

TRANSPORT MECHANISMS IN SEDIMENT RICH STREAMS
HEAVY METAL AND NUTRIENT LOAD OF THE
RIO SAN JOSE-RIO PUERCO SYSTEMS

by

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ABSTRACT

Because of the possibility that uranium mining and milling activities could contribute harmful substances to surface water, the project purpose was to determine physical and chemical characteristics of water and sediments in the San Jose-Puerco River system in New Mexico. Water samples were analyzed for general chemistries, sediment load, nutrients, heavy metals and radioactivity. Suspended sediments and bed-load sediments were analyzed for heavy metals and radioactivity. Dissolved metals in the Rio San Jose were not elevated with respect to the Rio Puerco. The lower Rio Puerco showed elevated levels of Mo and V with respect to the Rio Grande. Elevated levels of As, Cd, Co, Hg, Mo, U, V, and Zn were found in Rio San Jose suspended sediments. Analyses of bed-load sediments indicated elevated levels of As, Hg, and U in both the Rio San Jose and Rio Puerco. An attempt was made to study the means of transport of the elevated species.

Key Words

Rio Puerco

Rio San Jose

Uranium Mining, effect on surface water

Suspended sediments, heavy metals in

Bed-load sediments, heavy metals in

Transport mechanisms, sediment rich streams

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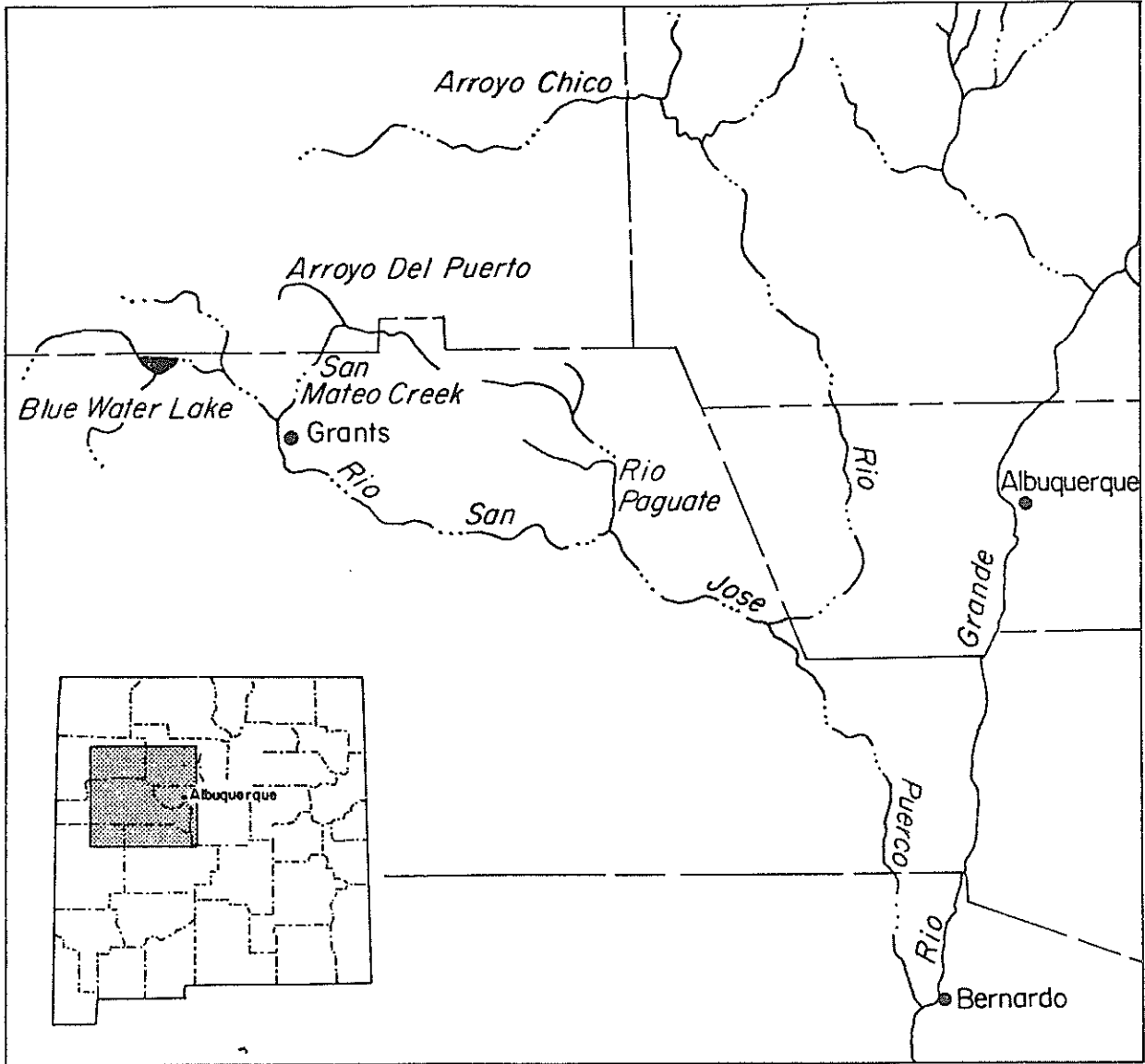
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INTRODUCTION

The overall energy situation with its increased demand for fuel for nuclear reactors has had a stimulatory effect on uranium exploration, mining, milling, and related activities in the area of New Mexico called the Grants Mineral Belt. In August of 1977, when the study reported here began there were 21 active uranium mines, 36 exploration drilling rigs and 32 development drilling rigs in the area (1). This extensive activity may have the potential to introduce toxic material and other substances into the Rio Grande, a major southwestern waterway.

The Grants Mineral Belt runs roughly from Albuquerque west to the Arizona-New Mexico border (Figure 1). The climate is semiarid to arid. Precipitation increases with increasing elevation. The average annual precipitation at Grants airport is 21 cm with up to 50 cm falling on Mt. Taylor at higher altitudes. With the exception of the volcanically formed Mt. Taylor area most of the region is plateau underlain by sedimentary rocks. Except for high elevations vegetation is generally sparse.

