University of California
LOS ALAMOS SCIENTIFIC LABORATORY
Post Office Box 1663 Los Alamos, New Mexico 8754

In reply refer to: H12-79-345
Mail stop: 495

August 23, 1979

Mr. Ross A. Scarano
New Facilities Section
Uranium Recovery Licensing Branch
Division of Waste Management
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Ross:

I am enclosing the final report describing the results of analyses of waters, soils, and vegetation collected at Canon City, Colorado. I have attempted to place these results into perspective regarding their potential hazard by comparing them with appropriate standards, ambient level goals, and background or typical concentrations. I hope this evaluation meets the needs which you expressed during our visit to Silver Spring on August 15.

We appreciated the opportunity to talk with you and your staff and Laura Santos and hope such discussions may lead to other studies to meet your confirmatory research needs. Please let me know if you have any questions (FTS:843-3004, Group Office:843-3331).

Sincerely,

Dave

David R. Dreesen
Group H-12, MS-495
Environmental Sciences

DRD:em
F217

Enc: a/s

xc: Mr. Ray Cooperstein, NRC, w/enc
Mr. Kenneth Weaver, Colorado Department of Health, w/enc

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Final Report

Investigation of Environmental Contamination

Canon City, Colorado

D.R. Dreesen
Los Alamos Scientific Laboratory

At the request of the Uranium Recovery Licensing Branch of the Nuclear Regulatory Commission, the Los Alamos Scientific Laboratory has collected and analyzed water, soil and vegetation samples in the Lincoln Park area of Canon City, Colorado near the Cotter Corporation uranium mill. Previous reports have given sampling locations, analytical methodology, analytical quality assurance, and preliminary interpretations of the surface and ground water data. This final report will present all the analytical results and perspectives by which to judge the severity of any apparent contamination.

The chemical analyses of the water samples are presented in Table 1 in group classifications described in the interim report on water samples. The concentrations of these elements (anions) in soils from the Lincoln Park area sampled at depths of 15 and 45cm are presented in Table 3. Typical soil concentrations and some limits for ambient goals are also included in Table 3. The vegetation analyses results are reported in Table 4 along with some typical vegetation concentrations and toxic limits.

The contamination of ground waters has been addressed in some detail in the interim report; however, the potential hazard posed by the use of these waters will be evaluated in the following discussion. Drinking water, irrigation, and livestock standards are presented in Table 2 along with MATE (Minimum Acute Toxicity Effluents), Ambient Level Goals (ALG) and New Mexico ground water regulations. The MATE values and Ambient Level Goals were developed for the US EPA by the Research Triangle Institute as a part of the Multimedia Environmental Goals (MEG's) program. MEG's are "levels of significant contaminants or degradents

(in ambient air, water or land or in emissions or effluents conveyed to the ambient media) that are judged to be (1) appropriate for preventing certain negative effects in the surrounding populations or ecosystems, or (2) representative of the control limits achievable through technology" (Cleland and Kingsbury, 1977). Minimum Acute Toxicity Effluents represent emission level goals, ie. "concentrations of pollutants in undiluted emission streams that will not adversely affect those persons or ecological systems exposed for short periods of time" (Cleland and Kingsbury, 1977). The Ambient Level Goals (ALG) "describe estimated permissible concentrations for continuous exposure" and "are based on: (1) current or proposed Federal ambient standards or criteria; (2) toxicity (acute and chronic effects considered); and (3) carcinogenic or teratogenic potential" (Cleland and Kingsbury, 1977). The New Mexico ground water regulations were issued in January 1977 as the "Amended Water Quality Control Commission Regulations".

