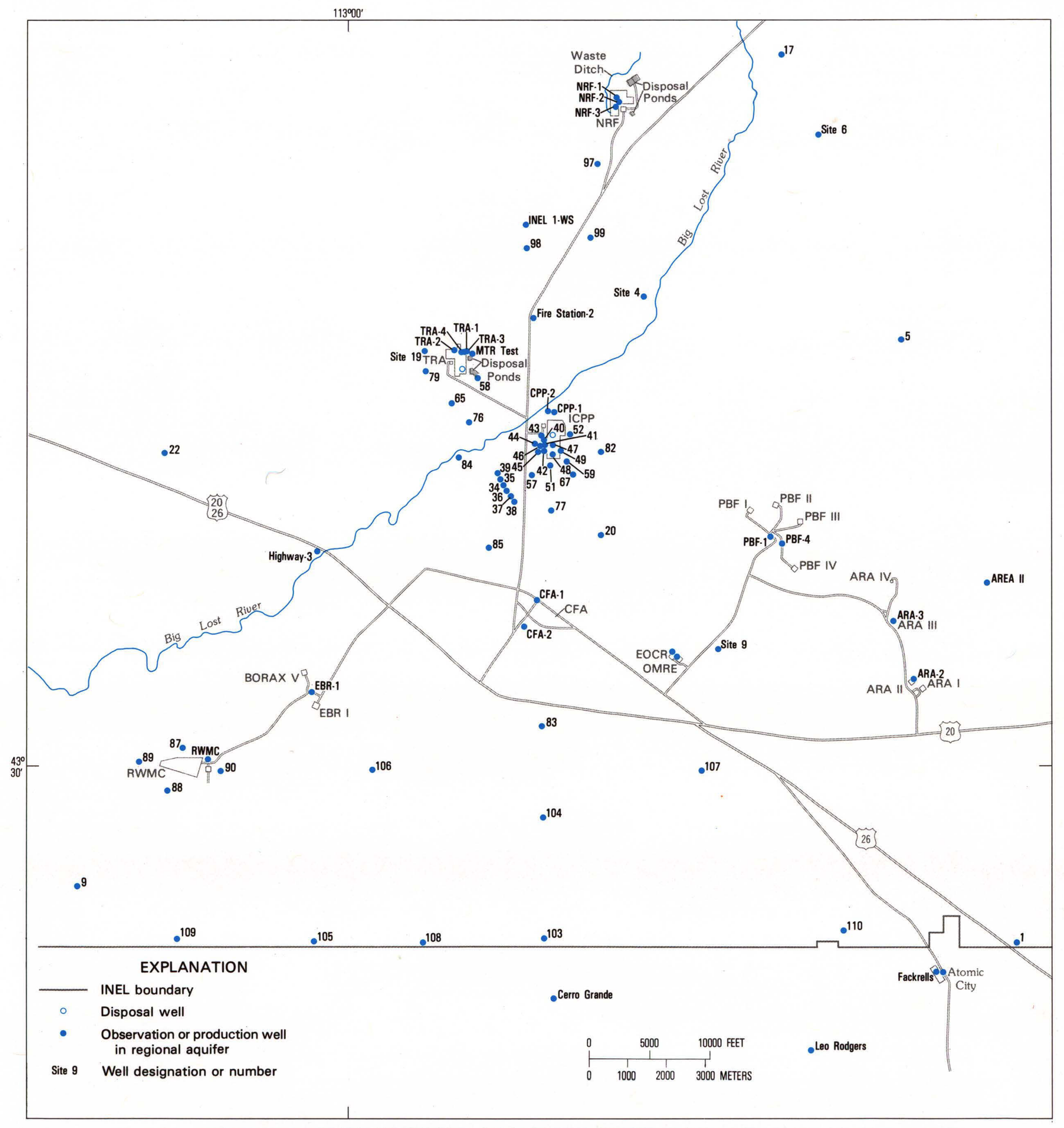

Figure 27.—LOCATION OF OBSERVATION WELLS COMPLETED IN THE SNAKE RIVER PLAIN AQUIFER, WASTE-DISPOSAL WELLS AND RADIOACTIVE-WASTE-DISPOSAL PONDS IN THE SOUTHCENTRAL INEL VICINITY