The area studied was that portion of the Grants Mineral Belt which drains east from the Continental Divide to the Rio Grande and is shown in Figure 1. The two main rivers are the Rio San Jose and the Rio Puerco. Two potentially important tributaries, because of their location, are San Mateo Creek and the Rio Pagate. San Mateo Creek enters the Rio San Jose only under flood conditions, while the Rio



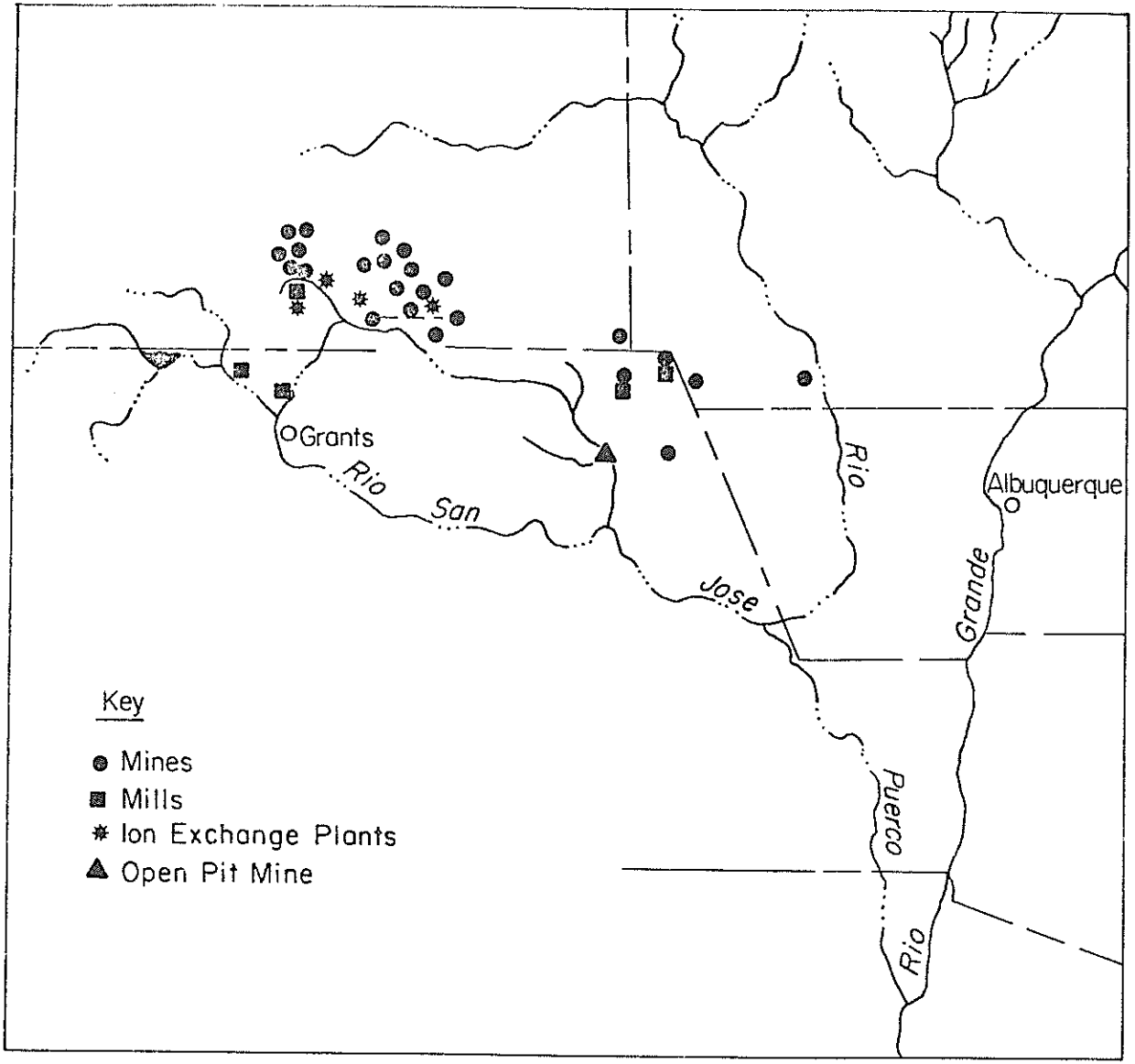
STUDY AREA
Figure 1

Paguete is now a small permanent stream because of mine dewatering. The Rio San Jose joins the Rio Puerco which enters the Rio Grande at Bernardo about 80 km south of Albuquerque. The lower reaches of the San Jose and Puerco rivers are intermittent with detectable flow less than 50% of the time (2,3). When the flow does occur it is often quite high, especially in the Puerco. Ten percent of the time, the flow is higher than 50 cfs, one percent of the time it is equal to or greater than 1000 cfs (4) and extreme floods of 20,000 cfs have been estimated (5). Material transported by the suspended particles may be especially significant for the Rio Puerco with its extremely high sediment load. The Puerco has been estimated to contribute only 16% of the water and over half the sediment to the Rio Grande below Bernardo (6). Because of this extreme variability in flow, the arid climate, the land use, and the geologic history of the region, the Rio Puerco has a very high sediment load. High flows mobilize sediments downstream and the sediments can then affect water quality. The average annual sediment load of the Puerco near Bernardo is 5,584 acre-feet. Above its meeting with the Rio Puerco, the yearly average for the Rio Grande is only 1,583 acre-feet (4). In contrast to this, the Rio Grande has been estimated to contribute more than 84% of the water which then may be affected by interaction with Rio Puerco water and sediments. Also, the Rio San Jose drainage has a large and growing population and water quality is important to the inhabitants.

Little information has been available on the effects of uranium mining in the Grants area on water quality. Unfortunately, there is essentially no record of the water quality in the streams before mining began. The United States Geological Survey maintains 9 gaging stations on the San Jose-Puerco system. With the exception of two very recently installed stations on Arroyo del Puerto and San Mateo Creek, these stations are used to measure only water quantity. Such measurements that have been done have only measured dissolved constituents and not substances carried by the suspended sediments.

Currently, there are 42 active mines, 5 mills and 4 ion exchange plants in the Grants area (Figure 2) (7). Uranium occurs most frequently in the Westwater Canyon Member of the Morrison Formation. This formation is also an aquifer and in order to mine uranium, water must constantly be pumped from the mines. This water generally passes through settling basins and then is either discharged, used as makeup water in the mills or for backfilling operations. As mining progresses, the uranium content of the mine water increases probably due to oxidation. Ion exchange plants are used to recover this uranium and these lower the uranium content to 0.5-1 ppm. Radium contained in the water is removed by co-precipitation with barium sulfate.

