concentrations. Other constituents are synthetic and, therefore, are evidence of contamination resulting from the activities of man. Both the intended use of the water and the degree of toxicity of individual constituents need to be considered when determining toxicity standards. Numerical standards based on various use classifications have been developed for Utah by the Utah Department of Social Services, Division of Health (1978), and the classification and standards are shown in tables 1-4.

The classification scheme for streams in Utah is shown in table 1. The classification of the Jordan River and three major tributaries is shown in table 2. Numerical standards for toxic substances are shown in tables 3 and 4.

TOXIC SUBSTANCES

In this report, "toxic substance" is used as a general term for a potentially toxic constituent. Each constituent in a stream segment must be evaluated individually in relation to the use classification of the stream segment; thus, a toxic substance may not be a problem if found in very small concentrations.

General Discussion of Toxic Substances That Exceeded State Standards in the Jordan River Study Area

The Jordan River and Little Cottonwood, Big Cottonwood, and Mill Creeks were sampled to determine concentrations of numerous toxic substances. This section of the report addresses only those substances that have been assigned numerical standards by the State. The numerical standards and classes that apply for 17 toxic substances that were actual or potential problems are listed in table 5, and each toxic substance is discussed in relation to the exceedance of State standards.

Table 1.--Classification of surface streams in Utah showing protection by type of use

[Utah Department of Social Services, Division of Health, 1978, part II, p. 5-6.]

Class	Use classification
1	Protected for use as a raw-water source for domestic water systems.
1A	Protected for domestic purposes without treatment.
1B	Protected for domestic purposes with prior disinfection.
1C	Protected for domestic purposes with prior treatment by standard complete treatment processes as required by the Utah Division of Health.
2	Protected for instream-recreational use and esthetics.
2A	Protected for recreational bathing (swimming).
2B	Protected for boating, waterskiing, and similar uses, excluding recreational bathing (swimming).
3	Protected for instream use by beneficial-aquatic wildlife.
3A	Protected for cold-water species of game fish and other cold-water aquatic life, including the necessary aquatic organisms in their food chain.
3B	Protected for warm-water species of game fish and other warm-water aquatic life, including the necessary aquatic organisms in their food chain.
3C	Protected for nongame fish and other aquatic life, including the necessary aquatic organisms in their food chain. Standards for this class will be determined on a case-by-case basis. (See table 4.)
3D	Protected for water fowl, shorebirds, and other water-oriented wildlife, including the necessary aquatic organisms in their food chain.
4	Protected for agricultural uses including irrigation of crops and stock watering.
5	Protected for industrial uses including cooling, boiler make-up and others with potential for human contact or exposure. Standards for this class will be determined on a case-by-case basis.
6	Protected for uses of water not generally suitable for the uses described above. Standards for this class will be determined on a case-by-case basis.

Table 2.--Classification of the Jordan River and three major tributaries in Salt Lake County

[Utah Department of Social Services, Division of Health, 1978, Part II, p. 13-14.]

River or stream segment	Classification
Jordan River from the Jordan Narrows to the confluence with Little Cottonwood Creek	2B, 3A, 4
Jordan River from the confluence with Little Cottonwood Creek to North Temple Street	2B, 3B, 4
Jordan River from North Temple Street to Farmington Bay	2B, 3C, 3D, 4
Little Cottonwood Creek from confluence with the Jordan River to Metropolitan Water-Treatment Plant	3A, 4
Big Cottonwood Creek from confluence with the Jordan River to Big Cottonwood Water-Treatment Plant	2B, 3A, 4
Mill Creek from confluence with the Jordan River to headwaters	2B, 3A, 4

Table 3.--Numerical standards for protection of beneficial uses of water in Utah

[Adapted from Utah Department of Social Services, Division of Health, 1978, Part II, p. 8; Water-quality standards pertaining to water-use classes for Aquatic Wildlife (3C), Industry (5), and Special (6) categories will be determined on a case-by-case basis.]

Constituent	Water-Use Classes								
	Domestic source			Recreation and esthetics		Aquatic wildlife			Agriculture
	1A	1B	1C	2A	2B	3A	3B	3D	4
<u>Chemical</u> (Maximum, milligrams per liter)									
Arsenic, dissolved	0.05	0.05	0.05	*	*	*	*	*	0.1
Barium, dissolved	1	1	1	*	*	*	*	*	*
Boron, dissolved	*	*	*	*	*	*	*	*	.75
Cadmium, dissolved	.010	.010	.010	*	*	[1]0.0004	[1]0.004	*	.01
Chromium, dissolved	.05	.05	.05	*	*	.10	.10	.10	.10
Copper, dissolved	*	*	*	*	*	.01	.01	*	.2
Cyanide	*	*	*	*	*	.005	.005	*	*
Iron, dissolved	*	*	*	*	*	1.0	1.0	1.0	*
Lead, dissolved	.05	.05	.05	*	*	.05	.05	*	.1
Mercury, total	.002	.002	.002	*	*	.00005	.00005	.00005	*
Selenium, dissolved	.01	.01	.01	*	*	.05	.05	*	.05
Silver, dissolved	.05	.05	.05	*	*	.01	.01	*	*
Zinc, dissolved	*	*	*	*	*	.05	.05	*	*
Ammonia as nitrogen (unionized)	*	*	*	*	*	.02	.02	*	*
Phenol	*	*	*	*	*	.01	.01	*	*
<u>Pesticides</u> (Maximum, micrograms per liter)									
Endrin	.2	.2	.2	*	*	.004	.004	.004	*
Lindane	4	4	4	*	*	.01	.01	.01	*
Methoxychlor	100	100	100	*	*	.03	.03	.03	*
Toxaphene	5	5	5	*	*	.005	.005	.005	*
2, 4-D herbicide	100	100	100	*	*	*	*	*	*
2, 4, 5-TP herbicide	10	10	10	*	*	*	*	*	*

* Insufficient evidence to warrant the establishment of numerical standard. Limits assigned on case-by-case basis.
[1] Limit shall be increased three-fold if $CaCO_3$ hardness in water exceeds 150 milligrams per liter.

