Circular 162 1978

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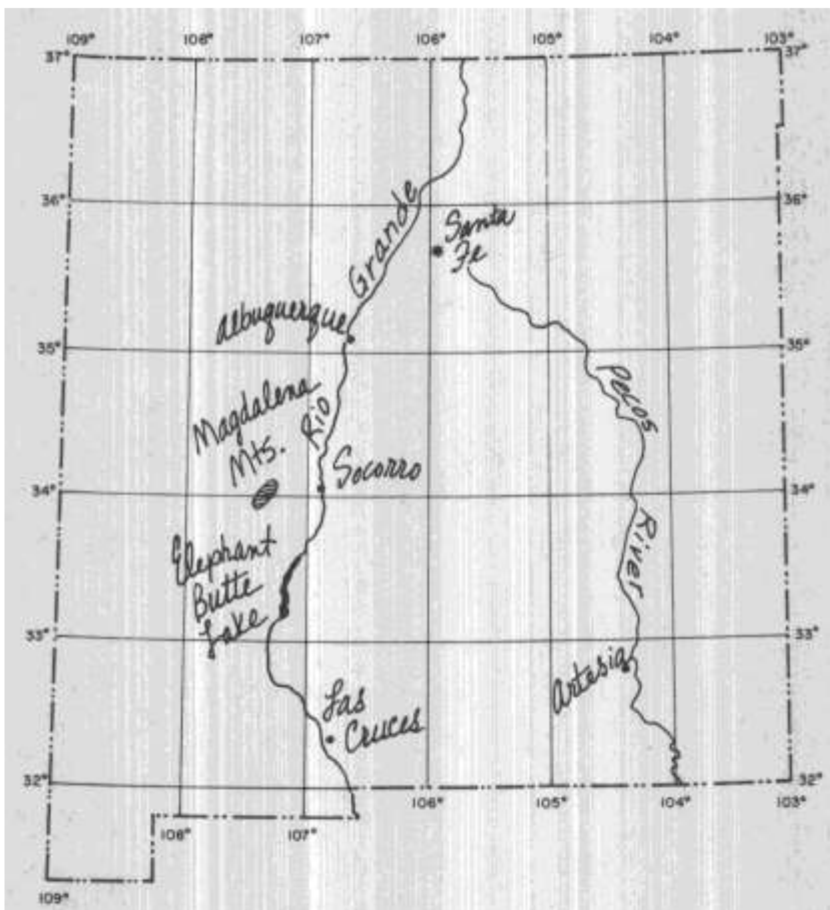
by Lynn A. Brandvold



New Mexico Bureau of Mines & Mineral Resources

A DIVISION OF
NEW MEXICO INSTITUTE OF MINING & TECHNOLOGY

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SOCORRO 1978

First printing, 1978

Published by Authority of State of New Mexico, NMSA 1953 Sec. 63-1-4
Printed by University of New Mexico Printing Plant, December 1978

Available from New Mexico Bureau of Mines & Mineral Resources, Socorro, NM 87801 Price $3.50

Preface

This study should be useful to hydrogeologists, geochemists, biologists, and environmentalists interested in mercury and its occurrence in the waters in New Mexico. When high mercury levels were discovered in fish and lakes in the eastern United States and Canada, no data were available indicating the levels of mercury in New Mexico's waters. This project was begun for the purpose of obtaining these data. The objectives were: 1) to determine if mercury levels were high enough to be a potential problem and, if so, to draw some conclusions about the sources and 2) to determine background mercury levels that might be used in later studies or enforcement actions.

Mercury had not been determined previously in New Mexican waters because of problems in sampling and analysis. Mercury is lost rapidly from solution and must be determined within five days of sampling. To collect samples from remote parts of the state and then to return immediately to the laboratory for analysis would have made this project very expensive; therefore, New Mexico Bureau of Mines and Mineral Resources personnel collected samples on field trips for other Bureau business. Their help is greatly appreciated, particularly that of Roy Foster who collected most of the samples from northeastern New Mexico. Tech students returning from vacations also collected samples, and their help is gratefully acknowledged. The help of George Austin and William Stone in reading the manuscript and their timely suggestions are appreciated. I would also like to thank Aaron Bond, Director of the New Mexico Scientific Laboratories System, State of New Mexico, Department of Health and Social Services, for reviewing the manuscript.

The results of this study indicate some further work that should be done. Samples of water and suspended sediment should be taken at intervals during spring runoff each year for several years along the Rio Grande to confirm the deposition of mercury in Elephant Butte Lake. The sediment in Elephant Butte Lake should be core sampled to a depth of several feet to determine the mercury content with depth. The amount of mercury bound to sediments should also be determined in Navajo Lake, Ute Lake, and Bill Evans Lake. Tissues from various species of fish in the above-mentioned lakes should be resampled to determine their level of mercury.

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Socorro
January 17, 1978

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Abstract

Samples taken from surface waters and a few wells in New Mexico over a 4 1/2-year period were analyzed for mercury content. A total of 151 samples were analyzed by flameless atomic absorption with a detection limit of 0.2 ppb. Mercury was below the detection limit in 46 percent of these samples. Only 12 samples contained 5.0 ppb or more, and all but 2 or possibly 3 appear to have a natural source. Preliminary results suggest that mercury could be building up in the sediments in Elephant Butte Lake.

Introduction

Mercury poisoning in humans has been known since ancient times. Although some mercury compounds are used medicinally, certain other forms of mercury can be fatal. Mercury vapors are toxic, and the methyl and ethyl mercury compounds used in seed dressings are even more toxic. Until recently, inorganic mercury was not considered a health problem, because it is readily excreted in the urine and not absorbed by the body in large amounts.