After treatment, the water is discharged to arroyos, etc. During the time samples were taken for this project the following average amounts of water were being discharged

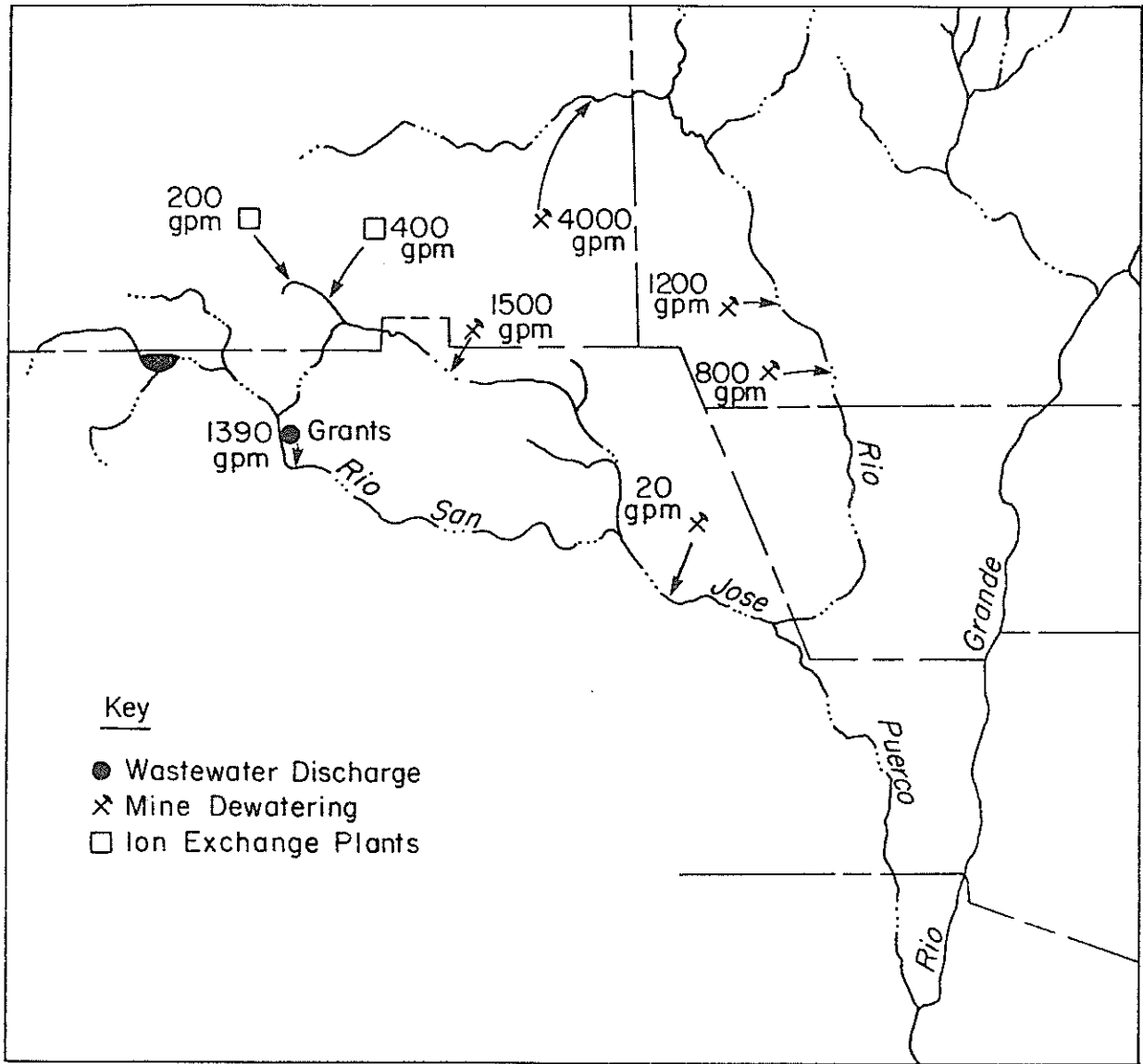


MINING AND MILLING ACTIVITY
Figure 2

(Figure 3): 200 gallons per minute (gpm) ion-exchange treated water to Arroyo del Puerto, 400 gpm from mine dewatering to Arroyo del Puerto, 1500 gpm from mine watering to San Mateo Creek, 4000 gpm from mine dewatering to San Lucas Arroyo, 1200 gpm to Juan Tafoya Creek, 800 gpm to Salado Creek and 20 gpm to Arroyo del Valle (7).

Although water from San Mateo Creek and Arroyo del Puerto does not normally enter the San Jose, it can do so under flood conditions remobilizing and transporting sorbed or precipitated constituents. Such a flood occurred in February of 1979 (8). Very high runoff water west of Grants in the spring of 1980 may also have mobilized some material. The Rio Paguete runs through the Jackpile open pit mine draining this area to the San Jose. Factors other than discharge of mine and process water can affect the surface water quality. Examples are leaching of tailings and stock piles by precipitation, wind blown dust from tailings piles, stock piles, open pit mining, and mine construction, later washed by precipitation into the drainage system. Besides uranium mining, other factors also affect the surface water quality. The city of Grants discharges treated sewage into the Rio San Jose and an old copper mining area, the Sierra Nacimiento, is drained by the Rio Puerco.

The project reported here involved determining physical and chemical parameters of the water in the San Jose-Puerco system in New Mexico between January 1979 and September 1980.

