APPENDIX A
CLIMATIC INFORMATION

Appendix A

A.1.0 Climatic Information

Rio Algom's Ambrosia Lake site is located in the climatological subdivision of New Mexico designated "Southwestern Mountains". This designation is characterized by low precipitation, abundant sunshine, low relative humidity, and moderate temperatures with large diurnal and annual ranges. The regional climate is classified as semi-arid, continental (BSw, or Steepe with a winter dry season Koppen-Geiger system).

The evaporation ponds are situated in a broad valley at elevations varying from approximately 6,880 to 6,944 feet. Two and half miles to the northeast, San Mateo Mesa rises to near 8,200 feet and a few miles to the west, Mesa Montanosa rises to approximately 7,500 feet. These topographical features create a significant blocking effect to synoptic scale influences and modify the wind regime in the area. Other meteorological parameters, however, would not be expected to differ greatly from those found at other stations of similar altitude in the region.

A.1.1. Speed, Wind Direction, and Stability

The topography in the area suggests a wind regime dominated by two major influences: night-time drainage of cold air from the high mesas, and channeling of synoptic winds through the northwest-southeast oriented valley.

Rio Algom's predecessor company "Quivira Mining Company" had a meteorological station in the area. However, the data was limited in scope and therefore additional data from other area sources were used in describing area's weather conditions.

Data from a New Mexico Environmental Department (NMED) operated site located approximately 3 miles northeast of the evaporation ponds, is presented in Tables A-1 to A-8. This site operated for nearly 11 months. Table A-1 presents a joint frequency distribution of wind direction by the six wind speed classes independent of stability. The predominant wind directions are westerly and north northwesterly, which agrees with expectations based upon terrain influence.

Tables A-2 through A-8 present joint frequency distributions of wind speed and direction by each of Pasquill's seven (7) stability classes.

Stability classes were delineated (according to the method described in NRC Regulatory Guide 1.23) by using Sigma Theta, the standard deviation of horizontal wind direction measurements. Hourly values were approximated by dividing the range of the hourly wind direction (width of the wind direction trace) by six (Markee, 1986) (Pendergast and Crawford, 1974). As this method may erroneously assign unstable classes when nighttime winds are light and variable, an algorithm described by Mitchell and Timbre was incorporated which assigns unstable nighttime classes to a neutral or stable class according to the wind speed.

TABLE A-1. JOINT FREQUENCY DISTRIBUTION - INDEPENDENT OF STABILITY

	Wind Speed Class (MPH)					
Direction	1-3	4-7	8-12	13-18	19-24	>24	Total
N	187	180	40	7	0	0	414
NNE	302	152	20	2	0	0	476
NE	214	43	12	1	1	0	271
ENE	145	17	7	6	0	0	175
E	185	23	6	2	0	0	216
ESE	107	53	23	9	0	0	192
SE	131	73	22	3	1	0	230
SSE	119	56	21	8	2	0	206
S	136	140	85	31	2	0	394
SSW	87	135	121	35	5	0	383
SW	94	74	80	42	9	0	301
WSW	81	90	99	87	12	0	369
W	133	153	169	127	28	0	610
WNW	84	102	88	50	14	1	445
NW	170	120	86	57	11	1	445
NNW	254	202	112	26	5	1	600
Total	2429	1613	993	493	90	3	

No. of Calms were 20
Total No. of Occurrences were 5641

TABLE A-2. CLASS A EXTREMELY UNSTABLE (STABILITY CLASS - 1)

	Wind Speed Class (MPH)						
Direction	1-3	4-7	8-12	13-18	19-24	>24	Total
N	2	0	0	0	0	0	2
NNE	2	0	0	0	0	0	2
NE	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0
E	1	0	0	0	0	0	1
ESE	0	1	0	0	0	0	1
SE	1	0	0	0	0	0	1
SSE	3	0	0	0	0	0	3
S	5	2	0	0	0	0	7
SSW	4	4	0	0	0	0	8
SW	4	5	0	0	0	0	9
WSW	12	4	0	0	0	0	16
W	2	7	0	0	0	0	9
WNW	4	1	0	0	0	0	5
NW	1	6	0	0	0	0	1
NNW	3	1	0	0	0	0	4
Total	44	31	0	0	0	0	

No. of Calms were 0
Total No. of Occurrences were 75

TABLE A-3. CLASS B MODERATELY UNSTABLE (STABILITY CLASS – 2)

	Wind Speed Class (MPH)						
Direction	1-3	4-7	8-12	13-18	19-24	>24	Total
N	2	5	0	0	0	0	7
NNE	3	3	1	0	0	0	7
NE	2	2	1	0	0	0	5
ENE	0	3	0	0	0	0	3
E	0	1	0	0	0	0	1
ESE	1	0	0	0	0	0	1
SE	3	1	0	0	0	0	4
SSE	9	2	1	0	0	0	12
S	12	10	0	0	0	0	22
SSW	7	11	2	0	0	0	20
SW	4	4	2	1	0	0	11
WSW	5	9	1	0	0	0	15
W	5	6	1	0	0	0	12
WNW	6	5	0	0	0	0	11
NW	4	13	0	0	0	0	17
NNW	4	8	0	0	0	0	12
Total	67	83	9	1	0	0	

No. of Calms were 0
Total No. of Occurrences were 160

TABLE A-4. CLASS C SLIGHTLY UNSTABLE (STABILITY CLASS – 3)

	Wind Speed Class (MPH)						
Direction	1-3	4-7	8-12	13-18	19-24	>24	Total
N	1	11	6	0	0	0	18
NNE	3	2	1	0	0	0	6
NE	0	5	0	0	0	0	5
ENE	1	1	0	0	0	0	2
E	1	1	0	0	0	0	2
ESE	4	4	0	0	0	0	8
SE	6	2	0	0	0	0	8
SSE	12	12	0	0	0	0	24
S	23	20	4	0	0	0	47
SSW	10	17	15	0	0	0	42
SW	10	9	4	1	0	0	24
WSW	7	10	16	3	0	0	36
W	17	19	12	4	0	0	52
WNW	8	21	2	0	0	0	31
NW	10	11	11	0	0	0	32
NNW	2	11	10	1	0	0	24
Total	115	156	81	9	0	0	

No. of Calms were 2
Total No. of Occurrences were 363

TABLE A-5. CLASS D NEUTRAL (STABILITY CLASS – 4)

	Wind Speed Class (MPH)						
Direction	1-3	4-7	8-12	13-18	19-24	>24	Total
N	45	34	10	2	0	0	91
NNE	25	6	3	1	0	0	35
NE	28	6	3	0	0	0	37
ENE	23	0	0	0	0	0	23
E	35	1	1	0	0	0	37
ESE	24	7	2	1	0	0	34
SE	35	15	8	0	0	0	58
SSE	24	14	6	1	0	0	45
S	28	32	25	9	0	0	94
SSW	21	29	33	5	1	0	89
SW	23	12	29	19	6	0	89
WSW	16	18	28	33	3	0	98
W	21	23	39	38	5	0	126
WNW	14	24	28	17	2	0	84
NW	30	19	28	11	0	0	88
NNW	53	35	28	5	1	0	122
Total	445	275	270	142	18	0	

No. of Calms were 4
Total No. of Occurrences were 1154

TABLE A-6. CLASS E SLIGHTLY STABLE (STABILITY CLASS – 5)

	Wind Speed Class (MPH)						
Direction	1-3	4-7	8-12	13-18	19-24	>24	Total
N	54	54	17	5	0	0	130
NNE	95	31	5	1	0	0	132
NE	64	12	4	1	0	0	81
ENE	57	6	3	4	0	0	70
E	80	13	3	0	0	0	96
ESE	43	23	12	3	0	0	81
SE	42	30	7	1	1	0	81
SSE	39	20	7	2	1	0	69
S	39	33	26	14	1	0	113
SSW	19	40	38	23	4	0	124
SW	26	23	25	15	2	0	91
WSW	23	26	27	37	9	0	122
W	39	47	55	58	17	0	216
WNW	28	24	27	22	11	1	113
NW	70	33	25	29	6	0	163
NNW	98	82	35	11	1	0	227
Total	816	497	316	226	53	1	

No. of Calms were 1
Total No. of Occurrences were 1910

TABLE A-7. CLASS F MODERATELY STABLE (STABILITY CLASS – 6)

	Wind Speed Class (MPH)						
Direction	1-3	4-7	8-12	13-18	19-24	>24	Total
N	26	54	6	0	0	0	86
NNE	93	67	8	0	0	0	168
NE	52	11	4	0	1	0	68
ENE	15	5	2	2	0	0	24
E	33	3	2	2	0	0	40
ESE	14	15	7	5	0	0	41
SE	16	13	7	2	0	0	38
SSE	12	5	7	5	0	0	29
S	14	36	23	7	1	0	81
SSW	9	29	28	6	0	0	72
SW	9	17	17	5	0	0	48
WSW	11	19	27	13	0	0	70
W	22	36	43	27	4	0	132
WNW	8	20	24	10	1	0	63
NW	14	24	16	16	3	1	74
NNW	45	43	32	5	3	1	129
Total	393	397	253	105	13	2	

No. of Calms were 3
Total No. of Occurrences were 1166

TABLE A-8. CLASS G EXTREMELY STABLE (STABILITY CLASS – 7)

	Wind Speed Class (MPH)						
Direction	1-3	4-7	8-12	13-18	19-24	>24	Total
N	10	18	1	0	0	0	29
NNE	18	39	2	0	0	0	59
NE	13	6	0	0	0	0	19
ENE	4	1	0	0	0	0	5
E	6	2	0	0	0	0	8
ESE	2	1	1	0	0	0	6
SE	6	8	0	0	0	0	14
SSE	3	1	0	0	1	0	5
S	1	6	7	0	0	0	14
SSW	2	3	4	1	0	0	10
SW	3	1	3	1	1	0	9
WSW	2	4	0	1	0	0	7
W	9	12	17	0	2	0	40
WNW	2	5	7	1	0	0	15
NW	2	11	6	1	2	0	22
NNW	7	18	7	4	0	0	36
Total	90	136	55	9	6	0	

No. of Calms were 2
Total No. of Occurrences were 298

A.1.2. Mixing Heights

A parameter closely related to stability class is the mixing height. This is a measurement of the thickness of the lower atmospheric layer in which airborne released constituents can disperse freely once daytime heating "burns off" the normal nocturnal temperature inversion. All other conditions being equal, the greater the afternoon mixing height, the better the dispersion. Holzworth (1972) studied mixing heights and wind speeds of 62 National Weather Service stations in the 48 contiguous states, for a five-year period of record. His data indicate that Albuquerque (and Ambrosia Lake) is in an area with the highest mean annual afternoon mixing heights in the country (2,788 meters overall). The mean annual morning mixing height in the area is approximately 485 meters overall based on the Holzworth study. Thus the Ambrosia Lake area has excellent dispersion characteristics due to these mixing heights.

A.1.3. Temperature and Relative Humidity

The Ambrosia Lake area exhibits a large diurnal range in temperature, which is conducive to nighttime inversion formations. Ten and one-half months of measurements made at the NMED monitoring site show a mean daily minimum of 40.9°F, and a mean daily maximum of 65.2°F. The mean daily average of 53.5°F agrees reasonably well with the long-term (1962-1974) average of 49.2°F measured at Lee Ranch near San Mateo.

Gulf Mineral Resources Company (now General Atomics) established several monitoring stations in the Mt. Taylor mine area near the community of San Mateo. San Mateo is approximately 9 miles to the southeast of the section 4 evaporation ponds. The temperature and relative humidity data from station #1 located at an elevation of 7,280 feet, is presented in Tables A-9 through A-10.

Relative humidity in the area ranged from an average of 65 percent at sunrise to roughly 30 percent by mid-afternoon, often dropping to less than 15 percent. The data in Table A-11 indicate an influx of moisture in July and August (the thunderstorm season).

TABLE A-9. MONTHLY & ANNUAL MEANS/EXTREMES OF TEMPERATURES (°F)

Month/Year	Monthly Mean	Mean		Temperature	
		Daily Maximum	Daily Minimum	Maximum	Minimum
February 76	37.1	46.2	28.7	58.0	14.0
March 76	34.6	45.6	22.5	63.0	10.5
April 76	48.0	57.3	36.9	65.5	19.0
May 76	55.2	64.7	45.1	76.0	30.0
June 76	64.5	75.1	52.8	84.0	42.0
July 76	67.3	78.3	57.1	86.0	52.0
August 76	66.2	76.5	56.7	83.0	44.5
September 76	59.8	70.4	49.8	82.0	39.5
October 76	48.3	57.6	38.9	72.0	29.5
November 76	38.8	49.8	28.3	62.0	5.0
December 76	31.9	43.8	22.4	58.0	10.0
January 77	28.5	38.3	20.3	48.0	3.0
Annual	48.4	58.7	40.3	86.0	5.0

TABLE A-10. MONTHLY & ANNUAL RELATIVE HUMIDITY (%)

Month/Year	Monthly Mean	Mean		Humidity	
		Daily Maximum	Daily Minimum	Maximum	Minimum
February 76	34	48	21	59	11
March 76	47	70	28	100	8
April 76	37	56	22	100	4
May 76	43	60	30	98	12
June 76	34	45	25	90	15
July 76	45	61	30	88	5
August 76	49	70	31	98	8
September 76	48	71	24	96	5
October 76	52	68	38	100	19
November 76	51	65	38	100	29
December 76	51	66	36	100	7
January 77	63	79	46	100	18

Annual	46	63	31	100	4

A.1.4. Precipitation

Most of the precipitation in the area occurs during the July-August thunderstorm season, although there is considerable monthly and annual variation in total rainfall. Table A-11 presents long-term precipitation measurements made at San Mateo (Floyd Lee Ranch) and three other nearby regional stations. The long-term annual average for San Mateo was 8.83 inches with a maximum of 13.55 inches in 1956. August was the wettest month with an average of 2.13 inches, and a maximum of 4.38 inches in 1948.

TABLE A-11. MONTHLY & ANNUAL PRECIPITATION (Inches)

Month/Year	San Mateo(a)	Grants(b)	Marquez(c)	San Fidel(d)
January	0.42	0.36	0.45	0.37
February	0.38	0.39	0.49	0.46
March	0.40	0.45	0.57	0.44
April	0.43	0.36	0.67	0.65
May	0.37	0.43	0.70	0.79
June	0.47	0.69	0.73	0.79
July	1.72	1.81	1.79	1.65
August	2.13	2.18	2.71	2.02
September	1.14	1.17	1.20	1.43
October	0.75	1.07	1.31	0.61
November	0.33	0.33	0.51	0.41
December	0.44	0.62	0.55	0.47
Annual	8.83(e)	10.04	11.68	10.09

(a) Elevation of 7250 feet MSL, period 1939-1974, U.S. Department of Commerce

(b) Elevation of 6480 feet MSL, period 1946-1960, U.S. Forest Service in 1973 in NMEI 1974.

(c) Elevation of 7620 feet MSL, period 1941-1970, U.S. Department of Commerce

(d) Elevation of 6160 feet MSL, period 1920-1954, U.S. Department of Commerce

(e) 24 Years of data available for annual mean.

A.1.5. Isolation

Central New Mexico receives approximately 75 percent of possible winter sunshine and 80 percent of possible summer sunshine. The annual average for Albuquerque is 77 percent, and similar figures can be expected in the Ambrosia Lake area.

A.1.6. Storms and Severe Weather

Thunderstorms are relatively frequent in the area during the summer months, occurring an average of 50 days per year, with two to four days per year reporting hail (Baldwin, 1973). Extreme winds may occur as a result of these thunderstorms and also under certain pressure gradient configurations. During the winter and spring, low-pressure weather systems approaching from the west can induce surface winds in excess of 60 mph. These strong winds, coming from the south-southwest to the west-southwest sectors, are somewhat mitigated in the area by the surrounding high mesas. Thorn (1968) estimated the following maximum wind speeds for the area, 10 meters above ground level, for various recurrence intervals as shown in Table A-12.

TABLE A-12
WIND SPEED

Recurrence Interval (years)	2	10	25	50	100
Maximum Speed (mph)	57	68	73	80	87

Rainfall in the area is generally associated with localized thunderstorms. Maximum precipitation of long duration is associated with the infrequent occurrence of tropical cyclones from the Gulf of Mexico and the Gulf of California (Houghton, 1972).

APPENDIX B
FLORA AND FAUNA

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C.1 FLORA AND FAUNA - AFFECTED ENVIRONMENT

The Ambrosia Lake tailings site is located in an arid desert environment and the flora and fauna of this area are adapted to the dry desert conditions. This characterization of the biota at the tailings and borrow sites is based on field surveys in the area (FBD, 1983; TAC 1985), consultations with natural resource personnel from state and Federal agencies, and review of the pertinent literature. A list of flora and fauna observed or expected to occur at the site plus scientific names of species referred to in this appendix appear in Tables C.1.1 through C.1.4.

These tables do not represent a complete listing of species from this area. Rather, they are common species observed at the site during reconnaisance-level surveys or species observed in the region by other workers. The plant list was derived from site-specific surveys (FBD, 1983) and a regional study conducted by Albee (1982). Faunal lists are based on limited site-specific data (FBD, 1983) and more detailed information from other sources as referenced on the tables. Table C.1.3 lists only nesting bird species observed or expected to occur in the area. The number of additional species that would be expected at the site as migrants or winter visitors may be as high as 86 (Albee, 1982).

Ambrosia Lake tailings site

The tailings pile has large areas devoid of vegetation with other areas sparsely populated with early successional species such as Russian thistle, squirreltail grass, and snakeweed. Small permanently wet areas occur at the base of the containment dikes and support bulrush, cattail, and a few willow, Russian olive, and salt cedar (FBD, 1983).

Wildlife use of the tailings pile is minimal. Ponded water on top of the tailings supports a limited number of migratory waterfowl and shorebirds (FBD, 1983). Pocket gophers were observed near the base of the dikes along with the red-spotted toad in the wet areas. In June of 1985, numerous cliff swallows were observed feeding near the tailings and Brewer's blackbird was noted nearby.

Borrow site 1

Borrow site 1 and the windblown contaminated area adjacent to the tailings pile are located in the Great Basin Grasslands habitat (Brown, 1982). Historically, these grasslands were dominated by sod-forming grasses such as grama grass (Bouteloua spp.). Presently, many of these areas are overgrazed causing a breakdown in the sod cover and enhancing the growth of various forbs and shrubs. Overgrazing has occurred in the region (Kinsky, 1977; DOI, 1980; Brown, 1982; Hubbard, 1985a) and at the site (FBD, 1983). Only vestiges of the grama grass association occur at the sites with species such as blue grama, bush muhly, and Fendler threeawn present. Common species include narrow leaf goosefoot, alkali sacaton, galleta, and other annual herbs and grasses. Scattered juniper are present at the west end of the sites (FBD, 1983).

Table C.1.1 Plant species observed in the Ambrosia Lake area

Species			
Scientific name	Common name	Observed at site	Observed in region
Abronia sp.	sandverbena		X
Agropyron smithii	western wheatgrass		X
Aristida fendleriana	Fendler threeawn	X	
Aristida longiseta	red threeawn		X
Aristida purpurea	purple threeawn		X
Artemisia nova	black sagebrush	X	X
Astragalus sp.	milkvetch		X
Aster sp.	aster		X
Atriplex canescens	fourwing saltbush	X	X
Atriplex confertifolia	shadscale		X
Atriplex obovata	saltbush		X
Atriplex saccaria	saltbush		X
Bouteloua gracilis	blue grama	X	
Bromus tectorum	cheatgrass		X
Cercocarpus montanus[a]	mountain mahogany	X	
Chenopodium dessicatum	goosefoot	X	
Chrysothamnus nauseosus	rubber rabbitbrush	X	X
Chrysothamnus viscidiflorus	green rabbitbrush		X
Cleome serrulata	Rocky Mountain beeplant	X	
Cowania mexicana	cliff rose		X
Cryptantha crassisepala	cats eye		X
Dithyrea wislizenii	spectaclepod		X
Elaeagnus angustifolia	Russian olive	X	
Ephedra torreyana	ephedra		X
Eriogonum sp.	buckwheat		X
Euphorbia fendleri	spurge		X
Eurotia lanata	winterfat		X
Festuca octoflora	sixweek fescue		X
Gutierrezia sarothrae	snakeweed	X	X
Haplopappus spinulosus	ironplant goldenweed	X	
Helianthus annuus	common sunflower	X	
Hilaria jamesii	galleta	X	
Hordeum pusillum	little barley		X
Juniperus sp.	juniper	X	X
Lactuca sp.	wild lettuce		X
Lappula sp.	stickseed		X
Leucelene ericoides	white aster	X	
Lycium pallidum	pale wolfberry		X
Muhlenbergia porteri	bush muhly	X	
Muhlenbergia torreyi	ring muhly		X
Oenothera albicaulis	evening primrose		X
Oenothera pallida	pale evening primrose		X
Opuntia macrorhiza	plains prickly pear	X	

Table C.1.1 Plant species observed in the Ambrosia Lake area (Concluded)

Species			
Scientific name	Common name	Observed at site	Observed in region
Opuntia whipplei	Whipple cholla	X	
Oryzopsis hymenoides	Indian ricegrass	X	X
Penstemon sp.	penstemon	X	X
Phacelia corrugata	scorpion weed		X
Phlox sp.	phlox		X
Pinus edulis[a]	pinon pine	X	
Pinus ponderosa[a]	ponderosa pine	X	
Plantago purshii	plantain		X
Psoralea lanceolata	scurfpea		X
Purshia tridentata	antelope bitterbrush		X
Rhus trilobata	skunkbush sumac		X
Rumex crispus	curly dock		X
Salix sp.	willow	X	
Salsola iberica	Russian thistle	X	
Sarcobatus vermiculatus	greasewood	X	X
Scirpus pallidus	bulrush	X	
Sisymbrium altissimum	tumble mustard	X	X
Sitanion hystrix	bottlebrush squirreltail	X	X
Solanum jamesii	James nightshade	X	
Sphaeralcea coccinea	scarlet globemallow	X	
Sphaeralcea parvifolia	globemallow		X
Sporobolus airoides	alkali sacaton		X
Sporobolus contractus	spike dropseed		X
Sporobolus cryptandrus	sand dropseed		X
Sporobolus giganteus	giant dropseed		X
Stipa comata	needle and thread		X
Stipa neomexicana	feathergrass		X
Suaeda torreyana	seepweed		X
Tamarix pentandra	saltcedar	X	
Tridens pulchellus	fluffgrass		X
Typha sp.	cattail	X	
Verbesina encelioides	golden crownsbeard		X
Yucca sp.	yucca	X	X
Zinnia grandiflora	desert zinnia	X	

[a] Observed only at borrow site 2.

Ref. FBD, 1983; Albee, 1982; McDougall, 1973; Isler and Middleton, 1985.

Table C.1.2 Amphibians and reptiles observed or expected to occur at the Ambrosia Lake tailings site

Species	Habitat			Comments
	Grassland/ shrub	Rocky slope/ cliffs	Pinon-juniper/ forest	
Plains spadefoot toad *Scaphiopus bombifrons*	X			Inhabits plains and hills in areas of low rainfall. Requires temporary or permanent bodies of water for reproduction.
Western spadefoot toad *Scaphiopus hammondi*	X			Inhabits areas of open vegetation in washes and floodplains. Requires temporary or permanent bodies of water for reproduction.
Red-spotted toad[a] *Bufo punctatus*	X			Occurs in rocky canyons, open grassland, and arroyos. Larva observed in wet area near tailings pile.
Tiger salamander *Ambystoma tigrinum*	X			Principally subterranean. Breeds in temporary or permanent water bodies.
Lesser earless lizard *Holbrookia maculata*	X			Common in areas with open vegetation and sandy soil.
Collared lizard *Crotaphytus collaris*		X	X	Inhabits rocky ledges, talus slopes, and brush near cliffs. Sparsely distributed in area.
Northern plateau lizard *Sceloporus undulatus*		X	X	Common in area. Cliff face and large boulders preferred.
Sagebrush lizard *Sceloporus graciosus*	X	X	X	Common in area. Prefers dense shrubs and sandy soils.

Table C.1.2 Amphibians and reptiles observed or expected to occur at the Ambrosia Lake tailings site (Concluded)

	Habitat			
Species	Grassland/ shrub	Rocky slope/ cliffs	Pinon-juniper/ forest	Comments
Side-blotched lizard[a] *Uta stansburiana*		X	X	Common on cliffs, talus slopes, and isolated large rocks.
Northern tree lizard *Urosaurus ornatus*		X	X	Found only in rocky areas. Uncommon in area.
Short-horned lizard[a] *Phrynosoma douglassi*	X			Occurs in grassland habitat. Observed in windblown contaminated area near tailings.
Plateau whiptail[a] *Cnemidophorus velox*	X		X	Observed in pinon-juniper woods at borrow site 2. Also occurs in open shrub desert.
Desert striped whipsnake *Masticophis taeniatus*	X			Inhabits shrubby areas. Uncommonly observed in area.
Painted desert glossy snake *Arizona elegans*		X		Inhabits rocky areas. Uncommon in area.
Gopher snake *Pituophis melanoleucus*	X	X	X	Occurs in all habitat types in area.
Prairie rattlesnake *Crotalus viridis*	X	X	X	Occurs in mixed grass/ shrub areas and rocky areas. Distributed at low density throughout area.

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[a] Observed at the Ambrosia Lake tailings site.

Ref. Albee, 1982; FBD, 1983; Jones, 1970; Stebbins, 1966.

Table C.1.3 Nesting birds observed or expected to occur at the Ambrosia Lake tailings site

	Habitat			Relative abundance		
Species	Grassland/ shrub	Rocky slope/ cliffs	Pinon-juniper/ forest	Common	Uncommon	Rare
Sharp-shinned hawk[a] *Accipiter striatus*		X	X		X	
Northern harrier *Circus cyaneus*	X			X		
Ferruginous hawk *Buteo regalis*			X			X
Red-tailed hawk[a] *Buteo jamaicensis*		X	X	X		
Swainson's hawk *Buteo swainsoni*			X			X
Golden eagle *Aquila chrysaetos*		X			X	
Prairie falcon *Falco mexicanus*		X			X	
American kestrel[a] *Falco sparverius*		X	X	X		
Scaled quail *Callipepla squamata*	X					X
Mourning dove[a] *Zenaida macroura*	X		X	X		
Roadrunner *Geococcyx californianus*	X		X			X
Great horned owl *Bubo virginianus*		X	X			X
Poorwill *Phalaenoptilus nuttallii*			X		X	
Common nighthawk *Chordeiles minor*	X				X	

Table C.1.3 Nesting birds observed or expected to occur at the Ambrosia Lake tailings site (Continued)

Species	Habitat			Relative abundance		
	Grassland/ shrub	Rocky slope/ cliffs	Pinon-juniper/ forest	Common	Uncommon	Rare
White-throated swift *Aeronautes saxatalis*		X			X	
Black-chinned hummingbird *Archilochus alexandri*	X				X	
Northern flicker[a] *Colaptes auratus*			X	X		
Western kingbird[a] *Tyrannus verticalis*	X				X	
Cassin's kingbird *Tyrannus vociferans*		X			X	
Ash-throated flycatcher *Myiarchus cinerascens*	X		X	X		
Say's phoebe[a] *Sayornis saya*	X	X	X	X		
Horned lark[a] *Eremophila alpestris*	X			X		
Cliff swallow[a] *Hirundo pyrrhonota*	X			X		
Scrub jay[a] *Aphelocoma coerulescens*			X	X		
Pinon jay[a] *Gymnorhinus cyanocephalus*	X	X			X	
Common raven[a] *Corvus corax*		X	X	X		
Plain titmouse *Parus inornatus*	X	X	X	X		
Bushtit *Psaltriparus minimus*			X	X		

Table C.1.3 Nesting birds observed or expected to occur at the Ambrosia Lake tailings site (Continued)

	Habitat			Relative abundance		
Species	Grassland/ shrub	Rocky slope/ cliffs	Pinon-juniper/ forest	Common	Uncommon	Rare
Bewick's wren[a] *Thryomanes bewickii*	X		X		X	
Rock wren[a] *Salpinctes obsoletus*		X	X	X		
Canyon wren *Catherpes mexicanus*		X			X	
Mountain bluebird *Sialia currucoides*			X	X		
Mockingbird[a] *Mimus polyglottos*	X			X		
Sage thrasher *Oreoscoptes montanus*	X		X	X		
Bendire's thrasher *Toxostoma bendirei*	X		X	X		
Loggerhead shrike[a] *Lanius ludovicianus*	X		X	X		
Western meadowlark[a] *Sturnella neglecta*	X			X		
Brewer's blackbird[a] *Euphagus cyanocephalus*	X				X	
House finch *Carpodacus mexicanus*	X		X	X		
Green-tailed towhee *Pipilo chlorurus*	X		X		X	
Brown towhee *Pipilo fuscus*	X		X	X		

Table C.1.3 Nesting birds observed or expected to occur at the Ambrosia Lake tailings site (Concluded)

	Habitat			Relative abundance		
Species	Grassland/ shrub	Rocky slope/ cliffs	Pinon-juniper/ forest	Common	Uncommon	Rare
Lark sparrow[a] *Chondestes grammacus*	X			X		
Black-throated sparrow[a] *Amphispiza bilineata*	X		X	X		
Sage sparrow *Amphispiza belli*	X		X	X		
Chipping sparrow *Spizella passerina*	X		X		X	
Brewer's sparrow *Spizella breweri*	X		X		X	

[a] Observed at Ambrosia Lake tailings site.

Ref. Albee, 1982; FBD, 1983; Kinsky, 1977.

Table C.1.4 Mammals observed or expected to occur at the Ambrosia Lake tailings site

	Habitat			Relative abundance		
Species	Grassland/ shrub	Rocky slope/ cliffs	Pinon-juniper/ forest	Common	Uncommon	Rare
Desert shrew *Notiosorex crawfordi*	X					X
Yuma myotis *Myotis yumanensis*	X					X
California myotis *Myotis californicus*		X				X
Silver-haired bat *Lasionycteris noctivagans*			X		X	
Townsend's big-eared bat *Plecotus townsendii*		X				X
Pallid bat *Antrozous pallidus*	X	X				X
Western pipistrelle *Pipistrellus hesperus*		X				X
Desert cottontail[a] *Sylvilagus audubonii*	X		X	X		
Black-tailed jackrabbit[a] *Lepus californicus*	X		X	X		
Colorado chipmunk *Eutamias quadrivittatus*			X	X		
White-tailed antelope squirrel *Ammospermophilus leucurus*	X	X	X	X		
Spotted ground squirrel *Spermophilus spilosoma*	X				X	
Botta's pocket gopher *Thomomys bottae*	X	X	X	X		
Plains pocket mouse *Perognathus flavescens*	X		X		X	

Table C.1.4 Mammals observed or expected to occur at the Ambrosia Lake tailings site (Continued)

	Habitat			Relative abundance		
Species	Grassland/ shrub	Rocky slope/ cliffs	Pinon-juniper/ forest	Common	Uncommon	Rare
Silky pocket mouse *Perognathus flavus*	X	X	X		X	
Ord's kangaroo rat *Dipodomys ordii*	X			X		
Banner-tailed kangaroo rat *Dipodomys spectabilis*	X				X	
Western harvest mouse *Reithrodontomys megalotis*	X		X		X	
Deer mouse *Peromyscus maniculatus*	X	X	X	X		
Canyon mouse *Peromyscus crinitus*		X	X		X	
Pinon mouse *Peromyscus truei*		X	X		X	
Northern grasshopper mouse *Onychomys leucogaster*	X	X			X	
White-throated woodrat *Neotoma albigula*	X		X		X	
Stephens woodrat *Neotoma stephensi*		X			X	
Bushy-tailed woodrat *Neotoma cinerea*		X	X		X	
Coyote[a] *Canis latrans*	X	X	X	X		
Red fox *Vulpes vulpes*	X	X	X			X
Kit fox *Vulpes macrotis*	X	X	X		X	

Table C.1.4 Mammals observed or expected to occur at the Ambrosia Lake tailings site (Concluded)

	Habitat			Relative abundance		
Species	Grassland/ shrub	Rocky slope/ cliffs	Pinon-juniper/ forest	Common	Uncommon	Rare
Badger *Taxidea taxus*	X				X	
Spotted skunk *Spilogale gracilis*	X	X	X			X
Striped skunk *Mephitis mephitis*	X	X	X			X
Bobcat *Felis rufus*		X	X		X	
Mule deer[b] *Odocoileus hemionus*	X	X	X	X		
Elk[b] *Cervus elaphus*			X		X	

[a] Observed at the Ambrosia Lake tailings site.
[b] Sign observed only.

Ref. Albee, 1982; Bailey, 1971; FBD, 1983; Kinsky, 1977; Whitaker, 1980.

The two principal wildlife habitat types which occur at these sites are grassland and rocky slopes-cliffs. The grassland habitat is the dominant type with rocky slopes-cliffs occurring at the west end near Roman Hill. Sixty-two species of wildlife were observed or are expected to occur in the grassland habitat while 42 species may be found in the cliff area (see Tables C.1.2 through C.1.4); an additional 30 to 40 species would be expected at the sites as migrants or wintering species (Albee, 1982).

A total of 11 species of reptiles and amphibians may occur at these sites (see Table C.1.2). Of the eight species of lizards listed, only the short-horned lizard and side-blotched lizard were observed. Three species are found principally in grasslands, four are more common in rock slopes-cliff areas, while one is expected from both habitat types. Amphibians and snakes are less common in terms of the number of species. The amphibians are most common in wet areas such as occur at the tailings pile, stock tanks, and ephemeral bodies of water. Very few snakes were encountered during herpetological investigations in the region (Jones, 1970; Albee, 1982).

A total of 28 species of nesting birds may occur in the grassland habitat and 14 species in the rocky slopes-cliff habitat (see Table C.1.3). The meadowlark and horned lark were the most common nesting birds observed in 1985 (TAC, 1985). Eleven additional species were observed in the grassland habitat. Reconnaissance of the Roman Hill area during the 1985 breeding season resulted in the observation of a sharp-shinned hawk, an active raven's nest, and an abandoned cliff nest that may have been used by prairie falcons. The mourning dove was the only gamebird observed. The scaled quail may occur rarely at the site because shrub cover necessary for this species is generally lacking.

A total of 23 species of mammals may occur in the grassland habitat while 20 species are expected in the rock-cliff area (see Table C.1.4). The only species observed on the site were the desert cottontail and coyote. The mule deer is the most common and widely distributed big game species in the region. The sites are not within the summer range of this species (Kinsky, 1977; DOI, 1980) although they do winter on the San Mateo Mesa directly west of the site (DOI, 1980). Occasional wintering animals from this area may use the site especially in the Roman Hill area. Elk also winter on the San Mateo Mesa (DOI, 1980) but would not be expected to occur at the borrow site or windblown area. The impact of overgrazing at these sites has reduced the carrying capacity for wildlife (DOI, 1980) and has resulted in much reduced use of the area by mule deer and the elimination of the pronghorn antelope (Antilocapra americana) from the area.

Borrow site 2

Borrow site 2 is located in the Great Basin conifer woodland type (Brown, 1982) with piñon pine and juniper being the dominant plant species. This site is almost completely wooded except for disturbed areas near the abandoned San Mateo uranium mine and clearings dominated by grass. A floristic survey was not conducted at this site but many of the species listed in Table C.1.1 occur at this site.. Although a field survey was not conducted, consultation was performed regarding the possible occurrence of threatened and endangered plant species at borrow site 2 (Price, 1985b). A computerized file search of the

New Mexico Natural Resources Information System indicated that none of the plant species being tracked by the New Mexico Natural Resources Department have been recorded in the Ambrosia Lake area and that appropriate habitat for these species is also lacking. Based on this consultation, additional surveys for threatened and endangered plants at borrow site 2 are not warranted at this time.

Fifty-nine species of wildlife were observed or are expected to occur in this area (see Tables C.1.2 through C.1.4). Eight species of herptiles may occur at the site (see Table C.1.2); the plateau whiptail was the only species observed (TAC, 1985). A total of 29 species of birds may nest at the site (see Table C.1.3). Five species of raptors may nest in this area; the red-tailed hawk and kestrel were the only species observed. The ferruginous and Swainson's hawks nest in pinon-pine woodlands (Smith and Murphy, 1982; Thurow and White, 1983), sometimes in close association with each other (Schmutz et al., 1980; Thurow and White, 1983). The proposed borrow site is located on the fringe of the ferruginous hawk breeding range (Armbruster, 1983). In addition, an extensive wildlife survey in the Chaco strippable coal area approximately 25 air miles north of the site resulted in the location of only four ferruginous hawk and one Swainson's hawk nests. This information indicates that it is unlikely that these two species nest at the proposed borrow site area.

A total of 22 species of mammals are expected to occur in the borrow site area; the black-tailed jackrabbit, desert cottontail, and coyote were the only species observed (see Table C.1.4). In addition, mule deer and elk sign were noted. Borrow site 2 is located within the winter range of both the mule deer and elk on the La Jara Mesa (Kinsky, 1977; DOI, 1980). Consultations with the New Mexico Department of Game and Fish indicate that borrow site 2 is located within critical wintering habitat for both species (Isler and Middleton, 1985). As the snow deepens on the La Jara Mesa, both species move downslope and typically by December are concentrated on the slopes of the mesa which include the borrow site 2 area. Browse transects conducted by the New Mexico Department of Game and Fish indicate that important browse species such as mountain mahogany and fourwing saltbush occur on the site and are used extensively during the winter (Isler and Middleton, 1985).

Threatened and endangered species

A total of 22 species of plants and animals are considered threatened or endangered (T and E) by the Federal government in New Mexico (USFWS, 1984, 1985). The black-footed ferret (Mustela nigripes), peregrine falcon (Falco peregrinus), and bald eagle (Haliaeetus leucocephalus) are the only species whose ranges include the Ambrosia Lake site. Consultation with the U.S. Fish and Wildlife Service (USFWS) resulted in a list of two endangered (black-footed ferret, American peregrine falcon), one proposed (rhizome fleabane, Erigeron rhizomatus); and one candidate (Pecos sunflower, Helianthus paradoxus) species which the Service feels may be affected by the project (Peterson, 1985a,b).

Bailey (1971) indicates that black-footed ferret range in New Mexico includes the plains region in the eastern and northern parts of the state. The nearest known observation of this species to the site was a ferret captured in a trap set for coyote near San Mateo in 1918 (Bailey, 1971). There have not been any confirmed sightings of this species in the state in recent decades (Hubbard et al., 1979) and the only known population occurs in Wyoming (Clark et al., 1984). This species is highly dependent on praire dogs and all active prarie dog towns are considered potential ferret habitat (Clark et al., 1984). Observations at the tailings pile, windblown area, and borrow sites indicate that prarie dogs do not exist on the sites (FBD, 1983; TAC, 1985). Therefore, it is unlikely that the black-footed ferret occurs at any of the sites.

The peregrine falcon is a rare and localized breeding species in mountainous regions of New Mexico (Hubbard et al., 1979). It migrates through the state and winters statewide. Peregrine falcons require steep cliffs fairly near water (usually flowing) for nesting purposes. Steep cliffs do occur near the site along the San Mateo Mesa but they are not near water. In addition, this species is not presently known to nest near or within 10 miles of the site (Hubbard, 1985b).

The bald eagle does not nest in New Mexico (USFWS, 1984) but it does winter within the state (Grubb and Kennedy, 1982). Wintering birds are typically found along major rivers or lakes with some also feeding in upland areas (Grubb and Kennedy, 1982). It is unlikely that the bald eagle winters anywhere near the study sites, though an occasional bird may fly over during migration.

In 1980, the rhizome fleabane was included in category one, candidate species being considered for threatened or endangered status (42 FR 82480). A proposed rule to list this species as threatened was submitted in 1984 (49 FR 17548) and, as yet, no action has been taken on this proposed ruling. The rhizome fleabane was first collected in 1943 in the Zuni Mountains near Ft. Wingate, New Mexico. This species was subsequently rediscovered near its type locality and in the Datil Mountains to the south (Sabo, 1982). Knight (1981) feels that it is unlikely that this species will be found outside this range. In all cases, this species occurs in soils " . . . partially derived from outcrops of Chinle Shale" (Sabo, 1982) and is found in ponderosa pine or pinon-juniper forest associations. Rock outcrops at borrow sites 1 and 2 are Mancos Shale and the appropriate plant community type does not occur near the tailings pile or the borrow site 1 area. For this reason, it is very unlikely that this species occurs at or near the tailings pile, windblown area, or borrow sites.

The Pecos sunflower (Helianthus paradoxus) is a Federal candidate species for listing as threatened or endangered. This species was originally observed in Pecos County, Texas (Heiser et al., 1969). Recently this species was discovered in Chaves and Cibola Counties, New Mexico (Seiler et al., 1981; NMNPPAC, 1984). This species is found in standing water or areas of shallow water table in heavy-saline soils. It typically occurs in wet areas along perennial streams or irrigation ditches. The only standing water at the site is on top of the tailings pile and this area is essentially devoid of vegetation. Given the lack of wetland habitat or perennial water bodies, it is assumed that this species does not occur at the Ambrosia Lake site or borrow sites.

Sixty-eight species of wildlife are listed as endangered in New Mexico. A review of the ranges of these species indicates that four may occur at the Ambrosia Lake site. Three (black-footed ferret, peregrine falcon, and bald eagle) were discussed above and the fourth species is the red-headed woodpecker (Melanerpes erythrocephalus). This species nests in riparian woods or planted groves of trees (Hubbard et al., 1979) and would not be expected to occur at the site.

The State of New Mexico has proposed legislation to create a list of state endangered plant species (NRD, 1985). A total of 55 plant taxa is proposed for listing. The rhizome fleabane and Pecos sunflower were included in this list and were discussed above. A computerized file search of the Natural Resources Information System (NRIS) conducted by personnel of the New Mexico Natural Resources Department indicated that there are no records of these proposed species at the Ambrosia Lake sites. In addition, appropriate habitat for the species being tracked by NRIS is also lacking at the Ambrosia Lake sites (Price, 1985a,b).

C.2 FLORA AND FAUNA - IMPACTS

Impacts to flora and fauna associated with stabilization in place are addressed in this appendix. Impacts of the no action and disposal at the Section 21 site alternatives are briefly addressed in Section 4.6 of the Environmental Assessment (EA).

Terrestrial ecosystems would be impacted directly and indirectly by the remedial action. Direct impacts include destruction of flora and fauna and loss of habitat and would result from the disposal of tailings, excavation of contaminated soils, borrow activities, and construction or upgrading of haulage roads. Indirect impacts include increased fugitive dust emissions, elevated noise levels, and human activities and would occur adjacent to the direct impact area. Direct impacts can either be short-term or long-term while indirect impacts are short-term (i.e., for the duration of the project).

A total of 799 acres would be affected during stabilization in place. This includes 111 acres at the existing tailings pile, 570 acres of windblown contamination adjacent to the pile, 60 acres at borrow site 1, 50 acres at borrow site 2, and eight acres along haulage roads. Presently, the tailings pile is almost devoid of vegetation and has little wildlife value. For this reason, the impact of remedial action activities on vegetation and wildlife at the tailings pile would be minimal.

Remedial action activities at the area of windblown contamination and at borrow site 1 (including haulage road construction) would impact approximately 631 acres of grassland habitat. Much of this area is overgrazed and represents marginal wildlife habitat. However, 62 species of vertebrates have been observed or are expected to occur in this area. Excavation of contaminated soils or borrow materials would result in the destruction of many less mobile animals such as small mammals and reptiles and force larger mammals and birds to vacate the area. These animals would be forced to compete with existing resident individuals or inhabit marginal habitat. The net result would be a reduced survivorship for these displaced individuals. Analysis of plant and animal species which inhabit this area indicates that no concentration areas or important habitat features for economically important species would be disturbed. In addition, no threatened or endangered species are known to occur in this area.

Borrow site 2 is comprised of a pinon-pine plant community. An estimated 59 species of wildlife may occur in the area. The exact location of borrow site 2 within the proposed area would be determined by the Remedial Action Contractor (RAC) and the U.S. Department of Energy (DOE). Direct impacts on wildlife in this area would be similar to those described for the windblown area and borrow site 1. The major direct impact on wildlife would be the elimination of approximately 50 acres of critical winter habitat for mule deer and elk. Mule deer and elk sign were found to increase upslope (southwest) from the San Mateo Mine (Isler and Middleton, 1985; TAC, 1985). In addition, the area near the San Mateo Mine is on the periphery of the winter range which would indicate that the closer the borrow site is to the mine, the lower would be the direct impacts on wintering mule deer and elk.

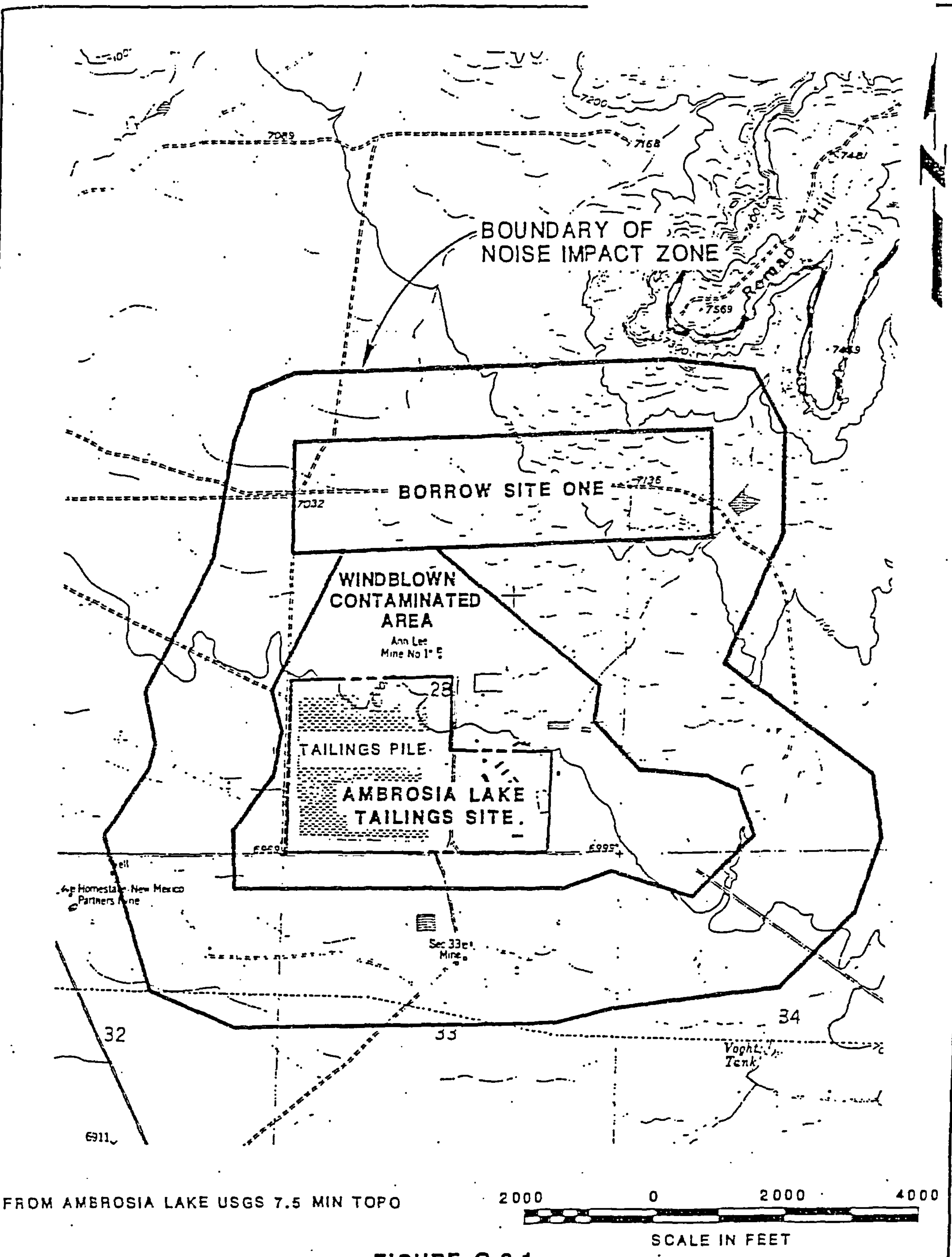
The duration of direct impacts from remedial action activities would depend on the level of restoration undertaken. Research has shown that the rate and extent of vegetation recovery on untreated mine lands varies widely depending on the restoration method employed (Wagner et al., 1978; Aldon, 1981). The hypothetical maximum impact would involve no restoration which would result in the recovery of the biotic community on land devoid of topsoil. In this case primary succession (i.e., a sequence of plant communities developing in a newly exposed habitat devoid of life) (Ricklefs, 1979) would take place and recovery would take years. Full recovery of a pinon-juniper plant community at borrow site 2 could take approximately 100 to 300 years (Tausch and Tueller, 1977; Everett and Ward, 1984). In addition, the reestablishment of important shrub browse species for wintering mule deer would be difficult. The establishment of a grassland habitat at the site may benefit wintering elk (Isler and Middleton, 1985).

Prior to initiation of surface disturbing activities, the plan for restoration of excavated areas would be determined by the RAC and the DOE in consultation with the appropriate regulatory agency or other authority. Requirements for restoration typically include measures such as backfilling, recontouring, and revegetating. Impacts would be mitigated by sequencing restoration as soon as possible after completion of surface disturbing activities.

Indirect impacts on plants and wildlife would result from increased fugitive dust emissions, elevated noise levels, and human activity, and would occur primarily outside the direct impact zone. The effects of fugitive dust include reduced palatability of vegetation for wildlife and physiological stress on plants. It is estimated that these dust emissions would preclude wildlife use within 200 feet of the source; this impact would decrease to zero 1200 feet from the dust emission source (Hoover and Associates, 1984).

The effect of noise on wildlife varies from direct effects on hearing to indirect effects such as masking (the inability to hear important environmental cues) and loss of usable habitat. The effects of noise can be compounded by the presence of humans and the impact of noise and human presence is often hard to separate (Dufour, 1980). The projected noise levels would increase from background levels of 35 to 40 decibels to about 90 decibels 100 feet from construction activities and 50 to 60 decibels one mile from the source. The impact of noise on wildlife is poorly understood but many species of wildlife seem to be able to adjust to relatively constant noise levels of up to 70 decibels (Dufour, 1980). Noise levels of this magnitude or greater can be expected up to 2000 feet from the source and wildlife use in this zone would be impacted.

The effects of dust, noise, and human activity at the tailings site, windblown area, and borrow site 1 would influence wildlife use in approximately a 1500-acre area (Figure C.2.1). Most of this area (1450 acres) would be low-quality overgrazed wildlife habitat while the remaining 50 acres would be rocky slopes and cliff habitat near Roman Hill. A total of 43 species of wildlife were observed and/or are expected to occur in the rocky slope-cliff habitat; 24 species are more or less restricted to this habitat type (see Tables C.1.2 through C.1.4). Birds of prey may nest in the cliff habitat and



FROM AMBROSIA LAKE USGS 7.5 MIN TOPO

FIGURE C.2.1
NOISE IMPACT ZONE AT AND AROUND
THE AMBROSIA LAKE TAILINGS SITE AND BORROW SITE ONE

project-generated noise may preclude their use of about 3000 feet of the cliff habitat at Roman Hill. These impacts would occur only during the 18-month project duration.

The effects of dust, noise, and human activity on biota at borrow site 2 may extend out for 700 feet from the site (Figure C.2.2). For purposes of analysis, borrow site 2 was assumed to be in the center of the proposed area. The most important indirect impact at borrow site 2 would be the disturbance of wintering mule deer and elk over a 132-acre area. Mule deer and elk use the same winter range from year to year (Kerr, 1981; Young, 1982). It is expected that animals who traditionally use at least part of the 700-foot area around the site would be displaced as has been observed by various researchers for human disturbance associated with logging and mining (Kuck et al., 1985; Edge et al., 1985). The magnitude of these short-term impacts would be relatively minor during the non-wintering period (April through November) and greatest during the wintering period (December through March). It is expected that these construction related activities would not extend the full 700 feet from the source since the disturbance would be buffered by extensive vegetative cover and topographic barriers as has been observed in other studies (Edge et al., 1985). In summary, the indirect short-term impacts of the seven-month construction period at this site would be minor during the non-wintering period but would affect a relatively large number of animals during the wintering period.

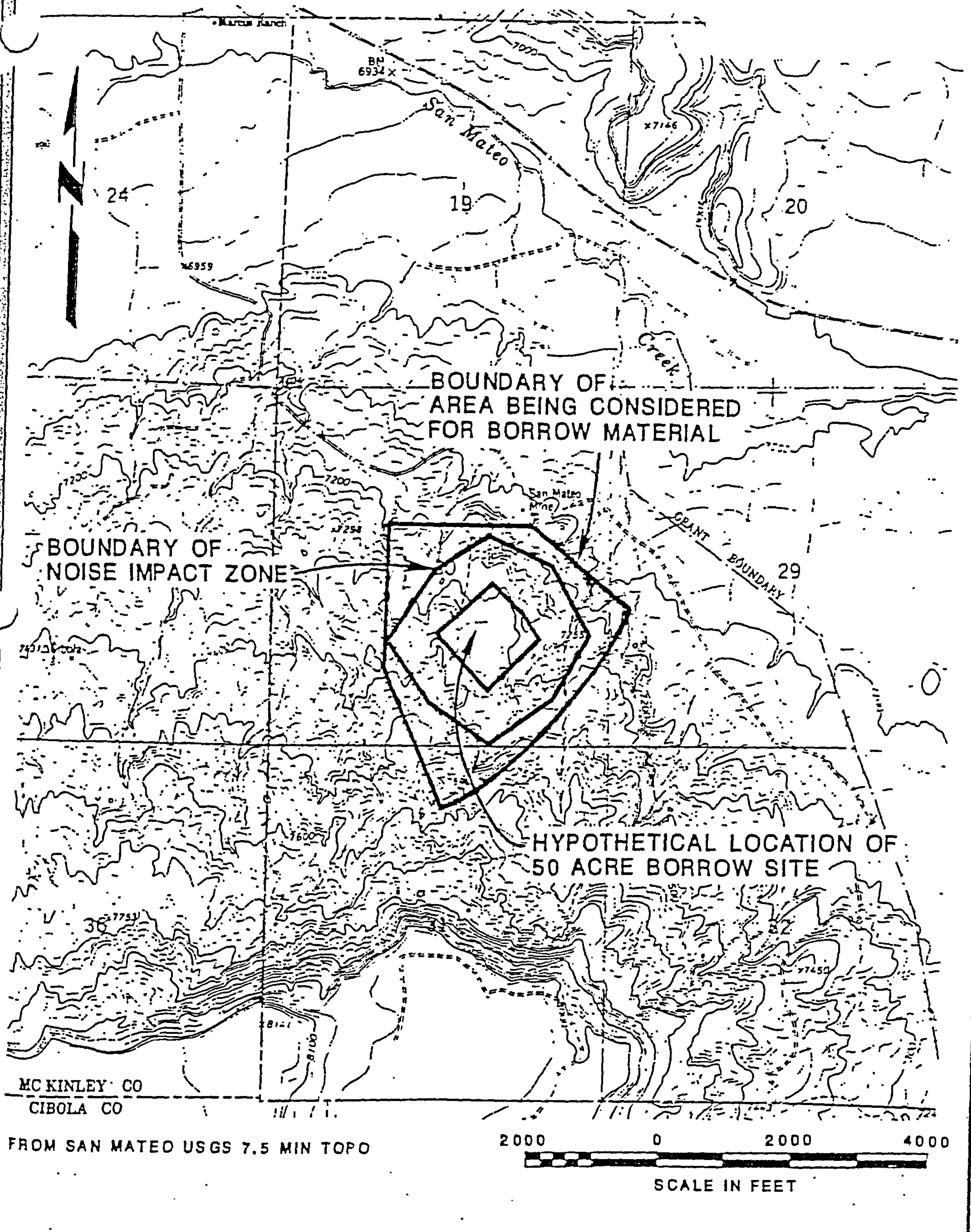


FIGURE C.2.2
NOISE IMPACT ZONE AROUND BORROW SITE TWO

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APPENDIX C
CULTURAL RESOURCES

ECOSYSTEM

MANAGEMENT, INC.

Cultural Resource Survey Report

Of 39 Hectares (97 Acres) at Rio Algom Mine, Near Ambrosia Lake, McKinley County, New Mexico

Prepared By

Ecosystem Management
4004 Carlisle NE, Suite C1
Albuquerque, New Mexico 87107

Prepared For

Rio Algom Mining LLC

JULY 2003

Cultural Resource Survey

Class III Survey of 39 Hectares (97 Acres) for Rio Algom Mining LLC, Near Grants, McKinley County, New Mexico

Prepared by
Richard Burleson
And Robert Phippen

Under

BLM Permit Number 157-2920-03-E
New Mexico State Land Permit Number NM-03-107

NMCRIS NO. 84367

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For
Rio Algom Mining, LLC.

EMI Report Number 552

July 2003

ABSTRACT

On July 10, 2003, Ecosystem Management, Inc. (EMI) conducted a Class I archival search and a Class III pedestrian cultural resource survey of approximately 39 hectares (ha) (97 acres [ac]) near Ambrosia Lake, McKinley County, New Mexico. The project consists of two survey areas. Survey Area 1 is approximately 32 ha (80 ac) and is located within Township 14 North, Range 9 West, Section 33 on the US Geological Survey (USGS) Ambrosia Lake, NM 7.5 minute quadrangle. Survey Area 2 is approximately 7 ha (17 ac) and is located within Township 13 North, Range 9 West, Section 3 on the US Geological Survey (USGS) Ambrosia Lake, NM 7.5 minute quadrangle.

Three previously unrecorded cultural resource sites (LA 140033, LA 140034, and LA 140035) and five isolated occurrences (IOs) were identified and recorded during the Class III survey. LA 140033 is a prehistoric Puebloan ceramic and lithic scatter. LA 140034 is the remnants of an historic structure and associated artifact scatter. LA 140035 is a Pueblo II period residential site consisting of two jacal structures, a possible kiva depression, midden, and associated artifact scatter.

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INTRODUCTION/ PROJECT DESCRIPTION

On July 10, 2003, Ecosystem Management, Inc. (EMI) conducted a Class I archival search and a Class III pedestrian cultural resource survey of approximately 28 hectares (ha) (97 acres [ac]) near Ambrosia Lake, McKinley County, New Mexico. The project consists of two survey areas. Survey Area 1 is approximately 32 ha (80 ac) and is located within Township 14 North, Range 9 West, Section 33 on the US Geological Survey (USGS) Ambrosia Lake, NM 7.5 minute quadrangle. Survey Area 2 is approximately 7 ha (17 ac) and is located within Township 13 North, Range 9 West, Section 3 on the US Geological Survey (USGS) Ambrosia Lake, NM 7.5 minute quadrangle.

Three previously unrecorded cultural resource sites (LA 140033, LA 140034, and LA 140035) and five isolated occurrences (IOs) were identified and recorded during the Class III survey. LA 140033 is a prehistoric Puebloan ceramic and lithic scatter. LA 140034 is the remnants of an historic structure and associated artifact scatter. LA 140035 is a Pueblo II period residential site consisting of two jacal structures, a possible kiva depression, midden, and associated artifact scatter. LA 140034 is recommended as not eligible for listing on the National Register of Historic Places. LA 140033 and LA 140035 are recommended as eligible for listing on the National Register of Historic Places under criterion D, information potential.

This undertaking complies with the provisions of the National Historic Preservation Act of 1966, as amended through 1992, and applicable regulations. The report is consistent with applicable federal and state standards for cultural resource management. The archaeological field work was completed by Richard Burleson and Robert Phippen. Richard Burleson served as principal investigator and Robert Phippen served as field director.

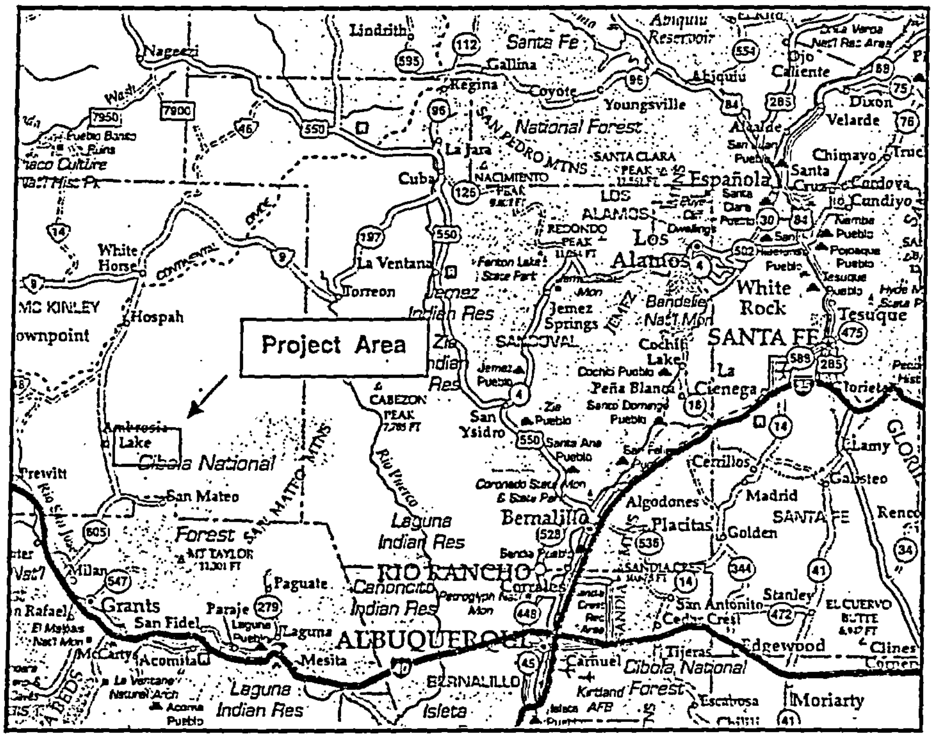

Figure 1. Project location in northwest New Mexico.
Source: Recreational Map of New Mexico, GTR Mapping (2000 Edition)

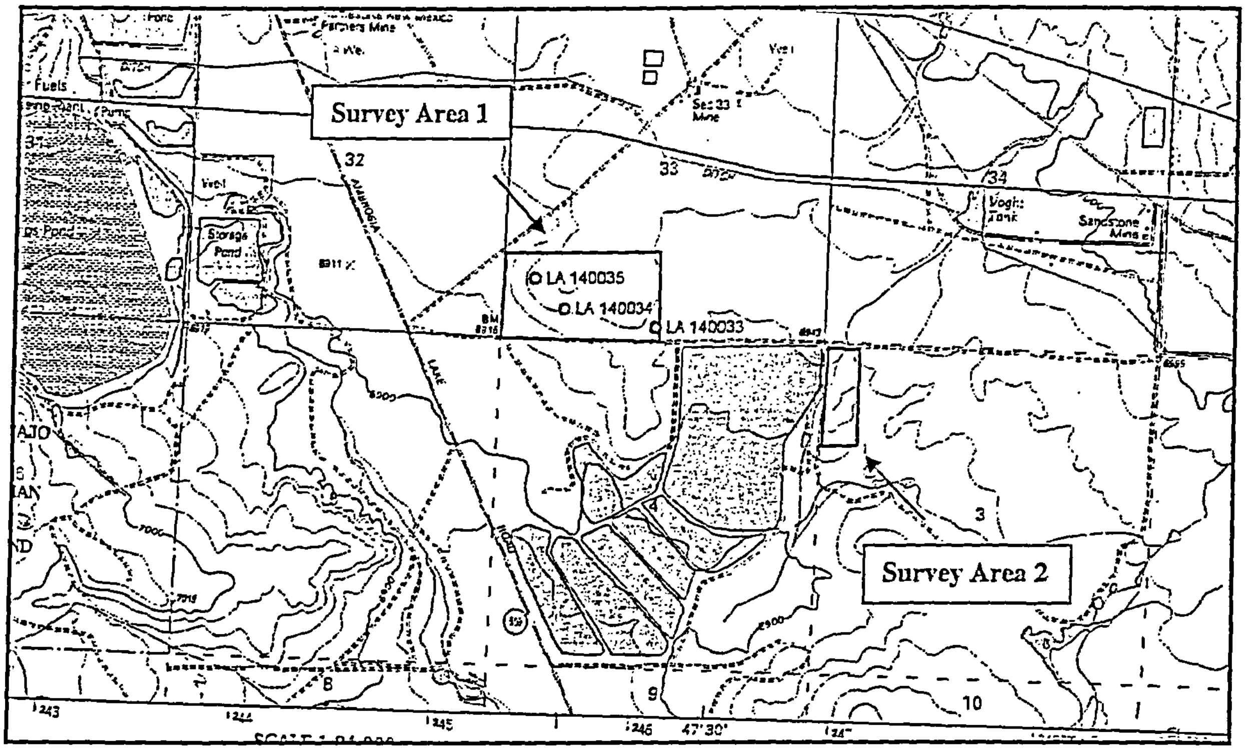

Figure 2. Ambrosia Lake 7.5-minute quadrangle showing survey area locations

ENVIRONMENTAL SETTING

Physiography

The project area is within the central portion of McKinley County in northwestern New Mexico (Figure 1). This area is in the Navajo Section of the Colorado Plateau Province of the North American continent. The Colorado Plateau is characterized by deep canyons, high altitude, steep escarpments, flat plateaus comprised of gently dipping sedimentary rocks, and an arid climate (Thornbury 1965) (Figure 3). The most distinctive structural feature of the province is its large number of monoclines. The monoclines are broken throughout the province by structural basins and up warps of considerable relief. Volcanic structures are concentrated around the plateau's margin but are also scattered throughout its interior (Kelley 1955).

The Navajo Section of the province is a poorly defined area of scarped plateaus that lack the degree of dissection that occurs elsewhere in the province (Thornbury 1965). Surfaces in the Navajo Section are mesas, buttes, and cuestas rather than clinal ridges and hogbacks. The section is bounded on the west and south by the Little Colorado River and the Echo Cliffs monocline near the Colorado River. The northern boundary is along the lower San Juan River to the Four Corners area, then northeast to the San Juan Mountains. The southeast boundary extends from the Sierra Nacimiento to Mt. Taylor and onward to the Puerco River.

The Navajo Section has numerous volcanic features that include vents, flows, and pyroclastic deposits that are referred to collectively as the Navajo-Hopi Volcanic Field. Other major structural features of the section include the Black Mesa Basin, the Defiance Upwarp, and the San Juan Basin. The Navajo-Hopi Volcanic Field is comprised of the Hopi Buttes, Monument Valley, and the Chuska Mountains. Basalt-capped mesas and buttes are common throughout the section (Thornbury 1965).

The exposed rocks of the Colorado Plateau range from the Precambrian to the Recent period in age (Thornbury 1965). Black Mesa is capped by the Cretaceous Mancos Shale and Mesa Verde Sandstone formations. The Defiance Upwarp has exposed the much older De Chelly Sandstone. The Navajo Section is characterized as a basin with thick layers of gently dipping Mesozoic and Cenozoic sedimentary shale, mudstone, and sandstone that contain coal seams. The area is generally characterized as rolling plains with cuestas and tablelands capped by sandstone. Canyons are typically broad and shallow (Williams 1986).

The character of the Colorado Plateau is a product of the interaction of three processes: uplift, volcanism, and erosion. Erosion is the primary force that has created the extant landscape. The tectonic event that uplifted the Colorado Plateau involved the westward movement of the North American plate, beginning about 75 million years ago. Over a period of the next 25 million years, the western portion of the North American plate broke, buckled, and was uplifted, forming the Rocky Mountains. The following 45 million years has been degradation as material has been removed from the surface of the plateau to form the Middle and Late Tertiary deposits in other regions. As recent as 10 million years ago, a large lake formed in what is now northeastern Arizona. Streams carried eroded materials from the south, east, and north. This ancient lake is referred to as Hopi Lake (Repenning et al. 1958).

As part of the plate tectonics, weak spots formed in the North American plate that allowed volcanic pipes to form, and the Hopi Buttes volcanic field was created from 8 to 4 million years ago (Wenrich 1989). Explosive eruptions ejected large quantities of tuff and basalt flows that spread outward from the vents. By the early Pleistocene, renewed uplift of the plateau had drained Lake Hopi and accelerated erosion from the province (Chronic 1983). The Colorado River was flowing through the Gulf of California by this time, with increased channel cutting. The Colorado Plateau has eroded to a greater degree than any other part of the United States (Thornbury 1965). The major drainages for the project area are Mitchell Draw that borders the east side of the project area and the headwaters of the Rio San Jose that is to the west and south of the project area. The project area elevation varies from 6915 ft in the southwestern portion of the project area to 6990 ft in the northeastern corner.

Climate

The climate is characterized as being arid to semi-arid with hot summers and mild winters. Temperatures across northwestern New Mexico vary mainly as a result of elevation and latitude. Winter temperatures drop about 1° centigrade (C) for every one-degree increment in latitude. Summer temperatures drop about 1°C for every 150 m (492 ft) increase in elevation (Sellers and Hill 1974). For Grants, New Mexico (1971 to 2000 records), the mean average summer high temperature ranges between 29° and 31° C (85° to 88° Fahrenheit [F]) and the average winter high temperature ranges between 7° and 10.5° C (46° to 51° F). The average number of frost-free days is about 120 days (Bennett 1986:38, 47).

Annual precipitation for Grants, New Mexico (1971 to 2000 records), is 25.4 centimeters (cm) (10 inches [in]). Most precipitation occurs from July through October. Average snowfall in Grants is 30.4 cm (12 in). Summer precipitation originates primarily from the Gulf of Mexico and the Atlantic Ocean. Precipitation from summer storms is brief, occurring primarily in the evening. These thunderstorms tend to be localized. Winter precipitation originates from the Pacific Ocean (Sellers and Hill 1974). Precipitation from winter storms is usually light to moderate. Most mountainous areas receive winter precipitation as snow.

The prevailing winds are from the southwest with winds from the west and southeast not uncommon. The most frequent wind velocities range between 13 and 19 km per hour (8 to 12 mi per hour) from March through June, with the predominate direction being from the southwest (Bennett 1986:50–51).

Biotic Communities

The project area lies in the Desert Scrub/Grasslands biotic community. This plant community is dominated by two cold-temperature conifers, juniper and piñon. Habitats tend to be rocky with adjacent areas being grassland with parkland and savanna-like mosaics. The understory consists of grasses and shrubs that include threadleaf groundsel, snakeweed, galleta grass, Indian ricegrass, western wheatgrass, dropseeds, and junegrass. Shrubs include rabbitbrush, winterfat, and sagebrush. Other plants not uncommon include cliffrose, Apache plume, Mormon-tea, fourwing saltbush, and soapweed (Brown 1994:52–55).

The Desert Scrub/Grasslands has several distinctive mammalian species that follow the vegetation communities of this biome. These taxa include pinyon mouse and the bushy-tailed woodrat (Brown 1994:52–55). Less common taxa include ground squirrel, kangaroo mouse, and vole. The coyote and black-tailed jackrabbit are found throughout the province. Large ungulates are poorly represented, with mule deer and elk being the most common. The pronghorn occurs as an incursionary species from adjacent or former grasslands.

Several avian species are characteristic of the Desert Scrub/Grasslands. These include the pinyon jay, gray flycatcher, and black-throated gray warbler (Brown 1994:56). Other taxa in the region include the plateau whiptail lizard, rattlesnake, and bobcat.

Paleoenvironment

It is estimated from adjacent dendroclimatological station data that there were eleven periods, each lasting more than one decade, from A.D. 700 to 1330 during which the mean tree-ring width values are more than 1.1 standard deviation units above the mean. These eleven periods include the decades A.D. 720 to 730, 780 to 800, 880 to 890, 910 to 920, 1010 to 1020, 1050 to 1070, 1110 to 1120, 1190 to 1200, 1230 to 1240, 1260 to 1270, and 1300 to 1330. These periods represent exceptionally wet and cool climatic episodes. In climatic contrast, ten periods, each spanning one or more decades, of exceptionally hot and dry years occurred from A.D. 700 to 710, 740 to 760, 830 to 840, 990 to 1000, 1030 to 1040, 1080 to 1100, 1130 to 1150, 1170 to 1180, 1210 to 1220, and 1280 to 1290 (Eck 1994:55). These climatic episodes of alternating exceptionally hot and dry, and cool and wet, events would have directly affected human use of the project area.

CULTURE HISTORY OVERVIEW

Paleoindian Period (11,000 to 6000 B.C.)

Paleoindian peoples are defined as early Holocene hunters and foragers who were the first to inhabit the North American continent. Originally believed to be dependent on now extinct megafauna such as bison, mammoth, and mastodon, recent research has shown that Paleoindian groups also utilized varied floral and faunal resources (Cordell 1997). Material remains include a toolkit consisting of lanceolate projectile points, end and side scrapers, knives, gravers, chisel gravers, drills, spokeshaves, and utility flakes (Judge 1973:327). Regional settlement is believed to have been seasonal although some reoccupation of campsites may have occurred. Kelley and Todd (1988) make a point that given the new migrants unfamiliarity with newly encountered floral and faunal species, the Paleoindians would have tended to concentrate on proven sources of food, i.e., migratory game animals such as mammoth and bison. Paleoindian mobility is, therefore, explained by the necessity to follow wide-ranging herd animals. Paleoindian sites are often found on promontories near water sources and are generally within the seasonal range of herbivorous animals (Judge 1973:330).

The various Paleoindian cultures represented in the region include Clovis (9500–9000 B.C.), Folsom (8800–8300 B.C.), and Plano Complexes (7000–6000 B.C.) (Irwin-Williams and Haynes 1970). In the San Juan basin there is thought to be a lapse in human occupation between 8000 and 6600 B.C., possibly as a result in a decrease of effective moisture during this period (Stuart and Gauthier 1981:29; Vivian 1990:81). Also, Paleoindians likely occupied upland areas (elevations from 2,128 to 3,040 m [7,000 to 10,000 ft]) in the region (Stuart and Gauthier 1981:29). The Paleoindian toolkit includes lanceolate projectile points/knives, end and side scrapers, knives, gravers, chisel gravers, drills, spokeshaves, and utility flakes (Judge 1973). There is a growing diversification in tool kits throughout the period, possibly explained by the extinction of megafauna later in the period and the tendency for groups to settle into territories and focus on local resources in a more restricted area (Stone 1999).

Archaic Period (6000 to 400 B.C.)

The Archaic period is characterized by continuation of the hunting and foraging economy of the preceding Paleoindian period with technological adaptations to changing climatic conditions. Around 6000 B.C. the North American climate changed to a much warmer and drier Altithermal pattern, causing widespread faunal and floral changes (Cordell 1997). Most megafauna became extinct and smaller modern species became predominant. Human populations adapted to these changes and material culture became diversified. A distinction is made between northern Archaic groups, referred to as the Oshara Tradition (Irwin-Williams 1973), and more southerly groups, referred to as the Cochise Tradition (Sayles and Antevs 1941). The Oshara Tradition includes five phases: Jay (5500–4800 B.C.), Bajada (4800–3300 B.C.), San Jose (3300–1800 B.C.), Armijo (1800–800 B.C.) and En Medio (800 B.C.–A.D. 400). This typological division is somewhat arbitrary as projectile point types from both traditions frequently overlap. Both groups employ smaller point styles with shouldered hafting elements occurring sometime around 3200 B.C.

A growing reliance on plant foods during the Archaic period is also evidenced by grinding tools such as one-handed manos and basin metates. Settlement patterns are diverse with no ecological determinants except that Archaic populations tended to camp near areas of high floral and faunal diversity. Later in the period, ca. 1800 B.C., maize was introduced. In some areas maize is quickly adopted and becomes a staple, in others it is less important compared to wild plant resources and is not habitually grown until the Basketmaker III period (Dello-Russo 1999).

The first evidence of definable architecture appears during the middle-to-late Archaic period (1800 B.C.–A.D. 600). Pitstructures, archaeologically defined by shallow oval enclosures surrounded by postholes and often associated with fire-cracked rock, appear to have been used for short term or seasonal habitation near abundant resource locations. This adaptation is scattered widely across the San Juan Basin. Habitation and resource areas tend to be located near permanent water sources and on upland dune ridges and mesa-canyon associations. Populations tended to depend on collecting wild plant foods such as grass seeds, piñon nuts, juniper berries, hackberry, amaranth, and cacti (Vivian 1990:99–105).

Basketmaker II–III Period (400 B.C. to A.D. 720)

The beginning of the Basketmaker period (Basketmaker II 400 B.C. to A.D. 500) is characterized by hunters/gatherers engaging in horticulture, while later in the period (Basketmaker III A.D. 500–720) storing excess foodstuffs beyond their seasonal needs. Instead of a mobile lifeway based on natural resource abundance, these people begin a longer seasonal habitation and possibly even permanent habitation in areas that are both productive for maize-based agriculture and seasonal hunting (Stuart and Gauthier 1981:36). The timing of this shift in subsistence strategy seems to vary widely across the southwest, and Stuart and Gauthier note that these changes are probably "fragile, sporadic and determined by local population density". They further note that this period is highly variable in terms of settlement pattern and site size and that surface surveys may miss Archaic period remains that lie beneath later occupations. The few consistent patterns during this period are the location of sites near permanent water sources and their proximity to mountainous areas (Stuart and Gauthier 1981:409).

Later habitation sites increase in size indicating population aggregation into villages generally in upland settings that average 1,976 m (6,500 ft) in elevation (Stuart and Gauthier 1981). Some authors argue that some peoples retained the hunting and gathering lifeway and that these groups essentially lived among sedentary groups (Stuart and Gauthier 1981). Pottery was developed at about A.D. 300 (Vivian 1990:99) and a significant reduction in the size of projectile point forms indicates the use of the bow and arrow.

Pueblo I Period (A.D. 720 to 920)

The Pueblo I period is characterized by linear and crescent-shaped surface storage and living structures in association with pitstructures. During this period there was a decrease in effective moisture with an increasing oscillation in precipitation from year to year. Most aggregated settlements were dependent on maize-based agriculture supplemented by seasonal hunting and wild seed gathering. Wild plant foods were probably still very important in years when precipitation would not permit excess agricultural production to last throughout the winter.

In the Chaco Canyon area, the initial construction of "Great Houses" begins during the Pueblo I period (Vivian 1990). Previously undecorated pottery assumed new decorated forms that included mineral-based paints and neck-banding on plain vessels (Dello-Russo 1992:43). Larger settlements continued to be occupied in upland settings (Stuart and Gauthier 1981). In some areas populations were more mobile with a segment of the population leaving seasonally and returning for the winter and/or summer months (Schmader 1994).

Pueblo II Period (A.D. 920 to 1120)

The Pueblo II period is defined by the building of small, linear, above ground habitation structures or roomblocks while retaining the pitstructure form as an auxiliary habitation or religious structure (kiva). Initially, there is a trend in aggregated settlements to be at higher elevations in riverine settings. By A.D. 1000, in nearly all areas of New Mexico, there is a reversal in this trend. There is an abandonment of higher elevation areas in favor of lower elevation basin settings (Stuart and Gauthier 1981). Pottery types such as Red Mesa and Gallup Black-on-white are characteristic of the period.