Comparing the concentrations in Table 1 with the standards and goals in Table 2, it is apparent that U values for groups I, II and III exceed the proposed drinking water standards and the ALG based on health effects. Groups I and II exceed the ALG and MATE based on ecological effects. Thus, the soluble uranium content of Lincoln Park ground waters is highly elevated with respect to Arkansas River water and exceeds suggested thresholds below which ecological and health effects are not expected. Molybdenum concentrations in these ground waters greatly exceed irrigation standards as well the ALG based on health and ecological effects and the levels in Group I waters exceed the MATE based on ecological effects. Only two surface water samples (W-1, W-9) from the Sand Creek area exceed any standards or goals for selenium yet in these two cases the concentrations (~100ppb) exceed all the standards and goals presented in Table 2. Sulfate concentrations in waters from Groups I and II exceed the livestock and secondary drinking water standards. However, only two water samples (W-1, W-2) have chloride concentrations greater than the secondary drinking waters standard.

In summary, on the basis of these samples being representative of surface and ground waters in the Lincoln Park area, these ground waters (Groups I, II and perhaps III) represent potential health and ecological hazards due to the concentrations of U and Mo which exceed standards and ambient level goals. Thus, these ground waters may cause adverse health effects if consumed and adverse ecological effects if these waters reach the surface via pumping for irrigation or natural discharge.

Table 3 presents the concentrations of U, Mo, Se, SO_4, and Cl in soil samples from depths of 15 and 45cm. The means and standard deviations are reported along with values for comparison including estimated background concentrations, typical soil concentrations (Brooks, 1972), soil concentrations in the Grants Mineral Belt (Dreesen and Marple. 1979), and MATE and ALG levels for land (Cleland and Kingsbury, 1977). Estimated background was selected as the lowest concentration found for samples S-10 through 17. This background compares well with the typical and the LASL soil concentrations for U and Mo and is from 2 to 5 times less for Se. If a level twice the estimated background is used as the lower limit indicating contamination, soil samples from the base of the Sand Creek Dam (S-1, S-2), Bosco Field (S-5, S-6) and McKellar Pasture (S-10) are apparently contaminated with uranium. However, the highest concentration (S-1), 13.8ppm, is only 4 times background and exceeds only the ALG based on health effects. This Ambient Level Goal of 0.6ppm is unrealistic since the goal is less than typical or background soil concentrations and thus will be ignored. In addition, the onset of adverse effects to plants occurs at soil U levels of about 50ppm (Hanson, 1974). Thus, these soil concentrations are probably not a significant hazard; this conclusion is substantiated by the relatively low U concentration in the vegetation which will be discussed later.

A number of samples exceed twice background for Mo; these include S-1 through S-7 and S-16. The highest molybdenum values, 24ppm, are about 15 times background and exceed the ALG's based on health and ecological effects. However, the ALG of

2ppm for ecological effects is approximately background concentration and is not appropriate for comparison. These Mo values in Lincoln Park do become a concern when compared with a pasture in Karnes County, Texas where uranium ore was stockpiled. Pasture soils contained from 4 to 8ppm Mo and cattle grazing on this pasture were diagnosed as suffering molybdenosis (Chappell, 1975; Dollahite et. al, 1972). Thus, the soil levels of Mo in the Sand Creek area, Bosco Field, Ransom Field, and Chase Residence pose potential hazards to ruminants grazing in these areas. Molybdenum levels in the vegetation will be addressed later.

Selenium concentrations in the soils are all near or below typical soil concentrations and exceed only the ALG based on health effects which is again perceived as being unrealistic. There is no indication that Se is a problem in the soils. Sulfate and chloride levels in the soils are quite variable perhaps as a result of fertilizers being applied to field and garden soils. The high sulfate levels in the Sand Creek area and the Bosco field may result from the high sulfate concentrations in the waters and may be advantageous since it is reported that additions of sulfate decrease the uptake of molybdenum by plants (Allaway, 1977).

In summary, the Mo concentration in the soils may be above or near hazardous levels to grazing by cattle or sheep. The interference of Mo uptake by sulfate may account for only a few instances of molybdenum toxicity being reported in the Lincoln Park area. Aluminum sulfate is often used to increase soil acidity and since Mo is less available at lower pH's and sulfate competes with the uptake of Mo, it may be advisable to add aluminum sulfate to pasture soils as a temporary mitigative measure.

