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Municipal Stormwater Sampling Program, Metropolitan Area, Albuquerque, New Mexico--Summary of Sampling, 1992-2002

INTRODUCTION

Since 1992, the U.S. Geological Survey (USGS), in cooperation with the City of Albuquerque, the Albuquerque Metropolitan Arroyo and Flood Control Authority (AMAFCA), the New Mexico Highway Department (NMHD), and the University of New Mexico (UNM), has collected stormwater-quality data to meet regulatory requirements for the application phase of the National Pollutant Discharge Elimination System (NPDES) stormwater permit. The phase I permit requirements apply to cities with populations of 100,000 or greater (U.S. Environmental Protection Agency, 1990). This report describes the stormwater sampling program implemented in the City of Albuquerque from 1992 to the present (2002).

DESCRIPTION OF THE STUDY AREA

The City of Albuquerque is located in north-central New Mexico (fig. 1). The eastern part of the city is built largely on the alluvial fans of the Sandia Mountains, the western part lies along the Rio Grande partly on the West Mesa, and the central part lies at lower altitudes on the Rio Grande flood plain. Altitudes in the city range from about 5,000 feet above sea level along the Rio Grande to about 7,000 feet at the foothills of the Sandia Mountains.

Albuquerque has a semiarid climate; average annual precipitation is about 8 inches in the lower altitudes near the Rio Grande and increases to about 12 inches at the foothills of the Sandia Mountains. The major part of precipitation occurs as thunderstorms during June through September. These storms are typically small, convective cells that move rapidly through the area and are often intense and can result in flash flooding. Occasionally, large frontal storms that originate from remnant hurricanes in the Gulf of Mexico move into the area.

Natural drainage east of the Rio Grande is through arroyos (dry channels that flow only in response to snowmelt or large rainstorms) that originate at the foothills of the Sandia Mountains, and flow is westward to the Rio Grande. In areas west of the Rio Grande, arroyos originate along the West Mesa, and flow is eastward to the Rio Grande. Many of the arroyos have been lined with concrete to enhance their capacity to convey storm runoff and prevent erosion damage, whereas others, particularly in the western part of the city, remain natural. Detention dams have been built across some arroyos to help prevent flooding, but most arroyos are free flowing.

Albuquerque has a population of about 450,000 (U.S. Census Bureau, 2001). Urban development initially focused along the Rio Grande, although some areas have remained in agricultural use. Since the 1980's, urbanization has increased rapidly, with development mainly focused in the northeast quadrant of the city. Since the 1990's, however, urban development has been primarily in the West Mesa area.

ALBUQUERQUE MUNICIPAL STORMWATER SAMPLING PROGRAM

To meet the requirements of the NPDES discharge permit, many municipalities chose to sample small, single land-use drainage basins. Municipal discharge storm loads are calculated by multiplying the water-quality load collected at each representative land use times the percentage of each land use in the contributing area to extrapolate storm and annual load. Load refers to the material or constituent in solution, suspension, and (or) in transport and is not synonymous with discharge, yield, or concentration. Load is expressed in terms of mass or volume (grams, tons, cubic feet, and so on). The sum of stormwater-quality loading in a small, single land-use drainage basin is assumed to be completely transported to the outlet of the drainage basin. In contrast, the basin outlets of the Albuquerque drainage basins sampled represent a large percentage of the city's area that drains to the Rio Grande. By sampling these large areas rather than extrapolating information from small, dispersed sample areas, it is more certain that the stormwater loading actually reaches the Rio Grande.

Beginning in 1992, USGS and City of Albuquerque personnel have collected stormwater samples at the outlet of five urban drainage basins (UR 9900, UR 300, UR 400a and b, UR 500, UR 200) to characterize stormwater quality from different regions of the city (fig. 1). These five basins were chosen for the urban stormwater network to represent different land uses (table 1) to