In the central San Juan Basin, local adaptations are referred to as the Early Bonito phase—A.D. 920 to 1020—and the Classic Bonito phase—A.D. 1020 to 1120. These phases indicate a shift in architecture and settlement patterns. The development of Chacoan communities begins, marked by the construction of planned, multi-storied "Great Houses" and large "Great Kivas". There is also a continuation of small house sites with linear pueblos associated with subterranean kivas (Vivian 1990:203–206). The population is estimated to have increased throughout the period and six-fold in the Chuska River Valley (Gillespe and Powers 1983). Subsistence resource shortfalls may have become more common and maize-based farming became more intensive with water control and conservation features becoming more common (Vivian 1990:214). An extensive road system was built that extended in a general radial pattern from Chaco Canyon to the margins of the San Juan Basin (Nials et al. 1983). Tainter and Gillio (1980) relate the rapid growth of population during the period in the San Mateo Valley that coincides with a period of increased and stable moisture. Pueblo II sites increase in density from approximately 4.8 per square mile early in the period, to 15.6 in the middle and 28.4 in the latter stages. During the middle to late Pueblo II period Chacoan influence in the San Mateo area produced three outlier sites El Rito, San Mateo, and Kin Nizhoni.

Pueblo III Period (A.D. 1120 to 1320)

The Pueblo III period was one of great change in the southwest. The San Juan Basin saw community development in its peripheries such as at Mesa Verde, Cibola, and Acoma. The Chaco core area fluoresces and then collapses with a general abandonment by the late 1170s. There is a reoccupation of Chaco Canyon by Mesa Verde peoples during the 1175 to 1250 period based on the sudden appearance of Mesa Verde style pottery and new pueblo construction as well as older pueblo reconstruction. In the San Mateo Valley Tainter and Gillio (1980) portray a sudden drop in population during the Hosta Butte Phase. The very high site density of the Late Pueblo II period dropped to 5.2 per square mile after the first 50 years of the period. A brief reoccupation occurred at approximately A.D. 1250 in the El Rito outlier area. Ceramics during this period relate to Mesa Verde influence in the Chaco outlier system.

The Rio Grande districts saw an increase in population. Aggregation of peoples in the eastern pueblos resulted in larger planned communities (50+ rooms). This probably resulted from a combination of immigration and local population growth (Crown et al. 1996). In addition to population growth there is a shift in settlements away from river terraces and floodplains to elevated upland settings. There was a corresponding shift to dry land agricultural techniques. New pottery decoration techniques were adopted using vegetal-based paints to create the nearly ubiquitous Santa Fe Black-on-white type.

Pueblo IV Period (A.D. 1320 to 1540)

The Pueblo IV period is considered one of cultural florescence in the Rio Grande region (Wendorf and Reed 1955). The tendency of aggregation into fewer and larger pueblos continued, and sites with 1000+ rooms are common in the Santa Fe (Galisteo), Chama, and Pajarito districts. These large settlements tend to be in riverine and valley bottom settings, lower in elevation than aggregated settlements during the preceding Pueblo III period. Outlying small fieldhouse sites were also built near varied resource areas (Snead 1995). It is during the Pueblo IV period that the population is considered to have reached its maximum levels, and material culture attained its most sophisticated level. Glaze-painted pottery becomes predominant and is roughly contemporaneous with Katsina cult iconography that indicates a new religion had spread into the region from the south (Adams 1991). Pueblo IV sites in western NM are associated with ancestral villages of Acoma and Zuni. These are located some distance from the project area.

Another development during this time is the migration of Athapaskan (Dineh and Apache) peoples from the north. The arrival date of the Athapaskans into northwest New Mexico is debated by scholars (Kelley 1982). Spanish colonists in the mid-sixteenth century referred to local Athapaskan peoples as "Apaches", and those living west of the Rio Grande as "Apaches de Navajo" (Brugge 1984). Exactly when the Navajo became distinct from other Apaches is not known. The subsistence pattern of the early Navajo was probably based on horticulture combined with hunting and gathering. Early Spanish records indicate the Navajo were farming by the early 1600s (McNitt 1972; Wozniak 1988), but whether they adopted horticulture from local Puebloan peoples or prior to their arrival in the Dinetah is unclear (Bailey and Bailey 1986). Betancourt (1980) uses the presence or absence of horticulture as the basis for distinction between the Navajo and other Athapaskan (Apache) peoples.

Historic Period (A.D. 1540 to Present)

The first Spanish colonial capital was established at the Tewa community of Yunge Oweenge in 1598. This changed Puebloan culture radically in economic, religious, social, and political terms. Endemic disease; raiding by Navajo, Ute, Apache, and Comanche peoples; and the Spanish system of land grants and mission establishment also took their toll. They drastically reduced traditionally held areas and population. The first European presence in the Grants and Bluewater areas was during the late sixteenth to mid-seventeenth centuries with Spanish exploratory and military expeditions. The early Spanish community of San Rafael is an example of an early Spanish colonial occupation with its mission and settlement. The arrival of the Spanish created tension between the indigenous peoples and Europeans.

In 1599 the Spanish, under the command of Viceroy Don Juan de Oñate, conducted punitive military action against Ácoma Pueblo, killing some 500 residents and imprisoning, enslaving, and maiming others. This action was in response to attacks on Spanish military scouting parties transgressing on Pueblo lands. The Pueblo Revolt of 1680 was a reaction to Spanish authority and the revolt did remove, temporarily, Spanish rule. In 1692, however, Spain with an army under De Vargas reasserted its claim on northern New Mexico and held it until 1821 when Mexico won its independence. Mexico held claim to what is now New Mexico until 1846 when the U.S. Army, under S. W. Kearny, took possession of the territory during the U.S. and Mexico War. Throughout this period...

> ...The landscape produced a dispersed pattern of settlement consisting of numerous small enclaves of population and culture. These Pueblo and Hispano villages became bastions of cultural preservation, for they were at once so self-sufficient that they had little need for the outside world and yet so poor that the outside world had little need for them. In isolation they persisted for centuries, changing little [DeBuys 1985].

The San Juan Basin remained Navajo territory throughout the early historic period while the Ute claimed the territory generally north of the San Juan River. The economy of the area was dominated by sheep herding and small-scale agriculture. In 1863, the U. S. army forced an initial 8,000 Navajos to relocate to the Mescalero Apache reservation at Bosque Redondo in east central New Mexico

(McNitt 1972). This action was a punitive reaction to raids by Navajos in the area and on the community of Santa Fe in 1860. A punitive military expedition mounted by Kit Carson in the San Juan Basin resulted in scorched earth policies and the persuasion of Navajo leaders Barboncito and Delgado to gather their followers and relocate to Bosque Redondo. More militant leaders, such as Manuelito, maintained guerilla warfare against the New Mexico militia and their Ute, Zuni, and Hopi allies. At Bosque Redondo, the relocated Navajos faced starvation and extremely poor living conditions that resulted in more than 2000 who died of disease and starvation. The Navajo returned to the San Juan Basin in 1868 under the guidelines of the Treaty of 1868 that was negotiated in Washington, D.C. by Federal officials and the Navajo leaders. In the 1870s a United States Army facility was established along the eastern flank of the San Juan Basin (Williams 1986:112). The facility was established to discourage periodic Navajo raiding of Puerco and Chama River Euroamerican settlements.

Euroamerican settlements that include Grants, Coolidge, and Thoreau were established during the late nineteenth century. Their settlement coincided with the construction of the Atlantic and Pacific railroad. The railroad made farming and ranching profitable. Mining and lumber milling developed in response to cheaper shipping by railroad. The railroad stimulated economic development in the Grants and Bluewater areas.

PREVIOUS ARCHAEOLOGICAL WORK

Prior to conducting the Class III pedestrian field survey, a site records search of the Archaeological Records Management Section (ARMS) in Santa Fe identified 43 previously recorded sites within 1.6 km (1 mi) of the proposed project areas. These sites are summarized in Table 1.

Table 1. Recorded sites within 1.6 km (1 mi) of the project area.

Site LA #	Cultural Affiliation	Type	Eligibility for NRHP
18190	Anasazi	Structural	Eligible
18193	Anasazi	Structural	Eligible
18194	Anasazi	Structural	Eligible
18195	Anasazi	Structural	Eligible
18196	Anasazi	Structural	Eligible
18197	Anasazi	Structural	Eligible
18198	Anasazi	Structural	Eligible
18199	Anasazi	Structural	Eligible
18200	Anasazi	Structural	Eligible
18201	Anasazi	Structural	Eligible
18202	Anasazi	Structural	Eligible
18209	Anasazi	Structural	Eligible
18210	Anasazi	Structural	Eligible
18211	Anasazi	Structural	Eligible
18212	Anasazi	Structural	Eligible
18214	Anasazi	Structural	Eligible
18215	Anasazi	Structural	Eligible
32684	Anasazi	Structural	Eligible
32685	Anasazi	Structural	Eligible
32686	Anasazi	Structural	Eligible
32688	Anasazi	Structural	Eligible

Site LA #	Cultural Affiliation	Type	Eligibility for NRHP
32689	Anasazi	Structural	Eligible
35102	Anasazi	Structural	Eligible
50359	Anasazi	Structural	Eligible
50360	Anasazi	Structural	Eligible
50361	Anasazi	Structural	Eligible
50362	Anasazi	Structural	Eligible
50367	Anasazi	Structural	Eligible
50368	Anasazi	Structural	Eligible
50369	Anasazi	Structural	Eligible
50370	Anasazi	Structural	Eligible
50371	Anasazi	Structural	Eligible
50374	Anasazi	Not listed	Not listed
50375	Anasazi	Not listed	Not listed
50376	Anasazi	Structural	Eligible
50377	Anasazi	Structural	Eligible
50378	Anasazi	Structural	Eligible
50379	Anasazi	Structural	Eligible
50380	Anasazi	Structural	Eligible
60606	Anasazi	Structural	Eligible
82633	Anasazi	Not listed	Not listed
82634	Anasazi	Not listed	Not listed
82635	Anasazi	Not listed	Not listed

FIELD METHODS

Cultural Resources

The term "cultural resources" refers to any historic or prehistoric resource. The term "historic property" specifically refers to a cultural resource that has been determined eligible for inclusion to the National Register of Historic Places (NRHP). These terms imply a great deal more than prehistoric and historic material remains, ruins, or standing structures. They encompass a wide range of material remains that have the potential to provide information about the occupation of the project area. These terms also refer to any records related to such a resource or property. A total of five classes of historic properties (districts, buildings, structures, sites, and objects) are defined as eligible for listing on the NRHP (36 CFR 60.3). Usually, historic properties are classified within more than one of these categories.

Archaeological Categories

- Archaeological Site
  A site is a concentration of cultural remains inferred to be the location of specific human activities.

- Archaeological Features
  A feature is defined as nonportable cultural remains including but not limited to hearths, storage pits, firepits, architecture, or undisturbed layers of deposited material.

- Artifact
  Artifacts are portable cultural remains that exhibit evidence of human use or alteration.

- Culturally Altered Landscape
  A culturally altered landscape is a landscape modified by human activity, including but not limited to roadways, agricultural fields, farming terraces, and irrigation ditches or other water control devices.

- Component
  A site component is defined by the New Mexico State Historic Preservation Division as a generally continuous site occupation with a single cultural affiliation.

- Historical Site
  An historic site is a location, building, or neighborhood more than 50 years old.

Archival Research

A review of the previous archaeological and/or historical work carried out in the vicinity of the project area was completed. This review included the records at the New Mexico Cultural Resources Information System (NMCRIS) maintained by the Archaeological Resource Management Section (ARMS).

Field Survey

A 100 percent pedestrian survey (Class III) of the project area was conducted on July 10, 2003. Nonoverlapping transects spaced at no greater than 15 m (50 ft) were used to traverse the project terrain. Cultural resources were recorded as a site using the following criteria: (1) ten or more artifacts of two or more artifact classes or types within a 400 m^2 area; or, (2) the presence of a structure, feature, or midden. Resources not meeting these criteria, in a severely disturbed, highly mobile context, or isolated features with poor data potential were recorded as isolated occurrences (IOs).

Sites were marked by driving a 46 centimeter (cm) (18 inch [in])-long metal rebar into the ground. The rebars have an aluminum cap stamped with an EMI field number. All cultural resources were documented using standard procedures and forms. No artifacts were collected. Archaeological site and isolated occurrence locational information was collected using a GPS Garmin *e-Trex* Vista that has an accuracy of ± 3 m (10 ft).

Two survey areas were inventoried (Figure 2). Survey Area 1 is approximately 32 ha (80 ac) and Survey Area 2 is approximately 7 ha (17 ac). Sparse and low lying vegetation across the project area allowed for an estimated 75 percent ground visibility. Three previously unrecorded archaeological sites and five IOs were identified. Richard Burleson and Robert Phippen conducted the survey. Richard Burleson served as principal investigator and Robert Phippen served as field director.

SURVEY RESULTS

A total of three previously unrecorded cultural resource sites (LA 140033, LA 140034, and LA 140035) and five isolated occurrences were identified during the Class III survey. The sites are summarized below.

Previously Unrecorded Sites

LA 140033
Land Status: Private
Quadrangle: Ambrosia Lake, New Mexico
Site Type: Prehistoric
UTM Coordinates: Z13, 246119 E 3919977 N
Legal: T13N, R9W, Section 3,
SE ¼, SE ¼, SE ¼
Site Dimensions: 25 m x 12 m (82 ft x 39 ft)
Elevation: 6740 ft
Topography: Hill slope/flat basin contact
Vegetation: Desert Scrub/Grassland

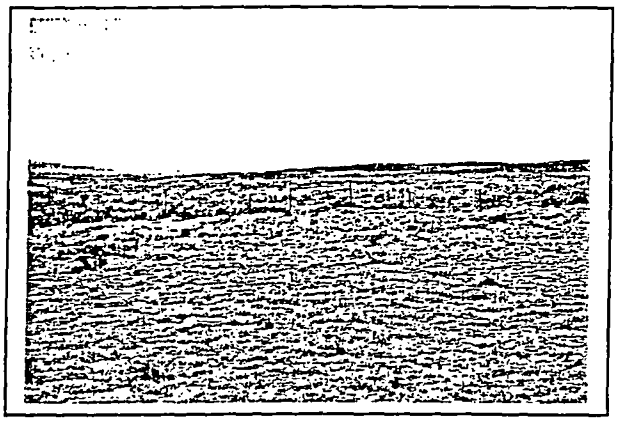

Figure 3. Site overview; aspect south.

LA 140033 is a prehistoric artifact scatter that is associated with Pueblo II and possibly Pueblo III activity during the period from A.D. 900 to A.D 1250. The site measures approximately 25 m N/S x 10 m E/W (82 ft x 39 ft) and is at an elevation of 6740 ft above mean sea level. It is located at the base of a low hill and a flat that appears to be the remains of an ancient playa system. The location provides a wide overview of the playas, plains, and mesas to the north and east. The vegetation communities are desert scrub and grassland. The area has been severely overgrazed leaving stunted woody scrub such as rabbitbrush, sand sage, and noxious grasses such as foxtail, stipa (needle and thread), and three awn. Other species observed include snakeweed, winterfat, globe mallow, and compositae. The composites form the most significant ground cover and prehistorically utilized grasses such as dropseed are rare.

Cultural materials are limited to 9 artifacts. Eight of these are ceramics that have been derived from three different vessels. Cibola Whiteware sherds without any diagnostic decoration and two different corrugated vessels are represented by the artifacts. All of the sherds are originated from jars or ollas. Moderately everted rims on the corrugated vessels may relate more closely to the Pueblo II period. The lithic artifact is the distal portion of a white chert flake. No use wear was apparent. The ceramic and lithic artifacts are deposited in a linear fashion along a flat area just below the toe of a gentle hill slope. Although somewhat sparse, this arrangement appears to represent a concentration that was probably produced as the result of depositing refuse east of a feature area. Whether the feature is a hearth, ramada or possibly a pitstructure, the location on the edge of the playa bed may indicate some type of agricultural activity. The playa system is served by a series of canyons that drain south and west into the site area.

Although the site is comprised of only nine artifacts, the presence of the three vessels probably indicates that there are subsurface cultural deposits. Further, the character of the artifact arrangement and the possibility that it may represent a refuse midden increases the possibility that there was a centralized activity area such as a feature, structure, or both. The potential for buried deposits are increased by the substantial amounts of sediment retained on the lower hillslope and bottomland. The fine sediment is highly mobile during sheet washing episodes and could easily bury ephemeral remains of a seasonally occupied site. The potential for subsurface deposits that may retain chronological, economic or other cultural data to exist is sufficient for the site to be considered eligible for nomination to the National Register of Historic Places and the State Register of Cultural Properties.

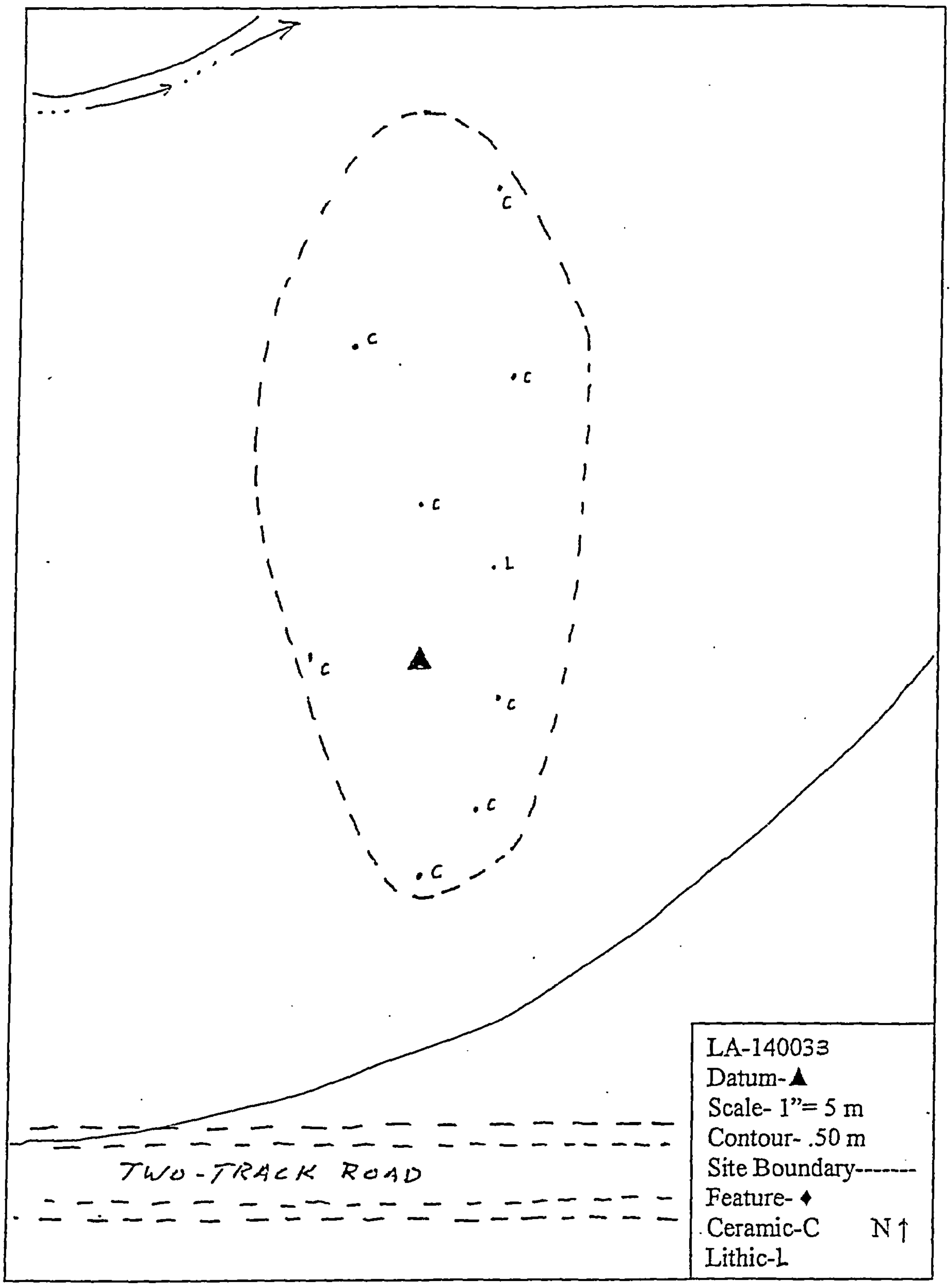

Figure 5. Site map for LA 140033.

LA 140034
Land Status: Private
Quadrangle: Ambrosia Lake, New Mexico
Site Type: Historic
UTM Coordinates: Z13, 245659 E 3919972 N
Legal: T13N, R9W, Section 3
SE ¼, SW ¼, SW ¼
Site Dimensions: 30 m x 20 m (98 ft x 66 ft)
Elevation: 6955 ft
Topography: Rincon below hill top caprock
Vegetation: Desert Scrub/Grassland

Figure 6. Site overview; aspect north.

LA 140034 is an early 20th century historic location exhibiting the remains of a chimney and fireplace, but no associated structure. The 30 m x 20 m (98 ft x 66 ft) site is located at an elevation of 6955 ft above mean sea level in a small rincon or alcove formed in the limestone and sandstone caprock of a low hill. The site feature is located on a flattened bench within the protected space. The location provides a wide overview of the plains to the south. The vegetation is a desert scrub/grassland association, but the area has been so overgrazed that very little remains of either community.

The cultural remains consists of an historic structure and very sparse artifact scatter. The most obvious feature is a collapsed chimney and fireplace remnant. The feature has collapsed in two directions across a leveled building pad area. The chimney and fireplace are constructed using locally obtained, unmodified limestone and sandstone slabs. These were apparently loosely coursed without the use of mortar. One section of the stacked stone elements remains semi-articulated as it fell leaving the direction of fall indicated by the strike and dip of the masonry. A dense concentration of slabs at the east end of the fallen chimney is interpreted as the fireplace area. Some of the slabs that appear to be lower portions of the structure are highly oxidized. The dimensions of the building pad on which it was located are somewhat eroded and highly disturbed by a rodent colony, but it is approximately 5 m E/W x 3 m N/S (16 ft x 10 ft). Whether the pad supported a wood frame structure is unknown. There are pieces of charcoal scattered over the area east of the structure and within the rodent disturbance but there are no nails scattered around to indicate burning or dismantling of the structure. Therefore, it may be inferred that the feature served a portable structure such as a cooks tent. The scatter of artifacts is very sparse. One piece of purple glass derived from a thin walled flask or phamaceutical bottle and a blue and white enamel ware basin were observed in the immediate structure area. A friction lid baking powder can was found downslope approximately 50 m (164 ft) from the structure. No lid was present therefore dating the container is problematic.

The remaining feature is somewhat unique in its presumed association with whatever type of structure it served. It was a labor intensive structure to build. However, there is very little artifactual material and the area on which the building was located is severly disrupted. The amount of washing and sediment turnover should have exposed any additional artifact dumps or structural material that was buried. Therefore, the likelihood for additional data potential is greatly reduced. If the chimney/fireplace arrangement was intact and it's unique character better preserved, there may have been a basis for potential eligibility to state and national registers. Given the absence of potential to provide architectural, chronological, or functional data, the site is not considered eligible for inclusion to the National Register of Historic Places or the State Register of Cultural Properties.

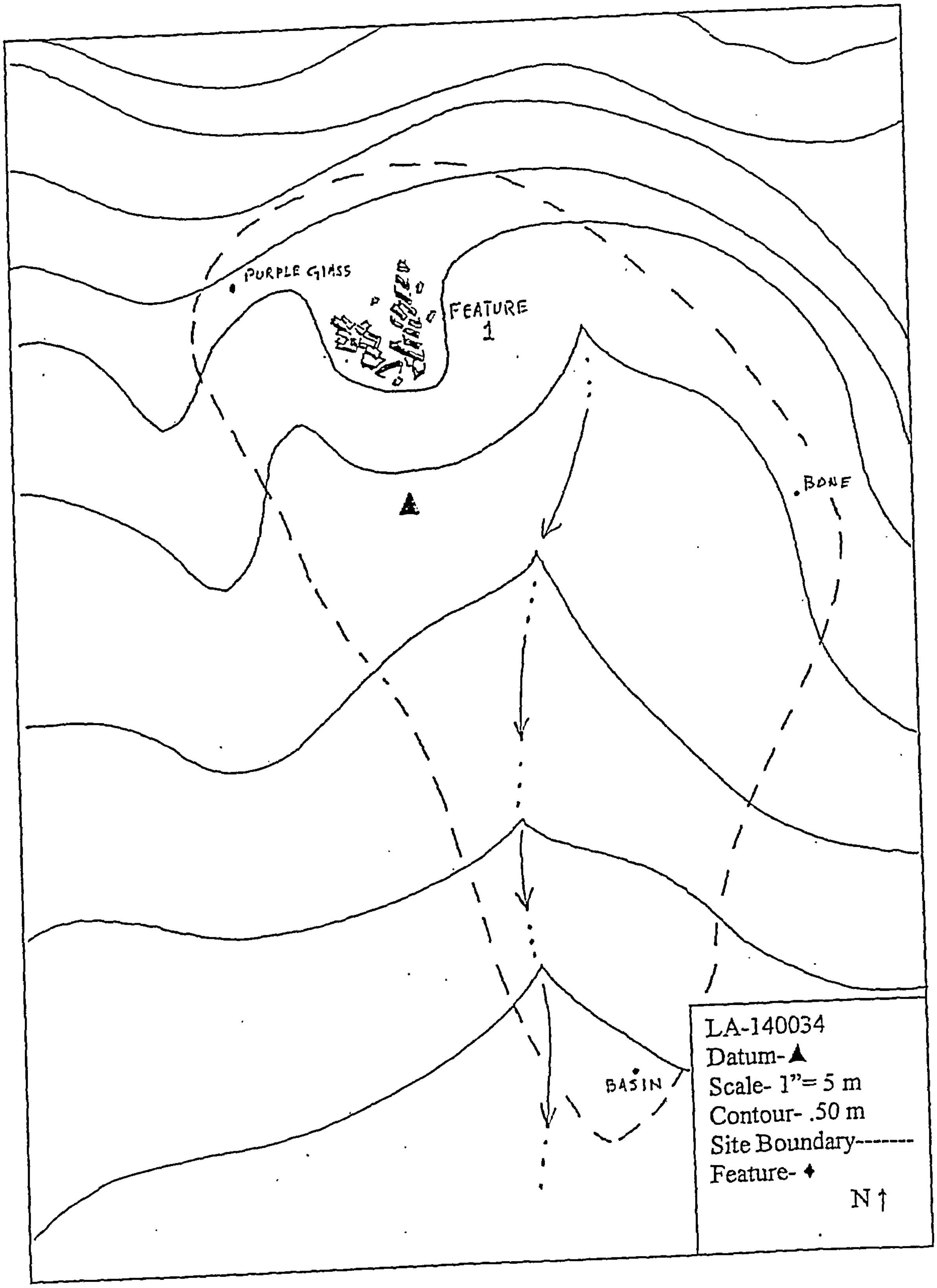

Figure 7. Site map for LA 140034.

LA 140035
Land Status: Private
Quadrangle: Ambrosia Lake, New Mexico
Site Type: Prehistoric
UTM Coordinates: Z13 245509 E 3920114 N
Legal: T13N, R9 W, Section 3
NW¼, SW¼, SW¼
Site Dimensions: 95 m x 95 m (312 ft x312 ft)
Elevation: 6768 ft.
Topography: Mesa top and slope
Vegetation: Desert Scrub/Grassland

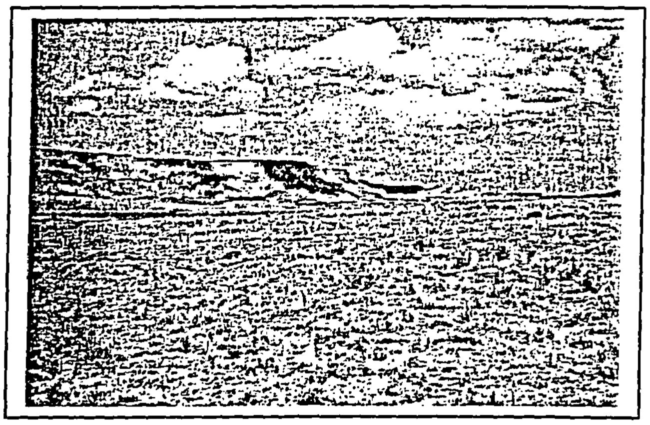

Figure 8. Site overview; aspect east.

Site LA 140035 is a cluster of prehistoric Anasazi structures and associated midden areas that relate to Pueblo II activity during the period from A.D.900 to A.D.1100. The 95 m N/S x 95 m E/W (312 ft x 312 ft) site is located on the north end/edge of a low rise at an elevation of 6970 feet above mean sea level. The low, mesa-like landform affords the occupants with an overview of a wide valley and associated drainages north from the edge of the elevated position. The vegetation is comprised of desert scrub and grassland communities. The vegetation has been severely overgrazed leaving little of the original community.

The cultural materials are centered around a small unit pueblo. Four features were identified on the site. Feature 1 is an 8 m N/S x 9 m E/W (26 ft x 30 ft) "C" shaped rubble mound. The roomblock is comprised of masonry based jacal construction, and appears to represent three to five rooms. Room divisions are evident where upright tabular slab jacal foundation elements form right angles at corners. The masonry present is loose and not heaped. Therefore, it is assmumed that the structure was exclusively jacal. Portions of the structure are highly deflated with no rubble heaping. This may also indicate that the structure is jacal rather than masonry construction. The interior of the "C" shaped roomblock is somewhat depressed and may or may not contain a small pit structure. A 5 m (16 ft) wide depression, designated Feature 2, is approximately 5 m (16 ft) east of the block and considered to be the main pitstructure and probable kiva. The midden area is located east of the depression. The ground surface is fairly well stabilized in the area and relatively few artifacts are exposed. The highest density of artifacts are located on the slope north of the structure, and in midden areas where washing has degraded the surface. Feature 3 is a 2-room jacal structure that measures 3 m N/S x 4 m E/W (10 ft x 13 ft) that was probably built prior to the unit pueblo and kiva arrangement. Potholes are excavated in each room of the structure. Feature 4 is cluster of tabular stone and artifacts that occur downslope from the main structures. The function and character of Feature 4 is not evident. The stone appears similar to that used in the main C-shaped structure, but does not appear to represent a very large entity. This feature may be the remains of a small jacal structure offset from the main site area.

The artifact assemblage consists of hundreds of ceramics scattered over a wide area. Lithic artifacts are noticeably limited in number when compared to the number of sherds. One piece of Chinle Chert was observed at the Feature 4 area. No groundstone was observed. The ceramics are predominantly derived from corrugated ollas. Cibola whitewares include Kiatuthlana Black-on-white, Red Mesa Black-on-white and what appears to be early Gallup Black-on-white. A variety of black-on-white pottery that has common design modes with the Cibola whiteware tradition, but has very dark paste and dark gray interior of the olla vessels were present throughout the site. The presence of the Kiatuthlana B/W (A.D. 850 to 950), and Red Mesa B/W (A.D. 850 to 1050), indicates an occupation during the early portion of the Pueblo II period. Slight to moderately everted rims on the corrugated vessels also point to the early and middle portion of the period. Therefore, the site may fit into a short time span from approximately A.D. 950 to A.D. 1000.

The site design is typical of small, probably extended family residential sites. What is not typical is the size of the pitstructure depression (probable kiva) at what appears to be a seasonal or possibly special use site. The residential structure is placed on an unprotected, wide open hill top that is distant from potential farming areas. Further, the mostly jacal structure appears to have been inhabited for a short period of time due to the minimal midden buildup. Jacal roomblocks are more common in the earlier portion of the P-II sequence prior to A.D.1000, and the larger kivas are usually not associated with the smaller jacal structures. Tainter and Gillio (1980) relate the increase in full masonry structures in the mid-to latter portion of the period. Therefore, the presence of the kiva with the larger "C" shaped jacal dwelling may point to a period of transition during the P-II period when the Chaco Canyon influence greatly inhanced the population dynamics in the San Mateo Valley. Over 30 previously recorded sites within 1.6 km (1 mi) of the project area have similar structural arrangements with associated kivas.

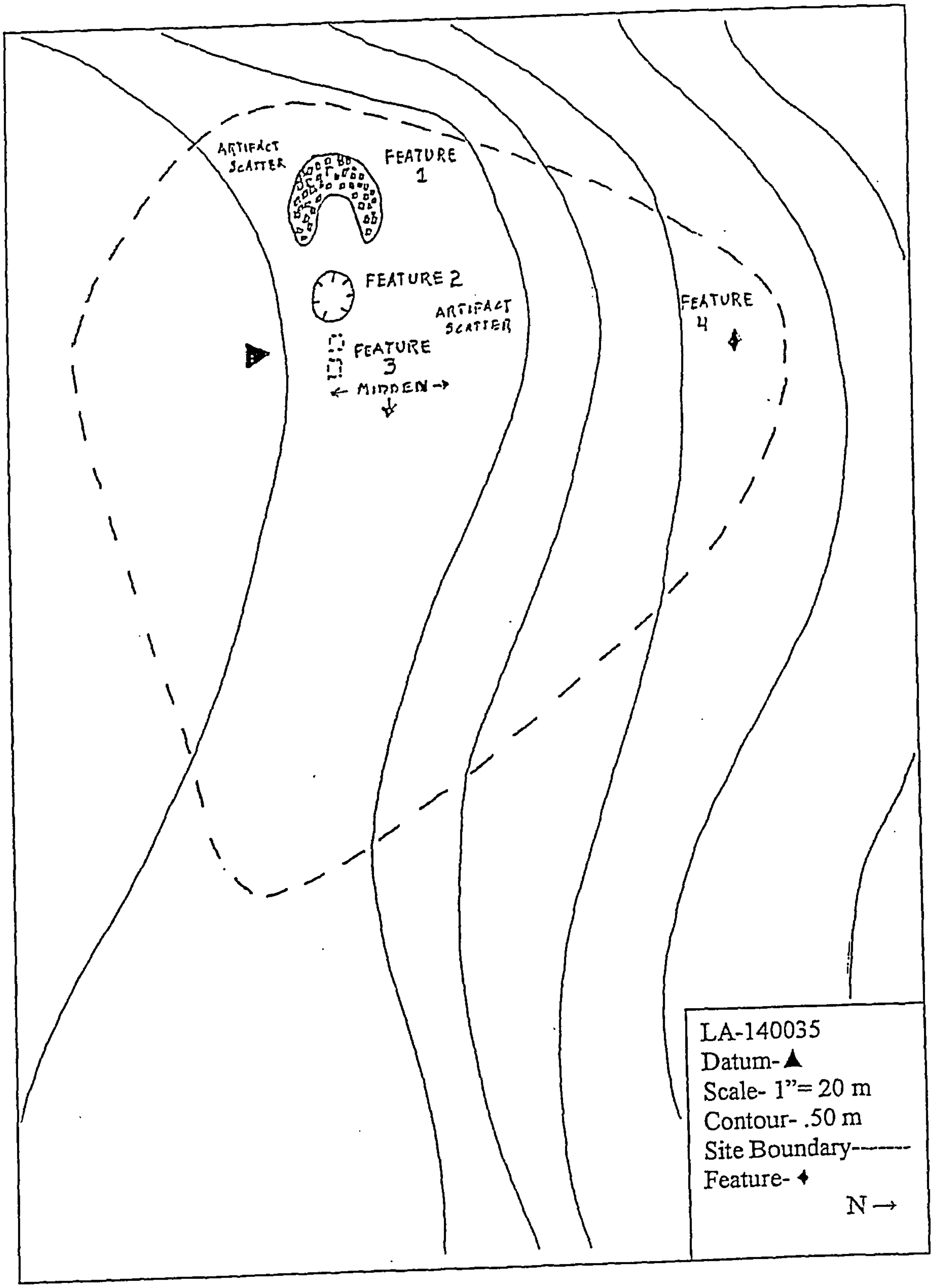

Figure 9. Site map for LA 140035.

ISOLATED OCCURRENCES

Five isolated occurrences (IOs) were recorded during the survey and consist of four ceramics and some fence remnants. Table 2 summarizes the five IOs. EMI considers the field recordation of the IOs as having exhausted their information potential and, therefore, they require no further work. None of the IOs are deemed eligible for listing on the National Register of Historic Places or State Register of Cultural Properties. Their locations are shown in Figure 10.

Table 2. Isolated occurrences summaries.

IO	Description
1	1 ceramic, Corrugated grayware
2	1 ceramic, Escavada Black-on-white
3	7 pieces of a fence remnant (secondary deposit)
4	1 ceramic, Corrugated grayware
5	1 ceramic, unidentified Cibola whiteware

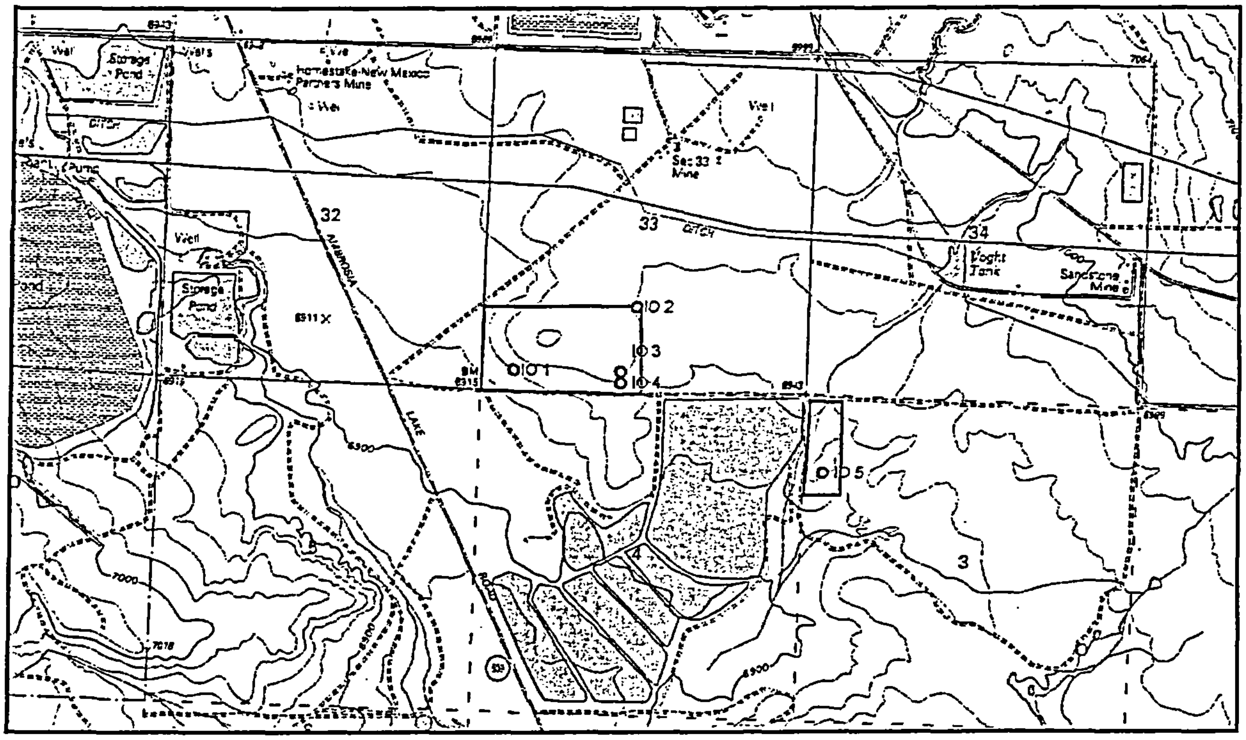

Figure 10. Isolated occurrences.

SUMMARY

A total of three previously unrecorded sites and five isolated occurrences were identified during the Class III cultural resources inventory. LA 140033 is a prehistoric artifact scatter that is associated with Pueblo II and possibly Pueblo III activity during the period from A.D. 900 to A.D 1250. The potential for subsurface deposits that may retain chronological, economic or other cultural data to exist is sufficient for the site to be considered eligible for nomination to the National Register of

Historic Places and the State Register of Cultural Properties under criterion D, information potential. LA 140034 is an early 20th century historic location exhibiting the remains of a chimney and fireplace, but no associated structure. Given the absence of potential to provide architectural, chronological, or functional data the site is not considered eligible for inclusion to the National Register of Historic Places or the State Register of Cultural Properties. Site LA 140035 is a cluster of prehistoric Anasazi structures and associated midden areas that relate to Pueblo II activity during the period from A.D.900 to A.D.1100. The presence of structures and potential for further subsurface deposits that may retain chronological, economic, or other cultural data to exist is sufficient for the site to be considered eligible for nomination to the National Register of Historic Places and the State Register of Cultural Properties under criterion D, information potential. It is recommended that LA 140033 and LA 140035 be avoided.

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Cultural Resource Survey

Class III Survey of 18.58 Hectares (45.91 Acres) for Rio Algom Mining LLC,
Near Ambrosia Lake,
McKinley County, New Mexico

Prepared by
Richard Burleson

Under

BLM Permit Number 157-2920-03-E
New Mexico State Land Permit Number NM-04-107

NMCRIS NO. 89898

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Rio Algom Mining, LLC.

EMI Report Number 612

September 2004

ABSTRACT

On August 31, 2004, Ecosystem Management, Inc. (EMI) conducted a Class I archival search and a Class III pedestrian cultural resource survey of approximately 18.58 hectares (ha) (45.91 acres [ac]) near Ambrosia Lake, McKinley County, New Mexico. The project is located within Township 14 North, Range 9 West, Sections 5 and 32 on the US Geological Survey (USGS) Ambrosia Lake, NM 7.5 minute quadrangle.

A total of eight isolated occurrences (IOs) were identified and recorded during the Class III survey. Their data potential has been exhausted by the present recording. No further cultural resource investigations are recommended at this time.

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INTRODUCTION/ PROJECT DESCRIPTION

On August 31, 2004, Ecosystem Management, Inc. (EMI) conducted a Class I archival search and a Class III pedestrian cultural resource survey of approximately 18.58 hectares (ha) (45.91 acres [ac]) near Ambrosia Lake, McKinley County, New Mexico. The project is located within Township 14 North, Range 9 West, Sections 5 and 32 on the US Geological Survey (USGS) Ambrosia Lake, NM 7.5 minute quadrangle.

A total of eight isolated occurrences (IOs) were identified and recorded during the Class III survey. Their data potential has been exhausted by the present recording. No further cultural resource investigations are recommended at this time.

This undertaking complies with the provisions of the National Historic Preservation Act of 1966, as amended through 1992, and applicable regulations. The report is consistent with applicable federal and state standards for cultural resource management. The archaeological field work was completed by Richard Burleson and Robert Phippen. Richard Burleson served as principal investigator and Robert Phippen served as field director.

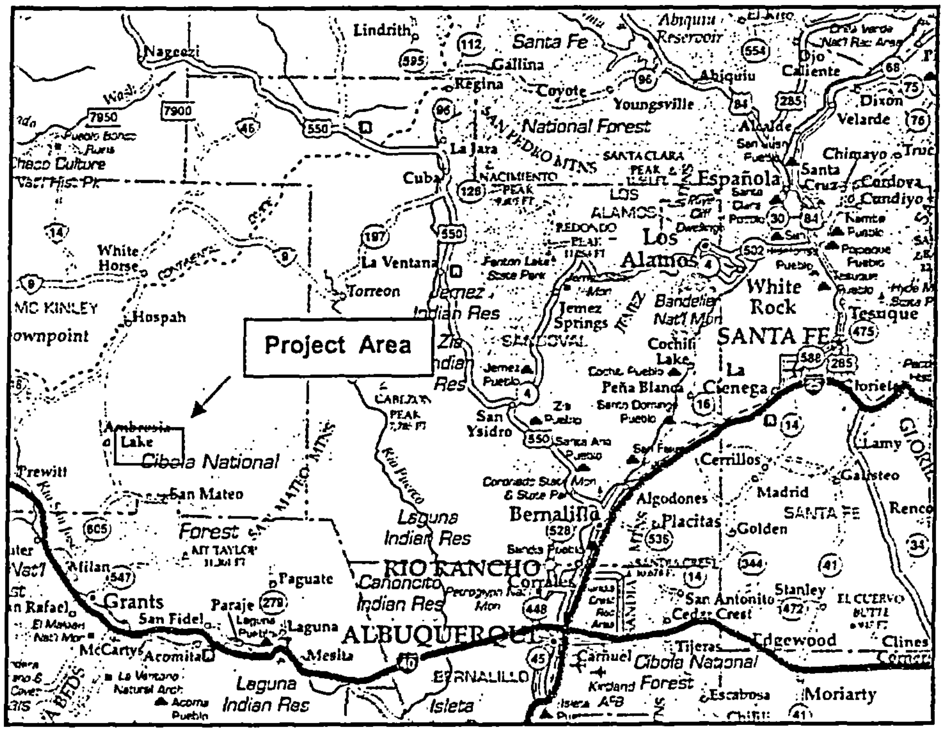

Figure 1. Project location in northwest New Mexico.
Source: Recreational Map of New Mexico, GTR Mapping (2000 Edition)

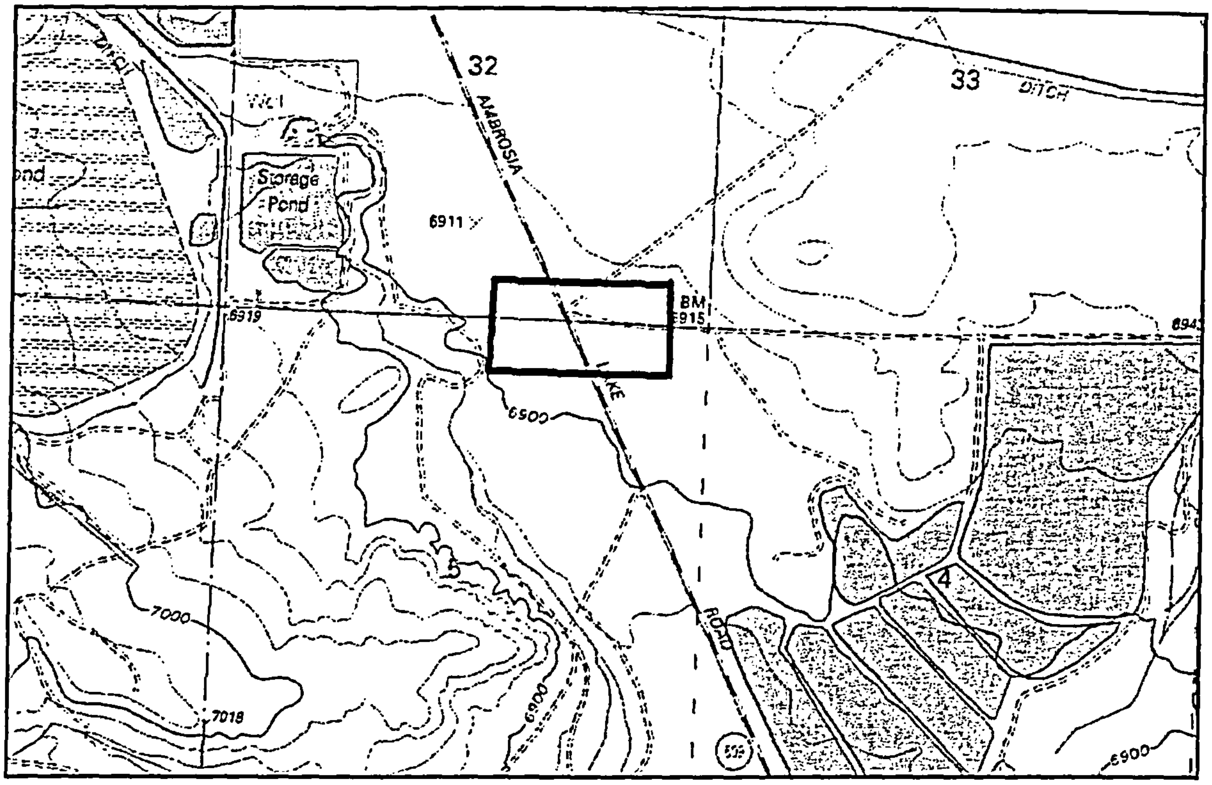

Figure 2. Ambrosia Lake 7.5-minute quadrangle showing survey area location.

ENVIRONMENTAL SETTING

Physiography

The project area is within the central portion of McKinley County in northwestern New Mexico (Figure 1). This area is in the Navajo Section of the Colorado Plateau Province of the North American continent. The Colorado Plateau is characterized by deep canyons, high altitude, steep escarpments, flat plateaus comprised of gently dipping sedimentary rocks, and an arid climate (Thornbury 1965) (Figure 3). The most distinctive structural feature of the province is its large number of monoclines. The monoclines are broken throughout the province by structural basins and up warps of considerable relief. Volcanic structures are concentrated around the plateau's margin but are also scattered throughout its interior (Kelley 1955).

The Navajo Section of the province is a poorly defined area of scarped plateaus that lack the degree of dissection that occurs elsewhere in the province (Thornbury 1965). Surfaces in the Navajo Section are mesas, buttes, and cuestas rather than clinal ridges and hogbacks. The section is bounded on the west and south by the Little Colorado River and the Echo Cliffs monocline near the Colorado River. The northern boundary is along the lower San Juan River to the Four Corners area, then northeast to the San Juan Mountains. The southeast boundary extends from the Sierra Nacimiento to Mt. Taylor and onward to the Puerco River.

The Navajo Section has numerous volcanic features that include vents, flows, and pyroclastic deposits that are referred to collectively as the Navajo-Hopi Volcanic Field. Other major structural features of the section include the Black Mesa Basin, the Defiance Upwarp, and the San Juan Basin. The Navajo-

Hopi Volcanic Field is comprised of the Hopi Buttes, Monument Valley, and the Chuska Mountains. Basalt-capped mesas and buttes are common throughout the section (Thornbury 1965).
The exposed rocks of the Colorado Plateau range from the Precambrian to the Recent period in age (Thornbury 1965). Black Mesa is capped by the Cretaceous Mancos Shale and Mesa Verde Sandstone formations. The Defiance Upwarp has exposed the much older De Chelly Sandstone. The Navajo Section is characterized as a basin with thick layers of gently dipping Mesozoic and Cenozoic sedimentary shale, mudstone, and sandstone that contain coal seams. The area is generally characterized as rolling plains with cuestas and tablelands capped by sandstone. Canyons are typically broad and shallow (Williams 1986).

The character of the Colorado Plateau is a product of the interaction of three processes: uplift, volcanism, and erosion. Erosion is the primary force that has created the extant landscape. The tectonic event that uplifted the Colorado Plateau involved the westward movement of the North American plate, beginning about 75 million years ago. Over a period of the next 25 million years, the western portion of the North American plate broke, buckled, and was uplifted, forming the Rocky Mountains. The following 45 million years has been degradation as material has been removed from the surface of the plateau to form the Middle and Late Tertiary deposits in other regions. As recent as 10 million years ago, a large lake formed in what is now northeastern Arizona. Streams carried eroded materials from the south, east, and north. This ancient lake is referred to as Hopi Lake (Repenning et al. 1958).

As part of the plate tectonics, weak spots formed in the North American plate that allowed volcanic pipes to form, and the Hopi Buttes volcanic field was created from 8 to 4 million years ago (Wenrich 1989). Explosive eruptions ejected large quantities of tuff and basalt flows that spread outward from the vents. By the early Pleistocene, renewed uplift of the plateau had drained Lake Hopi and accelerated erosion from the province (Chronic 1983). The Colorado River was flowing through the Gulf of California by this time, with increased channel cutting. The Colorado Plateau has eroded to a greater degree than any other part of the United States (Thornbury 1965). The major drainages for the project area are Mitchell Draw that borders the east side of the project area and the headwaters of the Rio San Jose that is to the west and south of the project area. The project area elevation is approximately 6900 feet above mean sea level.

Climate

The climate is characterized as being arid to semi-arid with hot summers and mild winters. Temperatures across northwestern New Mexico vary mainly as a result of elevation and latitude. Winter temperatures drop about 1° centigrade (C) for every one-degree increment in latitude. Summer temperatures drop about 1°C for every 150 m (492 ft) increase in elevation (Sellers and Hill 1974). For Grants, New Mexico (1971 to 2000 records), the mean average summer high temperature ranges between 29° and 31° C (85° to 88° Fahrenheit [F]) and the average winter high temperature ranges between 7° and 10.5° C (46° to 51° F). The average number of frost-free days is about 120 days (Bennett 1986:38, 47).

Annual precipitation for Grants, New Mexico (1971 to 2000 records), is 25.4 centimeters (cm) (10 inches [in]). Most precipitation occurs from July through October. Average snowfall in Grants is 30.4 cm (12 in). Summer precipitation originates primarily from the Gulf of Mexico and the Atlantic Ocean. Precipitation from summer storms is brief, occurring primarily in the evening. These thunderstorms tend to be localized. Winter precipitation originates from the Pacific Ocean (Sellers and Hill 1974). Precipitation from winter storms is usually light to moderate. Most mountainous areas receive winter precipitation as snow.

The prevailing winds are from the southwest with winds from the west and southeast not uncommon. The most frequent wind velocities range between 13 and 19 km per hour (8 to 12 mi per hour) from March through June, with the predominate direction being from the southwest (Bennett 1986:50–51).

Biotic Communities

The project area lies in the Desert Scrub/Grasslands biotic community. This plant community is dominated by two cold-temperature conifers, juniper and piñon. Habitats tend to be rocky with adjacent areas being grassland with parkland and savanna-like mosaics. The understory consists of grasses and shrubs that include threadleaf groundsel, snakeweed, galleta grass, Indian ricegrass, western wheatgrass, dropseeds, and junegrass. Shrubs include rabbitbrush, winterfat, and sagebrush. Other plants not uncommon include cliffrose, Apache plume, Mormon-tea, fourwing saltbush, and soapweed (Brown 1994:52–55).

The Desert Scrub/Grasslands has several distinctive mammalian species that follow the vegetation communities of this biome. These taxa include pinyon mouse and the bushy-tailed woodrat (Brown 1994:52–55). Less common taxa include ground squirrel, kangaroo mouse, and vole. The coyote and black-tailed jackrabbit are found throughout the province. Large ungulates are poorly represented, with mule deer and elk being the most common. The pronghorn occurs as an incursionary species from adjacent or former grasslands.

Several avian species are characteristic of the Desert Scrub/Grasslands. These include the pinyon jay, gray flycatcher, and black-throated gray warbler (Brown 1994:56). Other taxa in the region include the plateau whiptail lizard, rattlesnake, and bobcat.

Paleoenvironment

It is estimated from adjacent dendroclimatological station data that there were eleven periods, each lasting more than one decade, from A.D. 700 to 1330 during which the mean tree-ring width values are more than 1.1 standard deviation units above the mean. These eleven periods include the decades A.D. 720 to 730, 780 to 800, 880 to 890, 910 to 920, 1010 to 1020, 1050 to 1070, 1110 to 1120, 1190 to 1200, 1230 to 1240, 1260 to 1270, and 1300 to 1330. These periods represent exceptionally wet and cool climatic episodes. In climatic contrast, ten periods, each spanning one or more decades, of exceptionally hot and dry years occurred from A.D. 700 to 710, 740 to 760, 830 to 840, 990 to 1000, 1030 to 1040, 1080 to 1100, 1130 to 1150, 1170 to 1180, 1210 to 1220, and 1280 to 1290 (Eck 1994:55). These climatic episodes of alternating exceptionally hot and dry, and cool and wet, events would have directly affected human use of the project area.

CULTURE HISTORY OVERVIEW

Paleoindian Period (11,000 to 6000 B.C.)

Paleoindian peoples are defined as early Holocene hunters and foragers who were the first to inhabit the North American continent. Originally believed to be dependent on now extinct megafauna such as bison, mammoth, and mastodon, recent research has shown that Paleoindian groups also utilized varied floral and faunal resources (Cordell 1997). Material remains include a toolkit consisting of lanceolate projectile points, end and side scrapers, knives, gravers, chisel gravers, drills, spokeshaves, and utility flakes (Judge 1973:327). Regional settlement is believed to have been seasonal although some reoccupation of campsites may have occurred. Kelley and Todd (1988) make a point that given the new migrants unfamiliarity with newly encountered floral and faunal species, the Paleoindians would have tended to concentrate on proven sources of food, i.e., migratory game animals such as mammoth and bison. Paleoindian mobility is, therefore, explained by the necessity to follow wide-ranging herd animals. Paleoindian sites are often found on promontories near water sources and are generally within the seasonal range of herbivorous animals (Judge 1973:330).

The various Paleoindian cultures represented in the region include Clovis (9500–9000 B.C.), Folsom (8800–8300 B.C.), and Plano Complexes (7000–6000 B.C.) (Irwin-Williams and Haynes 1970). In the San Juan basin there is thought to be a lapse in human occupation between 8000 and 6600 B.C., possibly as a result in a decrease of effective moisture during this period (Stuart and Gauthier 1981:29; Vivian 1990:81). Also, Paleoindians likely occupied upland areas (elevations from 2,128 to 3,040 m [7,000 to 10,000 ft]) in the region (Stuart and Gauthier 1981:29). The Paleoindian toolkit includes lanceolate projectile points/knives, end and side scrapers, knives, gravers, chisel gravers, drills, spokeshaves, and utility flakes (Judge 1973). There is a growing diversification in tool kits throughout the period, possibly explained by the extinction of megafauna later in the period and the tendency for groups to settle into territories and focus on local resources in a more restricted area (Stone 1999).

Archaic Period (6000 to 400 B.C.)

The Archaic period is characterized by continuation of the hunting and foraging economy of the preceding Paleoindian period with technological adaptations to changing climatic conditions. Around 6000 B.C. the North American climate changed to a much warmer and drier Altithermal pattern, causing widespread faunal and floral changes (Cordell 1997). Most megafauna became extinct and smaller modern species became predominant. Human populations adapted to these changes and material culture became diversified. A distinction is made between northern Archaic groups, referred to as the Oshara Tradition (Irwin-Williams 1973), and more southerly groups, referred to as the Cochise Tradition (Sayles and Antevs 1941). The Oshara Tradition includes five phases: Jay (5500–4800 B.C.), Bajada (4800–3300 B.C.), San Jośe (3300–1800 B.C.), Armijo (1800–800 B.C.) and En Medio (800 B.C.–A.D. 400). This typological division is somewhat arbitrary as projectile point types from both traditions frequently overlap. Both groups employ smaller point styles with shouldered hafting elements occurring sometime around 3200 B.C.

A growing reliance on plant foods during the Archaic period is also evidenced by grinding tools such as one-handed manos and basin metates. Settlement patterns are diverse with no ecological determinants except that Archaic populations tended to camp near areas of high floral and faunal diversity. Later in the period, ca. 1800 B.C., maize was introduced. In some areas maize is quickly adopted and becomes a staple, in others it is less important compared to wild plant resources and is not habitually grown until the Basketmaker III period (Dello-Russo 1999).

The first evidence of definable architecture appears during the middle-to-late Archaic period (1800 B.C.–A.D. 600). Pitstructures, archaeologically defined by shallow oval enclosures surrounded by postholes and often associated with fire-cracked rock, appear to have been used for short term or seasonal habitation near abundant resource locations. This adaptation is scattered widely across the San Juan Basin. Habitation and resource areas tend to be located near permanent water sources and on upland dune ridges and mesa-canyon associations. Populations tended to depend on collecting wild plant foods such as grass seeds, piñon nuts, juniper berries, hackberry, amaranth, and cacti (Vivian 1990:99–105).

Basketmaker II–III Period (400 B.C. to A.D. 720)

The beginning of the Basketmaker period (Basketmaker II 400 B.C. to A.D. 500) is characterized by hunters/gatherers engaging in horticulture, while later in the period (Basketmaker III A.D. 500–720) storing excess foodstuffs beyond their seasonal needs. Instead of a mobile lifeway based on natural resource abundance, these people begin a longer seasonal habitation and possibly even permanent habitation in areas that are both productive for maize-based agriculture and seasonal hunting (Stuart and Gauthier 1981:36). The timing of this shift in subsistence strategy seems to vary widely across the southwest, and Stuart and Gauthier note that these changes are probably "fragile, sporadic and determined by local population density". They further note that this period is highly variable in terms of settlement pattern and site size and that surface surveys may miss Archaic period remains that lie beneath later occupations. The few consistent patterns during this period are the location of sites near permanent water sources and their proximity to mountainous areas (Stuart and Gauthier 1981:409).

Later habitation sites increase in size indicating population aggregation into villages generally in upland settings that average 1,976 m (6,500 ft) in elevation (Stuart and Gauthier 1981). Some authors argue that some peoples retained the hunting and gathering lifeway and that these groups essentially lived among sedentary groups (Stuart and Gauthier 1981). Pottery was developed at about A.D. 300 (Vivian 1990:99) and a significant reduction in the size of projectile point forms indicates the use of the bow and arrow.

Pueblo I Period (A.D. 720 to 920)

The Pueblo I period is characterized by linear and crescent-shaped surface storage and living structures in association with pitstructures. During this period there was a decrease in effective moisture with an increasing oscillation in precipitation from year to year. Most aggregated settlements were dependent on maize-based agriculture supplemented by seasonal hunting and wild seed gathering. Wild plant foods were probably still very important in years when precipitation would not permit excess agricultural production to last throughout the winter.

In the Chaco Canyon area, the initial construction of "Great Houses" begins during the Pueblo I period (Vivian 1990). Previously undecorated pottery assumed new decorated forms that included mineral-based paints and neck-banding on plain vessels (Dello-Russo 1992:43). Larger settlements continued to be occupied in upland settings (Stuart and Gauthier 1981). In some areas populations were more mobile with a segment of the population leaving seasonally and returning for the winter and/or summer months (Schmader 1994).

Pueblo II Period (A.D. 920 to 1120)

The Pueblo II period is defined by the building of small, linear, above ground habitation structures or roomblocks while retaining the pitstructure form as an auxiliary habitation or religious structure (kiva). Initially, there is a trend in aggregated settlements to be at higher elevations in riverine settings. By A.D. 1000, in nearly all areas of New Mexico, there is a reversal in this trend. There is an abandonment of higher elevation areas in favor of lower elevation basin settings (Stuart and Gauthier 1981). Pottery types such as Red Mesa and Gallup Black-on-white are characteristic of the period.

In the central San Juan Basin, local adaptations are referred to as the Early Bonito phase—A.D. 920 to 1020—and the Classic Bonito phase—A.D. 1020 to 1120. These phases indicate a shift in architecture and settlement patterns. The development of Chacoan communities begins, marked by the construction of planned, multi-storied "Great Houses" and large "Great Kivas". There is also a continuation of small house sites with linear pueblos associated with subterranean kivas (Vivian 1990:203–206). The population is estimated to have increased throughout the period and six-fold in the Chuska River Valley (Gillespe and Powers 1983). Subsistence resource shortfalls may have become more common and maize-based farming became more intensive with water control and conservation features becoming more common (Vivian 1990:214). An extensive road system was built that extended in a general radial pattern from Chaco Canyon to the margins of the San Juan Basin (Nials et al. 1983). Tainter and Gillio (1980) relate the rapid growth of population during the period in the San Mateo Valley that coincides with a period of increased and stable moisture. Pueblo II sites increase in density from approximately 4.8 per square mile early in the period, to 15.6 in the middle and 28.4 in the latter stages. During the middle to late Pueblo II period Chacoan influence in the San Mateo area produced three outlier sites El Rito, San Mateo, and Kin Nizhoni. Recent survey data in the project area indicates Pueblo II period occupation (Burleson and Phippen 2003).

Pueblo III Period (A.D. 1120 to 1320)

The Pueblo III period was one of great change in the southwest. The San Juan Basin saw community development in its peripheries such as at Mesa Verde, Cibola, and Acoma. The Chaco core area fluoresces and then collapses with a general abandonment by the late 1170s. There is a reoccupation of Chaco Canyon by Mesa Verde peoples during the 1175 to 1250 period based on the sudden appearance of Mesa Verde style pottery and new pueblo construction as well as older pueblo reconstruction. In the San Mateo Valley Tainter and Gillio (1980) portray a sudden drop in population during the Hosta Butte Phase. The very high site density of the Late Pueblo II period dropped to 5.2 per square mile after the first 50 years of the period. A brief reoccupation occurred at approximately A.D. 1250 in the El Rito outlier area. Ceramics during this period relate to Mesa Verde influence in the Chaco outlier system.

The Rio Grande districts saw an increase in population. Aggregation of peoples in the eastern pueblos resulted in larger planned communities (50+ rooms). This probably resulted from a combination of immigration and local population growth (Crown et al. 1996). In addition to population growth there is a shift in settlements away from river terraces and floodplains to elevated upland settings. There was a corresponding shift to dry land agricultural techniques. New pottery decoration techniques were adopted using vegetal-based paints to create the nearly ubiquitous Santa Fe Black-on-white type.

Pueblo IV Period (A.D. 1320 to 1540)

The Pueblo IV period is considered one of cultural florescence in the Rio Grande region (Wendorf and Reed 1955). The tendency of aggregation into fewer and larger pueblos continued, and sites with

1000+ rooms are common in the Santa Fe (Galisteo), Chama, and Pajarito districts. These large settlements tend to be in riverine and valley bottom settings, lower in elevation than aggregated settlements during the preceding Pueblo III period. Outlying small fieldhouse sites were also built near varied resource areas (Snead 1995). It is during the Pueblo IV period that the population is considered to have reached its maximum levels, and material culture attained its most sophisticated level. Glaze-painted pottery becomes predominant and is roughly contemporaneous with Katsina cult iconography that indicates a new religion had spread into the region from the south (Adams 1991). Pueblo IV sites in western NM are associated with ancestral villages of Acoma and Zuni. These are located some distance from the project area.

Another development during this time is the migration of Athapaskan (Dineh and Apache) peoples from the north. The arrival date of the Athapaskans into northwest New Mexico is debated by scholars (Kelley 1982). Spanish colonists in the mid-sixteenth century referred to local Athapaskan peoples as "Apaches", and those living west of the Rio Grande as "Apaches de Navajo" (Brugge 1984). Exactly when the Navajo became distinct from other Apaches is not known. The subsistence pattern of the early Navajo was probably based on horticulture combined with hunting and gathering. Early Spanish records indicate the Navajo were farming by the early 1600s (McNitt 1972; Wozniak 1988), but whether they adopted horticulture from local Puebloan peoples or prior to their arrival in the Dinetah is unclear (Bailey and Bailey 1986). Betancourt (1980) uses the presence or absence of horticulture as the basis for distinction between the Navajo and other Athapaskan (Apache) peoples.

Historic Period (A.D. 1540 to Present)

The first Spanish colonial capital was established at the Tewa community of Yunge Oweenge in 1598. This changed Puebloan culture radically in economic, religious, social, and political terms. Endemic disease; raiding by Navajo, Ute, Apache, and Comanche peoples; and the Spanish system of land grants and mission establishment also took their toll. They drastically reduced traditionally held areas and population. The first European presence in the Grants and Bluewater areas was during the late sixteenth to mid-seventeenth centuries with Spanish exploratory and military expeditions. The early Spanish community of San Rafael is an example of an early Spanish colonial occupation with its mission and settlement. The arrival of the Spanish created tension between the indigenous peoples and Europeans.

In 1599 the Spanish, under the command of Viceroy Don Juan de Oñate, conducted punitive military action against Ácoma Pueblo, killing some 500 residents and imprisoning, enslaving, and maiming others. This action was in response to attacks on Spanish military scouting parties transgressing on Pueblo lands. The Pueblo Revolt of 1680 was a reaction to Spanish authority and the revolt did remove, temporarily, Spanish rule. In 1692, however, Spain with an army under De Vargas reasserted its claim on northern New Mexico and held it until 1821 when Mexico won its independence. Mexico held claim to what is now New Mexico until 1846 when the U.S. Army, under S. W. Kearny, took possession of the territory during the U.S. and Mexico War. Throughout this period...

> ...The landscape produced a dispersed pattern of settlement consisting of numerous small enclaves of population and culture. These Pueblo and Hispano villages became bastions of cultural preservation, for they were at once so self-sufficient that they had little need for the outside world and yet so poor that the outside world had little need for them. In isolation they persisted for centuries, changing little [DeBuys 1985].

The San Juan Basin remained Navajo territory throughout the early historic period while the Ute claimed the territory generally north of the San Juan River. The economy of the area was dominated by sheep herding and small-scale agriculture. In 1863, the U. S. army forced an initial 8,000 Navajos to relocate to the Mescalero Apache reservation at Bosque Redondo in east central New Mexico (McNitt 1972). This action was a punitive reaction to raids by Navajos in the area and on the community of Santa Fe in 1860. A punitive military expedition mounted by Kit Carson in the San Juan Basin resulted in scorched earth policies and the persuasion of Navajo leaders Barboncito and Delgado to gather their followers and relocate to Bosque Redondo. More militant leaders, such as Manuelito, maintained guerilla warfare against the New Mexico militia and their Ute, Zuni, and Hopi allies. At Bosque Redondo, the relocated Navajos faced starvation and extremely poor living conditions that resulted in more than 2000 who died of disease and starvation. The Navajo returned to the San Juan Basin in 1868 under the guidelines of the Treaty of 1868 that was negotiated in Washington, D.C. by Federal officials and the Navajo leaders. In the 1870s a United States Army facility was established along the eastern flank of the San Juan Basin (Williams 1986:112). The facility was established to discourage periodic Navajo raiding of Puerco and Chama River Euroamerican settlements.

Euroamerican settlements that include Grants, Coolidge, and Thoreau were established during the late nineteenth century. Their settlement coincided with the construction of the Atlantic and Pacific railroad. The railroad made farming and ranching profitable. Mining and lumber milling developed in response to cheaper shipping by railroad. The railroad stimulated economic development in the Grants and Bluewater areas.

PREVIOUS ARCHAEOLOGICAL WORK

Prior to conducting the Class III pedestrian field survey, a site records search of the Archaeological Records Management Section (ARMS) in Santa Fe identified 46 previously recorded sites within 1.6 km (1 mi) of the proposed project areas. These sites are summarized in Table 1.

Table 1. Recorded sites within 1.6 km (1 mi) of the project area.

Site LA #	Cultural Affiliation	Type	Eligibility for NRHP
18190	Anasazi	Structural	Eligible
18193	Anasazi	Structural	Eligible
18194	Anasazi	Structural	Eligible
18195	Anasazi	Structural	Eligible
18196	Anasazi	Structural	Eligible
18197	Anasazi	Structural	Eligible
18198	Anasazi	Structural	Eligible
18199	Anasazi	Structural	Eligible
18200	Anasazi	Structural	Eligible
18201	Anasazi	Structural	Eligible
18202	Anasazi	Structural	Eligible
18209	Anasazi	Structural	Eligible
18210	Anasazi	Structural	Eligible
18211	Anasazi	Structural	Eligible
18212	Anasazi	Structural	Eligible
18214	Anasazi	Structural	Eligible
18215	Anasazi	Structural	Eligible
32684	Anasazi	Structural	Eligible
32685	Anasazi	Structural	Eligible
32686	Anasazi	Structural	Eligible

Site LA #	Cultural Affiliation	Type	Eligibility for NRHP
32688	Anasazi	Structural	Eligible
32689	Anasazi	Structural	Eligible
35102	Anasazi	Structural	Eligible
50359	Anasazi	Structural	Eligible
50360	Anasazi	Structural	Eligible
50361	Anasazi	Structural	Eligible
50362	Anasazi	Structural	Eligible
50367	Anasazi	Structural	Eligible
50368	Anasazi	Structural	Eligible
50369	Anasazi	Structural	Eligible
50370	Anasazi	Structural	Eligible
50371	Anasazi	Structural	Eligible
50374	Anasazi	Not listed	Not listed
50375	Anasazi	Not listed	Not listed
50376	Anasazi	Structural	Eligible
50377	Anasazi	Structural	Eligible
50378	Anasazi	Structural	Eligible
50379	Anasazi	Structural	Eligible
50380	Anasazi	Structural	Eligible
60606	Anasazi	Structural	Eligible
82633	Anasazi	Not listed	Not listed
82634	Anasazi	Not listed	Not listed
82635	Anasazi	Not listed	Not listed
140033	Anasazi	Nonstructural	Eligible
140034	Historic	Structural	Eligible
140035	Anasazi	Structural	Eligible

FIELD METHODS

Cultural Resources

The term “cultural resources” refers to any historic or prehistoric resource. The term “historic property” specifically refers to a cultural resource that has been determined eligible for inclusion to the National Register of Historic Places (NRHP). These terms imply a great deal more than prehistoric and historic material remains, ruins; or standing structures. They encompass a wide range of material remains that have the potential to provide information about the occupation of the project area. These terms also refer to any records related to such a resource or property. A total of five classes of historic properties (districts, buildings, structures, sites, and objects) are defined as eligible for listing on the NRHP (36 CFR 60.3). Usually, historic properties are classified within more than one of these categories.

Archaeological Categories

- **Archaeological Site**
  A site is a concentration of cultural remains inferred to be the location of specific human activities.

- **Archaeological Features**
  A feature is defined as nonportable cultural remains including but not limited to hearths, storage pits, firepits, architecture, or undisturbed layers of deposited material.
- **Artifact**
  Artifacts are portable cultural remains that exhibit evidence of human use or alteration.
- **Culturally Altered Landscape**
  A culturally altered landscape is a landscape modified by human activity, including but not limited to roadways, agricultural fields, farming terraces, and irrigation ditches or other water control devices.
- **Component**
  A site component is defined by the New Mexico State Historic Preservation Division as a generally continuous site occupation with a single cultural affiliation.
- **Historical Site**
  An historic site is a location, building, or neighborhood more than 50 years old.

Archival Research

A review of the previous archaeological and/or historical work carried out in the vicinity of the project area was completed. This review included the records at the New Mexico Cultural Resources Information System (NMCRIS) maintained by the Archaeological Resource Management Section (ARMS).

Field Survey

A 100 percent pedestrian survey (Class III) of the project area was conducted on August 31, 2004. Nonoverlapping transects spaced at no greater than 15 m (50 ft) were used to traverse the project terrain. Cultural resources were recorded as a site using the following criteria: (1) ten or more artifacts of two or more artifact classes or types within a 400 m^2 area; or, (2) the presence of a structure, feature, or midden. Resources not meeting these criteria, in a severely disturbed, highly mobile context, or isolated features with poor data potential were recorded as isolated occurrences (IOs).

Sites were to be marked by driving a 46 centimeter (cm) (18 inch [in])-long metal rebar into the ground. The rebars have an aluminum cap stamped with an EMI field number. All cultural resources were to be documented using standard procedures and forms. No artifacts were collected. Archaeological site and isolated occurrence locational information was collected using a GPS Garmin *e-Trex* Vista that has an accuracy of ± 3 m (10 ft). No sites were identified.

Sparse and low lying vegetation across the project area allowed for an estimated 75 percent ground visibility. Three previously unrecorded archaeological sites and five IOs were identified. Richard Burleson served as principal investigator and field director.

SURVEY RESULTS

No previously recorded or unrecorded cultural resource sites and eight isolated occurrences were identified during the Class III survey.

ISOLATED OCCURRENCES

Eight isolated occurrences (IOs) were recorded during the survey. Table 2 summarizes the eight IOs. EMI considers the field recordation of the IOs as having exhausted their information potential and, therefore, they require no further work. None of the IOs are deemed eligible for listing on the National Register of Historic Places or State Register of Cultural Properties. Their locations are shown in Figure 10.

Table 2. Isolated occurrences summaries.

IO	Description	UTM Location; Zone 13
1	Sandstone slab metate fragment	244990 E; 3919794 N
2	Highly weathered sandstone mano fragment	245173 E; 3919825 N
3	Nine corrugated whiteware sherds	245020 E; 3919981 N
4	Two unidentified Cibola whiteware sherds	244964 E; 3919942 N
5	Highly weathered sandstone mano fragment	244849 E; 3919703 N
6	Three Puerco Black-on-white sherds	244727 E; 3919739 N
7	Three Chaco Black-on-white sherds	244777 E; 3919969 N
8	One corrugated whiteware sherd	244725 E; 3919966 N

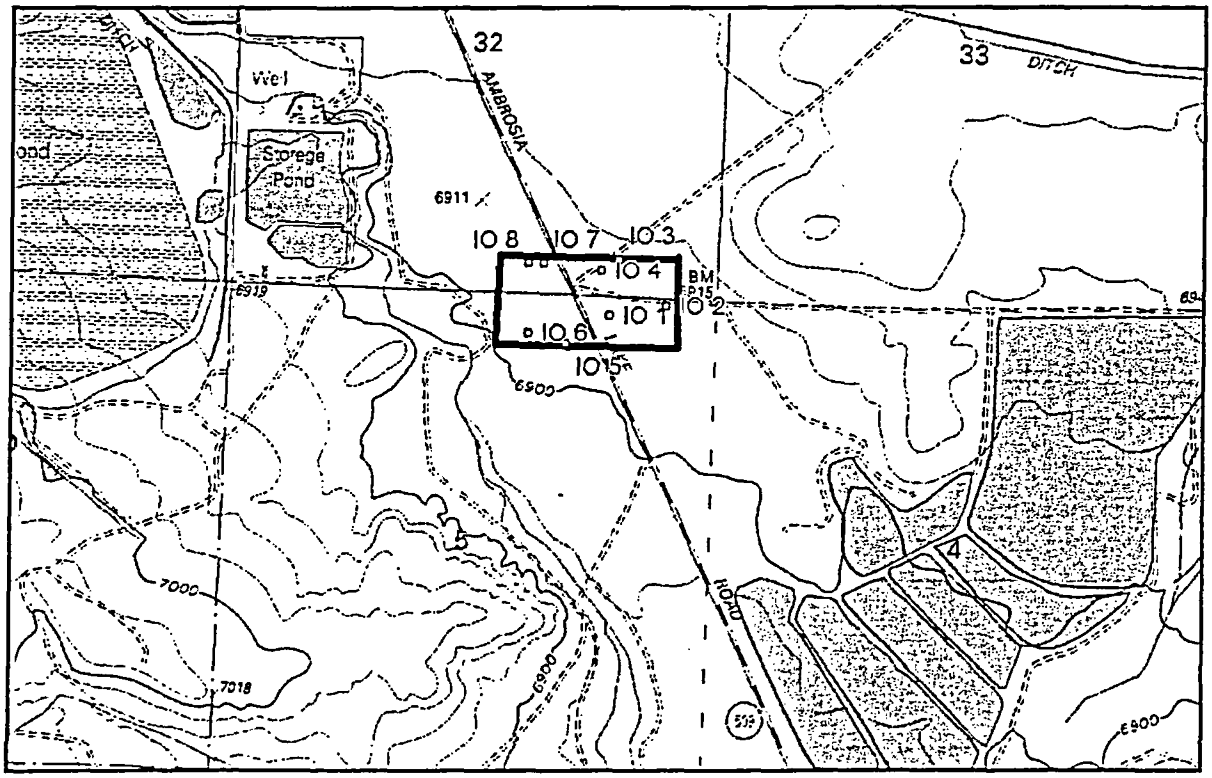

Figure 3. Isolated occurrences.

SUMMARY

A total of eight isolated occurrences were identified during the Class III cultural resources inventory. All of the isolated occurrences relate to the Late Pueblo II period from A.D. 1075 to A.D 1150. This assessment is based on the presence of Chaco Black-on-white and Chaco McElmo Black-on-white ceramics identified within the project area. The project area is situated on a flat, between areas of higher topographic relief that contain Pueblo II period residential sites. The isolated occurrences identified during this survey are likely material remains from those sites located just east and west of the current project area.

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A CULTURAL RESOURCES SURVEY SOUTH OF AMBROSIA LAKE, MCKINLEY COUNTY, NEW MEXICO

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PREPARED FOR:
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SW 424

May 2, 1997

ABSTRACT

This report summarizes an intensive cultural resources inventory survey of 32 ha (80 ac) of New Mexico State Trust Land slated for mining reclamation south of Ambrosia Lake in southeastern McKinley County. Legal description of the property is:

T14N, R9W Section 32 E½ of the SW¼;
SW¼ of the NW¼ of the SE¼;
SW¼ of the SW¼ of the SE¼;
portions of the NW¼;
and SE¼ of the SW¼ of the SE¼.