The concentrations of U, Mo, Se, SO_4, and Cl in vegetation samples are presented in Table 4 along with reported toxic levels to grazing animals (Chappell, 1975; Rosenfeld and Beath, 1964), recommended maximum concentrations in plant leaves (NRC, 1979), typical plant concentrations (Brooks, 1972; Hanson, 1974), and LASL results for plants growing in soils or tailings (Dreesen and Marple, 1979). One

anomalous uranium result (V-3), 390ppb, is the only vegetation sample exhibiting a U concentration significantly above typical plant concentrations. Since the soil from this sampling location had a relatively low U content, 3.9ppm, the only apparent explanation is that the particular grass species sampled had a greater propensity to assimilate U and also Mo. The molybdenum value for the grass in the Bosco Field, 60ppm, is well above toxic concentrations in grass from the Karnes County, Texas pasture, 15-45ppm. This sample exceeds toxic levels, 5-20ppm, and recommended maximum concentration by 20 times. The remaining vegetation samples (excluding the Peterson sample) fall into the range of 0.5-3.3ppm Mo which is somewhat lower than the concentration we found in plants growing in background Grants Mineral Belt soil. The selenium concentrations are not much greater than typical plant concentrations and are less than what we found in plants growing in the Grants soils. The sulfate and chloride concentrations are highly variable probably as a result of variability in SO_4 and Cl content of soil and species differences. Thus, the only vegetation sample of particular concern is the Bosco Field grass sample with 60ppm Mo. If this sample is representative of the entire Bosco Field and other species within the field, then there is clearly a significant hazard to ruminants grazing in this field. Even the high sulfate concentrations in the Bosco Field Well and soil have not competed enough with molybdenum uptake to make this vegetation innocuous. Any additional sulfate applications would probably have no significant effect on Mo uptake. Thus, grazing should be prohibited on this pasture under the assumption that the one vegetation sample is representative of concentration in vegetation throughout the field.

From the above discussions, it is apparent that Mo is probably a major concern regarding the contamination of soils and vegetation. Thus, an extensive and intensive sampling program is recommended to ascertain molybdenum levels in soils and vegetation with a greater degree of confidence. In addition, since U and Mo appear to be the elements of most concern in ground water, a more detailed

study of these parameters would better define the extent of contamination, the temporal variability in concentrations, and the health and ecological hazards resulting from the use of this water.

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Table 1. Chemical Analyses of Surface and Ground Water Samples from Canon City, Colorado

Group	Sample Number	Sample Location	U Conc. ppb	Mo Conc. ppm	Se Conc. ppb	SO_4 Conc. ppm	Cl Conc. ppm	pH
I	W-1	Sand Creek Dam Pond	5790	25	113	3600	320	7.7
I	W-9	Interception Trench	4400	11	115	2200	220	7.6
I	W-2	Sand Creek Dam Seep	2800	15	4	4600	370	8.[illegible]
I	W-4	Bosco Field Well	2160	24	<3	2400	120	7.7
II	W-3	Bosco House Well	640	2.3	<3	580	34	7.6
II	W-6	Peterson Well	540	3.8	<3	550	37	7.6
II	W-5	Ransom Well	460	1.0	<3	390	31	7.5
III	W-11	Boughton Well	54	0.70	<3	90	12	7.4
III	W-8	McKellar Well	40	0.03	<3	93	32	7.2
IV	W-10	Arkansas River Background	4	0.08	<3	20	2	8.2
IV	W-7	Dye Irrigation Ditch	3	0.08	<3	24	8	8.[illegible]
IV	W-12	Arkansas River Downstream	3	0.08	<3	21	2	7.8
		Group Means ø± Std. Dev.						
		I	3790±1630	19±6.9		3200±1120	260±110	
		II	550±90	2.4±1.4		510±100	34±3	
		III	47±10	0.4±0.4		92±2	22±14	
		IV	3±1	0.08		22±2	4±3	