Table 4.--Numerical standards pertaining to toxic substances for protection of Class 3C water use in the Jordan River from Farmington Bay to North Temple Street in Salt Lake City

[Adapted from Utah Department of Social Services, Division of Health, 1978, Part II, p. 30.]

Constituent	Standard
Chemical (Maximum, milligrams per liter)	
Cadmium, dissolved	0.004
Chromium, dissolved	.1
Copper, dissolved	.01
Cyanide	.005
Iron, dissolved	1.0
Lead, dissolved	.05
Mercury, total	.0005
Selenium, dissolved	.05
Silver, dissolved	.01
Zinc, dissolved	.05
Phenol	.01
Pesticides (Maximum, micrograms per liter)	
Endrin	.004
Lindane	.01
Methoxychlor	.03
Toxaphene	.005

Table 5.--Selected toxic substances in the Jordan River and three tributaries related to use classes and State standards

Use classes and State standards: See tables 1 and 3.

Constituent	Use classes	State standards (ug/L)	Total number of samples	Statistics for sample concentrations that exceeded State standards			
				Number of samples	Mean (ug/L)	Standard deviation (ug/L)	Maximum concentration (ug/L)
Ammonia	3A,3B	20	85	15	([1])	([1])	([1])
Arsenic	4	100	16	0	--	--	--
Boron	4	750	27	0	--	--	--
Cadmium	3A 3B,3C 4	0.4 4 10	228	20	3.1	2.48	10
Chromium	3A,3B,3C,3D,4	100	131	0	--	--	--
Copper	3A,3B,3C 4	10 200	228	20	15.4	5.00	28
Cyanide	3A,3B,3C	5	45	1	--	--	10
Iron	3A,3B,3C,3D	1,000	213	1	--	--	1,100
Lead	3A,3B,3C 4	50 100	213	4	64.5	13.28	80
Mercury	3A,3B,3C,3D	0.05	138	107	.17	.14	1.2
Phenol	3A,3B,3C	10	25	0	--	--	--
Selenium	3A,3B,3C,4	50	38	0	--	--	--
Silver	3A,3B,3C	10	38	0	--	--	--
Zinc	3A,3B,3C	50	220	13	103	66.37	280
Endrin	3A,3B,3C,3D	4	27	0	--	--	--
Lindane	3A,3B,3C,3D	10	6	0	--	--	--
Toxaphene	3A,3B,3C,3D	5	6	0	--	--	--

[1] Not applicable. Concentrations of ammonia that exceeded State standards are determined from a table using temperature, pH, and concentrations of ammonia nitrogen which produce an unionized ammonia concentration of 20 ug/L as N. (See Willingham, 1976, p. A19-73.)

Mercury.--The toxic substance that most frequently exceeded State standards was total mercury. Of the 138 analyses for total mercury, 107 (78 percent) exceeded the State standard of 0.05 microgram per liter. The analytical detection limit for mercury is 0.1 microgram per liter, which is double the standard. Concentrations of total mercury between the standard and the detection limit are unknown. Some samples listed as undetectable probably were within this range, thus the number of samples that exceeded the State standard may be underestimated. The maximum mercury concentration was 1.2 micrograms per liter, which is 24 times greater than the State standard. The mean of the mercury concentrations that exceeded the State standard was 0.17 microgram per liter, which is more than three times greater than the State standard. The distribution of the total mercury concentrations is shown below:

Number of samples	Analytical detection limit (ug/L)	Percentiles[1]					
		5	25	50	75	95	99
138	0.1	<0.1	0.1	0.1	0.2	0.3	1.08

[1] Percent of samples in which the concentration was equal to or less than the value shown.

Mercury is a heavy, silver-white, poisonous, metallic element. It is the only metal occurring as a liquid at room temperature. Mercury also occurs as univalent and divalent ions and compounds. Mercury is used in numerous types of electrical apparatus, control devices, thermometers, barometers, and vapor lamps. Other possible sources of mercury are industrial and mining wastes. Organic mercury compounds are found in pesticides, particularly in fungicides; and anaerobic bacteria in alkaline waters produce methylated mercuric compounds, which can be concentrated in the fatty tissue of fish at more than 100 times the water concentration.

Ammonia-Nitrogen.--Of the 85 analyses for ammonia-nitrogen, 15 (18 percent) exceeded the State standard of 20 micrograms per liter of unionized ammonia. Ammonia is present predominately as NH_4^+ (at normal pH's). The concentration of unionized ammonia (NH_3) which is toxic to aquatic organisms, is a function of the total dissolved ammonia-nitrogen concentration, water temperature, and pH. Ammonia is a pungent, colorless, gaseous, alkaline compound of nitrogen and hydrogen which is readily soluble in water. It is a normal biological degradation product of nitrogenous organic matter, and it is very common in effluents from wastewater-treatment plants. Unionized ammonia is toxic to fish, but its toxicity varies with the temperature and pH of the water.