Mr. Peter Luthiger of Quivira Mining Company, Inc. requested the survey. Archaeological survey led to the discovery of 15 isolated occurrences (I.O.s), but no archaeological sites.

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INTRODUCTION

On April 9 and 10, 1997, personnel from Southwest Archaeological Consultants, Inc. (Southwest) conducted a cultural resources survey of approximately 32.4 ha (80 acres) in southeastern McKinley County, New Mexico for Quivira Mining Company (Quivira). The project area is in the central portion of an unnamed valley south of San Mateo Mesa, approximately 19.3 km (12 mi) east-northeast of Prewitt and 16.1 km (10 mi) northwest of San Mateo, New Mexico (Figure 1). Owned by the state of New Mexico, project lands border the east side of Quivira's Kermac Nuclear Fuels Processing Plant and tailings dump complex (Figure 2). Legal description of the property is:

T14N, R9W	Section 32	E½ of the SW¼; SW¼ of the NW¼ of the SE¼; SW¼ of the SW¼ of the SE¼; portions of the NW¼; and SE¼ of the SW¼ of the SE¼.

Mr. Peter Luthiger of Quivira Mining Company requested the survey in accordance with state and federal laws on mining reclamation. The study area is slated for clean up and reclamation; the area is immediately downwind from the once-exposed uranium tailings pile that accumulated during operation of the Homestake-New Mexico Partners Mine. Thus, the ground surface was subject to aeolian contamination. Pending cultural resources clearance, surface deposits in the study area will be scraped off and disposed of elsewhere.

The author conducted fieldwork with the assistance of Anthony Sanchez under New Mexico State permit number SUA 128. Mr. Luthiger of Quivira Mining provided greatly appreciated logistical support in the field.

During intensive pedestrian survey of the proposed reclamation project parcel, we recorded 15 isolated occurrences (I.O.s) but no archaeological sites. This report details the physical environment, cultural setting, and previous archaeological research for the general project area. We also present a discussion of field methodology and survey results.

PROJECT SETTING

Physical Environment

The project area occurs on the south-central margin of the Chaco Slope in the Navajo Section of the Colorado Plateau Province (Fenneman 1931; PNM 1978). Located on the south margin of the San Juan Basin, the Chaco Slope is immediately adjacent to the Zuni Uplift on the southwest and the Mount Taylor Volcanic Field on the east-southeast.

More specifically, the surveyed land is in the central part of a narrow, unnamed valley bounded on the west-southwest by Mesa Montanosa, on the south-southeast by La Jara Mesa, and on the north-northeast by San Mateo Mesa. The study area occupies a gently southwest-sloping alluvial terrace incised by a large unnamed intermittent tributary. Study area elevations range from 2,103 to 2,109 m (6,900-6,920 ft) above mean sea level (msl).

Surface deposits are underlain by Cretaceous period Dakota sandstone and Mancos shale. Soils of the Lohmiller-San Mateo association cover the modern valley floor. These soils form in alluvium derived from the decomposition and translocation of sedimentary bedrock (PNM 1978:82).

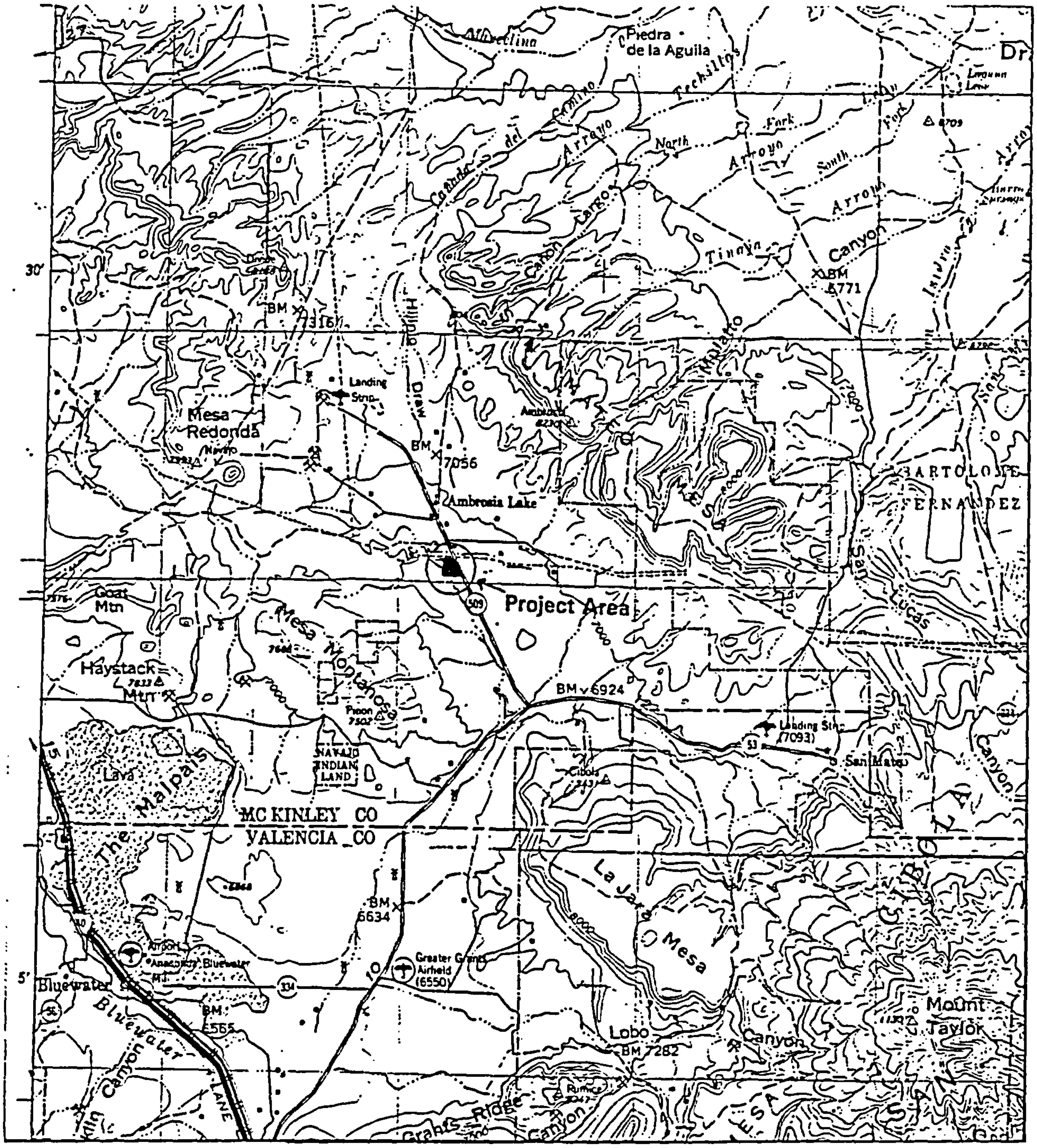

Figure 1: General project location. Map adapted from USGS Albuquerque, New Mexico (1963) 1:250,000 scale topographic series.

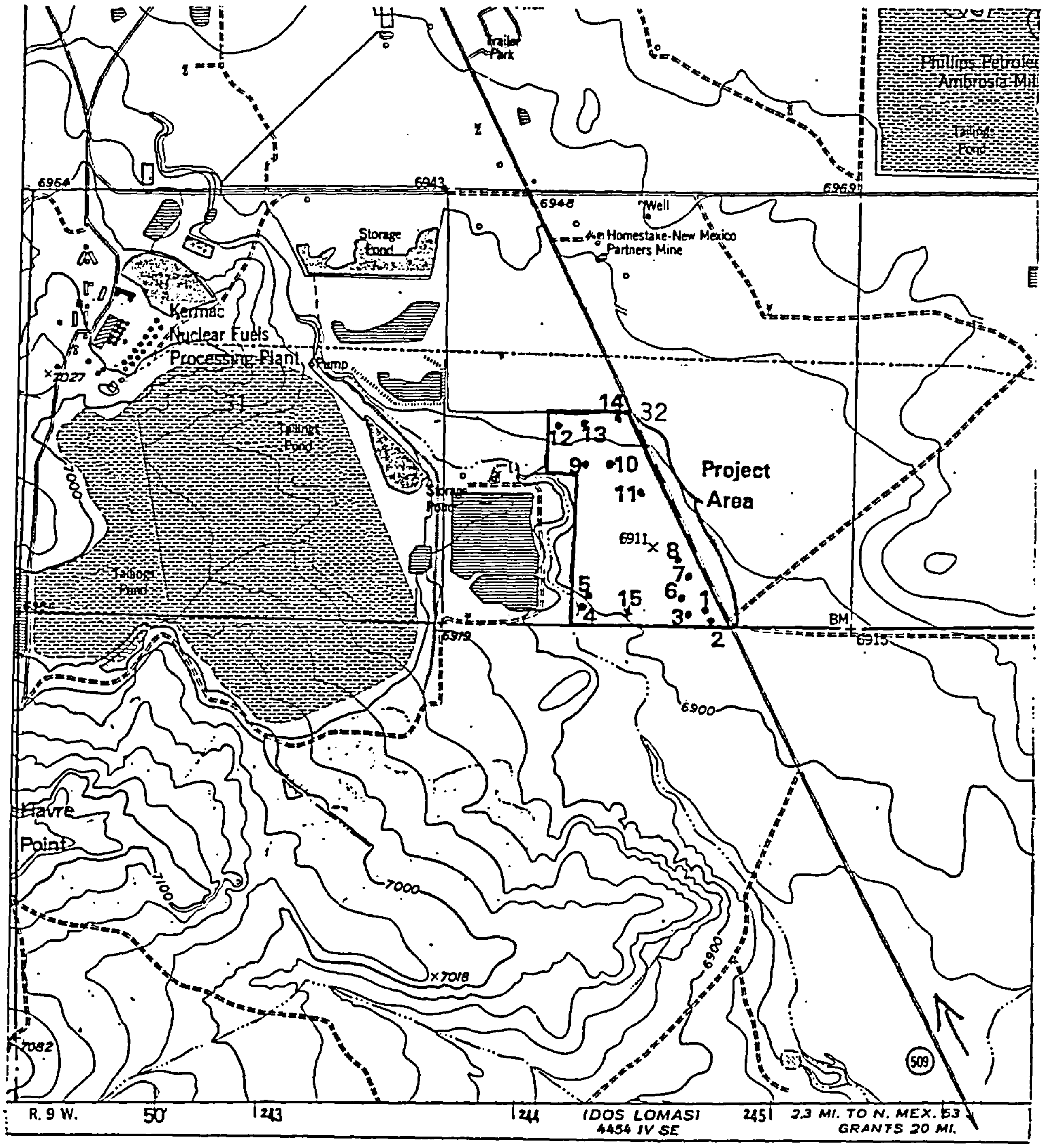

Figure 2: Project area with location of isolated occurrences 1 through 15. Map adapted from USGS Ambrosia Lake, New Mexico (1957, photorevised 1980), 7.5-minute series. Scale 1:24,000.

Vegetation is Upper Sonoran, characterized by mixed grama-galleta steppe grasslands (PNM 1978). While a variety of short grasses dominate project area vegetation, chamisa and four-wing saltbush are quite common, particularly along the west margin. Other vegetation includes sand sage, snakeweed, narrowleaf yucca and prickly pear. Riparian vegetation borders the drainage forming the study area's west boundary, which includes tamarisk and cattail.

Fauna common to the zone include mule deer, coyote, rabbits, many species of rodents and small birds, raptors and waterfowl. Observed fauna include prairie dogs, cottontail rabbits, black tail jackrabbits, ravens, burrowing owls, lizards and rattlesnakes.

Area climate is mild and arid (PNM 1978). Moisture is localized, resulting mostly from summer precipitation. Frost-free days average about 130 (PNM 1978), and rainfall in the Grants area is recorded at 25 to 30 cm (10-12 in) annually (PNM 1978).

Cultural Environment

This section is adapted from Deyloff (1993).

The Red Mesa Valley forms a natural pathway between population centers in the Little Colorado and the Puerco rivers to the west and the Río Grande to the east, thus encouraging the movement of people in both directions. Consequently, sites of various cultural traditions from all points in time occur in the area. But regardless of how many studies have examined those remains, only recently have regional syntheses emphasized subsistence-settlement patterns and cultural processes (Tainter and Gillio 1980; Scheick 1981, 1985, 1990).

The following discussion borrows heavily from the cited syntheses. Because nearly all of the I.O.s yielded Pueblo II and Pueblo III materials (A.D. 900-1300), developments before and after pre-Columbian Pueblo occupation of the area are discussed only briefly.

Paleoindian

Paleoindian culture is the first recorded evidence of human occupation in the Southwest (9500-5500 B.C.), and sites are identified by the presence of specific projectile point types found in association with chipped stone scatters. Primary subsistence was Pleistocene megafauna, such as the mastodon and *bison antiquus*, supplemented by smaller game and wild plants. Although characteristic projectile points, found either in isolation or on sites with remains of later occupations, are recorded for the region (Scheick 1979; Whitmore 1979), single component Paleoindian sites are few. Most of these finds occur in the highlands (Tainter and Gillio 1980). The lack of Paleoindian remains might be due to the absence of exposed geologic features associated with that time period (Cordell 1979).

Paleoindian use of the region apparently was transitory; most information comes from scattered surface artifacts and collected specimens. Documented sites occur in the general area, however, and include a site 21 km (13 mi) south of Grants on a ridgetop, a second a few kilometers northwest of Grants, and a third on the Acoma Reservation in a high altitude setting (Tainter and Gillio 1980).

Archaic

The Archaic lifeway (5500 B.C.-A.D. 400) succeeded the Paleoindian adaptation and also is identified by distinctive projectile point styles. Whether due to climatic changes and/or the disappearance of megafauna, populations relied increasingly on small game and wild plants. These mobile hunter-gatherers probably followed a seasonal circuit based on the availability of game and maturation of wild plants. In later Archaic periods, maize horticulture was introduced to the subsistence base.

Two Archaic cultural traditions are documented in the region, the Oshara and the Cochise. Generally, the Oshara tradition is thought to be characteristic of northwest New Mexico with its south boundary posited along the Río San José. The Cochise culture has been consigned to lands in southern New Mexico, Arizona and northern Mexico, with the Río San José as the suggested northern boundary. However, Cochise or Cochise-like diagnostics and Oshara diagnostics have been recorded on the same sites in the general project area (see Beal 1981; Scheick 1981, 1982).

The cultural-temporal phases of the Oshara developed from Cynthia Irwin-Williams' (1968) work in the middle Río Puerco Valley. These phases are: the Jay (5500-4800 B.C.), the Bajada (4800-3200 B.C.), the San José (3200-1800 B.C.), the Armijo (1800-800 B.C.), and the final En Medio (800 B.C.-A.D. 400). Evidence suggests a gradual change occurred from heavy reliance on hunting to greater reliance on plant foods over time, and by the final phase an increased emphasis on maize horticulture and food storage occurred. These changes were concomitant with regional population growth.

The Cochise culture was identified from Sayles and Antevs' (1941) work in Arizona. It is subdivided into phases that span a period of between circa 7,000 B.C. and A.D. 1 (Irwin-Williams 1979). Evidence suggests that by 7000 or 6000 B.C. populations practiced a mixed strategy of hunting-gathering. By the end of the Cochise sequence, however, site assemblages reflect a mixed foraging economy.

By about 2500 B.C. maize and squash were added to the Cochise diet, but apparently with little initial effect on the subsistence base. Changes in site locations, reduction in territory size, and the creation of surplus are postulated by about 750 B.C., possibly resulting from the introduction of a more productive variety of maize into the Southwest. Irwin-Williams (1973) believes Cochise tradition populations might have played an important role in the development of food processing and agriculture among the Oshara.

Archaic sites in the Red Mesa Valley, for the most part, represent limited activity locales associated with hunting, opportunistic foraging, and/or stone tool raw material acquisition (Scheick 1985). Preferred site locations seemingly were on wooded mesatops and elevated features in the piñon-juniper woodland in the highlands, and on ridgetops and/or dune slopes in the valleys. The ephemeral quality of these sites as well as shifting sand overburden might be responsible, in part, for the low number of Archaic sites recorded for the eastern Red Mesa Valley compared to surrounding regions (such as the San Juan Basin).

Pueblo

The discussion of Pueblo cultural development derives primarily from Scheick 1985 and Viklund and Scheick 1990.

Archaeologists view the Basketmaker period as transitional between a hunting-gathering population and an increasingly aggregated sedentary population that relied on horticulture (Irwin-Williams 1968). In the San Juan Basin subregion, Basketmaker manifestations presumably developed directly from the earlier San José Complex (Bryan and Toulouse 1943), which encompasses Irwin-Williams' San José, Armijo and En Medio phase distinctions. Irwin-Williams (1968) suggests the Trujillo phase, or Basketmaker III (A.D. 400 to 600), represents the maximum limit of a seasonal hunting-gathering strategy. She also suggests the shift to areas where horticulture could be practiced was in response to a severe drought between A.D. 600 and 700. Ruppe (1953) and Dittert (1959) equate the Basketmaker period in the Cebolleta Mesa region with Gladwin's White Mound Phase (A.D. 700-800). Ruppe (1953) believes the Basketmaker occupation of the Cebolleta area was late, and based on the lack of earlier Basketmaker sites in the area, he postulates the White Mound phase represents a settlement intrusion. Tainter and Gillio (1980) disagree with this view, contending that Ruppe relies on an outdated notion that in situ cultural evolution must pass through a specified series of stages.

Several hundred archaeological sites dating to the Pueblo period are recorded for the eastern Red Mesa Valley, yet very little is understood about the nature of that occupation. Most attempts at interpreting the wide range of variability exhibited in the archaeological record are speculative and biased by cultural developments in the San Juan Basin, particularly Chaco Canyon. This approach, however, has considerable precedent. Beginning with Gladwin (1945), the interpretation of occupation in this general area has been that it somehow was tied to the vagaries of the Chaco phenomenon. Gladwin saw these ties as developmental, while more recent authors view them as economic and/or social.

Gladwin isolated a series of phases within the broader periods defined by the Pecos system of Pueblo I through III. According to Gladwin (1945), during Basketmaker II, southern immigrants influenced the traditional or in situ Basketmaker culture. As a result, the culture evolved into what we recognize as Pueblo (see Whitmore 1979). Remains associated with each of Gladwin's developmental sequences show progressively more sophistication.

Gladwin begins his sequence with the White Mound phase (A.D. 750 to 800), named after a site he excavated in 1936. Sites consist of pithouses in conjunction with contiguous, aboveground, rectangular storage rooms of jacal. The associated pithouses contain many features believed characteristic of kivas. Ceramic types Gladwin identified as southern in origin occur on these sites.

During the following Kiatuthlanna phase (A.D. 800-850), visible architectural changes include the use of aboveground structures for habitation, the removal of dividing walls and the addition of benches in pithouses, a shift from clay to slab-lined firepits, and pole support modifications. Site ceramics still show a southern influence as well as the presence of southern types, but the beginnings of specialization can be seen in site material remains.

The Red Mesa phase (A.D. 850-925) apparently was a period of architectural experimentation. The remains of aboveground rectangular pueblos of four to six rooms are common; structure walls exhibit combinations of construction techniques, including adobe, wattle-and-daub, jacal and/or masonry. Firepits and/or hearths occur outside structures. Pithouses presumably functioned as both residential and ceremonial.

Wingate phase sites (A.D. 925-1000) differ considerably from their predecessors, with architectural features consisting almost entirely of masonry roomblocks. Pueblo remains contain from six to eight rooms as a rule. The use of pithouses continued, and kivas changed with the shift from benches to alcoves and/or recesses. Hearths occur both inside and outside rooms. Ceramic assemblages include the introduction of Gallup Black-on-white and Wingate Black-on-red. Nonlocal ceramics on area sites are thought to be rare. Gladwin believed the Red Mesa Valley was abandoned by A.D. 1050.

The Hosta Butte phase (A.D. 1000-1075) now applies only to sites located north of Crownpoint, New Mexico. Characteristics of these sites include their size (from 20 to 30 rooms), the presence of multiple kivas, and a distinct style of banded masonry. Chaco Black-on-white appears, and although McElmo Black-on-white does as well, it is considered intrusive.

Criticisms of Gladwin's work (Whitmore 1979; Tainter and Gillio 1980; Cordell 1982) focus on the simplified, mutually exclusive progression of cultural traits associated with each period, which are now known to be more complicated and interrelated. Further, important behavioral changes associated with changing material cultural traits largely were ignored. More recent discussions of area archaeology are structured within broad cultural periods (Pueblo I-IV) and focus on settlement patterns (Powell 1979), economic strategies (Sebastian 1983), and on economic and social organization (Marshall et al. 1979; Tainter 1980; Stuart and Gauthier 1981).

For example, Sebastian (1983) views Pueblo cultural periods in terms of settlement patterns and adjustments in economic strategy. Basketmaker II (100 B.C.-A.D. 400) sites are seen as ephemeral and are associated closely with arable land but also are in areas with access to hunting and gathering resources. The data suggest to Sebastian that earlier trends of wild resource dependence and population mobility continued. Basketmaker III (A.D. 400-700) habitation sites yield evidence of seasonal sedentism and some reliance on horticulture, although the location of limited activity sites still reflect exploitation of a wide variety of wild resources.

Pueblo I (A.D. 700-900) sites are closer to alluvial land where run-off occurs, seemingly emphasizing the importance of horticulture in the economic strategy. Evidence also indicates increases in both population and incidence of on-site storage. During Pueblo II (A.D. 900-1100) populations increased significantly, expanded into previously unoccupied areas, and formed community clusters of permanent and semipermanent settlements. By the middle of Pueblo II, populations became aggregated, and evidence exists for a region-wide interaction/exchange network identified as the Chacoan Phenomenon.

Specialized architectural features referred to as Chacoan outliers appear in locales removed from Chaco Canyon, suggesting changes in area social organization and local economies. In the Red Mesa Valley, outlier remains often occur near the base of a mesa in areas not densely settled by local populations. By the early part of Pueblo III (A.D. 1100-1300), outlier communities had become larger and more numerous. Like many other authors, Sebastian (1983) sees this as a consequence of the expanding Chacoan system, centered 69 km (43 mi) north of the project area in the San Juan Basin. Typically, Chacoan outliers are surrounded by a variety of site types, with the highest concentrations occurring within a 3 km (2 mi) radius (see Whitmore 1979). Within the first kilometer, most sites represent fieldhouses. The variety of site types increases with distance from the outlier, particularly in the third kilometer (see Scheick 1985). Also, the earliest sites are the farthest away, perhaps suggesting that deliberate congregation near previously established population centers occurred before the presence of the Chacoan outliers. Characteristics of the Chacoan system include sophisticated public architecture, extensive trade relationships, and support of a large population in a relatively small area (Sebastian 1983:13). Ultimately, many believe the collapse of the Chacoan system resulted in the collapse of the support systems, and many areas were abandoned.

Unfortunately, in the Red Mesa Valley, little evidence exists for increased reliance on maize agriculture during the Basketmaker period, and the similarity of these sites to earlier cultural remains argues for a continuation of largely marginal use of the area. Most Basketmaker II and II/III manifestations in the valley are isolated finds or small artifact scatters, while Basketmaker III sites commonly are sherd and lithic scatters with and without associated hearths or storage cists. Of interest, however, is that during Basketmaker III we see a shift from high resource diversity slopes or elevated locations toward valley bottom locations (Scheick 1985). No large habitation sites are known.

The larger number of sherd and lithic scatters, combined with a few small surface structural sites, reflects a gradual population increase during Basketmaker III over earlier periods. Nevertheless, use of the valley was still sporadic, and economic strategies focused on hunting and gathering, with possibly some attempts at horticulture.

Site data indicate a small increase in population during Pueblo I, with most recorded sites described as sherd and lithic scatters. Settlement patterns are identified more readily during Pueblo I, with elevation playing a vital role in site type/placement correlations (Scheick 1985). Pithouses and small surface structure remains tend to be in piñon-juniper fringe areas at elevations between 2,134 and 2,164 m (7,000 and 7,100 ft), while larger pithouse village remains are found at elevations up to 2,195 m (7,200 ft). Limited activity sites occur in these areas as well as in the lower grasslands.

By A.D. 800 Pueblo I/II occupation of the Red Mesa valley was seasonal, with semipermanent sites established on the valley slopes in elevations of 2,073 to 2,103 m (6,800-6,900 ft) as well as on mesatops. Sites containing late Pueblo I/early Pueblo II ceramics include surface rooms with associated pithouses, contiguous surface rooms with possible kivas, fieldhouses, and large villages. During this period, a number of traits developed that later solidified around the large Chacoan outliers. At the same time, however, pithouse villages with possible surface structures were established along the piñon-juniper fringes bordering secondary drainages of Casamero Draw in the highland areas (Scheick 1985:17).

Archaeological evidence is indicative of increased occupation and use of the region during Pueblo II (A.D. 900-1100). Discrete clusters of small, medium and large sites are spread out along the numerous drainages forming the Río San José headwaters. Early to middle Pueblo II sites consist of isolated fieldhouses associated spatially with small to medium sized roomblocks (3-6 rooms) with kivas, to groups of roomblocks of comparable and larger size (Historic Preservation Division, Archaeological Records Management Section, Survey Record Room Files). Limited activity sites, petroglyphs and rockshelters also are documented.

Occupation of elevations below 2,073 m (6,800 ft) became common, as Pueblo people farmed tributaries of the major drainages. The correlation of specific site types with particular elevations is pronounced for sites of this period. For example, the remains of farmsites (3-plus rooms, seasonally occupied and located near agricultural lands) occur at elevations between 2,073 and 2,195 m (6,800 and 6,900 ft) and between 2,195 and 2,225 m (7,200-7,300 ft); pueblos (primary habitations occupied semipermanently and located in the most favorable physiographic zones) occur at elevations between 2,103 and 2,134 m (6,900 and 7,000 ft); and fieldhouses (1 or 2 room sites occupied intermittently and located near agricultural lands) occur between 2,073 and 2,134 m (6,800 and 7,000 ft) and between 2,195 and 2,225 m (7,200 and 7,300 ft). Limited activity sites (usually containing no visible structures, representing specialized use of an area and thus occurring in various locations) appear at all elevations (Scheick 1985).

By late Pueblo II (A.D. 1000-1100), Chacoan outliers were well established in the eastern Red Mesa Valley. Three outliers occur south of the project area at the base of Mesa Montanosa (LA6022, LA12573-A and LA12573-D). The earliest constructed, LA12573-D, was occupied between late Pueblo I and early Pueblo II (A.D. 900-1000). The site is on a broad bench at an elevation of 2,115 m (6,940 ft). LA12573-A dates exclusively to Pueblo II (A.D. 1000) and was constructed on a broad sandy ridge at an elevation of 2,121 m (6,960 ft). LA6022 is the latest of the three, inhabited from late Pueblo II to early Pueblo III (A.D. 1000-1100). The site is also the largest of the three outliers and is at an elevation of 2,128 m (6,980 ft) above mean sea level (Marshal et al. 1979).

Other community types also are documented in the valley to the west of the project area and contain large multiple or isolated C- and T-shaped roomblocks with kivas at the center of the cluster (Powell 1979; Miller and Frizell 1980). Whitmore (1979:55) feels these communities are either part of a large interconnected regional pattern, in which the individual communities were associated directly with the outlier community, or they are a series of smaller independent communities. Interestingly, the nonoutlier community remnants (mainly habitation) are along the many tributaries and headwaters of the Río San José, while the outliers are in the Río San José Valley, an area never densely occupied before their introduction.

The upland nonoutlier populations probably were loosely related, mobile, and highly adaptive. Site types and locations are suggestive of a fluid system, and population alliances within that system might have been temporary and constantly changing. Outlier communities associated with the lowland valley drainages apparently were more localized and focused on resource exploitation, probably as a result of social and environmental circumscription rather than attempts at creating surplus for systematic exchange.

No evidence exists to suggest populations in either the lowland or the upland communities participated in long-distance trading of food. No evidence exists of technological specialization in the production of economic goods, only of expedient technology related to subsistence production. Excavated sites yielded no evidence of production, nor of storage of surplus food. The heavy reliance on native plants, combined with the small number of storage features, seemingly suggests little surplus.

The small numbers of intrusive ceramics on farmsites, fieldhouses and other residential sites suggest simple exchange occurred at the level of the site or group. Other evidence suggests intravalley exchange was far more common than exchange farther afield. Moreover, the small numbers of nonlocal goods in local Pueblo artifact inventories are not supportive of large-scale trade. No evidence exists for interruptions in the local ceramic and flake tool traditions that would suggest the introduction of new technological innovations.

Some believe Chacoan outliers might have developed in situ (Tainter and Gillio 1980; Doyel 1982) and that they fulfilled public or administrative functions. The role of outliers in the Red Mesa Valley is based largely on conjecture since few excavations have been conducted, and surveys have provided only limited data. Data from excavations of portions of the Casamero sustaining complex (Beal 1982) suggest the majority of the surrounding three and four room pueblos were farmsites occupied seasonally, and that by the early Pueblo III period populations were affected by nutritional stress. Beal (1982) feels pre-A.D. 1000 sites represent temporary, short-term occupations, while post-A.D. 1000 sites exhibit long-term or repeated use. Most importantly, no evidence exists suggesting local sites participated extensively in or benefited from trade with a sophisticated cultural system. Finally, no indications of surplus production or processing capacities beyond what was necessary for simple subsistence occur (Beal 1982:349).

Occupation of the Red Mesa Valley continued into Pueblo III (A.D. 1100-1300) but is represented by far fewer sites than seen for Pueblo II. Throughout Pueblo III, subsistence strategies continued to emphasize a mixed pattern of hunting, gathering and agriculture. During early Pueblo III, populations concentrated near small tributaries serving restricted drainage basins, on gentle slopes without established watercourses, and in the highlands that benefited from increased precipitation. By A.D. 1050, however, the climate might have become too wet, and floods possibly rendered the lower portions along the major watercourses unusable (Beal 1984). Populations began to abandon valley floor settlements, and by the latter half of Pueblo III, the outliers were abandoned as well.

Those sites constructed during Pueblo I and Pueblo II in the highlands continued to be occupied during Pueblo III. Reminiscent of earlier Pueblo I patterns, large permanent habitation sites of the period occur between 2,134 and 2,164 m (7,000 and 7,100 ft) along the edges of the piñon-juniper woodland. The fieldhouses and farmsites that occur are found normally above 2,134 m (7,000 ft), and their occupation probably was short-term and possibly intermittent. Limited activity sites occur in a wide variety of environmental situations.

Smaller pueblos of 8 to 10 rooms apparently were abandoned first in the highlands, about the same time as, or following those, in the lower major tributary valleys, leaving only a few large complexes in the most favorable areas (Scheick 1985:259). Abandonment of the general area was gradual and probably occurred in two separate episodes. Indications are that the relationships among upland and lower valley groups were severed by Pueblo III, possibly as a result of competition for arable land. Interestingly, the number of upland sites did not increase dramatically with abandonment of the lower valleys; rather, the increased site size in the uplands probably resulted from the abandonment of many of the smaller pueblos in the upland area previously. Moreover, Ruppe (1953) notes an increase in population and in western influences on local pottery assemblages in the Malpais-Cebolleta area during the Pilares phase (A.D. 1100-1200). A second surge of population increase occurred in the Malpais-Cebolleta area during the following Kowina phase (A.D. 1200-1400), perhaps as a result of abandonment of the large upland communities in the eastern Red Mesa Valley around A.D. 1200.

Between A.D. 1200 and 1250, the highlands of the Red Mesa Valley apparently were used as a source of wild plant and animal foods, as reflected in the increased number of limited activity sites dating to this time. Abandonment of the area occurred about A.D. 1250.

Historic Pueblo

A cultural hiatus apparently occurred in the Red Mesa Valley after A.D. 1250, presumably as the population center shifted eastward. By the time the Spanish arrived in 1539, the only occupied pueblo in the study area was Acoma, located 48.27 km (30 mi) southeast of the project area. The Acoma Pueblo use area extended a considerable distance from its mesatop location in all directions. Dittert (1959) defines the traditional Acoma Cultural Province as bordered by the Zuni Mountains on the west and Mt. Taylor on the north; this would place the project area just north of the province.

Current Acoma residents claim occupation for the mesatop pueblo since at least 1,000 years ago and group origins from the east and northeast, as far away as Mesa Verde (Ellis 1979). Interestingly, archaeological data from Dittert's excavations at Acoma indicate continuous occupation of the pueblo since around A.D. 1150. Both Dittert (1959) and Ruppe (1953) believe Acoma was an indigenous development with strong ties to sites on nearby Cebolleta Mesa. Dittert (1959) suggests the Acoma system of seasonal dispersion--or summer and fall occupation of satellite agricultural communities and winter aggregation at Acoma Pueblo -- gradually developed in situ and is traceable to the San José phase of the Archaic period.

Acoma participated in the Pueblo Rebellion of 1680, and in 1692 accepted Reconquest refugees from the Río Grande Pueblos of Cochiti, Cieneguilla, Santo Domingo and Jemez. Sometime between 1697 and 1699, those refugees and a few disgruntled Acomas split from the pueblo and founded Laguna Pueblo (Ellis 1979) to the northeast. Records indicate that Pueblo use of the general project region included seasonal agriculture, herding, yucca gathering, and mining for paints, gypsum, jasper and potash (Rands 1974a, 1974b; Winter 1980).

Lt. John Gregory Bourke in 1881 observed "... Acoma ... is remarkable for the number and distance of its outlying farms" (Rands 1974b). Constant Navajo raids, however, caused the size and location of the Acoma herding territories to fluctuate during the eighteenth and nineteenth centuries. Moreover, when the Spanish established ranches at the confluence of the Río Puerco and Río San José, their territory was reduced further still (Ellis 1979; Garcia-Mason 1979). During the late nineteenth and early twentieth centuries, Acoma summer ranges included the south slopes and top of Mt. Taylor and winter ranges centered around Laguna Monte and Laguna Ambrosia.

Historic Navajo

Dates for when the Navajo actually began to use/inhabit the east edge of the Red Mesa Valley are problematic. In 1583 Espéjo noted a group of Querechos (ancestral Navajos) living in the vicinity of what now is known as Mt. Taylor (Hester 1962; Bailey and Bailey 1982). Bailey and Bailey (1982) believe the Navajo inhabited much of the area by the middle of the seventeenth century. Throughout most of the seventeenth and eighteenth centuries, the area west of a line drawn from Taos to Laguna was considered the Navajo-Spanish frontier (Hester 1962). During that period, Navajo populations lived primarily within the piñon-juniper belt surrounding the San Juan Basin, remaining outside the sphere of Spanish control.

Relationships among the Navajo, Spanish and Río Grande Pueblo populations during the seventeenth century vacillated between trading and raiding, depending upon local conditions. Because of the threat the Navajo posed, Pueblo use area boundaries shifted and shrank considerably. Moreover, it was impossible for the Spanish to establish settlements in the area until the mid-1800s when the Navajo were forced onto reservations. It appears, however, that at least one peaceful Navajo group was allowed to remain in the area (see Schaafsma 1977). Early Navajo populations subsisted on trading, hunting, gathering and raiding, but with Spanish influence the herding of sheep and goats became important.

With the Navajo release from the Bosque Redondo in 1868, Navajos resettled their homelands in the northeast part of Arizona and the northwest part of New Mexico. By the 1880s herding was supplemented by wage-jobs with the railroad. Between 1880 and 1930, competition for optimum grazing lands increased but then fell between 1930 and 1950 as a result of the government-enforced stock reduction programs. Consequently, wage labor increased dramatically and included work as herders for American, Hispanic and Pueblo ranchers. In fact, after the 1950s, little herding of Navajo-owned stock occurred.

In the Red Mesa Valley, recorded sites most often reflect herding activities, with only a few habitation sites known. Sites occur in sheltered alcoves, near rock outcrops and escarpments, at canyon heads, and in piñon-juniper woodlands and grassland fringe areas (see Tainter and Gillio 1980).

Hispanic/American

When the Spanish first entered the region in 1539, the area already was occupied by Pueblo and Navajo populations. Although relative peace was established with the Pueblos after the Reconquest of 1696, Navajo hostilities prevented any permanent Spanish settlements until the 1800s. Since 1846, local sheep herders, Texas cattlemen, Oklahoma farmers, California gold seekers, Mormon settlers from Utah, and railroad workers have steadily populated the east end of the Red Mesa Valley. Bluewater, 22.5 km (14 mi) southwest of the project area, was settled as a small irrigated farm in 1850 by the Frenchman Martin Boure. In the 1870s other French families followed, moving into the area and organizing a cattle company, and a small reservoir was built to supply more irrigation water (Pearce 1965). In 1880 the AT & SF railroad was constructed, providing supplemental wage labor to the herding and farming subsistence base. The railroad sponsored construction of a larger reservoir so that the entire valley around Bluewater could be irrigated. The town of Grants, located 28.2 km (17.5 mi) southeast of the project area, was established in 1882 as a railroad construction camp, named for three brothers who were contractors for the railroad (Pearce 1965). Today, Grants is the largest community center in the area. Milan is the closest town (19.3 km or 12 mi south); it was incorporated in 1957 and named for the owner of the land, Salvador Milan.

By the 1930s the valley bottom between Bluewater and Grants supported truck crops, such as carrots, beets and asparagus. A local informant remembers the portion of the survey area just west of the mine's large tailings pile as a carrot farm in the late 1930s and early 1940s. The area remained an agricultural center until uranium was discovered at Haystack Mountain just west of Mesa Montanosa. Anaconda built a uranium processing mill at Bluewater in the early 1950s and began mining an open pit at Jackpile Mine on the Acoma reservation. The uranium boom lasted through the late 1970s (Cattle et al. 1981); the area is still considered the largest uranium producing and milling center for the United States.

When New Mexico became a state in 1912, the study area became public land administered by the Bureau of Land Management. The project area became state of New Mexico land in 1959 under State Grant Patent number 1191533.

PREVIOUS ARCHAEOLOGICAL RESEARCH

The majority of this discussion is from Scheick (1985), with comments from Deyloff (1993a) and annotations by the author. Again, the pre-Columbian Pueblo period is the focus of discussions. Most germane to the current project is research in the Red Mesa Valley and the Cebolleta Mesa region.

Basketmaker II, II/III and III sites have been documented in the eastern Red Mesa Valley as well as in the Cebolleta Mesa region, and these sites seemingly indicate locational preferences. Defined on the basis of diagnostic projectile points and Lino Gray ceramics, the sites most often are on the fringes of the piñon-juniper woodlands overlooking relatively flat, open uplands close to intermittent drainages (Powell 1979). The majority of Basketmaker II and II/III sites are isolated finds or small nondescript scatters, while the Basketmaker III sites are sherd scatters with or without associated hearths and/or storage cists. A shift from high diversity locations toward valley bottoms and horticulture is observable. No large habitation sites have been recorded.

A small increase in population is evident during Pueblo I. Dittert (1959), Powell (1979) and Scheick (1985) identify several sites dating to the Pueblo I period, and Viklund (1990) identifies two Pueblo I site components immediately north of and in the same section as the present project area. Almost all of these sites are sherd and lithic scatters, but a few are the remains of noncontiguous surface structures. Pueblo I/early Pueblo II sites (see Powell 1979; Scheick 1985; Dittert 1959) include surface rooms with associated pit structures, contiguous surface rooms with possible kivas, fieldhouses, and large villages.

During Pueblo II an increase occurred in the size and density of sites. Several hundred sites are spread out along the numerous drainages forming the Río San José headwaters. Early to middle Pueblo II sites consist of isolated fieldhouses associated spatially with small to medium sized roomblocks with pithouses/kivas, as well as larger groups of roomblocks (Historic Preservation Division, Archaeological Records Management Section, Survey Record Room Files). Limited activity sites, petroglyphs and rockshelters also are documented, including 11 plant food gathering sites just north of the present project, 4 of which date to Pueblo II and 7 to Pueblo II/III (Viklund and

Scheick 1990). Deyloff identified a Pueblo II sherd and lithic scatter (1994) and 16 Pueblo II/III site components (1993b), a third of which have structural remains. Mabry and associates (1996) recorded a Pueblo II/III limited activity site southwest of the current study area.

By late Pueblo II a pattern of community settlement existed in the Red Mesa Valley. At least six such communities are known within the general area (Kin Nizhoni, Haystack, Casamero, Andrews Ruin, Coyote Sings Here, and San Antonio Springs), and other community types are postulated from inventory surveys. Those other community types contain large multiple or isolated C- and T-shaped roomblocks with kivas at the center of the cluster (see Powell 1979; Miller an Frizell 1980; Scheick 1985). Whitmore (1979) feels area communities were either part of a large interconnected regional pattern in which the individual communities were associated directly with the outlier community or they were a series of smaller independent communities.

Personnel from the School of American Research (Beal 1982) conducted excavations on 23 sites within 4 km of the Casamero outlier. Thirteen of the sites are Pueblo, including Pueblo I (N=1), Pueblo II (N=8) and Pueblo III (N=4). Research focused on the relationship between project sites and Casamero, and on the "Chaco Phenomenon." Although data were limited, Beal observes no indications exist that local sites participated extensively in trade relations with a sophisticated cultural system. He cites the following evidence: economic diversification apparently related directly to subsistence requirements, not to a systematic trade relationship; no indications of technological specialization exist in the production of economic goods other than the endemic presence of expedient technology attributable to subsistence production; no evidence of surplus production or storage exists; and no luxury items are present in site assemblages. Beal suggests the local population occupied seasonal farming and gathering sites out of dire necessity.

Further, by early Pueblo II, populations apparently were affected by nutritional stress. Stratification of the small sites implies the earliest are nearer the slopes off the valley floor, while middle to late Pueblo II sites are on or directly adjacent to the valley floor of secondary drainages. Based on ceramic analysis, Lang (1982) notes that during late Pueblo II significant cultural changes were being demonstrated. A much wider sphere of outside contacts is visible in the ceramic assemblage: west to the Río Puerco, northwest to Flagstaff, and north to Mesa Verde. By early Pueblo III, contacts also included the Little Colorado River and the San Juan and Acoma areas. Just prior to abandonment, data exist for trade only with the Chuska and Acoma areas. Beal concludes that pre-A.D. 1000 sites represent temporary, short-term occupations, while post-A.D. 1000 sites exhibit long-term or repeated use.

Baugh (1990) excavated three small pueblos near Ambrosia Lake. Due to their close proximity to the Chacoan outlier of Kin Nizhoni, research focused on the relationship between the small pueblos and the outlier. Specifically, his research addressed chronological placement, subsistence and economy, and culture change and continuity relative to Kin Nizhoni. Data are indicative of year-round occupations by primarily Pueblo II individuals who might well have had close ties with the nuclear community of Lower Nizhoni. A second component at one site indicates a Pueblo III occupation that might have been related to the later Kin Nizhoni nuclear community. The basic subsistence pattern was agriculture supplemented by the collection of wild plants and the hunting of small game. The presence of Basketmaker III and Pueblo I sites in the southern periphery of his project area suggests to Baugh that the Ambrosia Lake sites represent an indigenous development rather than settlement by a migrant population from Chaco Canyon. Finally, Baugh suggests ceramic, obsidian and other artifact evidences indicates populations maintained at least ephemeral ties with the greater Chaco sphere.

Several kilometers southwest of the present project area, Scheick (1985) surveyed the Santa Fe Coal Rail Corridor and carried out the corresponding excavations. Pueblo II sites along this transect generally cluster near the Chacoan outliers of Andrews Ruin and Casamero. Both Scheick (1985) and Powell (1979) note that Pueblo II sites show a correlation with site type and elevation discussed previously. Also during Pueblo II an apparent dichotomy existed between upland and lowland communities. The remains of upland communities seemingly exhibit a dispersed settlement pattern with large pueblos composed of multiple roomblocks and kivas, some C-, E- or T- shaped, located between 2,103 and 2,134 m (6,900 and 7,000 ft); farmsites in a wide range of elevational zones; and fieldhouses in an even wider range. Site density often is so high it is impossible to distinguish from survey data where one site begins and another ends. In the lowlands, however, small pueblos, farmsites and fieldhouses tend to cluster around Chacoan outliers, apparently forming support communities. The relationship between the upland and lowland areas and/or communities is unclear. People continued to live in and utilize resources in the uplands of the eastern Red Mesa Valley after others might have moved downstream to more permanent water sources, possibly as far away as Acoma Pueblo.

Dittert's (1959) research in the Cebolleta Mesa region refined Ruppe's 1953 work, which resulted in the Cebolleta Mesa regional sequence. Ruppe (1953) notes increases in population and in western influences on local pottery assemblages in the Malpais-Cebolleta area during the Pilares phase (A.D. 1100-1200). Possibly, these increases also might reflect population movement out of the lowlands of the Red Mesa Valley (see Scheick 1985). Data from excavation at Acoma Pueblo led Dittert (1959) to postulate: Acoma was first occupied in A.D. 1150; it was closely allied with populations on Cebolleta Mesa; and it represents an indigenous development with later trait or site intrusions from Cebolleta Mesa and as far away as Mesa Verde. Historic Acoma Pueblo informants tell of farmsites as far north as Grants and Mt. Taylor and that at one time sites were located farther north and west than Grants. Dittert believes the archaeological data support these claims of Acoma Pueblo land usage and ancestral sites.

A smaller number of Pueblo III sites are recorded in the region, consisting of either limited activity sites on low mesas or fieldhouses and/or farmsites in the highlands above the drainages (Scheick 1985). A number of the large communities recorded by Powell (1979) have surface ceramics indicative of occupations into Pueblo III. Interestingly, these communities are in higher valleys along the piñon-juniper fringes. The Río San José Valley apparently was abandoned first and then the highlands, with the latest occupations occurring in the latter around A.D. 1250. During the final occupations, population densities were low, and site occupants practiced land-extensive economic strategies. How these particular sites relate to many of the habitation sites spanning Pueblo II and III is presently unknown.

RESEARCH AND SURVEY METHODS

Southwest personnel undertook the intensive, nondisturbing pedestrian cultural resources inventory survey of the study area to determine the presence, location, nature, extent and significance of cultural resources on the property potentially endangered by reclamation activities. Archaeological work conducted before field investigations involved an archival assessment of the current state of archaeological and historical knowledge of the project area. The author searched the site files maintained by the Archaeological Records Management Section (ARMS), Historic Preservation Bureau, State of New Mexico, at the Laboratory of Anthropology in Santa Fe for previously documented archaeological properties in and around the study area.

To inspect the proposed reclamation area, a survey team consisting of two archaeologists walked parallel transects. To ensure coverage, transect intervals normally did not exceed 12 m (40 ft). Field personnel zigzagged to inspect shallow arroyo cuts and the crests of low rises because of the frequent exposure of archaeological remains in these erosional and topographic settings.

Archaeologists located their on-the-ground positions by the use of a USGS 7.5-minute series Ambrosia Lake, New Mexico (1957 [photorevised 1980]) topographic quadrangle. The presence of fencing along all but the north boundary of the survey parcel facilitated these efforts.

When the survey archaeologists encountered artifacts, they made a more intensive search of the surrounding vicinity to determine the nature of the cultural debris, its distribution and frequency, its depositional context, and any possible interrelationships between these remains and other previously documented cultural materials. Following Southwest's guidelines for survey, an archaeological "site" is an aggregate of cultural remains consisting typically of more than 10 artifacts and possessing sufficient contextual integrity to indicate the material assemblage was the product of purposeful in situ human activity. Moreover, an archaeological site is a cultural property that likely possesses the potential to yield additional significant information beyond that which can be obtained through survey recording.

Other cultural remains whose information potential is exhausted through survey documentation are designated I.O.s. In practice I.O.s consist of extremely limited, surficial, and often severely eroded cultural resources. They most commonly occur as single artifacts or widely dispersed scatters of fewer than 10 artifacts. The documentation of I.O.s consists of the description of the archaeological remains and the recordation of their locations. Copies of all project field notes, I.O. descriptions and maps are on file at Southwest Archaeological Consultants, Inc., Santa Fe.

SURVEY RESULTS

Intensive pedestrian survey of the project parcel resulted in the discovery of 15 I.O.s. Table 1 provides a complete descriptive inventory of the I.O. assemblage and Figure 2 shows their locations. In order of increasing relative abundance, represented artifacts are indented corrugated jar sherds, plain grayware jar sherds, Black-on-white (mostly Gallup) jar sherds, and a quartzite flake. Sand temper dominates the ceramic assemblage, although a few whitewares have sherd temper.

TABLE 1: Isolated Occurrences

Small	0-10 mm
Medium	10-30 mm
Large	30+ mm

I.O. #	Description
1	Two indented corrugated jar sherds with sand temper.
2	Large, gray, coarse-grained quartzite secondary decortication flake.
3	Plain grayware jar sherd with sand temper.
4	Two Gallup Black-on-white jar sherds with sand temper; one unidentified Black-on-white jar body sherd with sand temper; one indented corrugated jar sherd with sand temper.
5	Gallup (probably) Black-on-white jar sherds with sand temper; one indented corrugated jar sherd with sand temper; one plain grayware jar sherd with sand temper.

Table 1 (cont'd.)

I.O. #	Description
6	Indented corrugated jar sherd with sand temper.
7	Plain grayware jar sherd with sand temper.
8	One unidentified black-on-white jar body sherd with sand temper; one unidentified Black-on-white jar sherd.
9	Indented corrugated jar sherd with sherd and sand temper.
10	Two conjoining unidentified black-on-white jar sherds with sand temper (one is a rim sherd).
11	Indented corrugated jar sherd with sand temper.
12	Unidentified black-on-white bowl sherd, white-slipped interior, 4 mm thick, sand temper.
13	Three plain grayware jar sherds with sand temper
14	Four indented corrugated jar sherds with sand temper (three are conjoining fragments).
15	Three indented corrugated jar sherds with sand temper (conjoining fragments); two plain grayware jar sherds with sand temper; four Gallup Black-on-white jar sherds with sherd and sand temper.

Surprisingly, we encountered no archaeological sites. This situation likely relates to both cultural and natural transformation processes. Regarding the latter, thick vegetation in much of the project area's west half reduced surface visibility. Across the study area, eolian deposition associated with once-exposed, very large mine tailings piles upwind and to the west might contribute to the absence of surface-observable sites. Two previously recorded sites occur immediately north of the current study area (Viklund 1990); perhaps these archaeological properties are related to the I.O.s recorded during this survey.

RECOMMENDATIONS

None of the 15 I.O.s found in the project area, in our opinion, possesses the potential to yield additional significant information. In each instance survey documentation exhausted their research potential beyond the level of redundancy and/or provenance. We recommend the 15 I.O.s be considered ineligible for nomination to the National Register of Historic Places and the State Register of Cultural Properties. Given the absence of significant archaeological remains on study area lands and the absence of properties listed on the National Register of Historic Places, we recommend cultural resources clearance for the proposed reclamation project.

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ARCHAEOLOGICAL INVESTIGATIONS ON THE HOMESTAKE-NEW MEXICO PARTNERS MINE

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PREPARED FOR:
Homestake Uranium Mine

October 3, 1990

SW 260

INTRODUCTION

On September 10 and 11, 1990, two archaeologists from Southwest Archaeological Consultants, Inc. conducted a cultural resources survey of approximately 55 ha (136 acres) of state land surrounding the Homestake-New Mexico Partners Mine west of State Route 509. The project area is 1.6 km (1 mile) south of Ambrosia Lake and 35 km (22 miles) northwest of Grants, New Mexico, in the northwest quarter of Section 32, T14N, R9W (Figure 1).

Work was conducted at the request of Homestake Uranium Mine, of Grants, New Mexico, in conjunction with land reclamation at the closed Homestake-New Mexico Partners Mine. The mine is on New Mexico State Trust land and was surveyed under State Permit No. 90-002.

ENVIRONMENT

The survey area is at the southern edge of the Chaco slope, a physiographic feature along the southern portion of the San Juan Basin, which is part of the Colorado Plateau province. To the east is the Mount Taylor Volcanic Field, to the south and west is the Zuni Uplift, and to the north is the Chaco Plateau and the Chaco Slope (PNM 1978:22; Anschuetz 1979). The region is characterized by sedimentary deposits of Cretaceous sandstones and shales.

Ambrosia Lake is at the west end of the San Mateo Valley within the Chaco Slope (Dulaney and Dosh 1981). This portion of the valley is oriented northwest-southeast and is bounded on the northeast by San Mateo Mesa and on the southwest by Mesa Montanosa. The primary drainage of the San Mateo Valley is Arroyo del Puerto, an intermittent tributary of San Mateo Creek. The valley is open and relatively level and cuts into the Mancos Shale formation. Soils consist of unconsolidated silt, sand and gravel alluvial fans extending south from San Mateo Mesa. They "are medium grained alluvium..." (Baugh 1990:11) and form an aquifer with ephemerally perched water tables. The grain size creates less permeability and more holding capacity, which may have contributed to the increased crop production of the Pueblo II period (Cordell 1982).

Hydrologically, the valley is not connected to the San Juan Basin since San Mateo Creek flows southward into the Rio San Jose, which in turn flows into the Rio Grande (Dulaney and Dosh 1981). No permanent water sources exist near Ambrosia Lake; the lake has been dry for almost half a century.

Climate is mild and arid (PNM 1978:100), with precipitation localized and summer-dominant. Average annual precipitation amounts range from 25 to 36 cm (10-14 inches) (PNM 1978:103, 104; Anschuetz 1979; Hammack 1985; Baugh 1990), and frost-free days average 120 (PNM 1978:109).

Area vegetation is Upper Sonoran, characterized by mixed grama-galleta steppe grasslands (PNM 1978:183). Within the project area, various short grasses, chamisa and tamarisk predominate. A single cottonwood grows next to a man-made tailings pond used by the mine.

Fauna common to the area consist primarily of rodents and lagomorphs, although coyotes, mule deer, and the occasional elk and pronghorn antelope also inhabit the valley.

CULTURAL OVERVIEW

Prehistoric Occupation

Ambrosia Lake is located in the west end of San Mateo Valley, northeast of the eastern Red Mesa Valley and south-southwest of the San Mateo Basin, a sub-basin of the San Juan Basin (Beal 1980). The Red Mesa Valley forms a natural pathway between population centers in the Little Colorado and Puerco rivers to the west and the Rio Grande to the east, while the San Mateo Valley connects the San Juan Basin to the eastern Red Mesa Valley. These natural corridors encouraged movement of people in both directions throughout time. Consequently, the potential exists for sites of various cultural traditions to be represented in the project area. Regardless of the number of archaeological studies conducted within these areas, however, only recently have regional syntheses emphasizing subsistence-settlement patterns and cultural processes been presented (Tainter and Gillio 1980; Scheick 1981, 1985, 1990; Baugh 1990).

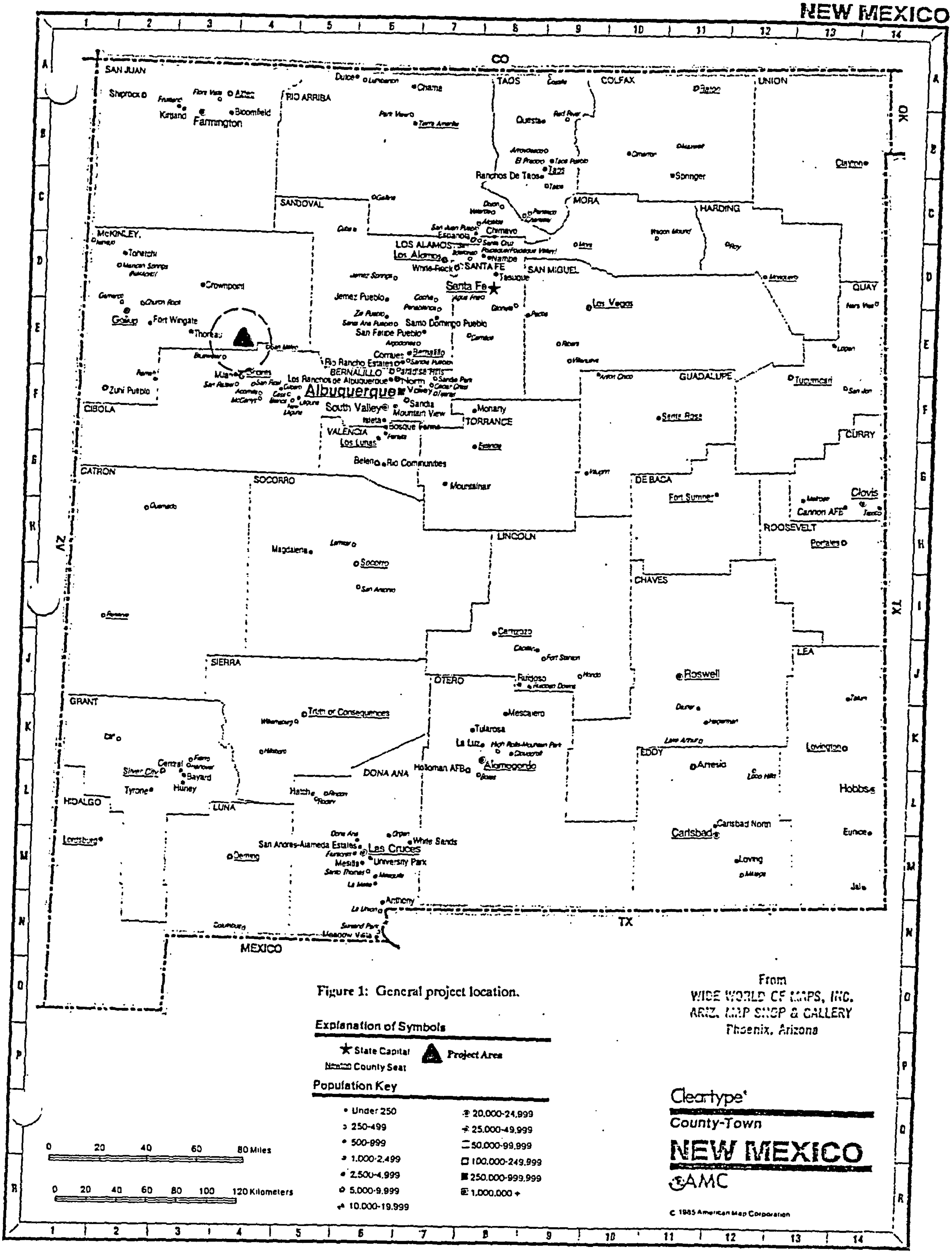

Figure 1: General project location.

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The following discussion borrows heavily from these published syntheses.

Paleoindian

Paleoindian cultural remains are the first recorded evidence of human occupation in the Southwest (9500-5500 B.C.), and sites are identified by the presence of specific projectile point types found in association with scatters of chipped stone. Primary subsistence was based on Pleistocene mastodon and *bison antiquus*, supplemented by smaller game and wild plants. Finds dating to the Paleoindian occur in wooded highlands (Tainter and Gillio 1980). Single component Paleoindian sites are few, although characteristic projectile points, found either in isolation or on sites with remains of later occupations, are recorded for the region (Scheick 1979; Whitmore 1979). As a rule, Paleoindian sites tend to have large amounts of unutilized white chert and obsidian debitage.

Although the lack of Paleoindian remains in the region may relate to the depth of their deposits (Cordell 1979), archaeological evidence still suggests Paleoindian use of the study area apparently was transitory and by small populations.

Because study of the Paleoindian period in the region has focused primarily on finding and identifying those sites, information on settlement patterns and area use is minimal. No Paleoindian finds are recorded near Ambrosia Lake.

Archaic

The Archaic cultural tradition (5500 B.C. - A.D. 400) succeeds the Paleoindian tradition and also is identified by distinctive projectile point styles. Whether due to climatic changes and/or the disappearance of the mastodon and *bison antiquus*, populations relied increasingly on small game and wild plants. These mobile hunter-gatherers probably followed a seasonal circuit based on the availability of game and maturation of wild plants. Later in the Archaic, maize horticulture was introduced to the subsistence base.

Sociotemporal and technological changes of the local Archaic culture follow cultural-temporal phases developed from Cynthia Irwin-Williams' work in the middle Rio Puerco Valley (1973) where she defined the Oshara tradition. Although the Rio Puerco Valley is east of Mount Taylor, generally, the Oshara tradition is associated with most of northwestern New Mexico with its southern boundary along the Rio San Jose. The Oshara tradition is divided into phases that span a period between 5500 B.C. and A.D. 400. Each phase is identified archaeologically by distinctive artifact assemblages.

The Jay phase (5500-4800 B.C.) is defined by distinctive stone tools and specific site locations suggesting game animal observation. Within the middle Rio Puerco Valley, these early populations apparently preferred basalt for chipped stone artifacts. The absence of groundstone in site assemblages seemingly reflects a reliance on hunting. Identified site types are the base camp, located near canyon heads and representing repeated returns to the same locality, and the specialized activity site, occurring in locations reflecting mixed but limited subsistence activities. Irwin-Williams (1973) believes the tool types, the limited faunal evidence, and the reoccupation of favorable localities suggest a mixed spectrum of subsistence activities adapted to year-round exploitation of a fixed complement of local resources by small groups of people.

The Bajada phase (4800-3200 B.C.) is an outgrowth of the Jay, sharing similar tool types and site locational preferences. Unlike the Jay phase, however, is the increasing number of large chopping tools and poorly made flake side scrapers, in artifact assemblages suggesting increased reliance on coarse plant foods. The larger number of recorded Bajada sites implies a population increase over that of Jay phase populations.

During the San Jose phase (3200-1800 B.C.), formal tool styles changed, the number of large chopping tools increased, and groundstone first appeared in artifact assemblages. The presence of groundstone suggests an increased importance of wild plants in the subsistence base. The multiple hearths characteristic of San Jose phase sites suggest populations either were larger and aggregating for short periods of time or they were serially reoccupying sites. Post-holes found on excavated San Jose phase sites indicate shelters were built at the larger camps. Habitation sites, or base camps, correlate with canyon heads above seeps and springs and on dunes or valley slopes (Beal 1980).

During the Armijo phase (1800-800 B.C.), maize horticulture was introduced, reflected in the archaeological records by increased types and frequency of groundstone on sites. Earlier site types and locational preferences continued with the addition of cliff tops and talus areas for base camps.

The En Medio phase (800 B.C. - A.D. 400) possesses recognizable antecedents of the Anasazi Puebloan tradition. Bifacial knives and drills are more common in these assemblages than those of San Jose phase assemblages. Armijo cliff shelters apparently were used during the fall and winter seasons, and dune sites during the summer (Irwin-Williams 1973:12). Winter sites often have slab-lined cists for food storage. Reliance on plant foods is more pronounced as demonstrated by the increasing number and types of groundstone tools on sites, with increased emphasis also placed on maize horticulture. These changes were concomitant with regional population growth.

A second Archaic tradition represented in the study area is the Cochise culture, normally found in southern New Mexico and Arizona and northern Mexico. Historically, the Rio San Jose is suggested as the northern boundary of the Cochise cultural tradition. As with all aceramic cultural traditions, recognition is by distinctive projectile point styles. Besides having different tool types, archaeological evidence indicates maize was incorporated into the diet earlier than in the Oshara tradition (Irwin-Williams 1973).

The Cochise culture also is subdivided into sequences, spanning the period between circa 7,000 B.C. and A.D. 1 (Irwin-Williams 1979:37). Phases are identified by their distinctive projectile point types and associated chipped stone assemblages. The earliest sites represent the remains of economically eclectic groups whose cultural remains include thin flat milling stones and cobble manos as well as percussion flaked choppers, scrapers and knives. Evidence suggests that by 7,000 or 6,000 B.C. populations practiced a mixed hunting-gathering strategy, but by the end of the Archaic, site assemblages reflect a mixed foraging economy with emphasis on a well-developed groundstone industry dominated by shallow basin-shaped metates and cobble manos. The wide variety of plants retrieved from sites, representing different environmental zones, suggests seasonal movement and scheduling were an integral parts of the settlement system. By about 2,500 B.C. maize and squash were added to the diet, but with little initial effect on the subsistence cycle. Changes in site locations, reduction in territory size, and the creation of surplus is postulated by about 750 B.C., when a more productive variety of maize was introduced into the Southwest. Other artifacts representative of the late Archaic Cochise tradition include crude choppers, various scraper forms, and a range of projectile point types.

Archaic sites in the project region, for the most part, were limited activity loci associated with hunting game, opportunistic foraging and/or stone tool raw material acquisition (Scheick 1985; Viklund and Scheick 1990). Preferred site locations include wooded mesatops and elevated features among pinon-juniper woodlands in the highlands and ridgetops and/or dune slopes in the valleys. Scheick (1985) suggests exploitation of the eastern Red Mesa Valley was during late summer/early autumn by transient groups possibly enroute to the foothills of the Zuni Mountains, and who also exploited the southeastern portion of the San Mateo Basin during the spring and summer months. Because of the ephemeral quality of the sites, and possibly due to shifting sand overburden, Archaic sites are not as well represented as in surrounding regions.

Of major research concern in the area is the presence of both the Oshara and the Cochise Archaic traditions. Often, these remains occur on the same site. Consequently, archaeologists are forced to reassess their assumptions about the spatial boundaries drawn and the relationships postulated for them. A second research issue concerns the applicability of the Oshara settlement-subsistence pattern as proposed by Irwin-Williams (1973) outside the Rio Puerco Valley. Evidence from adjacent areas suggests local variations occur and that the base camp-specialized activity locus model may be a specialized settlement pattern restricted to specific areas. Finally, the nature of Archaic occupation and land use within the region is only poorly understood, and inter-area relationships are not well defined.

The closest recorded Archaic sites to the project area are on Mesa Montanosa (Anschuetz 1979). On the mesa's northeast trending fingers, Archaic diagnostics occur on multicomponent sites with Basketmaker II and Pueblo I components.

Anasazi

The discussion of Puebloan cultural development is derived from Scheick 1985, and the reader is referred to that publication for more detailed information.

The Basketmaker period is viewed as transitional between the Archaic hunting/gathering population and the increasingly aggregated sedentary population that relied on horticulture (Irwin-Williams and Tompkins 1968:53). In the San Juan Basin subregion, Basketmaker manifestations are believed to have developed directly from the earlier San Jose Complex (Bryan and Toulouse 1943) and encompass Irwin-Williams' San Jose, Armijo and En Medio phases (3200 B.C. - A.D. 400). Grayware pottery is associated with San Juan Basin sites, as are corner-notched projectile points similar to those of the En Medio phase.

Cochise tradition-derived Lobo Complex (Bryan and Toulouse 1943:269) diagnostics comprise "...a group of stone implements consisting of serrated and nonserrated points smaller than those of the San Jose Complex, drills, knives, scrapers and grinding implements" (Bryan and Toulouse 1943:273). The Lobo Complex was identified first in the Grants area on the southwest flank of Mt. Taylor, but tools suggestive of the Lobo Complex also were found at En Medio Shelter on the Rio Puerco (Irwin-Williams and Tompkins 1968:18-19). Bryan and Toulouse (1943) propose that Lobo Complex materials are the remains of an Archaic/Pueblo interface in this portion of the San Juan Basin because they are associated with supposedly contemporaneous ceramics and Puebloan lithic materials. The lack of distinct Basketmaker sites in the area seemingly supports that theory.

Several hundred archaeological sites dating to the Anasazi period have been recorded in the region, yet very little is understood about the nature of that occupation. Most attempts at interpreting the wide range of variability exhibited in the archaeological record of the area have been speculative and biased by other developments in the San Juan Basin, particularly by Chaco Canyon. However, this approach has considerable precedent. Beginning with Gladwin (1945), the interpretation of occupation in this general area has been that it was somehow tied developmentally to the vagaries of the Chaco phenomenon. More recent authors view the ties as economic and/or religious (Judge 1989).

According to Gladwin (1945), during the White Mound phase, southern immigrants influenced the traditional Basketmaker culture, resulting in the cultural manifestation identified as the Kiatuthlanna Phase (Pueblo I). Later changes resulted in the Red Mesa Phase of the early half of Pueblo II, the Wingate Phase of late Pueblo II, the Hosta Butte phase of the early half of the Pueblo III, and finally the Bonito phase of late Pueblo III (Gladwin 1945:6). Architectural and material culture remains associated with each of these developmental sequences became progressively more sophisticated.

The earliest White Mound phase (A.D. 750-800) sites are found at lower elevations than Basketmaker sites and consist of pithouses in conjunction with contiguous, rectangular, aboveground storage rooms made of jacal. Associated pithouses contain many features characteristic of kivas. Southern ceramic types occur on those sites as well as other types that have strong similarities to southern types.

During the following Kiatuthlanna phase (A.D. 800-850), architectural changes include the use of aboveground structures for habitation, the removal of dividing walls in pithouses, a shift from clay to slab-lined firepits, pole support modifications, and the addition of benches. The ceramics still show a southern influence as well as the presence of actual southern types, but the beginnings of ceramic specialization can be seen.

The Red Mesa phase (A.D. 850-925) apparently was a period of architectural experimentation. Aboveground pueblos consist of four to six rooms and are rectangular. The walls exhibit combinations of construction techniques including adobe, wattle and daub, jacal or masonry. Firepits or hearths are located outside structures. Pit structures are assumed to be functioning as both habitations and kivas.

Wingate phase sites (A.D. 925-1000) are considerably different from their predecessors, with architecture consisting almost entirely of masonry roomblocks. Pueblos contain from six to eight rooms as a rule. Pithouses continue, and kivas changed with the reduction of benches to alcoves and/or recesses. Hearths occur inside and outside rooms. Ceramics include the introduction of Gallup Black-on-white and Wingate Black-on-red. Nonlocal ceramics on these sites are thought to be rare. According to Gladwin (1945), by A.D. 1050 the Red Mesa Valley was abandoned.

The Hosta Butte phase (A.D. 1000-1075) applies to sites located north of Crownpoint and are characterized by their 20 to 30 room size, the presence of multiple kivas, and a distinct style of banded masonry. The Chaco Black-on-white ceramic-style appears, and although McElmo Black-on-white does also, it is considered intrusive.

Criticisms of Gladwin's work (Whitmore 1979; Tainter and Gillio 1980; Cordell 1982) focus on the simplified, mutually exclusive progression of cultural traits associated with each period that are now known to be more complicated and interrelated. Site location patterns were not studied. Further, important behavioral changes associated with changing material cultural traits were largely ignored. More recent discussions of area archaeology are structured within broad cultural periods (Pueblo I-IV) and focus on settlement patterns (Powell 1979), economic strategies (Sebastian 1983), and economic and social organization (Marshall et al. 1979; Tainter 1980; Stuart and Gauthier 1981).

For example, Sebastian (1983) views Puebloan cultural periods in terms of settlement patterns and adjustments in economic strategy. Basketmaker II (100 B.C. - A.D. 400) sites are ephemeral and are associated closely with arable land, but also are found in areas with access to hunting and gathering resources. The data suggest that earlier trends of reliance on wild resources and population mobility continued. Basketmaker III (A.D. 400-700) habitation sites yield evidence of seasonal sedentism and some reliance on horticulture, although the location of limited activity sites still reflects exploitation of a wide variety of wild resources. By Pueblo I (A.D. 700-900) sites are located close to alluvial land where run-off occurs, emphasizing the importance of horticulture in the economic strategy. Evidence also indicates an increase in population and incidence of storage on sites. During Pueblo II (A.D. 900-1100) populations increased significantly, expanded into previously unoccupied areas, and formed community clusters of permanent and semipermanent settlements. By the middle of Pueblo II, populations became aggregated, and evidence exists for a region wide interaction-exchange network identified as the Chacoan Phenomenon. Specialized architectural features referred to as Chacoan outliers appear in locales removed from Chaco Canyon, suggesting changes in area social organization and local economies. In the project region, outliers often occur near the base of a mesa in areas never before densely settled by local populations. By Pueblo III (A.D. 1100-1300) outlier communities became pronounced, and Chaco roads were constructed, linking outliers to each other and to Chaco Canyon. Typically, Chacoan outliers are surrounded by a variety of site types, the highest concentrations occurring within a 3 km (2 mile) radius (Whitmore 1979). Within the first kilometer, most sites are fieldhouses, but the variety of site types increases with distance, particularly in the third kilometer (Scheick 1985). Also, the earliest sites are farthest away, suggesting a deliberate congregation near population centers before Chacoan influence in the area. Regardless, the formation of outlier communities is interpreted as a consequence of the expanding Chacoan system centered in the San Juan Basin 69 km (43 miles) to the north. The Chacoan system was characterized by sophisticated public architecture, extensive trade relationships, and support of a large population in a relatively small area (Sebastian 1983:13). Finally, Sebastian (1983) believes the collapse of the Chacoan system resulted in the collapse of the support systems, resulting in area abandonments.

Within the general project region, little evidence exists for increased reliance on maize horticulture during the Basketmaker period, and the similarity of sites to earlier cultural manifestations argues for continuation of largely marginal use of the area. Most Basketmaker II and II/III manifestations are isolated finds or small artifact scatters, while Basketmaker III sites are sherd and lithic scatters often with or without associated hearths or cists. Of interest, however, is that during Basketmaker III a shift from inhabiting high resource diversity slopes or elevated locations towards valley bottoms is seen and evidence of horticulture is apparent (Scheick 1985). No large habitation sites are known, although the larger number of sherd and lithic scatters combined with a few small surface structural sites reflects a gradual population increase over earlier periods. Nevertheless, use still was sporadic, and economic strategies focused on hunting and gathering, possibly with some attempts at horticulture made.

A further small increase in population is evident during Pueblo I, with most sites identified as sherd and lithic scatters. With an increase in population, an increase in sites occurred. Consequently, settlement patterns are identified more readily during Pueblo I. Apparently, elevation played a vital role in site type/placement correlations. Pithouses and small surface structures are located in pinon-juniper fringe areas at elevations between 2,134 and 2,164 m (7,000 and 7,100 feet), while larger pithouse villages occur at elevations up to 2,195 m (7,200 feet). Limited activity sites occur in these areas as well as in the lower grasslands (Scheick 1985).

By A.D. 800 Pueblo I/II occupation of the valley was seasonal, with semipermanent sites established on the valley slopes (6,800-6,900 feet) as well as on mesatops. Sites containing late Pueblo I/early Pueblo II ceramics include surface rooms with associated pit structures, small arcs of contiguous surface rooms with possible kivas, fieldhouses, and large villages. During this period, a number of traits developed that later solidified around large Chacoan outliers. Haystack Pueblo, a Chacoan outlier, was built during this period. Contemporaneous pithouse villages with possible surface structures also were established along the pinon-juniper fringes bordering secondary drainages in the highland areas (Scheick 1985:17). Ceramics include Kana'a and Lino graywares and Kiatuthlanna and Red Mesa black-on-white wares.

Archaeological evidence indicates occupation and use of the region increased during Pueblo II (A.D. 900-1100). Discrete clusters of small, medium and large sites are spread out along the numerous drainages that form the headwaters of the Rio San Jose. Early to middle Pueblo II sites consist of isolated fieldhouses associated spatially with small to medium-sized roomblocks (three to six rooms) with kivas, to larger groups of roomblocks (SHPO, ARMS files). Limited activity sites, petroglyphs, and rockshelters also are documented. Ceramics include Puerco, Escavada, Gallup and Chaco black-on-white wares, Wingate and Puerco black-on-reds, and Coolidge and Mancos corrugated wares.

Occupation of elevations below 2,073 m (6,800 feet) became common as tributaries of the major drainages were farmed. Correlations between specific site types and particular elevations is pronounced for sites of this period. For example, farmsites (3+ rooms, seasonally occupied and located near agricultural lands) occur at elevations between 2,073 and 2,103 m (6,800 and 6,900 feet) and between 2,195 and 2,225 m (7,200 and 7,300 feet), pueblos (primary habitations, semipermanently occupied and located in the most agriculturally favorable physiographic zones) occur at elevations between 2,103 and 2,134 m (6,900 and 7,000 feet), and fieldhouses (1 or 2 room sites occupied intermittently and located near agricultural lands) occur between 2,073 and 2,134 m (6,800 and 7,000 feet) and 2,195 and 2,225 m (7,200 and 7,300 feet). Limited activity sites (usually containing no visible structures, representing specialized use of an area) are found at all elevations (Scheick 1985).

By late Pueblo II (A.D. 1000-1100) Chaco Canyon had become what is believed to be a regional socioreligious center (Judge 1989), and Chacoan outliers were well established in the project region. Kin Nizhoni and Lower Nizhoni are 3.2 km (2 miles) southeast of the project area and date to early Pueblo III and late Pueblo II/early Pueblo III, respectively. A third outlier, the Haystack community, occurs 10 km (6 miles) southwest of the project area at the base of Mesa Montanosa (LA 6022, 12573-A and 12573-D). Possibly the earliest constructed component of Haystack, LA 12573-D, was occupied between late Pueblo I and early Pueblo II (A.D. 900-1000). LA 12573-A dates exclusively to Pueblo II (A.D. 1000). LA 6022 is the latest and largest of the three components, inhabited from late Pueblo II to early Pueblo III (A.D. 1000-1100) (Marshal et al. 1979).

Extending from both Kin Nizhoni and Haystack outliers are Chacoan roads; closest to the project area, one road can be traced from Kin Nizhoni 1.5 km toward Ambrosia Lake. The Chaco road system has been studied since the 1960s, and in the north part of the San Juan Basin roads are visible from one settlement to another. In the project region, however, roads are fragmented and lack definition between outliers (Nials, Stein and Roney 1987).

Other community types also are documented in the eastern Red Mesa Valley and contain large multiple or isolated C- and T-shaped roomblocks with kivas as the center of the cluster (Powell 1979; Miller and Frizell 1980). Interestingly, the alternate community types (mainly habitation) are located along the many tributaries and headwaters of the Rio San Jose, such as those in San Mateo Valley, while the outliers are located in areas never densely occupied prior to their introduction (Scheick 1985:17-18).

Further, upland populations were probably loosely related, mobile, and highly adaptive. The kinds and locations of sites in the uplands suggest a fluid social system, and population alliances within that system may have been temporary and constantly changing. Outlier communities in the lowland valley drainages apparently were local phenomenon and economically focused, probably as a result of social and environmental circumscription rather than attempts at creating surplus for systematic exchange.

No evidence exists to suggest that populations in the lowland or upland communities participated in long distance trading of food, and no evidence exists of technological specialization in the production of economic goods other than the presence of expedient technology related to subsistence production. The sites in the eastern Red Mesa Valley yielded no evidence of production or storage of surplus food. Indeed, the heavy reliance on native plants in combination with the small numbers of storage features suggests there was little surplus.

The low percentages of intrusive ceramics at farmsites, fieldhouses, and other residential sites suggest that simple exchange was conducted at the site or group level (Lang 1982; Post 1985). Evidence suggests intra-valley exchange was more common than inter-regional exchange. The low percentages of nonlocal goods in Puebloan inventories make suggestions of large-scale trade insupportable. No interruptions occurred in local ceramic or flake tool traditions that would suggest new innovations. Ceramic hybridization and combinations are interesting, but their presence can be attributed to experimentation, communication networks, etc. rather than to population movement.

Finally, some indications exist that Chacoan outliers may have been in situ developments (Tainter and Gillio 1980; Doyel 1982) and that they fulfilled public or administrative functions, while most recently, Fowler and others (1987) see them as evolutionary developments in a pan-Anasazi cultural development.

The role of outliers is based largely on conjecture since few excavations have been conducted and surveys have provided only limited data. Data from excavations by the School of American Research (Beal 1982) of portions of the Casamero sustaining complex suggest most of the surrounding three to four room pueblos were seasonally occupied farmsites, and that by early Pueblo III populations were affected by nutritional stress. Beal feels that pre-A.D. 1000 sites represent temporary, short-term occupation, while post-A.D. 1000 sites exhibit long-term or repeated use. Most importantly, no evidence suggests local sites participated extensively in or benefited from trade with a sophisticated cultural system. There is no indication of surplus production or processing capacities beyond what was necessary for simple subsistence (Beal 1982:349).