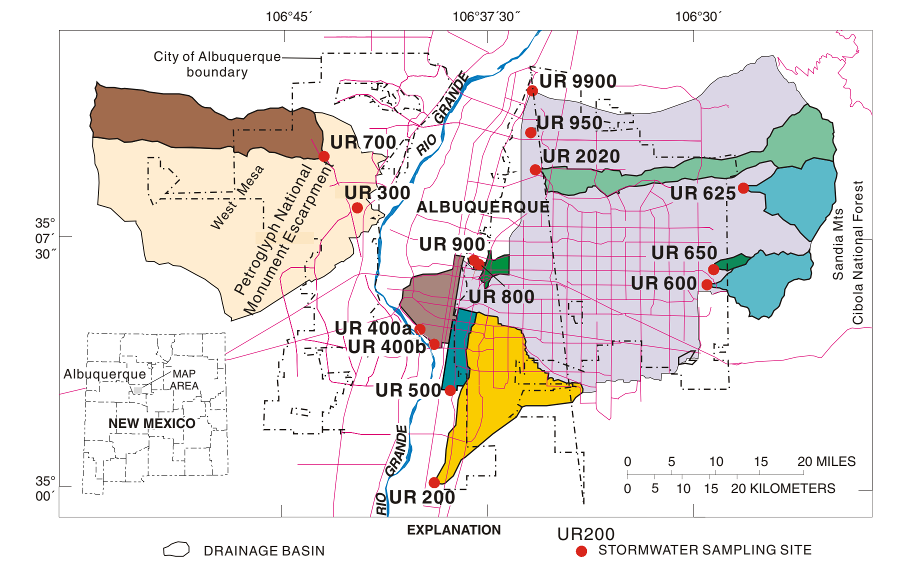


Figure 1. NPDES water-quality sampling sites and drainage basins in the Albuquerque metropolitan area.

Table 1. Stormwater sampling sites in the Albuquerque metropolitan area, 1992-2002
(Location of sampling site in figure 1. --, no station number)

USGS station number	Stormwater site name at outlet of drainage basin	Storm-water site number	Sampling period	Number of samples collected	Basin area, in square miles	Land use, in percent[1] Resi-dential	Commer-cial	Indus-trial	Undeveloped or forested	Open space or parks
--	Pedra Lisa Arroyo	UR 600	1993-96	2	0.4	0	0	0	0	100
08329720	Embudo Arroyo at Monte Largo	UR 650	1998-present	5	3.8	0.5	0	0	0	99
08329868	Bear Canyon Arroyo at Albuq.	UR 625	1999-present	0	5	0	0	0	0	100
08329882	Pino Arroyo at Jefferson Street	UR 2020	2001-present	5	8.3	49	39	4	6	2
--	Washington Business Park	UR 950	1997	2	0.0375	0	100	0	0	0
08329900	North Floodway Channel near Alameda	UR 9900	1992-present	35	89.7	41	15	4	36	4
--	Boca Negra Arroyo at Escarpment	UR 700	1993	2	3.4	0	0	0	0	100
083299375	Mariposa Diversion of San Antonio Arroyo at Albuq.	UR 300	1992-present	25	30.5	19	2	5	73	1
--	Menaul Filter Pond Inflow	UR 800	1996-97; 2000	9	0.8	0	100	0	0	0
--	Menaul Filter Pond Outflow	UR 900	1996-97; 2000	9	0.84	0	100	0	0	0
08330050	Alcalde Pump Station	UR 400a	1992-present	14	3.81	35	34	10	9	12
08330025	Barelas Pump Station	UR 400b	1992-present	10	3.81	35	34	10	9	12
08330200	San Jose Drain at Woodward Road at Albuq.	UR 500	1992-present	24	1.95	41	30	9	18	2
08330775	South Diversion Channel above Tijeras Arroyo near Albuq.	UR 200	1992-present	27	11	13	28	21	30	8

[1] Land use in some basins is not equal to 100 percent because of rounding.