Mercury poisonings in Japan completely changed the concepts about inorganic mercury. Since the early 1950's over 100 people have died or have been permanently disabled after eating mercury-contaminated fish from Minamata Bay, Japan (Irukayma, 1966). A substantial amount of time elapsed before it was established that the organic compound methyl mercury was the causative agent. Methyl mercury was known to be toxic, but no discharges of this form of mercury had been made to Minamata Bay. The methyl mercury was eventually traced to an industrial discharge containing 20 ppb (parts per billion) inorganic mercury. The inorganic mercury was rapidly converted by microorganisms to methyl mercury (Jensen and Jernelov, 1968; Wood, Kennedy, and Rosen, 1968). The methyl mercury was taken up by small fish and was concentrated up the food chain. The large fish were eaten by the people of Minamata, an action that resulted in death and disability.

This situation did not create any immediate awareness in the United States or Canada of the potential for similar crises on this continent. It wasn't until late 1969 that fish in the Saskatchewan River were analyzed and found to contain up to 10 ppm (parts per million) mercury (Bligh, 1972). Commercial fishing was immediately banned in the river. Subsequent analyses showed that fish from Cedar Lake, Lake Winnipeg, Lake St. Clair, parts of Lake Erie, Lake Huron, Lake Ontario, and from most of the St. Lawrence River were contaminated with mercury. Both private and commercial fishing was prohibited in most of these areas. Further investigation traced the source of mercury to chlor-alkali plants utilizing mercury cells and to mercury slimicides used in the pulp and paper industry (Fimreite, 1970). These industries are now regulated by very strict effluent regulations, and the pulp and paper industries have discontinued use of mercury slimicides.

The mercury problem is not easily solved, however. When mercury is discharged into a river or lake there is no appreciable uptake by aquatic plants, and most of it settles to the bottom. Bottom organisms cause the gradual release of mercury into the water as organic mercury compounds; it then may enter the food chain and be ingested directly by fish. Although the effluents no longer contain mercury, there continues to be a mobilization problem.

As late as the early 1970's the levels of mercury in New Mexico's surface waters were unknown. Because of the state's low population density and lack of highly industrialized areas, the possibilities of man-made mercury contamination are few. Commercial deposits of mercury are not known in New Mexico, although occurrences are reported in the Ladron and Magdalena Mountains (Northrop, 1959). Mercury occasionally occurs with silver, gold, lead, zinc, and copper—all mined in New Mexico. Mercury also occurs in the parts-per-billion range in New Mexico coals. This mercury could be released into the atmosphere by smelters and coal-burning power plants and washed by rain into rivers and reservoirs. New Mexico has two smelters, in the Silver City area, and two coal-burning power plants, in the Farmington area. Agriculture is another potential source of man-made mercury contamination. In the past, fungicides containing methyl mercury have been applied to seeds and crops. This mercury would show up in areas of irrigated agriculture.

Mercury is a naturally occurring element and could be expected to be found in any environment. The naturally occurring levels are important; presumably life has evolved to tolerate these levels. Knowledge of these natural levels is necessary before action can be taken against anyone or any company for mercury pollution.

Depending on the amounts of other ions present, the solubility of elemental mercury in water at 25 °C and atmospheric pressure is about 25 ppb and could be expected to control the amount of mercury in natural waters. However, this calculation neglects the effects of inorganic or organic complexes and the removal of mercury from the aqueous system by biota and by precipitation. Because the actual measured natural levels of soluble mercury are low, these mechanisms appear to be responsible for maintaining the low levels. Fig. 1 (appendix) is a simplified and partial diagram of the various forms of mercury in natural environments. Mercury exists in two basic forms, organic and inorganic. These forms may be soluble, absorbed, or insoluble. In trace amounts, methyl mercury is the only really dangerous form of mercury in water. However, because all forms of mercury can be converted to methyl mercury, all forms are potentially dangerous.

The National Interim Primary Drinking Water Standards are set at 2 ppb mercury as the maximum contaminant level in drinking water (Federal Register, 1975). This maximum contaminant level is for public-health reasons and is a direct result of the Federal Safe Drinking Water Act of 1974. Surface water in New Mexico is not generally used for drinking water; therefore, mercury in surface waters would not be a drinking-water concern. Nonetheless, mercury in surface waters is a concern because of possible concentration up the food chain. The level at which mercury begins to be concentrated is unknown. In Japan, a discharge of as little as 20 ppb became concentrated up the food chain to fish that were highly toxic when ingested by humans. When insufficient data are available, public-health officials usually insert a safety factor of about 10 so that a limit of 2 ppb mercury would be imposed on fishable waters. Thus, waters that contain 2 ppb or more mercury fall into a questionable-to-dangerous category. This limit is for total mercury, inorganic and organic, because all forms can be methylated by bacteria. To protect aquatic organisms, the National Academy of Sciences (1972) recommends a maximum total mercury concentration in unfiltered water of 0.2 ppb; therefore, concentrations above 0.2 ppb mercury are questionable.

Only recently have mercury concentrations in the parts-per-billion range been quantitatively detectable on a routine basis. This is due to the development of the flameless atomic absorption method of analysis (Hatch and Ott, 1968). By this method mercury is reduced to the elemental state with stannous chloride and aerated from solution in a closed system; elemental mercury is more soluble in air than in water. The mercury vapor passes through a quartz absorption cell of an atomic absorption spectrophotometer where its concentration is measured. Organic forms of mercury are not detected by this method, because they are not reduced by stannous chloride. Organic forms must first be oxidized and converted to mercuric ions. The EPA (Environmental Protection Agency) method for mercury (U.S. Environmental Protection Agency, 1971) includes a pre-oxidation step with permanganate and persulfate to include detection of organic mercury.

Methods

No effort was made to collect samples from a specific number of predetermined sites; New Mexico Bureau of Mines and Mineral Resources personnel collected samples whenever possible during their field trips. For this reason, the sampling procedure was kept as simple as possible. This sampling method is also the reason why the project extended over such a long period of time.