Prior to A.D. 900 sites in the San Mateo Valley also represented temporary, short-term occupations, while post-A.D. 900 sites were occupied on a long-term basis. Based on ceramic evidence, Baugh (1990) believes inhabitants of the Ambrosia Lake area were a sub-nuclear community of Kin Nizhoni. The nature of that articulation, however, is not well-defined.

Occupation of the general region continued through Pueblo III (A.D. 1100-1300) but is represented by far fewer sites than evidenced during Pueblo II. Throughout the period, subsistence strategies continued to emphasize a mixed pattern of hunting, gathering and agriculture. During early Pueblo III populations concentrated near small tributaries serving restricted drainage basins, on gentle slopes without established watercourses, or in the highlands that benefited from increased precipitation. By A.D. 1050, however, the climate became too wet, and possibly floods rendered the lower portions of major watercourses unusable (Beal 1984). Populations began to abandon valley floor settlements, and by the latter half of Pueblo III, the outliers also were abandoned.

Those sites constructed during Pueblo I and Pueblo II in the highlands continued to be occupied. Reminiscent of earlier Pueblo I patterns, large permanent habitation sites of Pueblo III occur between 2,134 and 2,164 m (7,000 and 7,100 feet) along the edges of the pinon-juniper woodland. Those fieldhouses and farmsites that occur are found normally above 2,134 m (7,000 feet), and occupation of these two site types probably was short-term and intermittent. Limited activity sites occur in a wide variety of environmental situations.

Smaller pueblos of 8 to 10 rooms were abandoned first in the highlands at about the same time as those in the lower major tributary valleys, leaving only a few large complexes in the most favorable areas (Scheick 1985:259). Abandonment of the area was gradual and probably occurred in two separate episodes. Indications are that the relationships between upland and lower valley groups were severed by Pueblo III, probably as a result of competition for arable land. The number of sites in the uplands did not increase dramatically with the abandonment of the lower valleys; rather, the increase in site size could be a result of the abandonment of many of the smaller pueblos already present in that area. Ruppe (1966) notes an increase in population and in western influences on local pottery assemblages in the Malpais-Cebolleta area during early Pueblo III (A.D. 1100-1200) and a surge of population during late Pueblo III to Pueblo IV (A.D. 1200-1400), perhaps as a result of abandonment of the large upland communities around A.D. 1200. The population increase to the east may have resulted from the abandonment of the eastern Red Mesa and San Mateo valleys.

Between A.D. 1200 and 1250, the upland areas were used as a source of wild plant and animal foods, as reflected in the increased number of limited activity sites dating to this time. Final abandonment of the area occurred about A.D. 1250.

Major research concerns of the Puebloan period in the area focus on the nature of Pueblo II expansion, the role of Chacoan Outliers, and the nature of Chacoan and indigenous population interactions.

Historic Occupation

Pueblo

A cultural hiatus occurs in the region after A.D. 1250, as the population center apparently shifted eastward. Upon the arrival of the Spanish in 1539, the Acoma Pueblo use area extended a considerable distance from its mesatop location in all directions. Modern Acoma residents claim the mesatop pueblo has been occupied continuously for at least 1,000 years and that their origins are from the east and northeast, as far away as Mesa Verde (Ellis 1979). Records indicate the early historic Puebloans relied on dry farming and ditch irrigation for their crops, and hunted and gathered in the mesas and mountains of Mount Taylor and the Zuni Mountains.

Acoma people participated in the Pueblo Rebellion of 1680, and in 1692 accepted Reconquest refugees from the Rio Grande Pueblos of Cochiti, Cieneguilla, Santo Domingo and Jemez. Sometime between 1697 and 1699, the refugees and a few resident Acomas split from the pueblo and founded Laguna Pueblo to the west (Ellis 1979).

Both pueblos relied on sheep and goat herding as well as agriculture during this period. But constant Navajo raids caused the size and location of their herding territories to fluctuate during the next century, and when the Spanish established ranches in the confluence of the Rio Puerco and Rio San Jose and at San Mateo, their territory was further reduced (Ellis 1979; Garcia-Mason 1979).

Today, the use area claimed by the Acoma people extends almost to Bluewater; while that of the Laguna is east of Grants. The project area occurs just north of the northwest corner of the historic Acoma territory (Rands 1974). Indications are that the flats east of San Mateo Creek were used for seasonal agriculture, and the highlands were used in the warm months for summer pastures, raw material acquisition, and wild plant food and game exploitation. The area of Ambrosia Lake no doubt served as pasture land and as a pass for access onto San Mateo Mesa. The Laguna often crossed the Red Mesa Valley, however, when traveling to the Zuni Mountains and/or to the Little Colorado River.

Recorded historic Puebloan sites consist mostly of herding camps. Preferred warm-weather herding site locations apparently consisted of open lands with a northern exposure and good sheep beds (a large shady juniper is important). Habitation openings most often are oriented to the east because of prevailing west winds, and normally a U-shaped hearth occurs 1 to 2 m in front of the door. No large corrals were built, but small lambing pens were used. In the winter herds were moved to lower elevations, and sites were established in areas with natural windbreaks, such as sheltered canyons, along talus slopes, and major mesa slopes surrounding drainage valleys (Cattle et al. 1981). Lambing pens were built across small rincons. Acoma summer ranges included the south slopes and top of Mount Taylor; winter ranges centered around Laguna del Monte and Ambrosia Lake. Laguna herds ranged farther south and east of these areas (Rands 1973).

Pueblo herding structures are of dry-laid, unshaped boulders that often incorporate natural features; wall heights average 40 cm. Few artifacts are found in association. Small cairns, consisting of two or three stacked rocks, often are nearby (Cattle et al. 1981). Since the early twentieth century, tents were used, leaving only rock rings or rectangles.

Navajo

Dates for when the Navajo began to use/inhabit the region are problematic. Predominantly nomadic hunter-gatherers, the Navajo were present when the Spanish entered the area and had been creating problems for the Puebloans by occasionally raiding them for crops and slaves. Because of the threat the Navajo posed, Puebloan use area boundaries shifted and shrank considerably. Moreover, it was impossible for the Spanish to establish settlements in the area until the mid-1800s when the Navajo were forced onto reservations. Indications are that at least one peaceful Navajo group, however, was allowed to remain in the area (Schaafsma 1977:26). Early Navajo populations subsisted on hunting, gathering, trading and raiding, but with Spanish influence, herding of sheep and goats became important. By the 1880s, however, herding was supplemented by wage-jobs with the railroad. Wage labor continued to increase and expand as Navajos began working as herders for Anglo, Hispanic and Puebloan ranchers. In fact, after the 1950s, little herding of their own stock occurred.

Recorded Navajo sites most often reflect herding activities, with only a few habitation sites known for the region. Sites are found in sheltered alcoves, near rock outcrops and escarpments, at canyon heads, and in pinon-juniper woodlands and grassland fringe areas (Tainter and Gillio 1980).

The primary research concerns in area historic archaeology are the identification of early Acoma and Navajo sites, settlement and use patterns, and the processes of acculturation as reflected in the archaeological record. Other than architectural features, such as hogans and sweatlodges, little material remains provide clues to the ethnic identity of the majority of historic sites in the area. Thus, establishment of site's cultural affiliation also is important for understanding area history.

Spanish/Anglo

Although the Spanish first entered the region in 1539, the area already was occupied by Puebloan and Navajo groups. Relative peace was established with the Puebloans after the Reconquest of 1696, but the Navajo resisted living in permanent settlements until the 1800s. However, after 1846, local sheep herders, Texas cattlemen, Oklahoma farmers, California gold seekers, Mormon settlers from Utah, and railroad workers increasingly populated the region. San Mateo was established in the mid-1800s (Pearce 1965:147), and the town of Grants was established in 1882 as a railroad construction camp. Ambrosia Lake was settled by a number of homesteaders in the nineteen-teens (Mr. A. Jebo, personal communication, September 11, 1990), and since the 1950s, the area surrounding Ambrosia Lake has supported uranium mines. Grants remains the largest community center in the area.

EVALUATION OF AREA RESEARCH

Archaeological research in the project region began in 1943 with the identification of the Archaic culture in the archaeological record (Bryan and Toulouse 1943). However, most research conducted during the early 1900s focused on investigating the large pueblo sites and documenting occurrences of specific groups using the area. During the 1950s, investigations took the form of salvage archaeology as highways began to be built across the land. By the 1960s, however, awareness of site variability increased, and settlement pattern studies became the focus of area archaeology. During the 1980s, systematic surveys still were not common. Also by the 1970s, site variability was recognized in the area and large tracts of land were being investigated, supported by increasing mining activities. Archaeological work thus far has been near Prewitt and Thoreau, west toward Gallup, in the San Mateo Valley, and on the Lee Ranch north of San Mateo. Within the last ten years, large tracts of land around Ambrosia Lake have been surveyed (Schaafsma 1977; Anschuetz 1979; Hewett 1981; Dulaney and Dosh 1981; Hammack 1985, 1988). Most projects address particular research concerns, but those that do not at least provide descriptive information. A brief overview of major research concerns for the region is presented below.

First, the identification of regional use groups is one of the earliest topics of research, with particular emphasis on the reassessment of Cochise and Oshara tradition boundaries. The Cochise presumably inhabited southern New Mexico, and the Oshara northeastern New Mexico. Segregation was assumed fairly rigid, but in the project region sites with diagnostic projectile points of either or both cultures occur (Scheick 1985, 1990). Is such a boundary between two cultures real? Also, did the Cochise introduce maize horticulture to Oshara or was it an in situ development?

A second research question concerns the transition from Archaic to Pueblo. Basketmaker/early Puebloan ceramics often are associated with late Archaic projectile points in the area. Are these sites multicomponent, or do they represent transitional cultures (Bryan and Toulouse 1943; Condie 1987)?

Third, Puebloan architectural sites are readily identifiable, but nondiagonsitc lithic scatters of both the Archaic and the Puebloan periods often are identical. Many of the sites recorded in the area are artifact scatters associated with limited activities, and since many sites lack diagnostic artifacts, differentiating between Archaic and Puebloan sites is an important research concern.

Fourth, settlement pattern definitions are a major issue, particularly during the Pueblo II period. Most notable is the role/influence of the Chacoan System in regional settlement-subsistence dynamics (Whitmore 1977; Beal 1977, 1979; Gossett and Gossett 1983; Acklen and Bertram 1985; Scheick 1985, 1990; Baugh 1990). Many assume that the Chacoan system disrupted/changed local settlement patterns by exerting highly organized, religious-based control over indigenous populations, but no concrete evidence of this exits to date. Furthermore, the outliers are assumed by some to have served as gathering centers for raw material and agricultural produce, which then were funneled into an extensive interaction network. Chaco Road surveys also have been conducted, but the roads cannot be identified as extensively as those adjacent to Chaco Canyon (Nials, Stein and Roney 1987). Finally, the abandonment of the project region is correlated with the collapse of the Chacoan system (Sebastian 1983:13-14). So far, the archaeological record does not support these assumptions.

Finally, investigations of historic sites focus on questions of ethnicity - who were the ancestors of the Acoma; when did the Navajo first inhabit the area? Are these sites affiliated with the Navajo or were they also made and used by the Historic Puebloan groups of Acoma and Laguna? Also, the processes involved in the acculturation of these groups is a major research

METHODS AND RESULTS

The project area boundaries either were defined by metal rods tied with flagging tape or were physiographically apparent. Parallel contiguous transects spaced 15 m apart were used to survey the project area, with flagging tape used to maintain transects and ensure total coverage. For the drainage ditches, the ditches themselves provided a centerline from which to establish transects; a total right-of-way width of 54 m (178 feet) was surveyed for each ditch.

Sites and isolated occurrences were recorded; recent trash was not. A site is defined as a collection of cultural material usually numbering at least ten artifacts and/or features that exhibit internal consistency, a concentrated distribution, and/or a specific activity orientation. An isolated occurrence usually consists of less than ten artifacts and exhibits none of the above-mentioned attributes.

Information was recorded in a field notebook. Categories of site information include physiographic location, site size, physical descriptions of the site, its features and artifacts, artifact inventories and distribution patterns, and site condition/disturbance. Site plan maps were drawn to scale and site overview photographs taken. Site locations were plotted on the appropriate U.S.G.S. topographic map. Isolated occurrences were described and photographed or sketched when appropriate. Again, locations were plotted on a U.S.G.S. topographic map.

Sites were marked on the ground by orange flagging tape tied along the apparent site boundaries; one flag, designated the numbered site flag in the plan maps, was marked with the site field number. Isolated occurrences were not marked on the ground.

The project area consists of four blocks of land (designated A through D) and two drainage ditches (E and F) (Figure 2). These areas include soil considered to be too high in radiation to leave uncovered (they were used to store ore, tailings and other waste) or soils to be used in covering 'hot' spots.

Area A is east of State Route 509, within the southeast corner of the State route and a road running east along the north boundary of Section 32. Area A surrounds the Homestake-New Mexico Partners Mine shaft complex and is bounded on the west by State Route 509, on the north by the gravel road leading to the Sandstone Mine in Section 34, and on the east by metal rods tied with pink flagging tape. The south boundary was defined by the corner flagged rod and the south side of the mining pond. Approximate acreage totals 18 ha (45 acres). Soil from the eastern half of Area A, east of the well on the hilltop, will be used to cover the western half, which surrounds the mine shaft. The boundaries of the area of soil to be used as cover are marked by rods with flagging.

The western half of Area A supported the mine shaft and was used to store raw uranium ore and waste products and equipment for approximately 30 years. The area has since undergone cleanup, and approximately 50 cm of ground surface has been scraped away by graders and bulldozers. The west side of the hill also is scraped slightly. Disturbance in the eastern half of Area A resulted from various activities. The eastern slope of the hill was used by the County as a stockpile location for road gravel; this area also is scraped lightly. Dirt roads and drillholes occur in the flats, and a transmission line parallels the northern boundary road.

All 18 ha were surveyed at inventory level. One site and 15 isolated occurrences were recorded. The site (260-1) is just outside the flagged boundary of soil to be used for covering up the western half; the site may be 'hot' and possibly will be covered.

Area B is west of State Route 509, directly across from the entrance into the Homestake-New Mexico Partners Mine complex. Roughly rectangular in shape, Area B is oriented northwest-southeast and consists of approximately 4 ha (10 acres). All boundaries are defined by rods tied with pink flagging. Also, the western edge is defined by a graded reclamation field created by the Quivera Mine.

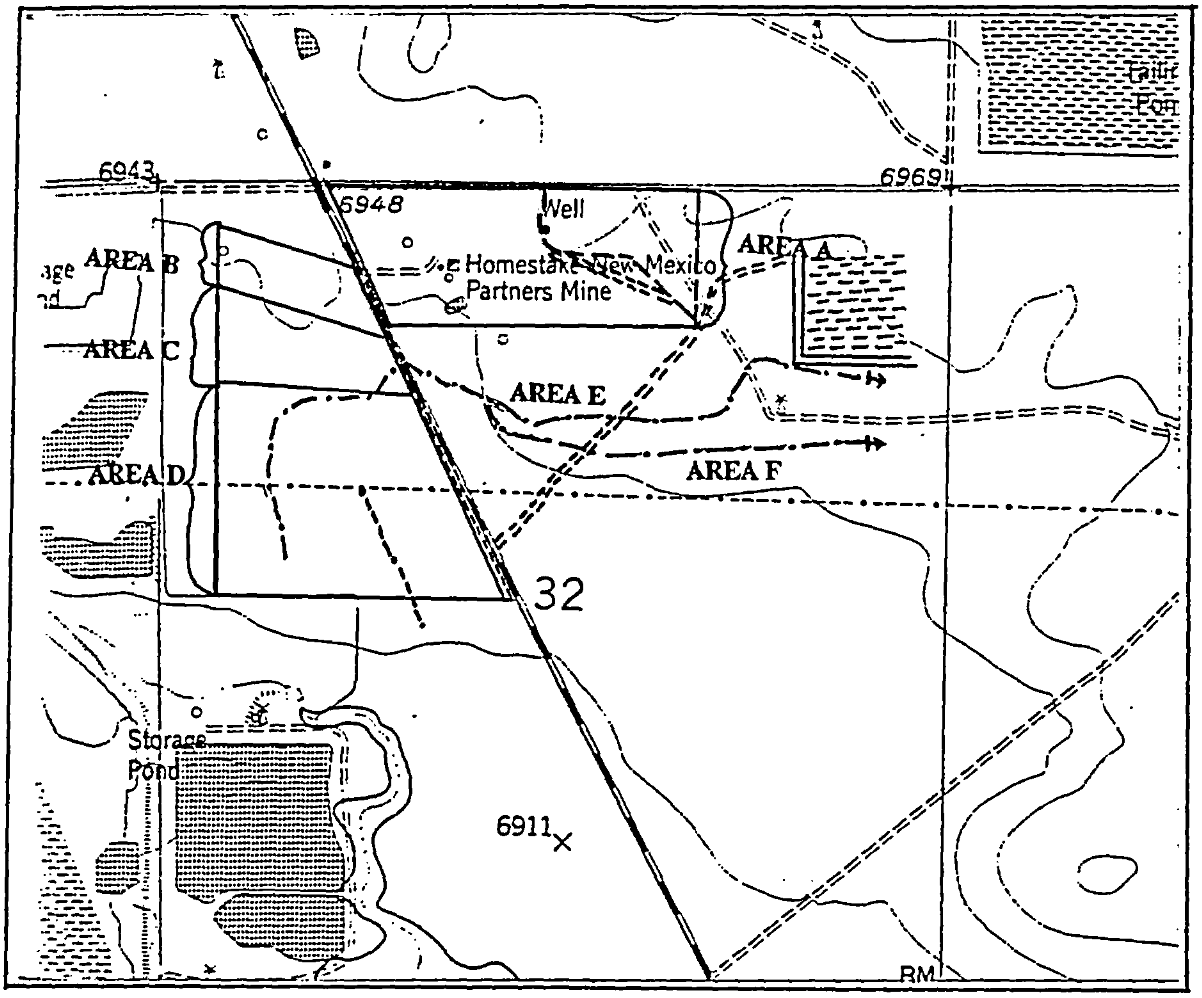

Figure 2: Project area. Map adapted from U.S.G.S. Ambrosia Lake, New Mexico Quadrangle (1957, photorevised 1980), 7.5-minute series. 1:24,000. Map has been enlarged 154 percent from original size.

•——•	Transmission line
—·—·—	Ditch
===	Dirt track
▨	Tailings pond

Area B will provide cover soil for Area C. Area B is only minimally disturbed; a dirt track parallels the fenced east boundary and an abandoned vent shaft is in the northwest corner.

Survey was at inventory level, and archaeologists found no cultural remains.

Area C is between areas B and D. The north boundary of Area C consists of the flagged rods of Area B, the east boundary is the fence along State Route 509, and the south and west boundaries are physiographically apparent; a ditch on the south, and the reclamation area on the west.

This area served as additional storage for raw ore, tailings and equipment, and much of the southwest portion was used as a pond. Therefore, the area is considered 'hot' and will be covered by fill dirt from areas C and D. The ore, tailings, etc., have been removed for some time and vegetation has grown back, but like the western half of Area A, graders have removed 30 to 50 cm of ground surface and no undisturbed portions remain.

Area C encompasses approximately 7 ha (17 acres). All 7 ha were surveyed at inventory level. Four isolated occurrences were found.

Area D is located immediately south of Area C, separated from C by a drainage ditch. The east boundary is the fence paralleling State Route 509 and the west boundary is the graded reclamation field. The west half of the south boundary is defined by more of the same graded field as it forms a corner. An east-bearing compass line from this graded area to the fence provided the rest of the south boundary.

Soil from Area D will be used to cover areas C, E and F, and portions of Area A if needed. Disturbance to the ground is restricted to the dirt track along the fence, two small ditches on either side of the track, two large ditches, and two sections of transmission line. One section of transmission line runs east-west and actually consists of three lines. The second section is perpendicular to the first and bisects the area in the eastern half of the survey area.

Area D encompasses almost 20 ha (50 acres). Two sites and 17 isolated occurrences were recorded. The distribution of the isolates forms southwest-northeast forms a band through the area.

Areas E and F are actually a ditch complex east of State Route 509, south of Area A. The two ditches begin as one at the highway but branch into north and south sections. Area E extends from the fence and includes the south branch. Survey was terminated at a clump of three tamarisk trees south of the tailings pond in the northeastern corner of Section 32. Area F is the north ditch as it splits from the main ditch complex. Termination is at the same longitude, approximately 50 m past the southwest corner of the tailings pond.

Both ditches were used by the Phillips Petroleum Mine in Section 33 to drain water from their mining operations. Although pipes carried the water within the ditches, leaks in the pipes have created 'hot pockets' that need to be buried. Low dirt berms occur on both sides of both ditches, and both ditches cross old dirt roads traversing the alluvial flats.

The acreage surveyed for the ditches is approximately 6 ha (14 acres). Each ditch was used as a centerline, and the archaeologists walked 15 m apart up one side of the ditch and down the other, creating a right-of-way width of 27 m (89 feet) to each side of the ditch.

Eighteen isolated occurrences were recorded in areas E and F (I.O.s 16-33).

DESCRIPTIONS AND DISCUSSIONS OF CULTURAL REMAINS

In all, three sites and 55 isolated occurrences were recorded (Figure 3). Sites are discussed first, followed by Table 1 listing the isolates. Legal descriptions for each site are presented along with the site's physiographic location, dominant on-site vegetation, and any physical disturbance to the site. Site attributes discussed include size, features, if present, and artifact types, numbers, dimensions, etc. Completing the site description is a discussion focusing on site type, cultural-temporal affinity and function.

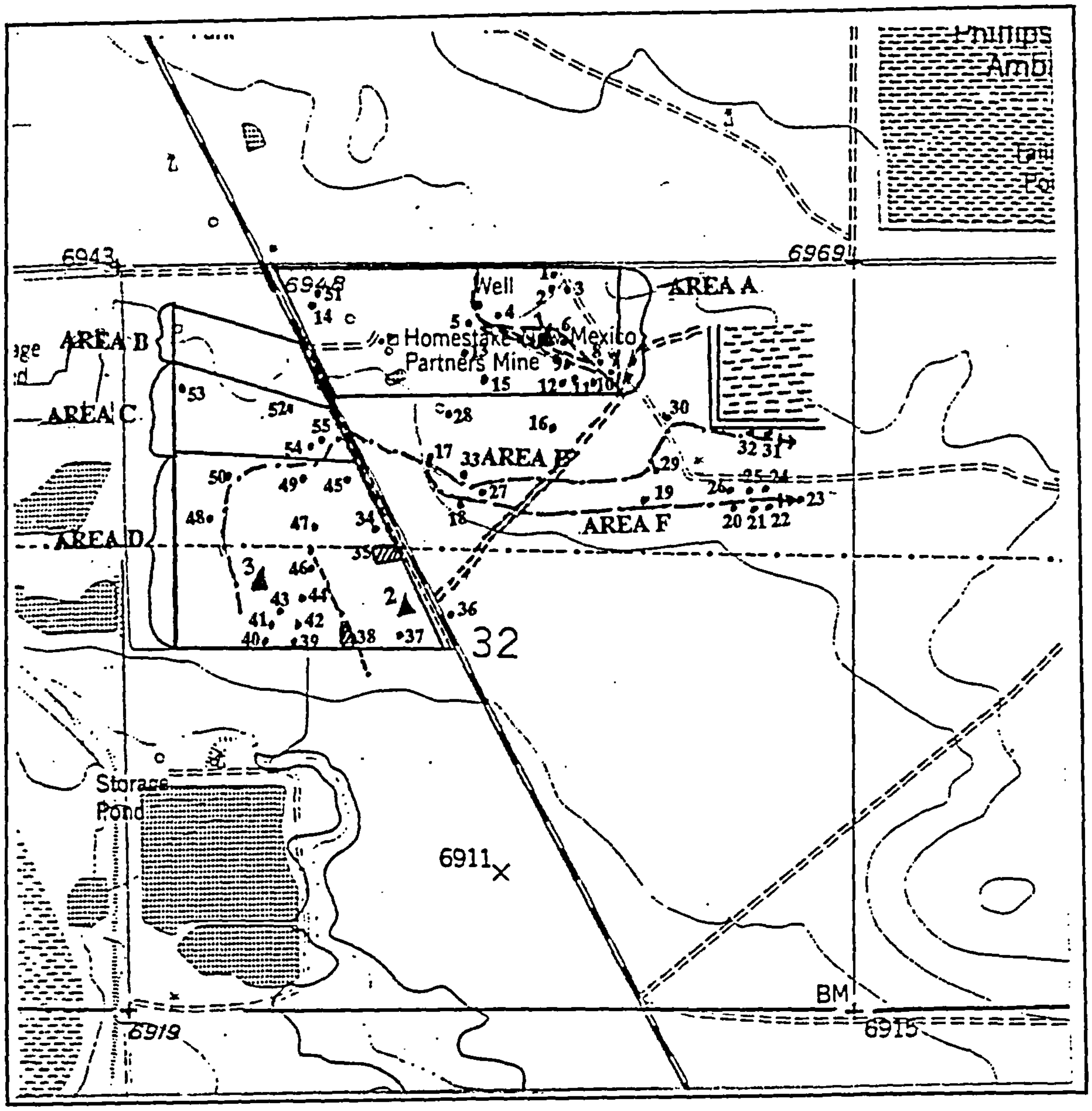

Figure 3: Location of sites and isolated occurrences. Map adapted from U.S.G.S. Ambrosia Lake, New Mexico Quadrangle (1957, photorevised 1980), 7.5-minute series. 1:24,000. Map has been enlarged 154 percent from original size.

▲ Site

•/▨ Isolated occurrences

Diagnostic artifacts were used primarily for defining cultural-temporal assignations and include projectile points and ceramics, for the most part. Both projectile point and ceramic styles changed through time, providing cultural-temporal markers. Since no projectile points were observed during survey, ceramics yielded most of the information. Ceramic styles progress from plain grayware to neck-corrugated to all over corrugations, while area decorated wares show changes from carbon paint to mineral paint with increasingly diverse design styles throughout the Pueblo into the Historic periods (Post 1985).

Less noticeable are changes in architecture. Architectural styles differ from culture to culture and through time. Structures prior to Pueblo I/Pueblo II often are not visible on the present ground surface, while later Puebloan architecture generally consists of surface masonry structures. However, concentrations of artifacts and small sandstone spalls often indicate the presence of pit structures, while larger sandstone slabs and dark stained soil indicate other subsurface features such as bins and hearths.

Site function is determined by the identification of intra- and intersite variability in artifact assemblages and occasionally by architecture. Lithic assemblage diversity is monitored by attributes such as reduction stage, assemblage size, types and numbers of formal artifacts, and types of visible wear patterns. The archaeological context of the artifacts also is considered, e.g., curation, storage, breakage, discard, tool manufacture, use or maintenance. Distribution patterns are assumed to relate directly to resource procurement strategies and are based on the following assumptions taken from Gossett and Beal (1984:287):

1. The number of items and the size of the concentration(s) indicates occupational intensity and/or reoccupation.

2. Intact, curated tools, including groundstone, in homogeneous assemblage evidences pre-planned resource procurement and thus anticipated activities.

3. Storage features and hearths indicate intrasite activity areas.

4. The lack of formal tools or tool fragments on a site and a high ratio of primary reduction flakes and flake tools suggest an expedient manufacture strategy (opportunistic utilization rather than pre-planned tool use).

5. High percentages of primary and secondary reduction flakes in conjunction with unfinished, broken tools indicate a complete tool manufacturing process, from raw material reduction to finished formal tools.

6. Tool maintenance is indicated by high percentages of trimming and microreduction flakes.

The selection of raw materials for tool manufacture and use relates to procurement strategies as well as to the types of tools. For example, with lithics, raw material types for tools used in expedient activities were more likely to be selected at random, resulting in unpatterned scatters at sites.

Three assumptions guide interpretations of artifact concentrations with respect to occupational episodes at a site (Gossett and Beal 1984:283-316):

1. Sites with artifact concentrations composed of artifacts of similar types and raw materials are considered single component episodes with possible reoccupation.

2. Large numbers of artifact concentrations with similar assemblages seemingly indicate intense occupation with similar recurring activities.

3. Variety in artifact and raw material types may indicate sites with multiple activities.

SITE DESCRIPTIONS

260-1 (Figure 4)

Location: T14N, R9W, NW 1/4 of NW 1/4 of NE 1/4, Section 32

UTM Coordinates: N 3921320, E 244730

Situation: The site lies off the southeast end of a small hill at the base. Although grasses predominate, chamisa is present. The site has three prairie dog towns within its boundaries, and a dirt track runs through the south edge of the site. Artifacts appear to have eroded downhill to the south slightly.

Site Character: Site 260-1 is a sherd and lithic scatter measuring 50 by 35 m. No distinct features were observed, but concentrations of small, possibly fire-reddened sandstone spalls suggest the likelihood of pit structures. A concentration of larger sandstone slabs within the prairie dog town may once have been a bin or cist.

Approximately 100 sherds and 20 lithics were recorded. Ceramics are predominantly indented corrugated wares, some of which appear to be Chuskan varieties. Plain graywares and clapboard corrugated wares also are plentiful. Painted wares include primarily Gallup and Puerco-style black-on-whites, followed by Red Mesa. A single possible Kiatuthlanna Black-on-white sherd was noted. One lug and one handle fragment were observed. All vessels recorded are jars fragments.

Lithics include chert (grays and pinks) primary, secondary and tertiary flakes; purple quartzite and white chalcedony secondary and tertiary flakes; and three pieces of unmodified vesicular basalt.

Discussion: Based on ceramic types present and other comparable sites in the area, 260-1 dates to the late Pueblo II-Pueblo III period (A.D. 825-1125). Based on excavations of other nearby sites, subsurface structures are possible (Baugh 1990). Consisting mostly of grayware jars, site activities emphasized cooking and temporary storage of foods, probably for transportation elsewhere. Lithics represented suggest initial reduction was conducted off-site.

260-2 (Figure 5)

Location: T14N, R9W, SE 1/4, SE 1/4, NW 1/4, Section 32

UTM Coordinates: N 3920460, E 244380

Situation: The site is just west of State Route 509 in the alluvial flats of the valley. On-site vegetation consists of grasses, Russian thistle and chamisa, although four-wing saltbush, sage and asters grow nearby. Along the east edge of the site is a dirt track paralleling the fence and highway. A small, narrow ditch 20 cm deep and 30 cm wide is here also. On the west edge of the site is another small ditch with similar dimensions. The dirt berm associated with the ditch is up to 50 cm wide.

Site Character: The sherd and lithic scatter measures 28 by 48 m. Like 260-1, no features are apparent on the present ground surface, but a few small sandstone spalls occur. Ceramics number at least 100 and consist primarily of indeterminate grayware and indented corrugated jar sherds (with some Chuska varieties). Clapboard corrugated also occurs. Painted wares are mostly bowl sherds, with a few jars of Gallup, Red Mesa and Puerco black-on-whites noted.

Lithics number almost 15 and occur all over the site. They include various colors of chert secondary flakes (one Chinle chert) and purple or brown quartzite primary and secondary flakes. One flake possibly was utilized. Also, three small pieces of unmodified vesicular basalt were observed.

Discussion: 260-2 is possibly a field site dating to late Pueblo I to Pueblo III (A.D. 800-1150). The sandstone spalls may represent either the remains of buried pit structures or deteriorated surface jacals. Ceramic types and forms present suggest storage and cooking of foodstuffs as well as some food service (again, evidence of a more habitational nature to the site). Lithics were reduced

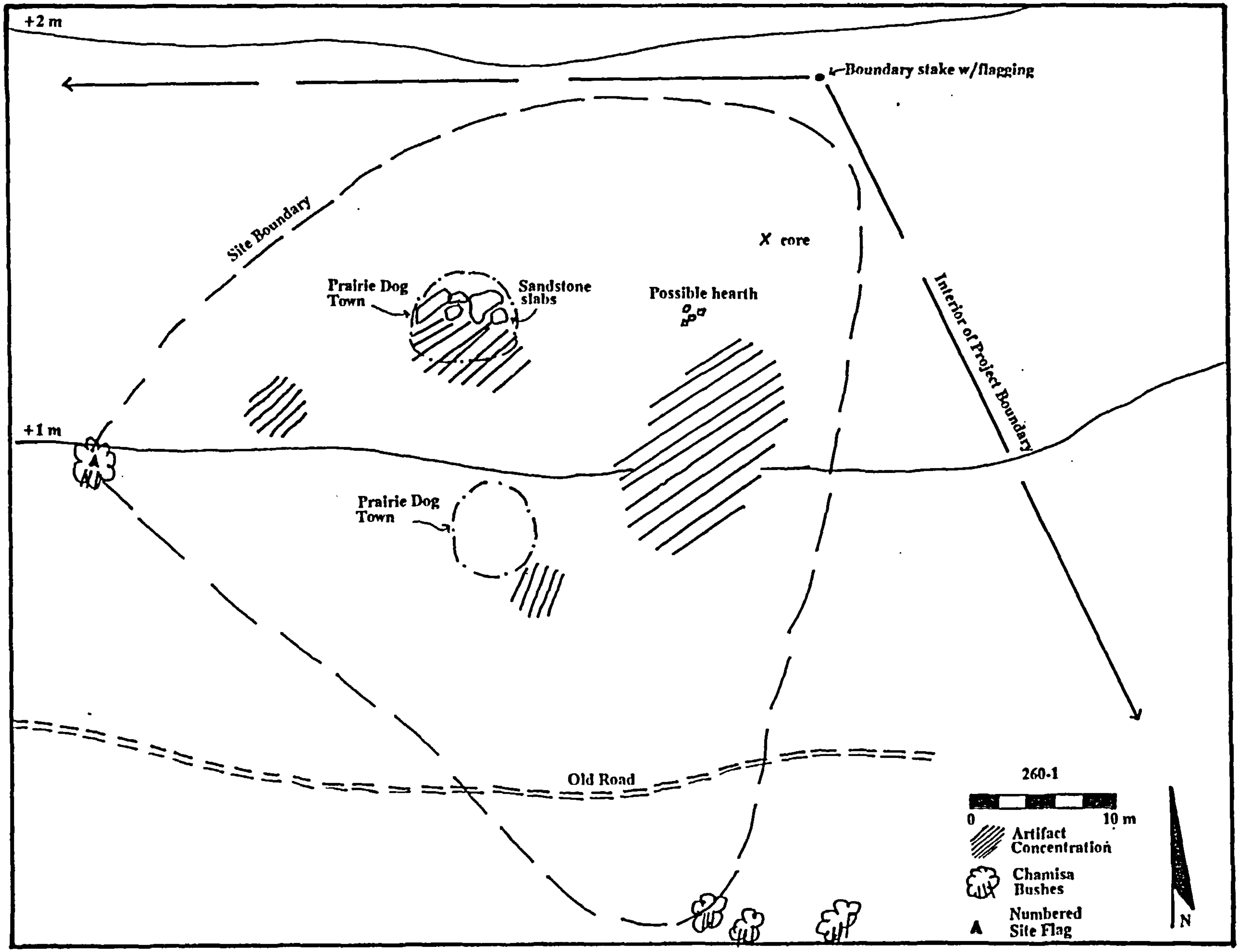

Figure 4: Site plan.

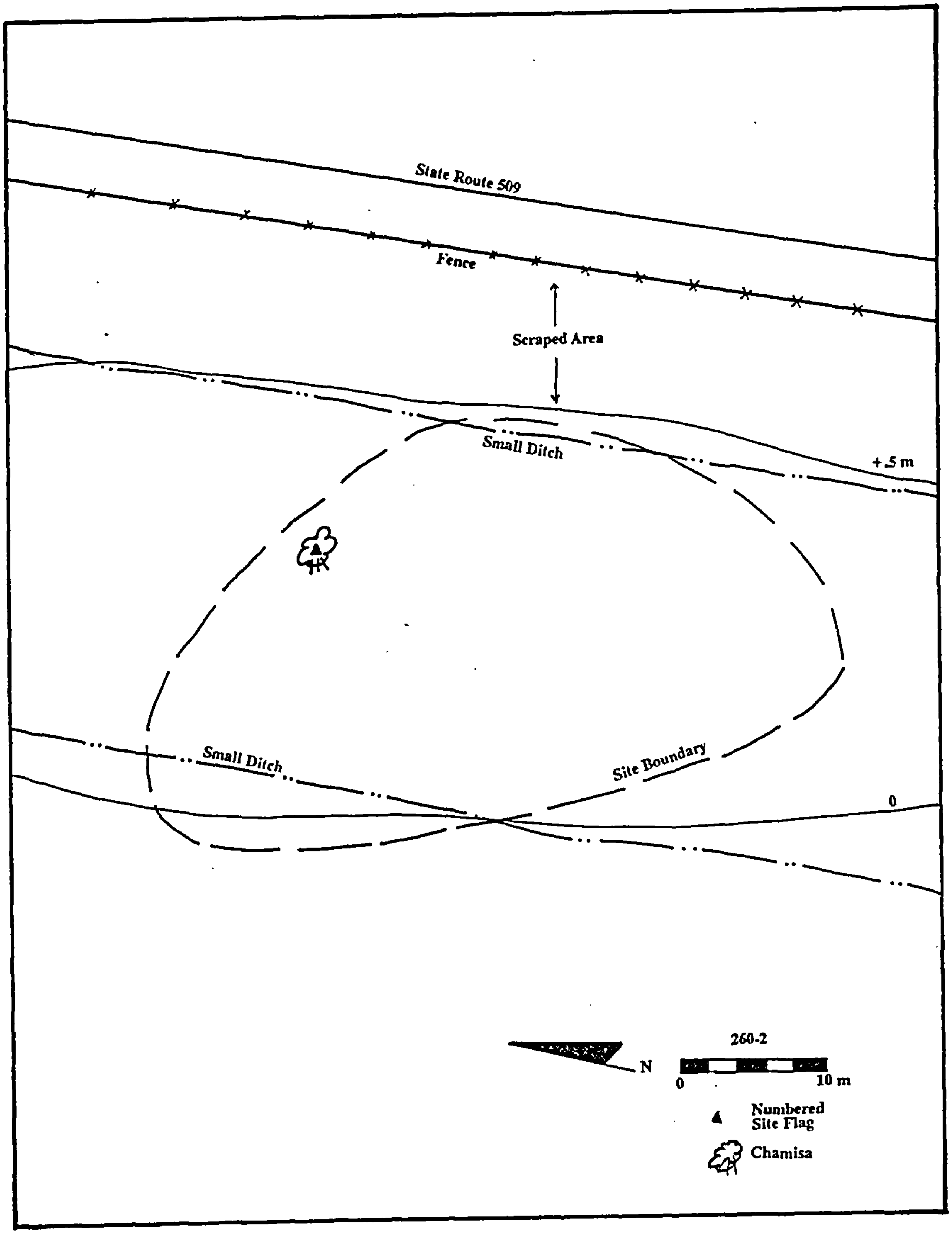

Figure 5: Site plan.

260-3 (Figure 6)

Location: T14N, R9W, SE 1/4, SW 1/4, NW 1/4, Section 32

UTM Coordinates: N 3920840, E 244200

Situation: The site is farther west and north of 260-2 but in the same alluvial flat. The site occurs among an extensive chamisa field. Needless to say, dominant on-site vegetation is chamisa and grasses, but sage occurs in smaller quantities. No disturbance has occurred to the site.

Site Character: The site measures 39 by 35 m. Like the other sites recorded during the project, subsurface features are not apparent. Only a few small sandstone spalls occur on the surface. Artifacts consist primarily of ceramics (55 recorded), predominantly indented corrugated and plain grayware jar sherds. Only two black-on-white jar sherds were observed a Red Mesa and an indeterminate pinchpot fragment. Only four chert quartzite secondary flakes (and one utilized) were observed, but a trough metate fragment and three pieces of unmodified vesicular basalt also were found.

Discussion: Based on ceramic types present, the site dates between late Pueblo I and Pueblo III (A.D. 800-1000) and probably represents a field site or gathering area. Given the presence of the metate fragment, processing of plant foods, probably of corn, was conducted. Some expedient flake tool use also occurred. The sandstone spalls may indicate a subterranean feature or the remains of an jacal surface structure.

TABLE 1: Isolated Occurrences from SW 260

Isolated Occurrence	Description
1	Small piece of unmodified vesicular basalt.
2	Two indented corrugated jar sherds.
3	Small piece of unmodified vesicular basalt.
4	Chaco-Gallup Black-on-white jar sherd.
5	Indented corrugated jar sherd.
6	Clapboard corrugated jar sherd.
7	Indented corrugated jar sherd.
8	Indented corrugated jar sherd.
9	Unmodified vesicular basalt bomb; clapboard corrugated jar sherd.
10	Two indeterminate whiteware sherds.
11	Two indented corrugated jar sherds.
12	Two indented corrugated jar sherds.
13	Indented corrugated jar sherd; indeterminate grayware jar sherd.

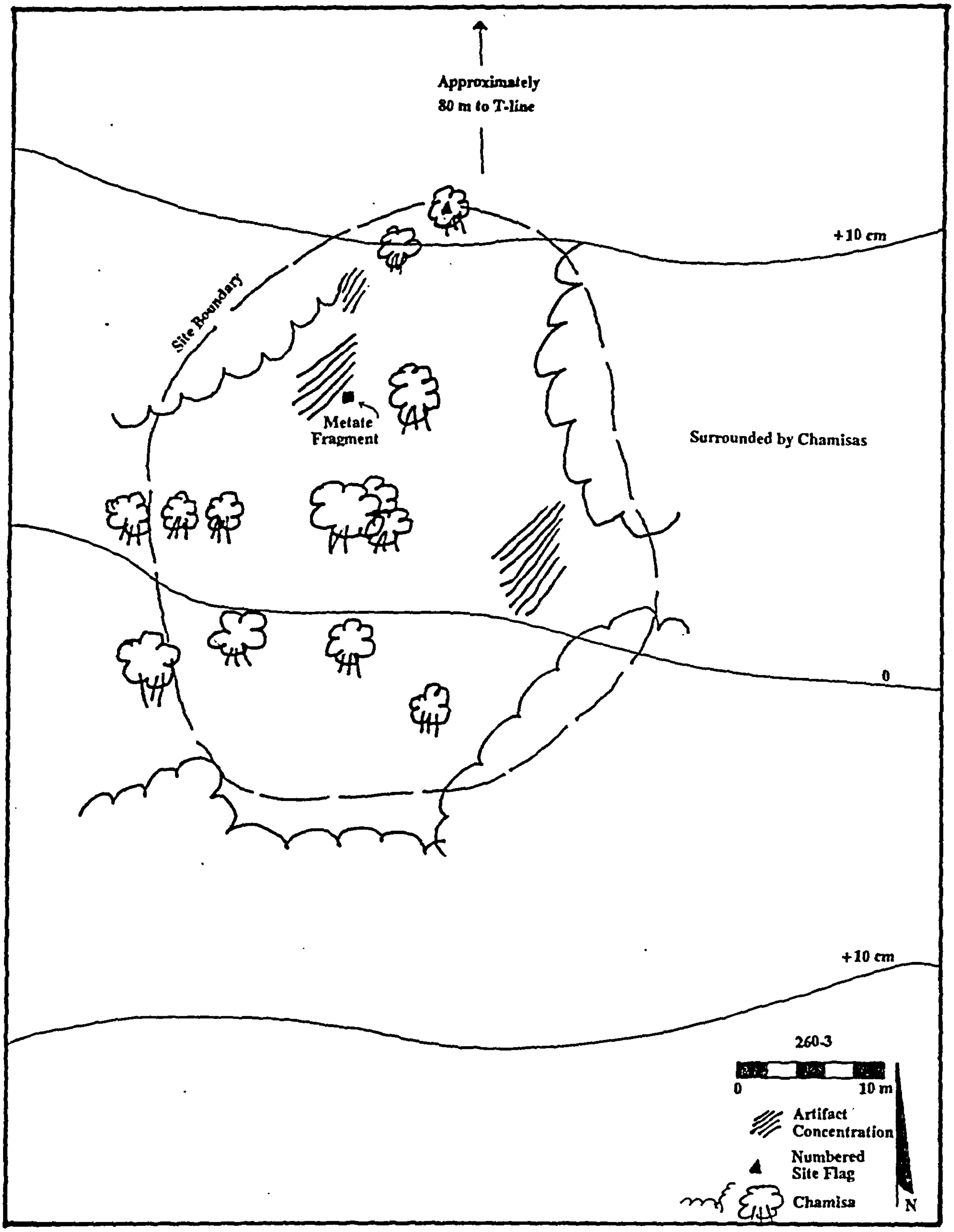

Figure 6: Site plan.

Table 1 (cont'd.)

Isolated Occurrence	Description
14	Large unmodified piece of vesicular basalt.
15	Indented corrugated jar sherd.
16	Indented corrugated jar sherd.
17	Indented corrugated jar sherd.
18	Indented corrugated jar sherd.
19	Clapboard corrugated jar sherd.
20	Two indented corrugated jar sherds.
21	Indented corrugated jar sherd.
22	Indeterminate whiteware jar sherds.
23	Four indeterminate whiteware jar sherds; opaque obsidian biface thinning flake with a possible prepared platform and retouch and on two edges, possible step fracture wear patterns.
24	Indeterminate whiteware jar sherd; indeterminate black-on-white jar sherd.
25	Indeterminate grayware jar sherd; gray quartzite hammerstone.
26	Gallup Black-on-white jar sherd.
27	Possible Red Mesa Black-on-white jar sherd.
28	Indeterminate grayware jar sherd.
29	Gallup Black-on-white bowl sherd.
30	Indented corrugated jar sherd; indeterminate whiteware jar sherd.
31	Red Mesa Black-on-white jar sherd; indeterminate whiteware jar sherd.
32	Indeterminate whiteware jar sherd.
33	Beige granular chert primary flake with one utilized flake on a noncortex edge.
34	1933 Nesbitt soda bottle.

Table 1 (cont'd.)

Isolated Occurrence	Description
35	Five indeterminate grayware jar sherds; two indeterminate black-on-white jar sherds; one each of Gallup Black-on-white bowl sherd and jar sherd - in an area 66 by 120 m.
36	Clapboard corrugated jar sherd; indented corrugated jar sherd; unmodified piece of vesicular basalt.
37	Indeterminate grayware jar sherd; indeterminate whiteware sherd.
38	Two Gallup Black-on-white bowl sherds; indeterminate whiteware sherd; indeterminate grayware sherd; brown quartzite secondary flake; gray quartzite secondary flake - in an area 66 by 30 m.
39	Three Puerco Black-on-white jar sherds.
40	Indented corrugated jar sherd; clapboard corrugated jar sherd.
41	Clapboard corrugated jar sherd.
42	Two clapboard corrugated jar sherds.
43	Indeterminate whiteware sherd; indeterminate black-on-white jar sherd.
44	Two indeterminate grayware jar sherds; two indented corrugated jar sherds, one with fingernail marks.
45	Indeterminate grayware jar sherd.
46	Two indented corrugated jar sherds.
47	Two indented whiteware jar sherds.
48	1960 Dr. Pepper soda bottle.
49	Indented corrugated jar sherd.
50	Indeterminate grayware jar sherd.
51	Puerco Black-on-white jar sherd.
52	Corrugated jar sherd.
53	Indeterminate black-on-white jar sherd.
54	Indeterminate black-on-white bowl sherd.
55	Indeterminate grayware jar sherd.

DISCUSSION AND EVALUATION

Data from earlier projects conducted in the eastern Red Mesa Valley, the San Mateo Basin, and the San Mateo Valley form the basis of the region's cultural history. The first step in the evaluative process is the establishment of data comparability between the three sites recorded during the present project and those used in formulating the cultural history presented earlier. Points of comparison include cultural-temporal identities of sites and components, distributional data based on major physiographic locations by cultural-temporal affinity, site type by cultural-temporal affinity, and site function.

All three sites recorded appear as multicomponent Anasazi sherd and lithic scatters on the ground surface. Ceramics documented on all three sites indicate they were inhabited during Pueblo II, but 260-2 and -3 also have late Pueblo I components, and 260-1 and -2 have Pueblo III components. Site 260-2 exhibits the widest range of use from late Pueblo I to Pueblo III. For the most part, lithics are nondiagnostic, although 260-3 yielded a trough metate fragment. The dates of occupation are consistent with other sites documented in the area.

The project was conducted in a single physiographic zone, the alluvial valley bottom near Ambrosia Lake. However, 260-1 is located at the base of a small hill within the valley, while the other two sites occur in an almost totally flat alluvial location. Comparable sites occur in similar situations to the west (Scheick 1985), and the pattern is consistent with known Ambrosia Lake area settlement patterns (Baugh 1990).

Site types are determined by the presence or absence of attributes as well as combinations of attributes. Attributes monitored include site size, artifact diversity and density, and presence or absence of architecture types and extramural features (Scheick 1985:55). Habitation sites have substantive architectural or material remains and indicate more than transitory occupation, whereas limited activity sites have expedient architectural forms and limited material culture, suggesting a more limited range of activities. Habitation is not equated with occupational permanency.

Based on sites excavated recently in the area (Scheick 1985; Baugh 1990), all three sites have the potential for external subsurface features, such as bins and hearths. Moreover, all three sites potentially contain dwellings; 260-1 probably has pit structures, 260-2 may have a pit structure or remnants of a ramada or jacal shelter, and 260-3 probably has the remains of an expedient shelter. The low variability exhibited in the material culture suggests short-term seasonal use. In all likelihood, all three sites represent limited activity agricultural loci.

Probable site functions were discussed earlier in the Site Description section of the report, but needless to say, limitations restrict those interpretations. For example, data gathered was from surface artifacts only, which may or may not be representative of overall site use. Clearly, agricultural and/or plant food procurement/processing was a primary on-site activity. Apparently, lithic tool manufacture was not a primary site activity, although tool use occurred. These interpretations are consistent with excavation data from similar sites in the area.

Data potentials for the sites are high. First, the sites are undisturbed. Second, few contemporary sites have been excavated in the vicinity of Ambrosia Lake, thus limiting the kinds of data available for interpretation. Finally, for sites of the Pueblo II-III period, emphasis has been on trying to establish relationships with Chaco outliers, and results are so far inconclusive (Baugh 1990:177). The project sites can add to the growing body of data needed to define these relationships as well as address most of the research topics identified earlier in the Cultural History section of this report.

The isolated occurrences reflect the behavioral and cultural-temporal parameters identified by the sites within the survey and surrounding areas. Consisting predominantly of indented corrugated jar sherds, followed by indeterminate whitewares and graywares. Clapboard corrugated and black-on-white wares, such as Gallup, Puerco and Red Mesa, and indeterminate black-on-whites occur in fewer numbers. Lithics recorded are few, consisting of flakes (often utilized) and unmodified pieces of vesicular basalt. Two historic bottle fragments (I.O.s 34 and 48) dating to the 1930s and 1960s, respectively, also were documented.

Isolated Occurrences 6 through 12 are located south and east of site 260-1, and no doubt are associated with the site. Isolated Occurrences 20 through 26, located at the eastern end of the ditch surveyed as Area F, occur within land already surveyed (Hammack 1985) and probably are associated with use of LA 50379 and LA 50380.

Finally, the isolated occurrences recorded in Area D occur in a band northeast to southwest. The phenomenon was examined through aerials to determine if the isolates indicate a Chacoan road through the valley, but such is not the case (Mr. J. Roney, personal communication September 21, 1990). Although a 1977 aerial examined at the New Mexico State Highway Department, Photogrammetry Section, depicts a definite trail (Miscellaneous Can No. 27, negative No. 102-105), given the project area once was ranch land, the trail may be a cow-path. Alternately, the band of artifacts may indeed indicate the location of a prehistoric trail. Nonetheless, the land has been disturbed by highway and transmission line construction and various ranching and mining activities, and the spatial arrangement of the isolates may be coincidental.

SUMMARY

All three sites contain Pueblo II components and may be part of the Kin Nizhoni subnuclear community (Baugh 1990). In all likelihood, they are farmsites, fieldhouses or field locations. The artifact inventories seemingly support this interpretation. The addition of bowl sherds in the 260-2 assemblage tends to support a more substantial occupation as reinforced by the potential for subsurface structure(s). The suggested site interpretations are consistent with the outlier community patterns observed.

The isolated occurrences recorded further substantiate area use as indicated by both the recorded sites and the cultural history of the region.

RECOMMENDATIONS

The State Register of Cultural Properties and the National Register of Historic Places were consulted, and no sites currently on or nominated to them occur within or in close proximity to the project boundaries.

All three sites are recommended as eligible for inclusion on the Nation and State registers based on their demonstrated research potentials. Consequently, any disturbance to the sites would require further work. However, upon consultation with the client, 260-2 and -3 can be avoided. These two sites can be fenced during land disturbing activities; fencing will be erected 33 m (100 feet) past flagged site boundaries to provide a protective buffer for any possible subsurface features. Fencing should be removed once land disturbing activities are finished.

Since the soil incorporated by 260-1 may be too radioactive to remain exposed to the air, the site is slated to be buried. Given existing soil conditions and the site's proposed treatment, for all intents and purposes, the site will be lost. Therefore, we recommend excavation of the site after submittal and approval of a data recovery plan to the New Mexico State Historic Preservation Office.

Research potentials of the isolated occurrences are exhausted as a result of field documentation and warrant no further investigation.

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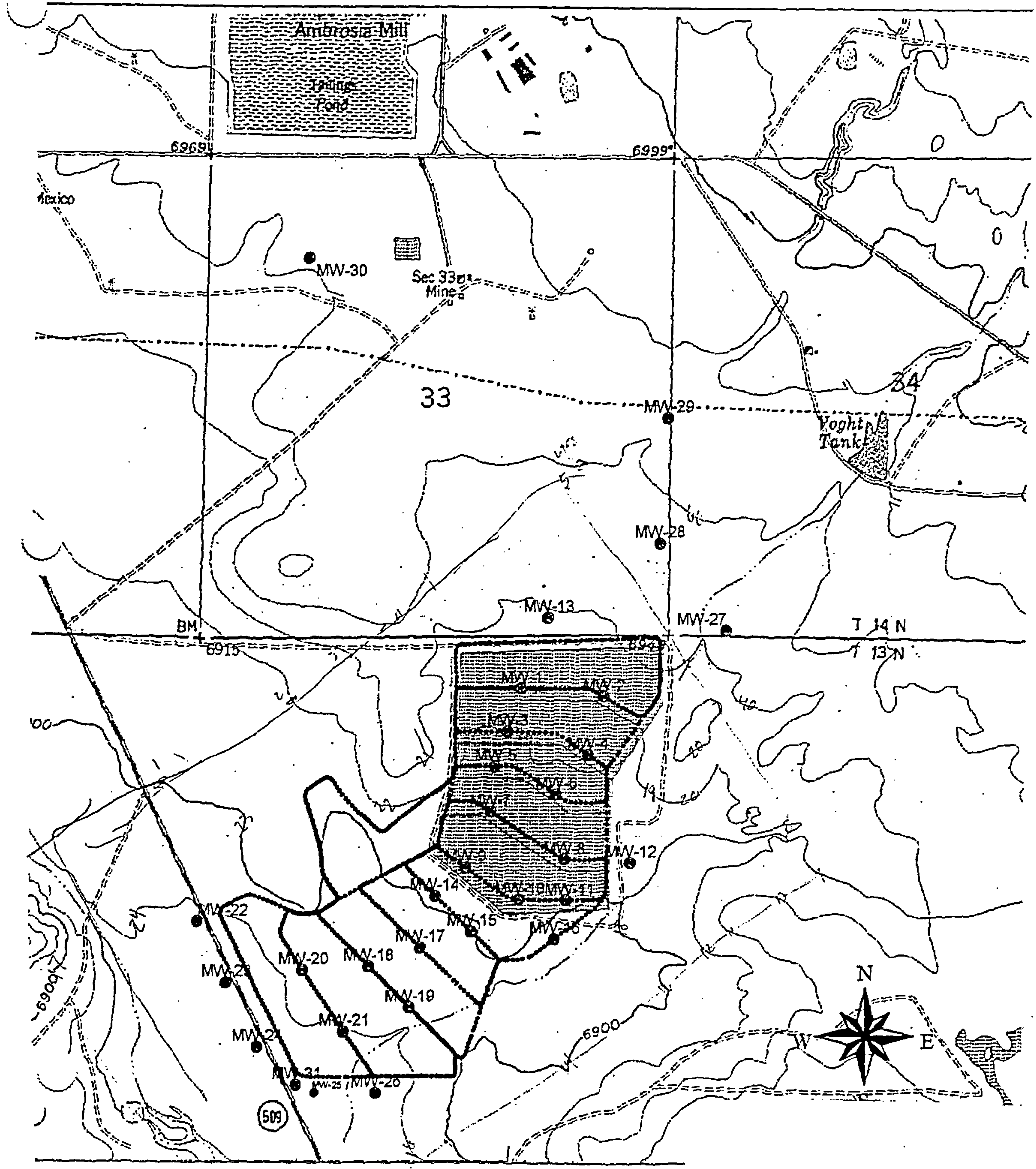
APPENDIX D

APPENDIX D-1
SECTION 4 EVAPORATION POND MAP AND MONITOR WELL LITHOLOGIC LOGS

FIGURE E-1
SECTION 4 POND MONITOR WELLS

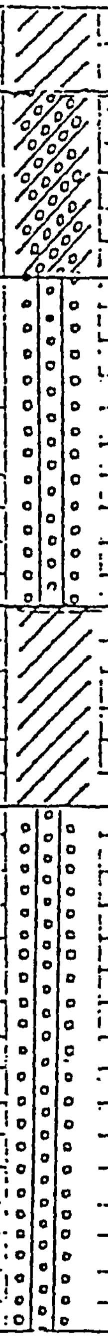


NW-1R

TEST BORING NO. M

PROJECT Monitor Well Installation
JOB NO. E80-1015 DATE 2/12/80

RIG TYPE CME-55
BORING TYPE 8" Hollow Stem Auger
SURFACE ELEV.
DATUM



Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								CL		SANDY CLAY, medium pla ticity, light brown
5								SC		CLAYEY SAND, predomina ly fine, medium plasti ity, light brown
10 15								SM		SILTY SAND, predominant ly fine, nonplastic, light brown
20								CL		SANDY CLAY, medium plas- ticity, dark brown
25 30 35 40								SM		SILTY SAND, predominant- ly fine, nonplastic, ta
45										Stopped auger at 40'

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE
A – Auger cuttings B

NW-7R

LOG OF TEST BORING NO. MW-

PROJECT Monitor Well Installation

JOB NO. E80-1015 DATE 2 2/80

RIG TYPE CME-55

BORING TYPE 8" Hollow Stem Auger

SURFACE ELEV.

DATUM

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		○ ○ ○						SM		SILTY SAND, predominantly fine, nonplastic, brown
5 10		▨						CL		SANDY CLAY, medium plasticity, brown
15		▨○						SC		CLAYEY SAND; predominantly fine, medium plasticity; dark brown
20		○ ○ ○						SM		SILTY SAND, predominantly fine, nonplastic, brown
25 30		▨						CL		SILTY CLAY, medium plasticity, brown
35 40		○ ○ ○						SM		SILTY SAND, predominantly fine, some clay, low plasticity, brown
45										Stopped auger at 40'

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE

A – Auger cuttings. B – Block sample

PROJECT Monitor Well Installation

JOB NO. E80-1015 DATE 2[illegible]2/80

LOG OF TEST BORING NO MW

RIG TYPE CME-55

BORING TYPE 8" Hollow Stem Auger

SURFACE ELEV.

DATUM

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0										CLAY, high plasticity, light gray
5								CL		
10										SANDY CLAY, medium plasticity, light brown
15								CL		
20										
25								CL		CLAY, high plasticity, dark brown
								CL		SANDY CLAY, medium plasticity, dark brown
30										SILTY SAND, predominantly fine, nonplastic, brown
								SM		
35										
40										Stopped auger at 40'
45										

GROUND WATER

DEPTH	HOUR	DATE
28'		2/12

SAMPLE TYPE

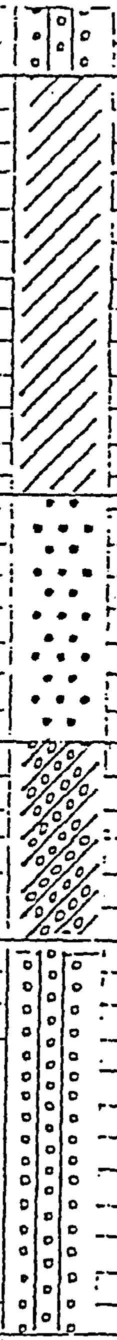
A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

PROJECT Monitor Well Installation
JOB NO. E80-1015 DATE [illegible]/13/80

NW-4R
LOG OF TEST BORING NO.

RIG TYPE CME-55
BORING TYPE 8" Hollow Stem Auger
SURFACE ELEV.
DATUM



Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SM		SILTY SAND, predomina ly fine, nonplastic, brown
5								CL		SANDY CLAY, medium pl. ticity, brown
10										
15								SP		SAND, predominantly fi nonplastic, light brow
20										
25								SC		CLAYEY SAND, predomina ly fine, medium plasti ity, gray
30								SM		SILTY SAND, predominant ly fine, nonplastic, ta
35										
40										Stopped auger at 40'
45										

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE

MW-3

[illegible] O[illegible] TEST BORING NO.

PROJECT Monitor Well In[illegible]all[illegible]ion

JOB NO. E80-1015 DATE [illegible]12/80

RIG TYPE CME-55

BORING TYPE 8" Hollow Stem Auger

SURFACE ELEV.

DATUM

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb, 30" free fall drop hammer	Dry Density Lbs, per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SM		SILTY SAND, predomina ly fine, nonplastic, brown
5								CL		SANDY CLAY, medium pl ticity, light brown
								CL		CLAY, high plasticity, dark brown
10								CL		CLAY, some gravel, med um plasticity, light brown
15								CL		SANDY CLAY, medium pla ticity, light brown
								SM		SILTY SAND, predominan ly fine, nonplastic, light brown
20								CL		CLAY, high plasticity, dark brown
25 30 35								SM		SILTY SAND, predominan ly fine, nonplastic, brown
40										Stopped auger at 40'
45										

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE

A — Auger cuttings. B — Block sample

PROJECT Monitor Well Installation

JOB NO. E80-1015 DATE 2/[illegible]/80

TEST BORING NO. MW-

RIG TYPE CME-55

BORING TYPE 8" Hollow Stem Auger

SURFACE ELEV.

DATUM

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SM		SILTY SAND, predominantly fine, nonplastic, brown
5								CL		CLAY, high plasticity, dark brown
10 15								SC		CLAYEY SAND, predominanly fine, some gravel, low plasticity, tan
20								CL		CLAY, high plasticity, brown
25								CL		SANDY CLAY, medium plasticity, reddish brown
								CL		SANDY CLAY, some gravel medium plasticity, dark brown
30 35								SM		SILTY SAND, predominantly fine, nonplastic, light brown
40 45										Stopped auger at 40'

GROUND WATER

DEPTH	HOUR	DATE
31'		2/12

SAMPLE TYPE

A – Auger cuttings. B – Block sample

MW-7R
TEST BORING NO. M

PROJECT Monitor Well In[illegible]all[illegible]ion
JOB NO. E80-1015 DATE 2.12/80

RIG TYPE CME-55
BORING TYPE 8" Hollow Stem Auger
SURFACE ELEV.
DATUM

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		○						SM		SILTY SAND, predomina ly fine, nonplastic, brown
		▨						CL		SANDY CLAY, medium pl ticity, tan
5		▨						CL		CLAY, high plasticity, dark brown to light brown
10		▨						CL		SANDY CLAY, medium pla ticity, brown
15		▨								
		▨								CLAY, high plasticity, dark brown
20		▨								
25		▨						CL		
≡ 30		▨								
35		○						SM		SILTY SAND, predominant ly fine, some gravel, nonplastic, brown
40										Stopped auger at 40'
45										

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE

MW-8R

TEST BORING NO. 11

PROJECT Monitor Well Installation
JOB NO. E80-1015 DATE 12/80

RIG TYPE CME-55
BORING TYPE 8" Hollow Stem Auger
SURFACE ELEV.
DATUM

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		○						SM		SILTY SAND, predominantly fine, nonplastic, brown
5		▨						CL		CLAY, high plasticity, dark brown
		▨						CL		SANDY CLAY, medium plasticity, dark brown
10		▨ ○						SC		CLAYEY SAND, predominantly fine, medium plasticity, dark brown
15		○						SM		SILTY SAND, predominant fine, nonplastic, tan
20 25		▨						CL		CLAY, high plasticity, dark brown
30		○						SM		SILTY SAND, predominantly fine, some gravel, nonplastic, brown
35		○						SM		SILTY SAND, predominantly fine, nonplastic, light brown
40										Stopped auger at 40'
45										

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE

MW-4R

G C. TEST BORING NO. M

PROJECT Monitor Well In[illegible]all[illegible]ion

JOB NO. E80-1015 DATE . 12/80

RIG TYPE CME-55

BORING TYPE 8" Hollow Stem Auger

SURFACE ELEV.

DATUM

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SM		SILTY SAND, predominan ly fine, nonplastic, brown
5 10								CL		SANDY CLAY, medium pla ticity, dark brown
15 20								SM		SILTY SAND, predominan ly fine, nonplastic, light brown
								SC		CLAYEY SAND, predominan ly fine, low plasticity brown
25								CL		SANDY CLAY, medium plas ticity, dark brown
30 35								SM		SILTY SAND, predominant fine, nonplastic, brown
								CL		CLAY, high plasticity, dark brown
40 45										Stopped auger at 40'

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE

A – Auger cuttings. B – Block sample

PROJECT Monitor Well [illegible]all[illegible]ion

JOB NO. E80-1015 DATE 2/12/80

MW-10R

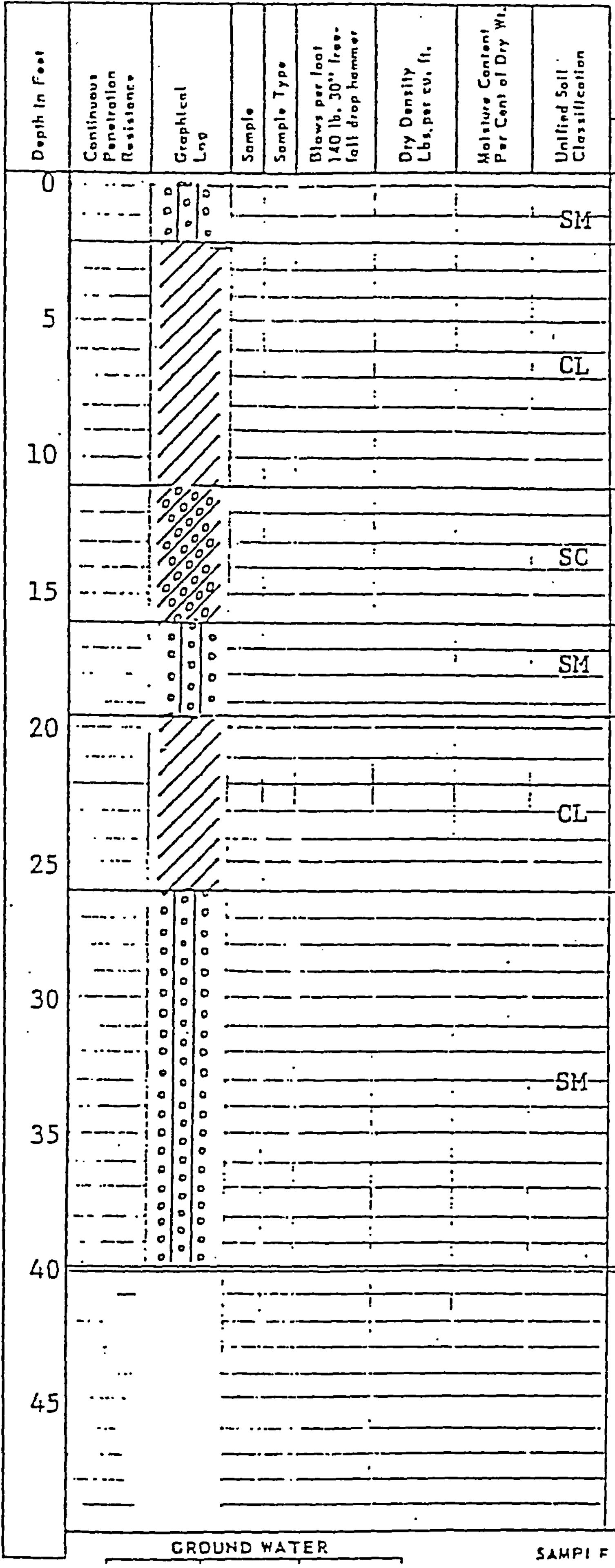
LOG OF TEST BORING NO.

RIG TYPE CME-55

BORING TYPE 8" Hollow Stem Auger

SURFACE ELEV.

DATUM



REMARKS

VISUAL CLASSIFICATION

SILTY SAND, predominantly fine, nonplastic, brown

SANDY CLAY, medium plasticity, light brown to dark brown

CLAYEY SAND, predominantly fine, medium plasticity, dark brown

SILTY SAND, predominantly fine, nonplastic, light brown

SANDY CLAY, medium plasticity, dark brown

SILTY SAND, predominantly fine, nonplastic, light brown

Stopped auger at 40'

PROJECT Monitor Well Installation

JOB NO. E80-1015 DATE 2 [illegible]2/80

MW-7' 'R

LOG OF TEST BORING NO. MW

RIG TYPE CME-55

BORING TYPE 8" Hollow Stem Auger

SURFACE ELEV.

DATUM

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SM		SILTY SAND, predominantly fine, nonplastic, brown
5 10								CL		SANDY CLAY, medium plasticity, light brown to dark brown
15								SC		CLAYEY SAND, predominantly fine, medium plasticity, dark brown
20								SM		SILTY SAND, predominantly fine, nonplastic, light brown
25 30								CL		SANDY CLAY, medium plasticity, dark brown
35								SM		SILTY SAND, predominantly fine, some gravel, nonplastic, brown
40 45										Stopped auger at 40'

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE

A – Auger cuttings. B – Bl[illegible]

Monitor Well MW-12

completed 10-27-77

0'	-	9'	moist sand and clay
9'	-	12'	sand
12'	-	13'	clay and sand
13'	-	18'	saturated zone of clay and sand
		18'	total depth drilled

13

PROJECT Section 4 [illegible]ds - Monitor Well [illegible]G OF TEST BORING NO.
JOB NO. E72-1162 DATE 1-2-80

RIG TYPE CME 55
BORING TYPE 6½" H.SA
SURFACE ELEV.
DATUM

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								CL		Sandy clay, mediu plasticity, light bro
5								SC		clayey Sand, predomin fine, low plasticity, light brown to reddish-b.
10								CL		Sandy Clay, medium to high plasticity, brov
15										
20								SC	▽	clayey Sand, predomine fine, low to medium plasticity, light tan.
25										
30										Sandstone, moderately weathered, soft to moderately hard, yellow - tan
										stopped Auger @ 29½'

GROUND WATER

SAMPLE TYPE

MW-14

PROJECT Monitor Well In[illegible]allation
JOB NO. E80-1015 DATE 8/2[illegible]80

LO[illegible] OF TEST BORING NO. 14

RIG TYPE CME-55
BORING TYPE 8" Hollow Stem Auger
SURFACE ELEV.
DATUM

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Percent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SC		CLAYEY SAND, predominantly fine, medium plasticity, light brown
5								CL		SANDY CLAY, medium plasticity, brown
								SC		CLAYEY SAND, predominantly fine, medium plasticity, brown
10								CL		SANDY CLAY, medium plasticity, brown
15								SM		SILTY SAND, predominantly fine, nonplastic, light brown
20										
25								SC		CLAYEY SAND, predominantly fine, medium plasticity, brown
30										
35								SM		SILTY SAND, predominantly fine, some sandstone fragments, nonplastic, light brown
40										
45								CL		SANDY CLAY, medium plasticity, brown
										Stopped auger @ 49'
50										

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE

SERGENT HAUSKINS & BECKWITH

MW-1

PROJECT Monitor Well Installation

JOB NO. E80-1015 DATE 20/80

OF TEST BORING NO. 1

RIG TYPE CME-55

BORING TYPE 8

SURFACE ELEV.

DATUM

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Percent of Dry Wt.	Unified Soil Classification	REMARKS	
0								SC		CLAYEY SAND, predominantly fine, medium plas ticity, light brown
5 10								CL		SANDY CLAY, medium plas ticity, light brown
15								SM		SILTY SAND, predominantly fine, nonplastic, light brown
								SC		CLAYEY SAND, predominantly fine, medium plasticity, brown
20 25								SP		SAND, predominantly fine, nonplastic, light brown
30								CL		SANDY CLAY, medium plas ticity, dark brown
35 40								SM		SILTY SAND, predominantly fine, some fine gravel, nonplastic, tan
										SANDSTONE, soft, light brown
45										Stopped auger @ 44'

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE

A – Auger cuttings. B – Block sample

SERGENT, HAUSKINS & BECKWIT

MW-16

PROJECT Monitor Well Installation

L OF TEST BORING NO. 16

JOB NO. E80-1015 DATE 8/21/80

RIG TYPE CME 55

BORING TYPE 8'

SURFACE ELEV.

DATUM

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Percent of Dry Wt.	Unified Soil Classification	REMARKS	
0								SC		CLAYEY SAND, predominantly fine, medium plasticity, light brown
5										SANDY CLAY, medium plasticity, brown
								CL		
10										
								SM		
15										SILTY SAND, predominantly fine, nonplastic, light brown
										SANDY CLAY, medium plasticity, dark brown
20								CL		
25										
								SM		SILTY SAND, predominantly fine, nonplastic, light brown
30										
										SANDY CLAY, medium plasticity, brown
35								CL		
40										Stopped auger @ 39'

GROUND WATER

SAMPLE TYPE

PROJECT Monitor Well I[illegible]tallation
JOB NO. E80-1015 DATE 8/20/80

RIG TYPE
BORING TYPE
SURFACE ELEV.
DATUM

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Percent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		▨						SC		CLAYEY SAND, predominantly fine, medium plasticity, light brown
5 10		▨						CL		SANDY CLAY, medium plasticity, brown
15		⁘						SP		SAND, predominantly fine, nonplastic, light brown
20 25 30		▨						CL		SANDY CLAY, some fine gravel, medium plasticity, brown
		○						SM		SILTY SAND, predominantly fine, nonplastic, light brown
35 40 45		▨						CL		SANDY CLAY, medium plasticity, brown
		○						SM		SILTY SAND, predominantly fine, nonplastic, light brown
										Stopped auger @ 49'
50										

GROUND WATER

SAMPLE TYPE

MW-18

PROJECT Monitor Well In[illegible]allation

JOB NO. E80-1015 DATE 8/[illegible]/80

L[illegible] OF TEST BORING NO. 18

RIG TYPE CME-55

BORING TYPE

SURFACE ELEV.

DATUM

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Percent of Dry Wt.	Unified Soil Classification	REMARKS	
0								SC		CLAYEY SAND, predominantly fine, medium plasticity, light brown
5								CL		SANDY CLAY, medium plasticity, brown
10										
										SILTY SAND, predominantly fine, nonplastic, light brown
15										
20								SM		
25										
30								SM		SILTY SAND, predominantly fine, some fine gravel, nonplastic, light brown
35										SANDY CLAY, medium plasticity, brown
40								CL		
45										
50										

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE

A – Auger cuttings. B – Block sample

SERGENT, HAUSKINS & BECKWIT

MW-18

PROJECT Monitor Well Installation
JOB NO. E80-1015 DATE 8/20/80

LOG OF TEST BORING NO. 18

RIG TYPE
BORING TYPE
SURFACE ELEV.
DATUM

CNT 55

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Percent of Dry Wt.	Unified Soil Classification	REMARKS	
50								SM		SILTY SAND, fine, non-plastic, light brown
55										
60										Stopped auger @ 59'

GROUND WATER

SAMPLE TYPE

SERGENT, HAUSKINS & BECKWIT

MW-19

PROJECT Monitor Well I[illegible]allation

JOB NO. E80-1015 DATE 8/20/80

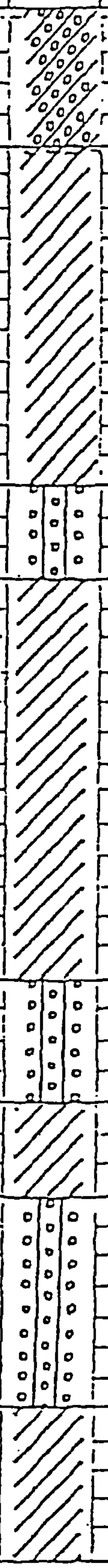
L[illegible] OF TEST BORING NO. 19

RIG TYPE CME 55

BORING TYPE

SURFACE ELEV

DATUM



Depth in Feet	Continuous Penetration Resistance	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Percent of Dry Wt.	Unified Soil Classification	REMARKS	
0							SC		CLAYEY SAND, predominantly fine, medium plasticity, light brown
5									SANDY CLAY, medium plasticity, brown
10							CL		
15							SM		SILTY SAND, predominantly fine, nonplastic, light brown
20									SANDY CLAY, medium plasticity, brown
25							CL		
30							SM		SILTY SAND, predominantly fine, some gravel, nonplastic, brown
35							CL		SANDY CLAY, medium plasticity, brown
40							SM		SILTY SAND, predominantly fine, nonplastic, light brown
45							CL		SANDY CLAY, medium plasticity, brown
									Stopped auger @ 50'
50									

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE

SERGENT, HAUSKINS & BECKWITH

mw-2

PROJECT Monitor Well I[illegible]allation

L[illegible] OF TEST BORING NO. 20

JOB NO. E80-1015 DATE 8/21/80

RIG TYPE_____
BORING TYPE_____
SURFACE ELEV.
DATUM_____

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Percent of Dry Wt.	Unified Soil Classification	REMARKS	
0								SC		CLAYEY SAND, predominantly fine, medium plasticity, light brown
5								CL		SANDY CLAY, medium plasticity, brown
10										SILTY SAND, predominantly fine, nonplastic, light brown
15										
20								SM		
25										
30								CL		SANDY CLAY, medium plasticity, dark brown
35								SM		SILTY SAND, predominantly fine, nonplastic, light brown
40								CL		SANDY CLAY, medium plasticity, dark brown
45								SM		SILTY SAND, predominantly fine, nonplastic, light brown
50										

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE

SERGENT, HAUSKINS & BECKWIT

Page 2 of 2 MW-

PROJECT Monitor Well Inst allation

JOB NO. E80-1015 DATE 8/21/80

LO OF TEST BORING NO. 2

RIG TYPE CME-55

BORING TYPE 8" Hollow Stem Auger

SURFACE ELEV.

DATUM

REMARKS

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Percent of Dry Wt.	Unified Soil Classification	Remarks	
50		○ ○ ○								
55		▨						CL		SANDY CLAY, medium pl ticity, brown
60										Stopped auger @ 59'

MW-21

PROJECT Monitor Well In[illegible]llation L OF TEST BORING NO. 2

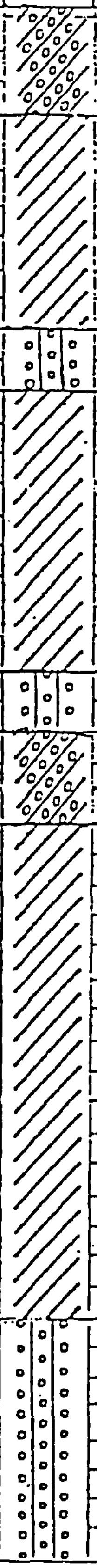
JOB NO. E80-1015 DATE 8/21/80

RIG TYPE

BORING TYPE

SURFACE ELEV.

