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REPORT ON PHASE IIB  
GEOCHEMICAL DISPERSION OF ELEMENTS  
IN THE ROCKY MOUNTAIN ARSENAL AREA

A SPRING FOLLOW-UP  
ON THE FALL PHASE IIa PROGRAM

Prepared for  
THE DEPARTMENT OF THE ARMY

By  
IntraSearch, Inc.  
Denver, Colorado  
September, 1976

Dr. Paul B. Trest

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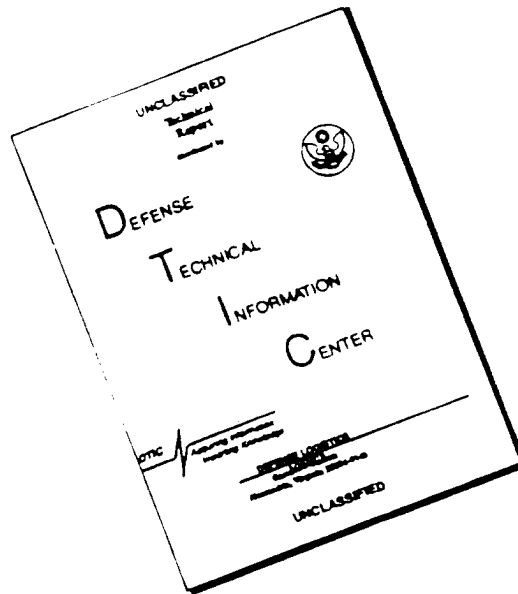
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13. ABSTRACT (Maximum 200 words)  THE OBJECTIVE OF THE SPRING PROGRAM WAS TO DETERMINE IF THERE ARE SIGNIFICANT SEASONAL VARIATIONS IN TRACE ELEMENT CONCENTRATIONS IN THE SOIL, WATER, AND PLANT SAMPLES. A SIGNIFICANT SEASONAL VARIATION WAS OBSERVED FOR CONDUCTIVITIES IN BOTH SURFACE AND GROUND WATER. AN INCREASE IN AS IN GROUND WATER WAS OBSERVED IN THE SPRING, AND DIMP CONCENTRATIONS ARE TIME DEPENDENT. THE CONCENTRATIONS OF HG, CL, AND CA IN SOILS DECREASED IN THE SPRING. NO SIGNIFICANT SEASONAL EFFECT WAS OBSERVED FOR MG AND SO4. CU CONCENTRATIONS INCREASED IN COTTONWOOD TWIGS IN THE SPRING. THIS DOCUMENT CONSISTS OF TWO PARTS: PART 1 TEXT, AND REDUCED COPIES OF 10 MAPS. PART 2 INCLUDES 11 FULL SIZE MAPS.				
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RESULTS AND CONCLUSIONS

Phase IIb was conducted during late May to early July, 1976, as a follow-up program to the fall sampling (Phase IIa). The object of the spring program was to determine if there are significant seasonal variations in trace element concentrations in the soil, water, and plant entities. Sampling was restricted to those areas known to contain anomalous concentrations of trace elements and compared to those areas of similar geologic setting but removed from any possible influence of Arsenal activities.

Results of the spring sampling program were compared to the fall sampling program. A significant seasonal variation was observed for conductivities in both surface and groundwater samples. Lower spring conductivities were observed in all cases except for those wells located close to Reservoir F. In these wells the concentrations were found to increase. This increase in conductivities again suggests Reservoir F is leaking. Previous studies by Trost have shown the southeast corner to be the major source of the leakage.

Arsenic was again found in one well on the Arsenal ground. Increase in the arsenic content was observed in the spring sampling as compared to the fall sampling. This increase should be expected due to a lowering of pH and temperature which would increase the solubility. Arsenic dispersion was similar to that observed in the fall program, being restricted to only one well.

A very shallow well ( $\approx 10$  ft) located in Mr. Land's wheatfield, was found to contain anomalous DIMP but no DCPD. The conductivity was also extremely high in this shallow aquifer. Presence of DIMP in this well suggests a RMA source for a portion of the water traversing his wheatfield. Past studies by Trost and others have shown a close correlation exists between DIMP and Cl. Thus at least a portion of the high salt content in Mr. Land's field is due to RMA sources, however the relative

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amounts due to RMA versus natural sources is difficult to assess. A resampling of the field well showed DIMP concentration levels to be highly time dependent. The lack of DCPD in this shallow well, coupled with the high DIMP concentration again suggests different dispersion paths for these two contaminants is operating. In addition, different sources and/or time of influx may be present.

Both Mr. Larry Land's and Jim Land's wells were also sampled. These wells were not made available for sampling last fall during the Phase IIa program. No anomalous copper, arsenic or conductivities were found in Mr. Larry Land's well. Mr. Jim Land had two wells, both of which were sampled, a deep well ( $\approx 350$  ft.) and a shallow well ( $\approx 100$  ft.). The deep well showed background concentrations of copper, arsenic, and conductivity. The shallow well showed a threshold value of copper. No anomalous arsenic, mercury or conductivity was observed in this well.

Significant seasonal variations were observed in the concentration levels of mercury, chloride and calcium, in the soils of both Land's field and the control field south of the arsenal. This decrease is due to higher water table coupled with downward infiltration and leaching of the salts by the spring rains. No significant seasonal effect was observed for magnesium or sulfate. It is therefore imperative that all soil sampling data be interpreted utilizing this seasonal concentration variance.

Significant seasonal variations were also observed in the concentration levels of copper in cottonwood twigs. In general the copper concentration was found to increase due to the larger volume of sap running through the twigs in the spring. Mercury concentration levels were, however, found to decrease as compared to the fall concentration levels. This decrease is probably related to a decrease in the chloride content in ground waters by normal dilution. Since mercury would migrate as a chloride complex its

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concentration levels in the water, and thus available to the plant, would decrease.