When feasible, liquid samples were taken just under the surface in the middle of the body of water or from a spot where the water appeared to be well mixed. Most samples were not filtered and so the data represent dissolved and suspended amounts except where noted. In table 1 (appendix), mercury is listed as total mercury, and this total does not include mercury associated with nonsuspended sediments or biota. Those samples indicated as filtered were filtered in the field through 0.45 micron paper. The filter papers containing the residues were placed in plastic bags for later analysis of the residues.

Many investigators have reported the loss of mercuric ions from dilute solution (Chau and Saitoh, 1970; Omang, 1971; Coyne and Collins, 1972; Rosain and Wai, 1973; Feldman, 1974). In order to avoid the loss of mercuric ions in the time between sampling and analysis, the sample preservation method of Coyne and Collins (1972) described below was used. Also as recommended by Coyne and Collins, all mercury determinations were completed within five days of sampling.

Samples were collected in 130 ml glass bottles fitted with caps that had Teflon liners. The bottles, with caps in place, were rinsed with 10 ml HNO_3, then with three successive portions of 25 ml of distilled water. Just before a sampling trip, 2 ml of nitric acid was added to each bottle, and the bottle was capped. In the field, 100 ml of water was measured with a polyethylene graduate cylinder, added to the uncapped bottle, and the bottle was recapped. Filtered samples were handled the same way after filtration. The filter papers and residues were dissolved in aqua regia in sealed Teflon-lined bombs and then analyzed for mercury. Duplicate samples were taken whenever possible.

In the laboratory, the following procedure, a modification of the EPA method (U.S. Environmental Protection Agency, 1971), was used. The sample bottles were uncapped; 5 ml of concentrated sulfuric acid, 1 ml of 5-percent w/v (weight to volume) potassium permanganate, and 2 ml of 5-percent w/v potassium persulfate were added. Each bottle was capped and mixed by shaking. The bottles were placed in a 90°C water bath for two hours. Duplicate reagent blanks containing 100 ml of distilled deionized water were also prepared. The botties were removed from the bath and allowed to come to room temperature. After this stage, each sample was carried through the procedure individually. A 10-percent w/v solution of hydroxylamine-hydrochloride was added dropwise to the sample until the purple permanganate color disappeared. The sample was then transferred to the aeration flask. The same flask was used for each sample and rinsed with 3-25 ml portions of distilled-deionized water between each sample. Then 5 ml of 10-percent w/v stannous chloride in 20-percent w/v hydrochloric acid solution was added. The flask was transferred to the aeration apparatus described by the EPA, and the procedure was completed as described. The aeration apparatus was used in connection with a Perkin-Elmer Model 303 atomic absorption unit equipped with a DCR-1 concentration readout. Following this procedure, our detection limit was determined to be 0.2 ppb.

Results

Table 1 lists the mercury data obtained. The condition of the water or the actual silt value is included where available. Part of the data obtained for the Rio Grande (samples 79-90) includes results for both dissolved and suspended mercury. Although almost all of the samples are from surface waters, several well samples (samples 34, 38, 74, 78, 127, 128, and 129) were analyzed because the samples were available.

For clarification, the data have been divided into three groups: samples that contained no detectable mercury (less than 0.2 ppb), samples that contained mercury between 0.2 and 2.0 ppb, and samples that contained mercury above 2.0 ppb. These data, along with the locations, are shown on the color-keyed map (fig. 3, appendix).

Discussion

The total number of samples collected and analyzed was 151. In 90 samples, mercury could not be detected. Forty-five samples contained between 0.2 and 2.0 ppb mercury. Most of the samples (87 percent) contained little or no mercury. Of those samples that contained over 2.0 ppb mercury (26 percent), 12 contained 5.0 ppb or more. Of the well samples, only sample 78 contained a significant amount of mercury.

Magdalena Mountains area

Several of the samples containing high concentrations of mercury were taken from the Magdalena Mountains area in south-central New Mexico (fig. 2, appendix). The Magdalena Mountains area is highly mineralized; the mineralization occurs in Paleozoic limestones and Tertiary volcanic rocks or in veins and dikes cutting these units. Mercury occurs sometimes with copper, zinc, silver, gold, and lead, all of which have been mined in this area, along with manganese, tungsten, barium, and vanadium. Occurrences of mercury have been reported in the Magdalena Mountains (Northrop, 1959).

One of the samples, containing 5.0 ppb mercury, was taken from the stream in Copper Canyon during the spring runoff (fig. 2; sample 1). Because of the remote location and the mineralization in the area, the source of mercury is probably natural. The stream does not have any fish in it, is not a source of drinking water, and should not cause any concern. This finding is of interest because the unusually high level of mercury is apparently natural.

Two other samples with high levels of mercury were taken from the tailings ponds of a company mining lead and zinc (fig. 2; samples 76 and 77). These tailings ponds were not lined. The ponds were sampled in January 1974; the company ceased operations in the early spring of 1976, and the ponds dried up. About 3/4 mi down gradient from the site of these ponds is the old Magdalena municipal well. The well, no longer used by the city, is 150 ft deep with a water depth of 54 ft. The water from this well (sample 78) contained 3.8 ppb mercury in 1974. In November 1976 the well water was resampled (sample 127) and contained 0.2 ppb mercury. The mercury originally found probably came from the tailings ponds.

Slightly up gradient and about 1 mi east of the tailings ponds site is Pony Spring, a drainage from an old mine. This spring feeds a cattle watering trough directly and could only be sampled from the trough. This water was murky and had algae growing in it. The water from this spring (sample 75) contained 2.1 ppb mercury. This mercury could not have come there by moving through the ground water from the tailings ponds, because the spring is up gradient from the ponds. The mercury could have been a natural level, or it could have come from mining dust falling on the pond. Slightly down gradient and about 1/2 mi west of the municipal well is the Pearson Ranch well. This well is 150 ft deep with a water level at 50 ft. The water from this well (sample 74) contained no detectable mercury. These wells, along with another well and spring in the area, were resampled on November 24, 1976, almost three years after the first sampling. The tailings ponds had been dried up for five or six months, so they were not resampled. This time none of the wells or springs showed any detectable mercury, except for Pony Spring, which contained 0.2 ppb (samples 125, 126, 128, and 129). The mining activities probably were responsible for the mercury that was found earlier in the area, although the possibility of mercury moving in spikes in the ground water should not be ruled out.