DATUM



Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Percent of Dry Wt.	Unified Soil Classification	REMARKS	
0								SC		CLAYEY SAND, predominantly fine, medium plasticity, brown
5								CL		SANDY CLAY, medium plasticity, brown
10								SM		SILTY SAND, predominantly fine, nonplastic, brown
15 20								CL		SANDY CLAY, medium plasticity, dark brown
								SM		SILTY SAND, predominantly fine, nonplastic, ta
25								SC		CLAYEY SAND, predominantly fine, medium plasticity, light brown
30 35 40								CL		SANDY CLAY, medium plasticity, dark brown
45 50								SM		SILTY SAND, predominantly fine, nonplastic, light tan

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE

A – Auger cuttings B – Block sample

SERGENT, HAUSKINS & BECKWITH

MW-21

Page 2 of 2

LOG OF TEST BORING NO. 21

PROJECT Monitor Well Installation
JOB NO. E80-1015 DATE 8/2 /80

RIG TYPE CME-55
BORING TYPE 8" Hollow Stem Auger
SURFACE ELEV.
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb, 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Percent of Dry Wt.	Unified Soil Classification	REMARKS	
50		○ ○ ○								
55		▨						CL		SANDY CLAY, medium plasticity, brown
60										Stopped auger @ 59'

GROUND WATER

DEPTH	HOUR	DATE
42'		8/21

SAMPLE TYPE
A – Auger cuttings. B – Block sample
C – 2" O.D. 1.38" I.D. tube sample

SERGENT, HAUSKINS & BECKWITH

MW-22

TEST BORING NO.

PROJECT Monitor Well Installation

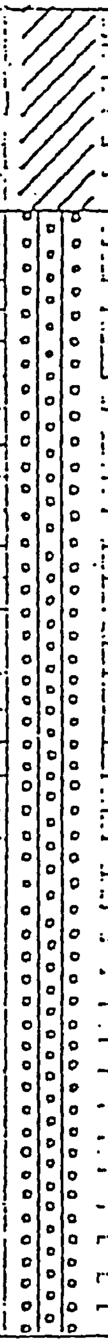
JOB NO. E80-1015 DATE 2/12/80

RIG TYPE CME-55

BORING TYPE 8" Hollow Stem Auger

SURFACE ELEV.

DATUM



Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb, 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0 5								CL		SANDY CLAY, medium pla ticity, tan
10 15 20 25 30 35								SM		SILTY SAND, predominan ly fine, nonplastic, t
40 45										Stopped auger at 40'

GROUND WATER

DEPTH	HOUR	DATE
25'		2/12

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D.

SERGENT HAUSKINS &

PROJECT Monitor Well Installation

JOB NO. E80-1015 DATE 2/12/80

TEST BORING NO. MW-2

RIG TYPE

BORING TYPE

SURFACE ELEV.

DATUM

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	
0										SILTY SAND, predominantly fine, nonplastic, ta
5										
10										
15										
20										
								SM		
25										
30										
35										
40										
45										Stopped auger at 45'
50										

GROUND WATER

DEPTH	HOUR	DATE
33½'		2/12

SAMPLE TYPE

A – Auger cuttings. B – Block sample

SERGENT, HAUSKINS & BECKWITH

MW-24

L[illegible] G[illegible] [illegible]EST BORING NO. MW

PROJECT Monitor Well In[illegible] .lla[illegible] .on

JOB NO. E80-1015 DATE 2/12/80

RIG TYPE CME-55

BORING TYPE $6\frac{1}{2}$" Hollow Stem Auger

SURFACE ELEV.

DATUM

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0										SILTY SAND, predominan ly fine, nonplastic, t
5										
10										
15										
20										
25								SM		
30										
35										
40										
45										Stopped auger at 50'
50										

GROUND WATER

SAMPLE TYPE

MW-25

G O[illegible] TEST BORING NO.

PROJECT Monitor Well I[illegible]all[illegible]ion

JOB NO. E80-1015 DATE 2/12/80

RIG TYPE CME-55

BORING TYPE 8" Hollow Stem Auger

SURFACE ELEV.

DATUM

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb, 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		▨						CL		SANDY CLAY, medium pl ticity, tan
5		○						SM		SILTY SAND, predominan ly fine, nonplastic, light brown
10 15		▨						CL		SANDY CLAY, medium pla ticity, tan
		○						SM		SILTY SAND, predominan ly fine, nonplastic, light brown
20		▨						CL		SANDY CLAY, medium pla ticity, brown
25 30 35 40		○						SM		SILTY SAND, predominan ly fine, nonplastic, brown
45										Stopped auger at 40'

GROUND WATER

SAMPLE TYPE

PROJECT Monitor Well Installation

JOB NO. E80-1015 DATE 2/12/80

MW-26

TEST BORING NO. MW

RIG TYPE CME-55

BORING TYPE 8" Hollow Stem Auger

SURFACE ELEV.

DATUM

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		o o o						SM		SILTY SAND, predominan ly fine, nonplastic, t
5		▨						CL		SANDY CLAY, medium pla ticity, light brown
10 15		o o o						SM		SILTY SAND, predominant ly fine, nonplastic, ta
20 25		o o o						SM		SILTY SAND, predominant ly fine, some gravel, nonplastic, dark brown
30		o o o						SM		SILTY SAND, predominant ly fine, nonplastic, brown
35 40										Stopped auger at 35'

GROUND WATER

SAMPLE TYPE

mw-27

PROJECT Monitor Well In[illegible]allation

L[illegible] OF TEST BORING NO. 27

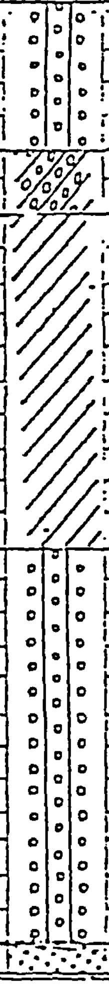
JOB NO. E80-1015 DATE 8/21/80

RIG TYPE CME-55

BORING TYPE 8" Hollow Stem Auger

SURFACE ELEV.

DATUM



Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot - 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Percent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SM		SILTY SAND, predominantly fine, nonplastic, light brown
5								SC		CLAYEY SAND, predominantly fine, medium plasticity, brown
10								CL		SANDY CLAY, medium plasticity, brown
15										
20								SM		SILTY SAND, predominantly fine, nonplastic, light brown
25										
										SANDSTONE, very weathered, soft, light tan
30										Stopped auger @ 29'

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE

SERGENT, HAUSKINS & BECKWITH

MW-2

PROJECT Monitor Well In[illegible]llation

JOB NO. E80-1015 DATE 8/21/80

L[illegible] OF TEST BORING NO. 28

RIG TYPE CME-55
BORING TYPE 8" Hollow Stem Auger
SURFACE ELEV.
DATUM

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Percent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0 5		○						SM		~~SILTY SAND, predominantly fine, nonplastic, light brown~~
10 15		▨						CL		SANDY CLAY, medium plasticity, brown
20		○						SM		SILTY SAND, predominantly fine, nonplastic, light brown
25 30		▨						CL		SANDY CLAY, medium plasticity, brown
35										SANDSTONE, very weathered, moderately hard, light tan
										Stopped auger @ 34'

GROUND WATER

SAMPLE TYPE

MW-2

PROJECT Monitor Well I[illegible]allation
JOB NO. E80-1015 DATE 8/ [illegible] 80

L OF TEST BORING NO. 29

RIG TYPE CME-55
BORING TYPE 8" Hollow Stem Auger
SURFACE ELEV.
DATUM

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Percent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SM		SILTY SAND, predominantly fine, nonplastic, light brown
5								SC		CLAYEY SAND, predominantly fine, medium plasticity, light brown
								SM		SILTY SAND, predominantly fine, nonplastic, light brown
10 15								CL		SANDY CLAY, medium plasticity, brown
20 25								SM		SILTY SAND, predominantly fine, nonplastic, light brown
										SANDSTONE, very weathered, light tan
30										Stopped auger @ 29'

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE
A – Auger cuttings. B – Block sample

WITH

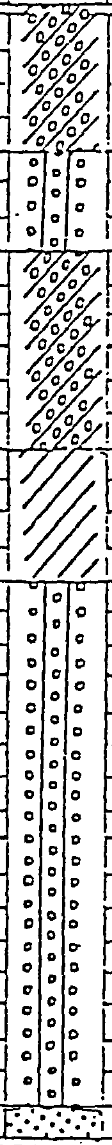
MW-

PROJECT Monitor Well I[illegible]llation

L[illegible] OF TEST BORING NO. 3

JOB NO. E80-1015 DATE 8/21/80

RIG TYPE CME-55
BORING TYPE 8" Hollow Stem Auger
SURFACE ELEV.
DATUM



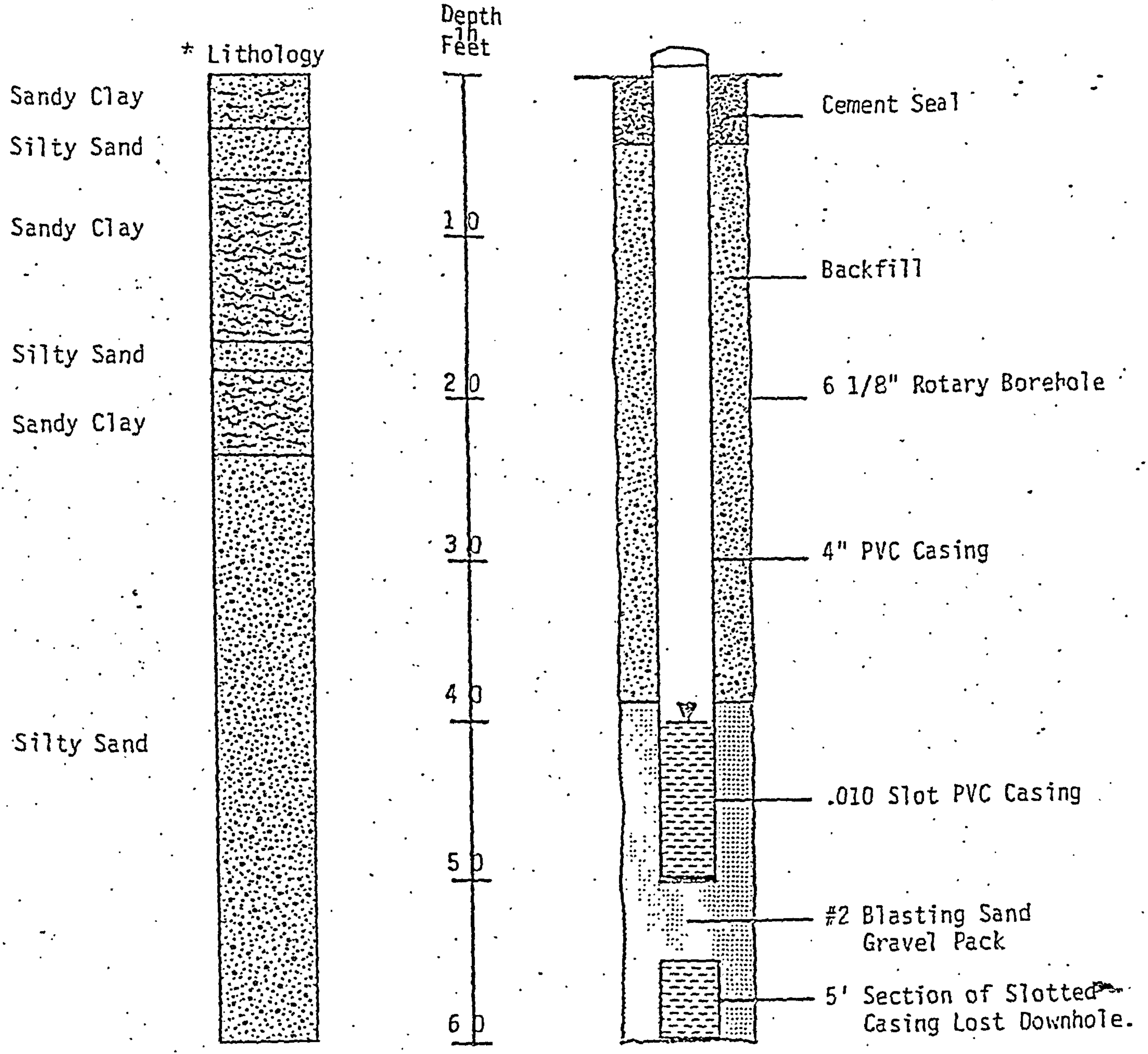
Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Percent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SC		CLAYEY SAND, predominantly fine, medium plasticity, light brown
5								SM		SILTY SAND, predominantly fine, nonplastic, light brown
10								SC		CLAYEY SAND, predominantly fine, medium plasticity, brown
15								CL		SANDY CLAY, medium plasticity, dark brown
20 25 30								SM		SILTY SAND, predominantly fine, nonplastic, light brown
										SANDSTONE, very weathered, soft, light tan
35										Stopped auger @ 34'

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE

Ambrosia Lake, NM
Section 4 Evaporation Ponds
Monitor Well M-31



* Samples of the cuttings were not obtained because of the rotary methods used. Lithology is inferred from M-25 located approximately 100' east.

Date drilled: 8-2-84

Depth to water: 39.48 from grade (8-3-84)

APPENDIX D-2
SECTION 4 SITE CORING PROGRAM
LITHLOGIC LOGS

ADDENUM A

SERGENT, HAUSKINS & BECKWITH CONSULTING SOIL AND FOUNDATION ENGINEERS
APPLIED SOIL MECHANICS • ENGINEERING GEOLOGY • MATERIALS ENGINEERING
B. DWAINE SERGENT, P.E. JOHN B. HAUSKINS, P.E. GEORGE H. BECKWITH, P.E.
DALE V. BEDENKOP, P.E. ROBERT D. BOOTH, P.E. BENNY E. McMILLAN, P.E.
BUD WOODWARD

April 16, 1979

Kerr-McGee Nuclear Corporation
Kerr-McGee Center
Oklahoma City, Oklahoma 73125

SHB Job No. E79-1033

Attention: Mr. John DeVito

Re: 150 Acre Evaporation Ponds
Ambrosia Lake, New Mexico

Gentlemen,

Our Geotechnical Investigation Report on the referenced project is herewith submitted. The report includes the results of test drilling and laboratory analyses along with our discussions and recommendations.

Should any questions arise concerning this report, we would be pleased to discuss them with you.

Respectfully submitted,
Sergent, Hauskins & Beckwith Engineers

By George H. Beckwith
George H. Beckwith, P.E.

GEORGE H. BECKWITH

And Robert D. Booth
Robert D. Booth, P.E.

Copies: Addressee (4)

REPLY TO: 2821 GIRARD BLVD., N.E., ALBUQUERQUE, NEW M
PHOENIX (602) 272-6846 ALBUQUERQUE (505) 345-8606 EL PASO (915) 591-8188

TABLE OF CONTENTS

SHB Job No. E79-1033

1. INTRODUCTION

This report is submitted pursuant to a geotechnical investigation made by this firm of the proposed 150 Acre Evaporation Ponds located at Ambrosia Lake, New Mexico. The object of this investigation was to evaluate the physical properties of subsoils and rock underlying the site to provide recommendations for embankment design, necessary foundation treatment and lining requirements, along with guide specifications for site grading.

In addition to the proposed area of the 150 acre ponds, an area to the south being considered for future expansion was also investigated.

It was not within the scope of this investigation to evaluate the chemical durability of the lining materials relative to the fluids which are to be retained.

2. PROJECT DESCRIPTION

Information on the proposed construction was provided to us by Mr. John DeVito of Kerr-McGee Nuclear Corporation. 150 acres of new ponds are to be constructed south and west of the existing ponds as shown on the site plan in Appendix A.

A series of five ponds are to be constructed, with a total surface area of approximately 150 acres. Shallow cuts are planned in the pond floors in such a way that the excavated material will approximately equal the required volume of dike embankments. Maximum height of water impounded will be approximately 10 feet. Tentatively, membrane lining is planned for the ponds. Slopes of the dikes will be lined with 36 mil reinforced polyester Hypalon, while 20 mil PVC will be utilized to line the floors. In accordance with the suppliers' requirements, 12 inches of clean gravel cover is planned over the PVC lining. The lining on the slopes will not be covered. Slopes of 3 horizontal to 1 vertical will be necessary to meet requirements for facing the lining. It is understood that a similar lining system has been used on the existing ponds.

The waste waters to be retained are highly acidic, with the pH being in the range of 1.0 to 1.3.

3. INVESTIGATION

3.1 Subsurface Exploration

Fifty-three exploratory borings were drilled to depths varying from 2½ to 80 feet utilizing a CME-55 truck-mounted drill rig and 6 5/8 inch O.D. hollow stem auger. Standard penetration testing and open-end drive sampling were performed at selected intervals in the borings.

The results of the field investigation are presented in Appendix A, which includes a brief description of drilling and sampling equipment and procedures, a site plan showing boring locations and logs of the test borings. The field investigation was supervised by staff engineer Richard A. DeBoer of this firm.

3.2 Laboratory Analysis

Moisture content determinations were made on selected samples recovered, while dry densities were determined for the 2.42 inch open-end drive samples. The results of these tests are shown on the boring logs.

Grain-size analysis, Atterberg Limits and consolidation tests were performed on selected samples. The results of these tests are given in Appendix B, along with a brief description of consolidation testing procedures.

4. SITE CONDITIONS & GEOTECHNICAL PROFILE

4.1 Site Conditions

The area of proposed ponds consists of gently sloping terrain, with the vegetative cover consisting of a moderate growth of grass and weeds. Low ridges are present to the northwest and southeast of the site.

4.2 Geotechnical Profile

The geotechnical profile beneath the site can be generalized into a two strata system as follows:

A. Alluvial soils composed predominantly of highly stratified deposits of nonplastic silty sands and sandy and silty clays of medium plasticity. Lesser stratifications or lenses of highly plastic clays and clayey sands are present within these overburden soils.

The overburden soils are up to 58 feet or more in depth over much of the site, but become shallow near the ridges to the northwest and southeast. In the possible area of future development to the south, the soils become as shallow as 2 feet on the slopes of the ridge.

The dry portions of the alluvium above the water table were found to range from soft to relatively firm. Some weak lime cementation was present. The softer soils which were found to be quite extensive would be substantially weakened by moisture increases. Soils below the water table were generally soft to moderately firm or medium dense.

B. Sandstones and highly plastic clay-shales of the Mancos Formation underlie the alluvial overburden soils. The upper few feet of these materials were generally weathered and relatively soft from a geologic standpoint. The rocks became less weathered and moderately hard with depth.

According to Santos and Thaden*, the Mancos Formation is up to about 250 feet in thickness in the general area of the project. The Mancos is underlain by the Dakota Sandstone which is about 75 feet in thickness in the project area

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*Santos, E.S. and Thaden, R.E., "Geologic Map of the Ambrosia Lake Quadrangle, McKinley County, New Mexico", USGS Geologic Quad Map No. GQ-515, 1966.

and rests on the Morrison Formation. Suspected north to northeast trending normal faults are shown crossing the site in the mapping by Santos and Thaden.

4.3 Soil Moisture & Ground Water Conditions

Free ground water is perched in the overburden soils over the Mancos Formation beneath much of the site. Free ground water was encountered in 14 of the borings, with the saturated thickness above the Mancos Formation being as much as 30 feet. Depth to ground water varied from 12 to 41 feet in the various borings. The perched water is generally deepest in the westerly part of the site and shallower to the east.

Soil moisture contents in the materials above the water table were found to be in the range of the very low values typical of the semi-arid region of the site except for the upper few feet that had been wetted by recent precipitation.

In the general area of the site, the Dakota Sandstone and Westwater Canyon Member of the Morrison Formation are considered to be aquifers which may yield substantial water to wells. These aquifers are generally under artesian conditions, and are separated from the shallow perched water by the Mancos Formation which appears to form a completely impervious barrier.

5. DISCUSSION & RECOMMENDATIONS

5.1 Analysis of Results

A substantial portion of the dry alluvium above the water table is relatively low in density and moisture sensitive. Even considering the relatively low embankments involved and the shallow depth of impounded water, it appears that large moisture increases in these soils would create embankment settlements up to 12 inches or more in some areas of the site. It appears to be technically feasible to utilize the medium plastic clays in the area of the site to line the ponds. However, moisture increases below the embankments could potentially cause large differential settlements and could produce embankment cracking. An extensive drain of clean granular materials, in conjunction with a filter system, would be necessary to protect the embankments against this possibility. Considering the cost of drains, it therefore appears to be more practical to line the ponds with flexible membranes which can withstand relatively large amounts of differential movements. Recommendations for a lined pond system are presented in the following sections of this report.

Minor leaks in the membrane lining would have the potential for creating differential settlement and possibly embankment cracking. To guard against the remote possibility of leakage and piping through cracks of this type, the following provisions are incorporated into the recommendations.

A. Clay materials should be placed in the center of the embankments, with the silty sand materials being placed at the exterior. This will both protect the clay core from shrinkage cracking due to drying and provide a more flexible shell in the event of large differential movements.

B. All embankment materials should be compacted at or above optimum moisture content to produce as flexible embankments as possible.

C. A certain amount of the soft soils immediately below the embankment should be subexcavated and recompacted to minimize the potential for settlements.

It is understood that minor leakage of highly acidic waste waters through the lining of the existing ponds has reacted with the soils and created gas bubbles beneath the lining. Damage to the lining has been created by this phenomenon. This phenomenon may be the result of a reaction with calcium carbonate within the soils. Possible methods for minimizing the possibility of this problem developing on the new ponds are discussed in Section 5.4.

5.2 Recommended Embankment Section

The recommended embankment section and zoning are shown in Figure 1, Appendix C. Upstream slope of embankments should be no steeper than 3 horizontal to 1 vertical to allow efficient placement of lining. Downstream slopes on the exterior ponds of no steeper than 2½ horizontal to 1 vertical are recommended. Based on very conservative shear strength assumptions (0' = 25°; C' = 300 psf) and the assumption of steady-state seepage through a leak in the embankment, a factor of safety of 2.1 is computed for this slope by methods published by Hoek and Bray*.

The width of tops of embankments should be at least 12.0 feet, and a minimum of 3.0 feet of freeboard should be provided.

As illustrated in Figure 1, the silty sand materials should be placed in the shells of the embankments, while the interior portion should consist of medium plastic clays.

5.3 Grading Recommendations

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*Hoek, E. and Bray, J.W., "Rock Slope Engineering", Revised Second Edition, Institution of Mining and Metallurgy, London, 1977.

5.3.1 Observations & Tests

The geotechnical engineer should act as the owner's representative, should be the interpreter of the site grading specifications and should make observations and tests as considered necessary to judge the performance thereunder. During dike construction, continuous observations and tests of grading operations should be made by representatives of the geotechnical engineer. All tests should be performed in accordance with the procedures set forth in Parts 14 and 19 of the 1978 Book of ASTM Standards.

5.3.2 Clearing & Stripping

All vegetation and debris should be removed from throughout the site. Stumps, matted roots and roots larger than 2 inches in diameter should be removed from within 6 inches of the surface of areas on which fills are to be constructed and subgrades. All soils loosened and weakened by clearing should be overexcavated and removed.

5.3.3 Surface Preparation

The upper 12 inches of existing native soils should be subexcavated beneath the embankments and the cut surfaces should then be inspected by a representative of the geotechnical engineer. If any extremely soft zones are found, further subexcavation should be carried out in the identified localized areas. The upper 6 inches of native soils beneath cut surfaces should then be scarified, brought to the optimum moisture content or above and compacted to a minimum of 95 percent of maximum dry density as determined by ASTM D698.

The upper 6 inches of native soils beneath the pond subgrades (or beneath any fills in the pond floors) should also be scarified, brought to the optimum moisture content or above and compacted to at least 95 percent of maximum dry density as determined by ASTM D698.

5.3.4 Embankments

Clay materials should be placed in the center of the embankments to at least the extent shown on Figure 1. Nonplastic silty sands should be placed and compacted on the outer portions of the embankments as illustrated in that Figure. It appears that all materials excavated from the floors of the ponds, and from beneath the embankments, will be suitable for use as fill. It also appears that the relative proportion of the clays and nonplastic silty sands will be such that sufficient material to meet the minimum core requirements will be available, yet enough silty sand will be present to construct relatively thick shells. The suitability of the materials for the various zones should be determined by a representative of the geotechnical engineer in the field.

All embankment materials should be compacted to a minimum of 95 percent of maximum dry density as determined by ASTM D698. Moisture content during compaction should be maintained at or above the optimum moisture content.

5.4 Membrane Lining Considerations

Requirements for type of cover material and base should be established by the supplier of the materials based on their exact characteristics.

Special care in sealing joints will be of particular importance for this job due to the possibility of settlements due to leakage and formation of air bubbles.

Providing a system for positive relief of air bubbles beneath the membrane on the slopes appears to be a difficult problem, in that the permeability to air of even ordinary granular bases is relatively low. Open graded permeable crushed rock base materials would be difficult to place on the slopes and would be a poor working surface. A grid of small perforated pipes extending to the top of the dikes could be used. However, it would be necessary to place the pipes on close centers to achieve rapid response to air bubbles over the entire bottom of

TEST DRILLING EQUIPMENT & PROCEDURES

Drilling Equipment Truck-mounted CME-55 drill rigs powered with 4 or 6 cylinder Ford industrial engines are used in advancing test borings. The 4 cylinder and 6 cylinder engines are capable of delivering about 4,350 and 6,500 foot/pounds torque to the drill spindle, respectively. The spindle is advanced with twin hydraulic rams capable of exerting 12,000 pounds downward force. Drilling through soil or softer rock is performed with 6 1/2 O.D., 3 1/4 I.D. hollow stem auger or 4 1/2 inch continuous flight auger. Carbide insert teeth are normally used on the auger bits so they can often penetrate rock or very strongly cemented soils which require blasting or very heavy equipment for excavation. Where refusal is experienced in auger drilling, the holes are sometimes advanced with tricone gear bits and NX rods using water or air as a drilling fluid.

Sampling Procedures Dynamically driven tube samples are usually obtained at selected intervals in the borings by the ASTM D1586 procedure. In many cases, 2" O.D., 1 3/8" I.D. samplers are used to obtain the standard penetration resistance. "Undisturbed" samples of firmer soils are often obtained with 3" O.D. samplers lined with 2.42" I.D. brass rings. The driving energy is generally recorded as the number of blows of a 140 pound 30 inch free fall drop hammer required to advance the samplers in 6 inch increments. However, in stratified soils, driving resistance is sometimes recorded in 2 or 3 inch increments so that soil changes and the presence of scattered gravel or cemented layers can be readily detected and the realistic penetration values obtained for consideration in design. These values are expressed in blows per foot on the logs. "Undisturbed" sampling of softer soils is sometimes performed with thin walled Shelby tubes (ASTM D1587). Where samples of rock are required, they are obtained by NX diamond core drilling (ASTM D2113). Tube samples are labeled and placed in watertight containers to maintain field moisture contents for testing. When necessary for testing, larger bulk samples are taken from auger cuttings.

Continuous Penetration Tests Continuous penetration tests are performed by driving a 2" O.D. blunt nosed penetrometer adjacent to or in the bottom of borings. The penetrometer is attached to 1 5/8" O.D. drill rods to provide clearance to minimize side friction so that penetration values are as nearly as possible a measure of end resistance. Penetration values are recorded as the number of blows of a 140 pound 30 inch free fall drop hammer required to advance the penetrometer in one foot increments or less.

Boring Records Drilling operations are directed by our field engineer or geologist who examines soil recovery and prepares boring logs. Soils are visually classified in accordance with the Unified Soil Classification System (ASTM D2487) with appropriate group symbols being shown on the logs.

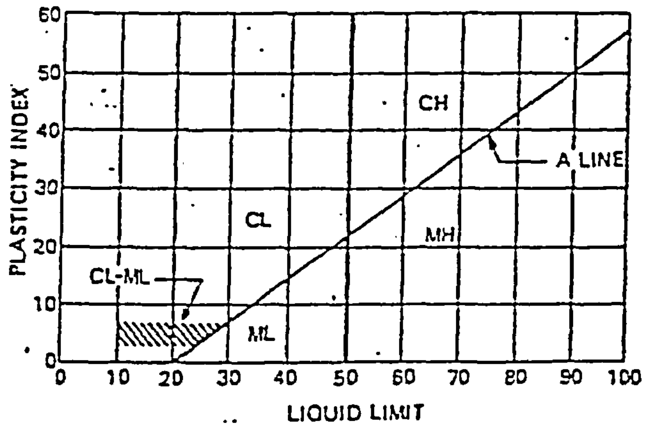
UNIFIED SOIL CLASSIFICATION SYSTEM

Soils are visually classified by the Unified Soil Classification system on the boring logs presented in this report. Grain-size analysis and Atterberg Limits Tests are often performed on selected samples to aid in classification. The classification system is briefly outlined on this chart. For a more detailed description of the system, see "The Unified Soil Classification System" Corp of Engineers, US Army Technical Memorandum No. 3-357 (Revised April 1960) or ASTM Designation: D2487-66T.

MAJOR DIVISIONS				GRAPHIC SYMBOL	GROUP SYMBOL	TYPICAL NAMES
COARSE-GRAINED SOILS (Less than 50% passes No. 200 sieve)	GRAVELS (50% or less of coarse fraction passes No. 4 sieve)	CLEAN GRAVELS (Less than 5% passes No. 200 sieve)		⁘	GW	Well graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures.
				⁘	GP	Poorly graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures.
		GRAVELS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart	⁘	GM	Silty gravels, gravel-sand-silt mixtures.
			Limits plot above "A" line & hatched zone on plasticity chart	▨	GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS (More than 50% of coarse fraction passes No. 4 sieve)	CLEAN SANDS (Less than 5% passes No. 200 seive)		⁘	SW	Well graded sands, gravelly sands.
				⁘	SP	Poorly graded sands, gravelly sands.
		SANDS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart	⁘	SM	Silty sands, sand-silt mixtures.
			Limits plot above "A" line & hatched zone on plasticity chart	▨	SC	Clayey sands, sand-clay mixtures.
FINE-GRAINED SOILS (50% or more passes No. 200 sieve)	SILTS Limits plot below "A" line & hatched zone on plasticity chart	SILTS OF LOW PLASTICITY (Liquid Limit Less Than 50)		▥	ML	Inorganic silts, clayey silts with slight plasticity.
		SILTS OF HIGH PLASTICITY (Liquid Limit More Than 50)		▥	MH	Inorganic silts, micaceous or diatomaceous silty soils, elastic silts.
	CLAYS Limits plot above "A" line & hatched zone on plasticity chart	CLAYS OF LOW PLASTICITY (Liquid Limit Less Than 50)		▨	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		CLAYS OF HIGH PLASTICITY (Liquid Limit More Than 50)		▨	CH	Inorganic clays of high plasticity, fat clays, sandy clays of high plasticity.

NOTE: Coarse grained soils with between 5% & 12% passing the No. 200 sieve and fine grained soils with limits plotting in the hatched zone on the plasticity chart to have double symbol.

PLASTICITY CHART



DEFINITIONS OF SOIL FRACTIONS

SOIL COMPONENT	PARTICLE SIZE RANGE
Cobbles	Above 3 in.
Gravel	3 in. to No. 4 sieve
Coarse gravel	3 in. to ¾ in.
Fine gravel	¾ in. to No. 4 sieve
Sand	No. 4 to No. 200
Coarse	No. 4 to No. 10
Medium	No. 10 to No. 40
Fine	No. 40 to No. 200
Fines (silt or clay)	Below No. 200 sieve

TERMINOLOGY USED TO DESCRIBE THE RELATIVE DENSITY, CONSISTENCY OR FIRMNESS OF SOILS

The terminology used on the boring logs to describe the relative density, consistency or firmness of soils relative to the standard penetration resistance is presented below. The standard penetration resistance (N) in blows per foot is obtained by the ASTM D1586 procedure using 2" O.D., 1 3/8" I.D. samplers.

1. Relative Density. Terms for description of relative density of cohesionless, uncemented sands and sand-gravel mixtures.

N	Relative Density
0-4	Very loose
5-10	Loose
11-30	Medium dense
31-50	Dense
50+	Very dense

2. Relative Consistency. Terms for description of clays which are saturated or near saturation.

N	Relative Consistency	Remarks
0-2	Very soft	Easily penetrated several inches with fist.
3-4	Soft	Easily penetrated several inches with thumb.
5-8	Medium stiff	Can be penetrated several inches with thumb with moderate effort.
9-15	Stiff	Readily indented with thumb, but penetrated only with great effort.
16-30	Very stiff	Readily indented with thumbnail.
30+	Hard	Indented only with difficulty by thumbnail.

3. Relative Firmness. Terms for description of partially saturated and/or cemented soils which commonly occur in the Southwest including clays, cemented granular materials, silts and silty and clayey granular soils.

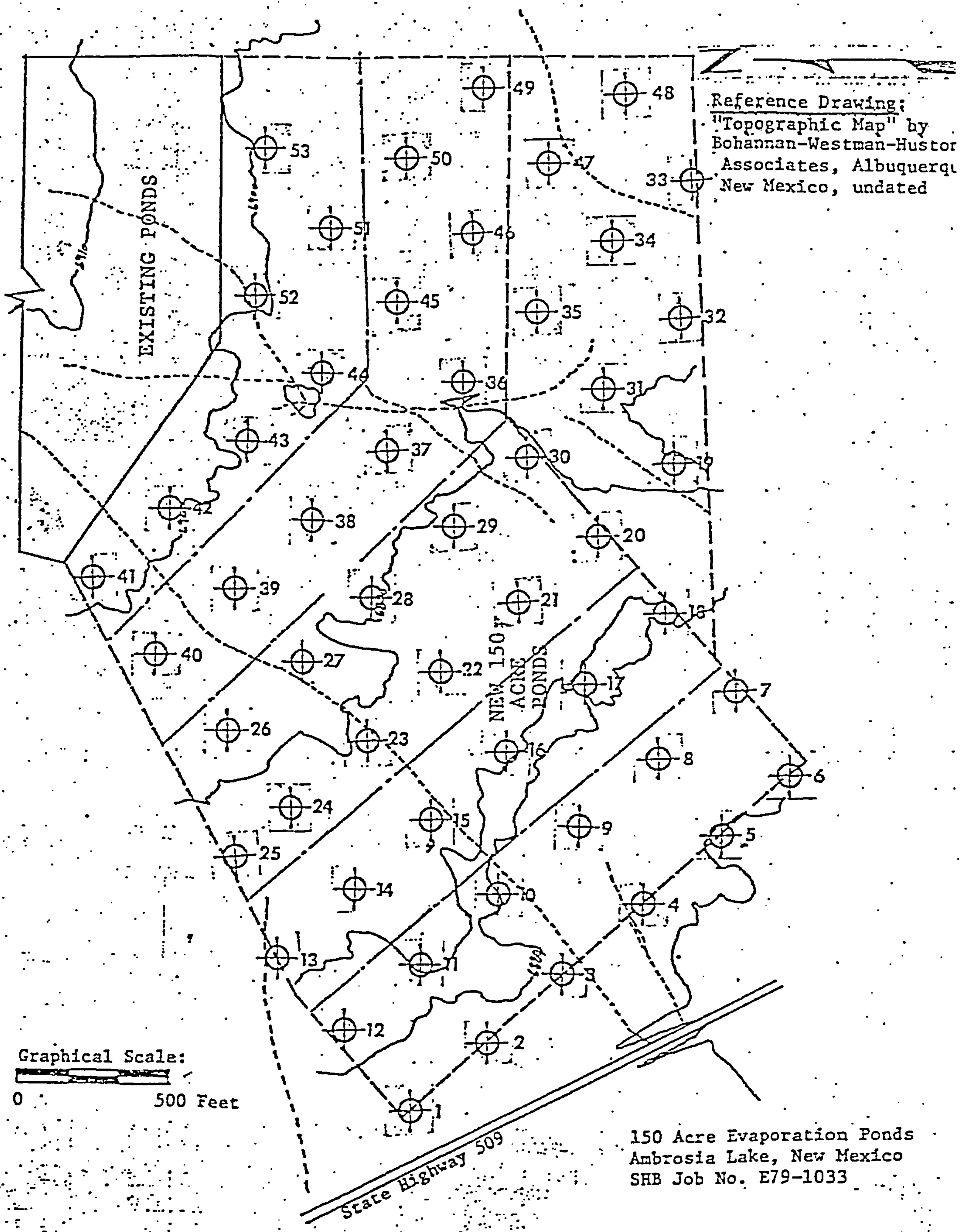
N	Relative Firmness
0-4	Very soft
5-8	Soft
9-15	Moderately firm
16-30	Firm
31-50	Very firm
50+	Hard

TERMINOLOGY FOR THE DESCRIPTION OF ROCK

General Property	Descriptive Term	Visual or Physical Properties
WEATHERING	VERY WEATHERED	Abundant fractures coated with oxides, carbonates, sulfates, mud, etc., thorough discoloration, rock disintegration, mineral decomposition
	MODERATELY WEATHERED	Some fracture coating, moderate or localized discoloration, little to no effect on cementation, slight mineral decomposition
	SLIGHTLY WEATHERED	A few stained fractures, slight discoloration, little to no effect on cementation, no mineral decomposition
	FRESH	Unaffected by weathering agents, no appreciable change with depth
FRACTURING	INTENSELY FRACTURED	less than 1" spacing
	VERY FRACTURED	1" to 6" spacing
	MODERATELY FRACTURED	6" to 12" spacing
	SLIGHTLY FRACTURED	12" to 36" spacing
	SOLID	36" spacing or greater
STRATIFICATION	THINLY LAMINATED	less than 1/10"
	LAMINATED	1/10" to 1/2"
	VERY THINLY BEDDED	1/2" to 2"
	THINLY BEDDED	2" to 2 feet
	THICKLY BEDDED	more than 2 feet
HARDNESS	SOFT	Can be dug by hand and crushed by fingers
	MODERATELY HARD	Friable, can be gouged deeply with knife and will crumble readily under light hammer blows
	HARD	Knife scratch leaves dust trace, will withstand a few hammer blows before breaking
	VERY HARD	Scratched with knife with difficulty, difficult to break with hammer blows

SITE PLAN

SHOWING LOCATIONS OF TEST BORINGS



150 Acre Evaporation Ponds
Ambrosia Lake, New Mexico
SHB Job No. E79-1033

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 2/27/79

LOG OF TEST BORING NO. 1

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6879±

DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	12		11		loose to medium dense	SILTY SAND, predominantly fine, trace gravel, nonplastic to low plasticity, light brown
			☒	S	6		4			
5			☒	S	21		5			
								SC-SM		
10			☒	S	17		5			
15			☒	S	24		6			
20			☒	S	27		18		firm	SILTY CLAY, medium plasticity, greenish-brown
25			☒	S	29		18	CL		
30			☒	S	14		6		very loose to medium dense	SILTY SAND, predominantly fine, angular, nonplastic, brown
35			☒	S	3		24			
								SM		
40			☒	S	9		18			
45			☒	S	18		17			
50			☒	S	16		18			

GROUND WATER

DEPTH	HOUR	DATE
41'	11 am	2/27

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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Page 2 of 2

LOG OF TEST BORING NO.__

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 2/27/79

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6879±

DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
50		°°°	☒							
										Stopped auger at 49½' Stopped sampler at 51
55										
60										

GROUND WATER

DEPTH	HOUR	DATE
41'	11 am	2/27

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 2/27/79

LOG OF TEST BORING NO. 2

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6878±
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		▨	☒	S	20		14		firm to very firm	SANDY CLAY, medium to high plasticity, light brown
5		▨	☒	S	32		12			
10		▨	☒	S	32		12			
		▨						CL		
15		▨	☒	S	29		8			
20		▨	☒	S	33		16			
25		▨	☒	S	16		4		medium dense	CLAYEY SAND, predominantly fine, trace gravel, angular, low plasticity, light brown
		▨						SC		
30		▨	☒	S	11		22			
										Stopped auger at 29½' Stopped sampler at 31'
35										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 2/27/79

LOG OF TEST BORING NO. 3

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6878±

DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0									loose to medium dense	SILTY SAND, predominantly fine, angular, nonplastic, light brow
			☒	S	10		2			
5			☒	S	14		2	SM		
									moderately firm to firm	SILTY CLAY, medium pla ticity, light brown
10			☒	S	14		8			
								CL		
15			☒	S	26		11			
									very firm	CLAY, trace sand, high plasticity, brown
20			☒	S	46		18	CH		
25			☒	S	13		20	SC	medium dense	CLAYEY SAND, predominantly fine to medium, angular, low plasticity brown
								CL		
30			☒	S	9		31		moderately firm	SILTY CLAY, medium plas ticity, dark brown
										Stopped auger at 29½' Stopped sampler at 31'
35										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sam

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 2/27/79

LOG OF TEST BORING NO.

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6871+

DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		▨							soft	SILTY CLAY, some sand medium plasticity, green-brown
		▨	☒	S	7		9			
5		▨	☒	S	11		20			
		▨						CL		
10		▨	☒	S	7		17			
15		▨	☒	S	9		26		moderately firm	SILTY CLAY, trace sand medium plasticity, dar brown
		▨						CL		
		▨					35			
20		○	☒	S	13		5		medium dense to loose	SILTY SAND, predominantly fine, angular, nonplastic to low plasticity, brown
		○						SM		
25		○	☒	S	7					
										Stopped auger at 24½' Stopped sampler at 26'
30										
35										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

LOG OF TEST BORING NO. 5

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 2/27/79

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6870±

DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	13		6	SM-SC	moderately firm	CLAYEY SAND, predominantly fine, low plasticity, light brown
5			☒	S	18		14	CL	moderately firm	SILTY CLAY, medium plasticity, dark brown
10			☒	S	13		3	SM	medium dense	SILTY SAND, predominantly fine, angular, nonplastic, light brown
15			☒	S	6		27	SC	loose	CLAYEY SAND, predominantly fine, low plasticity, brown note: some thin lenses (3-4"±) of medium plasticity clay
20			☒	S	13		30			
										Stopped auger at 19½' Stopped sampler at 21'
25										
30										
35										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

PROJECT 150 Acre Evaporation Ponds

LOG OF TEST BORING NO. 6

JOB NO. E79-1033 DATE 2/27/79

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6871±
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0									medium dense	SILTY SAND, predominantly fine, angular, nonplastic to low plasticity, brown
			☒	S	14		11			
5			☒	U	51	95	5			note: some thin (3-4") lenses medium plasticity clay
10			☒	S	12		12	SM		
15			☒	S	9		22			
									stiff	SANDY CLAY, trace gravel, medium plasticity, dark brown
20			☒	S	9		29	CL		
										Stopped auger at 19½' Stopped sampler at 21'
25										
30										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 2/27/79

LOG OF TEST BORING NO. 7

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6875±

DATUM MSL

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		▨						CH	slightly moist	SANDY CLAY, medium plasticity, dark brown
		▨	☒	S	35				very firm	
5		○	☒	S	12				slightly moist	SILTY SAND, predominantly fine, very low plasticity, brown
		○						SM	medium dense	
10		○	☒	S	12		10			
15		○	☒	S	8			SM	dry loose	SILTY SAND, predominantly fine, angular, nonplastic to low plasticity, brown
		▨						CL	very moist	SANDY CLAY, medium plasticity, brown
20		▨	☒	S	9				moderately firm	
										Stopped auger at 19½' Stopped sampler at 21'
25										
30										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin walled Shelby tube

PROJECT 150 Acre Evaporation Ponds
JOB NO. E79-1033 DATE 2/28/79

LOG OF TEST BORING NO. 8

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6875±
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		▨	☒	S	14			CL	slightly moist moderately firm	SANDY CLAY, medium plasticity, brown
5		⁘	☒	S	15			SM	dry medium dense	SILTY SAND, predominantly fine, nonplasti to low plasticity, light brown
10		⁘	☒	S	13					
15		▨	☒	U	15 (no recovery)			CH	very moist soft to very soft	SILTY CLAY, medium plasticity, brown
20		▨	☒	S	2		35			
25		▨	☒	S	14		31			
30										Stopped auger at 24½' Stopped sampler at 26'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE
A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 2/28/79

LOG OF TEST BORING NO. 9

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6875±

DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	13		14	CL	moderately firm	SILTY CLAY, medium plasticity, dark brown
			☒	S	14		6		medium dense to loose	SILTY SAND, some clay, predominantly fine, nonplastic to low plasticity, light brown
5			☒	S	9		24	SC		
10			☒	S	6		14		soft to moderately firm	SILTY CLAY, medium plasticity, brown
								CL		
15			☒	U	12	101	17			
20			☒	S	13		30			
25			☒	S	6		28	SM	loose	SILTY SAND, predominantly fine, angular, nonplastic to low plasticity, brown
30										Stopped auger at 24½' Stopped sampler at 26'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

PROJECT 150 Acre Evaporation Ponds
JOB NO. E79-1033 DATE 2/28/79

LOG OF TEST BORING NO.___

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6880±
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		▨	☒	S	11				moist to dry	SILTY CLAY, low plasticity, light brown
		▨	☒	S	14				moderately firm	
5		▨	☒	S	12					
10		▨	☒	S	16		8	CL		
15		▨	☒	S	15					
20		▨	☒	S	11				moist moderately firm to firm	SANDY CLAY, medium-hig plasticity, dark brown
25		▨	☒	S	16			CL		
30		○	☒	S	3 (no recovery)			SM	very moist very loose to loose	SILTY SAND, predominantly fine, angular, nonplastic, brown
35		○	☒	S	6					
										Stopped auger at 34½' Stopped sampler at 36'
40										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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PROJECT 150 Acre Evaporation Ponds
JOB NO. E79-1033 DATE 2/28/79

LOG OF TEST BORING NO. 11

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6882±
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	12			SM	moist to dry medium dense	SILTY SAND, predominantly fine, angular, nonplastic, light brown
			☒	S	12					
5			☒	S	8			SM	dry loose	SILTY SAND, predominantly fine, low plasticity, light brown
10			☒	S	9				dry loose to medium dense	SILTY SAND, predominantly fine, angular, nonplastic, light brown
15			☒	S	12			SM		
20			☒	S	17					
25			☒	S	16			SM-SC	moist medium dense	SILTY SAND, predominantly fine, trace clay, low plasticity, brown
30			☒	S	15			SM	moist medium dense	SILTY SAND, predominantly fine, angular, nonplastic to very low plasticity, brown
35										Stopped auger at 29½' Stopped sampler at 31'
40										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 2/28/79

LOG OF TEST BORING NO. 1

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6880±

DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		▨	☒	S	5			CL	slightly moist soft to moderately firm	SANDY CLAY, medium pla ticity, dark brown
		▨	☒	S	9					
5		▨	☒	S	20		9		dry moderately firm to firm	SILTY CLAY, medium pla ticity, light brown
10		▨	☒	S	10					
15		▨	☒	S	10			CL		
20		▨	☒	S	14					
25		▨	☒	S	18					
30		○	☒	S	7			SM	slightly moist to very moist medium dense to very loose	SILTY SAND, predominantly fine, angular, nonplastic to very low plasticity, brown
35		○	☒	S	2					
40										Stopped auger at 34½' Stopped sampler at 36'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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PROJECT 150 Acre Evaporation Ponds

LOG OF TEST BORING NO. 13

JOB NO. E79-1033 DATE 2/28/79

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6883±
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		▨	☒	S	18			CL	moist firm	SILTY CLAY, medium plasticity, dark brown
		○	☒	S	21			SM	dry medium dense to very loose	SILTY SAND, predominantly fine, angular, nonplastic, light brown
5		○	☒	S	13					
10		○	☒	S	4					
		▨						CL	dry firm	SILTY CLAY, low plasticity, dark brown
15		▨	☒	S	25					
		○						SM	dry, becoming very moist above the water table medium dense	SILTY SAND, predominantly fine, angular, nonplastic, light brown note: some clay stratification
20		○	☒	S	19					
25		○	☒	S	15					
30		○	☒	S	18					
		○	☒	S	110					
35										Auger refused at 34' Sampler refused at 35'
40										

GROUND WATER

DEPTH	HOUR	DATE
33'	6 pm	2/28

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

PROJECT 150 Acre Evaporation Ponds
JOB NO. E79-1033 DATE 3/1/79

LOG OF TEST BORING NO. 1

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6285±
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	17				slightly moist to dry medium dense	SILTY SAND, predominantly fine, angular, nonplastic to low plasticity, light brown
			☒	S	13					
5			☒	S	15					
								SM		
10			☒	S	15					
15			☒	S	7				slightly moist soft	SILTY CLAY, low plasticity, dark greenish-brown
								GH		
20			☒	S	8					
25			☒	S	16				very moist firm	SILTY CLAY, medium to high plasticity, brown
								CH		
30			☒	S	140					SHALE, very weathered, moderately fractured, thinly bedded, soft to moderately hard, brown
35			☒	S	140					
										Stopped auger at 34½' Sampler refused at 35½'
40										

GROUND WATER

DEPTH	HOUR	DATE
34½'	2:40	3/1
	pm	

SAMPLE TYPE
A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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PROJECT 150 Acre Evaporation Ponds
JOB NO. E79-1033 DATE 3/1/79

LOG OF TEST BORING NO. 15

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6884±
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	12				moist to dry medium dense	SILTY SAND, predominantly fine, angular, nonplastic to low plasticity, light brown note: some thin lenses of medium plasticity clay
			☒	S	24					
5			☒	S	10					
								SM		
10			☒	S	12					
15			☒	U	22				dry, becoming very moist loose to medium dense	SILTY SAND, predominantly medium, angular, nonplastic, light brown interbedded with numerous lenses of medium plastic clay
20			☒	S	5			SM with CL		
25			☒	U	16 (no recovery)					
30			☒	S	10					
35			☒	S	6					
										Stopped auger at 34½' Stopped sampler at 36'
40										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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PROJECT 150 Acre Evaporation Ponds
JOB NO. E79-1033 DATE 3/1/79

LOG OF TEST BORING NO. 1

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6882±
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		○○							medium dense	SILTY SAND, predominantly fine, angular, nonplastic to low plasticity, light brown
		○○	☒	S	28		4	SM		
5		○○	☒	S	10		6			
10		▨	☒	S	13		18		loose to medium dense	SILTY CLAY, medium plasticity, dark brown, interbedded with numerous stratifications of silty sand
15		▨	☒	S	8		20			
		▨						CL with SM		
20		▨	☒	S	8		12			
25		▨	☒	S	7		22			
										Stopped auger at 24½' Stopped sampler at 26'
30										
35										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

LOG OF TEST BORING NO. 17

PROJECT 150 Acre Evaporation Ponds
JOB NO. E79-1033 DATE 3/2/79

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6881±
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		▨							slightly moist to very moist	SILTY CLAY, low to medium plasticity, dark brown
		▨	☒	S	11					
5		▨	☒	S	12		25	CL	moderately firm	
10		▨	☒	S	7					
15		▨	☒	S	7			SC	moist loose	CLAYEY SAND, predominantly fine, low plasticity, brown
20		○	☒	S	5			SM	wet loose	SILTY SAND, predominantly fine, nonplastic, brown
25		▨	☒	S	6				moist to very moist soft to firm	SILTY CLAY, medium plasticity, dark brown
30		▨	☒	S	15					
35		▨	☒	S	31			CL		
40		▨	☒	S	21					
45		▨	☒	S	15					
50										

GROUND WATER

DEPTH	HOUR	DATE
:	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

H

Page 2 of 2

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 3/2/79

LOG OF TEST BORING NO. 1

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6881±
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
50			☒	S	24			CL		becomes orange-brown
55			☒	S	52			SP	very wet very dense	SAND, some clay, predominantly medium, angular, nonplastic to low plasticity, brown with orange streaks
60			☒	S	33					SHALE, moderately to very weathered, thinly bedded, soft to moderately hard, tan to gra
65			☒	S	120					
70				S	50/1" (no recovery)					
75				S	50/0" (no recovery)					
80				S	100/0"					Stopped auger at 80' Sampler refused at 80'
85										
90										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 3/2/79

LOG OF TEST BORING NO. 18

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6881±

DATUM MSL

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	9			SM-SC	slightly moist loose	SILTY SAND, some clay, predominantly fine, angular, nonplastic, brown
5			☒	S	13			CL	slightly moist moderately firm	SILTY CLAY, medium pla: ticity, brown
10			☒	S	9			SM-SC	dry to very moist loose	SILTY SAND, some clay, predominantly fine, angular, nonplastic, brown
15			☒	S	7					
20			☒	S	7					
25										Stopped auger at 19½' Stopped sampler at 21'
30										
35										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

TH

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 3/3/79

LOG OF TEST BORING NO. 1

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6897±

DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb, 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		▨	☒	S	5			CL	slightly moist	SANDY CLAY, medium plasticity, light brow
		▤	☒	S	50/4"				soft	
		▤		S	50/0"					
5										SANDY SHALE, moderatel weathered, thinly bedded, moderately har tan
										Auger refused at 4' Sampler refused at 4'
10										
15										
20										
25										
30										
35										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 3/3/79

LOG OF TEST BORING NO.

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6887
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		○ ○							slightly moist	SILTY SAND, predominantly fine, angular, nonplastic to very lo plasticity, light bro
		○ ○	☒	S	8		8			
		○ ○							loose	
5		○ ○	☒	S	8			SM		
10		○ ○	☒	S	6					
15		▨	☒	U	15			CL	slightly moist moderately firm	SILTY CLAY, some sand, medium plasticity, dark brown
20		○ ○	☒	S	29			SM-SC	dry medium dense	SILTY SAND, trace clay predominantly fine, angular, nonplastic, orange
25		≡	☒	S	43					SHALE, very weathered, thinly bedded, soft to moderately hard, brown to yellow-brown
30		≡	☒	S	90					
										Stopped auger at 29½' Sampler refused at 30½'
35										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.33" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube

TH

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 3/3/79

LOG OF TEST BORING NO. 2

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6884±
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		▨							slightly moist firm	SANDY CLAY, medium-hig plasticity, brown
		▨	☒	S	22			CL		
5		▨	☒	S	11					
10		▨	☒	S	6				slightly moist to wet soft	SILTY CLAY, high plasticity, brown, interbedded with numerous layers of silty sand, predominantly fine, angular, nonplastic, orange-brown note: silty sand layers are up to about 8-10" in thickness
15		▨	☒	S	6					
20		▨	☒	S	6			CL with SM		
25		▨	☒	S	3					
30		▨	☒	S	5					
35										Stopped auger at 29½' Stopped sampler at 31'

GROUND WATER

DEPTH	HOUR	DATE
29'	10:45	3/3
	am	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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PROJECT 150 Acre Evaporation Ponds

LOG OF TEST BORING NO. 2

JOB NO. E79-1033 DATE 3/3/79

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6886±
DATUM MSL

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	13		7		medium dense	SILTY SAND, predominantly medium, angular nonplastic to very low plasticity, light brow
			☒	S	16		3	SM		
5			☒	S	8		6			
10			☒	S	7		26		loose to medium dense	SILTY SAND, considerab clay, predominantly fine, angular, nonplastic to low plasticity, orange-brown
15			☒	S	6		14			
								SM-SC		
20			☒	S	5		18			
25			☒	S	5		29			
30			☒	S	13		25			
35										Stopped auger at 29½' Stopped sampler at 31'

GROUND WATER

DEPTH	HOUR	DATE
27'	11:30 am	3/3

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin walled Shelby tube

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 3/3/79

LOG OF TEST BORING NO. 2

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6889±

DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	10				slightly moist moderately firm	SILTY SAND, predominantly fine, nonplastic to very low plasticity, light brown
			☒	S	11					
5			☒	S	10		7			
								SM		
10			☒	S	13					
									dry to wet loose to medium dense	SILTY SAND, predominantly medium, angular nonplastic, orange-brown note: occasional thin (3"±) layers of medium plasticity clay
15			☒	S	8					
20			☒	S	9					
								SM		
25			☒	S	7					
30			☒	U	31					
			☒	S	50/5½"					
35										Auger refused at 32½' Sampler refused at 33'
40										

GROUND WATER

DEPTH	HOUR	DATE
25½'	1:30	3/3
	pm	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

H

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 3/3/79

LOG OF TEST BORING NO. 2

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6888±
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop-hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	21				slightly moist moderately firm	SILTY SAND, predominantly fine, low plasticity, light brown
			☒	S	22			SM		
5			☒	S	16				dry firm to hard	SILTY SAND, predominantly fine, angular, nonplastic, orange-brown note: apparently sandstone weathered in plac
								SM		
10				S	50/3"(no recovery)					
15										Auger refused at 9'9" Sampler refused at 10'
20										
25										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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CONSULTING SOIL AND FOUNDATION ENGINEERS
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PROJECT ~~150 Acre Evaporation Ponds~~
JOB NO. E79-1033 DATE 3/3/79

LOG OF TEST BORING NO.__

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6888±
DATUM MSL

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	17				slightly moist to dry	CLAYEY SAND, predominantly fine, low plasticity, orange-br
			☒	S	16			SM-SC		
5			☒	S	14					
				S	50/4"					SANDSTONE, very weathered, intensely fractured, thinly bedded, soft to moderate hard, yellow-tan
10										
15										Auger refused at 9'8" Sampler refused at 10'
20										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

PROJECT 150 Acre Evaporation Ponds

LOG OF TEST BORING NO. 2

JOB NO. E79-1033 DATE 3/3/79

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6893±
DATUM MSL

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	14				slightly moist to dry moderately firm to firm	SILTY SAND, predominantly fine, low plasticity, trace clay, light orange-brown
			☒	S	19			SM-SC		
5			☒	S	16					
10			☒	S	14			SM	dry medium dense	SILTY SAND, predominantly fine, medium-high plasticity, orang brown
15			☒	S	37				slightly moist to moist very firm	SILTY CLAY, trace sand, medium plasticity, dark brown
								CL		
20			☒	S	29					
25			☒	S	200					SANDSTONE, fine grained orange
										Auger refused at 25' Sampler refused at 25'2'
30										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 3/3/79

LOG OF TEST BORING NO. 27

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6893±

DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	22			SM-SC	slightly moist to dry medium dense	SILTY SAND, trace clay, predominantly fine, low plasticity, brown
			☒	S	16					
5			☒	S	14			SM	dry medium dense	SILTY SAND, predominantly fine, nonplastic brown
10			☒	S	18					
15			☒	S	5			SC	slightly moist to moist soft	CLAYEY SAND, low plasticity, predominantly fine, orange-brown
20			☒	S	7					
25			☒	U	30			SM	very moist	SILTY SAND, trace gravel, predominantly fine, nonplastic, orange-brown note: occasional lenses of medium plasticity silty clay
30			☒	S	2					
35			☒	S	18					
40			☒	S	68					SANDSTONE, very weathered, thinly bedded, soft, yellow-brown
45										Stopped auger at 39½' Stopped sampler at 41'

GROUND WATER

DEPTH	HOUR	DATE
36½'	5:30	3/3
	pm	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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Page 1 of 2

PROJECT 150 Acre Evaporation Ponds
JOB NO. E79-1033 DATE 3/4/79

LOG OF TEST BORING NO. 28

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6890±
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0									firm	SILTY SAND, trace clay, predominantly fine, low plasticity, light brown
			☒	S	28		8	SM-SC		
5			☒	S	18		6		moderately firm	SILTY CLAY, medium plasticity, brown note: silty sand present in thin lenses (3"±)
								CL		
10			☒	S	13		14			
15			☒	S	20		12		medium dense to loose	SILTY SAND, trace gravel, predominantly fine, angular, nonplastic, brown note: silty clay present in thin lenses
20			☒	S	8		11	SM		
25			☒	S	8		21			
30			☒	S	12		20		moderately firm to firm	SILTY CLAY, medium plasticity, dark brown
35			☒	S	16		19			
40			☒	S	20		20	CL		
45			☒	S	28		18			
-50								SM-SC		

GROUND WATER

DEPTH	HOUR	DATE
25½'	1:15 pm	3/4

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

Page 2 of 2

PROJECT 150 Acre Evaporation Ponds
JOB NO. E79-1033 DATE 3/4/79

LOG OF TEST BORING NO. 2

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6890±
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
50			☒	S	29		21	SM-SC	medium dense to very dense	SILTY SAND, trace clay predominantly fine, lo plasticity, brown
55			☒	S	56		12			
60			☒	S	52		16			SANDY SHALE, very weat ered, thinly bedded, soft, yellow to tan
65				S	50/5½"		15			
70				S	50/3"		12			
				S	50/1"		17			
75										Auger refused at 74' Sampler refused at 74'
80										

GROUND WATER

DEPTH	HOUR	DATE
25½'	1:15 pm	3/4

SAMPLE TYPE
A – Auger cuttings. B – Block sample
S – 2" O.D. 1.33" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 3/4/79

LOG OF TEST BORING NO. 2

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6888±

DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		▨							slightly moist	SILTY CLAY, medium pla ticity, light brown
			☒	S	12					
5			☒	S	15		11	CL	moderately firm	
10		○	☒	S	19				dry medium dense to dense	SILTY SAND, predominantly fine, nonplasti orange-brown
15			☒	S	10			SM		
20			☒	S	32					
25										Stopped auger at 19½' Stopped sampler at 21'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block samp

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

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PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 3/4/79

LOG OF TEST BORING NO. 3

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6888±
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0									slightly moist to dry	SILTY SAND, trace clay predominantly fine, lo plasticity, light brow
			☒	S	11					
								SM-SC	moderately firm	
5			☒	S	15					
10			☒	S	35					
										SANDSTONE, slightly weathered, intensely fractured, thinly bedded, hard, tan
15										Stopped sampler at 11' Auger refused at 11'
20										
25										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

PROJECT 150 Acre Evaporation Ponds

LOG OF TEST BORING NO. 3

JOB NO. E79-1033 DATE 3/4/79

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6903+
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	8			SM-SC	dry moderately firm	SILTY SAND, trace clay predominantly fine, lc plasticity, light brow
				S	50/1" (no recovery)					
5										Auger refused at 2½' Sampler refused at 2½' on sandstone
10										
15										
20										
25										
30										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

PROJECT 150 Acre Evaporation Ponds

LOG OF TEST BORING NO. 3

JOB NO. E79-1033 DATE 3/4/79

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6902±
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0									slightly moist to dry firm	SILTY SAND, trace clay predominantly fine, lo plasticity, brown
			☒	S	19			SM-SC		
5									dry dense	SILTY CLAY, medium pla ticity, orange-brown
			☒	S	29			SP		
				S	50/0"					
										Auger refused at 7½' Sampler refused at 7½' on sandstone
10										
15										
20										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 3/5/79

LOG OF TEST BORING NO. 33

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6909±

DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	12			SM-SC	slightly moist medium dense	SILTY SAND, trace clay, predominantly fine, low plasticity, orange-brown
			☒	S	100					
5	–			S	50/½" (no recovery)					SANDSTONE, very weathered, thinly bedded, soft to moderately hard, tan
				S	100/1"					
10										
										Sampler refused at 10'. Auger refused at 11' on sandstone
15										
20										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 3/4/79

LOG OF TEST BORING NO. 34

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6891±

DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		▨	☒	S	11			CL	moist moderately firm	SILTY CLAY, medium pla ticity, dark brown
5	—	░	☒	~~U~~	~~100/6" (no recovery)~~					SANDSTONE, fine grained, very weathered, thinly bedded, moderately hard, tan
10										Sampler refused at 5' Auger refused at 6' on sandstone
15										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

PROJECT 150 Acre Evaporation Ponds
JOB NO. E79-1033 DATE 3/5/79

LOG OF TEST BORING NO. 35

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6891±
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		▨	☒	S	5				moist to slightly moist	SANDY CLAY, medium plasticity, orange-brown
		▨	☒	S	17		9			
		▨						CL		
5		▨	☒	S	5				soft to moderately firm	note: some thin (3"±) lenses of clean sand in upper 10'
10		▨	☒	S	11			SC	moderately firm	CLAYEY SAND, predominantly fine, low plasticity, brown
15		▤	☒	S	59		13			SANDY SHALE, very weathered, thinly laminated, soft to moderately hard, yellow to light brown
		▤		S	50/3"					
20										Stopped auger at 20' Sampler refused at 20'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE
A – Auger cuttings. B – Block sample
S – 2" O.D. 1.33" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.

H

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 3/5/79

LOG OF TEST BORING NO. 36

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6891±

DATUM MSL

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	9			SC	slightly moist moderately firm	CLAYEY SAND, predominantly fine, medium plasticity, brown
			☒	U	9	86	34			
5			☒	S	9			CL	moist moderately firm	SILTY CLAY, medium plasticity, brown
10			☒	S	10			SM	moist medium dense	SILTY SAND, predominantly fine, nonplastic, orange-brown
15			☒	S	100					SANDSTONE, very weathered, thinly bedded, soft, tan
20				S	50/½"					Sampler refused at 20'. Auger refused at 20' on sandstone
25										

GROUND WATER

DEPTH	HOUR	DATE
15'	10:45 am	3/5

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

ITH

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 3/5/79

LOG OF TEST BORING NO. 37

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6895±

DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	10				dry	SILTY SAND, predominantly fine, nonplastic, light brown
			☒	S	9			SM	loose	
5			☒	S	11					
									dry	SILTY SAND, predominantly fine, nonplastic to low plasticity, light brown
10			☒	S	12		5	SM	medium dense	
15			☒	S	7			SM	slightly moist loose	SILTY SAND, trace clay, predominantly fine, low plasticity, orange-brown
20			☒	S	5			CL	wet soft	SILTY CLAY, medium plasticity, brown
25										Stopped auger at 19½' Stopped sampler at 21'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

PROJECT 150 Acre Evaporation Ponds

LOG OF TEST BORING NO. 38

JOB NO. E79-1033 DATE 3/5/79

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6894+
DATUM MSL

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	12		11		slightly moist to dry medium dense	SILTY SAND, predominantly fine, nonplastic, light brown
			☒	S	14		4			
								SM		
5			☒	S	11		5			
10			☒	S	8		9	SM	slightly moist loose	SILTY SAND, predominantly fine, angular, nonplastic to very low plasticity, brown
15			☒	S	11		12		slightly moist to very moist moderately firm	SILTY CLAY, medium plasticity, brown
								CL		
20			☒	S	13		21			
										Stopped auger at 19½' Stopped sampler at 21'
25										
30										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 3/5/79

LOG OF TEST BORING NO. 39

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6896±
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	4			SM	slightly moist loose	SILTY SAND, predominantly fine, nonplastic, light brown
			☒	S	14					
5			☒	S	8			CL	dry moderately firm	SANDY CLAY, medium plasticity, light brown
10			☒	S	8					
15			☒	S	8			SM	dry loose	SILTY SAND, predominantly fine, nonplastic, brown
20			☒	S	7					
25										Stopped auger at 19½' Stopped sampler at 21'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.

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PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 3/5/79

LOG OF TEST BORING NO.

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6896±

DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	32			SM-SC	slightly moist to dry very firm	SILTY SAND, trace cla predominantly fine, l plasticity, light bro
			☒	S	15					
5			☒	U	22	103	6			
								SM	dry loose	SILTY SAND, predominantly fine, nonplastic, light brown
10			☒	S	9					
15			☒	S	10			CL	slightly moist moderately firm	SILTY CLAY, medium pl ticity, dark brown
20			☒	S	11					
25										

Stopped auger at 19½'
Stopped sampler at 21'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sampl
S – 2" O.D. 1.33" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.

KWIT

PROJECT 150 Acre Evaporation Ponds

LOG OF TEST BORING NO. 4

JOB NO. E79-1033 DATE 3/5/79

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6899±
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		○	☒	S	15		13	SM-SC	moderately firm	SILTY SAND, trace clay predominantly fine, lo plasticity, light brow
		▨	☒	S	18		14		very firm	SILTY CLAY, medium pla ticity, brown
5	—	▨	☒	S	21		10	CL		
10		○	☒	S	13		7	SM	medium dense	SILTY SAND, predominantly fine, nonplasti to low plasticity, orange-brown
15		▨	☒	S	17		19	CL	moderately firm	SILTY CLAY, medium pla ticity, dark brown
20		▨	☒	S	13		26			
										Stopped auger at 19½' Stopped sampler at 21'
25										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 3/5/79

LOG OF TEST BORING NO. 4

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6898±

DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	10			SM-SC	slightly moist moderately firm	SILTY SAND, trace clay predominantly fine, lc plasticity, light brow
			☒	S	11					
5			☒	S	6			SM	dry loose	SILTY SAND, predominantly fine, nonplasti to very low plasticity brown
10			☒	U	40	105	19	CL	slightly moist firm	SILTY CLAY, medium pla ticity, dark brown
15			☒	S	15			SM	slightly moist medium dense to loose	SILTY SAND, predominantly fine, nonplasti brown
20			☒	S	8					
25										Stopped auger at 19½' Stopped sampler at 21'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

PROJECT 150 Acre Evaporation Ponds

LOG OF TEST BORING NO. 45

JOB NO. E79-1033 DATE 3/6/79

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6892±
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	14			SM- SC	slightly moist to dry firm	SILTY SAND, trace clay predominantly fine, lo
			☒	S	19					
5			☒	S	26		12		slightly moist to moist	SILTY CLAY, medium pla ticity, brown
									moderately firm to firm	note: some thin lenses of silty sand to about 4" thickness
10			☒	S	7					
								CL		
15			☒	S	12					
20			☒	S	24					
										Stopped auger at 19½' Stopped sampler at 21'
25										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube

VITH

PROJECT 150 Acre Evaporation Ponds

LOG OF TEST BORING NO. 46

JOB NO. E79-1033 DATE 3/6/79

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6893±
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb, 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		▨	☒	S	4				very moist	SILTY CLAY, medium pla ticity, dark brown
		▨	☒	S	8				soft to moderately firm	note: some stratifications of nonplastic silty fine sands
5		▨	☒	S	9			CL with SM		
10		▨	☒	S	15					
15		▨	☒	U	7	110	14			
		▨		S	50/½"					
20										Sampler refused at 20' Auger refused at 20' apparently on sandstone
25										

GROUND WATER

DEPTH	HOUR	DATE
19'	9:40 am	3/6

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 3/6/79

LOG OF TEST BORING NO. 47

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6892+

DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		▨	☒	S	7			CL	moist soft	SILTY CLAY, medium plasticity, reddish brown
		⠿	☒	S	131					SANDSTONE, very weathered, soft to medium hard, light tan
5										Sampler refused at 3½' Auger refused at 4'
10										
15										
20										
25										
30										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sampl

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

ITH

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 3/6/79

LOG OF TEST BORING NO. 48

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6901±

DATUM MSL

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	12			SM-SC	slightly moist moderately firm	SILTY SAND, trace clay predominantly fine, lo plasticity, light brow
			☒	S	55					
5			☒	S	102					SHALE, moderately weathered, thinly bedded, soft to moderately har dark brown
10				S	50/4½"					
15				S	50/1"					
										Sampler refused at 15' Auger refused at 16'
20										

GROUND WATER

DEPTH	HOUR	DATE
--	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

ITH

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 3/6/79

LOG OF TEST BORING NO. 40

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6892±

DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification
0		▨	☒	S	19			
		▨	☒	S	10			
5		▨	☒	S	22			
		▨						CL
10		▨	☒	S	14			
15		▤	☒	S	133			
		░		S	50/½"			
20								
25								

REMARKS	VISUAL CLASSIFICATION
slightly moist to wet moderately firm to firm	SILTY CLAY, medium plasticity, brown note: some thin layers of silty sand
	SHALE, very weathered, thinly bedded, soft to medium hard, brown
	SANDSTONE, moderately weathered, thinly bedded, moderately hard, yellow brown
	Auger refused at 19' Sampler refused at 19'

GROUND WATER

DEPTH	HOUR	DATE
16'	11:40 am	3/6

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.38" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

PROJECT 150 Acre Evaporation Ponds

JOB NO. E79-1033 DATE 3/6/79

LOG OF TEST BORING NO. 50

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6893±

DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification
0		▨	☒	S	15			
		▨	☒	S	4		33	
5	—	▨	☒	S	9			
		▨						CL
10		▨	☒	S	5			
▽		▨						
15		▨	☒	S	5			
20		▨	☒	S	15			
25								

REMARKS	VISUAL CLASSIFICATION
moist above water table soft to stiff	SILTY CLAY, medium plasticity, brown
	Stopped auger at 19½' Stopped sampler at 21'

GROUND WATER

DEPTH	HOUR	DATE
12'	12:30 pm	3/6

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.33" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube.

TH

PROJECT 150 Acre Evaporation Ponds

LOG OF TEST BORING NO. 51

JOB NO. E79-1033 DATE 3/6/79

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6895±
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		▨	☒	S	7				slightly moist to dry soft to moderately firm	SILTY CLAY, medium plasticity, brown
		▨	☒	S	7					
5		▨	☒	S	7					
		▨						CL		
10		▨	☒	S	13					
15		▧	☒	S	10				saturated moderately firm to firm	CLAYEY SAND, predominantly fine, low plasticity, orange-brown
		▧						SC		
20		▧	☒	S	15					
										Stopped auger at 19½' Stopped sampler at 21'
25										

GROUND WATER

DEPTH	HOUR	DATE
14'3"	2:00 pm	3/6

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

PROJECT 150 Acre Evaporation Ponds

LOG OF TEST BORING NO. 52

JOB NO. E79-1033 DATE 3/6/79

RIG TYPE CME-75

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 6900±

DATUM MSL

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		▨	☒	S	22			CL	slightly moist firm	SILTY CLAY, medium pla ticity, dark brown
		▨	☒	S	14					
5		○	☒	S	8			SM-SC	dry loose to medium dense	SILTY SAND, trace clay, predominantly fine, lo plasticity, light brow
10		○	☒	S	13					
		▨						CL	moist to wet soft to medium stiff	SILTY CLAY, medium plas ticity, brown
15		▨	☒	S	5	(no recovery)				
20		▨	☒	S	9					
25										Stopped auger at 19½' Stopped sampler at 21'

GROUND WATER

DEPTH	HOUR	DATE
16'	2:45	3/6
	pm	

SAMPLE TYPE

A – Auger cuttings. B – Block sample

S – 2" O.D. 1.33" I.D. tube sample.

U – 3" O.D. 2.42" I.D. tube sample.

T – 3" O.D. thin-walled Shelby tube

PROJECT 150 Acre Evaporation Ponds
JOB NO. E79-1033 DATE 3/6/79

LOG OF TEST BORING NO. 53

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 6898±
DATUM MSL

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		⁘	☒	S	30			SM	slightly moist firm	SILTY SAND, predominantly fine, nonplasti to low plasticity, orange-brown
		▨	☒	S	12					
5		▨	☒	S	5				dry above water table	CLAY, some sand, mediu to high plasticity, da brown note: scattered gravel encountered in interva of 2½-5'
		▨						CH		
10		▨	☒	S	17					
▽ 15		▨	☒	S	15					
20		░	☒	S	11					SANDSTONE, weathered in place forming silty sand, fine, very low plasticity to nonplastic, tan
25										Stopped auger at 19½' Stopped sampler at 21'

GROUND WATER

DEPTH	HOUR	DATE
14'	3:30	3/6
	pm	

SAMPLE TYPE
A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube

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PROJECT 150 Acre Evaporation

JOB NO. E79-1033 DATE 3/6/79

LOG OF TEST BORING NO. 5

RIG TYPE CME-75
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV.
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot. 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification
0								
5								
10								
15								
20								
25								

REMARKS	VISUAL CLASSIFICATION
Inaccessible due to mud and water	

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.33" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube

APPENDIX D-3
LINER CORRECTIVE ACTIONS AND DAMAGE REPORTS

KERR-McGEE NUCLEAR CORPORATION
KERR-McGEE CENTER • OKLAHOMA CITY, OKLAHOMA 73125

December ~~13~~ 27, 1979

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

Mr. G. W. Stewart
NMEID Radiation Protection Section
P. O. Box 968 - Crown Building
Santa Fe, New Mexico 87503

Re: Ambrosia Lake Mill Evaporation Pond #15

Dear Mr. Stewart:

Recently, you were informed by Kerr-McGee of some liner damage in Pond 15. By phone, I informed you of our intent to repair and we agreed to proceed.

As an interim measure to provide more waste liquor storage capacity through the winter months, the liner was patched with 30 mil CPE and placed in service.

Subsequently, it is our intention in the summer of 1980 to draw the pond down again and replace that entire section of the slope with reinforced 30 mil CPE or equal.

If you have any questions, please call me.

Very truly yours,

W J Shelley

W. J. Shelley, Director
Regulation and Control

WJS:pls

Quivira Mining Company

April 26, 1991

Certified Mail
Return Receipt Requested P 568 963 650

Mr. Richard Ohrbom
Water Resource Specialist
Groundwater Section
New Mexico Environmental Department
P.O. Box 968
Santa Fe, New Mexico 87504-0968

Re: Ambrosia Lake Facility
Discharge Plan - 71

Dear Mr. Ohrbom:

Pursuant to our previous telephone conversations, enclosed is a report describing the events and remedial actions resulting from a liner tear at evaporation pond #20. The tear in the liner was caused by abnormally high winds.

Mr. Pete Garcia and yourself were notified on March 13 at approximately 3:00 and 3:30 p.m. respectively, even though the dollar amount of damage was judged to be minor and not required to be reported under the provisions as contained in NRC's regulation 10 CFR §20.403(b)(4). Presently, the extent of the damage is estimated to be $1,000. At the initial time of notification, each of you were notified of the extent of damage and the corrective measures being initiated to remediate the tear.

As indicated in the attached report, due to the time required to lower the water level below the liner tear, approximately 1.5 feet, an earthen berm was constructed to isolate the evaporation pond water from the liner tear area. The berm was completed at approximately 2:00 p.m. on March 15. Thirty (30) minutes later, all water behind the berm area had been pumped out and into evaporation pond #19. Subsequently, the area behind the berm has been dry with no fluids in contact with the liner tear.

The damaged liner is scheduled to be repaired this summer due to the curing temperature requirements for the patching material. Until the liner is repaired, the berm will be maintained with a pump stationed at the site to remove any fluids that might accumulate. Currently, the area is dry and is not expected to become wet.

6305 Waterford Boulevard, Suite 325, Oklahoma City, Oklahoma 73118 • (405) 848-1190 • FAX (405) 848-1208

On March 21, Ms. Cynthia Corbett of the NRC Uranium Recovery Field Office (URFO) inspected the evaporation pond area and indicated satisfaction with the corrective actions taken by the facility.

Based on the extent of the tear, the area of exposed alluvium, and the time of actual contact, it is estimated the quantity of water that seeped into the underlying formation to be minimal. However, as a precaution, groundwater samples were collected from down dip monitor wells and sent out to be analyzed for the NRC alluvial hazardous constituents. Due to the slow groundwater migration rates within the alluvium, samples will be collected and analyzed semi-annually for the NRC alluvial hazardous constituents in addition to the required quarterly monitoring groundwater samples as prescribed in the discharge plan.

Quivira believes that due to the minimal quantity of water which may have seeped into the alluvium and in combination of the retardation factors of soils within the Ambrosia Lake area, the hazardous constituents normally associated with the evaporation pond solutions will not migrate beyond the disposal area boundary. Although not anticipated to migrate beyond the disposal area, in the unlikely event they do, Quivira will implement appropriate actions in conjunction with NMED and NRC approvals.

If we may be of further assistance or should you have other questions, please contact me at (405) 842-1773.