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INTRODUCTION

During the summer of 1975 IntraSearch was retained by the Rocky Mountain Arsenal to conduct a remote sensing program to determine if Reservoir F was leaking (Phase I). This study resulted in the definition of areas containing vegetative stress. To evaluate these areas of vegetative stress a two phase geochemical program was initiated. Phase IIa was conducted in October through December, 1975, with samples of soil, plants, surface waters, groundwaters, and reservoir waters, collected and geochemically evaluated. Results are contained in a report dated March 1976 by IntraSearch. Phase IIb was initiated in late May, 1976. Again soil, plants, surface waters and groundwaters were collected and have been geochemically evaluated. Results of the two phases have been interpreted and compared to determine if significant seasonal variations are present.

Seasonal variances could be present due to the following factors:

1. Higher groundwater table resulting in:
  - a. Different dispersion paths
  - b. Dissolution of contaminants contained in the soil above the normal water table level
  - c. Lower temperatures of the unconfined aquifer resulting in changes in solubilities of some contaminants, especially arsenic compounds.
2. Recharge of potentially contaminated aquifers at different sites than during the summer/fall months.
3. Ponding in Reservoir A, followed by downward percolation through contaminated sediments and entering the groundwater system.
4. Northward dispersion of potentially contaminated water as a surge or front. This could result in highly anomalous concentrations in certain wells for a relatively short time period.

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Dr. Paul B. Trost, a geochemist with Martin-Trost Associates, was retained by IntraSearch to conduct both programs.

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OBJECTIVES

The objectives of Phase IIb were to determine if seasonal variations in temperature, groundwater levels and spring recharge of the shallow aquifer would have a significant effect on concentration levels of trace and major elements in the soil, plants and water. Sample sites selected in Phase IIa were resampled in a similar manner and re-analyzed by the same commercial laboratory utilizing the same digestion and analytical techniques.

Objectives to be specifically accomplished were:

1. Determine if Reservoir F is leaking.
2. Determine if Mr. Land's wheatfield in S/2, Sec. 14, T2S, R67W, contains anomalous concentrations of elements relatable to present or past Arsenal activities and if these concentrations are variable due to seasonal effects.
3. Compare the concentrations of trace and major elements from Phase IIa and Phase IIb.
4. Develop additional data for a uniform sampling schedule as related to any seasonal variances.

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FIELD AND ANALYTICAL METHODS EMPLOYED

All sampling and analysis were conducted in locations and manners as those obtained for Phase IIa. This was done to insure any variances observed were relatable to seasonal effects.

Please refer to the March 1976 report by Trost for a complete description of sampling and analytical techniques employed during this phase.

Sampling was restricted to those areas which would be the most affected by seasonal variations and which would yield the most information regarding the integrity of Reservoir F, the salt content of Land's wheatfield, and effects of spring recharge in the unconfined aquifer.

Samples were collected from Land's wheatfield and from a control wheatfield south of the arsenal, located in NW/4 Sec. 17, T3S, R66W.

Groundwater samples were collected from most of the wells previously sampled during the fall/winter of 1975.

Cottonwood twigs were also resampled in order to compare any concentration changes in the twigs at the end of the growing season (fall/winter) as compared to the start of the growing season (spring/summer).

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SURFACE WATER SAMPLING RESULTS

Surface water samples were collected at sites previously sampled in Phase IIa. Sample results are tabulated in Appendix I. Results for the conductivity at each site has been plotted on Map I. Dispersion maps have not been prepared for arsenic or copper due to their lack of variance from the previous results of Phase IIa.

Conductivities of surface waters were generally lower by 10-15% as compared to the fall sampling. Sample sites of First Creek upstream and downstream of the plant's surface drainage ditch showed no change in conductivities. Thus water discharging from the plant's area at the time of the sampling was apparently only surface water. As was previously noted in Phase IIa, the surface waters show an increase in conductivity north of Reservoirs A and F as shown on Map I.

No significant changes in copper concentrations were observed. In general the spring values were slightly higher however most changes are within the reproducibility of the analytical method employed. Thus no statistically significant seasonal fluctuations for copper in surface waters were observed.

Mercury was not analyzed since the only anomalous concentrations observed in the fall sampling were from waters entering the Arsenal grounds from the Montbello area. No waters containing anomalous concentrations of mercury were found exiting the Arsenal grounds to the north.

The caustic pit, which previously contained anomalous arsenic in its standing waters, was not sampled.

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GROUNDWATER SAMPLING RESULTS

Groundwater (well water) samples were collected from most wells previously sampled during the fall of 1975. The purpose of the spring sampling was to determine if significant seasonal variances are present.

Sample results are tabulated in Appendix I and on Maps IIb, IIc.

Map IIb, copper in groundwater, showed no major concentration variances except for well 12D-4, which is located south or upstream of RMA. This particular shallow aquifer is tapped by two different wells located a few hundred feet apart. The well sampled in the fall was not available in the spring, thus the second well was sampled. This large variance reflects different conditions in the plumbing and not the aquifer. In general most wells showed a slightly higher copper concentration, however this may be due to an analytical error as compared to a seasonal variance, especially since most values are quite close to the detection limit.

In this spring sampling program additional wells were sampled which were not previously sampled during the fall program. These were Larry Land's well (LL1), J. Land's wells (JL1, JL2) and a shallow well located in the middle of Mr. Land's wheatfield north of the Arsenal (LLW). Larry Land's well (LL1) showed no anomalous copper concentration as compared to other wells in the area. Mr. J. Land's shallow well (JL2) did however show a copper concentration significantly higher than that of his deeper well (JL1). A difference in trace element concentrations between two hydrologically separated aquifers is not unusual. However JL2 should be resampled after being pumped for a minimum of 30 minutes to insure a representative sample. The sample collected in this study was obtained after 10 minutes of pumping. These results should then be compared to copper concentrations from wells tapping the same shallow aquifer and located south of the Arsenal.

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Sample LLW located in Mr. J. Land's wheatfield, was obtained from a depth of 5 feet below the surface by bailing. This well had extremely high salt content. This high salt content would allow greater concentrations of copper to remain in solution through the formation of a complex chloride anion such as  $\text{CuCl}_2^-$ , ( $K = 10^{-5.60}$ ). Thus interpreting the total copper concentration without considering its geochemical environment would be misleading. This shallow well was sampled on two different days, one in late May and again in mid June. A split of this sample was submitted to RMA for analysis of DIMP and DCPD. Results are shown below.