Cadmium.--Of the 228 analyses for dissolved cadmium, 20 (9 percent) exceeded the State standards. Cadmium is nonessential and nonbeneficial to any type of life and has a large toxic potential (U.S. Environmental Protection Agency, 1976, p. 27). The mean of the cadmium concentrations that exceeded the State standard was 3.1 micrograms per liter, and the maximum concentration was 10 micrograms per liter. Cadmium is a soft white metal similar to zinc and lead. Cadmium occurs in nature chiefly as a sulfide salt. Sources of cadmium are industrial discharge, pigment works, textile and chemical industries, mining waste, and metal electroplating.

Copper.--Of the 228 analyses for dissolved copper, 20 (9 percent) exceeded the State standard of 10 micrograms per liter. The mean of the copper concentrations that exceeded the State standard was 15.4 micrograms per liter, and the maximum concentration was 28 micrograms per liter. Copper is an essential trace element for the propagation of plants, and it also is required in animal metabolism. However, large concentrations of copper may be toxic to aquatic life. Copper occurs as a natural metal in cuprite, in sulfide, oxide, and carbonate ores. Oxides and sulfates of copper are used for pesticides, algacides, and fungicides, and copper often is added to paints and wood perservatives.

Zinc.--Of the 220 analyses for dissolved zinc, 13 (6 percent) exceeded the State standard of 50 micrograms per liter. The mean of the zinc concentrations that exceeded the State standard was 103 micrograms per liter. The maximum concentration was 280 micrograms per liter, which is 5.6 times greater than the State standard. Zinc usually is found in nature as a sulfide, and it often is associated with the sulfides of other metals. Zinc is used in galvanizing and the preparation of alloys for dye casting, and sources of zinc include industrial waste, metal plating, and sewage sludge.

Lead.--Of the 213 analyses for dissolved lead, 4 (2 percent) exceeded the State standard of 50 micrograms per liter. The mean of the concentrations that exceeded the State standard was 64.5 micrograms per liter, and the maximum concentration was 80 micrograms per liter. Lead is a soft, bivalent or tetravalent metallic element. Lead enters the aquatic environment through precipitation, atmospheric fallout, municipal and industrial wastes, leaching of soil, and deposits from streets and other surfaces that may be washed into a stream.

Cyanide.--Of the 45 analyses for total cyanide, only 1 exceeded the State standard of 5 micrograms per liter. This sample had a concentration of 10 micrograms per liter. Cyanide commonly is used in industry, especially for metal cleaning and electroplating, and it also is used as a fumigant.

Iron.--Of the 213 analyses for dissolved iron, only 1 exceeded the State standard of 1,000 micrograms per liter. This sample had an iron concentration of 1,100 micrograms per liter. Iron is the fourth most abundant element (by weight) in the Earth's crust. Iron is an essential trace element for both plants and animals, but in larger concentrations it may harm aquatic life.

Arsenic, chromium, phenol, selenium, silver, boron, endrin, lindane, and toxaphene.--Did not exceed State standards in samples collected from the Jordan River and its three major tributaries.

Distribution of Toxic Substances in the Jordan River Study Area

As the Jordan River flows through the study area, numerous factors affect the quality of its water. Several diversions remove water from the river for irrigation and flood control, thus reducing the river's capacity for dilution. The river also receives inflow from numerous tributaries, seven wastewater-treatment plants, numerous storm conduits, the ground-water system, irrigation-return flow, and other sources. All of these factors contribute to the dynamic system that determines the quality of the Jordan River.

Toxic Substances that Exceeded State Standards

The diversity of toxic substances with concentrations large enough to cause them to be problems increases from the Jordan Narrows to the next downstream sampling site at 9000 South Street. Mercury and zinc exceeded the State standard at the Jordan Narrows (table 6). Cadmium, copper, lead, mercury, and zinc exceeded the State standard at 9000 South Street. The diversity of toxic substances with problem concentrations increased again at the next downstream site at 5800 South Street where ammonia, cadmium, copper, cyanide, lead, mercury, and zinc exceeded the State standard. At the next downstream sampling site, the diversity of toxic substances with problem concentrations was reduced. Only ammonia, copper, mercury, and zinc concentrations exceeded the State standard at 1700 South Street. At 500 North Street, the sampling site farthest downstream, problem concentrations were observed for copper, lead, mercury, and zinc. Problem concentrations of ammonia were found at 1700 South and 5800 South Streets, a reach of the river to which most of the wastewater-treatment plants discharge (fig. 1). Problem concentrations were not found at 500 North Street, thus wastewater-treatment plants are the probable cause of the problem ammonia concentrations.

Problem concentrations of mercury and zinc were found at all sampling sites on the Jordan River. Problem concentrations of copper were found at all sites except the Jordan Narrows, and problem concentrations of lead were found at three of the five sites on the Jordan River.

The three major tributaries to the Jordan River were sampled near their confluence with the river. Problem concentrations of ammonia, cadmium, copper, iron, mercury, and zinc were detected in samples from Little Cottonwood Creek (table 6). Problem concentrations of ammonia, cadmium, copper, mercury, and zinc were detected in samples from Big Cottonwood Creek. Problem concentrations of cadmium, copper, and mercury were detected in samples from Mill Creek.

Table 6.--Toxic substances that exceeded State standards in the Jordan River and three major tributaries

Number of samples: -- indicates that no sample exceeded State standards.
First line--Number of samples that exceeded State standards.
Second line--Number of above samples collected during storm runoff.
Third line--Total number of samples.