Sincerely,

Bill Ferdinand

Bill Ferdinand, Manager
Radiation Safety, Licensing &
Regulatory Compliance

Attachments: as stated

xc: M. Freeman
G. Konwinski (NRC)
P. Luthiger
H. Whitacre
File

INTERNAL CORRESPONDENCE

QUIVIRA MINING COMPANY

(UNIT)

TO Bill Ferdinand DATE 8 April 1991

FROM Peter Luthiger SUBJECT Remedial Action Pond 20 Damage

March 12, 1991

On March 12, 1991 at 3:30 pm, after completing the daily mill inspection, the mill shift foreman informed me that part of the synthetic liner for evaporation pond 20 at Section 4 was damaged due to high winds. He stated that he replaced the liner as best as possible and placed lagging on top of it to prevent any additional damage until repairs can begin.

March 13, 1991

On March 13, at 7:00 am, G. Trujillo and myself went to Pond 20 to inspect the damage and if any immediate action was required. The damage to the liner is located in the northeast corner adjacent to Pond 19 (See Figure 1). The length of the rip is 110 feet and the width is 25 feet. The damage extends into the pond below the liquid level. This area has a buildup of sediment above the liner. To ascertain the location of the intact liner, a hole was dug through the sediment. The liner was found at a depth of one and a half (1.5) feet below the liquid level. However, due to the sediment buildup, most of the leakage is through the saturated sediment. The pond liquid is in direct contact with clean alluvium along only twenty (20) feet of the tear zone (See Figure 2).

Immediate remedial action was initiated to stop any additional seepage of liquid from occurring. On March 13 at 2:00 pm, a 300 gallon per minute (gpm) pump was brought to the location, but mechanical failure prevented operation. The necessary parts were obtained and repairs were initiated. Mr. Bill Ferdinand at Rio Algom's corporate offices was notified of the situation at 2:30 pm MST.

From the amount of damage that occurred, estimated at $1000, notification was not required, but was done as a good faith effort.

March 14, 1991

At 10:30 am on March 14, 1991, the pump was started. However, no liquid was being pumped due to inadequate pump head. After moving the pump down to the edge of the liquid level, steady pumping began at 1:30 pm at a rate of approximately 300 gpm. To lower the level of the liquid by two feet, it was estimated that it would take 20 to 30 days.

Due to the time involved, additional action would be required. After consulting with the mine, mill, and maintenance superintendents, it was decided that a berm will be constructed to isolate the damaged area from the rest of the pond. In addition to the berm, a 1500 gpm diesel pump was ordered to complement the 300 gpm pump.

Berm construction began on March 14, 1991 at 1:45 pm. The berm material used was alluvium from the area northwest of Pond 20. The mill superintendent stated that his shift foremen will check the pump status at least once a shift. Construction of the berm continued until 6:00 pm when darkness made conditions unsafe. Approximately half of the berm was completed.

March 15, 1991

Berm construction continued. The 1500 gpm diesel pump arrived, but was not put into service due to the rapid progress on the berm. The berm was completed at 2:00 pm thus isolating the pond liquid from the damaged zone (See Figure 3). The 300 gpm pump removed all standing liquid from behind the berm. All activities were completed by 2:30 pm. The mill superintendent stated that personnel working over the weekend will check condition of area at least once a shift and pump out any liquid that accumulated behind the berm.

March 16, 1991

On March 16, 1991, about 50 to 100 gallons were pumped out of the bermed area. Berm was in good condition.

March 17, 1991

No water was pumped out from behind the berm on March 17. The berm is in good condition and is effectively isolating the pond liquid from the damaged area.

March 18, 1991

On March 18, a tour of the area was conducted by H. Whitacre, A. Gebeau, T. Fletcher, and myself. No liquid was present behind the berm and sediment was beginning to dry out.

March 21, 1991

Inspectors from the Nuclear Regulatory Commission were onsite for their routine inspection. The inspectors were given a tour of Pond 20 and were satisfied with the action taken.

March 22, 1991

Groundwater samples were collected from monitor wells MW-20, MW-22, and MW-23 and sent to Barringer Laboratory for analysis.

Daily inspections performed by mill personnel indicate no additional liquid is ponding in the area behind the berm. The sediment continues to dry out.

Additional Measures Taken

Repair activities will proceed in conjunction with the annual liner repair schedule during the summer months. This is due to the bonding agent curing time requiring warm weather.

Until such time that repairs are completed, the berm will be maintained to prevent seepage of solutions into the underlying alluvium. As an additional preventive measure, the pump will be used to dewater the area behind the berm when required.

Peter Luthiger

Peter Luthiger

KM-3523-B

COMPANY	DEPARTMENT	JOB NUMBER	DRAWING NUMBER
DRAWING BY	DATE / CHECKED BY	DATE	SHEET OF

TITLE

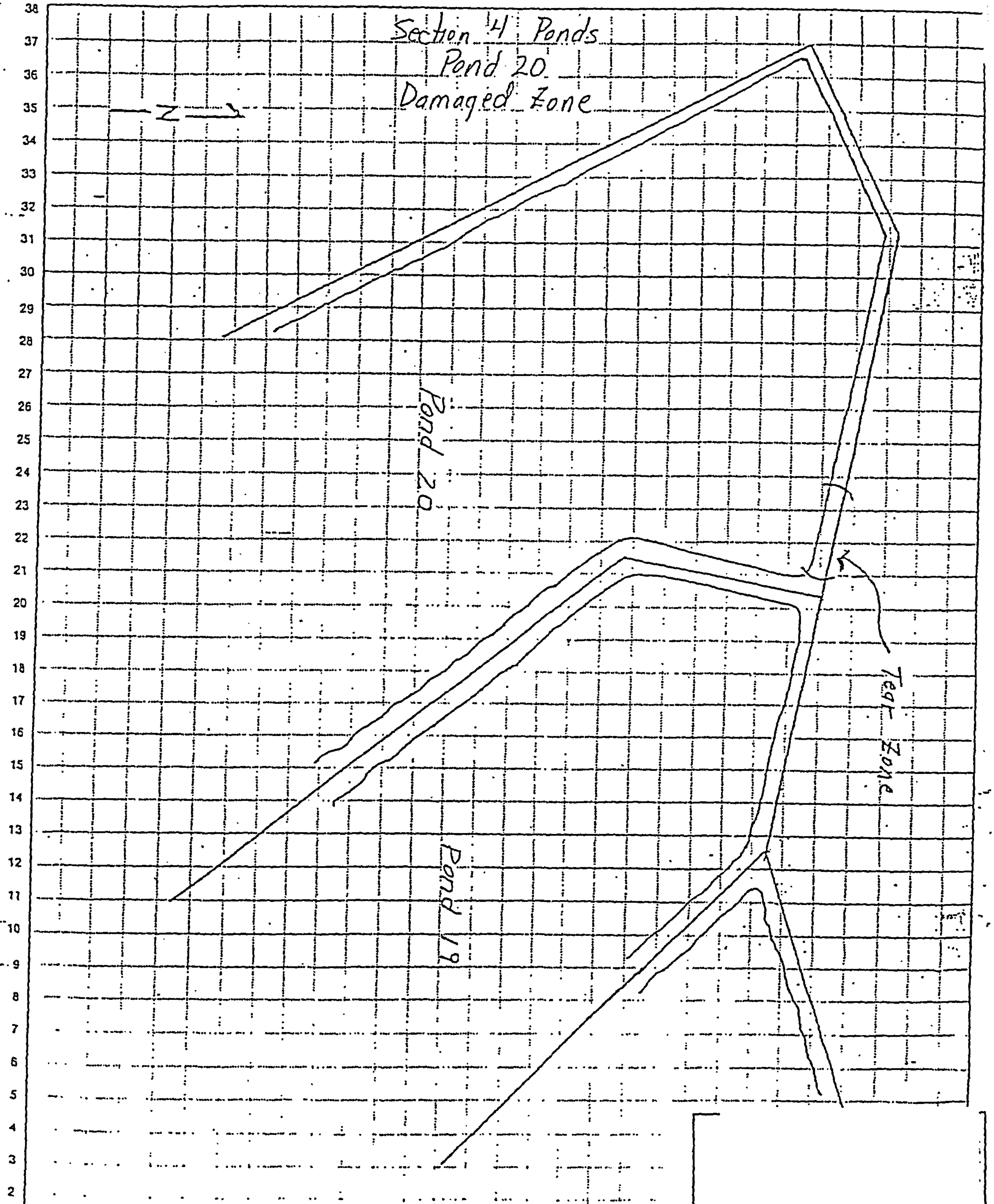


FIGURE 1

KM-3525-B

COMPANY

DEPARTMENT

DRAWING BY

DATE

CHECKED BY

TITLE

Pond 20 Northeast Corner

Damaged Liner Area

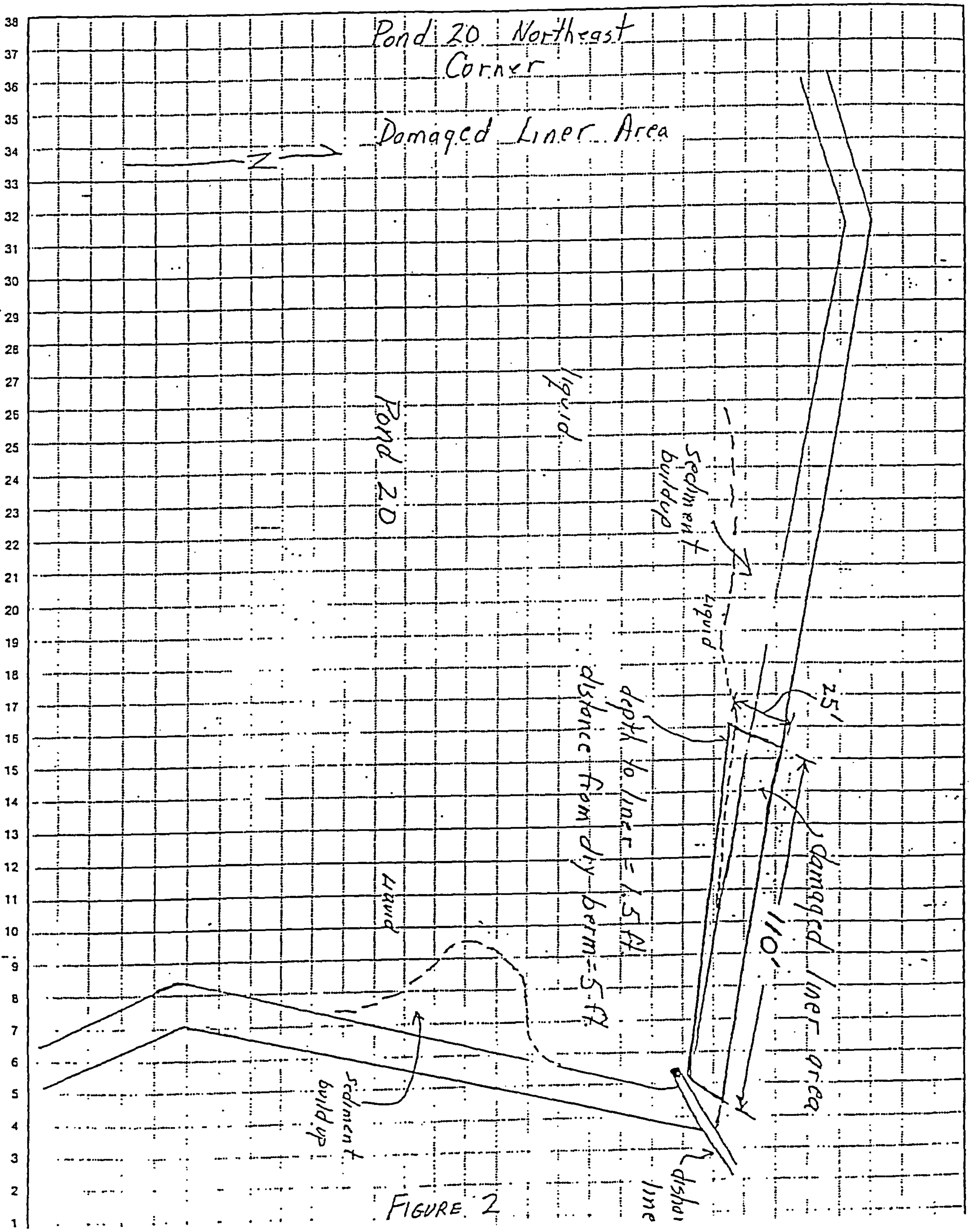


FIGURE 2

KH-3525-8

COMPANY

DEPARTMENT

DRAWING BY

DATE

CHECKED BY

TITLE

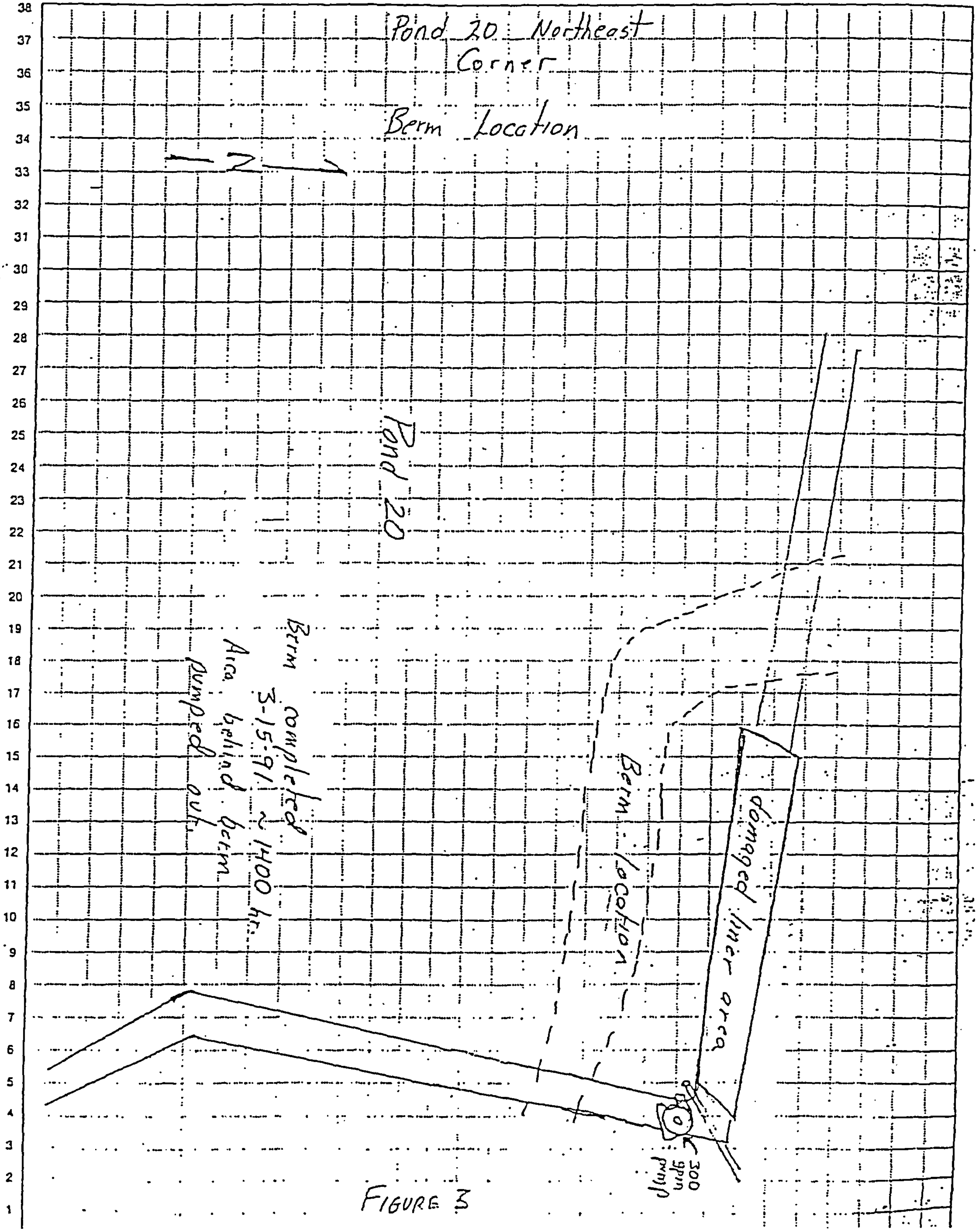


FIGURE 3

RIO ALGOM MINING CORP.

MEMO

To: Rob Luke

From: Marvin Freeman

Date: March 5, 1997

Subject: Pond 19 Liner Tear
Section 4 Lined Pond
Ambrosia Lake, New Mexico

I called Mr. Ken Hooks, NRC Project Manager, today (March 5) at 1:30 p.m. Oklahoma time to advise him that we had a liner tear above the water level along the east berm on Pond 19 that allowed the torn edge of the liner to sag ±6 inches below the water level along a portion of the tear and provided the following general information.

The tear was found late afternoon on March 4 and the portion that was below water level was brought back above the water level and stabilized that same afternoon. The ground in the tear area was wet and this will be allowed to dry out before the final repairs are made.

NRC notification was not required as there was no significant exposure or cost associated with the tear, but we were just advising them of the situation. I told Ken we would forward NRC a copy of the report when it is received.

Ken advised that he agreed that it was not a reportable event, but just to be on the safe side, he would e-mail the notice to his supervisors. Ken will call me if there is any concern by his supervisors.

Peter Luthiger will make a similar notification to the New Mexico Environmental Department today.

MDF:kb
cc: P. Luthiger
T. Fletcher
File - NM NRC

QUIVIRA MINING COMPANY
POST OFFICE BOX 218 • GRANTS, NEW MEXICO 87020

March 10, 1997

Certified Mail
Return Receipt Requested (P 268 360 597)

Mr. Richard Ohrbom
Groundwater Section
New Mexico Environment Department
P.O. Box 26110
Santa Fe, NM 87502

Re: Discharge Plan - 71

Dear Mr. Ohrbom,

As a follow-up and confirmation to our telephone conversation on Wednesday, March 5, 1997, Quivira hereby notifies the Ground Water Bureau of some minor liner damage which occurred to lined evaporation pond #19 due to abnormally strong winds. The damage was discovered at 2:30 p.m. MST on March 4, 1997.

The horizontal liner tear, which is located above the water level along the east berm adjacent to monitor well MW-19, allowed a portion of the lower segment of the liner to sag below the water level allowing pond solutions to seep into the earthen berm. The liner was brought back above the water level and stabilized that same afternoon. Repairs to the berm and liner have been initiated. A final report will be submitted to your office upon completion of repairs.

If you have any questions or need additional information, please call me at 287-8851.

Regards,

QUIVIRA MINING COMPANY

Peter Luthiger
Supervisor, Radiation Safety
and Environmental Affairs

Attachments: As stated

xc: T. Fletcher
M. Freeman
J. Holonich (NRC-MD)
NRC (Arlington)
file

QUIVIRA MINING COMPANY
POST OFFICE BOX 218 • GRANTS, NEW MEXICO 87020

April 1, 1997

Certified Mail
Return Receipt Requested (P 268 360 599)

Mr. Joe Holonich
U.S. Nuclear Regulatory Commission
Uranium Recovery Branch
Division of Low Level Waste Management & Decommissioning
M/S T7J9
11555 Rockville Pike
Rockville, MD 20850

Re: License SUA-1473
Docket No. 40-8905

Dear Mr. Holonich,

Pursuant to Mr. Marvin Freeman's telephone conversation with Mr. Ken Hooks of your staff on March 5, 1997, enclosed is a report describing the events and corrective actions implemented as a result of a liner tear on evaporation pond #19. The damage to the liner was caused by abnormally strong winds. Corrective measures were implemented immediately upon discovery; with final repairs completed on March 13, 1997.

If you have any questions, please call me at (505) 287-8851, extension 205.

Regards,

Peter Luthiger
Supervisor, Radiation Safety
and Environmental Affairs

Enclosure

xc: T. Fletcher
M. Freeman
NRC (Arlington, TX)
R. Ohrbom (NMED-GWPB)
file

QUIVIRA MINING COMPANY
License SUA-1473
Docket No. 40-8905

Completion Report of Minor Liner Damage to Evaporation Pond #19

On March 4, 1997, some minor liner damage was discovered on the east berm of lined evaporation pond #19 resulting from abnormally strong winds. The attached maps indicate the location of evaporation pond #19 and the location of the liner damage. The horizontal liner tear, which is located above the water level along the east berm adjacent to monitor well MW-19, allowed a portion of the lower segment of the liner to sag below the water level allowing pond water to contact the earthen berm under the liner.

Mr. Ken Hooks of the U.S. Nuclear Regulatory Commission and Mr. Richard Ohrbom of the New Mexico Environment Department (NMED) Ground Water Protection Bureau were notified on March 5, 1997 of the situation and that corrective actions were in progress.

Upon discovery, the sagging portion of the lower liner was immediately brought back above the water level to stop any further potential seepage into the pond berm. The damaged area was then stabilized that same afternoon to ensure that the lower liner would remain above the pond water level during repairs. As monitor well MW-19 is located adjacent to the damaged area, a sample was obtained from the well on March 4, 1997 and analyzed for any initial indication of seepage. Monitor well MW-19 is a component of the NMED approved discharge plan for the Section 4 lined evaporation ponds. Results of the water sample, which was analyzed for pH, chloride, and total dissolved solids, indicated no discernible impacts to the well.

Repairs to the berm and liner were initiated on March 5, 1997. As a result of the pond water being in contact with the earthen berm, some minor erosion occurred to the berm due to the wave action caused by the strong winds. Clean alluvial fill material was utilized to replace and refortify the pond berm and to facilitate repairs to the liner. Upon satisfactory completion of the berm restoration, repairs to the damaged liner were initiated.

The upper and lower portions of the torn liner were positioned on the earthen berm and all foreign matter and dirt were removed from the repair area in order to provide a good bonding surface. In addition to this, the edges of the liner along the tear were also cleaned to ensure proper bonding. To ensure a satisfactory seal, an additional piece of liner material was used to overlap the upper and lower liner segments. This "patch" was overlapped at least one (1) foot on all sides of the damaged area.

The bonding material, specifically Chevron Industrial Membrane (CIM), was prepared in accordance with the manufacturer's specifications. After spreading the CIM along all edges of the torn liner, the liner patch was then carefully positioned on top of the CIM layer. After additional CIM was placed on the patch to ensure proper sealing of all edges, the CIM was allowed to cure for approximately 24 hours.

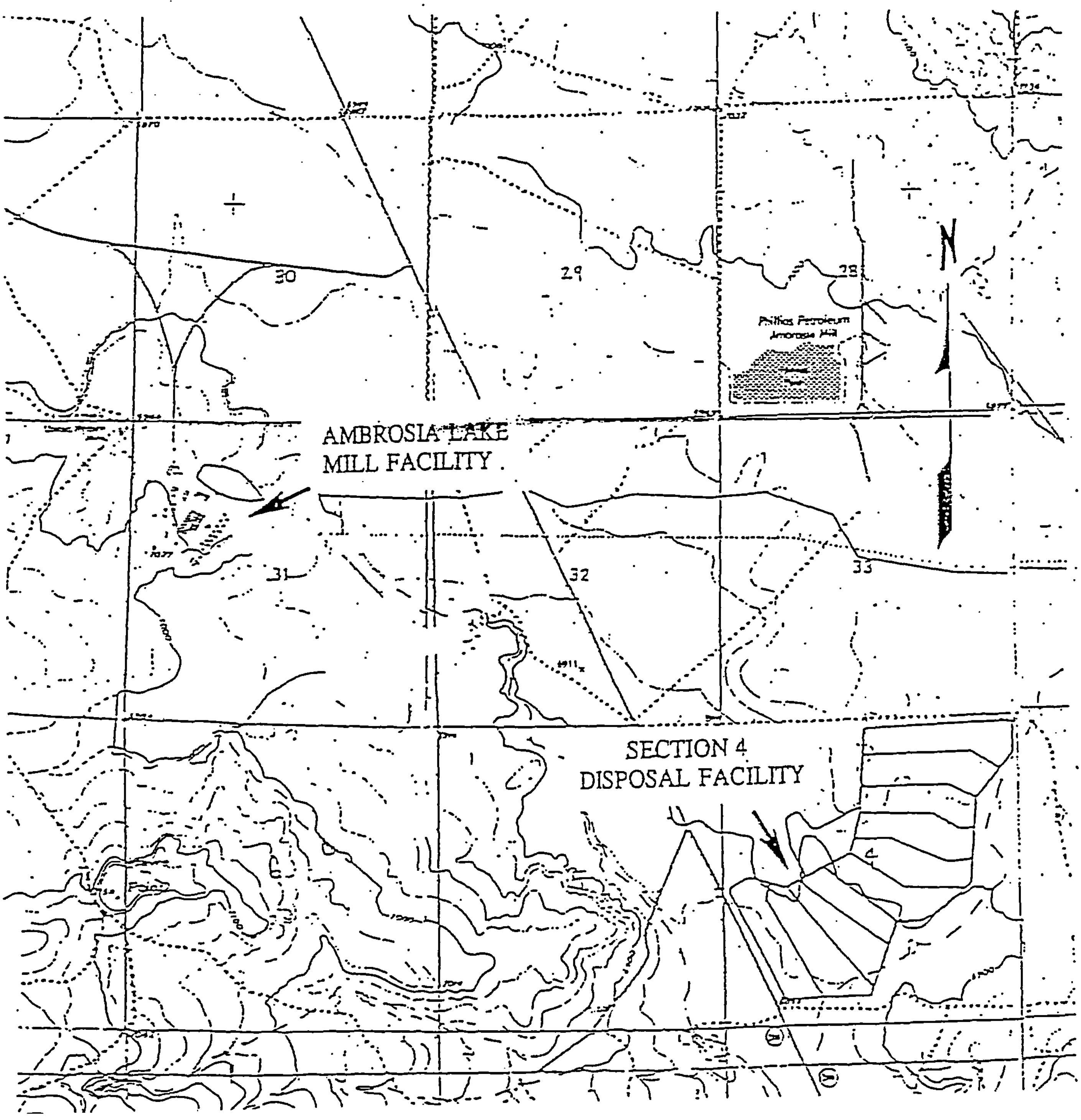
All repair work was inspected to ensure that the corrective measures implemented were successful in repairing the pond liner. Results of this inspection indicated that repairs were satisfactory. Pond 19 will not receive additional solutions for approximately one month in order to allow for continued surveillance of the repaired area.

Based on the extent of the liner tear, the area of exposed berm, and the time of actual contact, it is estimated that the quantity of pond water that seeped into the berm is minimal. However, as a precautionary measure, ground water sampling of the adjacent monitor wells will be performed on a quarterly frequency for pH, chloride, sulfate, total dissolved solids, and nitrate.

Quivira believes that due to the minimal quantity of pond water which may have seeped into the earthen berm, along with the retardation factors exhibited by soils in the Ambrosia Lake area; any seepage which may have occurred is not expected to migrate beyond the disposal area boundary. In the unlikely event monitoring indicates otherwise, Quivira will, in consultation with NRC and NMED, implement appropriate corrective actions.

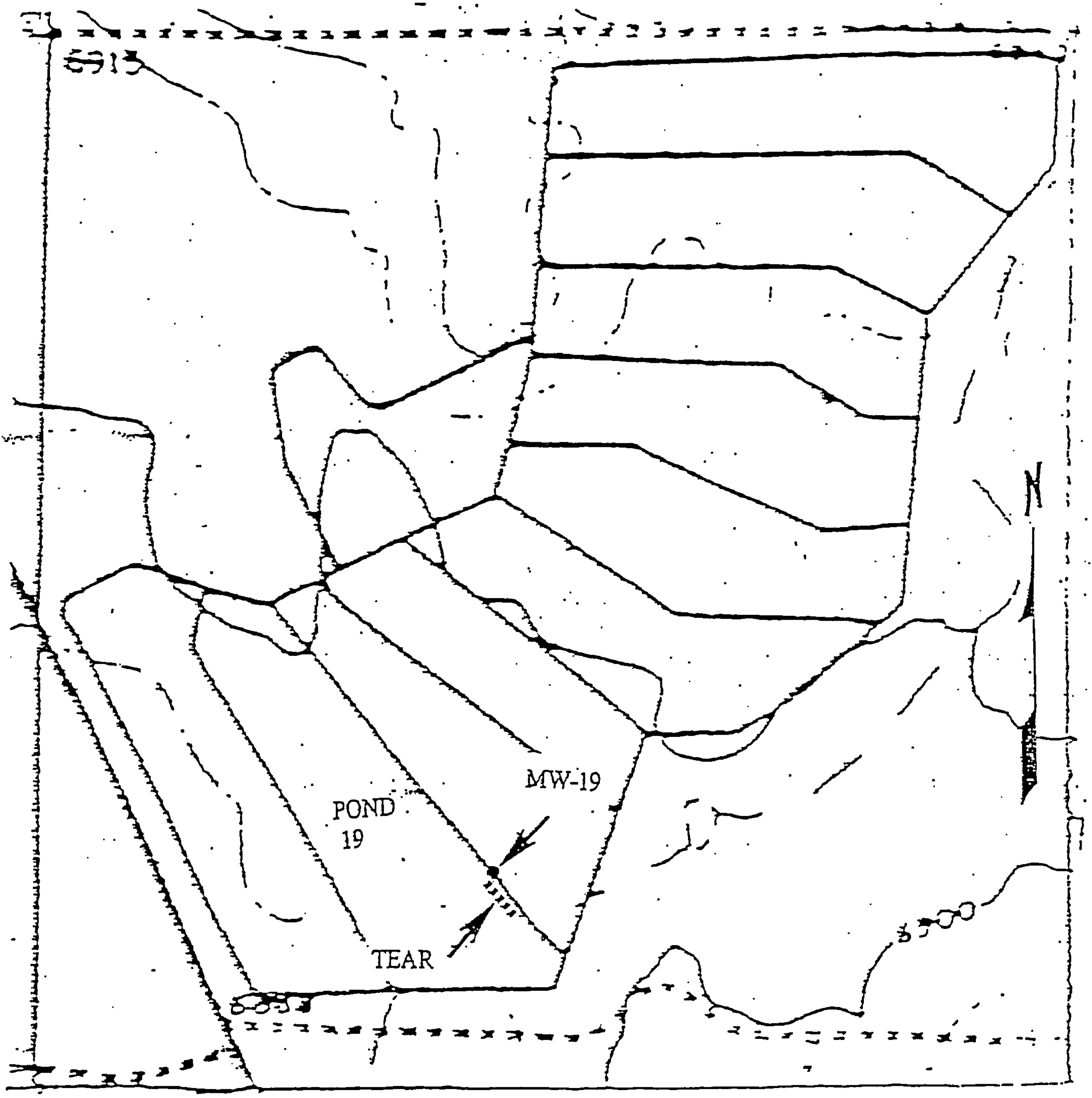
MAP 1

LOCATION OF SECTION 4 EVAPORATION PONDS



MAP 2

LOCATION OF POND 19 LINER TEAR



State of New Mexico
ENVIRONMENT DEPARTMENT
Ground Water Protection and Remediation Bureau
Harold Runnels Building
1190 St. Francis Drive, P.O. Box 26110
Santa Fe, New Mexico 87502
(505) 827-2918 phone
(505) 827-2965 fax

GARY E. JOHNSON
GOVERNOR

MARK E. WEIDLER
SECRETARY

April 15, 1997

Peter Luthiger, Supervisor
Radiation Safety and Environmental Affairs
Quivira Mining Company
P.O. Box 218
Grants, NM 87020

Re: Spill Report, Discharge Plan, DP-71, Section 4 Evaporation Ponds

Dear Mr. Luthiger:

The New Mexico Environment Department (NMED) has received your corrective action report dated March 10, 1997, for the spill which occurred in Pond # 19 on March 4, 1997. This report satisfies the requirements of § 1203 of the WQCC regulations. According to your letter the spill and response was as follows:

High winds on March 4, 1997 caused a 50 foot long horizontal tear in the liner of Pond # 19 which is one of 11 ponds in Quivira's discharge plan, DP-71, Section 4 Evaporation Ponds. The tear occurred above the water line along the east berm of the pond adjacent to monitor well # 19. The lower segment of the liner sagged below the water level allowing pond solutions to seep into the earthen berm. The liner was brought back above the water level and stabilized that same afternoon and repairs initiated. Final repairs consisted of reconstructing a small portion of the berm which was eroded due to wave action associated with high wind conditions, replacing the pond liner on the repaired berm, bonding and reconnecting the edges of the tear, and bonding a one foot overlapping patch over the tear.

Based on the information submitted by Quivira, this corrective action report is hereby approved.

Please be advised that the approval of this corrective action does not relieve Quivira of liability should your operation result in actual pollution of surface or ground water which may be actionable under other laws and/or regulations.

Sincerely,

Marcy Leavitt, Chief
Ground Water Quality Bureau

ML/RO/ro

cc: Dan Vigil, Acting District Manager, NMED District I
NMED Grants Field Office

Quivira Mining Company
P.O. Box 218, Grants, New Mexico, USA 87020

April 1, 1999

Certified Mail
Return Receipt Requested (P 268 361 019)

Ms. Katherine Yuhas
Groundwater Section
New Mexico Environment Department
P.O. Box 26110
Santa Fe, NM 87502

Re: Discharge Plan - 71

Dear Ms. Yuhas,

Pursuant to discharge plan DP-71, Quivira hereby provides the Ground Water Bureau of the New Mexico Environment Department with the attached written notification of a minor leak associated with the lined evaporation ponds authorized under the discharge plan. This written notice follows the verbal notification that Quivira provided to NMED on Friday, March 26, 1999.

Quivira believes that this minor discharge is not in such quantity as may with reasonable probability injure or be detrimental to human health, animal or plant life, or property, or unreasonably interfere with the public welfare or the use of property.

If you have any questions or need additional information, please call me at 287-8851, extension 205.

Regards,

Peter Luthiger
Supervisor, Radiation Safety
and Environmental Affairs

xc: T. Fletcher
P. Goranson
NRC - MD
NRC - TX
file

Notification of Discharge
DP-71

Quivira provides the New Mexico Environment Department following information pursuant to discharge plan DP-71 and Subpart 1203 of the Water Quality Control Commission Regulations.

1203.A.1.a, b. Name, address, and telephone number of person/owner/operator.

Quivira Mining Company
P.O. Box 218
Grants, NM 87020

1203.A.1.c,d. Date, time, duration of discharge.

Pond 12 liner damage identified March 25, 1999 at approximately 1430 MST. Pumping to remove solutions initiated at on March 25, 1999 at approximately 1500 MST. See attached map depicting the location of liner damage. Pond water level was lowered to below the damaged area on March 27, 1999 at approximately 0730 MST. Quivira will continue to lower pond water level in order to facilitate repair crew personnel.

1203.A.1.e. Description of discharge and composition.

Discharge consists of those solutions as described within and authorized under discharge plan DP-71.

1203.A.1.f Estimated volume of discharge.

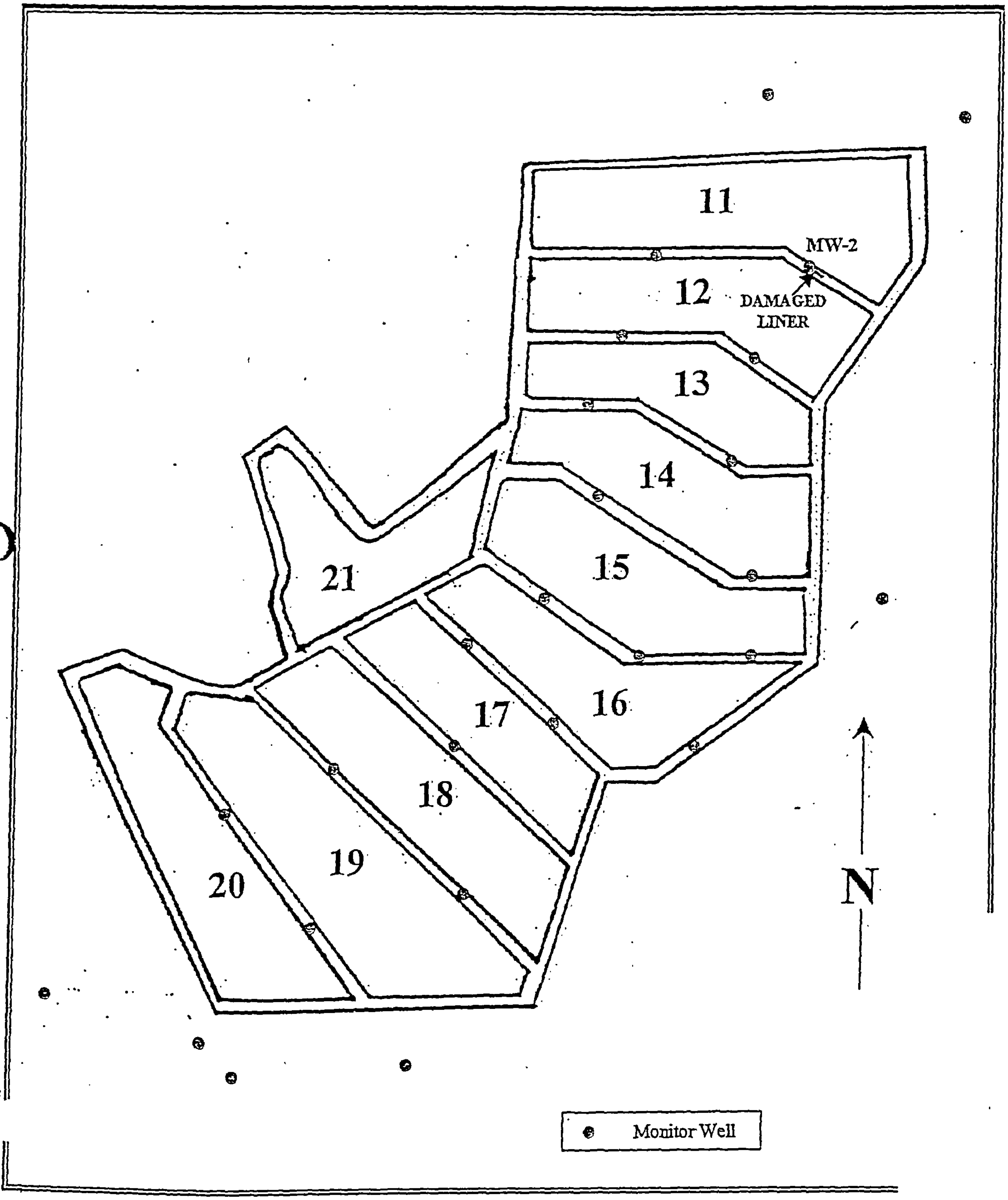
Due to the minor nature of the liner damage in conjunction with the geological properties of the underlying soils, Quivira believes that minimal pond water was discharged. The area of the damage is immediately adjacent to a monitoring well; which was monitored on March 25, 1999 at 1530 hours and was dry. Monitor well continues to be dry as of April 1, 1999.

1203.A.1.f. Actions to mitigate damage from discharge.

Pond 12 liner damage was identified on March 25, 1999 at approximately 1430 hours. Pumping to remove solutions initiated at on March 25, 1999 at approximately 1500 hours.

Quivira intends to initiate liner repairs as soon as the pond water level allows repair crew personnel to work safely around the affected area. This is anticipated to be on April 5, 1999. Quivira will provide a report to NMED upon completion of the repair work.

SECTION 4 EVAPORATION PONDS
DISCHARGE PLAN DP-71



Quivira Mining Company
P.O. Box 218, Grants, NM USA 87020 (505)287-8851

April 7, 1999

Certified Mail
Return Receipt Requested (P 268 360 907)

Mr. Ken Hooks
Uranium Recovery Branch
Division of Low-Level Waste Management
and Decommissioning
11555 Rockville Pike
Rockville, MD 20850

Re: **License SUA-1473**
Docket No. 40-8905

Dear Mr. Hooks,

This letter confirms our telephone conversation on March 30, 1999 and your conversation with Mr. Paul Goranson on March 29, 1999 in which Quivira informed NRC of discovering some minor liner damage on one of the lined evaporation ponds at the Ambrosia Lake facility. Quivira advised NRC of this situation even though notification was not required as there was no significant exposure or cost associated with the liner damage.

Quivira will submit a report to NRC describing the corrective measures that were implemented to repair the damaged liner.

If you have any questions or need additional information, please do not hesitate to call me at (505) 287-8851, extension 205.

Regards,

Peter Luthiger
Supervisor, Radiation Safety
and Environmental Affairs

Attachment: As Stated

xc: A. Delgado
T. Fletcher
P. Goranson

Quivira Mining Company
P.O. Box 218, Grants, NM USA 87020 (505)287-8851

June 2, 2000

Certified Mail
Return Receipt Requested (P 268 361 088)

Mr. Kurt Vollbrecht
Groundwater Section
New Mexico Environment Department
P.O. Box 26110
Santa Fe, NM 87502

Re: **Discharge Plan - 71**
1203 Notification

Dear Mr. Vollbrecht,

As a follow-up of our conversation on May 16, 2000 and as required by Subpart 1203 of the WQCC Regulations, Quivira is providing written notification that Quivira identified a torn liner at one of the Section 4 evaporation ponds. The ponds are permitted under discharge plan, DP-71.

If you have any questions or need additional information, please call me at 287-8851, extension 205.

Regards,

QUIVIRA MINING COMPANY

Peter Luthiger
Supervisor, Radiation Safety
and Environmental Affairs

Attachments: As stated

xc: T. Fletcher
P. Goranson
T. Essig (NRC-MD)
File

NOTIFICATION OF DISCHARGE
QUIVIRA MINING COMPANY
DP-71

Name of Discharger

Quivira Mining Company
P.O. Box 218
Grants, NM 87020
505.287.8851

General Manager: Mr. Terry Fletcher
Supvr. Envir. Affairs: Mr. Peter Luthiger

Nature and Duration of Discharge

On April 18, 2000, mill personnel identified an area on pond 19 approximately 250 feet northwest of well MW-18 where the berm liner was damaged allowing pond water to contact the underlying earthen material. Quivira believes that the liner damage is attributable to strong winds. The water present in the pond is potentially comprised of the following effluent streams: ion exchange brine, tailings dewatering, ground water, uranium processing wastewater, mill process solutions, and spills captured by the mill's spill prevention control and containment system. Pond 19 water quality, as reported to NMED in October 1999, are presented below.

Evaporation Pond Analytical Results

Pond	U	Se	Mo	Pb	As	NO_3	SO_4	TDS	Cl
19	14	3	3.3	<0.01	0.6	6	48800	83400	12600

Note: milligrams per liter.

Corrective Actions Taken To Eliminate Discharge

The mill immediately initiated (April 18, 2000) removal of solutions from pond 19 into pond 20. Removal rate was 600 gallons per minute. The pond level was lowered to below the damaged area during the week of April 24, 2000 at which time repairs to the damaged area were initiated. Repairs were completed during the week of May 8, 2000 and post repair inspections were initiated beginning May 15, 2000. Transfer of the pond solutions continued throughout the repair work in an effort to lower the water level as much as possible to allow additional inspection of other areas. Quivira estimates that the water seepage through the damaged liner occurred for at least two weeks.

Analytical sample results for well MW-18, received on May 15, 2000, indicated that the source of the water in the well was most likely from the lined evaporation ponds. Discharge appears to be isolated instance as no other wells in vicinity of MW-18 display any water quality changes.

APPENDIX E
LABORATORY ANALYTICAL RADIONUCLIDE RESULTS FOR SECTION 4 POND SEDIMENTS

LABORATORY ANALYTICAL REPORT

Client: Rio Algom Mining Corporation LLC
Project: 03-053
Lab ID: C03050140-001
Client Sample ID: Pond 11

Report Date: 05/22/03
Collection Date: 04/25/03 12:00
Date Received: 05/05/03
Matrix: Soil

Analyses	Result	Units	Qual	RL	MCL/ QCL	Method	Analysis Date / By
RADIONUCLIDES - TOTAL							
Radium 226	41.0	pCi/g-dry		0.1		E903.0	05/19/03 17:11 / rs
Radium 226 precision (±)	3.1	pCi/g-dry				E903.0	05/19/03 17:11 / rs
Thorium 230	555	pCi/g-dry		0.01		E907.0	05/14/03 10:30 / ph
Thorium 230 precision (±)	19	pCi/g-dry				E907.0	05/14/03 10:30 / ph
Uranium	102	pCi/g-dry		0.01		SW6020	05/16/03 02:16 / smd

- Thorium 230 results confirmed by analysis of a second sample aliquot.

Report Definitions:	RL - Analyte reporting limit.	MCL - Maximum contaminant level.
	QCL - Quality control limit.	ND - Not detected at th

ENERGY LABORATORIES
ENERGY LABORATORIES, INC. • 2393 Salt Creek Highway (82601) • P.O. Box 3258 • Casper, WY 82602
Toll Free 888.235.0515 • 307.235.0515 • Fax 307.234.1639 • casper@energylab.com • www.energylab.com

LABORATORY ANALYTICAL REPORT

Client:	Rio Algom Mining Corporation LLC	Report Date:	05/22/03
Project:	03-053	Collection Date:	04/25/03 12:00
Lab ID:	C03050140-002	Date Received:	05/05/03
Client Sample ID:	Pond 12	Matrix:	Soil

Analyses	Result	Units	Qual	RL	MCL/ QCL	Method	Analysis Date / By
RADIONUCLIDES - TOTAL							
Radium 226	43.8	pCi/g-dry		0.1		E903.0	05/19/03 18:12 / rs
Radium 226 precision (±)	3.0	pCi/g-dry				E903.0	05/19/03 18:12 / rs
Thorium 230	720	pCi/g-dry		0.01-		E907.0	05/14/03 10:30 / ph
Thorium 230 precision (±)	20	pCi/g-dry				E907.0	05/14/03 10:30 / ph
Uranium	41.6	pCi/g-dry		0.01		SW6020	05/16/03 02:36 / smd

- Thorium 230 results confirmed by analysis of a second sample aliquot.

t
efinitions: RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant
ND - Not detected at th

LABORATORY ANALYTICAL REPORT

Client: Rio Algom Mining Corporation LLC
Project: 03-053
Lab ID: C03050140-003
Client Sample ID: Pond 13

Report Date: 05/22/03
Collection Date: 04/25/03 12:00
Date Received: 05/05/03
Matrix: Soil

Analyses	Result	Units	Qual	RL	MCL/ QCL	Method	Analysis Date / By
RADIONUCLIDES - TOTAL							
Radium 226	36.7	pCi/g-dry		0.1		E903.0	05/19/03 19:12 / rs
Radium 226 precision (±)	3.0	pCi/g-dry				E903.0	05/19/03 19:12 / rs
Thorium 230	896	pCi/g-dry		0.01		E907.0	05/14/03 10:30 / ph
Thorium 230 precision (±)	23	pCi/g-dry				E907.0	05/14/03 10:30 / ph
Uranium	21.4	pCi/g-dry		0.01		SW6020	05/16/03 02:40 / smd

- Thorium 230 results confirmed by analysis of a second sample aliquot.

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

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ENERGY LABORATORIES, INC. • 2393 Salt Creek Highway (82601) • P.O. Box 3258 • Casper, WY 82602
Toll Free 888.235.0515 • 307.235.0515 • Fax 307.234.1639 • casper@energylab.com • www.energylab.com

LABORATORY ANALYTICAL REPORT

Client: Rio Algom Mining Corporation LLC
Project: 03-053
Lab ID: C03050140-004
Client Sample ID: Pond 14

Report Date: 05/22/03
Collection Date: 04/25/03 12:00
Date Received: 05/05/03
Matrix: Soil

Analyses	Result	Units	Qual	RL	MCL/ QCL	Method	Analysis Date / By
RADIONUCLIDES - TOTAL							
Radium 226	14.8	pCi/g-dry		0.1		E903.0	05/19/03 20:12 / rs
Radium 226 precision (±)	2.0	pCi/g-dry				E903.0	05/19/03 20:12 / rs
Thorium 230	1130	pCi/g-dry		0.01		E907.0	05/14/03 10:30 / ph
Thorium 230 precision (±)	32	pCi/g-dry				E907.0	05/14/03 10:30 / ph
Uranium	84.2	pCi/g-dry		0.01		SW6020	05/16/03 02:43 / smd

- Thorium 230 results confirmed by analysis of a second sample aliquot.

rt finitions: RL - Analyte reporting limit. QCL - Quality control limit.

MCL - Maximum contaminant level.
ND - Not detected at the r

LABORATORY ANALYTICAL REPORT

Client: Rio Algom Mining Corporation LLC
Project: 03-053
Lab ID: C03050140-005
Client Sample ID: Pond 15

Report Date: 05/22/03
Collection Date: 04/25/03 12:00
Date Received: 05/05/03
Matrix: Soil

Analyses	Result	Units	Qual	RL	MCL/ QCL	Method	Analysis Date / By
RADIONUCLIDES - TOTAL							
Radium 226	23.4	pCi/g-dry		0.1		E903.0	05/19/03 21:13 / rs
Radium 226 precision (±)	2.4	pCi/g-dry				E903.0	05/19/03 21:13 / rs
Thorium 230	520	pCi/g-dry		0.01		E907.0	05/14/03 10:30 / ph
Thorium 230 precision (±)	21	pCi/g-dry				E907.0	05/14/03 10:30 / ph
Uranium	48.7	pCi/g-dry		0.01		SW6020	05/16/03 02:46 / smd

- Thorium 230 results confirmed by analysis of a second sample aliquot.

ort RL - Analyte reporting limit. MCL - Maximum contaminant lev
efinitions: QCL - Quality control limit. ND - Not detected at t

LABORATORY ANALYTICAL REPORT

Client:	Rio Algom Mining Corporation LLC	**Report Date:**	05/22/03
Project:	03-053	**Collection Date:**	04/25/03 12:00
Lab ID:	C03050140-006	**Date Received:**	05/05/03
Client Sample ID:	Pond 16	**Matrix:**	Soil

Analyses	Result	Units	Qual	RL	MCL/ QCL	Method	Analysis Date / By
RADIONUCLIDES - TOTAL							
Radium 226	31.3	pCi/g-dry		0.1		E903.0	05/19/03 22:13 / rs
Radium 226 precision (±)	2.8	pCi/g-dry				E903.0	05/19/03 22:13 / rs
Thorium 230	352	pCi/g-dry		0.01		E907.0	05/14/03 10:30 / ph
Thorium 230 precision (±)	16	pCi/g-dry				E907.0	05/14/03 10:30 / ph
Uranium	56.8	pCi/g-dry		0.01		SW6020	05/16/03 02:50 / smd

- Thorium 230 results confirmed by analysis of a second sample aliquot.

Report Definitions:	RL - Analyte reporting limit.	MCL - Maximum contaminant level.
	QCL - Quality control limit.	ND - Not detected at

LABORATORY ANALYTICAL REPORT

Client: Rio Algom Mining Corporation LLC
Project: 03-053
Lab ID: C03050140-007
Client Sample ID: Pond 17

Report Date: 05/22/03
Collection Date: 04/25/03 12:00
Date Received: 05/05/03
Matrix: Soil

Analyses	Result	Units	Qual	RL	MCL/ QCL	Method	Analysis Date / By
RADIONUCLIDES - TOTAL							
Radium 226	60.6	pCi/g-dry		0.1		E903.0	05/19/03 23:13 / rs
Radium 226 precision (±)	3.8	pCi/g-dry				E903.0	05/19/03 23:13 / rs
Thorium 230	148	pCi/g-dry		0.01		E907.0	05/14/03 10:30 / ph
Thorium 230 precision (±)	11	pCi/g-dry				E907.0	05/14/03 10:30 / ph
Uranium	77.0	pCi/g-dry		0.01		SW6020	05/16/03 02:53 / smd

- Thorium 230 results confirmed by analysis of a second sample aliquot.

rt
efinitions: RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum cont
ND - Not detected at t

LABORATORY ANALYTICAL REPORT

Client: Rio Algom Mining Corporation LLC
Project: 03-053
Lab ID: C03050140-008
Client Sample ID: Pond 18

Report Date: 05/22/03
Collection Date: 04/25/03 12:00
Date Received: 05/05/03
Matrix: Soil

Analyses	Result	Units	Qual	RL	MCL/ QCL	Method	Analysis Date / By
RADIONUCLIDES - TOTAL							
Radium 226	63.5	pCi/g-dry		0.1		E903.0	05/20/03 00:14 / rs
Radium 226 precision (±)	3.8	pCi/g-dry				E903.0	05/20/03 00:14 / rs
Thorium 230	840	pCi/g-dry		0.01		E907.0	05/14/03 10:30 / ph
Thorium 230 precision (±)	28	pCi/g-dry				E907.0	05/14/03 10:30 / ph
Uranium	39.3	pCi/g-dry		0.01		SW6020	05/16/03 02:56 / smd

- Thorium 230 results confirmed by analysis of a second sample aliquot.

---

port Definitions:	RL - Analyte reporting limit.	MCL - Maximum conta
	QCL - Quality control limit.	ND - Not detected a

LABORATORY ANALYTICAL REPORT

Client:	Rio Algom Mining Corporation LLC	**Report Date:**	05/22/03
Project:	03-053	**Collection Date:**	04/25/03 12:00
Lab ID:	C03050140-009	**Date Received:**	05/05/03
Client Sample ID:	Pond 19	**Matrix:**	Soil

Analyses	Result	Units	Qual	RL	MCL/ QCL	Method	Analysis Date / By
RADIONUCLIDES - TOTAL							
Radium 226	26.7	pCi/g-dry		0.1		E903.0	05/20/03 01:14 / rs
Radium 226 precision (±)	2.5	pCi/g-dry				E903.0	05/20/03 01:14 / rs
Thorium 230	713	pCi/g-dry		0.01		E907.0	05/14/03 10:30 / ph
Thorium 230 precision (±)	24	pCi/g-dry				E907.0	05/14/03 10:30 / ph
Uranium	31.3	pCi/g-dry		0.01		SW6020	05/16/03 03:00 / smd

- Thorium 230 results confirmed by analysis of a second sample aliquot.

Report Definitions: RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level
ND - Not detected at

LABORATORY ANALYTICAL REPORT

Client: Rio Algom Mining Corporation LLC
Project: 03-053
Lab ID: C03050140-010
Client Sample ID: Pond 21

Report Date: 05/22/03
Collection Date: 04/25/03 12:00
Date Received: 05/05/03
Matrix: Soil

Analyses	Result	Units	Qual	RL	MCL/ QCL	Method	Analysis Date / By
RADIONUCLIDES - TOTAL							
Radium 226	33.6	pCi/g-dry		0.1		E903.0	05/20/03 02:14 / rs
Radium 226 precision (±)	2.9	pCi/g-dry				E903.0	05/20/03 02:14 / rs
Thorium 230	1050	pCi/g-dry		0.01		E907.0	05/14/03 10:30 / ph
Thorium 230 precision (±)	31	pCi/g-dry				E907.0	05/14/03 10:30 / ph
Uranium	18.6	pCi/g-dry		0.01		SW6020	05/16/03 03:03 / smd

- Thorium 230 results confirmed by analysis of a second sample aliquot.

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected

NO.

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ANALYTICAL SUMMARY REPORT

May 21, 2003

Peter Luthiger
Rio Algom Mining Corporation LLC
Hwy 605 & 509
PO Box 218
Grants, NM 87020

Workorder No.: C03050140
Project Name: 03-053

Energy Laboratories Inc. received the following 10 samples from Rio Algom Mining Corporation LLC on 5/5/2003 for analysis.

Sample ID	Client Sample ID	Collect Date	Receive Date	Matrix	Test
C03050140-001	Pond 11	04/25/03 12:00	05/05/03	Soil	Uranium, Total Digestion For RadioChemistry Radium 226 Thorium, Isotopic
C03050140-002	Pond 12		05/05/03	Soil	Same As Above
C03050140-003	Pond 13	04/25/03 12:00	05/05/03	Soil	Same As Above
C03050140-004	Pond 14	04/25/03 12:00	05/05/03	Soil	Same As Above
C03050140-005	Pond 15	04/25/03 12:00	05/05/03	Soil	Same As Above
C03050140-006	Pond 16	04/25/03 12:00	05/05/03	Soil	Same As Above
C03050140-007	Pond 17	04/25/03 12:00	05/05/03	Soil	Same As Above
C03050140-008	Pond 18	04/25/03 12:00	05/05/03	Soil	Same As Above
C03050140-009	Pond 19	04/25/03 12:00	05/05/03	Soil	Same As Above
C03050140-010	Pond 21	04/25/03 12:00	05/05/03	Soil	Same As Above

There were no problems with the analyses and all data for associated QC met EPA or laboratory specifications except where noted in the Case Narrative or Report.

If you have any questions regarding these tests results, please call.

Report Approved By:

Date: 21-May-03

CLIENT: Rio Algom Mining Corporation LLC
Project: 03-053
Sample Delivery Group: C03050140

CASE NARRATIVE

THIS IS THE FINAL PAGE OF THE LABORATORY ANALYTICAL REPORT

BRANCH LABORATORY LOCATIONS
eli-b - Energy Laboratories, Inc. - Billings, MT
eli-cs - Energy Laboratories, Inc. - College Station, TX
eli-g - Energy Laboratories, Inc. - Gillette, WY
eli-h - Energy Laboratories, Inc. - Helena, MT
eli-r - Energy Laboratories, Inc. - Rapid City, SD

SUBCONTRACTING ANALYSIS
Subcontracting of sample analyses to an outside laboratory may be required. If so, ENERGY LABORATORIES will utilize its branch laboratories or qualified contract laboratories for this service. Any such laboratories will be indicated within the Laboratory Analytical Report.

SAMPLE TEMPERATURE COMPLIANCE: 4°C (±2°C)
Temperature of samples received may not be considered properly preserved by accepted standards. Samples that are hand delivered immediately after collection shall be considered acceptable if there is evidence that the chilling process has begun.

ENERGY LABORATORIES, INC. - CASPER, WY certifies that certain method selections contained in this report meet requirements as set forth by NELAC. Some client specific reporting requirements may not require NELAC reporting protocol.

ELI appreciates the opportunity to provide you with this analytical service. For additional information and services visit our web page www.energylab.com.

The total number of pages of this report are indicated by the last four digits of the tracking number located in the lower right corner.

BARRINGER LABORATORIES INC.

15000 W. 6TH AVE SUITE 300
GOLDEN COLORADO 80401
PHONE 303 277 1687

1455 DEMING WAY SUITE 15
SPARKS NEVADA 89431
PHONE 702 359 1156

Quivira Mining
P.O. Box 218
Grants, NM 87020

ATTN: Bill Ferdinand

Client No.

Log No. 8223

Client PO No. 50837

Sample Type: soil

Date Collected: 5/27/88

Date Received: 6/1/88

Date Reported: 6/9/88

Sample Identification	Ra-226 pCi/g ±Precision*
AML/27MAY88/S/O/G/ST/Sec. 4EP-12T	7.4 ± 1.4
AML/27MAY88/S/O/G/ST/Sec. 4EP-12B	34 ± 3
AML/27MAY88/S/O/G/ST/Sec. 4EP-16T	26 ± 3
AML/27MAY88/S/O/G/ST/Sec. 4EP-19T	28 ± 3
AML/27MAY88/S/O/G/ST/Sec. 4EP-19B	7.4 ± 1.4
AML/27MAY88/S/O/G/ST/Sec. 4EP-20T	28 ± 3
AML/27MAY88/S/O/G/ST/Sec. 4EP-20B	26 ± 3

* Variability of the radioactive disintegration process (counting error) at the 95% confidence level, 2σ

Approved by

JUN 2 8 1990

BARRINGER LABORATORIES INC

15000 W. 6TH AVE., SUITE 300
GOLDEN, COLORADO 80401
PHONE: (303) 277-1687

1455 DEMING WAY, SUITE 15
SPARKS, NEVADA 89431
PHONE: (702) 358 1158

21-Jun-90

Bill Ferdinand
RIO ALGOM MINING COMP.
6305 Waterford Blvd. #325
Oklahoma City, OK 73118

Page: 1
Copy: 3 of 3
Set : 1

Attn: Rick Chavez
Project:

Received: 23-May-90 10:28
PO #: 51469 (90-091)

Job: 902502E

Status: Final

Sample Type: Soil

Sample Id	Th-230 Total pCi/g	Error 2σ*
AML/22MAY90/S/O/G/ST/EP-15 (0-1.5")	640	±10
AML/22MAY90/S/O/G/ST/EP-15 (1.5-12")	1000	±10
AML/22MAY90/S/O/G/ST/EP-17 (0-1.5")	310	±10
AML/22MAY90/S/O/G/ST/EP-17 (1.5-12")	750	±10
AML/22MAY90/S/O/G/ST/EP-19 (0-1.5")	490	±10
AML/22MAY90/S/O/G/ST/EP-19 (1.5-12")	810	±10
AML/22MAY90/S/O/G/ST/EP-20 (0-1.5")	1810	±20
AML/22MAY90/S/O/G/ST/EP-20 (1.5-12")	2030	±20

APPENDIX F
CATEGORICAL EXCLUSION FOR PROPOSED KGL HAUL ROAD OVERPASS (NM509) NEAR MILAN, NEW MEXICO

NEW MEXICO DEPARTMENT OF
TRANSPORTATION

CATEGORICAL EXCLUSION
STATE PROJECTS

Project Number:	Control Number:	NMDOT District: 6
NMDOT Environmental Services Contract Number:		
Proposed Project: **Proposed KGL Haul Road Overpass (NM 509)**		
Location: **Crossing NM 509 at MP 3.4 near Milan, New Mexico**		County: **McKinley**
Land Ownership: **State Trust Land and NMDOT right-of-way**	Environmental Consultant: **Marron and Associates**	
Contractor: **KGL Associates, Inc.**		

DESCRIPTION OF PROPOSED PROJECT:

KGL Associates, Inc. is planning to construct a two-lane haul road to move uranium mine tailings from a pile located on the north side of NM 509 to a site on the south side of NM 509. The haul road project includes construction of an overpass over NM 509 at milepost (MP) 3.4. The overpass will be 150 feet wide and 700 feet long. The project plans indicate that the foundations for the overpass will be constructed within the NMDOT right of way. The haul road will be in operation for 18 to 24 months and will be removed when the hauling operation is completed. The mine tailings will be transported with a CAT 773B truck. The road bed and shoulders shall be monitored for debris and any waste materials that may fall from the trucks. Monitoring personnel shall be properly trained and provided with appropriate personnel protective equipment. The NMDOT Environmental Geology Section (EGS) has stated that the all mine tailings must be wetted down and covered before they can be transported through NMDOT right-of-way. The NMDOT EGS requires that the construction manager conduct tests of the NMDOT right-of-way within thirty days prior to and after hauling takes place to assure that there is no contamination.

☒ Project Location Map Attached.

GENERAL ENVIRONMENTAL SETTING:

The project area is within a Plains-Mesa Grassland vegetation type located in a large valley with Juniper Savanna to the south and north. Other common plants in the project area include common sunflower, Russian thistle, milkweed, hoary aster nightshade, kochia, ring muhly, gumweed, fleabane, ragwort, alkali sacaton, globemallow, and four-wing saltbush. The project elevation ranges from 6909 to 6915 feet above mean sea level. There are no waterways or wetlands within or adjacent to the project area. The average annual temperature at San Mateo, New Mexico is 48.15 degrees Fahrenheit, and average annual precipitation is 8.66 inches.

OTHER INFORMATION:

NMDOT CATEGORICAL EXCLUSION – STATE PROJECTS

Project Number: | Control Number: | NMDOT District:6

NOTE: 1) The dates entered in sections 1 – 14 refer to when each of the environmental analysis was completed.
2) Attach copies of all agency correspondence including any project specific permits and/or mitigation measures.

---

1 **CULTURAL RESOURCE INVESTIGATIONS:** Conduct cultural resource investigations as directed by the NMDOT Environmental Section.

DATE: ____

☐ No potential to impact cultural resources.
☐ Inventory conducted, no cultural resources located within the area of potential effect other than isolated occurrences, and coordination with land managing agencies and State Historic Preservation Officer completed.
☐ Cultural resources identified, management recommendations developed, and coordination with land managing agencies and State Historic Preservation Officer completed.
☐ Cultural resources identified within the area of potential effect that are currently included in the New Mexico State Register of Cultural Properties or the National Register of Historic Places.

---

2 **TRADITIONAL CULTURAL PROPERTIES:** Contact Janet Spivey, NMDOT Native American/Tribal Coordinator at 505-827-0964.

DATE: ____

☐ Traditional Cultural Property Section 106 coordinated and completed by NMDOT Native American/Tribal Coordinator: **No** Traditional Cultural Property consultations with tribes are needed for this project. See attached documentation.
☐ Traditional Cultural Property consultations completed, **No** Traditional Cultural Properties located within the area of potential effect, and coordination with land managing agencies and Tribal/State Historic Preservation Officer completed.
☐ Traditional Cultural Property consultations completed, Traditional Cultural Properties **Identified**, management recommendations developed, and coordination with land managing agencies and Tribal/State Historic Preservation Officer completed.

---

3 **THREATENED AND ENDANGERED SPECIES:** Conduct threatened and endangered species investigations as directed by the NMDOT Environmental Section.

DATE: 9-12-04

☒ No potential impacts to threatened and endangered species as a result of the proposed project.
☐ Potential impacts to threatened and endangered species have been identified as a result of the proposed project, minimization measures developed and consultation with regulatory agencies completed.
☐ Other biological issues identified:
☐ Biological report prepared.

NMDOT CATEGORICAL EXCLUSION – STATE PROJECTS

Project Number:	Control Number:	NMDOT District: 6

4 **BUREAU OF LAND MANAGEMENT:** If the project traverses BLM managed land, contact the appropriate BLM Field Office to address the potential impacts, alternatives and possible mitigating measures for the proposed action regarding the following Environmental/Program Elements, if applicable:

DATE: 9-12-04

☒ No BLM managed lands identified and no additional coordination required.
☐ BLM managed lands identified, consultations with BLM completed and no additional coordination required.
☐ *BLM managed lands identified, special stipulations and/or mitigating measures apply to the following:

- ☐ Area of Critical Environmental Concern (ACEC)
- ☐ Wilderness or Wilderness Study Area (WSA)
- ☐ Lands (conflicts with other rights-of-ways)
- ☐ Prime or Unique Farmlands
- ☐ Recreation/Visual Resources
- ☐ Planning/Cumulative Impacts
- ☐ Range (special fencing requirements)
- ☐ Special Management Area (SMA)
- ☐ Environmental Justice
- ☐ Wild and Scenic River
- ☐ Flood Plains
- ☐ Minerals (active leases)
- ☐ Forestry/Fire
- ☐ Other:

***See Section 15 – Summary of Environmental Commitments**

5 **SURFACE WATER QUALITY ANALYSIS:** Determine if Waters of the United States, subject to jurisdictional authority under the Clean Water Act, including wetlands, will be impacted by the proposed project.

DATE: 9-12-04

☒ No impacts to jurisdictional Waters of the United States.
☐ Impacts to Waters of the United States, 404 permit obtained, no 401 water quality certification required.
☐ Impacts to Waters of the United States, 404 permit and 401 water quality certification obtained.
☐ Impacts to jurisdictional wetlands, a mitigation plan is being developed in consultation with the appropriate agencies.

6 **GROUND WATER QUALITY ANALYSIS:** Determine if the project will impound water that discharges into ground water and if a Notice of Intent to discharge to ground water is required.

DATE: 9-12-04

☒ No discharges into ground water and no additional coordination required.
☐ Discharges into ground water have been identified, mitigation measures developed in consultation with the appropriate agencies.

NMDOT CATEGORICAL EXCLUSION – STATE PROJECTS

Project Number:	Control Number:	NMDOT District: 6

7 **RIGHT-OF-WAY REQUIREMENTS:** Determine if new right-of-way, construction maintenance easement (CME), temporary construction permit (TCP), or work permits are needed.

DATE: 9-12-04

☒ No new right-of-way is required for the proposed project.
☐ New right-of-way is required. The amount and type of right-of-way required is:

8 **TEMPORARY EROSION AND SEDIMENT CONTROL:** Determine if the provisions of the NPDES General Permit issued by the EPA apply to the proposed project.

DATE: 9-12-04

☒ Less than 0.4 hectares (1 acre) of earth disturbed, NPDES General Permit not required.
☐ The project will disturbed Less than 0.4 hectares (1 acre) of earth, but is located near perennial streams; therefore, a TESCP is being developed.
☐ More than 0.4 hectares (1 acre) of earth disturbed, a SWPPP is being prepared in accordance with the NPDES General Permit issued by the EPA.

9 **REVEGETATION PLAN:** Determine if Revegetation of the project area is needed after construction is completed.

DATE: 9-12-04

☒ No Revegetation of construction area needed.
☐ Revegetation of construction area needed and Revegetation plan developed.

10 **NOXIOUS WEEDS:** Determine if noxious weeds recognized by the New Mexico Department of Agriculture are present within the project limits.

DATE: 9-12-04

☐ No noxious weeds are present and no additional coordination required.
☒ Noxious weeds identified, mitigation measures developed and coordination completed. The species and classification (A, B and/or C) of noxious weeds identified within the project limits are: **Bindweed, a class C noxious weed weed, was documented in the project area.**

11 **AIR QUALITY ANALYSIS:** Determine if the project will affect air quality, if permits are required, if it is located in a non-attainment or maintenance area, and if state or local regulations apply.

DATE: 9-12-04

☒ No air quality issues identified and no additional coordination needed.
☐ Air quality issues identified and regulatory agency coordination completed.

NMDOT CATEGORICAL EXCLUSION – STATE PROJECTS

Project:	Control Number:	NMDOT District: 6

12 **NOISE ANALYSIS:** Determine if noise levels associated with the proposed project will impact receptors on adjacent properties and determine if local noise abatement ordinances apply.

DATE: 9-12-04

☒ No noise issues identified and no additional coordination required.
☐ Noise impacts identified and mitigation measures developed.

---

13 **HAZARDOUS MATERIALS ANALYSIS:** Contact the Environmental Geology Section (EGS) for a level of effort determination at 505-827-0705.

DATE: _____

☐ The EGS has determined no additional investigations are required.
☐ The EGS has determined additional investigations are required. The EGS will coordinate the effort.

---

14 **OTHER ANALYSIS:** Determine if any other environmental requirements/issues apply to the proposed project that have not been addressed in the previous sections 1 – 13.

DATE: 9-12-04

☒ No other environmental requirements/issues identified and no additional coordination required.
☐ Additional environmental requirements/issues identified:

NMDOT CATEGORICAL EXCLUSION – STATE PROJECTS

Project Number:	Control Number:	NMDOT District: 6

15 **SUMMARY OF ENVIRONMENTAL COMMITMENTS:**

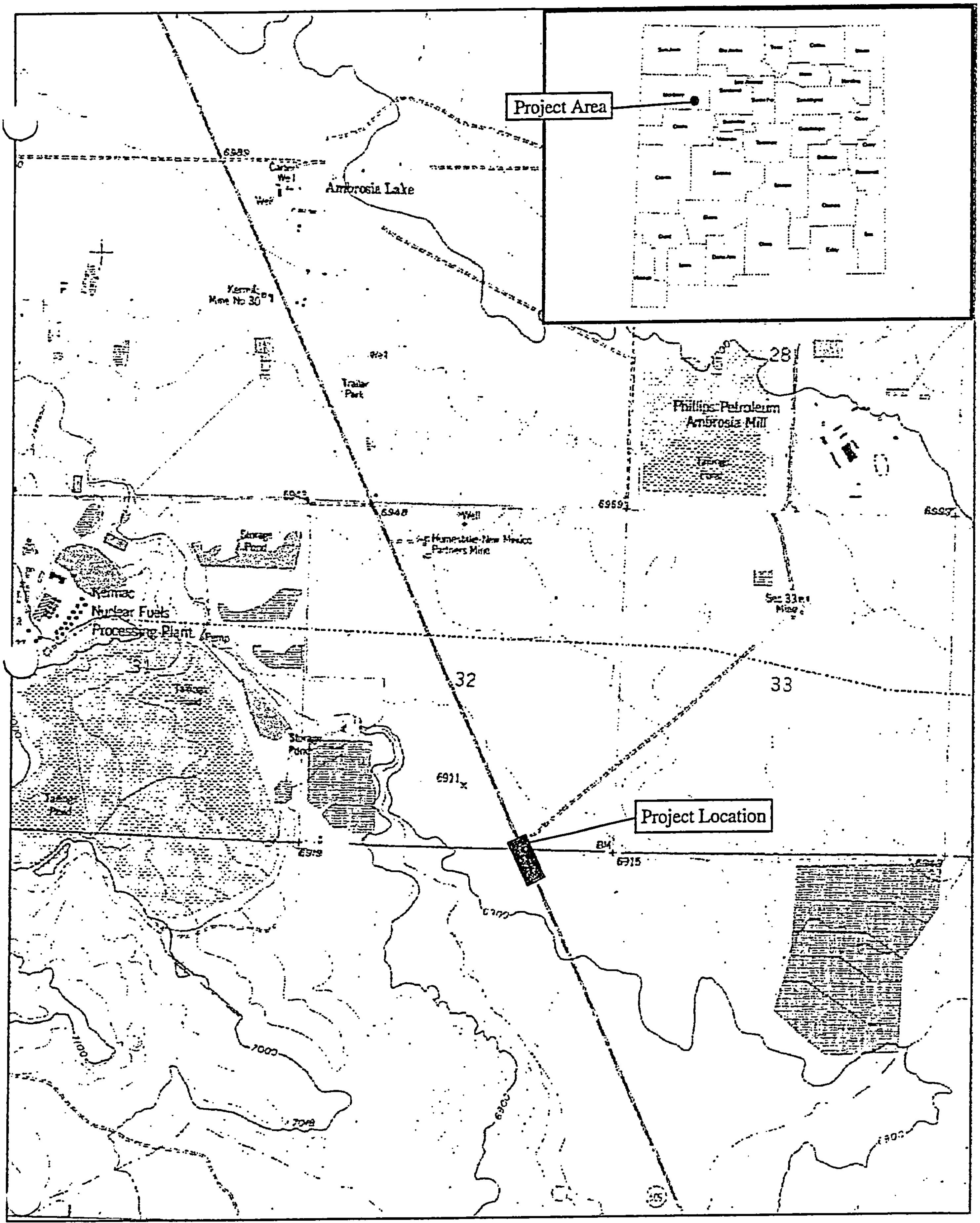
1. **The construction manager will keep the project area clean, and all trash will be disposed of off-site. At the completion of the project, all equipment, and materials will be removed from the project area.**
2. **Monitoring of this project is required by state and federal regulations. Monitoring personnel shall be properly trained and provided with appropriate personnel protective equipment in accordance with 40 CFR 1910.120.**
3. **The NMDOT Environmental Geology Section (EGS) has stated that the all mine tailings must be wetted down and covered before they can be transported through NMDOT right-of-way.**
4. **The NMDOT EGS requires that the construction manager conduct tests of the NMDOT right-of-way within thirty days prior to and after hauling takes place to assure that there is no contamination. Copies of the test reports must be sent to Kathy Kretz at the NMDOT EGS.**

The proposed project will have no significant impact on the quality of the human or natural environment, either singularly or cumulatively, provided stipulations identified during this analysis are met. Supporting documentation is available at the NMDOT Environmental Section.

9-23-04
Environmental Consultant Date

9-30-04
Contractor Date

Environmental Program Manager Date



KGL HAUL ROAD OVERPASS (NM 509) PROJECT

Marron and Associates, Inc.

N

0 0.4 Miles

Ambrosia Lake
Quadrangle, NM
1:24,000

Figure 1
Project Area and
Location Map

Biological Survey Memorandum
for the
KGL Haul Road Overpass (NM 509) Project
Milan, New Mexico (McKinley County)

Prepared by Marron and Associates, Inc.
15 September 2004

INTRODUCTION

KGL Associates, Inc. is planning to construct a two - lane haul road to move uranium mine tailings from a pile on the north side of NM 509 to a site on the south side of NM 509. The haul road project includes construction of an overpass of NM 509 at milepost 3.4. The overpass will be 150 feet wide and 700 feet long. The haul road will be in operation for 18 to 24 months and will be removed when the hauling operation is completed.

BIOLOGICAL SURVEY

A biologist from Marron and Associates, Inc. conducted a biological survey for the project area on September 2, 2004. The survey identified any biological resources that may be impacted by the project, including general vegetation, wildlife, migratory birds, wetlands, noxious weeds, and protected plant and wildlife species. References and databases containing information on biological resources in the project area were reviewed beforehand, including lists of federal and state protected species and the New Mexico Noxious Weed List.

Vegetation

The project area is within a Plains-Mesa Grassland vegetation type located in a large valley with Juniper Savanna to the south and north. The project area is dominated by blue grama grass (*Bouteloua gracilis),* winterfat (*Krascheninnikovia lanata*), rabbitbrush (*Ericamaria nauseosa),* and snakeweed (*Gutierrezia sarothrae*). Other common plants in the project area include common sunflower (*Helianthus annuus),* Russian thistle (*Salsola tragus),* milkweed (*Asclepias subverticillata),* hoary aster (*Machaeranthera canescens)* nightshade (*Solanum elaeagnifolium),* kochia (*Kochia scoparia),* ring muhly (*Muhlenbergia torreyi),* gumweed (*Grindelia acutifolia*), fleabane (*Erigeron* sp.*),* ragwort (*Senecio* sp.), alkali sacaton (*Sporobolus airoides),* pale evening primrose (*Oenothera pallida),* globemallow (*Sphaeralcea* sp.) and four-wing saltbush (*Atriplex canescens).* There were no unusual or rare plant communities within the project area. Upon completion of the project, this area should be replanted with native plant species to reduce soil erosion and provide wildlife habitat.

Wetlands

There were no wetlands or aquatic habitats within the project area.

Noxious Weeds

There were no New Mexico Class A, or B noxious weeds present. Bindweed (*Convolvulus arvensis)* was the only Class C noxious weed in the project area.

Wildlife

A number of vertebrate animals potentially reside in the project area. The majority of the mammals and reptiles in the area are permanent residents in the area and have limited mobility. Many of the birds will be seasonal residents, migrating in and out of the area in the spring and fall, respectively. The birds expected in the project area may include northern mockingbird (*Mimus polyglottos*), mourning dove (*Zenaida macroura*), turkey vulture (*Carthartes aura*), western kingbird (*Tyrannus verticalis*), barn swallow (*Hirundo rustica*), Chihuahuan raven (*Corvus corax*), and scaled quail (*Callipepla squamata).* A turkey vulture was observed during the biological survey. No bird nests were observed within the project area. Other vertebrate species that may be found in the area include pocket gopher (*Thomomys* sp.) desert cottontail (*Sylvilagus auduboni*), black-tailed jackrabbit (*Lepus californicus),* mule deer (*Odocoileus hemionus*), pronghorn (*Antilocapra americana)* coyote (*Canis latrans*), New Mexico whiptail (*Cnemidophorus neomexicanus*), and striped whipsnake (*Masticophis taeniatus*). Mammals detected in the project area were desert cottontail, pocket gopher, kangaroo rat (*Dipodomys ordi),* and mule deer *(Odocoileus hemionus* . This activity will temporarily disturb some wildlife, particularly affecting the habitat of a few birds, small mammals, and reptiles. The project will have a very small effect on wildlife habitat, because the area is already disturbed by fences, mowing, vehicles, and other human activities. These areas currently provide poor quality wildlife habitat. Overall, the proposed project will have a minimal effect on the overall wildlife habitat in the area.