Artesia area

Another high mercury value (sample 43) was found in water from the Pecos River, east of Artesia. Other samples taken from the Pecos River at various times did not show mercury values of over 5.0 ppb, although several were over 2.0 ppb. Artesia discharges its sewage into the Pecos River near where sample 43 was obtained, and so this could have been the source of mercury. This area would not currently be a source of mercury because the federal government now regulates the discharge; this was not true when the sample was taken. It is also possible that the mercury is leached into the surface water from ground-water sources. Several water wells in the Artesia, Roswell, and Carlsbad areas exceed 2.0 ppb mercury (New Mexico Water Quality Control Commission, 1976).

Rio Grande area

All of the other high mercury values were noted along the Rio Grande (samples 64, 69, 81, 82, 83, 85, 86, and 87). Of these samples, six were taken at approximately the same time and were filtered so that there are values for both the filtrate and residue. Very little mercury was found in the water itself, but relatively high mercury was found in the suspended sediments during the spring sampling. No mercury was detected in samples taken at the same places during the summer or winter. Above Espanola no mercury was detected, and below Espanola the mercury level in the suspended sediment remained high until Elephant Butte Dam. This appears to indicate more than one source of mercury, because the mercury level in the sediments was consistently high until Elephant Butte Dam, where the sediments settled out of the water. The sources of mercury appear to be natural. The mercury could be entering from the Chama, Red River, and Rio Puerco systems as well as from other tributaries. Using flow data obtained from the U.S.G.S. for the day the samples were taken (686 cfs at San Marcial) and the amount of mercury in the sample taken at San Marcial (14.8 mg/1), approximately 800 g of mercury were dumped into Elephant Butte Lake on that day. This calculation assumes a constant flow rate and a constant homogeneous amount of mercury on the suspended matter. Both of these assumptions are open to question, but this calculation does give one an approximation to consider. The day samples were taken could have been a rather unusual day or it could represent what happens during the spring runoff every day. If the latter is true, high amounts of mercury could be building up in the sediments in Elephant Butte Lake. The Cochiti Dam, recently built across the Rio Grande at Cochiti, should be expected to reduce this suspected mercury; however, the dam will not reduce the mercury completely, and a buildup would then begin here.

During June 1971 the New Mexico Environmental Improvement Agency (NMEIA) collected fish from various surface waters in the state and had them analyzed for mercury (White, personal communication, 1977). In Navajo, Ute, and Bill Evans Lakes, some of the collected fish were found to contain mercury over the mercury toleration limit set by the FDA (Food and Drug Administration). At that time, the NMEIA recommended that an individual not eat more than two pounds of fish per week from these lakes. Fish from Elephant Butte Lake contained less mercury than the FDA toleration limit.

It is difficult to compare the above data with the total mercury in these waters as determined for this report, because the fish data were obtained in 1971 and the water data from 1972 to 1976. This report found mercury in the water above the recommended limit in Ute Lake and Elephant Butte Lake, but not in Navajo Lake or Bill Evans Lake. The mercury level in the fish should be rechecked in these lakes, and the amount of mercury bound to the sediments in these lakes should be determined.

Conclusions

Minute amounts of mercury occur in many surface waters in New Mexico. The mercury that is present appears to have a natural source-not unexpected because New Mexico has a low population density and little industry. Two or perhaps three samples containing more than 5.0 ppb mercury appear to have a man-induced source. Two of these samples were taken from mining company tailings ponds, which have since dried up. The third sample was taken from the Pecos River near Artesia, and the mercury may have come from the city sewage discharge. If the mercury was from the discharge it would no longer be causing a problem because of strict EPA effluent limitations. This area should be resampled and reassayed.

Mercury could be building up in the sediments in Elephant Butte Lake and also above Cochiti Dam. If mercury is building up in the sediments it could also be building up in the biota. On the other hand, if the mercury at Elephant Butte Lake has been deposited there over many years, an equilibrium condition may have been established between the top layer of sediments and the aquatic environment, with mercury in the biota remaining at a constant level. Further investigation is required to determine if harmful levels of mercury are building up in this particular environment. The amount of mercury bound to sediments should also be determined in Navajo Lake, Ute Lake, and Bill Evans Lake.

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Appendix

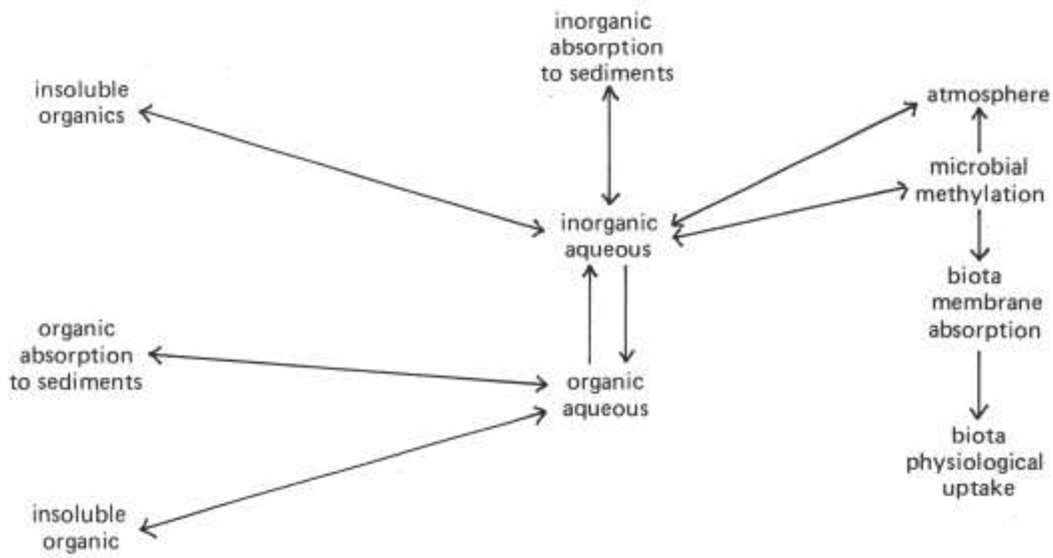

FIGURE 1—Simplified, partial pathway of mercury in natural environment.