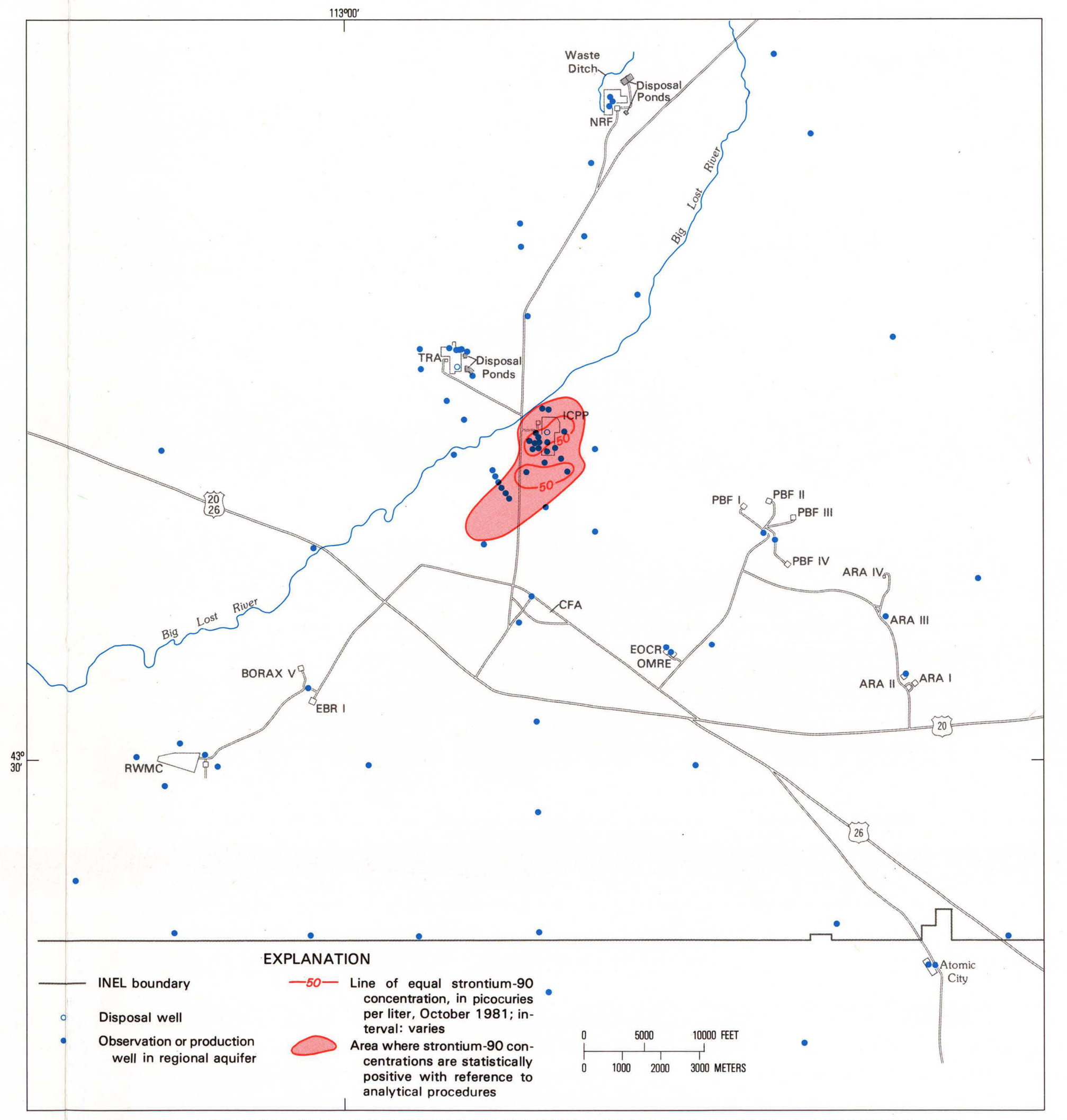

Figure 29.—DISTRIBUTION OF STRONTIUM-90 IN THE SNAKE RIVER PLAIN AQUIFER, SOUTHCENTRAL INEL VICINITY, OCTOBER 1981

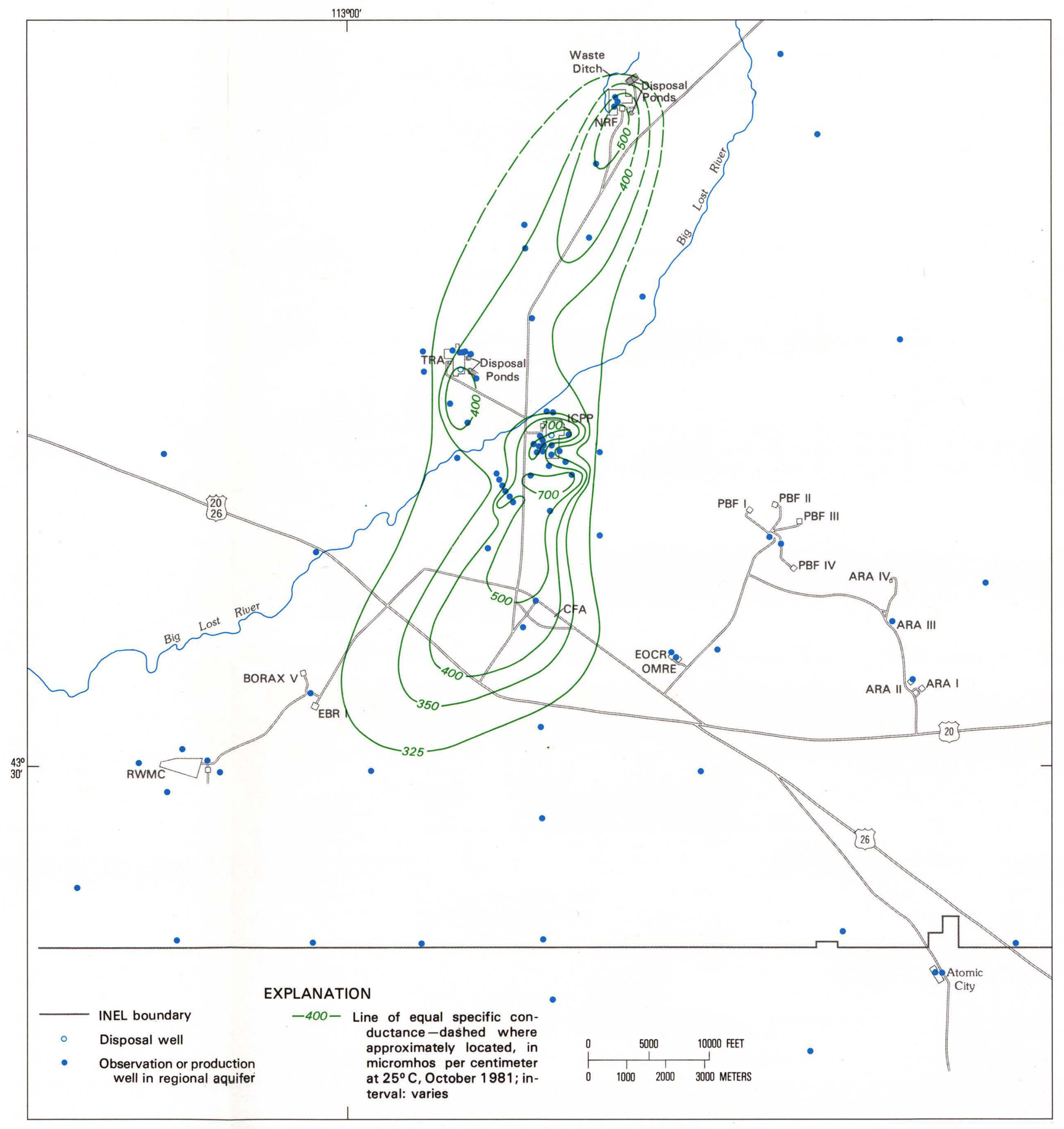

Figure 31.—SPECIFIC CONDUCTANCE OF WATER SAMPLES FROM THE SNAKE RIVER PLAIN AQUIFER, SOUTH-CENTRAL INEL VICINITY, OCTOBER 1981

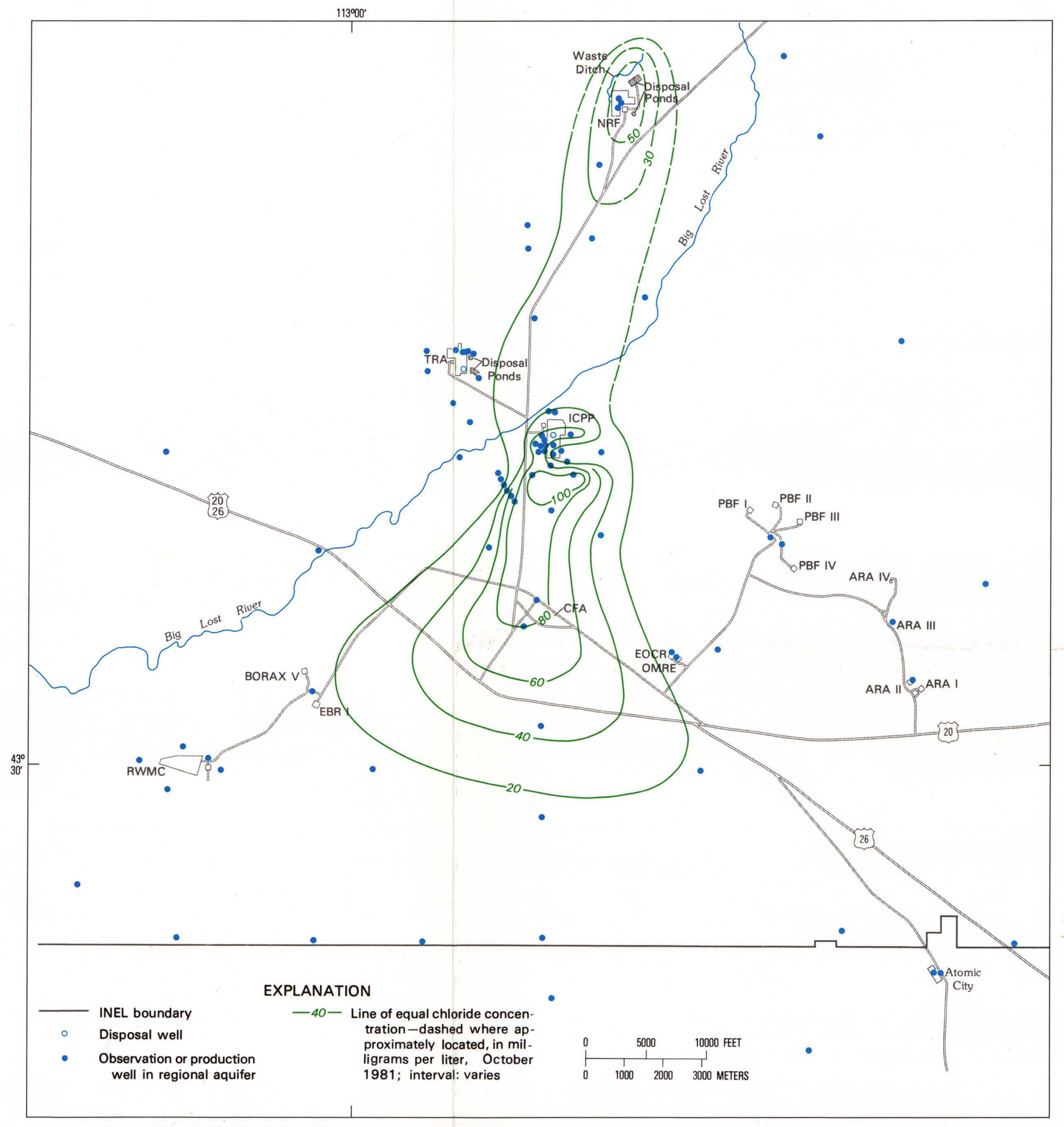

Figure 33.—DISTRIBUTION OF WASTE CHLORIDE IN THE SNAKE RIVER PLAIN AQUIFER, SOUTHCENTRAL INEL VICINITY, OCTOBER 1981

CONSTITUENTS IN SNAKE RIVER PLAIN AQUIFER

The distribution of the principal radioactive and nonradioactive waste in the Snake River Plain aquifer is discussed and illustrated in the following section, and waste product concentrations are compared and contrasted, where applicable, to the natural quality of water in the regional aquifer. Olmsted (1962) stated that the natural quality of water in the Snake River Plain aquifer in the INEL area could be divided into two general categories: 1) a calcium, magnesium, bicarbonate, and carbonate dominated water underlying the western part of the INEL reflects the abundance of these constituents from the recharge areas north and west of the INEL, which are mainly composed of limestone and dolomite; and 2) whereas a similar type of water underlies the eastern part of the site, it contains greater percentages of sodium and potassium, indicating that recharge to this part of the aquifer originates in the mountains north and northeast of the INEL, an area predominantly composed of silicic volcanic rocks. Analyses of water samples collected from the regional aquifer, in areas not affected by waste disposal, show that these type characterizations are correct (Lewis and Goldstein, 1982).