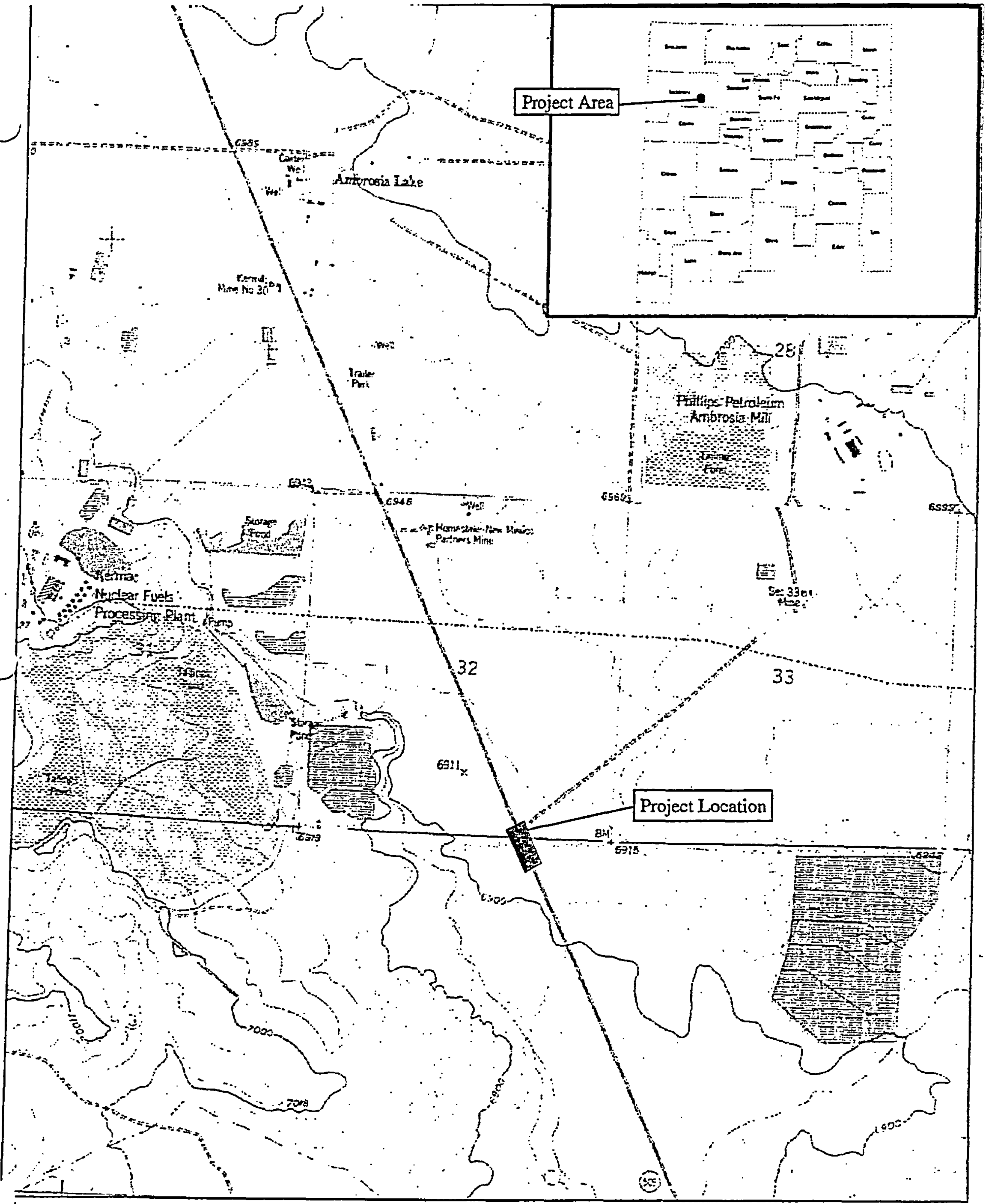
Endangered, Threatened, and Species of Concern

Bird species, such as, peregrine falcon (*Falco peregrinus anatum, Falco peregrinus tundrius)* and bald eagle (*Haliaaeetus leucocephalus*) may fly over the project area. The project area is unsuitable for the bald eagle and many other birds, because there are very few shrubs and no trees for perching and nesting. In addition, there are no cliffs in the project area, which are the preferred habitat of the peregine falcon. There is suitable grassland habitat in the general area outside the project area for mountain plover (*Charadrius montanus).* No mountain plovers were observed in the project area and grassland within the right-of-way is too tall for plover habitat. The project area does not contain suitable habitat (coniferous woodland) for the Mexican spotted owl (*Strix occidentalis lucida),* northern goshawk (*Accipiter gentilis),* and gray vireo (*Vireo vicinior).* The project area lacks any riparian habitats that are required by the southwestern willow flycatcher (*Empidomax traiilii extimus),* yellow-billed cuckoo (*Coccyzus americanus),* and black tern (*Chlidonas niger).* Western burrowing owl (*Athene cunicularia*) and black-tailed prairie dog (*Cynomys ludovicianus*) were searched for, but not found. No federal or state listed wildlife species were detected in the project area, and project activities will not affect any of these listed species.

The listed plants that occur in McKinley County include Gooding's onion (*Allium goodingii),* Acoma fleabane (*Erigeron acomanus),* Sivinsky's fleabane (*Erigeron sivinskii),* Parish's alkali grass (*Puccinellia parishii),* and Zuni fleabane (*Erigeron rhizomatus).* There is no suitable habitat in the project area for these listed plants.

CONCLUSIONS

After completion of the project, it is recommended that the cleared area be revegetated with native plants. No wetlands or other surface water sources occur in the project area. Bindweed was the only Class C noxious weed found in the project area. The biological survey did not detect any federal or New Mexico listed wildlife or plants within the project area. Overall, the project will have minimal effects to vegetation, wildlife, and the environment.



KGL HAUL ROAD OVERPASS (NM 509) PROJECT

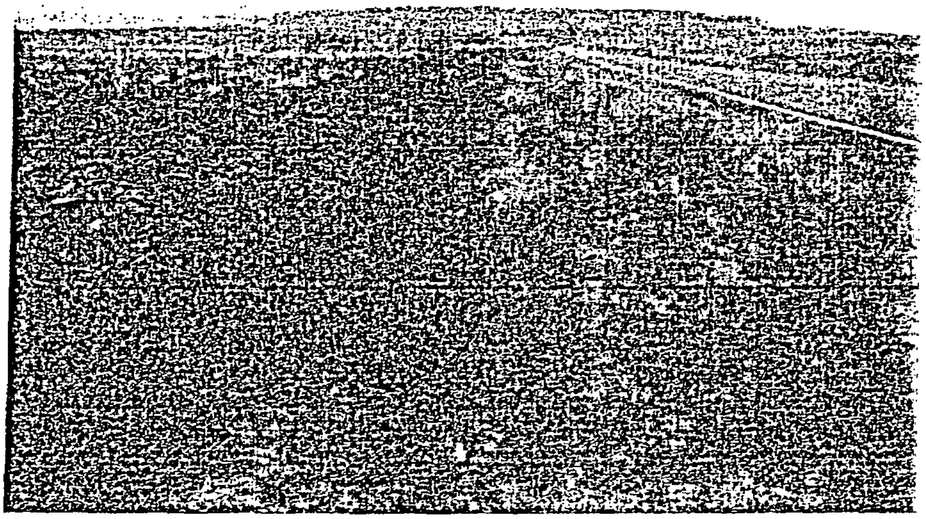
Marron and Associates, Inc.

N

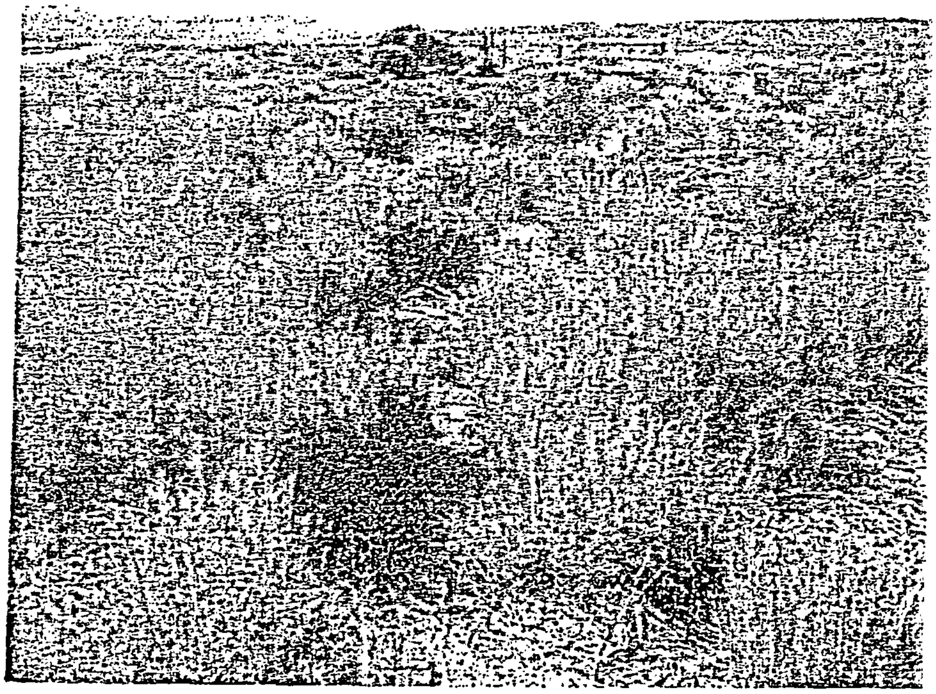
0 0.4 Miles

Ambrosia Lake
Quadrangle, NM
1:24,000

Figure 1
Project Area and
Location Map



Photograph of existing NM 509-- adjacent to the project area.



Typical vegetation in the project area.

KGL HAUL ROAD OVERPASS (NM 509) PROJECT

Marron
and Associates, Inc.

Figure 2
Photographs of the
Project Area

Marron and Associates, Inc.

CULTURAL RESOURCE REPORT

Class I and Class III Cultural Resource Survey for a Proposed Mine Tailings Haul Road Across NM 509 South of Ambrosia Lake, McKinley County, New Mexico

PREPARED BY
Marron and Associates, Inc.
7511 Fourth Street NW
Albuquerque, New Mexico 87107

PREPARED FOR
Bohannan Huston, Inc.
Courtyard One, 7500 Jefferson NE
Albuquerque, New Mexico 87109

SEPTEMBER 2004

CULTURAL RESOURCE REPORT

Class I and Class III Cultural Resource Survey for a Proposed Mine Tailings Haul Road Across NM 509 South of Ambrosia Lake, McKinley County, New Mexico

By
Timothy G. McEnany

NM State Permit No. NM-04-160

Prepared by
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Marron and Associates Cultural Resource Report No. 0095

NMCRIS Project No. 89969

September 2004

STATE LAND NEGATIVE SURVEY REPORT FORM

1. **Type of project and brief description (include highway number and mileposts, if applicable):** Bohannan Huston of Albuquerque, New Mexico is consulting with KGL Associates, Inc., in Golden, Colorado in preparation for proposed construction of a mine tailings haul road 3.2 km (2 mi) southeast of Ambrosia Lake in McKinley County, northwest New Mexico. The project Area of Potential Effect (APE) is in the NM 509 right-of-way. The northern two-thirds of the project APE is on New Mexico State Trust Land and the southern two-thirds of the project is on New Mexico Department of Transportation (NMDOT) right-of-way acquired from private sources. The Class I records search and Class III cultural resource survey was performed by Marron and Associates, Inc. (Marron) at the request of Mr. Rob Croft of Bohannan Huston. Inc. The records search and fieldwork were completed on September 2, 2004.

The proposed KGL haul road will cross NM 509 at Mile Post 3.4 southeast of Ambrosia Lake. The haul road is expected to be in use for a period of 18 to 24 months. Mine tailings will be moved from the west side of NM 509 and deposited on the east side of the highway. The proposed project has two options for crossing NM 509. Option A consists of a proposed two-lane overpass consisting of a 44-ft long structural plate span over NM 509. Option B is a 100-ft long single span pre-stressed concrete girder bridge on NM 509. The span would be of sufficient height to provide adequate clearance for the haul road lanes below.

The NM 509 right-of-way is 46 m (151 ft) wide. An area 107 m (350 ft) long was examined for cultural resources on each side of the haul road centerline that is perpendicular to the NM 509 right-of-way. Corner points of the surveyed rectangular parcel, measuring 221 m (725 ft) long and 46 m (151 ft) wide were marked with flagging tape and recorded with a Garmin GPS unit. NM 509 has two 3.7 m (12 ft) wide lanes with 2.4 m (8 ft) shoulders. The unpaved rights-of-way on each side of NM 509 are 16.8 m (55 ft) wide. These areas were inspected for cultural resources by walking two parallel transects spaced no greater than 10 m (33 ft). Each side of NM 509 within the project APE was 0.36 ha (0.9 ac), with a surveyed APE totaling 0.73 ha (1.8 ac).

This undertaking complies with the provisions of the National Historic Preservation Act of 1966 (16 USC 470, as amended), Protection of Historic and Cultural Properties (36 CFR 800), New Mexico Cultural Properties Protection Act, and applicable regulations. This report is consistent with applicable state standards for cultural resource management. Kenneth Brown served as the Principal Investigator for the project. Timothy McEnany conducted the cultural resource survey. A total of 5 person-hours (including drive time) and a total driving distance of 280 km (175 mi) were required to complete the survey.

NM 509 is a two-lane paved road. The project area had been affected by past highway construction. Vegetation cover averaged 30 percent. In addition, two side roads enter the right-of-way from east and west of NM 509. No cultural resources were discerned.

The survey area is in the SE1/4, SW1/4, SE1/4 of Section 32, Township 14 North, Range 9 West, and the (protracted) NE1/4, NW1/4, NE1/4 and the NE1/4, NE1/4, NW1/4 of Section 5, Township 13 North, Range 9 West on the Ambrosia Lake 1957/1980 (35107-D7) 7.5 minute quadrangle. The following table summarizes the UTM coordinates (Zone 13) for the project area landmarks. The coordinate data was collected using a Garmin (Legend) GPS unit. The unit has an estimated error of no greater than 3 m (10 ft).

The total surveyed APE was 0.73 ha (1.8 ac) of which 0.24 (0.6 ac) was New Mexico State Trust Land and 049 ha (1.2 ac) is NMDOT NM 509 right-of-way acquired from private sources. The project area in Section 5 is NMDOT right-of-way and the area in Section 32 is New Mexico State Trust Land.

Project area UTM coordinates (Zone 13)

Landmarks	UTM Coordinates Zone 13	
	Easting	Northing
Northeast Corner of APE	244879	3919921
East Side Haul Road Centerline	244926	3919822
Southeast Corner of APE	244974	3919721
Northwest Corner of APE	244839	3919903
West Side Haul Road Centerline	244888	3919803
Southwest Corner of APE	244934	3919703

2. **Agency Project Number (if applicable):** N/A

3. Report title. : *Class I and Class III Cultural Resource Survey for a Proposed Mine Tailings Haul Road Across NM 509 South of Ambrosia Lake in McKinley County, New Mexico.*

4. **Author:** Timothy G. McEnany, edited by Kenneth L. Brown

5. **Report number:** Marron and Associates, Inc., Cultural Resource Report No. 0095

6. **Cultural resource consultant:**
   a. **Company name:** Marron and Associates, Inc.
   b. **Address:** 7511 Fourth Street NW, Albuquerque, New Mexico 87107
   c. **Phone number:** (505) 898-8848
   d. **Field supervisor:** Timothy G. McEnany
   e. **Field personnel:** Timothy G. McEnany

7. **Permit number:**
   a. **State Land Permit:** NM-04-160
   b. **Other Agency Permit:** NA

8. **NMCRIS Project Activity Number:** 89969

9. **Sponsor/contractor name, address and phone number:** Bohannan Huston, Inc., Courtyard 1, 7500 Jefferson Street NE, Albuquerque, New Mexico. (505-823-1000)

10. **Acreage by land status:**
   a. **Federal:** None
   b. **State Land:** 0.6 acres (Trust); 1.2 acres NMDOT right-of-way from private sources
   c. **Private:**
   d. **Total Number of Acres Surveyed:** 1.8 acres

11. **Location: (Attach 7.5'maps)**
   a. **County:** McKinley
   b. **Nearest city or town:** Milan

c. **Legal description:** SE1/4, SW1/4, SE1/4 of Section 32, T 14 N, R 9 W, and the (protracted) NE1/4, NW1/4, NE1/4 and NE1/4, NE1/4, NW1/4 of Section 5, T 13 N, R 9 W

d. **7.5' map name:** Ambrosia Lake 1957/1980 (35107-D7)

e. **Size of survey area (length by width):** two 221 by 16.8 m (725 by 55 ft) parcels adjacent to NM 509

12. **Date of records search:**
    a. **NMCRIS:** August 30, 2004
    b. **Other Records (please indicate which records and date of search):** None

13. **List by LA# and site type all sites within 1 mile of project area:** (see table below). Twenty-one archaeological sites have been recorded within a 1.6 km (1 mi) radius of the haul road project area. The twenty-one previously recorded sites are summarized and referenced in the following table. There are no properties listed on the National Register of Historic Places (NRHP) or the New Mexico State Register of Cultural Properties (SRCP) within a 1.6 km (1 mi) radius of the project area. The Kin Nizhoni Chacoan structures and associated community, however, lie just beyond the limits of this area east of NM 509 (Marshall et al. 1979; Powers et al. 1983). The Chacoan structures (LA 18226 and LA 18166) are on the south side of a small mesa 0.8 km (0.5 mi) from NM 509. The associated community sites are distributed in a v-shaped arc around the west, south, and east sides of the mesa. The community dates to the late Pueblo II and early Pueblo III periods (ca. AD 1000 to 1200). The Kin Nizhoni Archaeological district is listed on both the SRCP and NRHP. At least one archaeological site is present in all but the smallest of previously surveyed areas in the vicinity.

Recorded archaeological sites within 1.6 km (1 mi) of the project area.

LA No.	*Cultural Affiliation*	Reference	NMCRIS No.
22487	Anasazi, wall	Dulaney and Dosh 1981	5811
22488	Anasazi, masonry roomblock	Dulaney and Dosh 1981	5811
22489	Anasazi, masonry roomblock	Dulaney and Dosh 1981 Betancourt 1978	5811 11728
22490	Anasazi, artifact scatter	Dulaney and Dosh 1981	5811
50370	Anasazi, hearth and midden	Hammack 1985	7112
50371	Anasazi, hearth and midden	Hammack 1985 Baugh et al. 1990	7112 32192
50372	Anasazi, hearth	Hammack 1985	7112
50373	Anasazi, hearth and midden	Hammack 1985	7112
50374	Anasazi, artifact scatter	Hammack 1985	7112
50375	Anasazi, artifact scatter	Hammack 1985	7112
50376	Anasazi, kiva and roomblock	Hammack 1985	7112
50377	Anasazi, hearth	Hammack 1985	7112
50378	Anasazi, hearth	Hammack 1985	7112
50379	Anasazi, hearth	Hammack 1985	7112
50380	Anasazi, kiva, midden, and mound	Hammack 1985	7112
82633	Anasazi, artifact scatter	Viklund 1990	35139
82634	Anasazi, artifact scatter	Viklund 1990	35139
82635	Anasazi, artifact scatter	Viklund 1990	35139
140033	Reserved	Applied Ecosystem Management	84367
140034	Reserved	Applied Ecosystem Management	84367
140035	Reserved	Applied Ecosystem Management	84367

In addition to these surveys, three projects (see table below) have been conducted in the vicinity of the haul road project that did not yield any recorded sites within a radius of 1.6 km (1 mi).

Surveys conducted near the project area that did not yield recorded sites within 1.6 km (1 mi) of the project area.

NMCRIS No.	Reference	NMCRIS No.	Reference
16327	Snow 1976	18663	Hammack 1987
22740	Hammack 1988		

14. Pertinent cultural overview references and relevant recent major research in the project area:

Applied Ecosystem Management
n.d. Reserved

Baugh, T. G.
1990 *Ambrosia Lake Project: 3 Small Sites Associated with the Chacoan Outlier of Kin Nizhoni for MK-Ferguson, New Mexico Prehistoric New Mexico, Background for Survey.* University of New Mexico Press, Albuquerque. NMCRIS 32192.

Betancourt, Julio L.
1978 Underground Telephone Cable to Kippen Mine for Mountain Bell Telephone Co. Office of Contract Archaeology Report 185-002KK, University of New Mexico, Albuquerque. NMCRIS 11728.

Dulaney, Alan R., and Steven G. Dosh
1981 *A Class II Cultural Resources Inventory of the Southern Portion of the Chaco Planning Unit, McKinley and Sandoval Counties, New Mexico.* Museum of Northern Arizona, Flagstaff. NMCRIS 5811.

Hammack, Laurens C.
1985 *Ambrosia Lake, New Mexico Tailings Site for Jacobs Engineering Group.* Complete Archaeological Services Paper No. 11. Cortez. NMCRIS 7112.

1987 *Cultural Resource Inventory of Various Construction-related Features, NMSHTD Project ST-(S)1344(200) at Ambrosia Lake, McKinley County, New Mexico.* Complete Archaeological Services. Cortez. NMCRIS 18663.

1988 Voight Tank Area, *Ambrosia Lake Unit for MK-Ferguson Co..* Complete Archaeological Services. Cortez. NMCRIS 22740.

Marshall, Michael P., John R. Stein, Richard W. Loose, and Judith E. Novotny
1979 *Anasazi Communities of the San Juan Basin.* Public Service Company of New Mexico, Albuquerque, and Historic Preservation Bureau, Santa Fe.

Powers, Robert P., William B. Gillespie, and Stephen H. Lekson
1983 *The Outlier Survey: a Regional View of Settlement in the San Juan Basin.* Division of Cultural Research, National Park Service, Albuquerque.

Snow, David H.
1976 *Two Right-of-ways in the Ambrosia Lake Area for Mountain Bell Telephone Company*. Office of Cultural Affairs, Museum of New Mexico, Santa Fe. NMCRIS 16327.

Stuart, David E., and Rory P. Gauthier
1981 *Prehistoric New Mexico, Background for Survey*. University of New Mexico Press, Albuquerque.

Viklund, L.
1981 *Homestake-New Mexico Partners Mine for Homestake Uranium Mine*. Southwest Archaeological Consultants Report 260. NMCRIS 35139.

15. **Environmental setting (include discussion of amount of vegetative cover):** The project area lies at an elevation of 2112 m (6930 ft) northwest of the confluence of Arroyo del Puerto and San Mateo Creek. San Mateo Mesa rises to an elevation of approximately 2499 m (8200 ft) east of the project area. Mesa Montenosa is visible to the southwest. In the valley, several mine tailing ponds are near Havre Point northwest of the project area. Ground visibility averaged 70 percent. Local vegetation includes snakeweed, rabbitbrush, globe mallow, prickly pear, grama grass, Russian thistle, and four-wing saltbush. Surface soil deposits consist of a brown sandy loam with limestone gravel.

16. **Condition of survey area (grazed, bladed, dense vegetation cover, undisturbed, etc.):** The project area has been affected by past highway construction and maintenance. Vegetation cover averaged 30 percent. Two side roads enter the NM 509 right-of-way from the east and west.

17. **Percent ground visibility:** 70 percent average

18. **Field Methods:**
    a. **Transect intervals:** 10 m
    b. **Crew size:** one person
    c. **Time in field:** 5 person hours

19. **Cultural resource results (include possible reasons for lack of sites in project area, such as known distribution, or lack thereof, of sites; land modification, vegetative cover, size of project area, etc):** No cultural resources were discerned in the project APE. The absence of prehistoric or historic sites is attributed to ground modification from highway construction and maintenance as well as mining activities (e.g., side roads within the project APE). Also, the project APE is small and would less likely contain cultural resources. Vegetation cover was not a factor.

20. **The following attachments must be included:**
    a. **Project location map**
    b. **Table of Isolated Occurrence descriptions and locations (shown on map), if applicable**
    c. **Bridge photos, if applicable (if older than 1971 and no effect)**
    d. **NMCRIS Project/Activity Form**
    e. **Historic Cultural Properties Inventory (HCPI) form, if applicable**
    f. **Cover letter from sponsoring agency**

I certify that the information provided above is correct and accurate and meets all New Mexico State Land guidelines.

Permitted PI Kenneth L Brown 9/9/04

Signature
Kenneth L. Brown

Date
September 9, 2004

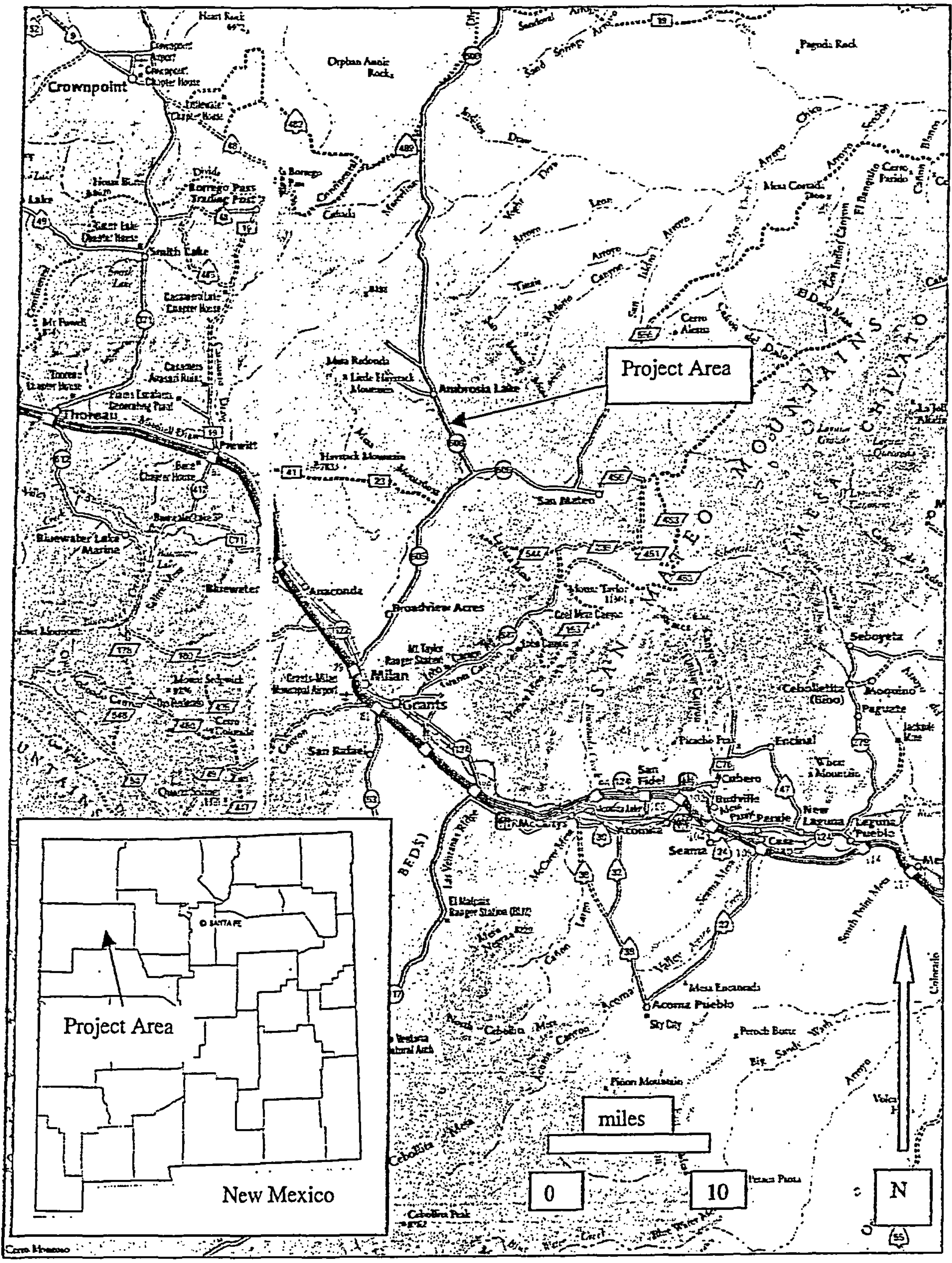


Figure 1. Project area in northwestern New Mexico (from Benchmark Maps).

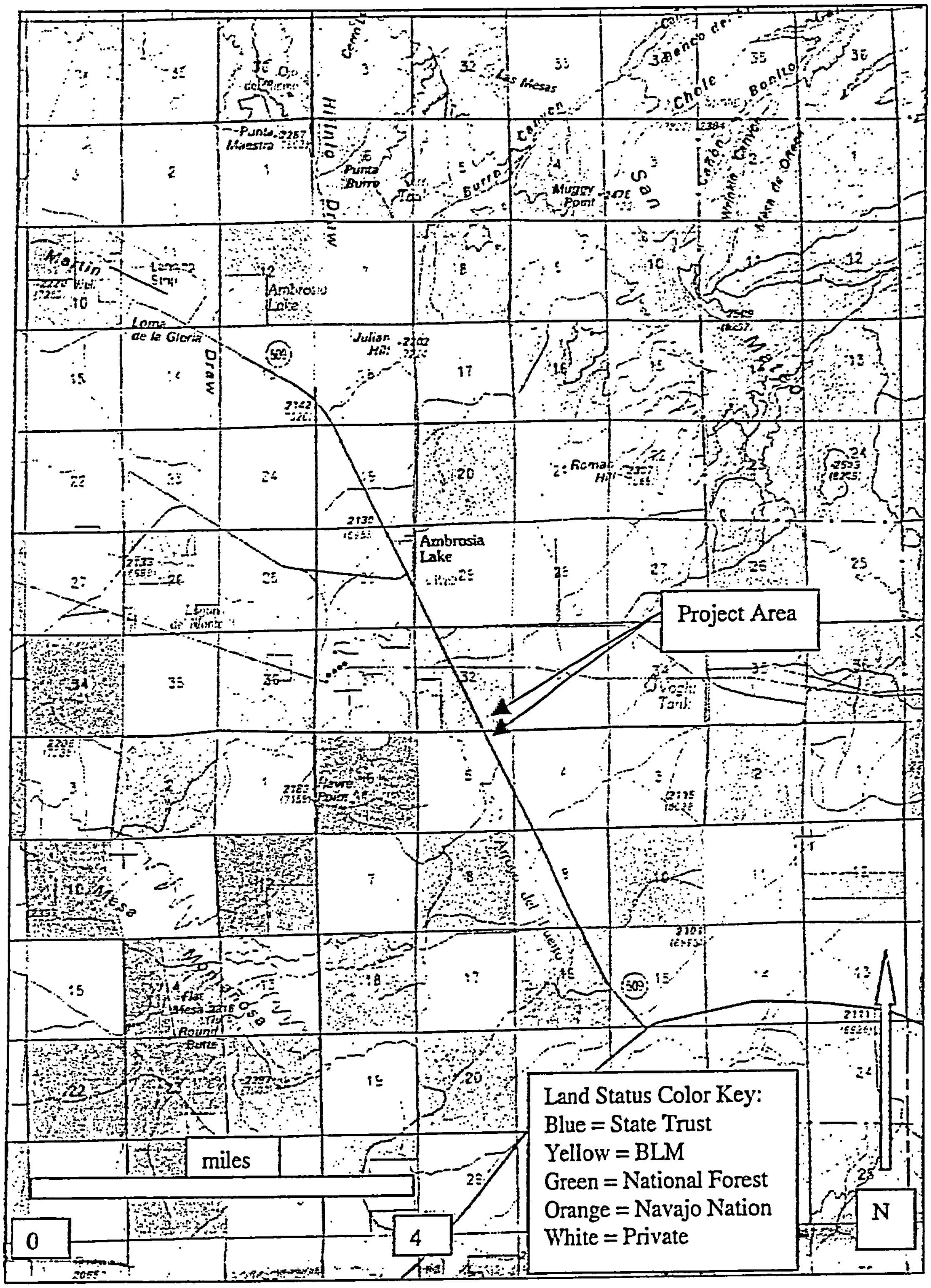
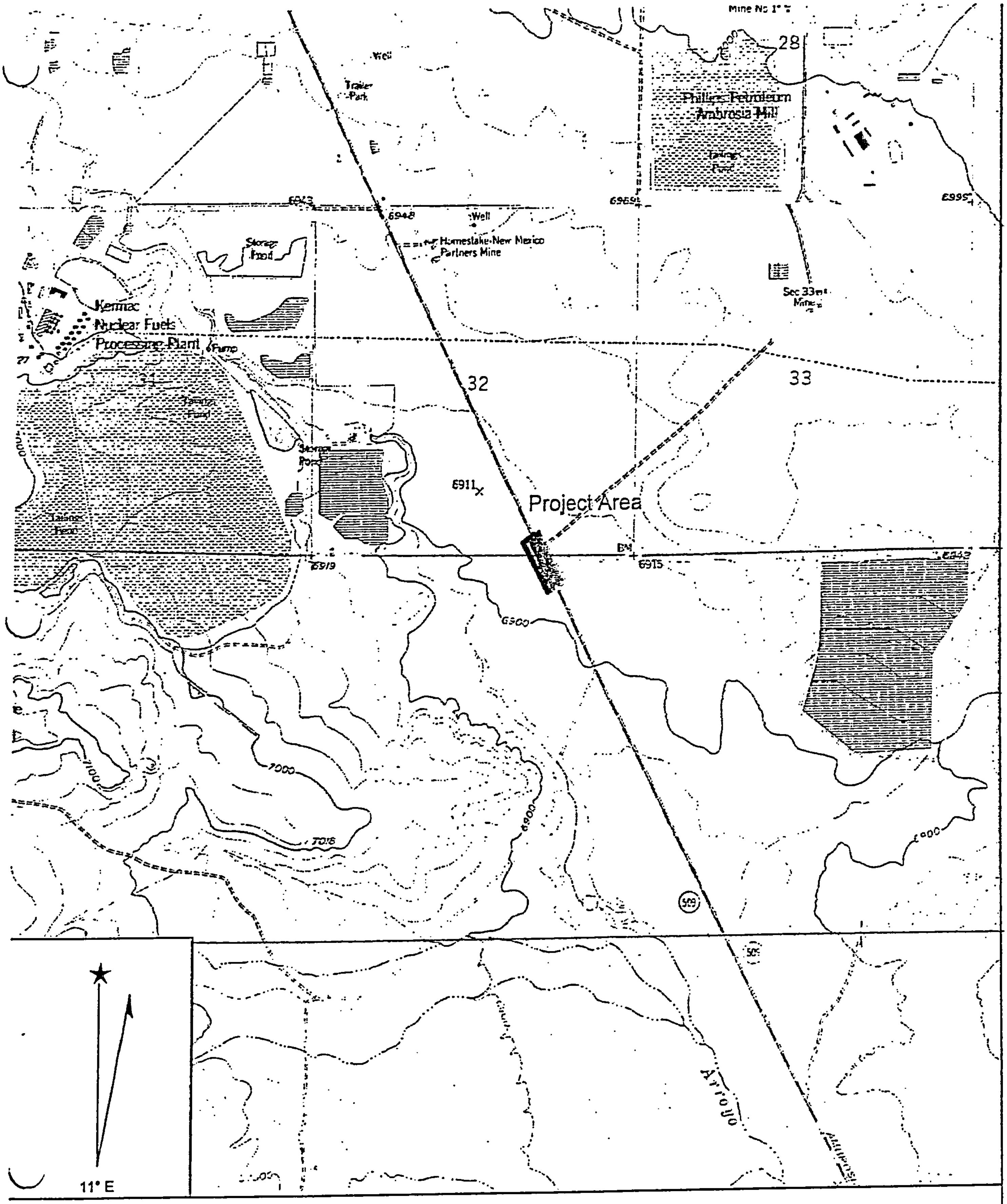


Figure 2. Project area land status (from BLM land status map).



Name: AMBROSIA LAKE
Date: 9/8/2004
Scale: 1 inch equals 2000 feet
1:24,000

Location: 13 244676 E 3919782 N
Caption: Figure 3. Project area on the Ambrosia Lake 7.5 minute quadrangle.

LABORATORY OF ANTHROPOLOGY INVESTIGATION RECORD

1. PROJECT AND ACTIVITY DATA

NMCRIS Activity No.: 89969 (NMCRIS Activity Nos. assigned by ARMS staff or NMCRIS registration page; see NMCRIS User's Guide)

Sponsoring Agency: New Mexico DOT

Project ID Number: Marron and Associates CRM Report No. 0095 Project Name: Mine Haul Road

Description of Undertaking (optional): *Class I and Class III Cultural Resource Survey for a Proposed Mine Tailings Haul Road Across NM 509 South of Ambrosia Lake, McKinley County, New Mexico.*

Other Permitting Agencies: SHPO

Performing Agency: Marron and Associates, Inc.

Activity ID number: 89969 Activity Name: Marron Report No. 0095

Dates of Investigation: 2-Sept-2004 to 2-Sept-2004

Investigation Type: ☐ research design ☐ excavations ☐ monitoring/damage assessment

☐ overview/lit. review ☒ survey/inventory ☐ ethnographic study

☐ test excavations ☐ collections/non-field studies

☐ other activities (specify):

Description of Investigation (optional):

2. SURVEY DATA

Total Area Surveyed: 1.8 acres Total Activity Area (if < 100% coverage): 1.8 acres

Total Tribal Area Surveyed: 0 acres

Intensity (choose one): ☒ *intensive inventory (100% coverage)* ☐ reconnaissance (<100% coverage)

Configuration: ☒ block survey units ☐ linear survey units ☐ other survey units (specify):

Scope (choose one): ☒ non-selective (all sites recorded) ☐ selective/thematic (selected sites recorded)

Coverage Method (choose one): ☒ systematic pedestrian coverage ☐ other method (describe):

Standard Survey Interval: 10 meters **Standard Crew size:** 1

Survey Person Hours: 5 **Site Recording Person Hours:** 0

Source Graphics:

☒ USGS 7.5' (1:24,000) topo maps ☐ rectified aerial photos [Scale: _____]

☐ other topo maps [Scale: _____] ☐ unrectified aerial photos [Scale: _____]

☒ GPS unit* *GPS Accuracy: ☐ < 1.0 m ☒ 1-10 m ☐ 10-100 m ☐ >100 m

☐ other source (describe):

Survey Results:

sites discovered and registered	0
Sites discovered and NOT registered	0
previously recorded sites revisited	0
total sites visited	0
Total isolated occurrences recorded	0

☐ Non-selective IO recording?

Surveyed Land Ownership*

Owner Name:	State:	Acres Surveyed:
NMDOT right-of-way from private sources	NM	1.2
NMDOT within State Trust	NM	0.6
	NM	

*(Govt. agencies: enter agency name and administrative unit; Private owners and Land Grants: combine into one "Private" group)

Counties Surveyed: McKinley

Surveyed USGS Quadrangles

Quadrangle Name/ Date:	USGS Code:
Ambrosia Lake 1957/1980	35107-D7

APPENDIX G

APPENDIX G-1
RIO ALGOM MINING LLC, AMBROSIA LAKE FACILITY HEALTH PHYSICS AND ENVIRONMENTAL MONITORING PROGRAM MANUAL

HEALTH PHYSICS

Table of Contents

APPLICABLE STANDARDS/GUIDELINES

1. Bioassay (Urinary Results) - Table I of NRC Regulatory Guide 8.22 will be used as a guideline for QMC's Bioassay Program.

   Source - Regulatory Guide 8.22, Paragraph 5 and Material License SUA-1473, Condition #10

2. Equipment Release (Unconditional Use Empty) - The following table will be used as a guideline and is in accordance with Material License Condition #25 and Regulatory Guide 8.30.

Average	5,000 dpm alpha per 100 cm^2	Average over no more than 1 m^2
Maximum	15,000 dpm alpha	Applies to an area of not more than 100 cm^2
Removable	1,000 dpm alpha	Determined by smearing 100 cm^2 with dry filter or soft absorbent paper, applying moderate pressure, & assessing the amount of radioactive material on the smear.
Beta - Gamma	0.2 mRad/Hr (avg.) 1.0 mRad/Hr (max.)	at 1 cm at 1 cm

Source - Material License SUA-1473, Condition 25 & Regulatory Guide 8.30, Paragraph 1.7

4. Gamma - whole body dose of 5 rems per calendar year if all exposure is due to external sources.

   Source - 10 CFR 20.1201.
   If exposure composed of external and internal exposures, the exposure limit is 5 rems based on the sum of the external and internal exposures (total effective dose equivalent).

   Source 10 CFR 20.1201.

5. Gamma (Declared Pregnancy) - total effective dose equivalent of 0.5 rems during gestation.

   Source - Regulatory Guide 8.13, Paragraph C and 10 CFR 20.1208.

6. Personnel Contamination - 1000 dpm/100 cm^2 removable alpha activity.

Source - Regulatory Guide 8.30 paragraph 1.6

7. Radon Daughters (inhalation) - 100 microcuries (4 Working Level Months (WLM)) per calendar year).

   Source - 10 CFR 20, Appendix B, Table 1.

9. Respiratory Protection Equipment - 100 dpm/100 cm^2.

   Source - Regulatory Guide 8.30, Paragraph 1.10

10. Surface Contamination (Lunchrooms, Change Rooms, Offices etc.) See Equipment Release (Unconditional Use Empty) values.

    Source - Regulatory Guide 8.30, Paragraph 1.5

11. Uranium (U_{nat}) - 5 x 10^{-10} uCi/ml (1.11 dpm/liter) gross alpha activity.
    Source - 10 CFR 20, Appendix B, Table 1 (Based on Class D).

12. Soluble uranium (yellowcake) Intake – 10 milligrams per week.
    Source - 10 CFR 20.1201.(e).

BIOASSAY PROGRAM

Purpose

The objective of the Bioassay Program is to determine the effectiveness of the facility health physics monitoring program, determine internal exposures when applicable, and to evaluate the effectiveness of the respiratory protection program.

Program Elements

The program consists of two modes of operation where bioassay sampling may be necessary. These include routine operations, non-routine operations and emergency actions. Each of these conditions will dictate when bioassay sampling is warranted and the frequency of sampling.

1. Routine Operations

Routine operations include normal production activities which are generally repetitive and are carried out under acceptable conditions. This includes activities conducted under an SOP such as IX plant operation and maintenance activities.

In the event that personnel exposure to uranium exceeds 25% of the DAC listed within 10 CFR 20 for soluble natural uranium (DAC = 5 e-10 :Ci/ml), bioassay sampling will be collected on a semi-monthly basis. This frequency will remain until three (3) consecutive routine health physics surveys indicate exposures to airborne concentrations are below the 25% action limit.

2. Non-Routine Operations

Non-routine operations include non-production activities that occur infrequently or at times when engineering controls are impracticable or are inoperable. This includes maintenance activities that are required to re-establish normal operations. These activities are usually addressed under a radiation work permit.

Bioassay sample collection will be dictated by the radiation work permit and/or the task performed. The radiation safety officer or designee will determine the need for bioassay sampling if the RWP does not specify a frequency; and will be based on available health physics monitoring data.

3. Emergency Operations

Emergencies are unexpected occurrences that may require the use of respiratory protection to control intake and those which may potentially pose hazardous health consequences.

These include tailings facility failures and process spills/releases.

Bioassay sample collection will be dictated by the specific conditions surrounding the incident. The radiation safety officer will determine the need for bioassay sampling.

Procedures

1. Sample Preparation

   Health physics department personnel shall prepare bioassay kits for distribution.

   a. Determine which employees will be requested to submit a bioassay sample and assign a bioassay number to them.
   b. Place the sample identification code onto a clean bottle.
   c. Place bottle into a resealable bag.
   d. Place a bioassay instruction sheet into the bag and seal the bag.
   e. Distribute the bioassay kits to appropriate employees.

2. Sample Collection

   a. Employees should attempt to void into the sample bottle the morning he or she is scheduled to return to work after their regular scheduled days off. Collection should be between 48 and 96 hours since leaving the site. This will depend on employee schedules.
   b. The employee will fill out the information form contained with the bioassay kit.
   c. In the event the employee fails to submit a sample, a sample will be obtained as early as possible upon their return to work.
   d. Samples will be collected and prepared by health physics department personnel for shipment to contract laboratory.

3. Quality Control Samples

   Quality control samples should be included in the bioassay shipment to provide information on the laboratory capabilities. Health physics personnel shall prepare the QA samples.

   a. QA samples should be submitted with each batch of samples. The actual number of QA samples will be dictated by the size of the batch.
   b. QA sample concentrations should be: 1)blank; 2)15 ug/L; 3)30 ug/L; or 4)45 ug/L. other concentrations may be prepared under the direction of the RSO.
   c. The appropriate quantity of the spiked solution will be carefully added to 100 ml of uncontaminated urine or water.
   d. QA samples will be assigned a specific identification number so as to provide identification upon receipt of results.

4. Action Limits

   a. QA Samples

If analyses of the QA samples consistently are in error by more than 30%, the contract lab will be notified of the discrepancies and an investigation in the reason will be initiated. Documentation of incidents/discrepancies will be prepared and maintained on site.

b. Employee Samples

Employee results will be reviewed by the RSO and appropriate actions shall be initiated based on the results. The Action table will be used as a guide.

ACTION TABLE FOR BIOASSAY RESULTS

Urine Concentration (ug/L)	Actions
Less than 15	No action required
15 to 35	1. confirm results 2. identify cause 3. determine why air samples did not warn of unusual concentrations 4. determine if other employees exposed and obtain bioassays 5. consider work assignment changes 6. implement investigation findings
Greater than 35	1. take actions described above 2. continue operations only if no exceedences over 35 ug/L will occur 3. normal work assignments until results confirmed. If result above limit, work restrictions applied.
Greater than 35 for 2 consecutive samples; 1 sample greater than 130 ug/L; or air sampling results in excess of a quarterly limit of intake	1. take actions described above 2. test urine for albuminuria 3. immediate work restrictions applied if any sample over 130 ug/L until results are below 35 ug/L.

DAILY SITE INSPECTION

Purpose

The purpose of the daily site inspection is to ensure proper implementation of the radiation safety program. Results of the inspection are recorded with appropriate actions taken on identified items.

Procedure

The daily site inspection is conducted daily during normal scheduled workdays of the radiation safety officer or designee. The inspection is primarily a visual inspection of the work areas to ensure that process designs and procedural methods for maintaining exposures ALARA are being implemented and used correctly.

The walk through inspection is intended to assist both supervisory personnel and employees in maintaining an awareness of potential radiological hazards and to institute preventive or corrective measures in a timely manner when required.

Areas to be inspected include:
- IX plant
- Active work areas
- Respirator room

During the inspection, the inspector will document the results of the inspection on the Daily Inspection form. Any area in which the inspector indicates a "NEEDS ACTION" on the form, a corrective order or general work order will be issued and given to the appropriate supervisor. A radiation work permit will be issued if the radiation safety officer or designee determines a significant radiological hazard to employees or the environment exists.

Recordkeeping

The Daily Inspection form will be completed by the inspector and given to the radiation safety officer for review and filing.

WEEKLY INSPECTION BY RADIATION SAFETY OFFICER

Purpose

The purpose of the weekly RSO inspection is to observe that general radiation control practices, cleanliness, and housekeeping practices are in line with the ALARA principle. Record of the inspection is maintained.

Procedure

The RSO will perform an inspection of pertinent site areas to observe that general control practices, cleanliness, and housekeeping practices are in line with the ALARA principle. Areas where work is being performed should be visited. The inspection is primarily a visual inspection of the work areas to ensure that process designs and procedural methods for maintaining exposures ALARA are being implemented and used correctly.

The walk through inspection is intended to assist both supervisory personnel and employees in maintaining an awareness of potential radiological hazards and to institute preventive or corrective measures.

Additional items that are reviewed include assessing the status of all active radiation work permits and corrective orders. The status of these items along with the inspection observations will be documented on the *Weekly RSO Radiological Inspection* form.

Recordkeeping

The Weekly RSO Radiological Inspection form will be completed and filed for future reference/review.

GAMMA SURVEY

Instruments

Ludlum Model 19 Gamma Meter

Purpose

The semi-annual gamma survey is performed in order to ensure all areas within the facility are posted in accordance with NRC regulations and to maintain external exposures ALARA.

Procedure

To perform the semi-annual gamma survey, use the Ludlum Model 19 survey instrument. Prior to making the survey, the instrument must be function tested to ensure that the instrument is operating properly. This is done by placing the check source onto the circle indicated on the meter housing. Turn the instrument on and test the batteries. If low, replace. With the source in place, read the gamma level indicated on the meter dial. The reading should fall within the limits noted on the function check sheet for that particular instrument. If the instrument reading falls within the range, the meter is functioning properly and may be used. Enter all applicable information onto the function test form. If the reading does not fall within the specified range, investigate the cause, which may include re-calibration prior to use.

With the meter successfully function tested, the gamma survey may be initiated. To begin, walk through the working areas. As you walk, note the gamma radiation reading on the meter. In areas in which you note a drastic increase in intensity above background (20 microRoentgen per hour), investigate the area. Identify the source of the radiation and record a surface reading for that item or area. Obtain readings at one meter off the ground or at a position to mimic likely employee exposure scenario. If a surface reading is needed, a surface reading is made by placing the meter directly on the surface of the object and noting the meter reading. Record readings and any other pertinent information on the survey form.

In areas in which radionuclides are not expected to be present, keep the meter multiplier on the lowest scale. Walk through the area and record all areas in excess of background (20 uR/hr).

Data Reduction

Upon completion of the survey, the results will be reviewed, and all areas will be posted in accordance with NRC regulations and to maintain gamma exposures ALARA.

All areas shall be posted in accordance with 10 CFR 20.1902. All areas which exceed 5 milliRoentgen per hour (mR/hr) will be posted *CAUTION - RADIATION AREA.* All other areas less than 5 mR/hr will be posted in accordance with License Condition #28.

PERSONNEL EXPOSURE MONITORING

Purpose

Gamma monitoring using dosimeters are performed to determine compliance with 10 CFR 20.1201 and to maintain doses ALARA.

Instrument(s)

Personnel dosimeter

Monitoring

Monitoring shall be performed by issuing personnel dosimeters to any employee who the RSO deems is required to wear monitoring devices. The personnel dosimeters shall be issued to female employees monthly and male employees quarterly. Employees will be held responsible for proper control of the personnel dosimeters.

The personnel dosimeters issued shall be processed and evaluated by a dosimetry processor holding a valid personnel dosimetry accreditation from the National Voluntary Laboratory *Accreditation Program (NVLAP) program.*

Female badges are issued monthly to ensure adequate and timely information of a female employee who declares herself pregnant. When an employee declares herself pregnant in writing an immediate gamma dose investigation will be initiated. The investigation will include the dosage incurred during the estimated gestation period and year to date. All information will then be forwarded to the facility Industrial Relations manager in order to implement the company policy concerning radiation exposure to pregnant employees.

Personnel dosimeters will be exchanged upon receipt of the new batch from the dosimeter processor with the exposed personnel dosimeters being repackaged and sent to the processor for analysis.

Data Reduction

Results received from the dosimeter processor shall be placed on the individual gamma recording cards. In the event that a personnel dosimeter was not returned for processing, an estimated dose for that individual will be made. The dose estimation shall take into consideration previous dose received, job function, area of work, and amount of time on the job.

In addition, the dose received by each individual will be entered into the radiation exposure program after the results are received.

A monthly ALARA report for females and a quarterly ALARA report for males will be completed to determine that exposures are being maintained ALARA.

RADON DAUGHTER MONITORING USING KUSNETZ METHOD

General

Sampling and analysis for radon daughter concentrations can be performed using the Kusnetz Method. Radon daughter particulates are collected on a 25 mm glass fiber filter utilizing a pump pulling a minimum of 2 liters per minute for 5 minutes. The sample filter is allowed to decay between 40 and 90 minutes after the end of collection before counting. A working level concentration for the sample is derived by dividing the counts per minute, minus background, by the counter efficiency, the volume of air and a sample specific time factor.

Equipment

Air sampling pump unit
25 mm glass fiber filters and filter housing
Field logbook
Timepiece
Filter holder
Counting Equipment
Time Factor Table

Sample Collection

1. Obtain sampling pump unit.

2. Perform a calibration on the sampling pump to ensure the pump flow rate is 2 liters per minute ("lpm"). Refer to the procedure entitled, "Calibration – Air Pumps" for calibrating the pump.

3. Record the results of the calibration in the logbook used for calibration of pumps used for radon daughter sampling. The pump will be ready for use after a successful calibration is achieved.

4. Obtain sufficient 25 mm glass fiber filters for use in the sampling event.

5. Proceed to the desired sampling location with the sampling pump, filters, field logbook, and timepiece.

6. At the sampling location, place one filter into the filter housing. To assist the individual collecting the samples, a small non-destructive mark may be made on the collection side of each filter to ensure filters will be analyzed correctly.

7. Begin collecting the sample by starting the pump. The collection time is 5 minutes.

8. Record all pertinent information in the field logbook including location, start time, pump ID, individual performing sampling, and any unusual conditions that may be present at the sampling location.

9. Turn pump off upon completion of the 5 minute collection time. Record the stop time in the logbook.

10. Carefully remove the filter from the sampling cassette and store in a filter holder that identifies the sample.

11. Proceed to any additional sampling locations and repeat Steps 6 through 10 at each location. When obtaining additional samples, keep in mind that samples must be analyzed between 40 minutes to 90 minutes after collection.

12. Return the samples to the counting location upon completion of sampling.

Sample Analysis

A. Function Check

Prior to actually counting the samples, a function check must first be performed.

1. To start the function check, turn the power on to the counting system. Allow the system to warm up prior to using.
2. Place the alpha check source into the drawer counter.
3. Start the function check by pressing the reset and start buttons located on the timer/scaler.
4. At the end of the counting cycle, a total activity count number will be displayed. Record this value.
5. Calculate the average counts per minute (cpm) by dividing the gross counts by the count time.
6. Record the cpm and other necessary information such as your initials and date into the SAC function check logbook.

7. If the calculated cpm falls between the acceptable counting range as determined during SAC calibration, the counting system is operating correctly.

8. If the observed count falls outside the range, investigate the cause.

B. Background Determination

To ensure that the sampling data are properly determined, the background activity will be subtracted from the actual sample activity.

1. Place an unused glass fiber filter into the drawer counter.

2. Count the filter to obtain a total count.

3. Calculate the cpm by dividing the total count by the count time. This value is to be used as the background cpm.

C. Sample Analysis

1. All samples must be analyzed between 40 minutes to 90 minutes after collection.

2. Place a filter sample into the drawer counter and initiate the counting process.

3. Upon completion of the counting process, a gross count will be displayed. Record this value.

4. *Remove the filter from the drawer counter.*

5. If additional filter samples are to be counted, repeat Step 2 through 4 for each sample.

6. Upon completion of sample counting, Include any pertinent information on the printout such as date, technician, system efficiency, and count times.

Airborne Radon Daughter Concentration Determination

Airborne radon daughter concentrations are calculated in units of working levels ("wl"). The following steps are to be used to determine wl for the air samples.

1. Calculate a gross count rate for each sample by dividing the total observed counts by the count time in minutes to obtain the sample gross counts per minute ("cpm") for each sample.

2. Subtract the background cpm from the gross cpm to obtain a net cpm for each sample.

3. Obtain the sample net disintegrations per minute ("dpm") by dividing the net cpm by the counting system efficiency.

4. Obtain a sample concentration by dividing the sample dpm by the sample volume in liters.

5. Determine a time factor. The time factor is dependent on the time elapsed between end of sampling and the beginning of counting. The time factor relates dpm per liter of air from 40 to 90 minutes after sampling to the decay activity that would be present from an initial concentration of 1 wl. Table 1 provides the time factors for the time period between 40 and 90 minutes after sample collection.

6. Calculate the sample wl concentration by dividing the sample activity (dpm/L) by the time factor obtained in Step 5.

7. Obtain an average wl concentration for each area. For example, the average wl concentration for location X is determined by averaging all samples collected within location X.

8. Compare the area average wl value to the action limit of 0.08 wl to determine whether proper radiological controls are being utilized. If the area average wl is below the action limit, no further action is required.

9. If the area average wl is at or above the action limit, obtain additional samples to better characterize the area average concentration and/or investigate the potential cause. Usually, increasing ventilation to the area will resolve the situation.

10. Perform any follow-up sampling to confirm that the corrective actions taken result in area average concentrations below the action limit.

11. A report will be generated and included within the monthly health physics report that will summarize each month's sampling results.

TABLE 1
TIME FACTORS

Time after Sampling	Time Factor		Time after Sampling (minutes)	Time Factor
40	150		66	98
41	148		67	96
42	146		68	94
43	144		69	92
44	142		70	90
45	140		71	88
46	138		72	87
47	136		73	85
48	134		74	83
49	132		75	82
50	130		76	80
51	128		77	79
52	126		78	77
53	124		79	76
54	122		80	75
55	120		81	74
56	118		82	72
57	116		83	70
58	114		84	69
59	112		85	68
60	110		86	67
61	108		87	65
62	106		88	63
63	104		89	62
64	102		90	60

65	100			

RESPIRATORY PROTECTION EQUIPMENT SCANNING

Instruments

Smear Paper
Scintillation Alpha Counter (SAC)
Portable Alpha Scanner

Purpose

Monitoring for residual alpha contamination on reusable respiratory protection equipment is performed to ensure proper radiological health protection and maintain exposures ALARA.

Monitoring

Monitoring for residual alpha contamination is performed following the cleaning steps as outlined in Ambrosia Lake's *Respiratory Protection Program.* Once the drying phase of the cleaning and sanitizing procedures have been completed, a representative number of the respirators, approximately 10% need to be checked for alpha contamination.

There are two acceptable methods to check for residual alpha contamination of the respirator.

The first method is by physically taking a swipe sample. Using a smear paper, smear the accessible areas on the respirator. Obtain an alpha activity for the smear sample by using a alpha detection instrument. Record all pertinent information as described in the Data Reduction section of this procedure.

If the resultant counts per minute converted to disintegrations per minute exceed 100 dpm per 100 cm^2, reclean the entire batch of respirators.

The other acceptable method of obtaining a gross alpha count is by using the alpha scanner. Although the alpha scanner counts both removable and fixed alpha activity, or in other words total alpha activity, as long as the total alpha activity does not exceed the 100 dpm per 100 cm^2 recommended limit, it can be surmised that the respirator is acceptable for use.

To count the respirator for contamination using the alpha scanner first remove the yoke of the respirator so the flexible plastic can be manipulated. Scan the entire respirator manipulating the flexible plastic so the area can be properly counted. Record all pertinent information as indicated in "Data Reduction" section. To obtain the net alpha activity on the respirator subtract the background count from the gross alpha activity count. If the net counts per minute converted to disintegrations per minute (dpm) exceed 100 dpm/100 cm^2, reclean the entire batch of respirators.

Data Reduction

Upon completion of cleaning and scanning each batch of respirators, record the alpha activity within the log book located within the respirator room entitled "Respirator Cleaning Log Book" the date, your initials, and the resultant activity. Reassemble the respirators, place in protective bag and place in appropriate storage location.

URANIUM AIR SAMPLING AND ANALYSIS

Purpose

Airborne uranium samples are collected to determine employee exposures and to maintain compliance with federal and company regulations and rules. The samples are also used to determine if airborne uranium concentrations are being maintained ALARA.

Instruments

High volume Air Sampler
102 mm Type A/E Glass Fiber Filter
Sample Holding Envelopes
SAC counting system

Sample Collection

Prior to collecting air samples, verify the high volume sampler's calibration is current. If not, calibrate the sampler prior to using for sample collection.

To collect a sample, place a 102 millimeter filter into the filter holder of the sampler. Visually inspect the filter to ensure filter is not damaged. To start the collection sequence, press the start button on the pump. Note and record the start time and volume of air being pulled through the filter by reading the pump air gauge. Let the sampler run for five minutes. At the end of the five minute period stop the pump by depressing the stop button found on the pump. Note and record the stop time and the volume of air being drawn through the filter at the end of the pumping period.

At the end of your sample period remove the filter and place the collected sample into an envelope that identifies the sample. Be careful not to rub or touch the collection area of the filter. Age the filter for at least four hours prior to analysis in order to eliminate short-lived radon daughters.

Sample Analysis

Function Check

Prior to counting the activity on the filter, a function test is to be made on the counting equipment to ensure proper calibration and operation. To start the function check turn the power on.

Place the alpha check source into the drawer counter. Start the function check by pressing the reset and start buttons located on the timer/scaler. At the end of the counting cycle, a total activity count number will be displayed. Record this on the datasheet.

Calculate the average counts per minutes (cpm) by dividing the gross counts by the count time. Record the cpm and other necessary information into the SAC function check logbook. If the calculated cpm falls between the acceptable counting range as determined during SAC calibration, the counting system is operating correctly. If the calculated count rate falls outside the established range, investigate the cause which may include recalibration of instrument.

Background Check

Prior to actually counting your air samples, a background count must first be collected. Place a clean 102 mm filter into the drawer counter. Count the filter and determine the counts per minute. This value is to be used for the background cpm. The count period will be the same for the background sample as for the actual air samples. Typically, this count time will be 3 minutes.

Counting the Sample

Place one sample in the drawer counter with the exposed side facing the detector and close the drawer. To start counting, press the reset and start button on the timer/scaler. At the end of the counting cycle the gross alpha counts will be shown in the scaler display window. Record this value. Remove the filter from the sample tray and place the next sample on the tray and close the drawer. Continue the process until all samples have been collected. Observe the gross counts for any anomalous readings and recount any sample indicating suspect results to verify original count.

Data Reduction

The results of the uranium monitoring are obtained by entering the data into a computer program. The necessary data items including date, machine counting efficiency, background counts, air volume and gross counts for each sample. The resultant computer printout will contain the airborne concentration for each sampling location. Evaluate the results to ensure all applicable limits are not exceeded and that the results are consistent with expected results. The report will also be reviewed by the RSO/designee.

CONTAMINATION SURVEYS FOR UNRESTRICTED RELEASE OF MATERIALS AND EQUIPMENT

Instruments

Ludlum Model 19 Gamma Meter
Model 4 Alpha Meter with 44-10 probe
(equivalent equipment may be substituted)

Purpose

Contamination surveys of potentially contaminated materials to be released to the general public for unrestricted use must be performed to ensure compliance with material license condition #25 and Nuclear Regulatory Commission (NRC) Regulatory Guide 8.30. This procedure applies to company owned property associated with NRC regulated activities as well as rental equipment and material. Adherence to this procedure is essential to ensure no radiological problems will arise from the release of equipment from Rio Algom Mining LLC property.

For the purposes of this procedure, *potentially contaminated* means "the likelihood for radiological contamination to be present on an item based on the judgement of the individual performing the radiation survey taking into account what the item(s) is and the location(s) where the item(s) was used." As an example, a used yellowcake drum and ore cars would require a survey, while an office desk from a mine site may not.

Procedure

A. the procedure to be followed for release of materials to the general public for unrestricted use is presented below.

1. Upon determining that an item will be released to the general public via surplus sales or for another reason (repair, rental return, etc..), the individual initiating the transaction shall notify the Environment Department and request a radiation survey be performed.

2. An Environment Department employee shall determine whether the item(s) for which a survey request has been made may be released to the general public. This is necessary since some items may not be released due to composition or prior use.

3. The Environment Department employee shall determine one of the following:

    a) If the item may not be released, the employee shall notify the initiator of the transaction of the determination and justification.

    b) If the item may be released, the items shall require a radiation survey prior to release.

4. If the surveyor determines that the item is not potentially contaminated and no survey is needed, proceed with completion of paperwork.

5. If the surveyor determines that the item is potentially contaminated and will require a survey, determine if the item has already been surveyed by reviewing records for the item or resurvey the item.

6. If the item has been previously surveyed and is below the limits, proceed with the completion of paperwork.

7. If the item has not been previously surveyed, perform a survey in accordance with Section B. of this procedure.

8. If the survey results indicate radiation levels above limits, inform the initiator of the transaction of the outcome of the survey and provide the following options:

    a) Item will require decontamination and re-survey until the radiation levels meet the limits; or

    b) Item will not be released. Another similar item may be chosen. If additional items are requested, the initiator shall notify the Environment Department and request a radiation survey be performed on the new item(s).

9. If the survey results indicate radiation levels below the limits, proceed with completion of paperwork.

10. Upon completion of the survey, the surveyor shall complete the radiation survey form for material for unrestricted use. If no survey was necessary, the surveyor shall state this on the form.

11. If a shipping document will be required, the surveyor shall complete the applicable sections on the shipping document. Ensure any conversions\units are correct.

12. The surveyor shall notify the initiator of the transaction that the paperwork pertaining to the radiation survey is complete, and that the item may be released.

B. Survey Techniques

The survey of contaminated equipment for unrestricted use is made by measuring for alpha and gamma radiation.

The first measurement is alpha. The alpha scintillation probe is used to determine the fixed and removable alpha contamination. All material released for unrestricted use will be scanned to determine compliance with license condition #25 and Regulatory Guide 8.30.

To perform an alpha survey, the alpha probe is placed approximately 1/4 of an inch from the surface of the material in question. The alpha scanner measures total alpha. Thus, if the total alpha activity is less than the limits for removable alpha, then it can be surmised that the removable limits are acceptable.

However, if the total net counts exceeds the limits noted on the instruments for removable alpha, then a smear sample is required. A 100 cm^2 smear will be taken of the area and counted. If the removable alpha activity limit is exceeded when counting the smear sample, the material shall not be released from the restricted area until the material has been cleaned to meet the regulatory limits.

The alpha release limits are normally expressed in disintegrations per minute per 100 cm^2 (dpm/100 cm^2). In order to facilitate the counting and determination, all dpm/100 cm^2 limits have been converted for each alpha scan instrument into the limits expressed in cpm. The alpha release limits in cpm are also posted on each instrument.

On materials having dimensions too small to be covered by the entire surface of the probe or on inner surfaces which are inaccessible to the probe, smear samples are recommended. However, because the circumstances, the surveyor may have to make an on site determination as to the most appropriate sampling method to employ.

The second measurement to be made is for gamma radiation. The Ludlum meter reads in microRoentgen per hour (uR/hr).

To perform a gamma survey on the material to be released, set the meter scale at the lowest scale. Again, as a guideline scan the material in at least six areas at surface contact or at least a 1/4 inch from the surface. More scans may be necessary to adequately determine the extent of contamination. Scan the area and note the gamma reading. When the gamma radiation limit is exceeded, the material shall not be released until item is decontaminated and resurvey indicates that levels are below appropriate limits.

Heavy castings or other dense materials on equipment that is known to be potentially contaminated which can shield gamma radiation and which have inner surfaces inaccessible to alpha surveys of any type must be assumed to be contaminated in excess of the limits and shall not be released.

Equipment Release Limits

Average Alpha	5,000 dpm alpha per 100 cm^2	Average over no more than 1 m^2
Maximum Alpha	15,000 dpm alpha	Applies to an area of not more than 100 cm^2
Removable Alpha	1,000 dpm alpha	Determined by smearing 100 cm^2 with dry filter or soft absorbent paper, applying moderate pressure, & assessing the amount of radioactive material on the smear.

Beta-Gamma	0.2 mRad/Hr (avg.) 1.0 mRad/Hr (max.)	at 1 cm at 1 cm

PERSONNEL CONTAMINATION

Instrument(s)

Ludlum Model 4 meter with 44-10 alpha probe
(other alpha radiation detection instruments may be used)

Purpose

Personnel contamination surveys are performed on site employees to ensure that exposures are maintained ALARA and to confine potential contamination within the restricted area. This procedure addresses surveys performed by Health Physics staff and survey performed by employees.

Health Physics Staff Surveys

Monitoring

1. Function Check

   Prior to performing a personnel contamination survey, the alpha instrument should be checked for proper calibration and function. The alpha counter function check is made by placing the alpha source onto the probe and the template line up. Note and record all pertinent information as requested on the Function Check Form. Compare to counts against the acceptable range as previously determined during instrument calibration. If the observed count falls between the expected range as listed on the check form, the instrument is operating properly. If not, investigate the cause of the reading, which may include recalibration.

2. Personnel Scanning

   Radiological personnel contamination monitoring should be performed on random individuals at random times when the employee has completed the work shift and is preparing to go home. Other times may be established as determined by the RSO.

   Slowly move the probe over the hands, forearms, clothing, shoes, and other exposed areas of the employee. Keep the probe as close as possible to the surface being surveyed. Make sure that while you are scanning the employee, protruding objects do not come in contact with the mylar face of the probe. Possible damage to the probe and the mylar face could occur.

   While scanning, if you note excessive alpha activity in a particular body area, maintain the probe in that area to determine a maximum count. Note and record the information of the Personnel Contamination Survey Form.

   Compare the survey results to the action level for the instrument. The action level counts correspond to the NRC recommended removable alpha activity of 1000 dpm per 100 cm^2. Although the alpha scanner measures both fixed and removable alpha contamination, the scanner provides for a conservative, ALARA approach in preventing contamination and maintaining exposures ALARA. If the action level is exceeded, instruct the individual to take the appropriate action as deemed necessary. Appropriate action includes washing suspect areas, showering, or laundering clothes.

Rescan the individual once the appropriate actions have been completed to ensure that the contamination levels are acceptable. Take the necessary actions needed in the event that the resurvey indicates levels over the accepted limits. The RSO shall be informed of any readings that required decontamination efforts.

Employee Self Scans

1. Employees are encouraged to perform self scans at any time they suspect potential contamination concerns. The instrument is available at all times for use by employees and all are instructed in the proper use of the radiation survey instrument. Additionally, written instructions are available at the survey location.

2. The steps described within Section 2 - Personnel Scanning above should be used for survey techniques.

Contamination Limits

Item Surveyed	Contamination Limit
Skin and clothing	1000 dpm/100 cm^2
Soles of shoes	5000 dpm/100 cm^2

SURFACE CONTAMINATION

Instrument

Swipe Paper
Scintillation Alpha Counter (SAC)
(other alpha radiation detection instruments may be used)

Purpose

Surface contamination surveys are performed to ensure that radiological contamination is maintained at a minimum and to ensure that exposures are maintained ALARA.

Procedure

Surface contamination is checked by swiping a 100 square centimeter (100 cm^2) area and analyzing the the gross alpha activity on the sample. To obtain a sample, place the paper on the area to be sampled. Apply moderate pressure on the paper and rub an area approximately twice the length and width of the paper (approximately 100 cm^2). Place the sample into the sample holder, being careful not to disturb the sample.

Function Check and Background Check

Prior to actually counting the samples, a function check and a background count must first be collected. To start the function check turn the power on. Place the alpha check source into the drawer counter. Start the function check by pressing the reset and start buttons located on the timer/scaler. At the end of the counting cycle, a total activity count number will be displayed. Record this value on the datasheet.

Calculate the average counts per minute (cpm) by dividing the gross counts by the count time. Record the cpm and other necessary information such as your initials and date into the SAC function check logbook. If the calculated cpm falls between the acceptable counting range as determined during SAC calibration, the counting system is operating correctly. If the observed count falls outside the range, investigate the cause.

A background count is collected by placing an unused swipe paper into the drawer counter. Count the swipe and determine the counts per minute. This value is to be used for the background cpm, which will be subtracted from the gross sample count.

Counting the Sample

Place one sample in the drawer counter with the smeared side facing up towards the detector and close the drawer. Record the results of the counting cycle on a datasheet. Remove the counted sample and place an uncounted sample in the drawer and repeat the process until all samples have been counted. Observe the results for any abnormal results and recount any suspect samples. Inform the RSO of any confirmed elevated results.

Action Level

Calculate the contamination level for the samples and review the results to determine if any action is necessary.

The action level counts correspond to the NRC recommended removable alpha activity of 1000 dpm per 100 cm^2. If the action level is exceeded, take the appropriate action as deemed necessary to reduce the contamination level. This is typically achieved by decontamination efforts using water and wet wipe cloths. Inform the RSO, who will determine whether additional investigation is warranted.

Data Reduction

All pertinent data including place of sample, date, counting efficiency, background count, and gross counts will be entered into the computer program for surface contamination with the resultant information to be included into the monthly report.

GRAVIMETRIC AIR SAMPLING
PREPARATION, SAMPLING, AND ANALYSIS OF SAMPLES

Instruments

Personal Sampling Pumps
Lapel Sampler with appropriate attachments

Purpose

Gravimetric dust samples are used to determine material concentrations in the air, including uranium. Gravimetric dust samples may also be used to determine gross alpha activity in working areas on routine work or on a radiation work permit.

Preparing Sample Cassette

Before the actual sampling begins, the filter cassettes must be made. Components of the cassette are plugs, top and bottom sections of the filter holder, rigid backing plate to support the filter, and the filter. The cassette is held together with cellulose bands. Each cassette is assigned a specific identification number. Spare cassettes are stored in a clean area.

Preparing Sampling Unit

The sampling unit consists of a portable air pump and a lapel sampler unit that consists of a cyclone and housing, filter cassette, and tubing to connect the pump to the cassette. Sampling units are maintained in a ready to use state. The HP technician is responsible for ensuring equipment is in a useable condition.

The sampling units are checked out by the user by completing the sampling datasheet that is maintained with the sampling units. Information to be entered includes date, user, job assignment information, sampling unit number, and filter number. The HP technician may also issue and distribute sampling units.

Collecting a Sample

After checking out the sampling unit, the user will proceed to the work location. Prior to start of work, the sampling unit is placed on the user. The pump clips onto the individual's belt and lapel holder is clipped onto the collar or near the breathing zone. The user will record the sampling start time which coincides with the start of the task.

The pump is to continuously run while performing the assigned task. Should the task extend over lunch or be performed intermittently during the shift, the pump should be turned off when not performing the task. The user should record any stop times and subsequent start times. This will ensure accurate sampling times which are necessary to obtain airborne concentrations. In the event that the pump stops operating, the user should leave the work area and retrieve or request a replacement sampling unit.

Upon completion of the task or at the end of the shift, the sampling units should be returned for analysis. The user should complete the paperwork including entering the start and stop times, any unusual conditions that occurred during the job, and any other employees working on the same task.

Analyzing the Sample

Samples need to be analyzed in a timely manner so that proper evaluation of work areas can be performed. If a sample was required on a radiation work permit, the sample must be analyzed within 2 working days from collection.

To count for gross alpha activity, age the sample for at least 4 hours after the end of the sampling period so short lived alpha emitters will decay. Samples are typically analyzed utilizing the SAC unit. Perform the necessary function checks on the SAC to ensure proper operation. To start the function check turn the power on. Place the alpha check source into the drawer counter. Start the function check by pressing the reset and start buttons located on the timer/scaler. At the end of the counting cycle, a total activity count number will be displayed. Calculate the average counts per minute (cpm) by dividing the gross counts by the count time and compare the results to the expected operating range. If the result falls within the range, the unit is acceptable for use.

Obtain a background count by placing an unexposed filter into the SAC and count the blank sample. The count time is typically three (3) minutes. Remove the blank sample from the SAC and record the result. To count the exposed filter, carefully open the cassette and take out the exposed filter with tweezers. Place the filter into the SAC and analyze the filter for gross alpha activity. Upon completion of the analysis, remove the sample and store or dispose of the sample.

Data Analysis

Determination of airborne concentration is performed to determine whether proper controls and procedures are implemented on the task. This is performed by utilizing the information contained on the sampling datasheet such as run time and the sample counting results. Results are reported on the *Radionuclide Control Report* form via use of a computer program that facilitates calculating sample concentrations and uranium intake. Inform the RSO of any unusual results. Based on the results, appropriate measures will be implemented as needed to ensure airborne concentrations and intakes are minimized.

Exposure Determinations

After determining the airborne concentrations and any uranium intake associated with the sample, it is necessary to evaluate the results and determine whether actual employee exposures (in Rem) should be determined as required by NRC License Condition #17.

Historical concentrations at the facility have consistently been well below those levels requiring employee monitoring as per 10 CFR 20.1502(b). However, if any sample indicates an airborne concentration exceeding 25% of the Derived Air Concentration (DAC) for soluble natural uranium (5e-10 uCi/mL), determine the actual radiation exposure incurred by individuals associated with the sample.

The following method should be used to determine employee exposure for a given sample:

1. Determine uranium intake in microCuries by multiplying the intake (mg) by 6.77e6.

2. Use Equation 1 within NRC Regulatory Guide 8.34, which is:

$$CEDE = (5 * I) / ALI$$

where: CEDE = Committed Effective Dose Equivalent (Rem)
I = Intake (uCi)
ALI = Annual Limit on Intake (uCi)
For soluble natural uranium, the ALI = 1 uCi

3. For presentation purposes, the CEDE can be represented in the units of millirem on the *Radionuclide Exposure Report.*

RADIOACTIVE SOURCE LEAK TEST

Purpose

Leak checks are performed on sealed sources in order to ensure that none of the encapsulated radioactive material is escaping from the sealed container.

Instrument(s)

Scintillation Alpha Counter (SAC)
4 inch cotton swabs
Envelopes/baggies

Monitoring

Leak tests are made on all sealed sources associated with the State of New Mexico license to ensure the integrity of the source is not compromised. Measuring equipment must have the detection ability to measure 11,100 dpm of radioactive material.

Pick the radioactive source up with the source holder so as not to come in contact with the source itself. *Carefully wipe the sides of the source with the swab and when* finished placed the swab into a plastic baggy. Place the source back into the protective lead pig when finished.

If the source is an alpha radiation emitter, such as Ra-226 or Am-241, place the sample in a scintillation alpha counter (SAC) and count it for five minutes. Calculate the *activity of the sample. If the total activity of the sample is less than 0.005 uCi (11,100* dpm), the source is considered leak free.

If the source is a beta/gamma emitter, such as Cs-137, send the swab to an outside accredited lab for analysis. Upon receipt of the results, review them to determine whether sources are leaking or not.

If the results of the leak check reveals the presence of 11,100 dpm or more of removable contamination, the source will be removed from service and either repaired or disposed of according to the manufacturer's recommendations and regulatory requirements.

Instrument Calibration

CALIBRATION - SAC

Purpose

The purpose of calibrating the Scintillation Alpha Counter (SAC) is to derive an efficiency value for the instrument. This enables reliable assessments as to employee exposure and helps to determine if ALARA concentrations are being maintained. Calibration should be done on an annual basis.

Equipment

5" Drawer Counter
SAC Counting Intrumentation
Two Alpha Sources
    High Activity S/N #10788, 1585 dpm
    Low Activity S/N #10786, 616 dpm
Calibration template for the Drawer Counter

Calibration Procedure

Voltage Determination

The first task is to determine the proper operating voltage for the instrument. This is determined by performing a plateau check on the system. The principle is that as the voltage is increased, the detection ability of the system increases until continuous discharge of the detector occurs. The operating voltage is selected on the curve in a way which will result in no drastic variations in observed counts with a drift in voltage.

1. Prepare a graph with voltage on the horizontal axis and observed counts on the vertical axis. Include date, time, source information, and initials.
2. Adjust the high voltage setting for the SAC at 500 volts.
3. Insert the high activity source into the drawer counter and run a one minute count.
4. Upon completion of the count period, record the observed counts and place a point on the graph corresponding to the voltage setting and the observed counts.
5. Increase the voltage in 25 volt increments and perform a one minute count at each setting and plot the result on the graph.
6. Continue to increase the voltage until the observed count shows a dramatic increase.

7. Upon completion, draw a curve through the points on the graph. The curve should begin flat (no observed counts) and then begin to rise. This indicates that sufficient voltage is available to detect some radiation decay events. The curve will eventually level out. This range is called the plateau. The curve indicates that as voltage is varied within the range indicated by the plateau, there is an insignificant change in the observed counts. This represents the most reliable counting region. As the voltage is increased, the curve will then begin to curve upwards.

8. Adjust the voltage of the SAC to correspond with the voltage setting indicated near the middle of the plateau region. This will be the SAC operating voltage. Adjust the voltage setting on the SAC to the new setting and indicate the new operating voltage on the SAC.