characterize stormwater runoff to the Rio Grande. The samples collected at the North Floodway Channel near Alameda site (UR 9900) represent the stormwater quality from an 89.7-mi^2 basin in the northeastern part of Albuquerque. Most of this basin is residential, with some commercial development along the major roads, and undeveloped and forested land, which is mostly concentrated in the upper part of the basin. The South Diversion Channel above Tijeras Arroyo site (UR 200) represents conditions in the 11-mi^2 basin in the southeastern part of the city. This area consists of residential areas, the University of New Mexico campus, commercial areas including the Albuquerque airport, and undeveloped land. The two stormwater-pump stations, the Alcalde site (UR 400a) and the Barelas site (UR 400b), both pump stormwater from a 3.81-mi^2 basin over the levee into the Rio Grande. These sites are located in the Albuquerque downtown area on the east side of the Rio Grande and are about 3,000 feet from each other. Flow in the San Jose Drain at Woodward Road site (UR 500), a 1.95-mi^2 basin in the south valley area on the east side of the river, is down a long canal that eventually enters the Rio Grande at the south end of town. The Mariposa Diversion of San Antonio Arroyo site (UR 300) drains a 30.5-mi^2 basin on the west side of the river that is primarily undeveloped land with some residential property; the upper reaches of this basin include the Petroglyph National Monument and designated City of Albuquerque open space on the West Mesa (fig. 1).

After the initial effort of characterizing stormwater for the five basins, samples have been collected from nine additional basins to help answer questions that the original analyses raised. During 1993, stormflow at the Pedra Lisa Arroyo site (UR 600) was sampled (fig. 1) to determine background stormwater quality from undeveloped land on the east side of Albuquerque. Additionally in 1993, two stormwater samples were collected from Boca Negra Arroyo at Escarpment site (UR 700) upstream from the Petroglyph National Monument Escarpment (fig. 1) to determine background stormwater quality from the northwest side of Albuquerque. During 1996-97, a 2-year stormwater sampling program was conducted at the Menaul Filter Pond Inflow (UR 800) and Outflow (UR 900) sites (fig. 1); paired stormwater samples of inflow and outflow were analyzed to determine the water-quality improvements from this type of stormwater-quality control. In 2000, water samples collected from the Menaul Filter Pond Inflow and Outflow sites were analyzed for fecal coliform bacteria for 5 successive days after a storm. During 1997, the Washington Business Park site (UR 950), a small commercial drainage basin (fig. 1), was sampled after a prolonged dry period and 1 day after a storm to determine how antecedent conditions affect stormwater quality in this type of urban setting.

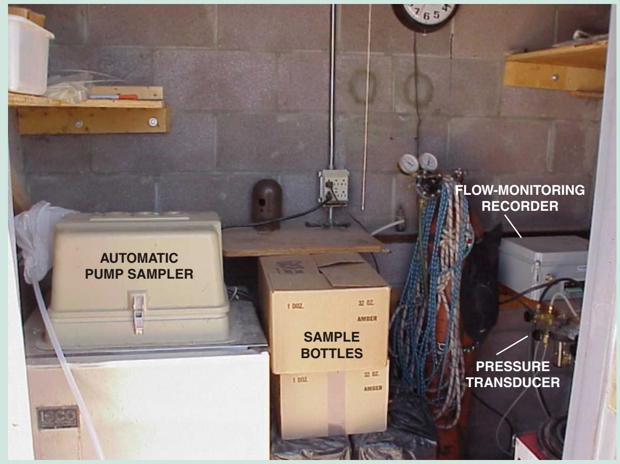
During 1998-99, two permanent background stormwater-quality sites (Embudo Arroyo (UR 650) and Bear Canyon Arroyo (UR 625)), were established along the border between Albuquerque's east boundary and the Cibola National Forest (fig. 1). Samples collected at these two sites represent stormwater quality from undeveloped land. Finally, the Pino Arroyo at Jefferson Street site (UR 2020) was added in 2001 (fig. 1) to represent the water quality from a drainage basin draining into the North Diversion Channel. At this site, water samples from an off-channel retention pond designed for the removal of floatable trash downstream were analyzed for fecal coliform bacteria for 7 days after a storm. A bacterial-source study at the nine sites currently active (2002) is being conducted for the Albuquerque metropolitan area.

In 1999, a stormwater sample from the North Floodway Channel near Alameda site (UR 9900) and a sample from the Rio Grande were combined in varying proportions for a bioassay analysis. In this analysis, immature snub-nosed minnows and water fleas were incubated to determine their tolerance for North Floodway stormwater mixed with Rio Grande water. This analysis will help determine if stormwater has deleterious effects on the Rio Grande.