Location	Ammonia, unionized	Cadmium, dissolved	Copper, dissolved	Cyanide, total	Iron, dissolved	Lead, dissolved	Mercury, total	Zinc, dissolved
				Number of samples				
				Jordan River				
Jordan Narrows	--	--	--	--	--	--	15	1
	--	--	--	--	--	--	2	0
	16	28	28	5	25	25	21	28
9000 South Street	--	7	1	--	--	2	14	1
	--	3	0	--	--	0	2	0
	16	33	33	4	30	30	17	25
5800 South Street	7	5	5	1	--	1	14	2
	0	2	1	0	--	0	3	1
	17	33	33	24	30	30	22	33
1700 South Street	6	--	4	--	--	--	27	3
	0	--	2	--	--	--	3	0
	16	43	43	5	40	40	31	43
500 North Street	--	--	2	--	--	1	18	4
	--	--	1	--	--	1	4	1
	16	36	36	5	33	33	21	36
				Tributaries				
Little Cottonwood Creek	1	4	5	--	1	--	8	1
	0	3	4	--	1	--	4	1
	2	21	21	1	21	21	9	21
Big Cottonwood Creek	1	2	2	--	--	--	5	1
	0	1	1	--	--	--	2	1
	1	17	17	1	17	17	9	17
Mill Creek	--	2	1	--	--	--	6	--
	--	2	1	--	--	--	4	--
	1	17	17	0	17	17	8	17

Organic Toxic Substances

Water samples obtained at the five sites on the Jordan River and at the three major tributaries were analyzed for 19 pesticides and total polychlorinated biphenyls (PCB). Bottom-material samples from the same sites were analyzed for 17 pesticides and total PCB. The water and bottom-material samples were collected during August 1981 and August 1982, and the compounds for which analyses were made are listed below.

Water Samples

Aldrin	Chlordane	DDD
DDE	DDT	Dieldrin
Endosulfan	Endrin	Heptachlor
Heptachlor epoxide	Lindane	Mirex
Napthalenes, polychlorinated	PCB	Silvex
Perthane	2,4-D	2,4-DP
Toxaphene		
2,4,5-T		

Bottom-Material Samples

Aldrin	DDD	DDE
DDT	Dieldrin	Endosulfan
Endrin	Heptachlor	Heptachlor epoxide
Lindane	Methoxychlor	Perthane
PCB	Silvex	Toxaphene
2,4-D	2,4-DP	2,4,5-T

Only 11 of the 20 compounds were detected at least once in either water or bottom-material samples (table 7). PCB in bottom materials was detected most frequently. The largest concentrations of PCB were detected at the Jordan Narrows, and were substantially greater than the concentrations detected at all other sites.

The largest pesticide concentration was for 2,4-D which was 320 micrograms per kilogram in a bottom-material sample from Big Cottonwood Creek. DDD, DDE, dieldrin, and methoxychlor were detected frequently in bottom materials. Few pesticides were detected in water samples. DDE was detected once, Silvex three times, and 2,4-D four times in water samples.

Table 7.--Concentrations of pesticides and PCB's detected in the Jordan River and three major tributaries

Organic compound: Total in bottom materials, except as noted.
Concentration: ND indicates not detected.
First line--Samples collected August 1981.
Second line--Samples collected August 1982.

Organic compound	Jordan River					Tributaries		
	Jordan Narrows	9000 South Street	5800 South Street	1700 South Street	500 North Street	Little Cottonwood Creek	Big Cottonwood Creek	Mill Creek
	Concentration, in ug/kg except as noted							
DDD	ND	--	ND	0.3	3.8	0.2	3.2	--
	ND	0.2	0.4	1.0	4.9	ND	1.0	35
DDE	ND	--	.3	.2	3.3	.2	2.0	--
	ND	.5	1.4	.8	2.0	.4	ND	14
DDE, total (ug/L) (in water)	ND	--	ND	.01	ND	ND	ND	--
	--	--	--	ND	--	--	--	--
DDT	ND	--	ND	ND	1.4	ND	ND	--
	ND	ND	ND	.2	.5	ND	.5	ND
Dieldrin	ND	--	ND	.1	.4	.1	.9	--
	ND	ND	.2	ND	1.8	.2	1.0	.5
Heptachlor	ND	--	ND	ND	ND	ND	ND	--
	ND	ND	ND	--	.3	ND	.1	ND
Methoxychlor	--	--	5.2	--	--	--	--	--
	80	7.4	8.8	5.2	12	7.5	13	1.1
PCB	320	--	2	6	14	2	17	--
	230	2	1	6	37	4	26	50
Silvex, total (ug/L) (in water)	ND	ND	ND	.01	.01	ND	.02	--
	--	--	ND	--	--	--	--	ND
2,4-D	ND	--	ND	.06	.09	ND	ND	--
	ND	ND	ND	--	--	ND	320	--
2,4-D, total (ug/L) (in water)	.02	--	.05	--	--	.06	.06	--
	--	--	--	--	--	ND	--	ND

Water samples from the five sites on the Jordan River were collected during June and August 1982 for analysis of 27 volatile-organic compounds. Only 1 of the 27 volatile compounds was detected. Tetrachloroethylene was detected in the Jordan River at 500 North Street in a concentration of 5 micrograms per liter in June and in a concentration of 1 microgram per liter in August. A list of the 27 volatile compounds is shown below:

- Chloroethylene
- Carbon tetrachloride
- Chloroethane
- Dichlorodifluoromethane
- Methylenechloride
- Trichloroethylene
- 1,1-dichloroethylene
- 1,1,2-trichloroethane
- 1,2-dichloropropane
- Benzene
- Chlorobenzene
- Chloroform
- Ethylbenzene
- Tetrachloroethylene
- Trichlorofluoromethane
- 1,1-dichloroethane
- 1,1,2,2-tetrachloroethane
- 1,3-dichloropropane
- Bromoform
- Chlorodibromomethane
- Dichlorobromomethane
- Methylbromide
- Toluene
- Vinyl chloride
- 1,1,1-trichloroethane
- 1,2-dichloroethane
- 2-chloroethyl vinyl ether

Trace Elements in Stream-Bottom Materials

Samples of stream-bottom materials from the Jordan River and the three major tributaries were analyzed for 11 trace elements, each of which could be considered as a toxic substance if present in large enough quantities. The trace elements were: Arsenic, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, selenium, silver, and zinc. With the exception of beryllium, all these trace elements were detected one or more times (table 8). Copper, lead, and zinc had the largest concentrations. Trace-element concentrations in the bottom materials in the Jordan River increased in a downstream direction. Substantial increases first were observed at 5800 South Street, and they were sustained throughout the remainder of the downstream segment of the study area.