Date	DIMP, ppb	DCPD, ppb	pH	Conductivity
28 May 1976	2100	0 odor	7.78	7620
22 June 1976	880	<10	7.15	not analyzed

This well should be closely monitored to determine if DCPD, dieldrin, endrin, or aldrin are ever present. Since this initial analysis has not shown DCPD to be present a different source and/or dispersion path is present for these two contaminants. The extremely high conductivity is predominately due to high chloride and sulfate concentrations with the chloride being the major anionic species. This common association of chloride and DIMP has been previously noted in both the Reservoir A and F areas. A correlation plot of DIMP vs. Chloride (Figure I) shows a fairly close relationship between these two parameters. Furthermore a previous report by Trost has shown a correlation coefficient of 0.8577 between DIMP and chloride. In 1956, Petri and Smith showed a very high chloride concentration was present in the immediate vicinity of Land's wheatfield; the source of which they attributed to the RMA area. The presence of DIMP in Land's field, coupled with its correlation with chloride, suggests a portion of the chloride content of Land's field is due to RMA sources. The relative amounts of the chloride concentration which can be ascribed to RMA versus natural sources is very difficult to assess with the present information.

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No arsenic was observed in any of the wells sampled except for RMA well no. 40. In this well, the arsenic content showed a 50% increase over the fall sampling. It is interesting to note that the conductivity showed a 20% decrease as compared to last fall. It therefore appears that either additional arsenic is leached from above the normal water table layer by spring rains and subsequent infiltration or that a change in ground water temperature and/or pH may be important. Arsenic compounds such as  $As_2O_5$ , and  $Ba_3(AsO_4)_2$  are known to be more soluble in cold water than in warm water. Thus temperature and pH should be monitored in all future sampling programs. As was previously noted in the fall sampling, the high arsenic concentrations in well no. 40 showed very restricted dispersion since other nearby wells were not found to contain anomalous arsenic concentrations.

Conductivities of the unconfined near-surface aquifer generally showed a 10-20% decrease except for those wells located close to Reservoir F (see Map IIc). These wells showed up to 50% increase in their conductivities as compared to last fall. During the winter very high water levels were observed in Reservoir F. This resulted in both splash-over and infiltration through the dike and into the southeast corner. In addition, portions of the liner generally located above the normal water level were submerged. Previous studies by Trost, have shown a poor liner integrity exists in the southeast corner. This has resulted in contaminants entering the shallow aquifer from this area. Thus aqueous solutions from Reservoir F could enter the shallow ground water system both through the southeast corner area and possibly through the upper levels of the liner. Only very minor changes in conductivities were observed for the deeper aquifers such as wells Wt 3D-5, 6, 7, and J11. Thus conductivity shows a significant seasonal variation for shallow aquifers but little for deeper aquifers (400 ft.). This seasonal variation may be useful in discriminating between shallow and deep aquifers and must be considered in future sampling programs and interpretation.

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No significant variance in the dispersion paths have been noted between the spring and fall sampling thereby suggesting higher ground water levels do not influence dispersion directions.

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### SOIL SAMPLING RESULTS

Soil samples were collected from Land's wheatfield north of the arsenal and from the wheatfield south of the arsenal. Soils samples from both the A and B soil horizons were collected in the same areas as previously sampled last fall. Sample results are presented on maps with separate maps for the A and B soil horizons. The mean and standard deviations for each sample area were calculated and are shown in Appendix II.

Descriptions of the areas sampled are:

AO - E14 Land's wheatfield located in SW/4, Sec. 14, T2S, R67W.

AAO - AE4-5 Area located south of the Arsenal in the NW/4 Sec. 17, T3S, R66W.

Mercury concentrations in both the A and B soil horizons were determined. Results are shown on Maps IIIcA and IIIcB. In general no significant seasonal variations in dispersion patterns were observed in the two wheatfields. It is noteworthy, however, that Land's wheatfield again showed a slightly elevated mean concentration level as compared to the wheatfield south of the Arsenal. This minor difference in the means is however negated by the large standard deviations.

There does exist a seasonal variance in the concentration levels for both data sets, with the spring sampling showing significantly less mercury content than the fall sampling. This is probably due to summer evaporation and concentration of mercuric salts from the near surface chloride-rich groundwater. This conclusion is further documented by the slightly higher mercury concentrations observed in the salt-rich B soil horizons. It is therefore imperative that all sampling be interpreted with regard

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to season. Failure to do so could result in a false seasonal anomaly. For example the fall mean mercury concentration for Land's wheat-field of 20.81 ppb does indeed appear anomalous compared to the spring value for the southern wheatfield of 8.10 ppb; whereas the fall mercury concentration in the southern wheatfield is 14.25 ppb which is comparable to the 20.81 ppb in Land's field.

The salt-rich B soil horizon contains slightly higher mercury concentrations than does the organic-rich A soil horizon. Apparently in areas of very high salt content, the formation of complex sulfate and chloride anions is a more controlling factor than the humic acid-mercury relationships.

Chloride content in soils is shown on Maps IIIIdA, IIIIdB. A significant seasonal variation in concentration levels was observed between the fall and spring sampling. The spring concentration levels are approximately 50% lower than the fall levels. This decrease is a result of downward flushing and mobilization by the spring rains and runoff. Thus it is again imperative that all soil sampling results be compared during the same seasonal period.

No major change in the dispersion patterns was observed between the spring and fall sampling periods. The low-lying recent alluvium areas in both wheatfields still contain the highest relative concentrations.

Sulfate content in soils is shown in Map IIIeA and Map IIIeB. No significant seasonal variation in concentration levels was observed between the spring and fall sampling. This is due to the insolubility of  $\text{CaSO}_4$ . Thus spring rains and runoff do not dissolve the  $\text{CaSO}_4$  whereas they do dissolve and mobilize the more soluble chloride salts e.g.  $\text{CaCl}_2$ ,  $\text{NaCl}$ . Concentration levels in both Land's field and the field south of the Arsenal are extremely similar to the fall results. The general distribution patterns are also very similar to the fall results.