Instrumentation of Sampling Sites

A typical stormwater-sampling site is shown in two photos. A streamflow-gaging station (the North Floodway Channel near Alameda site, UR 9900) is located about one-half mile upstream from a wetlands area that drains to the Rio Grande. All sampling sites are of similar design, with the exception of the Pedra Lisa Arroyo (UR 600), Boca Negra Arroyo at Escarpment (UR 700), and Washington Business Park (UR 950) sites, which have no permanent shelter to house a flow recorder or pump sampler. In general, instrumentation in the gaging stations consists of a flow-monitoring recorder, a flow-level sensor (a pressure transducer), and an automatic pump sampler.

North Floodway Channel near Alameda gaging station.



Instrumentation in shelter.

Mean daily flow has been published annually in USGS Water-Data Reports for the North Floodway Channel near Alameda site (UR 9900) since 1968 and for the South Diversion Channel above Tijeras Arroyo site (UR 200) since 1988. At most sampling sites, only flow hydrographs for the storms sampled are available because the flow-monitoring recorder has to be reset at the beginning of each flow. The flow recorders at all sites with permanent shelters are gradually being upgraded so that incremental flow for all storms can be monitored.

Stormwater Sampling Procedures

Since the inception of the program, two types of samples have been collected for each storm at the basin outflow sites in the Albuquerque network. During the first 20 minutes of storm runoff, a grab sample is collected. After the first 30 minutes, discrete stormwater samples are collected at even intervals ranging from 10 to 20 minutes during the first 3 hours of runoff. These discrete samples are then mixed together; the volume of each discrete sample added is dependent on the magnitude of flow when the sample was collected. The higher the flow at the time the sample was collected, the greater the volume of sample that is added to the mixture. The final mixture of all discrete samples is the flow-weighted composite sample, which represents the water quality of the stormflow during the 3 hours of runoff. A storm hydrograph recorded at the North Floodway Channel near Alameda site for September 28, 1995, shows the time intervals and the flow associated with each stormwater sample collected during that storm (fig. 2).

For all sampled storms, it is important that there is no substantial stormflow for 72 hours prior to sample collection. Although a 72-hour dry period is desired, the North Floodway Channel near Alameda site is rarely completely dry for 72 hours prior to sample collection during the summer monsoonal season (June - September). During this season in Albuquerque, minimal amounts of rain fall on some part of the 89.7-mi^2 drainage basin almost every day.

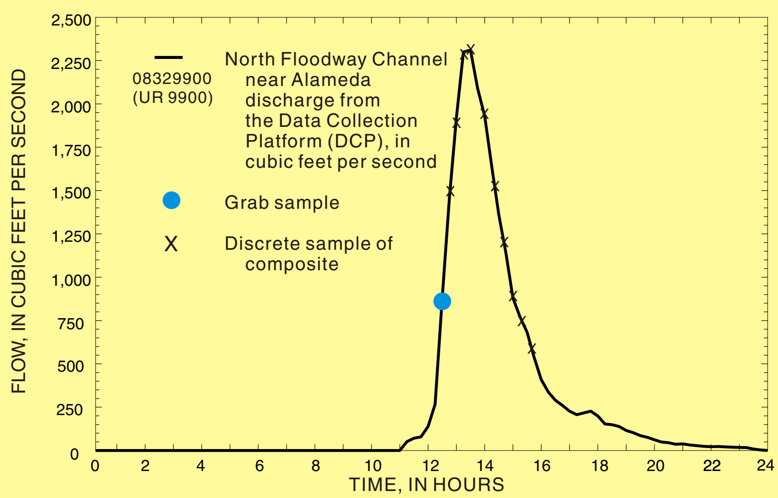


Figure 2. Storm hydrograph recorded at the North Floodway streamflow-gaging station near Alameda showing the time interval for sample collection in relation to streamflow, September 28, 1995.

Water-Quality Constituents Analyzed

The water-quality constituents analyzed in the grab and in the composite stormwater samples are listed in table 2. Twelve of the constituents analyzed in the composite samples are priority constituents selected by the U.S. Environmental Protection Agency (USEPA) as major contaminants in stormwater runoff. Annual stormwater load is estimated for these priority constituents. The priority constituents are dissolved solids, suspended solids, total Kjeldahl nitrogen, total nitrogen, dissolved phosphorus, total phosphorus, biochemical oxygen demand, chemical oxygen demand, total extractable cadmium, total extractable copper, total extractable lead, and total extractable zinc. Stormwater-runoff samples also were analyzed for the dissolved fraction of selected trace elements to determine the effect that stormwater runoff has on the Rio Grande. Fecal coliform and fecal streptococcus bacteria densities have been determined for each grab sample; the Rio Grande has a total maximum daily load (TMDL) established for fecal coliform. For most of the storms sampled at the North Floodway Channel near Alameda site, discrete suspended-sediment samples also were collected. Other constituents analyzed in the grab samples were selected pesticides and aroclors, selected semivolatile base neutral acids, phenols, oil and grease, total organic carbon, and selected volatile organic compounds.