Mean concentrations of arsenic, cadmium, chromium, and mercury in bottom materials were about twice as large at three downstream sites on the Jordan River (5800 South, 1700 South, and 500 North Streets) as they were at two upstream sites (Jordan Narrows and 9000 South Street). Mean copper and zinc concentrations were about six times larger and mean lead concentrations were about eight times larger at the three downstream sites than they were at the two upstream sites. The larger concentrations identified in the downstream reach of the river probably are due to runoff from urban areas and the significant inflow from wastewater-treatment plants.

Table 8.--Concentrations of selected trace elements in bottom materials in the Jordan River and three major tributaries

Concentrations:
First line--Samples collected during September 1980.
Second line--Samples collected during August 1981.
Third line--Samples collected during August 1982.

Location	Concentrations (micrograms per gram)										
	Arsenic	Beryllium	Cadmium	Chromium	Cobalt	Copper	Lead	Mercury	Selenium	Silver	Zinc
Jordan River											
Jordan Narrows	--	--	--	--	--	--	--	--	--	--	--
	6	<1	1	3	--	7	30	0.02	<1	--	35
	6	<1	1	2	--	10	40	.03	<1	1	47
9000 South Street	--	--	--	--	--	--	--	--	--	--	--
	--	--	1	3	<5	12	10	--	<1	--	23
	6	<1	<1	2	--	11	20	.03	<1	1	25
5800 South Street	--	--	--	--	--	--	--	--	--	--	--
	17	<1	1	3	--	90	200	.03	<1	--	140
	19	<1	3	4	--	120	480	.07	<1	2	230
1700 South Street	--	--	2	5	<5	49	90	--	1	1	130
	6	<1	1	5	--	54	130	.04	<1	--	130
	14	<1	3	4	--	73	200	.06	<1	1	250
500 North Street	--	--	3	10	20	44	130	--	1	2	145
	10	<1	1	6	--	47	200	.04	<1	--	330
	12	<1	2	7	--	39	110	.06	<1	1	140
Tributaries											
Little Cottonwood	--	--	2	7	10	67	250	--	<1	1	395
Creek	18	<1	1	3	--	50	210	.04	<1	--	400
	15	<1	2	2	--	34	200	.04	<1	1	270
Big Cottonwood	--	--	--	--	--	--	--	--	--	--	--
Creek	8	<1	1	6	--	23	50	.03	<1	--	75
	20	<1	1	3	--	35	230	.02	<1	1	390
Mill Creek	--	--	--	--	--	--	--	--	--	--	--
	--	--	4	20	30	80	180	--	3	3	240
	14	<1	3	10	--	59	220	.09	<1	1	210

With the exception of copper and zinc, concentrations of trace elements in bottom materials in Little Cottonwood, Big Cottonwood, and Mill Creeks were similar to the concentrations in the Jordan River at the three downstream sampling sites. Concentrations of zinc were generally larger in the three tributaries than in the Jordan River, whereas concentrations of copper generally were smaller in the tributaries. Copper, lead, and zinc had the largest concentrations whereas arsenic, cadmium, chromium, mercury, selenium, and silver were found in smaller concentrations at the three tributaries.

Trace elements in bottom materials are potential sources of toxicity to the aquatic environment, however, State standards for bottom materials are not available. Trace elements may be reintroduced to the aquatic environment by changes in water chemistry, dredging, or other processes. Many of the chemical mechanisms that may reintroduce trace elements to the aquatic environment are complex. A more intensive investigation would be required to determine if trace-element concentrations in bottom materials of the Jordan River or its major tributaries may be harmful.

The three major tributaries to the Jordan River were sampled near their confluence with the river. Problem concentrations of ammonia, cadmium, copper, iron, mercury, and zinc were detected in samples from Little Cottonwood Creek (table 6). Problem concentrations of ammonia, cadmium, copper, mercury, and zinc were detected in samples from Big Cottonwood Creek. Problem concentrations of cadmium, copper, and mercury were detected in samples from Mill Creek.

Toxic Substances in Storm Runoff From Urban Areas

Samples were collected during rainstorms to determine if runoff from the major urban areas caused a toxic-substance problem in the Jordan River and its three major tributaries. Major storm conduits that drain the urban areas and empty directly into the river were sampled for toxic substances during storm and nonstorm periods (table 9). Most problem concentrations were detected in samples collected during storm runoff. Cadmium, copper, lead, mercury, and zinc, which were detected in significant concentrations during storm runoff, may be washed off the impermeable parts of the urban areas and transported to the storm conduits and then rapidly to the Jordan River.

Problem concentrations of toxic substances in storm samples from the Jordan River and Little Cottonowood, Big Cottonwood, and Mill Creeks show no obvious trends when compared to nonstorm samples or when compared from site to site (table 6). Storm samples from the storm conduits however, do show increases in the number of problem concentrations of toxic substances when compared to nonstorm samples (table 9). Apparently the Jordan River and its major tributaries, which are the receiving waters for this storm water, had a sufficient volume of water to dilute the storm-water inflow, thus reducing the possibility of problem concentrations in the river due to urban-storm runoff.