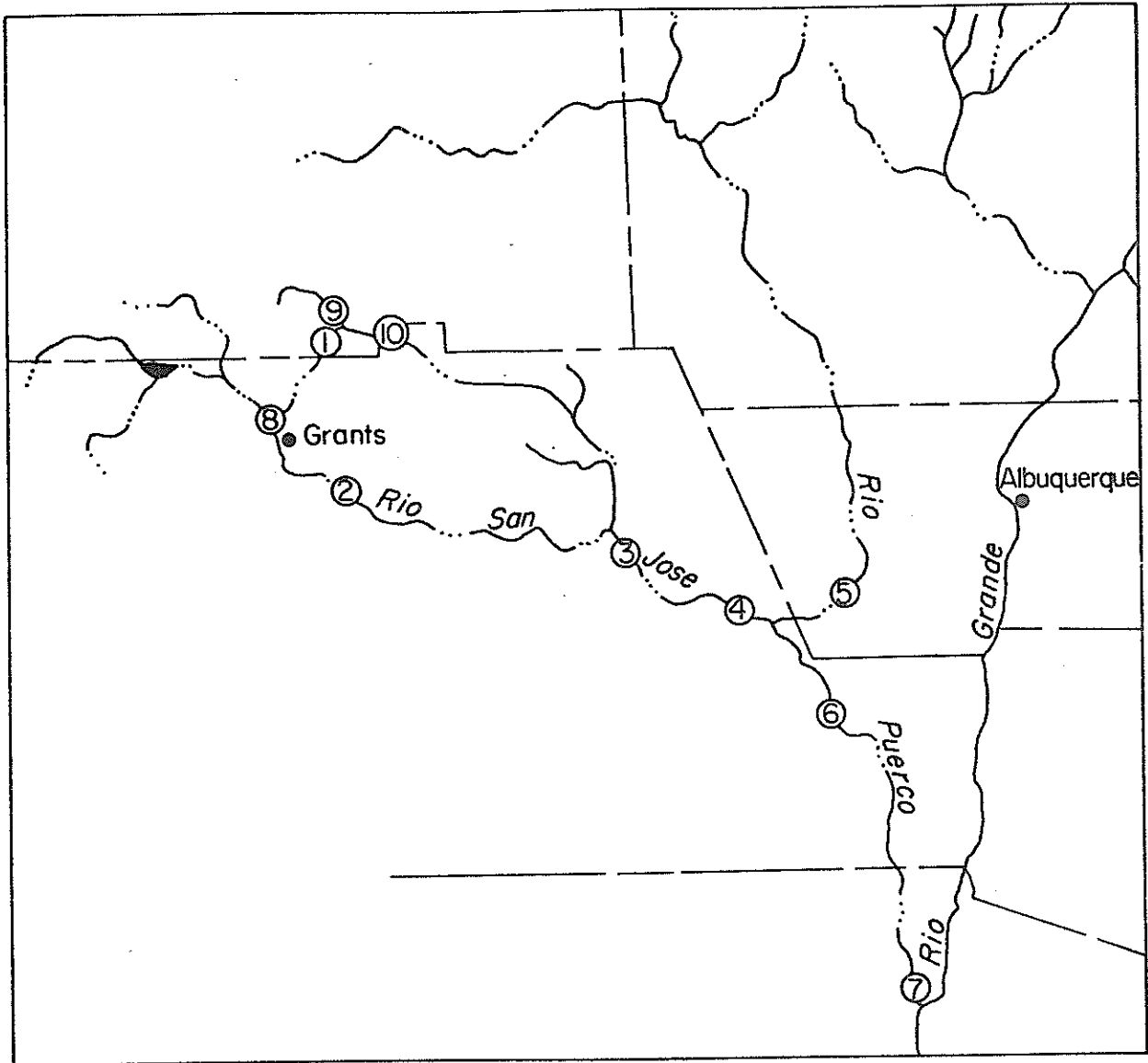


DISCHARGES TO SURFACE WATER
Figure 3

MATERIALS AND METHODS

Because of the intermittent flow throughout the system, sampling times were dependent on flow conditions. Nine sampling trips were taken and an attempt was made to distribute these on a seasonal basis. Summer samples were subject to dilution and runoff due to thunderstorms while spring samples reflect snow melt runoff. The sampling sites were located as shown in Figure 4. Site 1 was on San Mateo Creek 3.2 miles below the point where it is joined by Arroyo del Puerto. This site was dry at time of sampling with two exceptions. Site 2 was located in the lava beds just east of Grants. Site 3 was on the San Jose below the inflow from the Rio Paguete. Site 4 was also on the San Jose just before the confluence with the Puerco. Site 5 was on the Puerco where it is crossed by Interstate 40. Site 6 was on the Rio Puerco below the confluence with Rio San Jose. Two samples were collected from Bluewater Lake. The following sites were added after the first two sampling trips and were sampled when water was flowing: site 7 on the Rio Puerco just before it enters the Rio Grande at Bernardo, site 8 on the Rio San Jose above Grants and the intersection with San Mateo Creek, site 9 on Arroyo del Puerto before it joins San Mateo Creek, and site 10 on an arroyo which carries a mine dewatering discharge to San Mateo Creek. See photographs shown in Appendix A.

Field measurements were carried out for pH using an Orion Model 407 portable meter; conductivity using a Yellow Springs Instrument Model 33 conductivity meter, and alkalinity with a field test kit, model AL-AP manufactured by Hach Chemical



SAMPLING SITES

Figure 4

Company. Samples for laboratory analyses were collected in acid-washed polyethylene bottles. Samples used for heavy metal analyses were filtered as quickly as possible through 0.45 micron filters and acidified to pH 2 with redistilled or Ultrex (J.T. Baker) nitric acid. Water for analysis of nitrogen species was collected separately in 1 liter bottles containing 5 ml of 3N sulfuric acid saturated with chloroform to inhibit biological conversions.

General water chemistries were determined by standard methods (9,10). Zinc was determined by flame atomic absorption. Arsenic, barium, cadmium, cobalt, chromium, copper, lead, manganese, nickel, and vanadium were determined by flameless atomic absorption (AA) using a carbon furnace (Perkin-Elmer 403/HGA2000 or Varian 1200/63). Uranium (11) and molybdenum (12) were determined colorimetrically. Selenium was analyzed by a fluorometric method (13). Selenium was also done by the carbon furnace attachment to the atomic absorption using an electrodeless discharge lamp source on the Perkin-Elmer AA. Mercury was determined by the cold vapor method of Hatch and Ott using a Coleman MA5-50 mercury analyzer (14). Trace metal analyses were performed on both filtered and unfiltered samples. The unfiltered samples were digested by the EPA method (10). EPA standard Trace Metal Quality Control Sample 476B was used to check AA analyses each time a trace metal was analyzed.

Gross alpha counts were performed on filtered water samples using a zinc sulfide-photomultiplier detector. The alpha-counter was calibrated using a Th-232 standard of the

same configuration as the counting chamber. Water samples were evaporated onto aluminum foil disks. The procedure generally followed that outlined in "Standard Methods" (9).

Studies of the speciation of particulate trace metals were done using the method of Tessier et al. (15).

Kjeldahl nitrogen, nitrate, nitrite, and dissolved phosphate assays were carried out according to procedures described in the 1979 EPA Manual (10).