Table 2. Water-quality constituents analyzed in stormwater samples

(* indicates the 12 USEPA priority constituents)

Nutrients	Organic constituents	Bacteria
Kjeldahl nitrogen, total*	Organochlorine pesticides and aroclors (27 compounds)	Fecal coliform
Nitrogen, ammonia, dissolved as nitrogen		Fecal streptococcus
Nitrate, dissolved as nitrogen	Semivolatile base neutral acids (56 compounds)	
Nitrite plus nitrate, dissolved as nitrogen, total	Volatile organic compounds (61 compounds)	
Phosphorus, dissolved*	Total organic carbon	
Phosphorus, total*	Phenols	
Nitrogen, total*	Oil and grease	

Physical properties	Trace elements (all total concentrations are extractable)	
Biochemical oxygen demand*	Antimony, total	Aluminum, dissolved
Chemical oxygen demand*	Aluminum, total	Arsenic, dissolved
Dissolved solids*	Arsenic, total	Beryllium, dissolved
pH	Beryllium, total	Cadmium, dissolved
Specific conductance	Cadmium, total*	Chromium, dissolved
Suspended solids*	Chromium, total	Copper, dissolved
Inorganic constituents	Copper, total*	Lead, dissolved
	Cyanide, total	Mercury, dissolved
Alkalinity	Lead, total*	Nickel, dissolved
Calcium, dissolved	Mercury, total	Selenium, dissolved
Chloride, dissolved	Nickel, total	Silver, dissolved
Magnesium, dissolved	Selenium, total	Zinc, dissolved
Potassium, dissolved	Silver, total	
Sodium, dissolved	Thallium, total	
Sulfate, dissolved	Zinc, total*	

Quality Assurance and Quality Control

Quality-assurance procedures for the field and laboratory have been conducted since 1992. Field quality-assurance practices involve calibrating all field meters and probes and cleaning sampling equipment prior to all site visits. Immediately prior to each sampling, meters and probes are recalibrated. All calibration information is recorded on USGS water-quality field forms. Samples are collected, preserved, and shipped in accordance with applicable USGS protocols. During this study, three different water-quality laboratories have been used to analyze the stormwater samples. Quality-assurance procedures used at the USGS National Water Quality Laboratory (NWQL) in Arvada, Colorado, the City of Albuquerque laboratory at the wastewater-treatment plant, and the New Mexico State Laboratory in Albuquerque constitute the laboratory quality-assurance program implemented for this study. All laboratories have formal reviews of laboratory procedures. Presently (2002), the New Mexico State laboratory analyzes nutrients and selected organic compounds, whereas the City laboratory at the wastewater-treatment plant analyzes all other constituents and bacteria. An average of two replicate samples per year have been sent to the NWQL since 1994.

Four types of quality-control samples are collected during field sampling: replicate samples, equipment blanks, spiked samples, and field trip-blank samples. Replicate samples, sometimes called splits, are collected at all sites and are obtained by dividing the water collected for each analysis into two bottles. Separate laboratories analyze the split samples from a single site. The purpose of a replicate sample is to evaluate laboratory precision between samples. Equipment blank samples collected at each site are obtained by passing inorganic-free or organic-free blank water through all components of the sample-collection apparatus. Chemical analysis of these samples is designed to determine the adequacy of the process of equipment cleaning between sampled sites or to quantify carryover of any chemical contamination between sites. Spiked samples are additional samples of known concentration that are analyzed by the laboratory at the same time as the storm samples to make sure the analysis is correctly identifying concentrations of a constituent. Trip blanks are inorganic- or organic-free water that is carried along during sample collection and then analyzed by the laboratory to detect possible contamination during sample collection.

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