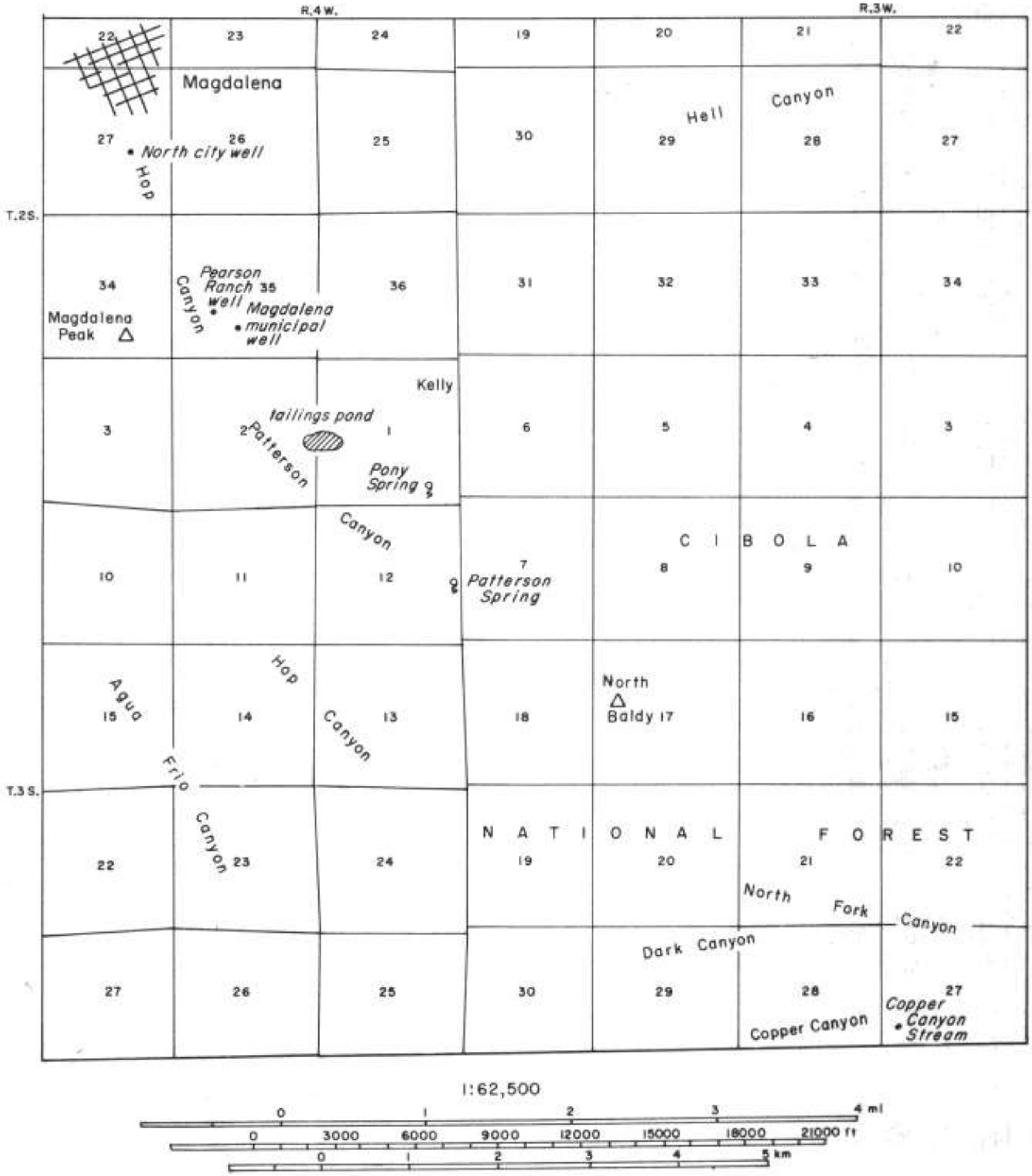

FIGURE 2—Sites sampled in Magdalena Mountains area.

TABLE 1—TOTAL MERCURY IN NEW MEXICO SURFACE-WATER SAMPLES AND SOME SELECTED WELL SAMPLES.