RESULTS AND DISCUSSION

Dissolved Trace Metals

Dissolved metal analyses performed on 0.45 micron filtered samples are shown in Table 1 . This data reflects species being carried in solution downstream from the discharge areas. The sites immediately downstream from the active mining areas on San Mateo Creek reflect elevated values for arsenic, lead, molybdenum, selenium and uranium. However, these levels decrease rapidly from site 1 and do not show up in the Rio San Jose below the city of Grants. San Mateo Creek goes underground before reaching the city of Milan and only flows to Grants during high runoff periods. Apparently these excess discharged ions are either going into the ground water system or absorbing onto alluvial valley fill sediments in this process. None of the metals in the Rio San Jose show elevated values relative to site 5 which is on the Rio Puerco upstream from its confluence with the Rio San Jose. It appears then that the dissolved

TABLE 1
Dissolved Metals in Filtered^a Water
Values in ppb (ug/l)

Metal	San Mateo Cr.			Rio San Jose				Rio Puerco			
	9	10	1	BW	8	2	3	4	5	6	7
Arsenic	39	30	3		2	7	5	4	3	5	21
Barium	91	160	117		69	64	62	80	59	82	76
Cadmium	1.4	3.8	1.6		.36	5.6	8.2	6.6	7.8	39	6.2
Cobalt	35	10	19		16	30	30	19	26	220	34
Chromium	1.7	3.5	14		.9	2.4	4.2	14	3.1	2.1	1.9
Copper	7.6	5.2	11		25	9.3	14	13	16	27	24
Lead	26	30	5.3		2.8	18	5.8	5.2	5.9	15	18
Manganese	25	230	15		58	107	2.3	2.3	63	90	39
Mercury	.17	.31	.25	1.0	0.1	.38	.49	.18	.48	.71	.68
Molybdenum	870	320	410		61	57	13	31	79	250	180
Nickel	47	29	44		41	45	62	49	56	58	104
Selenium	160	35	8	<5	4	6	6	5	7	13	8
Uranium ^b	1440	670	1020	70	80	85	57	69	65	53	58
Vanadium	100	71	71	<50	150	43	60	49	230	110	170
Zinc	90	32	50	90	80	43	58	80	52	57	79

a Filtered through 0.45μ membrane filters

b as U₃O₈

Samples are in order upstream to downstream

trace metal concentrations in the Rio Puerco are independent of dissolved metals in the Rio San Jose. These do not show elevated values at site 5. It is possible that these ions are being removed by some exchange process from sediments contributed by the Rio San Jose and are reflected in increased values at site 6 and at site 7 in the case of Mo. Dissolved values in the San Jose and Puerco compare closely with those found by Popp and Laquer (16) in the Rio Grande with the exception of Mo and V which are higher than recent values for the Rio Grande.

Metals in Suspended Sediments

Data for total trace metals associated with suspended sediments is shown in Table 2. Sites 1-4 are along San Mateo Creek (1) and the Rio San Jose (2-4) while sites 5-7 are along the Rio Puerco with site 5 upstream from the Rio San Jose and sites 6 and 7 downstream. Any effect from the San Jose should show up as differences between 5 and 6, 7. There is no indication of any differences for any of the metals between site 5 and site 6. In fact, the values are remarkably similar. There are however, elevated values in the San Mateo-San Jose sediments relative to the Rio Puerco for As, Cd, Co, Hg, Mo, U, V and Zn. In the cases of Co, U, Zn, and V the values are about 5 times greater, for Hg and Cd about 100 times greater, and for Mo about 1000 times greater. Most of these metals are associated with uranium ores and may be released in the mining

TABLE 2

TOTAL METALS IN SUSPENDED SEDIMENT
VALUES IN PPM ($\mu\text{g/g}$) OF DRIED SEDIMENT^a

	Rio San Jose				Rio Puerco		
	1	2	3	4	5	6	7
Arsenic		33 ⁺ -3 (4)	71 ⁺ -75 (4)	19 ⁺ -14 (4)	26 ⁺ -28 (6)	5.2 ⁺ -6.3 (7)	22 (2)
Barium	107 (2)	49 ⁺ -23 (5)	19 ⁺ -22 (4)	130 ⁺ -106 (3)	121 ⁺ -145 (5)	158 ⁺ -322 (6)	266 (2)
Cadmium	.10 (1)	5.6 (2)	10 ⁺ -10 (3)	9.4 (1)	.12 ⁺ -.08 (5)	0.2 (2)	.16 (2)
Cobalt			61 ⁺ -92 (3)	56 (2)	11 ⁺ -5 (5)	12 ⁺ -7 (5)	17 (2)
Chromium	21 (2)	22 ⁺ -19 (7)	33 ⁺ -46 (5)	31 ⁺ -40 (5)	31 ⁺ -29 (6)	23 ⁺ -18 (7)	19 (2)
Copper	12 (2)	93 ⁺ -102 (6)	87 ⁺ -91 (4)	26 ⁺ -38 (4)	89 ⁺ -132 (6)	89 ⁺ -143 (7)	71 (2)
Lead	15 (2)	27 ⁺ -31 (6)	132 ⁺ -240 (5)	29 ⁺ -35 (5)	45 ⁺ -39 (6)	25 ⁺ -28 (7)	56 (2)
Manganese	330 (2)	119 ⁺ -117 (5)	326 (2)	386 ⁺ -305 (3)	143 ⁺ -111 (4)	134 ⁺ -140 (5)	107 (2)
Mercury	3.4 (2)	7.1 ⁺ -9.8 (6)	1.7 ⁺ -.8 (3)	1.5 ⁺ -1.4 (3)	.043 ⁺ -.02 (5)	.044 ⁺ -.039 (6)	.062 (2)
Molybdenum	8.4 (1)	74 (2)	690 (3)	500 ⁺ -181 (4)	.68 ⁺ -.5 (6)	.54 ⁺ -.54 (5)	.16 (1)
Nickel	23 (1)	129 (1)	6.2 (1)	63 (2)	74 ⁺ -98 (5)	72 ⁺ -147 (6)	107 (2)
Selenium ^b	1.9 (1)			.12 (1)	.04 (2)		
Uranium	140 (1)	320 ⁺ -308 (5)	260 ⁺ -200 (5)	221 ⁺ -226 (5)	48 ⁺ -22 (6)	62 ⁺ -59 (7)	54 (2)
Vanadium	38 (1)	323 ⁺ -460 (4)	195 ⁺ -250 (3)	90 ⁺ -47 (4)	14 ⁺ -9 (6)	11 ⁺ -12 (8)	106 (2)
Zinc	4 (1)	1230 ⁺ -2230 (7)	456 ⁺ -589 (5)	390 ⁺ -590 (5)	69 ⁺ -41 (6)	63 ⁺ -46 (7)	309 (2)