Table 2. Standards and Recommended Levels for Contaminant Concentrations in Waters

Element	Units	Water Standard	Value	MATE* Based on Health Effects	MATE* Based on Ecological Effects	Ambient Level Goals Based on Health Effects	Ambient Level Goals Based on Ecological Effects	New Mexico Ground Water Regulations
U	ppb	Drinking Water	10**	60000	500	3	100	5000
Mo	ppm	Continuous Irrigation	0.01	75	7	0.07	1.4 0.01***	1.0***
Se	ppb	Continuous Irrigation	20	50	25	10	5	50
		Livestock	50					
		Drinking Water	10					
SO_4	ppm	Livestock	250					600
		Secondary Drinking Water	250					
Cl	ppm	Livestock	3000	1300				250
		Secondary Drinking Water	250					

*Minimum Acute Toxicity Effluents
**Proposed
***For irrigation

Table 3. Chemical Analyses of Soils Sampled at Depths of 15cm and 45cm in the Lincoln Park area of Canon City, Colorado.

Group*	Sample No. and Location	U Conc. 15cm**	U Conc. 45cm	Mo Conc. 15cm	Mo Conc. 45cm	Se Conc. 15cm	Se Conc. 45cm	SO_4 Conc.*** 15cm	SO_4 Conc.*** 45cm	Cl Conc.*** 15cm	Cl Conc.*** 45cm
		ppm	ppm	ppm	ppm	ppb	ppb	ppm	ppm	ppm	ppm
I	S-1, S-2 Sand Creek Dam	13.8	6.4	24	9.5	76	220	2300	3200	34	49
I	S-3, S-4 Sand Creek Downstream	6.1	4.2	4.0	3.2	19	22	63	1200	45	4200
I	S-5, S-6 Bosco Field	6.6	9.9	15	24	300	320	3500	3800	32	16
II	S-7, S-8 Ransom Field	3.5	3.5	5.9	2.6	280	250	120	130	130	28
II	S-9 Peterson Flower Bed	3.9		3.3		380		210		55	
III	S-10, S-11 McKellar Pasture	7.6	3.8	2.2	2.3	540	520	25	28	8	16
III	S-14, S-15 Boughton Residence	4.3	3.7	3.6	2.2	540	320	38	55	24	19
–	S-12, S-13 May Residence	3.3	2.8	1.9	1.6	430	240	55	42	52	37
–	S-16, S-17 Chase Residence	4.3	3.7	4.9	1.5	260	230	470	430	37	130
	Mean ± 1 S.D.	5.9±3.3	4.8±2.3	7.2±7.4	5.9±7.8	310±180	260±140	750±1260	1110±1530	46±35	560±1470
	Background	3.3	2.8	1.9	1.5	260	230	25	28	8	16
	Typical Soils	1	1	2.5	2.5	500	500				
	LASL Soils	1.5-3.6	1.5-3.6	0.3-1.9	0.3-1.9	600-1200	600-1200				
	MATE[a]										
	Health	12000	12000	15000	15000	10000	10000	–	–	2600	2600
	Ecological	100	100	1400	1400	5000	5000	–	–	–	–
	Ambient Level Goal[a]										
	Health	0.6	0.6	14	14	100	100	–	–	–	–
	Ecological	20	20	2	2	1000	1000	–	–	–	–

*Refers to group classification for water samples **Soil sampling depth ***Soil concentration extracted by carbonate-bicarbonate buffer

[a] MATE's and ALG's revised according to G.L. Kingsbury, 8/21/79.