Sample number	County	Sample	Location	Collection date	Water condition	Total mercury in ppb
1	Socorro	Copper Canyon	3S-3W-27.310	5/17/72	clear	5.0
2	Socorro	Water Canyon	3S-3W-26.140	5/17/72	clear	<0.2
3	Socorro	Hop Canyon	2S-4W-2.210	5/17/72	fairly clear	<0.2
4	Socorro	North Fork, Water Canyon	3S-3W-27.120	5/17/72	clear	<0.2
5	Socorro	Rock Spring Canyon	3S-4W-26.310	5/17/72	clear	<0.2
6	Socorro	Rio Salado, above Riley	2N-4W-23.100	5/17/72	clear	<0.2
7	Socorro	La Jara Spring	2N-5W-15.300	5/17/72	clear	<0.2
8	Socorro	Bear Spring	1N-4W-33.000	5/17/72	clear	<0.2
9	Socorro	Jaralosa Creek	2N-6W-1.100	5/17/72	clear	<0.2
10	Socorro	Abbe Spring	1N-5W-8.441	5/17/72	clear	<0.2
11	San Miguel	Sapello Creek	bridge over creek NM-266	7/24/72	muddy	2.3
12	Mora	Coyote Creek	4 mi N of Guadalupita-Coyote Creek State Park	7/24/72	clear	1.9
13	Mora	Murphy Lake	W of Sedoux	7/24/72	fairly clear	2.0
14	Taos	Rio Pueblo-1	22N-12E-1.000 jct. NM-3 & NM-75	7/24/72	clear	1.8
15	Taos	Rio Pueblo-2	21N-14E-5.000 1.5 mi SE of Angostura	7/24/72	clear	2.2
16	Harding	Chicosa Lake	21N-26E-22.000	7/25/72	fairly clear	3.3
17	Harding	Canadian River	bridge NM-120 20N-24E-35.000	7/25/72	muddy	2.0
18	Union	Carrizozo Creek	bridge NM-18 31N-37E-32.000	7/26/72	muddy	<0.2
19	Union	Dry Cimarron River	bridge NM-325 32N-34E-36.000	7/26/72	muddy	2.0
20	Colfax	Chicorica Creek	31N-24E-3.000	7/27/72	fairly clear	2.0
21	Colfax	Lake Maloya	32N-24E-27.000	7/27/72	fairly clear	<0.2
22	Colfax	Vermejo River	½ mi S of Dawson; W side of railroad bridge	7/27/72	muddy	0.5
23	Colfax	Ponil Creek	2 mi NW of Chase Ranch	7/27/72	muddy	2.5
24	Colfax	Cimarron River	Palisades picnic area US-64	7/27/72	clear	2.5
25	Taos	Red River	4 mi S of jct. with NM-38	7/27/72	clear	0.5
26	Union	Clayton Lake	boat ramp, SE side of lake 27N-34E-15.000	7/28/72	murky	2.4
27	Quay	Ute Lake	boat ramp-N side of lake 13N-33E-20.000	7/28/72	murky	3.0
28	San Juan	Morgan Lake	28N-15W	9/1/72		3.0
29	San Juan	Hogback-San Juan River	29N-16W-8.000	9/1/72		<0.2
30	San Juan	La Plata	30N-13W-32.000	9/1/72		0.8
31	San Juan	Animas River	30N-12W-32.000	9/1/72		0.8
32	San Juan	San Juan River at Bloomfield	29N-11W-27.140	9/1/72		1.1
33	San Juan	Navajo Reservoir	30N-7W	9/1/72		<0.2
33a	San Juan	Navajo Reservoir	30N-7W	7/9/76		<0.2
34	Colfax	Road Canyon well	31N-19E	9/10/72		<0.2
35	Colfax	York Canyon	31N-19E	9/10/72		1.4
36	Rio Arriba	Cajete Creek	21N-1E	9/12/72		1.0
37	Sandoval	Señorita Creek	20N-1W-11.000	9/12/72		1.0
38	Socorro	Bosque del Apache ground-water	6S-1W	3/15/73 5/16/73		0.5 1.0
39	Socorro	Rio Grande main ditch Bosque	6S-1E	3/15/73 5/16/73		0.6 1.3
40	Socorro	diversion ditch through Bosque	6S-1W	3/15/73 5/16/73		0.6 1.5
41	Eddy	Pecos River	US-31, NE of Loving 23S-28E-14.120	12/26/73		0.2
42	Eddy	Lake McMillan Spillway	20S-25E-2.440 US-82	12/26/73		1.4
43	Eddy	Pecos River, E of Artesia	17S-26E-18.110	12/26/73		7.4
44	Chaves	Pecos River, 2 mi E of Lake Arthur	15S-26E-23.000	12/26/73		0.7
45	Chaves	Pecos River, bridge E of Hagerman	14S-25E-7.000	12/26/73		<0.2
46	Chaves	Pecos River, bridge E of Dexter	13S-26E-14.000	12/26/73		<0.2
47	Chaves	Pecos River, bridge E of Roswell	10S-25E-34.000	12/26/73		1.0
48	Chaves	Pecos River, Bob Crosby Bridge	US-70 8S-25E-30.000	12/26/73		0.6
49	Chaves	Lea Lake, Bottomless Lakes	11S-25E	12/26/73		<0.2
50	Chaves	Devils Inkwell-Bottomless Lakes	11S-25E	12/26/73		0.3
51	Chaves	Britt Lake-Bottomless Lake	11S-25E	12/26/73		0.6
52	Lincoln	Government Springs	W of Lincoln 9S-16E	12/28/73		0.3

TABLE 1—(Continued)