^a Numbers in parentheses indicate number of samples^b Selenium only detected 4 times in suspended sediment

and milling of the ore. However, because of the high sediment load contributed by the Rio Puerco, these elements do not show elevated values in the Puerco sediments. In other words, the Puerco sediments mask or bury the elevated values shown in the San Jose sediments. Discharges from active mines have only recently been reaching the Rio Puerco upstream from the San Jose and metals may not yet have been added in sufficient quantities to show up in analyses. Comparison of average values for the San Jose and Puerco to crustal abundances is made in Table 3 . Several trends are evident in this comparison. In the Rio San Jose, As and Cd are an order of magnitude higher in concentration than crustal abundance while Hg, Mo, and U are 100 times more concentrated. The only high trends which carry over into the Rio Puerco are for As and U while all the other metals are in good agreement with crustal abundances. Selenium was found to be present predominately in the dissolved (0.45 micron filtered) portion of the water column and not associated with the suspended sediments. These data agree well with the findings of Popp and Laquer (16) who found high sediment concentrations for As, Cd, Hg and Mo for the Rio Grande in the same region, they did not analyze for U in the suspended sediment. High values in the Rio San Jose sediments as compared to the Rio Puerco indicate a contribution from the mining region but do not necessarily implicate mining and milling as the causes. This question perhaps can be answered by studies of the historical trace metal concentrations in the sediments.

TABLE 3
 Total Metals In Suspended Sediments
 Value In ppm ($\mu\text{g/g}$) Dried Sediment

	<u>Rio San Jose</u> <u>Averages^a</u>	<u>Rio Puerco</u> <u>Averages^b</u>	<u>Crustal</u> <u>Abundance(17)</u>	<u>Rio Grande</u> <u>at Bernardo(16)</u>
Arsenic	41 (12)	16 (15)	1.8	230
Barium	59 (12)	160 (13)	500	370
Cadmium	8.4 (6)	0.15 (9)	0.15	4.8
Cobalt	59 (5)	12 (12)	22	31
Chromium	29 (17)	26 (15)	100	73
Copper	72 (14)	87 (15)	50	41
Lead	60 (16)	37 (15)	12.5	20
Manganese	240 (10)	130 (11)	1000	620
Mercury	4.4 (12)	0.046 (13)	0.02	.72
Molybdenum	470 (9)	0.58 (12)	1.5	19
Nickel	65 (4)	78 (13)	75	69
Uranium	267 (15)	55 (15)	2.7	
Vanadium	200 (11)	24 (16)	110	75
Zinc	760 (17)	98 (15)	70	190

^a Sites 2-4 Average of 4-17 values. No. of analyses in parentheses

^b Sites 5-7 Average of 9-15 values. No. of analyses in parentheses

Bed-Load Sediment Analyses

In an attempt to answer the question of historical deposition, surface and 18" core samples of the bed-load were obtained. It was hoped that this might help in differentiating between trace metals associated with smaller suspended sediment particles and larger bed-load particles. The data are shown in Table 4 . There are no obvious trends between the surface sediments and the 18" core sediments. This is not surprising because these sediments are quite recent. Sedimentation (aggradation) rates for these streams have been estimated to be 2.5-5 cm/yr (18) and an 18" core would contain sediments around 10 years of age compared to mining activity dating back 30 years. Also, an 18" core from the Puerco would be younger than an 18" core from the San Jose because of the difference in sedimentation rates. However, comparisons can be made between the bed-load and suspended sediments and between bed-load concentration and crustal abundance.

As with the suspended sediment, the metal concentrations for As, Hg and U are greater than crustal abundances. In addition, Se values are high in the bed load sediments whereas Se was only rarely detected in the suspended sediments. The metals Cd, Mo and Zn which appeared to be high in the suspended sediments appear to be about average in the bed load sediments. This indicates a close association between these metals and the clay-sized particles and may allow for more rapid transport of these metals downstream because

TABLE 4

BED SEDIMENT ANALYSES - TOTAL METALS VALUES IN µg/g DRY WEIGHT
CORES APPROXIMATELY 18" DEPTH

	As	Ba	Cd	Cr	Cu	Pb	Mn	Hg	Mo	Ni	Se	U	V	Zn
Site 1	Sur ^a	16	.07	2.2	.72	3.7	64	.42	1.2	3.4	.27	41	9.1	30
	Core	157	41	.11	7.5	6.6	144	.46	8.9	10.6	1.6	50	18	34
Site 2	Sur	333	.14	20	11	14	255	1.3	3.3	14	.67	45	27	65
	Core							(Not obtained -- basalt bottom)						
Site 3	Sur	151	.10	7.4	3.2	4.8	106	.7	2.3	283	.23	25	14	32
	Core	100	26	.07	5.6	6.7	152	1.8	2.2	12	.26	38	13	16
Site 4	Sur	46	.08	6.8	1.6	4.0	70	1.7	5.8	6.6	.14	10	10	--
	Core							(Not obtained -- hard pan bottom)						
Site 5	Sur	30	.06	5.9	4.0	6.5	154	.90	3.2	6.8	.13	61	16	31
	Core	18	120	.11	4.2	2.8	156	.34	.88	31	.13	19	9.4	16
Site 6	Sur	208	.25	10	6.5	10	198	2.0	1.6	20	.27	56	30	--
	Core	.33	68	.08	4.9	3.9	112	.99	.38	10	.29	77	16	--
Site 7	Sur	1.3	.49	1.7	8.8	.51	96	1.9	4.2	--	.17	32	12	27
	Core	3.8	1.2	2.7	4.5	5.0	132	.18	1.3	--	.13	15	9.8	16
Crustal Abundance (17)	1.8	500	0.15	100	50	12.5	1000	.02	1.5	75	.05	2.7	110	70

^a surface

the bed-load will not travel as rapidly or as far as the clay sized material. There are also no clear differences between the bed load trace metal concentrations of the Rio San Jose and Rio Puerco which is a different conclusion than that seen for the suspended sediments. This again indicates that the smaller sized sediments are responsible for transporting the excess trace metals found.