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Calcium content in soils is shown on Map IIIfA and Map IIIfB. A significant variation in the calcium content of the B soil horizon was observed with the spring sampling showing lower concentrations. The A soil horizon did not show a significant change from the fall results. In the A soil horizon, the calcium is predominately present as the insoluble  $\text{CaSO}_4$ , whereas in the B soil horizon calcium is immobilized by both  $\text{CaSO}_4$  and clay adsorption. Thus spring flushing results in a decrease in calcium content due to desorption from the clays; whereas the insolubility of  $\text{CaSO}_4$  in the A horizon shows no seasonal affect.

No significant variation in the dispersion pattern was observed for either the A or B soil horizons in the spring or fall sampling.

Magnesium content in soils is shown on Map IIIgA and Map IIIgB. No significant changes were observed in either the concentrations or dispersion patterns of magnesium and the A and B soil horizons. This probably reflects absorption and adsorption of magnesium onto the clays with relatively minor amounts available as soluble sulfate or chloride salts which would be subject to seasonal variations.

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VEGETATIVE SAMPLING RESULTS

Cottonwood twigs were resampled in areas known to contain anomalous copper and mercury concentrations as delineated in the fall sampling program. These samples were compared with other cottonwood twigs obtained upstream from all RMA manufacturing activities. Samples were collected and analyzed in the same manner as the fall program. Tabulated results are in Appendix I.

Copper concentrations in twigs showed a slight increase in the spring sampling as compared to the fall sampling. This slight increase is a seasonal effect probably due to a large volume of sap running through the recent twigs to the new leaf growth. Although the copper concentration in the sap would probably be similar to the fall concentrations, the greater volume of flow would result in more copper being removed by the twig, and hence a higher twig copper concentration.

All areas that were anomalous in the fall program were also found anomalous in the spring program. In one area (Sample No. 12N-5) along First Creek the copper concentration was found anomalous in the spring sampling but not in the fall. This area should be resampled to insure no contamination was present. If the results are reproducible a source of copper such as the trailer court seepage lagoon located southeast of the Arsenal, would be suspected. No copper source due to RMA activities is reasonable for this area upstream of the plant's location.

A composite twig sample from numerous trees was taken from the transplanted cottonwoods along the north boundary near the bog. This sample was taken to provide a base line or background value for future sampling programs. The copper concentration was 13 ppm or average for those samples upstream of the plants area.

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No geochemical map was prepared for copper in twigs since no change was observed in dispersion patterns.

Mercury concentrations in cottonwood twigs showed a slight decrease as compared to the fall sampling results. This decrease is probably related to the decreased conductivity in the ground water during the spring. The decreased conductivity would reflect a decreased chloride concentration. Thus the formation of a stable mercury chloride complex would be inhibited and less mercury would be available in the ground water for the roots to assimilate.

The anomalous mercury concentrations observed in the fall sampling along the southern boundary of RMA was not observed in the spring program. This may be due to a decrease in mercury concentration in the effluents of the Montbello industrial area or less mercury mobilization due to a lower chloride content. No other significant changes in the dispersion pattern were noted. Due to the lack of significant dispersion changes no geochemical map has been compiled for mercury in cottonwood twigs.

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RECOMMENDATIONS

Based on the results of Phase IIa and Phase IIb the following recommendations are made:

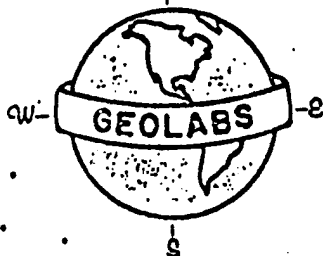
- (1) That the temperature and pH be measured at each well sampled to aid in data interpretation.
- (2) That Mr. Jim Land's shallow well be resampled after pumping for 1 hour to insure a fresh sample.
- (3) That all data be collected, interpreted, and compared during the same season to avoid seasonal variations.
- (4) That specific wells e.g. RMA no. 40, LLW, 118, RMA no. 60, 20N-1, 20N-2 be monitored and utilized to interpret seasonal facts on concentration levels.
- (5) That a sampling program be developed to determine if high concentrations of DIMP, DCPD, etc. move as a surge front. This will aid in predicting when and where high concentration levels of contaminants will appear.
- (6) That a correlation plot of DIMP vs Cl be prepared on a seasonal data base and utilized to interpret what relative amount of chloride, due to RMA sources, is present in Land's field in the shallow aquifer.

BN 912  
PN 55  
Fl Denver Plant  
FS 2  
PD 174 552/1-100

RSH 918

1578

GEOLABS  
 1100 Simms Street  
 Lakewood, Colorado  
 Phone (303) 233-8155



Mailing address:  
 P.O. Box 702  
 Edgemont Branch  
 Golden, Colorado 80401

September 29, 1976  
 Job: 6F27

A DIVISION OF  
 NATURAL RESOURCES LABORATORY, INC.

Dr. Paul B. Trost  
 Martin-Trost Associates  
 1301 Arapahoe  
 Golden, Colorado 80401

REPORT OF ANALYSES

Sample (soils)	Ca, %	Mg, %	Hg, ppb	SO <sub>4</sub> <sup>2-</sup> , meq/gm	Cl <sup>-</sup> , meq/gm
AA 0	0.43	0.29	10	36	6
OB	0.45	0.50	10	16	1
1.5	0.43	0.35	△0	6	4
1.5B	0.48	0.45	10	24	5
3.0	0.72	0.44	10	7	10
3.0B	0.69	0.62	△0	34	14
4.5	0.32	0.34	△0	32	1
4.5B	0.35	0.38	△0	△	2
AB 0	0.68	0.34	15	49	6
OB	0.47	0.43	△0	7	1
1.5	0.37	0.37	△0	7	2
1.5B	0.36	0.36	△0	7	2
3.0	0.53	0.35	△0	40	9
3.0B	0.42	0.54	△0	18	6
AC 0	0.41	0.35	△0	5	9
OB	0.55	0.56	△0	32	39
1.5	0.39	0.32	△0	4	4
1.5B	0.49	0.41	△0	10	3
3.0	0.96	0.61	△0	45	9
3.0B	0.70	0.79	△0	44	8
4.5	0.80	0.53	△0	30	3
4.5B	5.5	0.58	15	△	2
AD 0	0.40	0.26	△0	△	4
OB	0.38	0.33	△0	△	15
1.5	0.43	0.39	△0	△	3
1.5B	0.47	0.41	△0	△	16
3.0	1.1	0.48	15	28	8
3.0B	0.70	0.62	15	6	3
4.5	0.43	0.43	10	6	2
4.5B	0.48	0.58	15	6	2