The waste plumes south of ICPP have similar configurations and show corresponding decreasing concentrations downgradient from the waste discharge well. The waste plumes south of the TRA are not as well defined because of gaps in well coverage and because of dilution by recharge from the nearby Big Lost River. The lateral extents and dates of depiction are listed in table 1 for the detectable radiochemical and nonradiochemical waste plumes.

Table 1.—*Constituent or property depicted in waste plumes in the Snake River Plain aquifer in the south central INEL vicinity*

Constituent or property depicted	Date	Lateral waste migration, distance, in miles, from ICPP	TRA	NRF	Area of waste plume, in square miles
Tritium (H-3)	October 1981	7.6	7.9	0	42.1
Strontium-90	—Do—	2.1	0	0	2.0
Iodine-129	—Do—	6.2	0	0	9.5
Specific conductance	—Do—	5.5	6.1	11.2	27.6
Sodium	—Do—	3.6	—	—	7.9
Chloride	—Do—	5.3	0	10.6	26.2
Nitrate	October - December 1981	4.8	0	0	10.1

Figure 27 shows the areal location of observation wells completed in the regional aquifer, TRA disposal ponds, ICPP disposal well, NRF disposal areas, various facilities, and other geographical features in the south central INEL vicinity.

Tritium

The disposal of tritium at the ICPP has been monitored since December 1961 (fig. 13). During the past twenty years, a total of about 8,370 Ci of tritium has been discharged at the ICPP and reaches the Snake River Plain aquifer directly through the deep disposal well or indirectly, prior to 1967, by percolation of a small part of the tritiated water discharged to a waste disposal pit. This represents an average disposal rate of about 418 Ci per year. However, from 1979 through 1981, the rate of tritium disposal of 230 Ci per year was considerably less than the overall average. This injection into the regional aquifer of waste water plus the simultaneous percolation of waste water from the perched ground-water zone underlying the TRA has resulted in a large, dispersed plume of tritium in the regional ground-water system (fig. 28).

The October 1981 waste plume (fig. 28) illustrates the wide lateral dispersion and the preferred southward flow. The waste plume covers about 42 mi^2. The highest tritium values were found around the ICPP disposal well, south of the ICPP, and south of the disposal ponds at the TRA. Concentrations of tritium in water from the regional aquifer ranged from less than 0.4 to 156 pCi/mL in October 1981 (fig. 28). Tritium has migrated about 7.6 miles downgradient from the disposal well and 7.9 miles from the ponds since disposal began. The arrival of tritium at the Radioactive Waste Management Complex (RWMC) was first detected in 1975. The apparent velocity of tritium migration, based on first arrivals, from either the TRA radioactive waste ponds or the ICPP disposal well ranges from 4 to 5 feet per day since the beginning of disposal operations in 1952 and 1953.

The October 1981 tritium plume, illustrated by figure 28, is closely similar to a plume depicted by Lewis and Goldstein (1982) for October 1980. The highest tritium values are again found south of the ICPP and south of the disposal ponds at the TRA. However, concentrations south of the TRA ponds have decreased markedly during the past year and result from the continued lower-than-average discharge to the ponds during recent years (fig. 12). Conversely, the magnitude of concentration contours has increased slightly and the contours themselves have migrated downgradient slightly from the ICPP during the past year and may be resultant from the major increase of ICPP tritium disposal during 1981 over the previous few years (fig. 13).

Cobalt-60

As noted in a previous section, cobalt-60 is discharged to the radioactive-waste ponds at the TRA and detectable concentrations are present in the basalt perched aquifer underlying the TRA ponds. During the years prior to the 1979-1981 period of record, no cobalt-60 was detected in samples of water taken from wells which tap the Snake River Plain aquifer (Barraclough and Jensen, 1976; Barraclough, Lewis, and Jensen, 1981). However, during the past three years, several water samples taken from well 65, located about one-half mile downgradient from the TRA radioactive-waste ponds (see fig. 27 for location), have contained minor concentrations of cobalt-60. For example, a well 65 water sample collected in October 1981 contained 21.9 pCi/L of cobalt-60. These positive results indicate that after nearly 30 years of disposal to the radioactive-waste ponds, minor concentrations of cobalt-60 have percolated from the basalt perched aquifer to the Snake River Plain aquifer. However, with the continued decline of cobalt-60 discharge to the ponds which has occurred over the past three years, abatement of this percolative process will surely follow and quantities of cobalt-60 in well 65 water samples, taken from the Snake River Plain aquifer, will be increasingly more difficult to detect.

Very low concentrations of cobalt-60 are disposed of through the deep well at the ICPP, but to date no water samples taken in the immediate area from the regional aquifer, except for well 65, have contained detectable amounts of the radioisotope.

Strontium-90

A total of about 21 Ci of strontium-90 has been discharged to the ICPP well from 1952 through 1981. This is an average of about 0.7 Ci of strontium-90 per year. The current discharge of strontium-90 is somewhat less. For example, in 1979 a total of 0.43 Ci was discharged to the ICPP well, whereas in 1981 a total of 0.21 Ci of strontium-90 was discharged to the ICPP well. From 1979 through 1981, a total of 1.0 Ci of strontium-90 was discharged to the ICPP disposal well—an average of 0.33 Ci per year.

Figure 29 shows the distribution of strontium-90 in the Snake River Plain aquifer in October 1981. The strontium-90 plume covers about 2.0 mi^2 and has been detected less than 3 miles southwest of the disposal well at the ICPP. The overall size of the plume has decreased slightly from an April 1978 depiction made by Barraclough, Lewis, and Jensen (1981), but the strontium-90 concentrations within the plume have remained nearly the same. It appears that the decreased strontium-90 discharge for the past several years, coupled with the isotope's relatively long half-life of 28.6 years, causes a dynamic equilibrium within the regional-aquifer system. Size of the plume will change directly with discharge changes and radioactive decay will slowly tend to decrease the plume's size.

Iodine-129

An estimated 0.16 to 0.78 Ci of iodine-129 has been disposed of through the ICPP well from startup in 1952 through 1977 (Cordes, written commun., 1978). This is an average of about 0.01 to 0.03 Ci of iodine-129 discharged per year. Actual monitoring of iodine-129 radioactivity in waste water was begun in May 1976 (Barraclough, Lewis, and Jensen, 1981). In 1977, a total of 0.02 Ci was discharged to the ICPP well, and in 1978, 0.14 Ci of iodine-129 was discharged to the well. These two years of documented discharge show that 1977, was within the estimated average discharge range, but during 1978, discharge was significantly greater than this approximated average. This discharge variance may be simply due to different operating procedures at the ICPP and may not indicate an actual increase in the discharge rate. For example, many of the waste producing components of the ICPP facility were not operating for much of 1977. During the next three-year period, iodine-129 discharge was reduced to about 0.04 Ci per year, which illustrates again the variations in waste discharge due to plant operations.

Concentrations of iodine-129 in sampled well water in October 1981 ranged from 0.05 to 41 pCi/L for statistically positive values (fig. 30) and are high near the ICPP disposal well. Iodine-129 has migrated about 6.3 miles from the ICPP disposal well since discharge began in 1953, and it will remain in a small portion of the aquifer for years to come because of its very long half-life of about 16.4 million years.