Table 4. Chemical Analyses of Vegetation Samples from the Lincoln Park Area of Canon City, Colorado (Dry Weight Basis)

Group	Sample No. and Type	Sample Location	U Conc. ppb	Mo Conc. ppm	Se Conc. ppb	SO_4 Conc.* ppt (mg/g)	Cl Conc.* ppt (mg/g)
I	V-1 Rye Grass	Bosco Field	110	60	370	6.0	16.0
II	V-2 Grama Grass	Ransom Field	90	3.4	290	0.4	3.0
II	V-3 Grass	Peterson Flower Bed	390	7.1	180	0.7	1.1
III	V-6 Apples	Boughton Residence	80	1.9	110	4.1	2.6
III	V-7 Cherries	Boughton Residence	60	1.2	180	4.5	1.8
IV	V-4 Grass	Dye Ditch	60	3.2	88	4.2	17.0
–	V-5 Unknown Species	May Residence	30	3.3	190	1.2	4.2
–	V-8 Asparagus	Chase Residence	60	1.6	190	0.4	15.0
–	V-9 Cherries	Chase Residence	10	3.2	70	1.8	0.5
–	V-10 Apples	Shane Residence	20	0.5	40	6.9	1.8
	Toxic Levels			5-20	5000		
	Recommended Max. Conc.			3	3000		
	Typical Plant Conc.		50 <1000	0.65	100		
	LASL Results	Growing in Soils	10-100	2-13	1000-3100	–	1.1-14.3
		Growing in Tailings	150-3000	78-273	35000-74000	–	6.7-16.6

*Vegetation concentration extracted by carbonate-bicarbonate buffer.

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DOCKET

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In reply refer to: LS6-79-133
Mail stop: 495

December 18, 1979

Mr. Ray Cooperstein
New Facilities Section
Uranium Recovery Licensing Branch
Division of Waste Management
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Ray:

The purpose of this letter is to relay the analytical results of our sampling trip to Canon City, Colorado on October 15 and 16, 1979. In addition, some discussion of these results is included assessing the contamination found in waters, soils, and vegetation.

The data on the chemical analysis of the water samples are shown in Table 1 as well as the concentrations found in samples collected in June 1979. Indications of uranium contamination (>100ppb) are seen for stations S-13, S-5, OW-1, OW-4, 38, 42, 40, and 39 with slightly elevated levels at stations 41 and 20. However, the degree of uranium contamination has been reduced by 60 to 80% at stations 38, 39, 40, and 42 from the levels found in June 1979. Molybdenum levels are elevated (>0.2ppm) at stations S-13, S-5, OW-1, OW-4, OW-5, OW-6, 38, 42, 40, and 39 and station 41 and 20 show some Mo enrichment (>0.1ppm). Stations 38, 39, 40, and 42 show Mo concentrations reduced by 40 to 80% compared with the June 1979 samples. Sulfate and chloride concentrations at these four stations are reduced by 70 to 90% and 60 to 80%, respectively. Thus, the ground water at stations 38, 39,40, and 42 appears to have been diluted by infiltrating irrigation water or to have been displaced by higher quality ground water moving into these aquifers in the terrace deposits (and possibly into the Vermejo Formation for station 42). High sulfate concentrations at stations 41, OW-5, and OW-6 are not related to appreciably enhanced levels of Mo and U. Thus, the October 1979 samples show a reduction in contamination of ground water at stations 38, 39, 40 and 42. Additional locations sampled during October indicate slightly elevated U and Mo concentrations at sites 41 and 20.

The concentrations of U and Mo in surface soils (top 1 cm) and sub-surface soils (at 15 cm) are shown in Table 2. In addition, critical values have been calculated at three probability levels (P - 0.05, 0.01, and 0.0005) which are the minimum values significantly different from the mean of the four background concentrations. Those locations with significantly greater U (P - 0.05) in both surface and subsurface soils include Sand Creek Dam Pond Shoreline, Interception Trench, Bosco Field, Ransom Garden, and Sand Creek Drainage between Bosco and McKellar behind a stock pond dam. These