ANALYTICAL SERVICES AND RESEARCH

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BN 912  
 PN 55  
 FS 2  
 PD 174752/1-100  
 FL Denver Plant

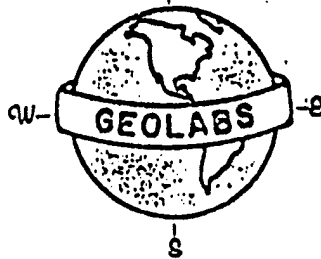
RSH 918

15719

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Page 2



Job: 6F27

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Sample (Soils)	Ca, %	Hg, %	Hg, ppb	SO <sub>4</sub> <sup>2-</sup> , meq/gm	Cl <sup>-</sup> , meq/gm
AE 0	1.4	0.45	15	54	12
OB	0.60	0.59	10	10	2
1.5	0.41	0.34	10	3	2
1.5B	0.66	0.56	25	16	7
3.0	0.40	0.33	10	2	1
3.0B	0.55	0.46	15	4	5
4.5	0.31	0.25	10	4	1
4.5B	0.47	0.39	10	7	3
A 0	0.58	0.43	10	3	4
OB	0.43	0.45	10	4	1
2	0.27	0.46	20	1	4
2B	0.32	0.57	20	1	4
4	0.32	0.53	25	3	4
4B	0.45	0.67	20	3	4
6	0.33	0.54	10	8	2
6B	0.35	0.47	10	8	2
8	0.22	0.44	10	8	2
8B	1.3	0.84	15	500	7
B 0	0.43	0.33	10	3	4
OB	0.43	0.39	10	2	2
2	0.34	0.45	15	3	3
2B	6.1	0.71	15	28	12
4X	0.45	0.54	15	110	28
4BX	1.1	0.86	20	470	12
6X	0.46	0.43	15	130	12
6BX	0.59	0.72	15	130	17
8X	0.50	0.45	15	210	10
8BX	0.55	0.64	15	120	10
10	0.34	0.45	15	2	2
10B	0.58	0.64	20	0	0
C 2	0.32	0.50	15	1	1
2B	0.31	0.50	15	2	1
4	0.47	0.55	15	130	6
4B	4.8	0.80	15	1100	12
6	0.39	0.43	15	50	18
6B	0.46	0.60	10	88	12
8	0.31	0.41	15	14	1
8B	0.47	0.76	35	49	1
10	0.37	0.52	10	3	4
10B	0.45	0.49	10	6	4

ANALYTICAL SERVICES AND RESEARCH

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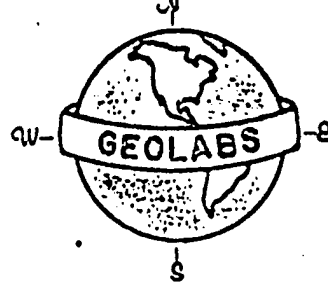
BN 412  
PN 55  
FL Denver Plant  
FS 2  
PD 174 352/L-100

RSH 918

1981

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 1100 Simms Street  
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Job: 6F27

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 P.O. Box 702  
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 Golden, Colorado 8040

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Sample (soils)	Ca, %	Mg, %	Hg, ppb	SO <sub>4</sub> <sup>2-</sup> , meq/gm	Cl <sup>-</sup> , meq/gm
C 12	0.31	0.49	15	2	VVVVV
12B	1.1	0.73	10	4	VVVVV
14	0.36	0.50	15	3	VVVVV
14B	0.42	0.60	20	4	VVVVV
D 2	0.32	0.49	10	1	VVVVV
2B	0.33	0.50	10	V	VVVVV
4	0.28	0.44	10	V	VVVVV
4B	0.30	0.47	10	1	VVVVV
6	0.38	0.48	10	2	VVVVV
6B	3.0	0.71	10	29	VVVVV
8	0.35	0.40	10	25	VVVVV
8B	0.34	0.45	10	13	VVVVV
10	0.34	0.46	10	V	VVVVV
10E	0.53	0.68	30	1	VVVVV
12	0.30	0.41	10	V	VVVVV
12B	0.39	0.54	10	2	VVVVV
14	0.25	0.37	10	2	VVVVV
14B	0.31	0.50	10	3	VVVVV
E 2	0.27	0.46	10	3	VVVVV
2B	0.32	0.58	10	4	VVVVV
4	0.28	0.48	10	2	VVVVV
4B	0.38	0.84	10	12	VVVVV
6X	0.42	0.53	10	57	VVVVV
6BX	0.39	0.36	10	60	VVVVV
8	0.38	0.53	10	2	VVVVV
8B	0.48	0.70	10	2	VVVVV
10	0.43	0.69	10	2	VVVVV
10B	0.50	0.66	10	2	VVVVV
12	0.27	0.39	10	3	VVVVV
12B	0.33	0.50	15	2	VVVVV
14	0.43	0.47	10	2	VVVVV
14B	0.46	0.48	10	2	VVVVV

BN 912  
 PN 55  
 FS 2  
 FL Denver Plant  
 PD 174758/1-100

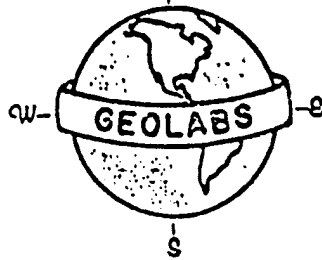
RSR 918

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GEOLABS  
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 Phone (303) 233-8155