The size of the plume depicted for October 1981 in figure 30 is significantly larger than one shown by Barraclough, Lewis, and Jensen (1981) for April 1977. As just noted, the amount of iodine-129 disposal through the ICPP well has been near a normal average for the past three years, and plume size should not have changed appreciably during that time period. However, the minimum concentration shown on the April 1977 depiction is 0.9 pCi/L (Barraclough, Lewis, and Jensen, 1981), and the comparable concentration for October 1981 is 0.05 pCi/L (fig. 30). The sample size was one liter during the 1977 sampling program and four liters during the 1981 program. The sample size was increased to four liters to increase the sensitivity of the analyses four-fold. Also, during the past three or four years, the analytical procedures employed in determining the iodine-129 concentrations in water samples have been refined and are much more sensitive. The ultimate result is that much lower concentrations of iodine-129 are detectable than was possible in the past, and the increased size of the waste plume is primarily due to this increased sensitivity.

Generally, iodine-129 concentrations shown inside comparable parts of the two plumes have varied very little. Notable exceptions are analyses of samples from wells nearest the disposal well. The October 1981 plume (fig. 30) shows that the iodine-129 concentrations in samples from several of these "easily" waste-affected wells is much lower than those shown by Barraclough, Lewis, and Jensen (1981) for April 1977. This unexpected occurrence is not presently understood but may, in part, be due to sampling that followed several months of little or no iodine-129 disposal. Subsequent sampling programs should help to explain this situation.

Cesium-137

About 22 Ci of cesium-137 (similar to the quantity of strontium-90) has been discharged to the ICPP disposal well since disposal began. However, it is sorbed more readily than strontium-90 and is detectable in only a few wells in the immediate area of the ICPP disposal well. Well 40 contains water with the highest concentration of cesium-137, about 170 pCi/L for October 1981; and wells 43, 44, and 47 (see fig. 27 for well locations) contain water with considerably smaller concentrations—most on an order of magnitude lower than that in well 40. Therefore, after 30 years of disposal, detectable quantities of cesium-137 have migrated a maximum of about 1,800 feet from the ICPP disposal well. Cesium-137 has not been detected in any water samples from the regional aquifer near the TRA.

Plutonium Isotopes

Monitoring of plutonium-238 and of plutonium-239, -240 (undivided) radionuclides being disposed through the ICPP disposal well began in 1974. Prior to that time, they were not separable in the undifferentiated alpha activity which was measured. From 1974 through 1981, a total of about 0.13 Ci of plutonium-238 and 0.05 Ci of plutonium-239, -240 was discharged through the well. This represents a respective average discharge of 0.016 Ci per year and 0.006 Ci per year. Plutonium was disposed in waste water which contained an average concentration of 0.012 pCi/mL of plutonium-238 and 0.005 pCi/mL of plutonium-239, -240. The decay rates of plutonium-238, plutonium-239, and plutonium-240 are 89 years, 24,360 years, and 6,600 years, respectively. This indicates that very small but detectable amounts of plutonium-239, -240 may remain in part of the regional aquifer for years to come regardless of future disposal practices.

Three consecutive monthly samples were taken from ground water in well 47 (fig. 27), located 740 feet south of the ICPP disposal well, from October through December of 1975 to evaluate the effects on the Snake River Plain aquifer of the disposal of wastes containing isotopes of plutonium. Several other wells were sampled, but well 47 was the only one which contained statistically positive concentrations of the plutonium isotopes. Analysis of these samples determined that the concentration of the plutonium isotopes in the regional ground water is very low. The mean concentration of plutonium-238 in the three samples from well 47 was 6.5 X 10^{-6} pCi/mL, and the mean value for plutonium-239, -240 was 2.4 X 10^{-6} pCi/mL. These concentrations are approximately one to two million times lower than the Federal and State of Idaho concentration guides for unrestricted discharge (Polzer, Percival, and Barraclough, 1976). The concentrations of plutonium-238 and plutonium-239, -240 in the observation well samples are also several orders of magnitude lower than those for the same nuclides in the waste water being discharged through the disposal well. This concentration reduction over a relatively short distance is an indication of dilution, dispersion, and more importantly, retardation of the soluble radioisotopes by sorption. Samples from well 47 were also analyzed for americium-241, but it was not detected. This is not an unexpected result because americium-241 has not been detected in water discharged through the ICPP disposal well.

During the summer of 1980, another study was made which determined the possibility of detectable amounts of the plutonium isotopes in wells 37, 40, 43, and 67 (see fig. 27 for well locations). This study determined that the plutonium concentrations in all well waters were very low, being statistically above the detection limit of 10 X 10^{-6} pCi/mL only in water from well 40 (Cleveland and Rees, 1982) and, in this well, only the plutonium-238 isotope was detected. Three consecutive samples of well 40 water contained an average concentration of about 66 X 10^{-6} pCi/mL of plutonium-238. When compared to the previous three-month discharge rate of the radioisotope through the discharge well of about 1,037 X 10^{-6} pCi/mL, the plutonium-238 concentration between the disposal well and well 40, located about 700 feet downgradient, is reduced by a factor of approximately sixteen (Cleveland and Rees, 1982). Therefore, this study also illustrates the effects of dilution, dispersion, and sorption on the soluble radioisotope over a short lateral distance.

Detectable quantities of certain plutonium isotopes were also present in water samples taken from well 90 near the RWMC (see fig. 27), but measurements thus far have been inconsistent. For example, samples collected during April 1981 contained detectable amounts of americium-241 and plutonium-238 that were determined to be about 2.0 X 10^{-4} and 1.1 X 10^{-4} pCi/mL, respectively; but an October 1981 sample contained only a detectable quantity of americium-241, which was measured at about 1.4 X 10^{-4} pCi/mL. Three quarterly samples prior to 1981 did not contain statistically positive amounts of any plutonium isotope. The source of the plutonium isotopes occasionally present in water from well 90 has not yet been determined, but may be due to downward migration of waste from the Radioactive Waste Management Complex (RWMC) or to introduction into the sample during the collection and analytical procedures.

Specific Conductance

Chemical wastes are also discharged to the ICPP disposal well. From 1979 through 1981, these wastes contained, on an annual average, about 397,000 lbs of sodium, 875,000 lbs of chloride, 140,000 lbs of sulfate, and 288,000 lbs of nitrate. The waste ditch and waste-disposal ponds at the NRF are also used to discharge chemical wastes. From 1979 through 1981, the NRF wastes contained an annual average of about 168,000 lbs of sodium, 228,000 lbs of chloride, 366,000 lbs of sulfate, and 4,000 lbs of phosphate. These chemical wastes increase the mineral content and, therefore, the specific conductance of the regional ground water. The specific conductance of ground water in the Snake River Plain aquifer containing no waste water generally ranges from 300 to 325 μmho/cm (at 25° C) in the ICPP-TRA area (Robertson, Schoen, and Barraclough, 1974).

Waste water disposed through the ICPP disposal well, seepage from the TRA chemical-waste disposal ponds, and seepage from the NRF waste ditch and waste-disposal ponds have increased the specific conductance of the regional ground water significantly (fig. 31). The specific conductance plume extends south of CFA in this southern part and is similar to a plume for October 1980 shown by Lewis and Goldstein (1982). The October 1981 plume (fig. 31), however, includes a much greater area to the north of the TRA and ICPP that is a direct result of chemical-waste disposal during the past several years at the NRF and lack of recharge dilution.

During the past three years, water samples taken from the observation and production wells located between the NRF and TRA-ICPP vicinity have shown increasingly greater specific conductance values. It appears that this part of the regional aquifer is also affected by waste migration from disposal points and, therefore, must be included in the October 1981 plume (fig. 31). This restructuring of the plume with high specific conductance values has increased the affected area of the Snake River Plain aquifer to nearly 27.6 mi^2.

Two wells penetrating the regional aquifer immediately downgradient from the RWMC also exhibit slightly higher-than-background specific conductance values. Wells 88 and 89 contain water with specific conductances of 380 and 350 μmho/cm, respectively. The cause for this anomaly is not presently known, but may result from naturally high specific conductance values that reflect normal aquifer conditions and are not affected by waste disposal. Robertson, Schoen, and Barraclough (1974) noted, however, that the dissolved solids (mineral content) of the ground water under the RWMC area, prior to INEL operations, was actually lower than the aquifer's average value. Another possibility is that part of the waste material stored at the ground surface of the RWMC has become mobilized, has been transported through the unsaturated zone, and has reached the underlying aquifer. Barraclough, Robertson, and Janzer (1976) discussed the migration of radioactive waste to the aquifer in the RWMC area and indicated that under normal climatological conditions, little migration would take place; during a significant hydrologic event, such as flooding, however, a mobilizing agent would be available and migration could take place.