Sample number	County	Sample	Location	Collection date	Water condition		Total mercury in ppb
53	Doña Ana	Rio Grande	above El Paso 29S-3E	1/14/74	murky		3.0
54	Doña Ana	Rio Grande	W of Mesquite 25S-2E	1/14/74	murky		<0.2
55	Doña Ana	Rio Grande	W of Las Cruces 23S-1W	1/14/74	murky		1.4
56	Doña Ana	Rio Grande	N of Las Cruces 21S-1W	1/14/74	murky		1.2
57	Doña Ana	Rio Grande	Hatch 19S-3W	1/14/74	murky		2.8
58	Sierra	Caballo Lake	16S-5W	1/14/74	murky		1.1
59	Sierra	neck of Caballo Lake	14S-4W	1/14/74	murky		1.1
60	Sierra	Caballo Lake	boat launch 14S-4W	1/14/74	murky		1.0
61	Sierra	Los Palomas River	at Palomas 14S-5W	1/14/74	murky		0.6
62	Sierra	Elephant Butte Dam	13S-3W	1/13/74	murky		1.0
63	Sierra	Elephant Butte Lake-middle	12S-3W	1/13/74	murky		1.9
64	Sierra	Elephant Butte Lake-head	10S-3W	1/13/74	murky		5.0
65	Socorro	Rio Grande at Tiffany	7S-1W	1/13/74	murky		1.1
66	Socorro	Rio Grande at San Antonio	4S-1E	1/13/74	murky		0.4
67	Socorro	Socorro sewage plant effluent	3S-1E	1/13/74	muddy		1.2
68	Socorro	Main Ditch-Rio Grande	Socorro 3S-1E	1/13/74	muddy		2.9
69	Socorro	Rio Grande at La Joya	2N-1E	1/15/74	murky		5.2
70	Valencia	Rio Grande at Belen	5N-2E	1/15/74	murky		0.9
71	Bernalillo	Rio Grande at Isleta	6N-2E	1/15/74	murky		0.9
72	Bernalillo	Rio Grande at Bernalillo	13N-4E	1/15/74	murky		<0.2
73	Sandoval	Peña Blanca	16N-5E	1/15/74	murky		0.3
74	Socorro	Pearson Ranch well	N of Magdalena 3S-4W	1/22/74	clear		<0.2
75	Socorro	Pony Spring	3S-4W	1/22/74			2.1
76	Socorro	lower tailings pond United Nuclear mine	N of Magdalena 3S-4W	1/22/74			6.7
77	Socorro	upper tailings pond United Nuclear mine	N of Magdalena 3S-4W	1/22/74			5.7
78	Socorro	Magdalena old municipal well	3S-4W	1/22/74			3.8
					Silt (grams/liter)	Filtrate (ppb)	Residue (micrograms/liter)
79	Taos	Rio Grande at Cerro	29N-12E	5/17/75	3.04	<0.2	<0.2
				7/28/75	0.24	<0.2	<0.2
				1/15/76	0.06	<0.2	<0.2
80	Taos	Rio Grande at Arroyo Hondo	27N-12E	5/17/75	1.08	<0.2	<0.2
				7/28/75	0.20	<0.2	<0.2
				1/15/76	0.03	<0.2	<0.2
81	Santa Fe	Rio Grande at Española	20N-8E	5/17/75	2.00	<0.2	8.0
				7/28/75	0.33	<0.2	<0.2
				1/15/76	0.64	<0.2	<0.2
82	Sandoval	Rio Grande at Bernalillo	13N-4E	5/17/75	1.40	0.6	8.0
				7/28/75	0.54	2.6	<0.2
				1/15/76	0.27	<0.2	<0.2
83	Bernalillo	Rio Grande at Isleta	6N-2E	5/17/75	1.40	0.6	14.0
				7/28/75	0.31	<0.2	<0.2
				1/15/76	0.18	<0.2	<0.2
84	Socorro	Rio Grande at Bernardo	2N-1E	5/17/75	0.40	<0.2	<0.2
				7/28/75	0.43	<0.2	<0.2
				1/15/76	2.04	<0.2	<0.2
85	Socorro	Rio Grande at Escondida	2S-1W	5/17/75	2.20	<0.2	13.0
				7/28/75	3.75	<0.2	<0.2
				1/15/76	0.46	<0.2	<0.2
86	Socorro	Rio Grande at San Antonio	4S-1E	5/17/75	2.20	<0.2	12.0
				7/28/75	1.04	<0.2	<0.2
				1/15/76	0.60	<0.2	<0.2
87	Socorro	Rio Grande at San Marcial	7S-2W	5/17/75	2.70	1.8	13.0
				7/28/75	0.62	<0.2	<0.2
				1/15/76	0.04	<0.2	<0.2
88	Sierra	Rio Grande at Caballo State Park	15S-5W	5/17/75	0.60	<0.2	<0.2
				7/28/75	0.25	<0.2	<0.2
				1/15/76	0.09	<0.2	<0.2
89	Doña Ana	Rio Grande at Radium Springs	21S-1W	5/17/75	0.80	<0.2	<0.2
				7/28/75	0.47	<0.2	<0.2
				1/15/76	0.9	<0.2	<0.2
90	Doña Ana	Rio Grande at Anthony	26S-3E	5/17/75	1.20	<0.2	<0.2
				7/28/75	1.92	<0.2	<0.2
				1/15/76	0.06	<0.2	<0.2
91	Eddy	Red Bluff Lake	26S-29E-3	6/11/76			<0.2
92	Eddy	Malaga Bend	24S-28E-2	6/11/76			<0.2
93	Eddy	Black River	24S-27E-2	6/11/76			<0.2
94	Eddy	Carlsbad Beach	22S-27E-1	6/11/76			<0.2
95	Eddy	Boiling Spring	20S-26E-4	6/11/76			<0.2

TABLE 1—(Continued)

Sample number	County	Sample	Location	Collection date	Water condition	Total mercury in ppb
96	Otero	Peñasco River	16S-16E-2	6/12/76		<0.2
97	Otero	Elk Silver	15S-14E-1	6/12/76		<0.2
98	Otero	Inn of the Mountain Gods Lake	11S-11E-2	6/12/76		<0.2
99	Lincoln	Ruidoso River	10S-15E-3	6/12/76		<0.2
100	Lincoln	Benito Lake	10S-13E-1	6/12/76		<0.2
101	Lincoln	Rio Hondo at Lincoln	9S-16E-4	6/12/76		<0.2
102	Sandoval	Bridge at Jemez Canyon	14N-3E	6/24/76		<0.2
103	Sandoval	Jemez River in Jemez Springs	18N-2E	6/24/76		<0.2
104	Sandoval	Diversion Channel of Jemez River	15N-2E	6/24/76		<0.2
105	Rio Arriba	Chama River at Chama	31N-3E	7/ 9/76		<0.2
106	Rio Arriba	Navajo Lake	22N-7W	7/ 9/76		<0.2
107	Rio Arriba	El Vado Lake	28N-2E	7/ 9/76		<0.2
108	Rio Arriba	Abiquiu Lake	24N-4E	7/ 9/76		<0.2
109	Grant	Lake Roberts	15S-13W	7/ 9/76	murky	<0.2
110	Grant	Bill Evans Lake	16S-17W	7/10/76	clear	<0.2
111	Grant	San Francisco River	7S-19W	7/10/76	clear	<0.2
112	Grant	Gila River	15S-17W	7/10/76	clear	<0.2
113	Grant	Snow Lake	10S-16W	7/10/76	clear	<0.2
114	Grant	Willow Creek	10S-17W	7/10/76	very clear	<0.2
115	Grant	Wall Lake	11S-12W	7/11/76	clear	<0.2
116	Grant	Iron Creek	11S-16W	7/11/76	clear	<0.2
117	Colfax	Vermejo River	27N-20E	8/3/76		<0.2
118	Colfax	Webster Lake	26N-19E	8/3/76		<0.2
119	Mora	Mora River	below Mora 20N-15E	8/3/76		<0.2
120	San Miguel	Storrie Lake	17N-16E	8/3/76		<0.2
121	Colfax	Eagle Nest Lake	26N-16E	8/3/76		<0.2
122	Colfax	Cimmeroncito Reservoir	26N-18E	8/3/76		<0.2
123	Colfax	Cimmeron River	25N-22E	8/3/76		<0.2
124	Colfax	Ponil Creek	27N-19E at Ponil Camp	8/3/76		<0.2
125	Socorro	Pony Spring	3S-4W	11/24/76	murky	0.2
126	Socorro	Patterson Mine Spring	3S-4W	11/24/76	clear	<0.2
127	Socorro	south Magdalena city well (old municipal well)	3S-4W	11/24/75	clear	<0.2
128	Socorro	north Magdalena city well	3S-4W	11/24/76	clear	<0.2
129	Socorro	Pearson Ranch well	3S-4W	11/24/76	clear	<0.2