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same locations had significantly elevated Mo except for one sample from Bosco Field and Ransom Garden and both surface and subsurface samples from the Sand Creek Drainage. The surface soil from the Petersen Lawn shows some indication of being elevated in U. In addition, the surface soils from Ransom Native Grass Pasture and the subsurface soils from Ransom Garden and Petersen Field may be slightly elevated in Mo concentration. Stations S-5 and S-13 have soils which are obviously contaminated with Mo and U. The soils which have been irrigated with contaminated ground water (stations 38 and 40) show elevated levels of U and Mo indicating accumulation of these contaminants in soils resulting from the application of contaminated ground water. Contamination of soils by applying irrigation water high in Mo has been predicted by Vlek and Lindsay (1977) for fine-textured soils where leaching of Mo out of the rootzone is not expected. This data seems to indicate an actual instance where the application of contaminated irrigation water has significantly elevated U and Mo levels in soils. The presence of pockets of contaminated sediments in the Sand Creek Drainage may indicate that contaminated irrigation water from the Bosco Field may have drained into Sand Creek at some time in the past or that wind blown tailings deposited on soils below Sand Creek Dam have been removed by water erosion and deposited in isolated areas where fine sediments could settle (such as behind the dike in Sand Creek).

The U, Mo, and Cu contents of vegetation growing in the Lincoln Park area are given in Table 3. The Cu/Mo ratio is also included. Those vegetation samples greater than two times the background sample concentrations are indicated by asterisks. The grass and Kochia samples from Sand Creek Dam and the Interception Trench are highly contaminated with U and Mo as a result of surficial contamination and/or plant uptake. The Sand Creek Drainage grass and Kochia are elevated somewhat in U; these samples came from the area behind the dike where elevated U levels were found in the soil. The alfalfa sample was not elevated in U and came from the sandy channel bottom were the soils had low levels of U. However, the alfalfa and grass contained high concentrations of Mo but neither soil sample had elevated levels of Mo. This discrepancy may be a result of sampling numerous scattered plants which might have been growing in sediments not represented by the two soil sample locations. At the Bosco Field location, the three grass types and the Kochia were all elevated in U and Mo as were the soils. High concentrations of Mo were found in the alfalfa growing in the Ransom Garden and the soil was slightly elevated in Mo. The grass from the Petersen Lawn was highly enriched in U and Mo compared with background grass concentrations; yet, the soil did not have significantly elevated levels of either U or Mo. Thus, it appears that those sites irrigated with contaminated water generally have elevated U and Mo soil concentrations and also elevated levels of these contaminants in the vegetation. In cases such as the Petersen Lawn, high concentrations in the vegetation would not have been expected from the low soil concentrations. Thus, the hazard posed by using contaminated irrigation water can not be assessed by looking only for accumulation in soils.

Other investigators have indicated that Cu:Mo ratios less than two in forage can cause molybenosis symptoms in grazing animals. At a number of stations we found Cu:Mo ratios less than two: Sand Creek Dam, Interception

TO: Mr. Ray Cooperstein DATE: December 18, 1979

Trench, Sand Creek Drainage, Bosco Field, Ransom Garden (alfalfa) and Petersen Lawn. All these stations (S-5, S-13, 38, 40, 42) have forage which has Mo concentrations elevated to such an extent that molybdenosis might occur if sufficient quantities of this vegetation were consumed by grazing animals. Thus, irrigation of pasture or alfalfa fields with contaminated ground water is not recommended until such time as the Mo levels in the ground water have been reduced and remain at low levels.

It appears that the most direct link to the contamination of soils and vegetation in the Lincoln Park area is the application of contaminated ground water. However, contamination of soils and vegetation in the Sand Creek Drainage can not be directly linked to application of contaminated ground water and other mechanisms may be responsible for these elevated levels.

If you have any questions regarding these results or interpretations, please let me know.