A final possibility is that the analyzed water sample is not representative of aquifer conditions. The sampled wells in question are pumped at a low rate of about 2 gpm. During completion of the wells, pressure-cementing techniques were used to preclude the possibility of contaminants entering the sampled well water from other-than-aquifer sources. The chemical makeup of cement used could be affecting the specific conductance values of water samples collected from these wells. Subsequent sampling of these wells by an increased pumping rate to ensure a proper and reliable connection with the aquifer will determine whether or not any of these causes are verifiable.

Sodium

The rate of discharge of sodium to the ICPP disposal well has been rather uniform over the years. The average concentration of sodium in the waste water is about 103 mg/L. The background or normal concentration of sodium in water from the Snake River Plain aquifer is from 8 to 10 mg/L. Figure 32 shows the concentration of sodium in well water and the area covered by the ICPP waste plume in October 1981. Average concentrations are similar to those published for September 1977 by Barraclough, Lewis, and Jensen, (1981), but the overall size of the waste plume has decreased slightly since that time. This may in part be due to the fact that the average concentration of sodium in effluent waste water of 88 mg/L from 1974 through 1976 is 14 percent lower than the average concentration (102 mg/L) over the entire period of record. The present configuration of the waste plume's outer boundary may be presently affected by this low disposal concentration, but the interior contours in the plume have increased and have migrated downgradient. This relationship is likely due to an increased disposal concentration over the past few years; for example, the 1979 through 1981 average annual disposal concentration was about 112 mg/L, and the part of the plume closest the disposal well will exhibit more readily the influence of more recent disposal practices.

The effects of sorption, ion exchange, or other chemical reactions on the migration of sodium are shown by figure 32. As noted earlier, a large amount of sodium is discharged to the chemical-waste disposal ponds at the TRA, and the waste ditch at the NRF was used during the subject three-year period which resulted in an average disposal concentration of about 176 mg/L. However, as waste water migrates downward towards the Snake River Plain aquifer from the TRA and NRF disposal areas, most of the sodium is apparently removed by the above mentioned chemical reactions. Therefore, an aquifer area affected by disposal at these facilities is very difficult to depict (fig. 32).

The regional ground water directly underlying and immediately downgradient from the RWMC again contains higher-than-background concentrations of sodium. Wells 87, 88, and 89 contain water with sodium concentrations of 20, 52, and 20 mg/L, respectively. The possible causes for the anomaly may be the same as those listed in the previous section on specific conductance. In the case of sodium, however, the affected aquifer area is somewhat larger. The work done by Robertson, Schoen, and Barraclough (1974) showed that the RWMC is located near two areas that exhibited anomalously high sodium concentrations prior to waste-disposal practices at the INEL. Coupled with the possibilities of not obtaining a representative sample by the thief-sampling method, pumping at low rates, and minor contributions from other artificial sources, a more comprehensive data base may have better delineated a naturally anomalous distribution of sodium in the underlying regional aquifer.

Total Chromium

As stated previously, chromium was discharged directly to the Snake River Plain aquifer via the TRA deep disposal well from 1964 to 1972. Since 1972, a different corrosion inhibiting process has been employed which utilizes no chromium compound. Chromium has also been discharged to the TRA radioactive waste ponds in the past and is present in the underlying perched ground water in the basalt. The total chromium content of the regional ground water was augmented by the direct disposal of waste water prior to 1972 and by percolation from the overlying perched zone. Well 65, located approximately 1,500 feet south of the TRA facility (fig. 27), is the only well which taps the regional aquifer that contained water with statistically positive total chromium concentrations for the period 1979 through 1981. Quarterly samples of water from well 65 during the latest period of record contained an average total chromium concentration of about 0.39 mg/L, and the values show little variance.

Chloride

The average concentration of waste chloride disposed through the ICPP well from 1979 through 1981 was 238 mg/L and the average concentration discharged to the NRF waste ditch was about 219 mg/L for the same three-year period. The background, or normal, concentration of chloride in the Snake River Plain aquifer in the south central INEL vicinity is usually between 8 and 15 mg/L. As a matter of interest, the Idaho Drinking Water Standards (1977) set the secondary quality standard for chloride concentration of drinking water at 250 mg/L. This concentration limit is based primarily on taste.

Figure 33 shows the distribution of waste chloride in the Snake River Plain aquifer in October 1981. The highest chloride values are found around the ICPP disposal well and south of the ICPP, with slightly higher-than-background concentrations being present near and immediately downgradient from the NRF and RWMC facilities. The chloride concentrations in water taken from wells near and south of the ICPP are similar to those depicted for September 1977 by Barraclough, Lewis, and Jensen (1981). Chloride concentrations in well water nearest the disposal well have, however, increased since that time and are probably due to an increasing amount of chloride disposed during the past several years. For example, from 1971 through 1973, an average of 386,000 lbs of chloride per year was discharged (Barraclough and Jensen, 1976); whereas, during the period 1974 through 1978, the average yearly discharge was 548,000 lbs (Barraclough, Lewis, and Jensen, 1981); and during the period 1979 through 1981, the average yearly discharge again increased to 875,000 lbs. This part of the October 1981 waste chloride plume is also similar to the figure depicted for October 1980 by Lewis and Goldstein (1982), but the concentration contours nearest the ICPP disposal well have migrated downgradient and include more area in the later figure. This also illustrates the effects of higher disposal amounts through the ICPP well.

The chloride disposed of at the NRF has increased the chloride concentration of the regional ground water to a point where the area between the NRF and ICPP must now be included with the plume created by disposal at the ICPP (fig. 33). The inclusion of the aquifer area affected by chloride disposal at the NRF has increased the overall size of the waste plume to about 26.2 mi^2. The plume may become two separate entities, a small one near the NRF and another larger one near and south of the ICPP, in the future because chloride disposal at the NRF has decreased significantly for each of the past few years. Recharge from the Big Lost River, which has been non-existent for the past several years, could dilute the chloride concentration in that part of the aquifer being recharged as it is located directly under the river and between the two facilities (fig. 33).

The aquifer area underlying and immediately downgradient from the RWMC also appears to contain waste chloride—which may be the result of the same three circumstances as listed in the specific conductance section. Wells 87, 88, and 89 contain water with chloride concentrations of 26, 66, and 44 mg/L, respectively. Chloride concentrations, as were noted for sodium concentrations, may be anomalously high background levels and not reflect artificial sources. The RWMC is situated over a part of the aquifer that lies between two anomalous aquifer areas which contained very high natural chloride concentrations (Robertson, Schoen, and Barraclough, 1974) and, with more comprehensive well coverage, could have been denoted as an area of similar nature. Well completion pressure cementing practices, may also influence the chloride concentration in sampled water. Proper well development, by pumping would determine the viability of this latter supposition.

Sulfate

The average concentration of sulfate in the waste water disposed through the ICPP well from 1979 through 1981 was about 39 mg/L and amounted to a yearly average of about 140,000 lbs. At the TRA deep disposal well, the yearly average concentration of the sulfate disposed was 218 mg/L for the entire three-year period, which amounted to a yearly average of about 492,000 lbs. At the NRF, an annual average sulfate concentration of 358 mg/L was discharged to the waste ditch and amounted to about 366,000 lbs per year. The background concentration of sulfate in the Snake River Plain aquifer is less than about 20 to 30 mg/L in the south central INEL vicinity. A sulfate waste plume was not mapped because the only water samples above the normal level are adjacent to and immediately south of the ICPP disposal well and south of the TRA deep disposal well (see fig. 27). The area south of the TRA is the largest area affected, with a measured value slightly above normal being recorded 1.3 miles from the facility. This small plume is a result of waste sulfate disposed through the deep well and of recharge from the overlying perched aquifer in the basalt. Apparently, the large amount and high concentration of sulfate discharge to the NRF waste ditch is negated by sorption and other chemical reactions as the waste water percolates through the unsaturated zone toward the regional aquifer because sampled wells downgradient from the NRF contain no sulfate concentration significantly above background levels.

Nitrate

Waste water containing nitrate has been disposed through the ICPP well since 1952, but 1973 was the first year in which the concentration in waste water was reported. During that year, the average waste nitrate concentration entering the Snake River Plain aquifer was 39 mg/L (calculated as NO_3), and over the next five years this average increased slightly to 40 mg/L, but it increased to 47 mg/L in 1977 and to 80 mg/L during 1978 (Barraclough, Lewis, and Jensen, 1981). The higher discharge rate was sustained over the next three years, 1979 through 1981, at an annual average of about 83 mg/L. This latter discharge rate amounts to about 288,000 lbs of nitrate disposal per year through the ICPP well. The normal or background level of nitrate in the regional ground water is generally less than 5 mg/L (Robertson, Schoen, and Barraclough, 1974).