Table 9.--Toxic substances that exceeded selected concentrations in storm conduits

Number of samples: -- indicates that no sample exceeded the selected concentration.
First line--Number of samples that exceeded selected concentrations.
Second line--Number of above samples collected during storm runoff.
Third line--Total number of samples.

Conduits	Cadmium, dissolved	Chromium, dissolved	Copper, dissolved	Cyanide, total	Iron, dissolved	Lead, dissolved	Mercury, total	Zinc, dissolved
	Selected concentrations (ug/L)[1]							
	12	100	10	5	1,000	50	0.05	50
	Number of samples							
9000 South	[2]6	--	9	--	--	3	12	14
	5	--	6	--	--	2	9	13
	27	10	27	1	27	27	14	24
2100 South	--	--	14	1	--	1	7	5
	--	--	9	0	--	1	4	5
	18	7	18	1	17	18	7	17
1300 South South Conduit	--	--	5	--	--	--	7	5
	--	--	5	--	--	--	3	4
	19	8	17	1	19	18	8	19
1300 South North Conduit	--	--	3	--	--	1	7	1
	--	--	2	--	--	1	4	1
	20	8	19	1	19	19	8	19
800 South South Conduit	--	--	3	--	--	--	4	4
	--	--	3	--	--	--	4	2
	20	6	20	1	20	20	6	20
800 South Middle Conduit	--	--	4	--	--	--	8	8
	--	--	3	--	--	--	6	5
	19	9	18	1	18	19	9	18
800 South North Conduit	--	1	5	1	1	1	8	7
	--	0	5	1	1	1	6	7
	21	9	21	1	20	21	9	20
North Temple	1	--	3	--	--	--	8	1
	1	--	2	--	--	--	6	1
	18	9	18	1	18	18	9	18

[1] Selected concentrations are similar to State standards; however, State standards do not apply at these sites.

[2] A selected concentration of 1.2 ug/L of cadmium was used at 9000 South Street to agree with the State 3A standard for the Jordan River in this reach.

Priority Pollutants and Additional Trace Elements in Storm Runoff from Urban Areas Detected in Storm Conduits

The U.S. Environmental Protection Agency prepared a list of priority pollutants of environmental interest which is shown in Keith and Telliard (1979, p. 417-419). From this list, 112 organic compounds, 13 metals, cyanide, and phenol were chosen for analysis from samples obtained at six major storm conduits that discharge into the Jordan River. These storm conduits, which drain the major urban areas of Salt Lake City, were sampled during a rainstorm on October 29, 1981.

Of the 112 organic compounds (table 10) for which analyses were made by the Utah Biomedical Test Laboratories, Salt Lake City, Utah, only one compound was detected. A concentration of 12 micrograms per liter of chloroform was detected in a water sample from the Middle Conduit of the 800 South Street Conduit.

Additional analyses made for 13 total metals, cyanide, and phenol showed large concentrations of lead and zinc in the discharge from most of the storm conduits (table 11). The maximum lead concentration was 340 micrograms per liter from the North Temple Street Conduit, and the maximum zinc concentration was 230 micrograms per liter from the 1300 South Conduit, South Conduit. The mean lead and zinc concentrations from all six storm conduits were 194 and 152 micrograms per liter.

Large concentrations of copper and phenol were found in most of the storm conduits. The maximum copper concentration was 38 micrograms per liter; and the maximum phenol concentration was 30 micrograms per liter.

Water samples from the October 29 storm also were analyzed for 13 trace elements which are not included among the priority pollutants listed by the U.S. Environmental Protection Agency (table 12). Aluminum and iron had the greatest concentrations. The maximum total aluminum and iron concentrations were 11,100 and 8,920 micrograms per liter, both at the North Temple Conduit.

Transport of Trace Elements

Standards for specific toxic substances may be given in the dissolved, total, or total-recoverable phase. The U.S. Environmental Protection Agency (1976) uses total or total recoverable concentrations to describe many toxic substances, whereas the State of Utah primarily uses dissolved concentrations to describe many of the same constituents (Utah Department of Social Services, Division of Health, 1978). It is helpful, therefore, to know how constituents are transported in a particular waterway, such as the Jordan River and its major tributaries.

Table 10.--Organic priority pollutants sampled on October 29, 1981, at six storm conduits

VOLATILE COMPOUNDS

acrolein
acrylonitrile
benzene
bis (chloromethyl) ether
bromodichloromethane
bromoform
bromomethane
carbon tetrachloride
chlorobenzene
chlorodibromomethane
chloroethane
2-chloroethylvinyl ether
chloroform
chloromethane
dichlorodifluoromethane
1,1-dichloroethane
1,2-dichloroethane
1,1-dichloroethene
trans-1,2-dichloroethene
dichloromethane
1,2-dichloropropane
cis-1,2-dichloropropene
trans-1,3-dichloropropene
ethylbenzene
1,1,2,2-tetrachloroethane
tetrachloroethene
toluene
1,1,1-trichloroethane
1,1,2-trichloroethane
trichloroethene
trichlorofluoromethane
vinyl chloride