Sincerely,

Dave

David R. Dreesen
Group LS-6, MS-495
Environmental Sciences

DRD:em
F217

xc: Mr. Ken Weaver, CDH
Mr. Dick Gamewell, CDH
Mr. Ross Scarano, NRC
Mr. Robert Maixner, Cotter Corp.

Table 3. Concentrations of U, Mo, and Cu in Vegetation from the Lincoln Park Area of Canon City, Colorado Collected in October 1979 (dry weight basis)

Station Number	Location	Vegetation Type	U Conc. (ppm)[d]	Mo Conc. (ppm)[d]	Cu Conc. (ppm)[d]	Cu/Mo Ratio
S 5	Sand Creek Dam	Grass	6.67*	118*	29	0.25*
	Pond Shoreline	Kochia	4.48*	38*	20	0.53*
S 13	Interception Trench	Grass	35.9*	50*	47	0.94*
	East End	Kochia	11.7*	46*	39	0.85*
-	Sand Creek Drainage	Grass	0.56*	89*	40	0.45*
	Between 37 and 38	Kochia	0.50*	3*	43	14.3
		Alfalfa[a]	0.10	14*	23	1.64*
38	Bosco Field	Grass #1	0.59*	187*	74	0.40*
	Near Well	Grass #2	1.51*	29*	46	1.59*
		Grass #3	0.73*	133*	48	0.36*
		Kochia	0.37*	111*	26	0.23*
41	Ransom Native	Grass	0.12	2	85	42.5
	Grass Pasture	Grass	0.09	4	36	9.0
40	Ransom Garden	Alfalfa	0.15	30*	20	0.67*
		Peas	0.02	9	5.3	0.59
42	Petersen Field	Kochia	0.02	3*	18	6.00*
	Petersen Lawn	Grass	2.04*	72*	34	0.47*
20	Calhoun	Alfalfa #1	0.07	8	21	2.63
		Alfalfa #2	0.07	5	23	4.60
		Peas[b]	0.01	11	7.3	0.66
24	Merlino Lawn	Grass	0.26	2	45	22.5
47	Silengo Alfalfa	Alfalfa	0.10	1	11	11.0
	Field	-	-	-	-	-
11	Salardino Lawn	Grass	0.09	1	33	33.0
		Kochia	0.14	1	22	22.0
-	East Background	Grass	0.12	4	27	6.75
	Four Mile Road	Kochia	0.05	<1	22	>22.0
	and Highway 50	Alfalfa	0.13	7	29	4.14
-	West Background	Grass #1	0.09	1	78	78.0
	Below Grape Creek	Grass #2	0.09	<1	45	>45.0
	at Arkansas River	Grass #3	0.27	5	41	8.20
		Kochia	0.16	1	23	23
		Alfalfa	0.23	5	26	5.20
	Critical Values[c]	Grass	0.54	10	-	3.4
		Kochia	0.32	2	-	11
		Alfalfa	0.46	14	-	2.1

[a] Probably included some white sweet clover

[b] Black-eyed peas or cowpeas

[c] Two times highest background sample of that vegetation type for U and Mo and one-half of the lowest Cu:Mo ratio for that vegetation type

[d] Analytical uncertainty U - ± 10% at conc. > 0.1 ppm
± 0.01 at conc. < 0.1 ppm
Mo - ± 10% at conc. > 10 ppm
± 1 ppm at conc. < [illegible] ppm
Cu - ± 10%

* Greater than critical value for U and Mo; Less than critical value for Cu:Mo ratio

Table 2. Uranium and Molybdenum Concentrations in Surface (top 1 cm) and Subsurface (at 15 cm) Soils from the Lincoln Park Area of Canon City, Colorado