The first recent comprehensive sampling of the observation wells in the regional aquifer for nitrate analyses was completed in January 1979 (Barraclough, Lewis, and Jensen, 1981) and indicated that a large nitrate waste plume existed. The January 1979 waste plume covered an area of about 8.7 mi^2 and was elongated to the south of the ICPP disposal well (Barraclough, Lewis, and Jensen, 1981). A second recent comprehensive sampling program for nitrate analyses was conducted between October and December of 1981. Figure 34 shows the plume revealed by this sampling program and subsequent nitrate analyses. The 1981 plume is similar in shape and in interior nitrate concentrations to the January 1979 depiction shown by Barraclough, Lewis, and Jensen (1981); however, the nitrate plume size has increased to 10.1 mi^2 over the past three years, and the nitrate concentrations in the sampled water from wells nearer the ICPP disposal well have generally increased over the same time period. The expanded plume size and concentration increases are results of the sustained higher nitrate disposal rate.

A notable difference in the figures is the abatement of nitrate concentrations in samples from wells south of the TRA. A small part of the aquifer near the RWMC also contains higher-than-background nitrate concentrations Well 89 contains water with a nitrate concentration of 7.1 mg/L. No nitrate disposal to the TRA disposal ponds or through the facilities' deep disposal well was recorded during 1979 through 1981. Apparently, recharge received from the overlying perched aquifer was not sufficient to sustain the small waste plume present in the regional aquifer as shown by the January 1979 figure (Barraclough, Lewis, and Jensen 1981); dilution, dispersion, and other chemical or physical processes have significantly reduced nitrate concentrations in this small part of the regional aquifer south of the TRA. All of the possible causes noted in the preceding sections for anomalous concentrations of other chemicals, in the aquifer near the RWMC area, could also apply here; but data are insufficient to make a reasonable analysis.

Phosphate

The average concentration of phosphate in the waste water disposed through the TRA disposal well and to the NRF waste ditch from 1979 through 1981 was 4.0 mg/L and 1.3 mg/L (concentrations measured as elemental phosphorous), respectively. In an earlier section of this report on the basalt perched aquifer underlying the TRA, it was noted that this perched water body contained minor concentrations of phosphate. Coupled with the other disposal sites, it was therefore appropriate to analyze the samples collected during the comprehensive October-December 1981 sampling program to determine what, if any, the disposal of low phosphate amounts may have on the chemistry of the regional ground water. The analyses showed that the range of the phosphate concentrations in the ground-water samples was from less than 0.01 to about 0.07 mg/L (measured as elemental phosphorous), with the only discernable pattern being that the higher values were in samples collected from wells nearest the ICPP disposal well—where no phosphate disposal is reported. Dilution, dispersion, sorption, and many other complex chemical reactions within the aquifer appear to be dissipating whatever low concentrations of phosphate may be artificially introduced. Little is known about the natural concentration of phosphate within the Snake River Plain aquifer.

SUMMARY

This atlas describes the continuing effects of the disposal of liquid radioactive and chemical wastes on the quality of the water in the Snake River Plain aquifer at the Idaho National Engineering Laboratory (INEL) with an emphasis on 1979-1981. The report covers the period following that summarized in a report by Robertson, Schoen, and Barraclough (1974), which discussed the influence of waste disposal at the INEL from 1952 to 1970; in a report by Barraclough and Jensen (1976), which summarized the influence of waste disposal from 1971 to 1973; and in a report by Barraclough, Lewis, and Jensen (1981), which discussed the influence of waste disposal from 1974 to 1978 on the water quality of the Snake River Plain aquifer.

The altitude of the regional water table at the INEL ranges from 4,582 feet above the vertical geodetic datum in the north to 4,423 feet in the southwest. The average water-table gradient is about 4 feet per mile to the south-southwest. Within the INEL boundaries, the depth to the regional water table ranges from about 200 feet below land surface in the northeast to more than 1,000 feet in the southeast. The net decline of the water table from July 1972 to July 1981 has ranged from as little as 2 feet near the north boundary of the INEL to more than 10 feet in its central and southern parts.

The Big Lost River brings considerable surface water onto the INEL during wet years. Recharge to the Snake River Plain aquifer from this flow has been significant. The average flow of the Big Lost River below Mackay Reservoir has been about 215,000 acre-feet yearly for the 64 years of recorded discharge. In 1979 the discharge was a below average 202,400 acre-feet; in 1980 the discharge rose to an above-average 249,500 acre-feet; and in 1981 the discharge fell slightly to 240,100 acre-feet. However, little or no flow was recorded at gaging stations on the INEL since 1977.

Recharge from the Big Lost River and other streams, to the north of the INEL, caused the water table in the aquifer to rise to record highs in 1972 over much of the INEL. The water level in one well rose 21.5 feet from 1964 to 1972. This is the largest fluctuation in water level in the Snake River Plain aquifer that has been observed at the INEL. Water levels have declined in many of the observation wells which penetrate the regional aquifer from the record high levels of 1972 to record lows by the end of 1981.

Twenty-five INEL production wells pumped 2.4 billion gallons of water per year from 1979 to 1981, an average of 6.6 million gallons per day. About 60 percent of this pumpage was returned to the aquifer.

The Test Reactor Area (TRA) utilized ponds and a deep well to dispose of about 354 million gallons of dilute waste water per year from 1979 through 1981. Infiltration from the radioactive-waste ponds has formed a large perched-water zone in the underlying basalt. The perched ground-water contains tritium, chromium-51, cobalt-60, strontium-90, and several non-radioactive chemicals. The lateral extent of the perched water body has decreased over the past few years due to decreases in the amount of waste water discharged to the various ponds. The concentrations of the radionuclides in the perched ground water have generally decreased during 1979 through 1981 also due to a reduction in their rates of disposal to the ponds. A notable exception is the tritium concentration which has increased significantly. This increase may be due in part to a slight increase in the overall yearly discharge rate to the ponds but may primarily be due to recharge water being restricted to and contained by a small perched water body.

The Idaho Chemical Processing Plant (ICPP) discharges low-level radioactive waste and chemical waste directly to the Snake River Plain aquifer through a disposal well 600 feet deep. During 1979 to 1981, the well was used to dispose of 697 Ci of radioactivity of which 689 Ci was as tritium (99 percent). The average yearly discharge was about 440 million gallons of waste water.

The Naval Reactors Facility (NRF) utilizes a waste ditch to discharge about 125 million gallons of dilute waste water annually. During 1979 through 1981, the waste ditch was used to dispose of about 168,000 lbs of sodium, 217,000 lbs of chloride, and 366,000 lbs of sulfate annually. The amount of waste water discharged yearly and the amounts of chemicals therein have decreased significantly over the past three years.

Radionuclides are subject to radioactive decay, sorption, and dilution by dispersion in the regional aquifer. Chemical wastes are subject to sorption and dilution by dispersion. Waste plumes in the south central INEL vicinity containing tritium, iodine-129, sodium, chloride, and nitrate have been mapped, and all have similar configurations. The plumes generally follow southerly flow lines and are laterally dispersed in that part of the aquifer underlying the INEL.

Tritium is distributed in the Snake River Plain aquifer over about 42 square miles. Since disposal began in 1952, tritium has migrated as much as 8 miles downgradient from discharge points.

The waste plume containing strontium-90 covers a much smaller area of the regional aquifer, about 2.1 square miles. Based on the relatively small size of the plume, it would appear that strontium-90 is sorbed from solution as it moves through the Snake River Plain aquifer. Cesium-137 has been discharged in quantities similar to those of strontium-90 but has not been detected in the perched-water zone and has been detected in only a few wells which tap the Snake River Plain aquifer and are located very near the ICPP disposal well. Following 30 years of disposal, detectable quantities of cesium-137 are measurable no farther than about 1,800 feet from the disposal well. Cesium-137 is strongly sorbed to the minerals in the alluvial sediments, basalt, and clay-to-silt interbeds.