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 Golden, Colorado 80401



Job: 6F27

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Sample (water)	Cu, ppb	As, ppb	K, $\mu$ mho/cm
13H-3	<10	<10	800
-4	10	>10	940
18N-1*	10	>10	460
-2	10	>10	433
-3	>10	>10	334
-4	>10	>10	333
-5	10	>10	986
17N-1	20	>10	951
-2	20	>10	472
-3	20	>10	443
-4	10	>10	885
10N-1	10	>10	973
-2	10	>10	1930
-3	10	>10	1310
-5	10	>10	439
12D-2	20	>10	600
-3	10	>10	886
-4	140	>10	1210
-5	10	>10	2020
24D-2	10	>10	780
2D-4	10	>10	800
-5	>10	>10	359
-6	10	>10	625
-7	40	>10	357
-8	10	>10	1230
1DC-1	20	>10	429
JL-1	10	>10	392
2	50	>10	751
2NP*	-	-	473
LLW**	75	>10	7620

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BN 918  
 PN 55  
 FL Denver Plant  
 FS 2  
 PD 174758/1-100

RSH 918

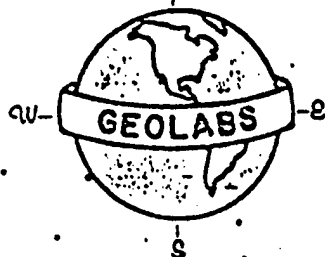
1588

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Sample (water)	Cu,ppb	As,ppb	K,umho/cm
LE 1***	65	<10	481
LE 1***	20	-	-
LE 1***	20	-	-
40	50	3000	8040
41	30	>10	3130
115	20	>10	1510
118	30	>10	3990
119	10	>10	1300
121	20	>10	2310
145	20	>10	2250
3A	10	>10	1580
17	20	>10	2190
37	20	>10	622
60	20	>10	1820
62	10	>10	1090
WTX 8.1	90	<10	645

\*No acidified sample received  
 \*\* 2 acidified samples received  
 \*\*\* 3 acidified samples received

Sample (water)	Hg,ppb	Cl <sup>-</sup> ,ppm (job 6J05)
JL-1	>0.1	5
-2	>0.1	130
-2NP	-	32
LLW (1)	0.1	2380
LLW (2)	>0.1	-
LLW (3)	>0.1	-
LE 1 (1)	>0.1	20
LE 1 (2)	>0.1	-
LE 1 (3)	>0.1	-

ANALYTICAL SERVICES AND RESEARCH

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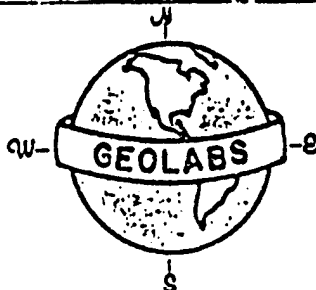
BN 912  
 PN 55  
 FL Denver Plant  
 ES 2  
 PD 174752/L-100

RSH 918

1583

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Job: 6827

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<u>Sample (plants)</u>	<u>Cu, ppm</u>	<u>Hg, ppb</u>
CT-1	29	25
2	25	20
3	15	20
6	10	40
11N-1	13	20
11N-2	10	10
11N-6	9	40
12N-5	27	20
17N-4	15	15
CT-Bog New	13	15

*Ronald L. Keil*  
 Ronald L. Keil

ANALYTICAL SERVICES AND RESEARCH

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912  
 BN 55  
 PN 55  
 FS 2  
 PD 174 3841-100  
 FL Denver Plant

RSH 918

1584

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APPENDIX II

<u>Ca%</u>			
<u>Sample Nos.</u>	<u>No. of Samples</u>	<u>Mean</u>	<u>Standard Deviation</u>
AAO - AE4-5	19	0.57	0.30
AAOB - AE4-5B	19	0.78	1.15
AO - E14	32	0.36	0.08
AOB - E14B	32	0.88	1.31
<u>Mg%</u>			
AAO - AE4-5	19	0.38	0.09
AAOB - AE4-5B	19	0.50	0.12
AO - E14	32	0.47	0.07
AOB - E14B	32	0.61	0.14
<u>Hg ppb</u>			
AAO - AE4-5	19	8.10	8.29
AAOB - AE4-5B	19	8.84	7.72
AO - E14	32	9.41	6.91
AOB - E14B	32	11.66	7.90
<u>SO<sub>4</sub> Meg/gm</u>			
AAO - AE4-5	19	0.57	0.30
AAOB - AE4-5B	19	0.78	1.15
AO - E14	32	0.36	0.08
AOB - E14B	32	0.88	1.31
AO - E14	32	0.36	0.08
AOB - E14B	32	0.88	1.31
<u>Cl</u>			
AAO - AE4-5	19	5.05	0.20
AAOB - AE4-5B	19	7.16	9.04
AO - E14	32	3.28	6.36
AOB - E14B	32	3.64	6.27
<u>Cu</u>			
Water Samples 13N-3	44	21.84	25.78
<u>K</u>			
	44	13.61	16.18

BN 912  
 PN 35  
 FL Denver Plant  
 FS 2  
 PD 177758/1-100

RSH 918

15815

Prof. 7397 Iib

# GEOCHEMICAL MAP III GA

MERCURY

in

A SOIL HORIZON (-80 Mesh)  
ROCKY MOUNTAIN ARSENAL AREA

COLORADO

Scale: as holed

Base map from U.S.S. topographic maps

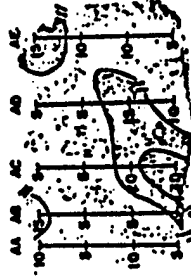
IntraSearch

Data prepared by Dr. Paul B. Trost

September, 1976



Scale: 1" = 1000'  
 Location: SW 1/4 Section 14, T2S, R67W  
 Land's wheatfield



Scale: 1" = 500'  
 Location: NW 1/4 Section 17, T3S, R66W  
 Wheatfield south of arsenal

EXPLA NATION  
 Hg, (ppb)

0-10	[Pattern]
11-20	[Pattern]
21-30	[Pattern]
> 30	[Pattern]