Station Number	Location	Sample	U Conc. (ppm)[d] Surface	U Conc. (ppm)[d] 15 cm	Mo Conc.[e] (ppm) Surface	Mo Conc.[e] (ppm) 16 cm
S 5	Sand Creek Dam	#1	50***	c	134***	c
	Pond Shoreline	#2	37***	42***	39***	25***
S 13	Interception Trench	#1	63***	11.2**	196***	17**
	East End	#2	73***	8.2*	106***	14**
-	Sand Creek Drainage	#1[a]	3.4	2.2	2	2
	Between 37 and 38	#2[b]	6.7*	25***	5	4
38	Bosco Field	#1	8.2*	10.4**	18**	10**
	Near Well	#2	9.0*	13.9**	4	24***
41	Ransom Native	#1	4.6	3.8	6	3
	Grass Pasture	#2	4.4	3.9	6	3
40	Ransom Garden	#1	8.3*	8.5**	7*	6
42	Petersen Field	#1	3.8	3.5	4	6
	Petersen Lawn	#1	5.3	3.4	5	4
20	Calhoun Alfalfa	#1	3.6	3.9	1	1
	Field	#2	3.7	3.7	1	1
24	Merlino Lawn	#1	3.9	3.7	2	1
47	Silengo Alfalfa Field	#1	4.1	4.1	2	2
11	Salardino Lawn	#1	3.5	3.5	2	2
		#2	3.8	3.6	2	1
-	East Background	#1	5.3	4.9	5	5
	Four Mile Road	#2	4.0	4.7	3	4
	and Highway 50					
-	West Background	#1	3.2	3.1	4	3
	Below Grape Creek	#2	3.1	3.7	2	3
	at Arkansas River					
	Critical Value		6.6*	6.3*	6.9*	6.3*
	Sign. Greater		9.1*	8.4**	10.0**	8.6**
	Than Mean of Backgrounds		18.6***	16.4***	22.1***	17.6***

[a] Sandy channel bottom

[b] Sediments behind dike - stock pond?

[c] No sample

[d] Analytical uncertainty ± 6%

[e] Analytical uncertainty ± 10% at conc. > 10 ppm
± 1 ppm at conc. < 10 ppm

* P = 0.05 one tailed test

** P = 0.01 one tailed test

*** P = 0.0005 one tailed test

Table 1. Concentrations of U, Mo, SO_4, Cl and pH in Waters Collected During June and October 1979 in the Lincoln Park Area of Canon City, Colorado

Station	Location	U Conc. (ppb) 6/79	U Conc. (ppb) 10/79	Mo Conc. (ppm) 6/79	Mo Conc. (ppm) 10/79	SO_4 Conc. (ppm) 6/79	SO_4 Conc. (ppm) 10/79	Cl Conc. (ppm) 6/79	Cl Conc. (ppm) 10/79	pH 6/79	pH 10/79
S-13	Interception Trench	4400	4930	11	25	2200	6500	220	210	7.6	7.7
S-5	Sand Creek Dam Pond	5790	4780	25	5.6	3600	3700	320	250	7.7	8.4
OW-1	Obs. Well OW-1A	–	3470	–	15.3	–	3700	–	240	–	7.4
OW-4	Obs. Well OW-4A	–	1690	–	8.3	–	1900	–	84	–	7.9
41	Ransom Field	–	58	–	0.10	–	580	–	49	–	7.6
38	Bosco Field	2160	720	24	5.2	2400	460	120	28	7.7	8.0
OW-5	Obs. Well OW-5A	–	8.6	–	0.39	–	360	–	14	–	10.5
11	Salardino	–	5.4	–	0.02	–	320	–	27	–	7.1
OW-6	Obs. Well OW-6A	–	8.5	–	0.29	–	290	–	24	–	7.8
42	Petersen	540	150	3.8	0.87	550	140	37	15	7.6	7.9
40	Ransom House	460	190	1.0	0.58	390	110	31	12	7.5	7.8
39	Bosco House	640	150	2.3	0.56	580	70	34	7	7.6	7.8
24	Merlino	–	23	–	0.02	–	60	–	13	–	7.5
47	Silengo	–	14	–	0.02	–	60	–	7	–	7.4
20	Calhoun	–	59	–	0.19	–	40	–	12	–	7.9