Detectablle plutonium radioisotopes and total chromium concentrations have been found in three wells which penetrate the Snake River Plain aquifer. Plutonium-238 and plutonium-239, -240 were detectable in well 47 south of the ICPP but in very minute quantities, and very low concentrations of plutonium-238 were detected in well 40. Both of these wells are located very near the ICPP disposal well. The low concentrations indicate that the effects of dilution, dispersion, and sorption reactions on this soluble radioisotope are significant. Total chromium concentrations were measurable at consistent levels in well 65 south of the TRA.

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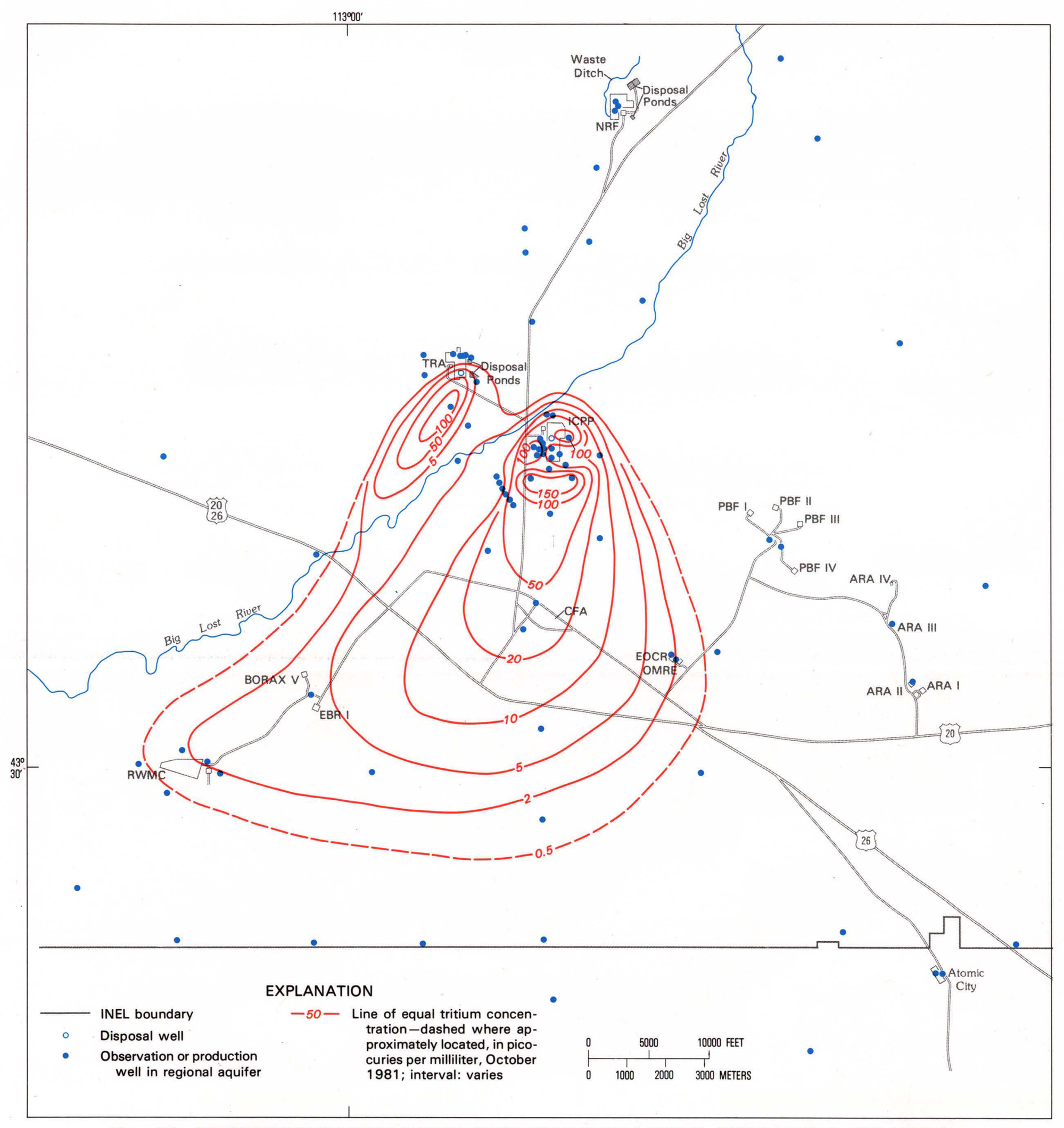