Trace Metal Speciation Studies

The very large amounts of suspended sediments in samples collected at sites 5 and 6 made it possible to study the speciation of some of the heavy metals present in these sediments. This study was not intended to be definitive but only very preliminary. Suspended sediments from the Jan. 1980 sample trip were filtered from 150 ml of solution and dried at 110°C. This resulted in about 6 g of dried material. One g of each sample was used to measure loss on ignition. The extraction procedure of Tessier et al. (15) as mentioned in the Methods section was followed. The results are presented in Table 5. As would be expected data from site 5 and 6 are similar. These sediments contain little organic material since loss on ignition at 500°C for 1 hour results in a weight loss of 9.79% (site 5) and 9.49% (site 6) and some of this must be water. Chromium, uranium and zinc are seen to be present mostly in the residual form. Vanadium is present in the highest percentage in the "bound to carbonate" fraction, although there are also high percentages in the "exchangeable" and "bound to Fe and Mn fraction".

TABLE 5
SPECIATION OF TRACE METALS IN SUSPENDED SEDIMENT

Fraction	Site 5				Site 6			
	% Cr	U ₃ O ₈	% V	% Zn	% Cr	U ₃ O ₈	% V	% Zn
Exchangeable	9.3	6.4	21.4	2.5	5.9	1.8	21.6	0.9
Bound to carbonate	8.1	7.4	30.6	3.7	8.3	1.7	34.2	3.3
Bound to Fe and Mn oxides	8.1	1.4	19.4	3.8	5.9	1.7	14.4	3.7
Bound to organic matter	3.5	4.6	12.2	6.3	3.5	0.4	11.7	10.3
Residual	70.9	80.5	16.3	84.7	76.5	94.3	18.0	81.8

Although the fractionation scheme was different, comparison can be made for Cr, V and Zn to that found by Popp and Laquer in the Rio Grande and Rio Puerco (16). These elements were predominantly in the crystalline (residual) phase but V and Zn also had a significant fraction in the hydrous metal oxide coatings. Chromium and zinc behaved similarly in this study while vanadium differed in being found in the carbonate phase. It should be noted that the separation scheme used by Popp and Laquer did not contain a carbonate phase and that only one sample was used in this study. Nevertheless the elemental distribution seems similar.

It would be very interesting to have comparable data from sites 2, 3 and 4. However, this wasn't possible in this study because there is so little suspended sediment at these sites. The metals transported to the Rio Puerco are, therefore, predominantly dissolved. Further transport downstream in the Puerco is complicated by the large suspended sediment load in that stream. Tracing the transport mechanism for heavy metals would be worthwhile and would involved a more thorough sampling schedule.

Gross Alpha Analyses

Values obtained for gross alpha counts in filtered waters are shown in Table 6. The values are high in waters directly below the active mining and milling activity along San Mateo Creek (sites 9, 10, 1). The water goes underground below site 1 and apparently the species responsible for high

TABLE 6

Gross Alpha Analyses

Averages, Standard Deviations and Number of Samples Shown

<u>Site #</u>	<u>Description</u>	<u>Gross Alpha (pCi/l)</u>		
9	Arroyo Del Puerto	520	± 280	(4)
10	San Mateo Creek	870	± 510	(4)
1	San Mateo Creek	330		(2)
2	Rio San Jose	7.0	± 5.2	(6)
3	Rio San Jose	11	± 6	(4)
4	Rio San Jose	15	± 9	(4)
5	Rio Puerco	13	± 10	(5)
6	Rio Puerco	9.8	± 4.4	(7)
7	Rio Puerco	20	± 5	(3)

activity do not reappear further downstream in the Rio San Jose. The values for the Rio San Jose and Rio Puerco are quite similar and are probably indicative of background for the area.

General Chemistry

Table 7 lists the average values for pH, total dissolved solids (TDS) and suspended sediment. pH values were average for New Mexico surface waters. The San Jose had a slightly higher average pH than the Puerco. The pH of the Puerco where it enters the Rio Grande is about the same as that of the Rio Grande (2). TDS increases as the system flows toward the Rio Grande. Part of the increase could be caused by evaporation but much can be attributed to redissolving previously deposited material since calcium and sulfate increase to a greater extent than sodium and chloride (see appendix B). A substantial part of the increase appears between sites 2 and 3 and is probably caused by input from the Rio Paguete which flows through the Jackpile mine. In September 1980 it was announced that this mine was suspending operations although by December 1980 it had not yet suspended operations. Continued monitoring of the San Jose after mining operations cease would show if input was mining related. The TDS of the Rio Puerco at site 5 is about the same as the San Jose at site 4. The TDS of the Rio Puerco at site 7 is 2442 as compared to the average of 360 ppm for the Rio Grande at Bernardo (16). It is obvious from Table 7 that most of the sediment is

TABLE 7
 AVERAGE VALUES FOR pH AND TDS AND SUSPENDED SEDIMENT^a

Site No.	pH	TDS (ppm)	Suspended Sediment g/l
Bluewater	8.06 (2) ^b	254 (2)	0.03 (1)
1	7.88 (2)	662 (2)	3.58 (2)
2	7.51 ± .51 (8)	726 ± 130 (8)	0.356 ± .13 (9)
3	7.95 ± .47 (5)	1595 ± 650 (7)	0.709 ± .816(7)
4	7.99 ± .4 (6)	1422 ± 503 (6)	1.251 ± 1.50 (6)
5	7.46 ± .62 (6)	1470 ± 466 (6)	55.938 ± 11.67 (6)
6	7.58 ± .54 (9)	2315 ± 856 (9)	63.480 ± 27.13 (8)
7	7.54 (3)	2442 (3)	71.40 (2)
8	7.88 (1)	185 (1)	1.06 (1)
9	7.26 (3)	1333 (3)	3.25 (2)
10	6.74 (3)	557 (3)	0 (3)

^a Averages include values from study done in 1978 (19).

^b Standard deviations were not calculated for 3 or less samples

contributed by the Rio Puerco (compare sites 4 and 5). For comparison the average load in the Rio Grande at Bernardo is 2200 ppm (16). For sample trips taken on 1/15/79, 3/19/79, and 6/7/79 the flow rate of the Rio San Jose was only 10% of that of the Rio Puerco (20). Flow rates for later dates are not available yet. The sediment load of the Rio Puerco for these same dates was 131 times greater than the Rio San Jose (Appendix B).

Table 8 lists nutrient and conductivity data. The levels of all nitrogen species and phosphate were elevated at station 9. The reason is unknown. A possibility is effluent from ion exchange plants. Otherwise nutrient levels are normal. The somewhat higher values at station 2 are probably due to sewage discharge from Grants.