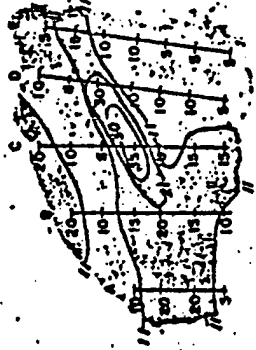
## PSH 918

# 1986

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BN 918  
 PN 55  
 FL AEWOR Plant  
 FS 2  
 PD 174 352/E-100

Proj. 7597 IIB



Scale: 1" = 1000'  
 Location: SW 1/4 Section 14, T 2 S, R 67W  
 Land's wheatfield



Scale: 1" = 500'  
 Location: NW 1/4 Section 17, T 3 S, R 66W  
 Wheatfield south of arsenal

EXPLANATION  
 H, ppb

0-10
11-20
21-30
>30

**GEOCHEMICAL MAP IIIcB**

MERCURY  
 in  
 B SOIL HORIZON (~80 Mesh)  
 ROCKY MOUNTAIN ARSENAL AREA  
 COLORADO

Scale: as noted  
 Base map from U.S.G.S. topographic maps  
 IntraSearch  
 Data prepared by Dr. Paul B. Trost  
 September 1976

**RSH 918**

**1587**

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912  
 PN 35  
 FL AERIALS  
 PD 173132/L-100  
 PLANT



Scale: 1" = 1000'  
 Location: SW 1/4 Section 14, T 2 S, R 67 W  
 Land's wheatfield

**GEOCHEMICAL MAP III d A**  
 CHLORIDE

in  
 A SOIL HORIZON (~80 Mesh)  
 ROCKY MOUNTAIN ARSENAL AREA  
 COLORADO

Scale: as noted  
 Base map from U.S.G.S. topographic maps

IntraSearch

Data prepared by Dr. Paul B. Trost  
 September 1976

EXPLANATION  
 Cl, mg/kg

< 5	5-10	11-15	> 15
-----	------	-------	------



Scale: 1" = 500'  
 Location: NW 1/4 Section 17, T 3 S, R 66 W  
 Wheatfield south of arsenal

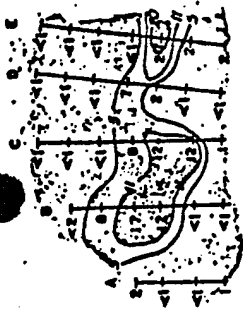
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BN 912  
 PN 55  
 FL Denver Plant  
 FS 2  
 PD 1777352/1-100

**PSH 918**

**1588**

Proj. 7597 IIc



Scale: 1" = 1000'  
 Location: SW 1/4 Section 14, T 2 S, R 67 W  
 Land's wheatfield

# GEOCHEMICAL MAP III.dB

CHLORIDE

in  
 B SOIL HORIZON (~80 Mesh)  
 ROCKY MOUNTAIN ARSENAL AREA  
 COLORADO

Scale: as noted

Base map from U.S.G.S. topographic maps

IntraSearch

Data prepared by Dr. Pau' B. Trost  
 September 1976

EXPLA NATION	Cl, mg/kg
	< 5
	5-10
	11-20
	> 20



Scale: 1" = 500'  
 Location: NW 1/4 Section 17, T 3 S, R 66 W  
 Wheatfield south of arsenal

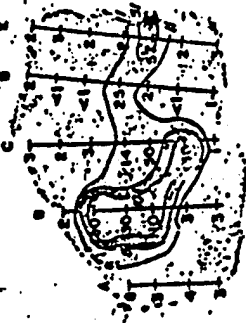
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BN 912  
 PN 55  
 FL AERUOR PLANT  
 FS 2  
 PD 1747354/L-100

15 8 77

Proj. 7597 IIb



Scale: 1" = 1000'  
 Location: SW 1/4 Section 14, T 2 S, R 67W  
 Land's wheatfield

# GEOCHEMICAL MAP IIIeA

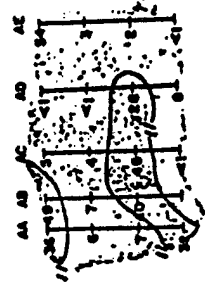
SULFATE  
 in  
 A SOIL HORIZON (-80 Mesh)  
 ROCKY MOUNTAIN ARSENAL AREA  
 COLORADO

Scale: as noted  
 Base map from U.S.G.S. topographic maps

IntraSearch

Data prepared by Dr. Paul B. Trost

EXPLANATION	SO <sub>4</sub> , mg/kg
1-10	[Symbol]
11-50	[Symbol]
51-100	[Symbol]
101-200	[Symbol]
> 200	[Symbol]



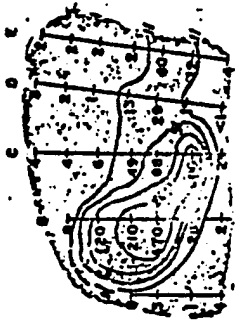
Scale: 1" = 500'  
 Location: NW 1/4 Section 17, T 3S, R 65W  
 Wheatfield south of arsenal

**RSH 918**

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DR. PAUL B. TROST  
 PN 55  
 FL Newer Plant  
 PN 174 X58/L-100  
 Co

Proj. 7597 IIb



Scale: 1" = 1000'  
 Location: SW 1/4 Section 14, T2S, R67W.  
 Land's wheatfield

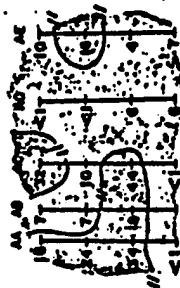
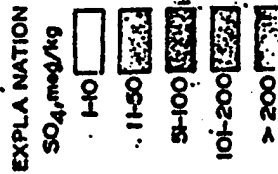
**GEOCHEMICAL MAP III eB**  
 SULFATE

in  
 B SOIL HORIZON (-80 Mesh)  
 ROCKY MOUNTAIN ARSENAL AREA  
 COLORADO

Scale: as noted  
 Base map from U.S.G.S. topographic maps

IntraSearch

Data prepared by Dr. Paul B. Trost  
 September 1976



Scale: 1" = 500'  
 Location: NW 1/4 Section 17, T3S, R66W  
 Wheatfield south of arsenal