Figure 28.—DISTRIBUTION OF TRITIUM IN THE SNAKE RIVER PLAIN AQUIFER, SOUTHCENTRAL INEL VICINITY, OCTOBER 1981

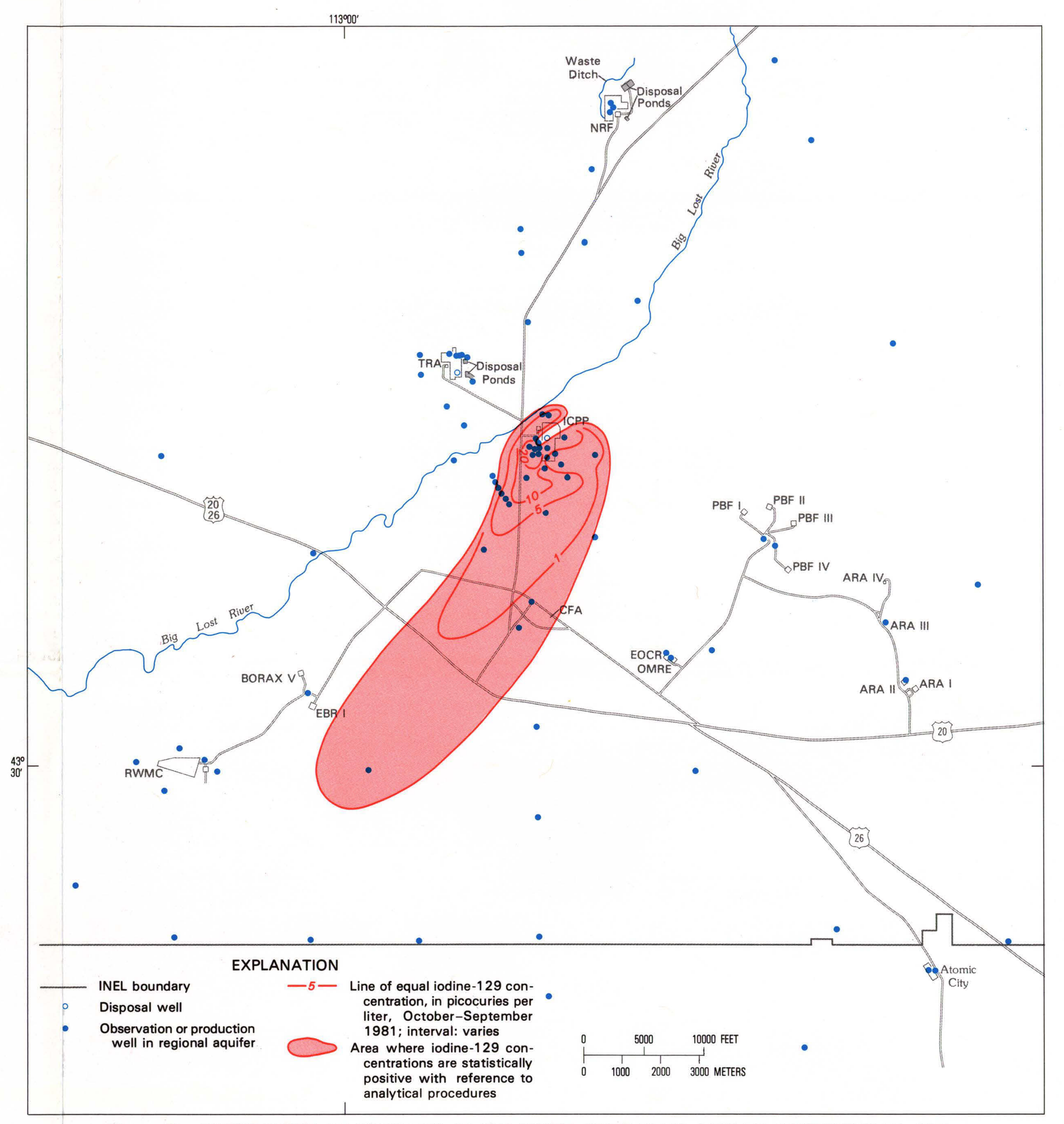

Figure 30.—DISTRIBUTION OF IODINE-129 IN THE SNAKE RIVER PLAIN AQUIFER, SOUTHCENTRAL INEL VICINITY, OCTOBER 1981

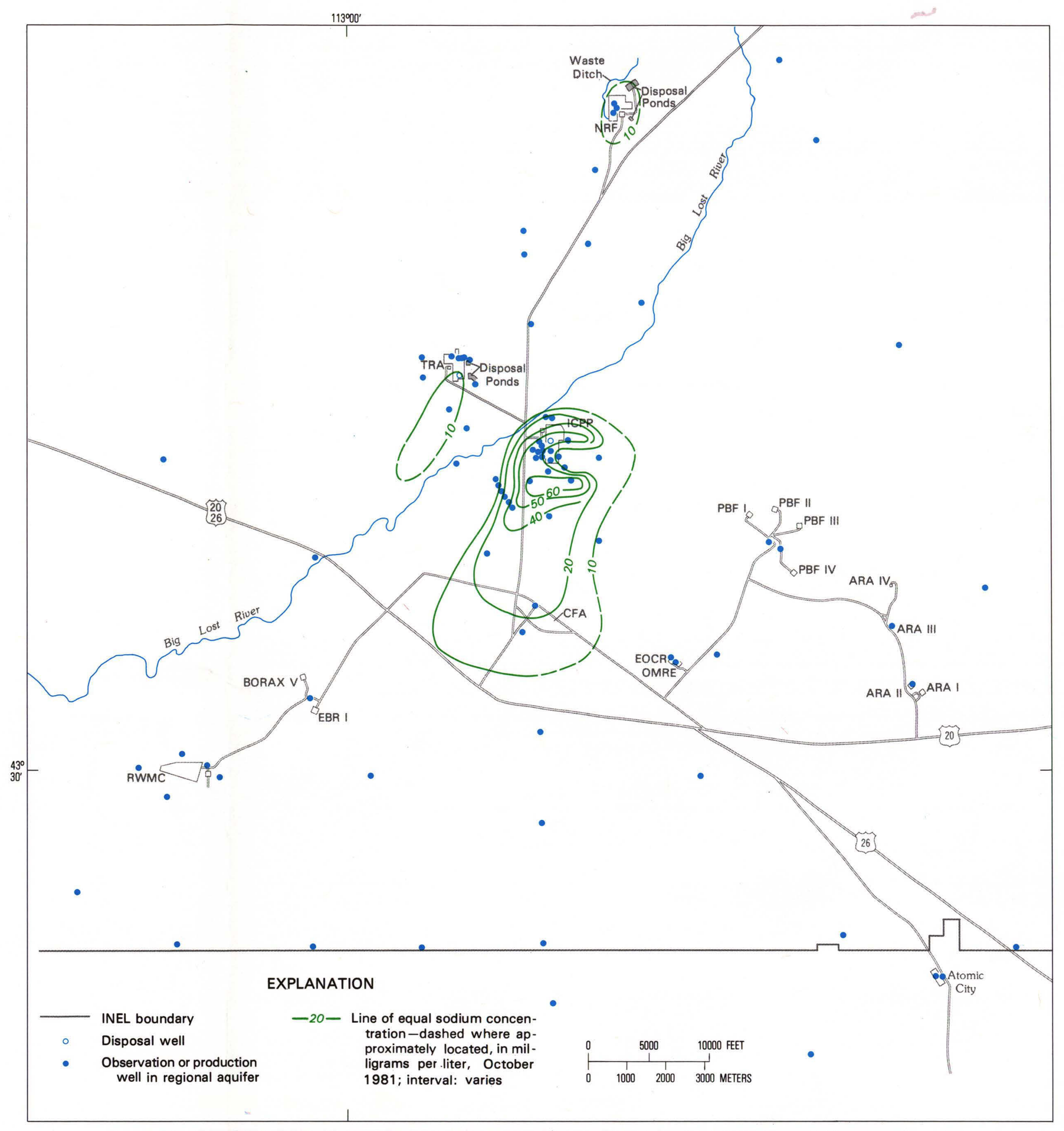

Figure 32.—DISTRIBUTION OF WASTE SODIUM IN THE SNAKE RIVER PLAIN AQUIFER, SOUTHCENTRAL INEL VICINITY, OCTOBER 1981

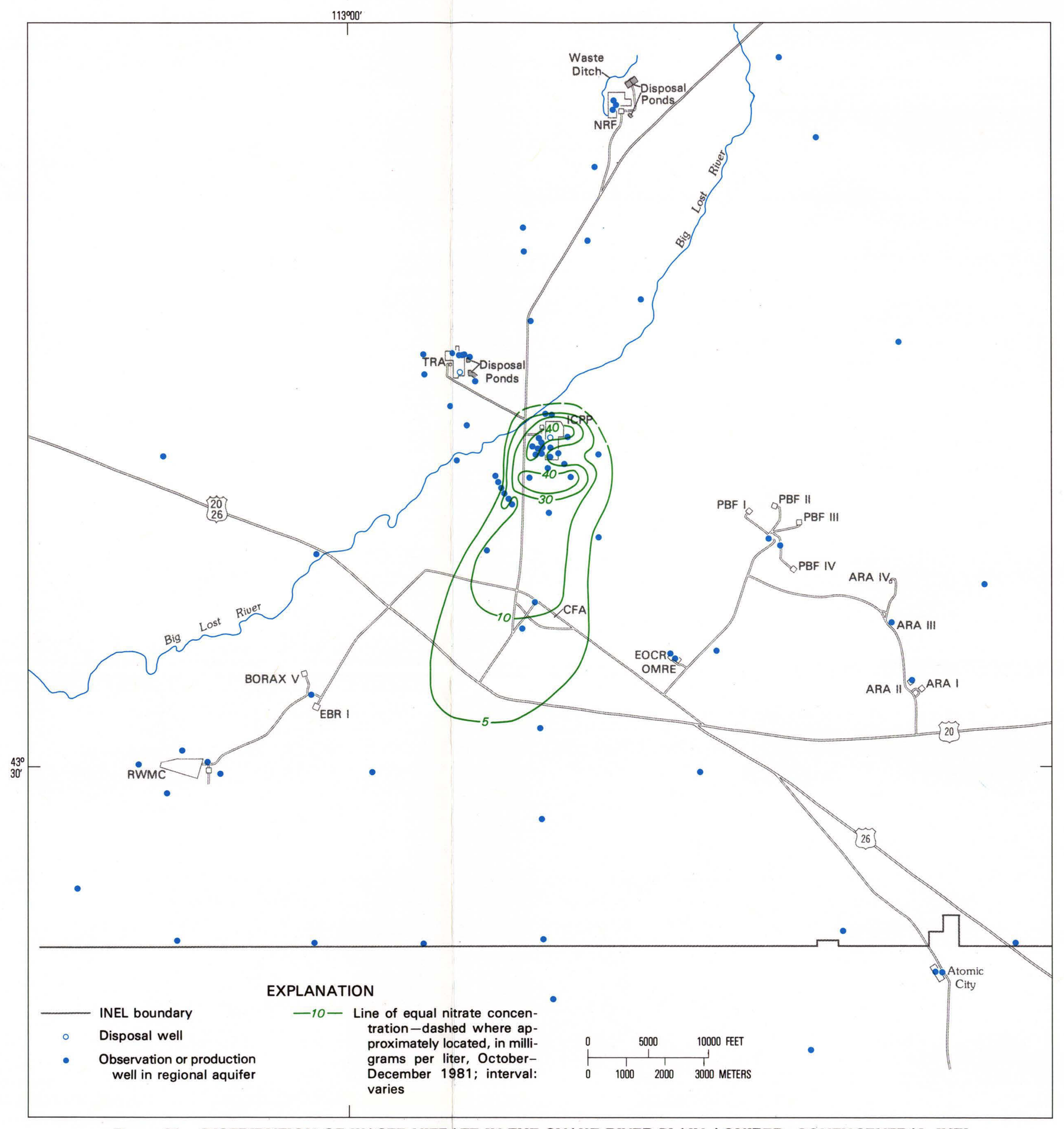

Figure 34.—DISTRIBUTION OF WASTE NITRATE IN THE SNAKE RIVER PLAIN AQUIFER, SOUTHCENTRAL INEL VICINITY, OCTOBER-DECEMBER 1981

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