BASE/NEUTRAL COMPOUNDS

acenaphthene
acenaphthylene
anthracene
benzo(a)anthracene
benzo(b)fluoranthene
benzo(k)fluoranthene
benzo(a)pyrene
benzo(ghi)perylene
benzidine
benzyl butyl phthalate
bis(2-chloroethoxy)methane
bis(2-chloroethyl)ether
bis(2-chloroisopropyl)ether
bis(2-ethylhexyl)phthalate
4-bromophenyl phenyl ether
2-chloronaphthalene
4-chlorophenyl phenyl ether
chrysene
dibenzo(a,h)anthracene
di-n-butyl phthalate
1,2-dichlorobenzene
1,3-dichlorobenzene
1,4-dichlorobenzene
3,3'-dichlorobenzidine
diethyl phthalate
dimethyl phthalate
2,4-dinitrotoluene
2,6-dinitrotoluene
di-n-octyl phthalate
1,2-diphenyhydrazine
fluoranthene
fluorene
hexachlorobenzene
hexachlorobutadiene
hexachlorocyclopentadiene
hexachloroethane
indeno(1,2,3-cd)pyrene
isophorone
naphthalene
nitrobenzene
N-nitrosodimethylamine
N-nitrosodiphenylamine
N-nitrosodi-n-propylamine
phenanthrene
pyrene
1,2,4-trichlorobenzene

ACID COMPOUNDS

4-chloro-3-methyl phenol
2-chlorophenol
2,4-dichlorophenol
2,4-dimethylphenol
2,4-dinitrophenol
2-methyl-4,6-dinitrophenol
2-nitrophenol
4-nitrophenol
pentachlorophenol
2,4,6-trichlorophenol

PESTICIDE COMPOUNDS

aldrin
alpha BHC
beta BHC
gamma BHC
delta BHC
chlordane
4,4'-DDD
4,4'-DDE
4,4'-DDT
dieldrin
endosulfan I
endosulfan II
endosulfan sulfate
endrin
heptachlor
heptachlor epoxide
PCB-1016
PCB-1221
PCB-1232
PCB-1242
PCB-1248
PCB-1254
PCB-1260
toxaphene

Table 11.--Selected metals, cyanide, and phenol in samples collected from six storm conduits on October 29, 1981, for analysis of priority pollutants

[Analyses by Utah Biomedical Test Laboratories, Salt Lake City, Utah.]

Concentration: ND, not detected.

Constituent (total)	Limit of detection (ug/L)	Sampling site					
		1300 South Street		800 South Street			North Temple Street
		South Conduit	North Conduit	South Conduit	Middle Conduit	North Conduit	
		Concentration (ug/L)					
Antimony	2	ND	ND	ND	ND	ND	ND
Arsenic	2	10	12	14	9	9	15
Beryllium	5	ND	ND	ND	ND	ND	ND
Cadmium	2	2	ND	2	ND	ND	ND
Chromium	2	32	29	21	100	51	83
Copper	1	38	17	20	4	24	25
Lead	2	270	130	150	86	190	340
Mercury	.2	ND	ND	ND	ND	ND	ND
Nickel	10	ND	ND	ND	ND	ND	ND
Selenium	2	2	ND	ND	ND	ND	ND
Silver	5	ND	ND	ND	ND	ND	ND
Thallium	5	ND	ND	ND	ND	ND	ND
Zinc	10	230	100	170	60	180	170
Cyanide	20	ND	ND	ND	ND	ND	ND
Phenol	10	20	20	20	ND	10	30

Table 12.--Trace-element concentrations in storm runoff on October 29, 1981, at six storm conduits

[Analyses by Versar, Inc., Springfield, Va.]

Concentration:
First line--Total concentration.
Second line--Dissolved concentration.

Constituent	Sampling site					
	1300 South Street		800 South Street			North Temple Street
	South Conduit	North Conduit	South Conduit	Middle Conduit	North Conduit	
	Concentration (ug/L)					
Aluminum	3,650	3,000	4,600	1,600	3,850	11,100
	50	50	<50	50	150	150
Barium	120	70	130	50	130	150
	40	40	40	30	20	40
Boron	100	60	140	80	100	70
	110	80	110	100	50	50
Cobalt	<10	<10	<10	<10	<10	<10
	<10	<10	<10	<10	<10	<10
Iron	3,720	2,740	4,480	1,760	4,900	8,920
	80	60	60	80	140	140
Lithium	30	10	20	20	<10	20
	30	10	20	20	<10	<10
Manganese	110	80	120	60	110	220
	40	40	40	30	20	50
Molybdenum	<10	<10	<10	<10	<10	<10
	<10	<10	<10	<10	<10	<10
Strontium	390	290	390	240	100	130
	370	330	350	240	70	90
Tin	<50	<50	<50	<50	<50	<50
	<50	<50	<50	<50	<50	<50
Titanium	130	100	180	60	170	350
	<10	<10	<10	<10	<10	<10
Vanadium	<10	<10	10	<10	<10	20
	<10	<10	<10	<10	<10	<10
Yttrium	<10	<10	<10	<10	<10	<10
	<10	<10	<10	<10	<10	<10

Transportation as a Dissolved or Suspended Constituent

Ten trace elements for which there are Utah water-quality standards and that part of each which is transported in the dissolved phase in the Jordan River, Big Cottonwood, Little Cottonwood, and Mill Creeks are listed in table 13. Chromium, copper, iron, lead, and zinc show the most variation. Most of the arsenic, barium, mercury, selenium, and silver in the Jordan River is transported in the dissolved phase, as is approximately one-third of the chromium, copper, lead, and zinc. By contrast, about 98 percent of the iron in the river is transported in the suspended phase.

Trace-Element Loads in the Jordan River

Instantaneous loads of 13 trace elements were determined for the five sampling sites on the Jordan River, and a mean load was calculated using a mean discharge for 24 hours. The mean loads shown in table 14 reflect a wide range of discharges, which is desirable to produce a more representative mean load for a specific sampling site. The variability of individual constituents also may affect the accuracy of the mean load calculated for these constituents if only a small number of samples are used in the calculation. Thus, the number of samples used in the load calculations also is included in table 14.