Typefaces: Text in 10-pt. English Times, leaded two points
References in 8-pt. English Times, leaded two points Display heads in 24-pt. English Times bold

Presswork: Miehle Single Color Offset
Harris Single Color Offset

Binding: Saddle stitch

Paper: Cover on 80 lb. Teton Blue
Text on 60 lb. White Offset
Maps, in pocket, on 60 lb. Moistrite opaque

Ink: Cover—PMS 877
Text—Black

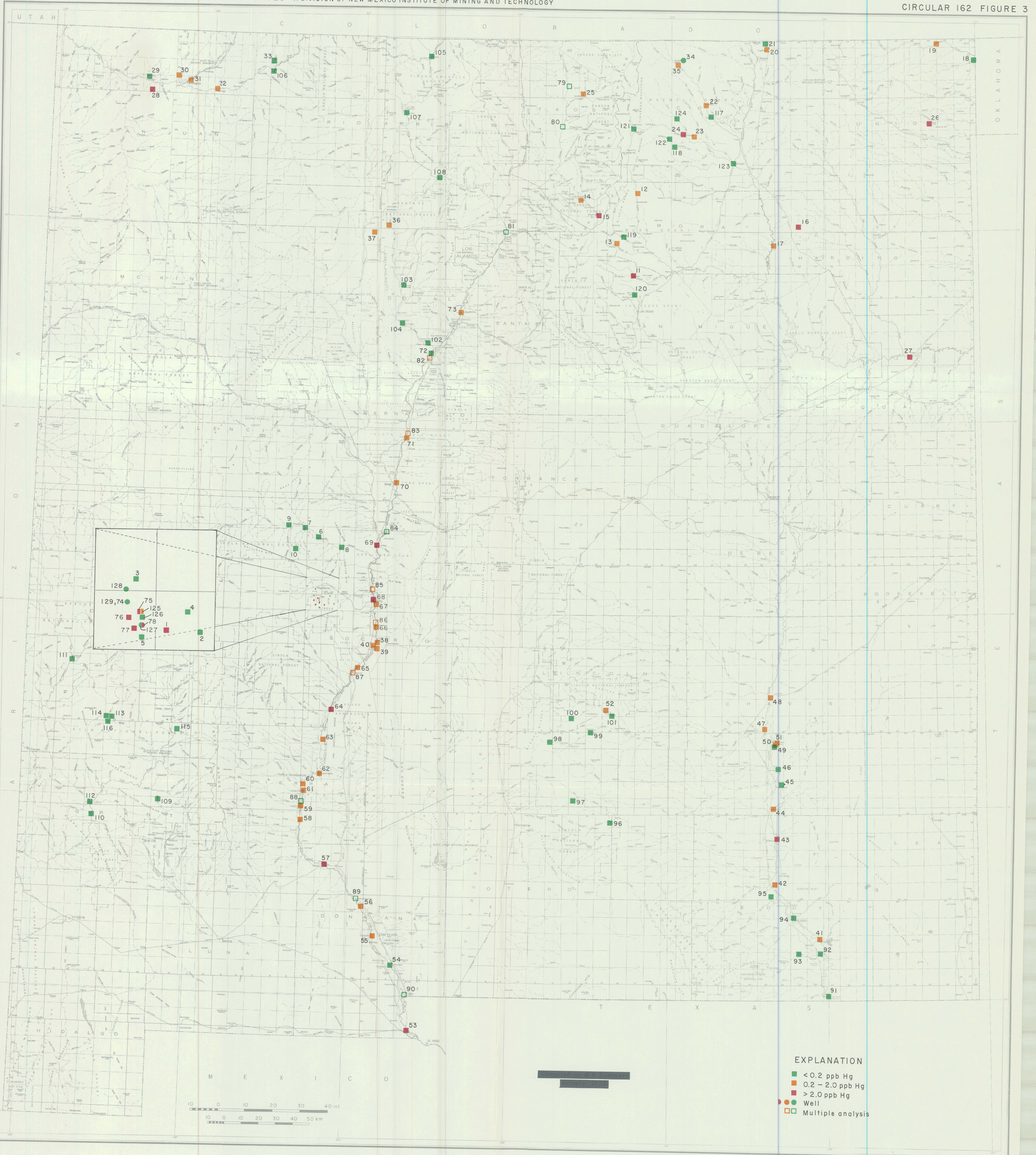

FIGURE 3—SITES SAMPLED AND APPROXIMATE LEVELS OF TOTAL MERCURY IN NEW MEXICO WATERS