CONCLUSIONS

Dissolved metals in the Rio San Jose are not elevated with respect to the Rio Puerco. These values compare closely with those found in the Rio Grande at Bernardo except for Mo and V which are higher in the lower Rio Puerco than recent values for the Rio Grande.

The trace metals As, Cd, Co, Hg, Mo, U, V and Zn show elevated values in suspended sediments in the Rio San Jose. These high values do not carry over into the Rio Puerco suspended sediments, probably because of the extremely high sediment loads in the Rio Puerco.

Analyses of bed-load material do not indicate elevated

TABLE 8

NUTRIENT DATA

<u>Species</u>	9	10	1	2	3	4	5	6	7
Phosphate	6.6 ⁺ -3.1	.07 ⁺ -.08	0.38	2.1 ⁺ -2.4	1.8 ⁺ -1.6	1.3 ⁺ -1.8	2.7 ⁺ -2.8	4.6 ⁺ -3.9	1.7 ⁺ -.5
Nitrite	.02 ⁺ -.01	.7 ⁺ -1.4	0.08 ⁺ -.13	0.06 ⁺ -.07	.02 ⁺ -.02	.02 ⁺ -.03	.02 ⁺ -.03	.15 ⁺ -.36	.05 ⁺ -.04
Nitrate	1.8 ⁺ -2.5	0.02 ⁺ -.08	1.60	0.7 ⁺ -.54	0.21 ⁺ -.27	.17 ⁺ -.26	.91 ⁺ -.7	.34 ⁺ -.31	1.9 ⁺ -2.4
Kjeldahl Nitrogen	2.3 ⁺ -1.0	.54 ⁺ -.75	1.32	5.5 ⁺ -6.4	1.8 ⁺ -2.0	3.6 ⁺ -3.4	2.7 ⁺ -2.1	4.1 ⁺ -1.6	0.38 ⁺ -1.1
Conductivity	1800 ⁺ -690	700 ⁺ -37	730	890 ⁺ -150	1800 ⁺ -420	1400 ⁺ -730	1700 ⁺ -300	1600 ⁺ -700	1700 ⁺ -1500

ALL VALUES ARE IN PPM EXCEPT CONDUCTIVITY WHICH IS IN μ MHOSNITROGEN VALUES AS N, PHOSPHATE VALUES AS PO₄

values except for As, Hg, and U so that most of the excess trace metal transport can be attributed to the smaller sized suspended sediments. Selenium is present primarily as a dissolved species and in the bed-load sediment and does not appear to be transported in the suspended sediments.

Gross alpha counts are elevated only at sites close to active mining and milling operations and do not appear to be carried downstream in the surface water.

Nutrient species are not significantly different at any of the sites and do not appear to be a function of mining and milling activity.

Because of recent increased activity in Rio Puerco drainage upstream from the confluence with the Rio San Jose, suspended sediments in the Rio Puerco should be monitored on a regular basis. Any increase in trace metals will quickly be moved downstream because of the high sediment loads and the tendency of excess trace metals to associate with the suspended sediments.

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APPENDIX A

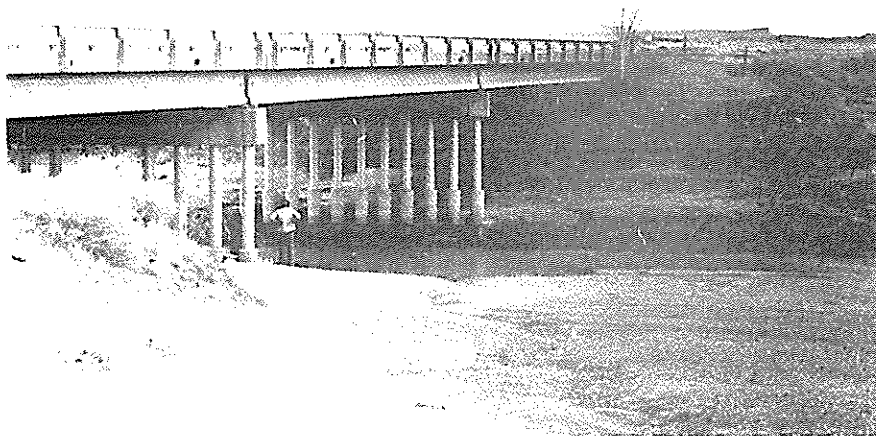
SAMPLING PHOTOGRAPHS



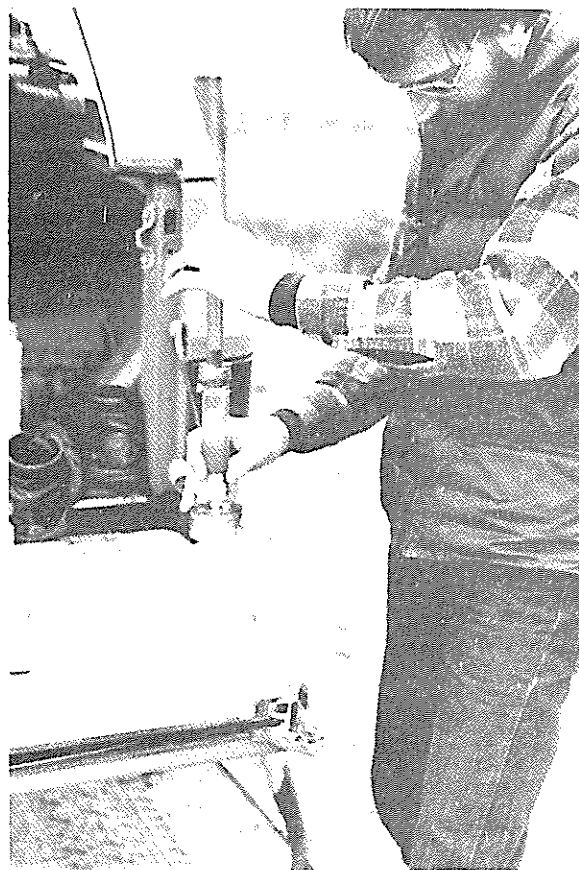
Collecting Surface Sediment Samples



Collecting Core Sediment Samples



Ready to Sample At Site 6



Pressure Filtering Puerco Sample



Pressure Filtering San Jose Sample

APPENDIX B

RAW DATA, AVERAGE AND STANDARD DEVIATIONS

This Appendix is available upon request from the New Mexico Water Resources Research Institute, P.O. Box 3167, NMSU, Las Cruces, NM 88003, for a copy charge of \$7.70.