The loads shown in table 14 should be considered as estimated loads that were calculated for nonstorm periods. Several of the loads for individual constituents show considerable variation from site to site. This is due principally to the various inflows and diversions that occur between sampling sites. For example, 72.4 percent of the annual flow in the Jordan River above 1700 South Street was diverted into the Surplus Canal during the 1981 water year.

Iron is transported in the greatest quantity in the Jordan River, with a mean load of 110 pounds per day. Notable loads of barium, boron, lead, and zinc also are transported by the river. A mean of 11.4 pounds per day of barium, 30.9 pounds per day of boron, 4.5 pounds per day of lead and 7.9 pounds per day of zinc are transported by the river. In general about 1 to 3 pounds per day of arsenic, chromium, copper, and less than 1 pound per day of cadmium, cyanide, mercury, selenium, and silver are transported by the river.

Table 13.--Part of selected trace elements transported in the dissolved phase in the Jordan River, Big Cottonwood, Little Cottonwood, and Mill Creeks

Standard deviation: A relative measure of variability.
Coefficient of variation: A dimensionless measure of variability calculated as the standard deviation expressed as a percentage of the mean.

Trace element	Part of element in dissolved phase (mean percent)	Number of samples	Standard deviation	Coefficient of variation
Arsenic	90	13	8	8
Barium	72	29	20	27
Chromium	32	50	29	89
Copper	36	165	22	62
Iron	2	112	3	145
Lead	27	143	26	95
Mercury	77	32	29	38
Selenium	96	30	12	13
Silver	96	18	19	20
Zinc	34	167	23	67

Table 14.--Mean loads of selected trace elements in the Jordan River for nonstorm periods

Load: Total load, unless noted otherwise.
First line--Mean load.
Second line--Number of samples used to calculate mean load.

Constituent	Site: Jordan Narrows	9000 South Street	5800 South Street	1700 South Street	500 North Street
	Load, in pounds per day				
Arsenic	1.14 5	1.27 4	1.97 5	1.24 16	1.48 5
Barium	10.8 5	9.26 4	13.7 5	11.5 16	11.2 5
Boron (dissolved)	25.8 5	29.6 4	45.4 5	24.6 5	29.0 5
Cadmium	.05 8	.06 14	.10 12	.10 26	.13 19
Chromium	1.18 19	1.04 24	1.45 23	1.04 36	1.77 29
Copper	1.03 19	2.65 24	3.34 23	2.38 36	4.16 29
Cyanide	<.01 5	<.01 4	<.01 24	<.01 5	<.01 5
Iron	111 16	88.1 14	110 16	109 26	129 15
Lead	.72 19	1.20 24	6.58 23	3.56 36	9.35 29
Mercury	.02 18	.02 16	.02 18	.01 28	.01 17
Selenium	.10 5	.22 4	.33 5	.14 16	.17 5
Silver	.06 8	.04 14	.05 32	.07 29	.11 19
Zinc	5.10 19	4.41 24	8.91 42	6.64 36	12.7 29

SUMMARY

A reconnaissance of toxic substances in the Jordan River was made during July 1980 to October 1982 as part of a larger study of the river that included studies of sanitary quality, dissolved oxygen, and turbidity. Separate reports were prepared for each subject and are summarized in a final report. Samples for toxic substances were collected at five sites on the Jordan River, at the mouths of three major tributaries, and at six storm conduits.

Of the toxic substances studied, concentrations of total mercury exceeded State standards most frequently. About 78 percent of the 138 samples for total mercury exceeded the State use standard of 0.05 microgram per liter. Other toxic substances that exceeded State standards were: ammonia--18 percent of the samples, cadmium--9 percent, copper--9 percent, zinc--6 percent, lead--2 percent, cyanide and iron--one sample each. Arsenic, chromium, phenol, selenium, silver, boron, endrin, lindane, and toxaphene did not exceed State standards in samples collected from the Jordan River and its three major tributaries.

The diversity of toxic substances with concentrations large enough to cause them to be problems increased from the most upstream sampling site at the Jordan Narrows to the next two downstream sites at 9000 South and 5800 South Streets. Concentrations of trace elements in stream-bottom materials also increased in a downstream direction. Large increases first were observed at 5800 South Street, and they were sustained throughout the downstream study area. Concentrations of most trace elements in bottom materials at the mouths of the three major tributaries were similar to the concentrations in the Jordan River at the three downstream-sampling sites. Copper and zinc were exceptions. The mean zinc concentration in the three major tributaries was 282.9 micrograms per gram, exceeding the mean concentration of 186.9 micrograms per gram in the three downstream Jordan River sites. The mean copper concentration in the three major tributaries was 49.7 micrograms per gram compared to the mean concentration of 64.5 micrograms per gram in the three downstream Jordan River sites.

Iron is transported in the greatest quantity of all the trace elements studied, with a mean load of 110 pounds per day. Notable loads of barium, boron, lead, and zinc also are transported by the river. Most of the arsenic, barium, mercury, selenium, and silver is transported in the dissolved phase, as is about one-third of the chromium, copper, lead, and zinc. Iron is transported almost totally in the suspended phase.

DDD, DDE, DDT, dieldrin, heptachlor, methoxychlor, PCB, and 2,4-D were detected in bottom-material samples from the Jordan River or tributaries. DDE, Silvex, and 2,4-D were detected in water samples. Most of the U.S. Environmental Protection Agency's list of priority pollutants were sampled at six storm conduits during a rainstorm on October 29, 1981. Only one of 112 organic compounds, chloroform, was detected. Several metals and phenol also were detected.

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