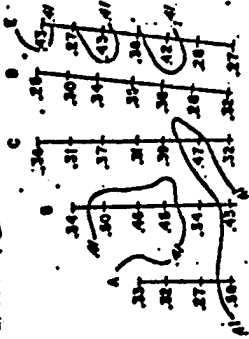
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AN 912 FS 2  
 PN 55 PD 174752/L-100  
 FL Acker Plant

**RSH 918**

1591

Proj. 7597 Iib



Scale: 1"=1000'  
 Location: SW 1/4 Section 14, T2S, R67W  
 Land's wheatfield

**GEOCHEMICAL MAP III f A**  
 CALCIUM

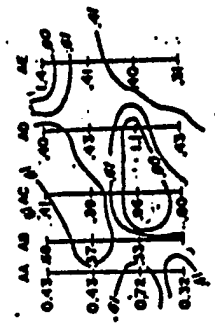
in  
 A SOIL HORIZON (-80 Mesh)  
 ROCKY MOUNTAIN ARSENAL AREA  
 COLORADO

Scale: as noted  
 Base map from U.S.G.S. topographic maps  
 IntraSearch

Data prepared by Dr Paul B. Trost  
 September 1976

EXPLANATION  
 Ca, %

< 0.41	<input type="checkbox"/>
41-60	<input type="checkbox"/>
61-80	<input type="checkbox"/>
> .80	<input type="checkbox"/>



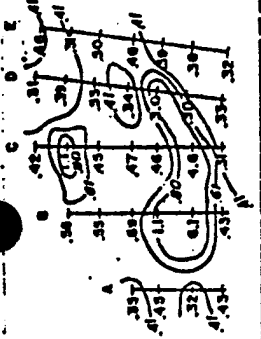
Scale: 1"=500'  
 Location: NW 1/4 Section 17, T3S, R66W  
 Wheatfield south of arsenal

NOTICE: If the film image is less clear than this notice, it is due to the quality of the document being filmed

BM 418  
 PN 55  
 Fl Denver  
 FS 2  
 PD 17438/1-100  
 PLANT

**PSH 918**

**15413**



Scale: 1" = 1000'  
 Location: SW 1/4 Section 14, T2S, R37W  
 Land's wheatfield

**GEOCHEMICAL MAP III f B**  
 in  
**CALCIUM**

**B SOIL HORIZON (-80 Mesh)**  
**ROCKY MOUNTAIN ARSENAL AREA**  
**COLORADO**

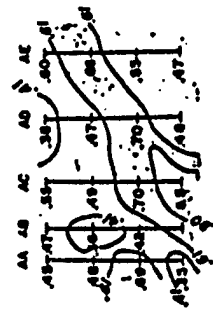
Scale: as noted  
 Base map from U.S.G.S. topographic maps

**IntraSearch**

Data prepared by Dr. Paul B. Trost  
 September 1973

EXPLANATION  
 Ca%

< .041	<input type="checkbox"/>
.41-.60	<input type="checkbox"/>
.61-.80	<input type="checkbox"/>
> .80	<input type="checkbox"/>



Scale: 1" = 500'  
 Location: NW 1/4 Section 17, T3S, R65W  
 Wheatfield south of arsenal

**RSH 918**

**15973**

NOTICE: If the film image is less clear than this notice, it is due to the quality of the document being filmed

BN 912  
 PMS 55  
 FL Denver Plant  
 FS 2  
 PG 174352/1-100  
 Co

Prof. 7597 Iib

# GEOCHEMICAL MAP III 9A

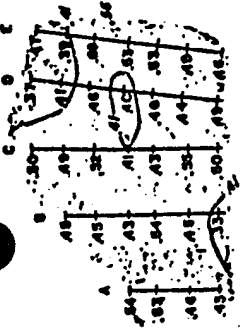
in  
A SOIL HORIZON (-80 Mesh)  
ROCKY MOUNTAIN ARSENAL AREA  
COLORADO

Scale: as noted  
Base map from U.S.G.S. topographic maps  
IntraSearch

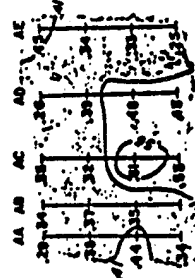
Date prepared by Dr. Paul B. Trost  
September 1976

EXPLA NATION  
Mg %

< 0.41	<input type="checkbox"/>
41-.55	<input type="checkbox"/>
.56-.70	<input type="checkbox"/>
>.70	<input type="checkbox"/>



Scale: 1" = 1000'  
Location: SW 1/4 Section 14, T2 S, R67W  
Land's wheatfield



Scale: 1" = 500'  
Location: NW 1/4 Section 17, T3S, R6SW  
Wheatfield south of arsenal.

## RSH 918

# 1594

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BN 912  
PN 55  
FL Denver Plant  
FS 2  
PD 1777358/1-100

Proj. 7597 Iib



Scale: 1" = 1000'  
 Location: SW 1/4 Section 14, T2S, R67W  
 Land's wheatfield

**GEOCHEMICAL MAP III 9B**  
 in  
**MAGNESIUM**

**B SOIL HORIZON (-80 Mesh)**  
**ROCKY MOUNTAIN ARSENAL AREA**  
**COLORADO**

Scale: as noted  
 Base map from U.S.G.S. topographic maps

**IntraSearch**

Date prepared by Dr. Paul B. Tront  
 September 1976

EXPLA NATION	Mg% %
< 0.41	<input type="checkbox"/>
41-55	<input type="checkbox"/>
56-70	<input type="checkbox"/>
> 70	<input type="checkbox"/>



Scale: 1" = 500'  
 Location: NW 1/4 Section 17, T3S, R66W  
 Wheatfield south of arsenal

**NOTICE:** If the film image is less clear than this notice, it is due to the quality of the document being filmed

BN 912  
 PN 55  
 FL Denver Plant  
 FS 2  
 PD 1727352/L-100

**PSH 918**

159151