SAC Calibration

1. If the system is not turned on, turn on the machine by pushing the red button in the upper right hand corner of the bin cabinet and allow it to warm up for 5 to 10 minutes.
2. Open the drawer on the drawer counter and insert the calibration template.
3. Remove the high activity source from its case being careful not to touch the active surface with your hands.
4. Place the source over the #1 position on the template.
5. Gently close the drawer so as not to move the source from its position.
6. Clear the scaler timer by pushing the reset button.
7. Push the start button to start counting.
8. At the end of 180.0 seconds the total observed counts for the 3 minute count period will be in the display of the scaler. Divide this value by three and record the results.
9. Repeat steps 4 through 8 each time relocating the source to the next position on the template until all calibration positions have been counted.
10. Replace the high activity source and repeat steps 3 through 9 using the low activity source.
11. Remove the template from the drawer counter.
12. Complete the calculations as indicated on the calibration form to derive the machine efficiency.

13. Calculate the restricted area release limits by completing the lower half of the form.
14. With a label maker, update the information on the drawer counter.
15. Calibration of the SAC is now complete.

Operating Range

1. Next the operating limits are established by taking the high activity source and placing it in the center of the drawer counter and gently closing it.
2. Set the scaler count time to 180 seconds.
3. Push the reset button to start the count cycle.
4. Record the total observed counts after completion of the 180.0 second period.
5. Repeat Steps 3 and 4 until 10 data points are acquired.
6. Remove the alpha source and put it back in its storage case.
7. Complete the necessary calculations on the SAC Operating Range Form to obtain the operating range for the system. Enter this range in the SAC function check log.
8. This range becomes the operating range for the function test that is to be run prior to each use of the machine.

DETERMININATION OF LOWER LIMIT OF DETECTION

For the purposes of this manual, the lower limit of detection ("LLD") is defined as the smallest concentration of radioactive material that has a 95% probability of being detected. Radioactive material is detected if the value measured on an instrument is high enough to conclude that activity above the system background is probably present.

The sampling and analytical methods used shall have an LLD equal to those listed below.

Survey Type	LLD
Uranium (gross alpha activity)	1e-11 uCi/ml
Radon Daughters	0.03 wl
Gamma Radiation	0.1 mR/hr
Alpha contamination	100 dpm/100 cm^2
Respirators	100 dpm/100 cm^2

For a particular measurement where radioactive disintegrations are detected, the LLD is calculated by:

$$LLD = \frac{4.66 \bullet S_b}{3.7e^4 \bullet E \bullet V \bullet Y \bullet e^{-\lambda t}}$$

Where:

LLD = lower limit of detection

S_b = standard deviation of the background count rate (counts per sec.)

$3.7e^4$ = number of disintegrations per second per microCurie
(this conversion factor is omitted if S_b is given in terms of microCuries)

E = Counting efficiency (counts per disintegrations)

V = Sample volume (ml)

Y = radiochemical yield (if applicable)

λ = decay constant for the particular radionuclide

t = elapsed time between sample collection and counting

The following example is provided.

Task: Determine the LLD for radon daughters using the modified Kusnetz method.
Answer: The background standard deviation is established by using blank filters. Assume the alpha counts on 10 blank filters counted for 1 minute each are shown below:

Sample Number	Alpha Counts
1	2
2	3
3	1
4	3
5	2
6	2
7	2
8	3
9	2
10	4

For these filters, S_b can be calculated to be 0.84 counts for a one minute count.

Assume the counting efficiency, E, is 0.27. Consider a low volume sampler with a flow rate of 5 liters per minute and a sample collection time of 5 minutes. Therefore, the sample volume will be 25,000 ml. The radiochemical yield is not applicable and is set equal to 1.

To calculate the radioactive decay, the value λ can be taken to be roughly 0.026 per minute (for lead-210, the radon daughter with the longest half life). The value of t is assumed to be 60 minutes, even though the value could range from 40 minutes to 90 minutes. Therefore $e^{-\lambda t}$ equals 0.21.

The LLD can now be calculated:

$$\text{LLD} = 4.66^{*} (0.84 \text{ cpm}) / [0.27 \text{ c/d} * 25 \text{ L} * 0.21]$$

$$= 2.8 \text{ dpm/L}$$

To convert this LLD into working levels (wl), divide by a factor obtained from Table 1 in the procedure entitled *Radon Daughter Monitoring Using Kusnetz Method.* This factor is determined to be 110 dpm/L/wl for a sample counted 60 minutes after collection. Therefore, the LLD in terms of wl is determined to be:

LLD = 0.03 wl

CALIBRATION - HURRICANE SAMPLER

Purpose

The purpose of calibrating the hurricane sampler is to develop an efficiency factor for the sampler flow indicator which can be used to derive the actual flow through the unit. This is done on an annual basis.

Equipment

Hurricane Sampler
Exhaust Tube
102 mm Filter
Manometer with 12" Pitot Tube Set Up to Measure Velocity Pressure
Calibration Sheet

Calibration procedure

1. Put a filter in the holder on the front of the sampler.
2. Turn on the sampler and let it run for a few minutes to warm up and stabilize.
3. Observe and record the pump gage reading and calculate the corrected pump flow rate by the following formula:

   Corrected reading = Pump gage reading x Current pump efficiency

4. Place the exhaust tube on the back end of the hurricane sampler.
5. Insert the pitot tube in the small hole near the rear of the exhaust tube. The probe end of the pitot tube should be pointing toward the sampler.
6. Allow the manometer to stabilize and record the value "VP" in inches of water. Calculate the calculated flow rate using the formulas on the datasheet.
7. Compare the values obtained in Step 3 and Step 6 and, if necessary, adjust the butterfly valve on the exhaust opening of the sampler until the pump gage reading closely corresponds to the corrected pump reading obtained in Step 3.

8. Record any adjustments on the calibration sheet.
9. If adjustments were made, reinstall the exhaust tube and pitot tube and manometer and resume calibration process.
10. Record the necessary data (flow indicator reading and pressure differential) on the calibration sheet in the "0 holes" row.
11. To create a pressure change across the filter and manometer, punch one hole in the filter and repeat Step 10 recording the values on the calibration form.
12. Continue adding an additional hole until a total of ten (10) holes are on the filter.
13. When the values are recorded, calculate the efficiency using the formulas listed on the calibration sheet.
14. Fill out the remainder of the information requested on the sheet.
15. Put the date of calibration and the efficiency on the hurricane sampler.

CALIBRATION - LAPEL SAMPLER PUMPS

Purpose

Calibration of the lapel sampling pumps ensure accurate radiological concentrations as calculations will be based on the pre-set flow rates. Flow rates for pumps used for radon daughter monitoring should be 2 liters per minute (lpm). Gravimetric dust sampling the flow rate must be 1.7 lpm as the aerodynamic functions of respirable dust are taken into design consideration of the sampling equipment.

Instruments

Sample pumps
1000 mm burette tube
Soap (Bubble Liquid)
Stop watch

Procedure

The bubble tube is generally a large diameter graduated cylinder, marked with a volume scale. The procedure for calibrating pumps using the bubble tube is to connect an in-line filter holder containing a filter between the top of the bubble tube and the inlet of the pump. When the pump is turned on and a bowl of soapy water is raised up to the bottom of the cylinder a bubble will form and move up the tube. The volume of air evacuated by the pump is indicated by the distance traveled by the bubble with reference to the graduated scale on the tube. This method also requires the use of a stop watch to determine the flow rate. If a bubble tube of 800 ml in volume is utilized, the following times are utilized for the tube:

28 seconds	1.7 liters per minute
24 seconds	2.0 liters per minute
19 seconds	2.5 liters per minute

Perform flowrate checks on each pump until 3 consecutive successful tests are obtained. Use a screwdriver to adjust pump flow rate by turning the small set screw on the pump.

Pumps shall be calibrated when received, when repairs are made, or at least quarterly.

CALIBRATION - GAMMA METER

Purpose

Gamma meters are checked against a known source on an annual basis to ensure that it is functioning properly.

Calibration Procedure

Gamma radiation instruments shall be calibrated by using the services provided by a contract vendor or manufacturer. The HP technician is responsible for preparing the meter for shipment to the vendor.

Upon return of the meter and calibration report, the report shall be reviewed by the RSO/designee for completeness and if any discrepancies are found, the vendor that performed the calibration will be contacted to resolve any questions that exist.

Operating Range Determination

Prior to using the newly calibrated instrument, an operating range determination must be established. Utilize a radium-226 check source and obtain ten readings while the source is located in a predetermined location on the instrument case. Record these readings on the operating range form and determine the range using the formulas on the form. Record this range on the function test form for the specific instrument.

CALIBRATION - MULTICHANNEL ANALYZER

Instruments

Multichannel Analyzer (MCA) with sodium iodide detector
Radium-226 Gamma sources
Personal computer with printer
Canberra Genie PC software

Purpose

In order to determine the amount of radium-226 or other radionuclide, the Canberra Genie-PC Multichannel Analyzer (MCA) must be calibrated to indicate an accurate spectroscopy analysis. This is accomplished by performing an energy calibration on the energy spectrum obtained from a radium standard.

Procedure

The gamma spectroscopy system consists of a personal computer with MCA hardware, sodium iodide detector with photomultiplier tube, and Canberra software applications package.

1. Turn the computer on and access the Genie PC software.
2. Set up the system in order to acquire a spectrum from a radium-226 standard.
3. Set up the collection time to be 1 hour.
4. Clear any data in the window and initiate the collection period. During the collection period, the operator can input pertinent information into the window regarding the specific purpose of the analysis in the "Sample Info" window.
5. When the collection period is complete, save the file.
6. Access the Gamma Spectroscopy Assistant applications window and retrieve the saved file.
7. Access the Calibrate menu. This menu allows you to perform the calibration, view the results, and obtain printouts of the results.
8. Select the Energy Full option.
9. Select the Populate option.
10. Select the Current Database option.

11. Enter the peak locations for several prominent peaks across the entire spectrum. Enter at least six (6) peaks. Make sure one of the peaks is the Bi-214 peak at 609 keV. Select OK when finished.

12. Select the Energy Show option to view the calibration graph. A good calibration exists if the measured values (dots) coincide closely with the calculated value (line). If the chart does not reflect an acceptable calibration, investigate the cause, including possibly performing the calibration sequence again.

13. Save the newly generated files.

14. Generate a print out of the calibration. Include the calibration graph and the energy calibration report.

CALIBRATION - LUDLUM MODEL 4 WITH PROBE 43-5

Purpose

The Ludlum Model 4 with alpha probe 43-5 is checked on a semi-annual basis to establish an operating voltage and determine a detector efficiency.

Equipment

Ludlum Model 4 Survey Meter
Ludlum Alpha Probe 43-5
Probe Template
Low Activity Source (ie., Source #10786)
High Activity Source (ie,. Source #10788)

Procedure

Voltage Determination

To determine the proper operating voltage for the instrument, perform a plateau check on the system. The principle is that as the voltage is increased, the detection ability of the system increases until continuous discharge of the detector occurs. The operating voltage is selected on the curve in a way which will result in no drastic variations in observed counts with a drift in voltage.

1. Prepare a graph with voltage on the horizontal axis and observed counts on the vertical axis. Include date, time, source information, and initials.
2. Adjust the high voltage setting for the instrument at 400 volts.
3. Insert the high activity source into the template and place the probe on the template to obtain an average count rate.
4. Obtain an average count rate, record it and place a point on the graph corresponding to the voltage setting and the observed count rate.
5. Increase the voltage in 50 volt increments and obtain the count rate and plot the result on the graph.
6. Continue to increase the voltage in 50 volt increments to approximately 800 volts or until the observed count rate shows a dramatic increase.
7. Upon completion, draw a curve through the points on the graph. The curve should begin flat (no observed counts) and then begin to rise. This indicates that sufficient

voltage is available to detect some disintegrations. The curve will eventually level out. This range is called the plateau. The curve indicates that as voltage is varied within the range indicated by the plateau, there is an insignificant change in the observed counts. This represents the most reliable counting region. As the voltage is increased, the curve will then begin to curve upwards.

8. Adjust the voltage of the instrument to correspond with the voltage setting indicated near the middle of the plateau region. This will be the operating voltage.

9. Perform the same voltage determination over the same range of voltage with no source in the template to establish a curve for the background curve. The point selected as the voltage setting in Step 8 should be at a setting that does not indicate an elevated background reading.

Efficiency Determination

1. Turn the Ludlum Model 4 Survey Meter on.

2. Place the low activity source onto one of the circles inside the probe template on the calculation sheet. Set the probe on top of the source so it is aligned with the template. Record the average cpm in the column labeled CPM_1.

3. Repeat step 2 until the source has been placed onto each of the circles.

4. Repeat steps 2 and 3 with the high activity source and record the results in the column labeled CPM_2.

5. Calculate the total and average cpm for each source.

6. Calculate the instrument efficiency (EFF) using the following formula:

$$efficiency = \frac{\frac{cpm_{1_{avg}}}{dpm_1} x \frac{cpm_{2_{avg}}}{dpm_2}}{2}$$

Where:

AVG. CPM_1 = Average cpm of low activity source
AVG. CPM_2 = Average cpm of high activity source
DPM_1 = Low source disintegrations per minute
DPM_2 = High source disintegrations per minute

6. Complete the certificate of calibration. In addition, place all the pertinent information

regarding calibration date, and release limits onto the meter for easy reference.

Operating Range

1. Next the operating limits are established by taking a check source and placing it in the center of the template.
2. Place the probe onto the template and source and obtain an average count rate
3. Obtain 10 readings.
4. Remove the alpha source and put it back in its storage case.
5. Complete the necessary calculations on the Operating Range Form to obtain the operating range for the system. This range becomes the limits for the function test that is to be run prior to the using the machine for the first time each day the instrument is used.

CHI-SQUARE TEST - SAC

Purpose

A chi-square test is performed on the scintillation alpha counter (SAC) counter to determine if the system is operating within an expected statistical certainty. The objective of the test is to confirm the reproducability of a count sequence under similar conditions. The well known statistical distribution to determine this is known as the chi-square distribution. The frequency for this test shall be quarterly.

Equipment

SAC Counting System
High Activity Source (S/N 10788)

Procedure

1. Turn on the SAC and allow the system to warm up.

2. After the system is warmed up and a function check has been successfully performed, place the high activity source into the center of the drawer counter of the SAC.

3. Set the SAC system settings for counting a one (1) minute time period.

4. Push the RESET button and then push the START button. The SAC will begin performing the one (1) minute count. Record the number of observed counts on the datasheet.

5. Repeat this until twenty (20) consecutive one minute count results are acquired for use in the chi-square calculations.

6. Perform the necessary calculations as indicated on the form.

7. If the end result falls within the expected range, the SAC counting system is operating properly.

8. If the end result does not fall within the expected range, perform a calculation check on the data. If the result is still outside the expected range, perform any necessary checks/calibrations on the SAC system. After any changes have been performed, run another chi-square test on the system.

ENVIRONMENTAL

APPLICABLE STANDARDS/GUIDELINES

1. High Volume Sampler: (may be averaged over a period not greater than one year)

U (nat)	Ra-226	Th-230	Pb-210
uCi/ml	uCi/ml	uCi/ml	uCi/ml
3 X 10^{-12}	9 X 10^{-13}	2 X 10^{-14}	6 X 10^{-13}

Source - 10 CFR 20 Appendix B, Table II

2. Radon - (Based on annual average)

uCi/ml

1 X 10^{-10}

Source - 10 CFR 20 Appendix B, Table II

3. Radiation Exposure - (annual dose equivalent)

100 millirems in a year

Source - 10 CFR 20.1301

4. Soil - Radium 226 Content

Top 15 cm layer/100 m^2 - 5 pCi/gram
Succeeding 15 cm layer/100 m^2 - 15 pCi/gram

Source - 40 CFR 192.12 and 10 CFR 40, Appendix A, Criterion 6.

5. Vegetation

To date, no specific standard for radionuclide release and subsequent uptake for vegetation have been established.

6. Sediment

To date, no specific standard for radionuclide within sediments have been established.

7. Surface Water Discharges - NRC Regulated Activities

U (nat) uCi/ml	Ra-226 uCi/ml	Th-230 uCi/ml	Pb-210 uCi/ml	Po-210 uCi/ml
3 X 10^{-7}	6 X 10^{-8}	1 X 10^{-7}	1 X 10^{-8}	4 X 10^{-8}

Source - 10 CFR 20 Appendix B, Table II

8. Surface Water Discharges - EPA Regulated Activities

	U (nat) mg/l	Ra-226(s) pCi/l	Ra-226(t) pCi/l	TSS mg/l	COD mg/l	Zinc mg/l
Average	2	3	10	20	100	0.5
Maximum	4	10	30	30	125	1.0

	Se(t) mg/l	Cd(t) mg/l	Gross Alpha pCi/l
Average	0.0013	0.0067	10
Maximum	0.002	0..01	15

Source - EPA NPDES Permit NM0020532

GROUNDWATER SAMPLING PROCEDURES

Instruments

- Bailers
  - 4" Diameter
  - 2" Diameter
- Hand Crank
- Cubitainers with preservatives as appropriate
- pH and conductivity meter
- Depth To Water Meter
- Hydrology Truck with Mechanized Bailer
- Distilled Water
- Tape Measure
- Bucket/container

Purpose

Groundwater monitoring wells are sampled at predetermined intervals to ascertain the effects of the operations on the nearby surrounding geologic formations and to maintain compliance with federal, state, and company regulations and rules.

Procedure

Prior to the actual field sampling of the monitoring wells, the specific conductivity and pH meters must be function checked to ensure proper operation and calibration. Both methods to check these instruments are located within the calibration section for environmental equipment. Please refer to these instructions for further information.

Next, obtain the proper containers in which to store the collected water samples. The size of the containers depend on the number of parameters and the type of analysis being performed.

The actual collection procedure begins when the individual arrives at the monitoring well itself. Upon arrival, note any unusual conditions pertaining to the well including but not limited to surrounding water ponding, cracks in the footing of the well casing, missing well caps, or other damage which is identifiable to the well. The comments should be noted on the field data sheet. In the event the well has incurred damage, repair if possible.

Depth To Water and Total Depth Measurement

1. Hand Bailing

The first step in monitoring a groundwater well is to measure the static water level. This is accomplished by using the Depth To Water Meter. The meter is simply a device which has an open electrical circuit within its probe, and when contacting water, the circuit is subsequently closed sounding a small buzzer on the instrument. This notifies the user that water is present and has completed the electrical circuit. To begin, remove the cap on the well placing it upside down on a dry surface. This prevents foreign material from being deposited within the well once the cap is placed back onto the well when finished sampling.

Turn the meter on and test the functionality of the probe by depressing the test button located on the spool. If the buzzer sounds and the water light appears, the instrument is functioning properly. Place the probe of the meter within the well and slowly lower the probe. Upon contact with the static water level, the buzzer will sound indicating the presence of water. Slowly raise the probe until the buzzing stops. At this juncture note the point on the Depth to Water line in reference to the well reference point. Measure the distance between the markers on the line and the noted point on the line. This resultant measurement is the depth to water. Record the depth to water to the nearest 0.01 foot on the field survey sheet.

Turn off the meter and continue to lower the probe until the line becomes limp. Hoist the line until the tautness returns. Repeat this several times until you determine the spot on the Depth to Water line at which the tautness occurs. Measure the distance between the markers on the line to the spot where tautness occurs to determine the total depth of the monitor well. Record the value on the field sheet to the nearest 0.01 foot.

Hoist the line using the spool until the probe is clear of the well. Wash and clean the line and probe with distilled water and clean cloths to remove any contamination that may be on the equipment.

2. Mechanical Bailing

When using the hydrology truck to obtain the static water level, begin by backing the vehicle to the well being careful not to damage the well. Unlock the spool arm. Rotate the spool arm until it is in line with the well. Adjust the length of the arm so the cable is located in the middle of the well. Select the conductivity probe and screw it onto the cable line. Remove the well cap and place upside down on a dry clean surface. This prevents foreign material from being deposited into the well when placing the cap back onto the well. Place the probe into the well aligning the probe offset marker with the top of the well.

Adjust the rpm on the vehicle to approximately 1500. Turn on the main panel 12 volt breaker, the convertor, and the water level meter. Check the convertor to ensure that it reads approximately 60 hertz. Set the depth meter at 1.7, which adjusts for the offset depth of the water level meter within the probe. Slowly lower the probe into the well using the drum brake and spool drum motor. When the probe touches the static water level, the buzzer will sound indicating the presence of water. Slowly raise the probe until the buzzing stops. This is the depth to water reading for that monitor well. Record the depth to water to the nearest 0.1 foot. Hoist the probe to surface and remove the probe. Clean the probe with distilled water and clean wipe towels.

Total depth is measured by using the water collection bailer. Screw the collection bailer onto the cable. Place the bailer into the well and slowly lower it using the brake and the spool drum motor. As the cable is lowered, notice the line weight meter. As the bailer goes deeper, the weight increases. You will notice that upon reaching the static water level, the weight will slightly decrease. Continue watching the line weight meter as the bailer is lowered. When the bailer reaches the bottom of the well, the weight indicated on the meter will suddenly decrease. Stop lowering the bailer. Now slowly hoist the bailer until the line weight suddenly increases. The reading on the depth meter indicates the total depth for this monitor well. Record the reading on the field survey sheet. Hoist the bailer and remove it from the cable when it reaches the collar of the well. Again, completely clean and rinse the instruments with distilled water and clean cloths.

Collecting a Water Sample

Collection of groundwater samples varies according to each wells' capability to recover from the extraction of water. This is because of the low permeability of the deeper geologic formations and also the lack of water within the alluvial layer within the Ambrosia Lake area. Recoveries within these types of wells are usually extremely slow, sometimes taking weeks. As such, two methods are employed to obtain water samples which are indicated by the water within the formations. Both methods have been tested by Rio Algom Mining LLC and New Mexico Environment Department Ground Water Quality Bureau and agreed upon as the methodologies to use. The results have indicated little appreciable water quality changes between the initial bailed grab sample and any subsequent recharged water.

The first method employed is when the monitor well, based on historical records, normally has less than 10 feet of static water. In these cases such as those found in alluvium wells on Section 4, the bailer should be submerged as low as possible into the water being careful not to agitate material from the bottom of the well. Hoist the bailer containing the water until the bailer is at the collar level of the well. Pull the bailer from the well and pour the collected water sample into the gallon beaker. When finished collecting the sample from each well, the equipment will be rinsed and cleaned with distilled water to prevent cross contamination.

The second method is used when historical information indicates the monitor well has a static water level normally over 10 feet. In these cases, the well will be bailed a minimum of at least three times prior to obtaining a sample. Slowly lower the bailer to prevent damage to it and remove three (3) bailers of water. Water which is removed from the well needs to be spread on the ground away from the well location. Once the well has been bailed accordingly, obtain a sample and hoist the bailer to surface for collection.

1. Hand Bailing

Generally, wells with a depth of 125 feet or less can be hand bailed. Otherwise the use of the hydrology truck is usually required.

To begin hand bailing, place the hand crank bailer over the well head so the end line is centered over the well hole. Next, attach the bailer to the hand bailer line. It is very important that the bailer is securely attached so it does not become accidently released. Should it become detached, severe and or unrepairable damage could happen to the well, bailer, or both.

After securing the bailer to the line, place the bailer so the line is in the center of the monitor well. Slowly lower the bailer into the monitoring well. Normally, upon contact with the static water, an echo of the contact may be heard. Depending on the availability of water and the methodology employed to collect the water sample, collect the necessary amount of water.

2. Mechanical Bailing

Carefully back the hydrology truck up to the monitor well. Unlock the spool arm of the line feed. Rotate the arm until it is in line with the well. Adjust the length of the arm so the cable is located in the middle of the well. Select the sample collection bailer and screw it onto the cable line. Remove the well cap and place upside down on a dry clean surface. This prevents material being deposited into the well when placing the cap back onto the well. Place the sample collection probe into the well.

Adjust the rpm on the vehicle to approximately 1500. Turn on the main panel 12 volt breaker and convertor. Check the convertor to ensure that it reads approximately 60 hertz. Slowly lower the bailer into the well using the drum brake and spool drum. As the bailer is lowered notice the depth meter. As the depth approaches the static water level, reduce the speed of the bailer. When the bailer reaches the static water level, continue down the well. Depending on the availability of water and the methodology employed to evacuate and collect the water, perform the necessary tasks needed to obtain a water sample. Hoist the probe to surface and collect the water. Clean the bailer with distilled water and clean cloths.

Field Analysis

pH Measurements

Immediately (no later than 15 minutes) after collecting a sample, pH is measured in the field. Place the pH probe into the collected water sample. Let the sample come into equilibrium before recording the pH reading. Upon obtaining a pH reading, turn the meter off and remove the probe from the water. Rinse the probe and cord with distilled water and clean cloths.

Conductivity and Temperature Measurements

Specific conductivity measurements are also determined in the field. Upon completion of measuring the pH, place the conductivity probe into the container containing the water sample and turn the meter on. Do not allow the probe to rest on the bottom or sides of the container. Allow the probe to come into equilibrium then measure the temperature and the conductivity of the sample. Record the measurements on the field sample sheet. Turn the specific conductivity meter off and thoroughly wash the probe in distilled water.

Sample Preservation

Samples should be properly preserved to ensure valid and defensible results. Refer to the procedure entitled *Grab Sampling and Preservation of Aqueous Environmental Samples*. The contract laboratory may provide pre-preserved bottles for use in sample collection.

Lab Analysis

All regulatory compliance samples will be sent to the contract lab for analyses. The parameters for each set of samples will be documented on a completed chain of custody form which is to accompany each set of samples.

Data Reduction

Upon receipt of the analytical results from the contract laboratory, the results shall be reviewed for correctness by comparing the data on the chain of custody to the report. Information to be reviewed includes proper date, sample I.D., parameters analyzed, QA/QC report. In addition, the results will be compared to historical results for that parameter for that specific well. The contract laboratory shall be notified of any anomalous results and perform a check on the QA/QC program, calculations, and transcription errors. If all lab checks identify no errors, a re-analysis may be requested. Re-analysis will be based on comparison of current results to historical concentrations.

All information including name, date, well number, field data, and any other pertinent information will be entered into the computer and with the resultant printouts forwarded to appropriate regulatory entities.

RADON GAS SURVEYS (TRACK-ETCH)

Instruments

Track-etch chips in protective cups

Purpose

Track-etch radon surveys are performed to provide integrated radon concentration data over a specified time period (usually quarterly). Radon concentrations are determined for areas around the site in order to provide environmental data.

Procedures

A. Installing New Sample

1. Remove one Track Etch cup from its protective envelope.
2. Place the cup inside the protective container at the sampling location.
3. Record pertinent information of sample form including sample number and date.

B. Removing Exposed Sample

1. When the measurements are completed, remove the exposed sample from its protective container. Wipe off any dust or dirt from the outside of the sample cup. Record any unusual conditions such as finding sample on the ground.
2. Replace the Track Etch cups in the protective bag.
3. Return the cups promptly to vendor for processing.

C. Data Review and Analysis

1. Review the results to previous historical results and if unusual or questionable issues arise, initiate appropriate actions to resolve the issues.

SEDIMENT SAMPLES

Instruments

Five pound capacity sample bags
Trowel or scoop

Purpose

Samples may be collected from Puertocito Creek to acquire water quality data.

Procedures

To obtain a sediment sample at a selected location, first clear a sample area in the middle of the stream (about 1' X 1') of loose debris, rocks, and vegetation. Next, begin to remove the sample with a trowel or scoop. Drain excess water and clean out and discard, as much as possible, plant root systems in the sediment. Continue to sample to a maximum depth of two inches until the five pound sample bag is essentially full. If necessary, clean the sampling tool to minimize cross contamination. Be aware of and protect yourself from any sharp edges on sampling tool.

Upon completion of sampling all locations, send the samples to the approved contract lab for analysis. Samples are analyzed for Unat, Th-230, Ra-226, and Pb-210.

Data Review and Analysis

Review the laboratory results and compare to historical results to determine if any follow-up actions with lab are necessary.

In the event lab QA checks and/or re-analysis confirm result, investigate possible reasons for results, such as changes in operating parameters, deposition of material into the creek from wind or other possible causes.

SOIL SAMPLES

Instruments

Five pound capacity sample bags
Gardening trowel

Purpose

Soil samples are obtained to determine the extent of contamination of the soil from settled dust derived from site operations.

Procedures

To obtain a soil sample at a selected location, first clear the sample area (approximately 6" X 6") of loose debris, rocks, vegetation, and other organic material. Next, begin to remove the sample with a trowel. Clean out and discard, as much as possible, plant root systems in the soil. Continue to sample to a maximum depth of two inches until the sample bag has approximately 1500 grams of material. If necessary, clean the sampling tool to minimize cross contamination. Be aware of and protect yourself from any sharp edges on sampling tool.

All samples are to be sent to the approved contract lab for analysis. Samples are analyzed for U-nat, Th-230, Ra-226, and Pb-210.

Data Review and Analysis

Review the laboratory results and compare to historical results to determine if any follow-up actions with lab are necessary.

In the event lab QA checks and/or re-analysis confirm result, investigate possible reasons for results, such as changes in operating parameters, deposition of material from wind or other possible causes.

ENVIRONMENTAL GAMMA MONITORING

Instruments

Environmental Dosimeters

Purpose

Dosimeters measure integrated doses of external radiation (primarily gamma) over a specified time period (usually quarterly). Dosimeters can be used to determine gamma radiation levels in vicinity of the mill.

Procedures

Place the Dosimeters at predetermined locations approximately three feet above the ground. Posts must be installed when necessary. Make sure there are no metal tanks, plates, or other similar equipment near the Dosimeters which may shield or cause backscattering of gamma radiation. After the specified exposure period has ended, replace the Dosimeters as quickly as possible and send the exposed Dosimeters to the contract lab for analysis. The current period of sampling is quarterly.

VEGETATION SAMPLES

Instruments

Large plastic bags
Cutting tool

Purpose

Vegetation samples are obtained near the site perimeter in order to determine the extent of contamination and/or uptake by forage of elements that may be associated with site activities.

Procedures

When obtaining a vegetation sample from a selected location, select mainly grasses or leafy plants which would normally be used as forage for domestic and wild animals as opposed to woody plants such as pinon, juniper, and sagebrush. Cut the plants within a few inches of the ground and place in the plastic bag until the bag contains about three to four pounds of vegetation. Be aware of and protect yourself from any sharp edges on cutting tool.

Samples are collected quarterly during the 2nd, 3rd, and 4th quarter. No sample is collected during the 1st quarter due to the winter months.

All samples are to be sent to the approved contract lab for analysis. Samples are analyzed for U nat, Th-230, Ra-226, and Pb-210.

Data Review and Analysis

Review the laboratory results and compare to historical results to determine if any follow-up actions with lab are necessary.

In the event lab QA checks and/or re-analysis confirm result, investigate possible reasons for results, such as changes in operating parameters, deposition of material from wind or other possible causes.

HIGH VOLUME AMBIENT AIR SAMPLING

Purpose

Ambient air sampling is performed for the purpose of providing data associated with concentrations in ambient air in the vicinity of the facility. Samples are collected on a continuous basis with the filters exchanged on approximately a weekly basis. Filters are composited quarterly and are sent to a laboratory for analysis of uranium, thorium-230, radium-226, and lead-210.

Instruments

High volume air sampler
Filter papers with envelopes
Air flow meter

Procedure

A. Filter Preparation

1. Obtain a clean filter paper and inspect it for any defects. Discard any filters which appear to be defective.
2. Carefully write the sequential filter number on the filter in one corner and record the filter number and sample location in the filter logbook.
3. If total suspended particulates are desired, the unexposed filter must be weighed.
4. Place the unexposed filter into the envelope designated for the sample location.
5. Repeat Steps 1 through 4 for each additional filter to be placed in the field.

B. Filter Exchange

Filter exchange is identical for each sampler.

1. Upon arrival at the sampling location, observe the surrounding area for any unusual conditions which may influence sample condition. The sampler should be running continuously. If the sampler is off, investigate the cause. Perform filter exchange in weather conditions which will not significantly impact filters.
2. Open the sampler door and record the stop date, stop time, and elapsed time in the field logbook.

3. Record the stop flow rate by using the rotameter maintained at the sample location.
4. Open the protective cover to expose the filter cassette. Observe the filter for any unusual conditions. This may include excessive loading, filter damage, etc..
5. Unscrew the tightening knobs and remove the top metal plate to access the filter. Inspect the gasket for damage.
6. Carefully remove the exposed filter from the sampler intake. Fold the filter in order to prevent loss of collected material.
7. Place the filter into the proper envelope.
8. Remove the unexposed filter from its envelope and carefully place it unto the sampler intake screen.
9. Reinstall the top cover plate and secure it by tightening the knobs. Close the protective cover.
10. Record the start flow rate of the sampler by using the rotameter.
11. Use the stop date, stop time and elapsed time from the exposed filter as the start date, start time and elapsed time start for the unexposed filter.
12. Close the sampler door.
13. Return exposed filter(s) to the lab/office. If total suspended particulate concentration is desired, the weight of the exposed filter must be determined.
14. Store the exposed filters in a safe location.

C. Preparing Filters For Laboratory Analysis

Filters are composited quarterly and are sent to a laboratory for analysis of uranium, thorium-230, radium-226, and lead-210. The procedure for compositing filters is the same for each sample location.

1. Obtain the stored filters for the previous time period.
2. Check filters to ensure that all are accounted for.
3. Band the envelopes containing the individual filters in order to make one pile for the sample location.

4. Determine the total volume of air for the sampling period for the composited sample.

5. Prepare the necessary paperwork (chain of custody, sample volume report) and package the samples for shipment. Ship samples to contract laboratory.

D. Data Analysis

Review the analytical results received from the laboratory and evaluate the data. Compare results to historical results for any unusual readings. If the reviewer identifies areas requiring clarification, initiate contact with laboratory to resolve issues.

GRAB SAMPLING AND PRESERVATION OF AQUEOUS ENVIRONMENTAL SAMPLES

Purpose

The purpose of this procedure is to provide guidelines, commensurate with both Environmental Protection Agency (EPA) regulations or other site specific accepted method for sampling and preservation of aqueous systems for environmental control.

Grab Sampling

Proper sampling is both the most important and often most difficult aspect of obtaining good analytical results on aqueous systems. Because concentrations are in trace levels for many constituents, minimizing contamination is of vital importance. Additionally, few aqueous systems are truly homogeneous over a one-day period of time; hence, obtaining a representative sample is not always possible or convenient.

If the sample containers have already been prepared with the necessary preservative, no additional action is needed other than collecting the sample. If this is the case, be careful not to overflow the container as some of the preservative will be lost in the overflow. One way to prevent this is to use a collection bottle and transfer this to the actual sample bottle.

If new containers are used to collect the sample, they must not have been previously used and are free of possible contamination. If the container appears to be spoiled, do not used it for sample collection. Prior to collecting the water sample, wash the sample container several times with the water you are going to collect. This will help remove any foreign material in the sampling container. Fill the container leaving adequate room for the sample to be shaken upon addition of any preservative. When filling the container, let water run into the bottle from the "upstream" side while your hands are on the "downstream" side of the container. This will help prevent any contamination that you have on your hands or gloves from accidentally being collected.

If filtering is needed, collect sufficient volume in a clean container and then filter through appropriate filter media into the final sample container.

Sample Containers

Containers recommended by EPA should be used for sample collection. Where EPA recommends either plastic or glass, plastic should be used.

Sample Preservation

The sample preservation guidelines set forth by EPA should be followed when analyzing samples for regulatory purposes. This includes the refrigeration of samples. Refrigeration of samples has a noticeable, positive effect upon sample quality and, where possible, all samples should be refrigerated. For trace metals preservation, HNO_3 should be used. For other parameters, use the appropriate preservative as outlined in the preservative tables contained in this procedure.

Complete preservation of samples, either domestic sewage, industrial wastes, or natural waters, is a practical impossibility. Regardless of the nature of the sample, complete stability for every constituent can never be achieved. At best, preservation techniques can only retard the chemical and biological changes that take place in a sample after the sample is removed from the parent source. To maintain the integrity of the sample, appropriate selection of containers, pretreatment of containers if necessary and the holding times form the integral part of the sample preservation program.

A. Methods of Preservation

Methods of preservation are relatively limited and are intended generally to: 1) retard biological action; 2) retard hydrolysis of chemical compounds and complexes; and 3) reduce volatility of constituents.

Preservation methods are generally limited to chemical addition, pH control, refrigeration, and freezing. Combinations of these methods are often used for the preservation of the sample.

1. Chemical Addition

The most convenient preservative is a chemical which can be added to a sample bottle prior to sampling. When the sample is added, the preservative disperses immediately, stabilizing the parameter(s) of concern for extended periods of time. When the preservative added interferes with other parameters being measured, additional samples for those parameters must be collected. For example, concentrated nitric acid added for the preservation of some of the metals would interfere with BOD, so an additional sample must be collected for BOD.

2. pH Control

pH control to preserve the sample is dependent upon chemical addition.

As an example, to keep metal ions in a dissolved state concentrated nitric acid is added to lower the pH to less than 2.

3. Freezing

Freezing has been the subject of many preservation studies. It is felt by some that freezing would be a method for increasing the holding time and allowing collection of a single sample for all analysis. However, the residue solids components (filterable and nonfilterable) of the sample change with freezing and thawing. Therefore, return to equilibrium and then high speed homogenization is necessary before any analysis can be run. This method may be acceptable for certain analysis but not as a general preservation method.

4. Refrigeration

Refrigeration or icing has also been studied with various results. This is a common method used in field work and has no detrimental effect on sample composition. Although it does not maintain integrity for all parameters, it does not interfere with any analytical methods.

5. Preservation Guidelines

For NPDES Samples, the permit holder must use specific preservatives if the sample cannot be analyzed immediately after collection. If preserved, the analyses must be conducted within a specified time frame.

6. Alternative Preservation Methods

Alternative preservation methods with different preservatives or storage conditions can be used if its effectiveness can be demonstrated by supporting data through preservation studies. Such preservation studies must specify:

a. Type of water/wastewater used as a sample in the experiment
b. Type of containers used
c. Pretreatment of the container and the glassware used
d. Preservation methods used
e. Specific temperatures or temperature range used

Sample Parameters Required for Analysis

Where different containers and/or preservatives are specified, separate samples are required.

Generally, from one to four separate samples are required. All samples should be cooled to 4 degrees C.

Where determinations for CN, Hg, etc., are required, special samples are necessary using the proper preservative and container. Contact the contract lab for specific preservatives and volume amounts they require.

If the samples are to be filtered, use a 0.45 micron membrane filter and pressure (not vacuum).

Table 1

Recommended Preservation Methods

Measurement	Volume (ml)	Container[1]	Preservative[2,3]	Holding Time[4]
Conductance	100	P, G	Cool, 4° C	28 days
PH	25	P, G	None	Analyze Immediately
TDS	100	P, G	Cool, 4° C	7 days
TSS	100	P, G	Cool, 4° C	7 days
Temperature	1000	P, G	None	Analyze Immediately
Metals, Dissolved	200	P,G	Filter (0.45 um) HNO_3 to pH<2	6 months
Metals, Total	100	P, G	HNO_3 to pH<2	6 months
Alkalinity	100	P,G	Cool, 4° C	14 days
Chloride	50	P,G	None	28 days
Cyanide	500	P,G	Cool, 4° C NaOH to pH>12	14 days
Nitrate plus Nitrite	100	P,G	Cool, 4° C H_2SO_4 to pH<2	28 days
Nitrate	100	P,G	Cool, 4° C	48 hours
Sulfate	50	P,G	Cool, 4° C	28 days
BOD	1000	P,G	Cool, 4° C	48 hours
COD	50	P,G	Cool, 4° C H_2SO_4 to pH<2	28 days

Notes:

1. P = plastic. G = glass.
2. Sample preservation should be performed immediately upon sample collection. For composite samples, each aliquot should be preserved at the time of collection. If automatic sampler prevents sample preservation of each aliquot, maintain sample temperature at 4° C until sample collected.
3. When samples shipped via common carrier, it must comply with USDOT regulations (49 CFR 172). DOT regulations do not apply to: Nitric acid in water solution at 0.15% by weight or less; sulfuric acid in water solution at 0.35% by weight or less; or sodium hydroxide in water solution at 0.080% by weight.
4. Samples should be analyzed as soon after sample collection. Times listed denote maximum times that samples may be held before analysis and still be considered valid.

RADIATION SURVEY USING GPS UNIT

Purpose

Radiation surveys performed in combination with a global positioning system (GPS) are performed in order to provide the user with a tool that can present the radiation survey and GPS via specialized computer software to facilitate evaluation of survey findings in a accurate and efficient manner. The system collects data associated with location and radiation levels and is transferred to a computer system for presentation of survey results.

Equipment

GPS system including product software
Ludlum 2221 Ratemeter with RS232 capability
Ludlum 44-10 sodium iodide detector (2" x 2" crystal) with cable
RS232 cable assembly
Carrying assembly (backpack or vehicle mounted system)
Computer and printer/plotter
Computer software for data management
Radioactive check source

Procedure

1. System Set-up and Assembly

To ensure proper data collection, the GPS unit must be properly assembled. This is achieved by checking the following items:

a. backup battery packs are installed and plugged in.

b. GPS unit and handheld datalogger is properly installed. (yellow cable at top of datalogger; black cable at bottom).

c. Ratemeter RS-232 cable connected to GPS cable.

d. Detector probe sleeve is available (if used).

2. Radiation Detector System Function Check

Prior to initiating surveys, a function check is performed to determine if the radiation detector is functioning properly. This is achieved by using a radiation source and comparing the observed result to the expected result. If results are within established limits, the unit is considered acceptable for use. Function checks will be performed at the beginning and end of each day that the system is used for survey purposes.

a. Turn the ratemeter on and check that the battery voltage is above 4.4 volts. If it is below this value, replace batteries.

b. Ensure that the WINDOW switch on the ratemeter is in the OUT position.

c. Place the detector into the soil source beaker and obtain a one minute count. This is achieved by placing the meter in the "SCALER" mode and putting the timing switch to 1.0 and pressing COUNT.

d. Record appropriate information on the Function Check Form. Compare the observed value to the expected range. If the observed value falls within the expected range, the unit is considered acceptable for use.

e. Perform a background check by repeating Steps c and d with the source moved away from the detector.

3. Data Collection

To initiate data collection, ensure that the radiation instrument is on. Utilize the GPS unit manufacturer's instruction in activating the system.

a. Turn datalogger on and allow time for system checks.

b. Select 'Data Collection' and enter appropriate information regarding file name and collection method.

c. Activate external sensor (Ludlum ratemeter).

d. Begin collecting data by transversing the survey area in a manner that allows for a minimum of five data points within each 100 square meter survey grid. If walking is the survey method, this is achieved if the speed of the survey is normal walking speed and the spacing between 'passes' is no greater than ten (10) feet.

e. When survey data collection is done, turn the GPS datalogger off or place in pause mode. Return to the computer system for downloading data.

f. Perform a function check on the radiation instrument if no additional survey data collection is to be performed for the day.

4. Data Transfer

The data that was collected with the GPS survey system is downloadined to a computer via manufacturer's software where it can be imported into a software system to provide data presentation capabilities.

a. Downloading and Exporting Data

1. Hook up datalogger to transfer cable and turn unit on to File Manager.
2. Access GPS system software and initiate data transfer of desired files. When transfer is complete turn off GPS datalogger.
3. To export files, access the "Utilities" mode and select "Export."
4. Select the desired files to export and initiate exporting process. When exporting process is complete, you may exit out of the GPS software program.

5. Data Presentation

The ArcView software is used to view and output the imported data. As a result of the extensive capabilities of the software system and the options in data presentation, it impractical to present and describe all potential uses of the software system.

SOIL SAMPLING FOR RADIUM^{226}

Purpose

The purpose of this procedure is to provide for collection of soil samples that represent the concentrations of radionuclides in the soil at the location being sampled.

Soil sampling is necessary to demonstrate that concentrations of radionuclides in soil at the site satisfy the applicable release criteria. In this case, the criteria are those described at 10 CFR 40, Appendix A, Criterion 6(6). For the purpose of this procedure, that is determination of concentrations of radionuclides in the top six inches, or successive six inch increments of soil averaged over 100 square meters (100m^2).

Scope

This procedure applies to collection of soil samples that are associated with the site surface remediation program.

Equipment

The following is a list of equipment that may be required by this procedure:

- Health and safety equipment and protective clothing
- Field log
- Description of sampling locations
- Chain-of-custody forms
- Disposable gloves or means to wash hands
- Decontamination equipment:
- Trash bag(s)
- Large ziplock bags
- Ink pen(s)
- Marker for labeling sample bags
- Duct tape
- Tape measure (at least 16 feet)
- Stakes, flags, etc ...
- Sampling tools:
  - Hand auger
  - Hand trowel
  - Other

- o Hammer

Procedure

Background: The verification of clean-up of soil at the site includes evaluation of concentration of radioactivity in soil. This evaluation is based on collection and analysis of soil samples. The samples are collected in a known and consistent fashion and with respect to a pre-established location reference system. Soil plugs are collected from five evenly spaced locations across a 10m x 10m (100m^2) area. The five soil plugs are combined to create one composite soil sample. Each composite soil sample is assigned a unique identification.

Safety: Soil sampling may expose the individual to various hazards including physical exertion, weather, wildlife, (esp. snakes), and walking on uneven terrain.

A. Documentation of Sampling Activities

a. Details regarding the sampling exercise should be included in a field log. Information to consider including in the field log is:

- Identification of person(s) collecting samples
- Date and time of sampling
- Weather
- Sample identification
- Sample location
- Sample depth
- Description of sample collection method
- Sample location map or sketch
- Field observation of prior surface disturbance, outcrops, or relevant geologic information
- Field observation of sample appearance
- Any deviation from procedure
- Acknowledgement of decontamination of equipment

- Chain-of-custody number(s)
- Any other significant information

b. Field log entries should be detailed enough, when combined with the procedure, to describe the sampling exercise to someone not present during the sampling activity.

c. The field log should not be completed in pencil. Corrections shall be made with single line-out and initialed by the individual making the correction. Opaque substances such as "Liquid Paper" shall not be used for making corrections.

B. Equipment Decontamination

a. To reduce the potential for cross contamination between samples, the sampling tool should be free of soil or other debris before beginning a sampling exercise and between composite soil sample locations.

i. Clean to remove all visible soil.

ii. Transport and store the equipment to maintain clean condition.

b. *If conditions warrant it, the following precautions should also be* considered:

i. Personnel should clean hands between composite soil sample locations if they are excessively dirty.

ii. Sample collection activities should proceed from areas of least impact to areas of greater impact.

C. Sample Collection

a. Establish the sample location

i. Mark the center of the 10m x 10m square from which the composite soil sample will be collected:

1. Determine the coordinates for this location. This may be done within a reasonable time period before or after the sample collection exercise.

a. If coordinates for this location will be determined after sample collection, mark the location with a semi-permanent marker (e.g. stake, flag, etc ...).

ii. Mark either:

1. the boundaries of the 10m x 10m square using the center point as reference, or

2. the five evenly spaced plug locations within the 10m x 10m square.

b. Collect and composite the soil plugs

i. Place the sample tool on the ground and insert it into the soil to the desired depth.

ii. Extract the sample tool with the soil plug and place the soil plug into the sample container (e.g. zip-lock bag).

iii. Remove rocks, vegetation, and other non-soil.

iv. Repeat Steps i. through iii. for the other four soil plugs of the subject sample location using the same sample container.

v. Mark the sample container with sample identification, depth, date, initials of person collecting sample, and any other necessary information.

vi. If a sample for a depth below six inches is desired, excavate an area down to the six inch depth so that a sample can be collected. Construct the hole to minimize the possibility of the second layer soil sample from containing material from the top six inch level.

D. Schedule for Collection of Replicate Samples

a. One replicate sample shall be collected for every 20 original samples.

b. Replicate samples shall be collected:

i. after the original sample

ii. in the same manner as the original sample except from five new evenly spaced plugs within the same 10m x 10m square

c. The sample identification shall be the same as the original sample except that it will preceded by an "R" to indicate that the sample is a replicate sample.

PREPARATION OF SOIL SAMPLES FOR RADIOMETRIC ANALYSIS

Purpose

The purpose of this procedure is to provide for consistent preparation of soil samples for subsequent determination of radioactivity concentration.

Scope

This procedure applies to preparation of soil samples that are associated with the surface remediation program.

Equipment

The following is a list of equipment that may be used by this procedure:

- Oven
- Drying pans
- Crusher
- Mixer/blender
- Splitter
- Scale
- Scoop or spoon
- Sample container
- Electrical tape
- Labels
- Permanent marker

Procedure

Background: The verification of clean-up of soil at the site includes evaluation of concentration of radioactivity in soil. This evaluation is based on collection and analysis of soil samples. The samples are collected in a known and consistent fashion. The samples must be prepared to facilitate analysis for radioactivity concentration. The preparation must be of a known and consistent manner in order that analysis results are reproducible.

Safety: Preparation of soil samples may present various hazards. Be aware of hazards associated with electrical, crushing, noise, and inhalation of dust. Although most soil samples are expected to contain low concentrations of radioactivity and silica dust, use of a respirator/dust mask is recommended during crushing, mixing/blending, and splitting of soil samples. Safety glasses are required during soil sample preparation activities. Hearing protection is recommended during crushing activities.

Prerequisites: Particular attention should be provided to minimizing the potential for cross-contaminating samples. The sample preparation area should be kept clean and orderly.

The sample preparation equipment should be kept clean and in good operating condition. Segregation should be maintained of samples in different stages of preparation. Segregation should be maintained of samples from different sampling events.

E. Documentation of Sample Preparation Activities

a. Details regarding the sample preparation should be included in a laboratory log. Information to consider including in the laboratory log is:

- Sample identification
- Date of sample preparation
- Identification of individual preparing sample
- Net dry weight of the soil sample to the nearest gram
- Any deviation from preparation procedure
- Any other significant information

b. Laboratory log entries should be complete enough, when combined with the procedure, to describe the sample preparation to someone not present during the preparation activities.

c. The laboratory log should not be completed in pencil. Corrections shall be made with single line-out and initialed by the individual making the correction. Opaque substances such as "Liquid Paper" shall not be used for making corrections.

F. Equipment Decontamination

a. If conditions warrant, the sample preparation equipment should be cleaned between sample preparations.

i. Remove visible aggregate soil from sample preparation equipment.

ii. If the crusher is suspected of containing internal contamination due to excess sample moisture, pass clean soil through the sample preparation equipment.

b. In addition to use of properly cleaned equipment, the following precautions should also be considered if conditions warrant their use.

   i. Personnel should clean hands between sample preparations if they are dirty.

   ii. Sample preparation activities should proceed from samples of least radioactivity concentration to samples of greater radioactivity concentration. This condition may not be known: it might be assessed via gross instrument readings or historical information.

G. Sample Preparation

a. Drying

   i. Place the field sample in an appropriate container.

   ii. Remove rocks, vegetation, and other non-soil material.

   iii. Dry the field soil sample at ambient until dry or at 100 °F for 24 hours.

Comment: I don't think this is necessary at this point. We'll cover it at the crushing step (next). This is just getting the obvious non-soil stuff out.

b. Crushing

   i. Prior to placing a dried soil sample into the crusher, ensure that the crusher sample collection tray is empty and the feeder area is clear of debris.

   ii. Place one dried soil sample into the crusher and crush the sample. The crushed sample will be collected in a catch tray/bin

      1. If the dried soil sample contains larger chunks of soil, they may need to be broken up prior to using the crusher.

c. Mixer/blender

   i. If sample blending is required, follow the steps described below.

   ii. Prior to placing a crushed soil sample into the mixer/blender, ensure that the mixer/blender is empty and the feeder area is clear of debris.

   iii. Place one crushed, dried soil sample into the mixer/blender and mix/blend the sample for approximately five minutes.

iv. Return the mixed/blended sample to the field sample container and place in storage, or proceed to fill a laboratory sample container.

d. Fill laboratory sample container

i. In the case of samples for gamma spectrometry only, complete the following steps:

1. Fill a laboratory sample container with the sample. The typical sample volume is half full Marinelli beaker; but the volume of sample may vary from full to half full. Ensure no large void spaces remain within the sample volume in the container.

2. Place a lid on the laboratory sample container and seal with electrical tape.

3. Place a label on the lid of the filled laboratory sample container. The label should include the following information:

- Sample identification.

- Date the filled laboratory sample container was sealed.

- Net weight of the filled laboratory sample container. Sample weighing may be performed at a later time.

- Any other significant information.

ii. In the case of samples for gamma spectrometry and radiochemical analysis, split the sample to create the necessary number of samples as follows:

1. Remove the mixed/blended sample to the splitting tool.

2. Use the splitting tool to separate the sample into two equal portions.

3. Fill a laboratory sample container as described above from each of the equal portions of the mixed/blended sample.

iii. Place the filled laboratory sample container(s) in storage.

H. Schedule for Creation of Duplicate/Split Samples

a. One duplicate/split sample shall be created for every 20 mixed/blended samples.

b. Duplicate/split samples shall be created from the mixed/blended sample as follows:

   i. Remove the mixed/blended sample to the splitting tool.

   ii. Use the splitting tool to separate the sample into two equal portions.

   iii. Fill a laboratory sample container as described above from each of the equal portions of the mixed/blended sample.

c. The laboratory sample identification shall be the same as the field sample except that it will followed by a "S" to indicate that the sample is a duplicate/split sample.

I. Chain-of-Custody

a. Chain-of-custody procedures shall be followed to maintain a written record concerning sample movement to the contract laboratory.

SAMPLE ANALYSIS FOR RADIUM-226

A. Sample analysis

The Canberra Genie-PC multichannel analyzer software program is used to perform gamma spectroscopy analysis. Prior to initiating soil analysis via gamma spectroscopy, ensure that the MCA calibration status is current. Refer to MCA calibration procedure if calibration is required.

1. Counting Efficiency

Prior to determining system efficiency, check the system response by placing a elevated radium-226 source in the counting well and start the count. The Bi-214 peak should be generated with the peak maximum very near channel 305 on the MCA. If it is not centered on this channel, adjust the MCA settings (typical the gain) until the peak is centered. Following this test, remove the radium-226 source and place a Cs-137 source into the counting well and start the count cycle. The Cs-137 peak should be centered near 662 keV, which will be channel 331 on the MCA. Adjust the MCA as needed to center the peak.

The first step in analysis is obtaining counting efficiencies for radium-226 soil samples is to define the range of channels that the radium-226 daughter product bismuth-214 would be found. Bismuth 214 is counted because it is one of the two daughter products which has a relative short half life of 19.7 minutes and is a gamma emitter. The main gamma energy level of bismuth 214 is at 609 keV. Since the MCA is calibrated at 2 keV per channel, channel 305 is used as the peak of bismuth-214.

Place the radium 226 lab source inside the lead pig that will surround the sodium iodine crystal. Initiate the computer software program and count the source for 1000 seconds. Upon completion of the counting period, utilize the manufacturer's software to calculate the system efficiency to be used for that day. Compare the calculated efficiency to the historical expected values. If any discrepancies arise, investigate for possible causes.

2. Background

Background for the counting system is determined by counting an empty soil beaker and calculating the background in counts per minute. During comparison tests, the count times were varied to determine whether a greater count period for a background sample would be necessary. Background activity at the standard 1000 second count period was compared to an extended background count over a 24 hour period with the results indicating that the system background is approximately 15 cpm.

This background value has been incorporated into the computer program algorithm and automatically subtracts the system background when calculating the radium-226 concentrations for each soil sample.

3. Sample analysis

   a. Place the sample into the counting pig and place the detector on the sample.

   b. Count the sample for 1000 seconds. During the counting period, enter any necessary information pertaining to the sample and system efficiency in the sample information window.

   c. Upon completion of the counting period, save the file.

   d. To obtain a printout of the sample results utilize the manufacturer's software to perform radium content calculations.

   e. If additional samples are to be analyzed, clear the data from the MCA prior to starting another count.

3. Quality Assurance/Quality Control

   To ensure the data obtained from the soil sampling is valid, it is necessary to maintain proper controls and cross checks pertaining to sample handling and analysis.

   a. Recounts

      One sample should be recounted for every ten samples analyzed on the facility counting system; with a minimum of one recount per day when soil analysis is performed. If the recount agrees favorably with the original count, the sample results for the ten previous samples will be considered acceptable. Agreement means that the concentrations overlap each other (i.e., the concentration and uncertainties of the two samples overlap.)

      Sample concentrations, must be considered when evaluating the recount data. When two small values are being compared, the greater the variation will appear between the two samples due to the low values. Additionally, the concentrations of the sample should be compared in relation to the release criteria. For example, if a first count of the sample resulted in 1.2± 0.3 pCi/g and the recount resulted in 1.6 ±0.3 pCi/g, the recount should be considered acceptable as the result is well below the release criteria of 5 pCi/g plus background.

   b. Gamma Spectroscopy - Outside Lab

Approximately five percent (5%) of the samples analyzed should be sent to an outside laboratory for radium-226 analysis via gamma spectroscopy.

c. Radiochemical Analyses - Outside Lab

Two percent (2%) of the samples analyzed should be sent to an outside laboratory for radium-226 analysis via radiochemical analysis.

Data associated with the QA/QC program will be reviewed and updated to reflect trends associated with the data.

RADON FLUX SAMPLING

Purpose

Radon flux measurements may be obtained within specific areas of the facility tailings impoundments to determine compliance with federal standards outlined in 40 CFR 61 and 10 CFR 40, Appendix A, Criterion 6. The standard requires that the average release rate of radon does not exceed 20 picocuries per square meter per second. Samples are collected utilizing EPA Method 115.

Equipment

Sample collection system (PVC sampler unit)
Activated charcoal
Charcoal containers
Sling psychrometer
shovel
Multichannel analyzer (MCA) system
Charcoal standards

Procedure

1. Charcoal Preparation

The activated charcoal used in the sampling must be purged prior to use. This is accomplished by placing the charcoal into an oven for at least 24 hours at 110 degrees celcius (240 degrees farhenheit). The ovens in the mill laboratory may be utilized for the purge process.

After the charcoal is purged, individual samples are prepared. Each sample should weigh approximately 180 grams. The individual samples are placed into air tight containers to isolate the charcoal. Each container is identified by a number.

2. Determining Radon Background For Each Flux Sample

Each sample is to be counted for a background flux concentration prior to being used. The background activity is subtracted from the gross sample activity obtained during sample collection. This will provide a net activity for the charcoal.

To obtain the background reading, place the container of charcoal inside the lead counting well. The sodium iodine crystal is than placed on top of the container and counted for ten minutes. The net peak counts observed in the region of interest between channels 272 and 333 correspond to the bismuth-214 decay peak, which is centered on channel 305. This net peak count is recorded on the datasheet as the background count for the charcoal.

3. Sample Preparation

Radon flux measurements using EPA Method 115 requires the assembly of a radon collection system. This system is comprised of activated charcoal, 10 inch PVC end cap, scrubber pads, support grid, and a retainer ring.

Select an sampling area that is relatively flat and free of rocks and vegetation. Samples should be collected at regularly spaced intervals over the entire sampling area.

Remove the retaining rods on the canister and remove the first layer of filter and mesh. Open a charcoal container and pour it into the support grid. Replace the mesh and filter and secure the unit with the retaining rods.

Place the sampler onto the ground and place a soil barrier around the edge of the sampler. The collection period is 24 hours.

Record all necessary information on the datasheet including location, date, time temperature, relative humidity, cannister number, charcoal container number, and any unusual conditions.

After 24 hours, retrieve the sampler. Remove the retaining rods, and upper layers of filter and mesh and transfer the exposed charcoal back into the initial charcoal container and seal it with tape. Record all necessary information including date, time temperature, relative humidity, and any unusual conditions.

Allow the sample to decay for at least four (4) hours prior to counting to allow for radon and its daughters to reach equilibrium.

4. Efficiency Determination for Radon Flux Measurements

The system counting efficiency is determined by counting charcoal spiked with a radium 226 standard. The method involves sources containing approximately 180 grams of activated charcoal spiked with known concentrations of radium.

The counting system efficiency is determined by counting each spiked activity sample (2 samples) for a ten minute period. The total observed counts comprising the net peak area for bismuth-214 (channels 272 to 333) is recorded from the display. An efficiency factor is calculated by dividing the average measured radioactivity of the two charcoal sources in counts per minute by the known radioactivity of the charcoal sources in disintegrations per minute.

5. Sample Counting

Place an sealed container into the lead counting pig and place the detector on top of the container.

The counting time is ten (10) minutes. Clear any data from the MCA and begin the counting period. Record all necessary information including start date and time, and sample ID on the radon flux sampling datasheet.

After the count period, the necessary counting data is recorded on the radon flux counting datasheet including the net peak counts for the sample and the stop date and stop time. The net counts for each sample is determined by subtracting the background counts, which was obtained In Step 2 above, from the net peak counts of the exposed charcoal. This net count is then used to determine the radon flux for that location.

The radon flux concentration is calculated by using the following formula:

$$J = \frac{C8^2}{KAE(1-e^{-8t1})[e^{-8(t2-t1)} - e^{-8(t3-t1)}]}$$

Where:

J = Radon flux pCi/m^2-sec
C = Net counts under bismuth 214 peak
8= Radon decay constant [2.097 e-6/sec]
A = Area of collector [m^2]
E = Efficiency of detector
K = Conversion from dps to pCi [0.037 dps per pCi]
t1 = Exposure time [sec]
t2 = Time from start of collection to start of count [sec]
t3 = Time from start of collection to end of count [sec]

The standard deviation associated with this result is also determined. The following equation is used:

$$\Phi = 2 * \rho J$$

where:

J = radon flux concentration
Φ = standard deviation of count

6. Quality Assurance/Quality Control

To ensure that the data obtained from the radon flux program is valid, it is necessary to maintain proper controls pertaining to sample handling and custody. Documentation is important at each point of the process including sample preparation, pre-exposure analysis, exposure, and post-exposure analysis.

Daily efficiency determinations on the counting system will be performed while radon flux samples are counted. The procedure described in Section 4 above are to be used.

One sample comprising a blank sample (unexposed charcoal) will be counted on a daily basis. A new blank will be utilized for each counting day. The blank will provide assurances that a sample expected to contain negligible concentrations are indeed being acquired.

A randomly selected group of 10% of the total number of exposed samples should be recounted. The recount should fall within 10% of the original sample. Concentrations must be taken into consideration regarding recount evaluation.

Five percent (5%) of the samples analyzed shall be either blanks or spikes (standards).

The precision, accuracy, and completeness of the measurements and analyses shall be within the following limits for samples measuring greater than 1.0 pCi/m^2-sec:

A. Precision: 10%

Precision = [standard deviation / measured flux] * 100

B. Accuracy: ± 10%

Accuracy = [(true value – observed value) / true value] * 100%

C. At least 85% of the measurements must yield useable results. Samples considered unuseable include those which resulted in a measurable loss of charcoal, frost, standing water at sample, broken seal on sample collection unit or container, or off-scale counts.

CALIBRATION - CONDUCTIVITY METER

Purpose

The purpose of calibrating the meter is to ensure that the meter is operating within specified limits prior to each use.

Equipment

Meter
Distilled Water
TDS Conductivity Standard Solution 2070 and 7000 Microhms or equivalent

Procedure

1. Remove the cap and turn unit on.
2. Pour out two separate portions of your calibration standard and one of de-ionized water into separate clean containers.
3. Press the MODE key to select Conductivity Mode.
4. Rinse your probe with de-ionized water, then rinse the probe in one of the portions of calibration standard.
5. Immerse the probe into the second portion of calibration standard. Be sure to tap probe to remove air bubbles.
6. Wait for the reading to stabilize. The READY indicator lights when the reading is stable.
7. Press the CAL/MEAS key.
8. Press the ⇑ or ⇓ keys to scroll to the value of your conductivity standard.
9. Press the ENTER key to confirm calibration.
10. For calibration in other ranges repeat steps 2 through 9 with the appropriate calibration standards.
11. Press ON/OFF key to turn unit off. There is an automatic shut off after 30 minutes to conserve batteries.

12. Store the probe in its cap filled with electrode storage solution.

CALIBRATION - pH Meter

Purpose

The purpose for calibrating the pH meter is to ensure that the meter is operating within accepted tolerances. Calibration should be checked prior to each use.

Equipment

Oakton pH/CON 10 Meter
Standard Buffer Solutions 4.0 pH, 7.0 pH and 10.0 pH or equivalent
Distilled Water

Calibration Procedures

1. Remove the cap and turn unit on.
2. If necessary, press the MODE key to select Ph mode.
3. Rinse the probe thoroughly de-ionized water
4. Dip the probe into the calibration buffer.
5. Wait for the measured pH value to stabilize. The READY indicator will display when the reading stabilizes.
6. Press CAL/MEAS to enter pH calibration mode. Press the ⇑ or ⇓ keys to select your pH buffer value.
7. Wait for the measured pH value to stabilize.
8. After the READY indicator turns on, press ENTER to confirm calibration. The meter is now calibrated at the buffer indicated in the secondary display. If you are performing multipoint calibration, got to step 9. If you are performing one-point calibration, got to step 11.
9. Press the ⇑ or ⇓ keys to select the next buffer.
10. Rinse the probe with de-ionized water or a rinse solution, and place it in the next pH buffer.

11. When the calibration is complete, press CAL/MEAS to return to pH measurement mode.

12. Press ON/OFF key to turn unit off. There is an automatic shut off after 30 minutes to conserve batteries.

13. Store the probe in its cap filled with electrode storage solution.

CALIBRATION - STEVENS RECORDER

Purpose

The purpose for calibrating the Stevens recorder is to ensure that the flow measurement on the chart correlates with that of the flume staff gauge. Calibration is checked daily and adjusted as needed.

Equipment

Stevens F Recorder

Calibration Procedures

1. Remove the cover from over the recorder unit.
2. Check recorder reading against the staff gauge in the Parshall flume.
3. If they match, record the values and replace the cover.
4. If they do not match, gently lift the pen from the paper and loosen the float pully nut. The nut is located on the end of the shaft holding the float pulley.
5. Holding the float pulley firmly, rotate the recording drum in the direction needed to correct the discrepancy.
6. Gently replace the pen back on the paper and check the value indicated against the staff gauge. Repeat step 5 until the two readings match.
7. Tighten the float pulley nut and check the chart reading one more time.
8. Replace the cover on the recorder.

CALIBRATION - HIGH VOLUME AIR SAMPLER

Purpose

High volume air samplers are used to determine ambient air concentrations in the vicinity of the facility. Proper operation of the sampler is necessary to determine total air volume during sampling period.

Instruments

High volume air sampler
Filter papers
Calibration kit

Procedure

The unit must be calibrated with a new filter in the unit while it is running.

1. Set up the water manometer and open it to the atmosphere.
2. Mount the top loader adaptor onto the sampler directly on top of the new filter.
3. Place a restrictor plate onto the calibration unit and secure the orifice.
4. Connect the flexible tubing to the port on the adaptor and unto the manometer and obtain a pressure reading.
5. Record the value on the calibration sheet.
6. Record the flow rate by using the rotameter maintained at the sampler.
7. Repeat Steps 3 through 6 for each of the additional restrictor plates.
8. Use the manometer readings obtained to determine an actual flow rate from the calibration curve for each data point.
9. Record this value and divide it by the observed flow rate recorded from the rotameter to obtain a ratio of actual to observed flow.
10. Obtain an average efficiency of the unit. The table below provides an example. Record any additional information on the calibration sheet.

Flow Calibration Form

Plate	Rotameter Reading (cfm)	Manometer Reading (in. water)	Actual Volume (cfm)	Ratio Actual/Rotameter
5	35	3.0	33	0.94
7	40	3.6	38	0.94
10	45	4.6	43.5	0.97
13	50	5.6	48	0.96
18	55	6.0	50	0.91
				0.94

SURFACE WATER SAMPLING

Purpose

Collection of surface water samples may occur as part of an in house monitoring program or as a special project. For the purposes of this sampling procedure, surface water refers to treated mine water that is present as surface water. These samples would represent a grab sample. Information obtained from this program can be used to evaluate the environmental effects of activities. Samples collected as a component of the NPDES permit are collected in accordance with sampling requirements specified within the EPA permit.

Equipment

Sample Bottles
Sampling tool (extender arm to provide added reach)
Field Measurement Instruments (if necessary)
Filtering instrumentation (if necessary)
Preservatives (if necessary)

Procedure

Proceed to the desired location for sample collection. This may be a designated location or it may be a general area description. Observe the surrounding area and note if there is any unusual conditions present that may have influence on sample collection. Record these if any are present.

If field parameters, such as pH, temperature, or conductivity are desired, obtain a sample of the water and perform necessary tests on a water sample that has not been filtered or preserved.

If the sample containers have already been prepared with the necessary preservative, no additional action is needed other than collecting the sample. If this is the case, be careful not to overflow the container as some of the preservative will be lost in the overflow. One way to prevent this is to use a collection bottle and transfer this to the actual sample bottle. In the event access to sample collection is impeded due to vegetation or other reason, the extender arm sampling tool may be used to help in collecting a sample.

If new containers are used to collect the sample, they must not have been previously used and are free of possible contamination. If the container appears to be spoiled, do not use it for sample collection. Prior to collecting the water sample, wash the sample container several times with the water you are going to collect. This will help remove any foreign material in the sampling container. Fill the container leaving adequate room for the sample to be shaken upon addition of any preservative. When filling the container, let water run into the bottle from the "upstream" side while your hands are on the "downstream" side of the container. This will help prevent any contamination that you have on your hands or gloves from accidentally being collected.

If filtering is needed, collect sufficient volume in a clean container and then filter through appropriate filter media into the final sample container that is marked identifying the sample. Add any necessary preservative after filtering is completed. Upon collection of samples, prepare the samples for shipment to laboratory for any analysis that is required.

Evaporation Pond Sampling

Purpose

Samples may be collected from the facility lined evaporation ponds in order to determine water quality characteristics present within the pond at that point in time. This information can be used to assist in evaluating potential environmental effects associated with the use of the ponds.

Equipment

Sample Bottles
Sampling tool (extender arm to provide added reach)
Field Measurement Instruments (if necessary)
Filtering instrumentation (if necessary)
Preservatives (if necessary)

Procedure

Proceed to the desired location for sample collection. This may be a designated location or it may be a general area description. Caution must be exercised around the lined cells as damage to the liner should be prevented. Additionally, appropriate judgment must be used if access to solution within a pond is limited or access will create an undue safety hazard to the sampler. Observe the surrounding area and note if there is any unusual conditions present that may have influence on sample collection. Record these if any are present.

To prevent contact with the solutions, gloves should be used. Use a collection bottle and transfer this to the actual sample bottle. In the event access to sample collection is impeded due to vegetation or other reason, the extender arm sampling tool may be used to help in collecting a sample.

If field parameters, such as pH, temperature, or conductivity are desired, obtain a sample of the water and perform necessary tests on a water sample that has not been filtered or preserved.

If the sample containers have already been prepared with the necessary preservative, no additional action is needed other than collecting the sample.

If new containers are used to collect the sample, they must not have been previously used and are free of possible contamination. If the container appears to be spoiled, do not use it for sample collection. Prior to collecting the water sample, wash the sample container several times with the solution you are going to collect. This will help remove any foreign material in the sampling container. Fill the container leaving adequate room for the sample to be shaken upon addition of any preservative.

If filtering is needed, collect sufficient volume in a clean container and then filter through appropriate filter media into the final sample container that is marked identifying the sample. Add any necessary preservative after filtering is completed. Upon collection of samples, prepare the samples for shipment to laboratory for any analysis that is required.

Water Sample Collection - NPDES Permit

Purpose

NPDES permit requirements
may include sampling discharges associated with the permit on a specific frequency as required by the permit. Information collected under this permit is submitted to EPA within discharge monitoring reports supplied by EPA. Reporting frequency to EPA is monthly.

Equipment

Sample Bottles
Composite sampler unit
Field Parameter instrumentation
Cooler/ice
Filtering instrumentation (if necessary)
Preservatives (if necessary)

Procedure

Samples under NPDES permit requires collection of monthly samples at designated outfall locations. Present locations are the "B-3" outfall, which requires a grab sample; and the Section 5 outfall, which requires a 24-hour composite sample. A 24 hour composite sample means a sample consisting of a minimum of 8 grab samples of effluents collected at regular intervals over a normal operating day and combined proportional to flow, or a ample continuously collected proportional to flow over a normal operating day.

B-3 Location

Sample collection at B-3 requires a grab sample. Follow procedures as described in the " Surface Water Sampling" procedure.

Samples will be sent to laboratory for required analyses.

Outfall 001 Location

Outfall 001 requires composite sampling to be performed. The procedures for composite sampling are outlined on the following pages from the Manning S-5000 manual.

Functional Description

Each sampling cycle begins with a purging action. Air pressure is directed by the positive side of the compressor through a 4-way valve into the measuring chamber. The pinch valve below the chamber is held closed, forcing the pressurized air out through the intake hose to purge the line of possible obstructions. The purge action takes approximately 7 seconds.

When the purge is completed the controller switches the 4-way valve to the negative (suction) side of the compressor. The pinch valve remains closed and suction draws fluid up the intake hose into the measuring chamber.

When the measuring chamber is full a sensor at the top of the chamber signals the controller to open the pressure ports of the 4-way valve to reverse compressor action. Air is again directed under pressure to the measuring chamber, forcing excess sampled liquid out through the intake tube into the channel flow.

When fluid level in the measuring chamber drops to the preset opening in the siphon the controller opens the pinch valve, allowing pressure to discharge the sample out the chamber into the sample bottle.

Flow

With the function knob in the FLOW position the S-5000 Sampler can be driven by a flowmeter or total flow computer by means of a momentary dry circuit contact closure to provide flow proportional sampling. In this mode if contact closure remains closed, the MIN-HRS timer will sample-command at the end of each time interval. The contact closure must be 1K ohms or less.

An internal crystal quartz clock with a time interval select switch (S4) on the control panel controls the frequency of sampling cycles. Ten sampling intervals, from 3.75 minutes to 24 hours, can be selected. With the function switch set to TIME, placing the POWER switch to ON will immediately start the sampling cycle and automatically initiate a new sampling cycle at the end of each time frame. If an initial (immediate) sample is not desirable turn the POWER switch to ON, then place the function switch to the TIME position. This sequence delays the sample command for the time period set at the MIN-HRS switch. Thereafter, at each elapsed interval the sampler will automatically initiate a new sample cycle.

PRE-OPERATION CHECKS

Check that connections at the terminal barrier strip are complete and secure

Check that the function knob is in the OFF position.

Check that the POWER switch is in the OFF position.

Prior to operation of the S-5000 Sampler, familiarization with the functions and operating sequences of the unit as well as testing for sampling results can be accomplished as follows:

a. Place a container with several gallons of water near the Sampler.

b. Place the intake hose in the container with the open end resting on the bottom.

c. Remove the wingnuts from the top of the measuring chamber and lift the siphon tube out.

d. Adjust the opening in the siphon spiral slit tube for the desired sample volume.

NOTE: For precise adjustment of sample volume (from 50 ml to 1000 ml) make an initial, approximate adjustment and place the siphon back in the measuring chamber and observe at eye level the position of the center of the opening with respect to the milliliter increments on the chamber. This action may have to be repeated several times. Accurate volume setting is indicated when the center of the opening in the spiral tube is level with the milliliter increment desired.

e. Fine adjustment of chamber volume should be made as follows:

1. Obtain a beaker with milliliter increments of known accuracy.
2. Adjust the opening in the spiral slit tube for the desired sample volume.
3. Position the beaker under the outlet tube and draw a sample.
4. When the sample is discharged into the beaker, check the milliliter reading on the beaker with respect to the liquid level.
5. If the reading varies from the setting made in the chamber, adjust the spiral slit tube for more, or less, volume, as applicable.
6. Precise sample volume may require repeating these procedures several times.

f. Place the POWER ON-OFF knob to ON.

g. Set the MIN-HRS knob to the desired sampling time (TIME mode only).

h. Place the function knob to the TIME position.

NOTE: Upon completion of Step (h) the sampler will at the end of the time set, purge, draw a sample, purge excess liquid, discharge the measured sample into the sample bottle, and shut down and wait for the next signal to take a sample.

OPERATION

a. With the sampler positioned at its permanent location, place the intake hose in the channel flow.

NOTE: If the sampler is equipped with the optional strainer, push the strainer hose barb into the hose until the hose is against the hexagonal fitting.

NOTE: The intake hose should be placed in the channel main flow, not in an eddy or at the edge of the flow. Where the possibility of clogging of the intake hose opening by debris exists, provisions should be made for deflecting such debris.

Vertical positioning of the intake will depend on the type of sample to be taken; for example, placement at the bottom of the flow will result in heavier concentration of solids in the sample, while placement at or near the top of the flow will eliminate most solids and detect oils, fats, or other floating or suspended contaminates.

NOTE: To prevent the intake from being pulled to the surface of a channel with fast flow, fasten a weight with wire or other means to maintain proper intake position.

b. Perform Steps (c) through (h) of paragraph 3.1.2 in sequence. The sampling operation will begin and continue as dictated by the settings at the control panel.

Flow Proportional Sampling

Immediate Sample

Connect the Flowmeter cable to the FLOW and COMMON terminals at the barrier strip. A sample will be taken immediately on contact closure

Time Delay Sample

Connect the Flowmeter cable to the COMMON and TIME terminals at the barrier strip. Sample initiation will be delayed by the time setting at the MIN-HRS switch

NOTES: When positioning the intake hose and strainer in a channel make certain that the hose is short enough to extend from the sampler to the channel in a consistently straight or sloping line, avoiding dips that will act as a "trap".

Liquid from previous samples will remain in a trap, unaffected by purging action, and will cause cross-contamination of samples.

Water Sampling – Mines

Purpose

Water samples may be required to be collected at the mines for the purpose of obtaining water quality information.

Equipment

Probe Truck (if needed)
Sample Bottles
Field Parameter instrumentation
Cooler/ice
Filtering instrumentation (if necessary)
Preservatives (if necessary)

Procedure

If the mine requiring sampling is not being pumped, use the probe truck and obtain sample from mine as if it were a large well. Follow procedures outlined in Groundwater Sampling procedure.

If mine requiring sampling is being pumped, obtain a sample from the sampling port located in the pipeline near the collar location.

1. Open the sampling valve slowly to prevent spraying of water and/or air and adjust flow to facilitate sample collection.
2. If field parameters will be required fill a clean container with mine water and close valve.
3. Obtain field measurements.
4. If some samples will not require filtering, directly fill sample bottles with water and add any preservative, if needed.
5. If filtering will be required, fill a container with sufficient volume of water.
6. Filter desired quantity by using filtering pump and allowing water to pour directly into sample bottles.
7. Add appropriate amount of preservative to samples, as needed.
8. Ensure all bottles are properly labeled.
9. Return samples to office and prepare for shipping to contract laboratory.

RIO ALGOM MINING LLC

Ambrosia Lake Facility

Health Physics and Environmental Procedures and Technical Manual

Original:
February 1988

Reviewed/Revised

February 1989
February 1990
February 1991
February 1992
June 1992
February 1993
December 1993
February 1994
June 1994
February 1995
March 1995
September 1995
February 1996
August 1996
January 1997
January 1998
December 1998
March 1999
November 1999
August 2000
August 2001
January 2002
January 2003
July 2003
August 2003
November 2003
April 2004

RIO ALGOM MINING LLC

Ambrosia Lake Facility
Health Physics and Environmental Procedures and Technical Manual

In accordance with License Condition #16 of NRC Source Material License SUA-1473, each procedure contained within this manual was reviewed and revised as necessary.

Approval: ______________________ Date: ______________
Radiation Safety Officer

Approval: ______________________ Date: ______________
General Manager

APPENDIX G-2
RIO ALGOM MINING LLC, AMBROSIA LAKE FACILITY PERSONNEL CONTAMINATION CONTROL PROTOCOL

Rio Algom

November 11, 2003

SHOWER POLICY

In keeping with Rio Algom Mining LLC's policies pertaining to regulatory compliance and keeping radiation exposures As Low As Reasonably Achievable (ALARA), the following procedures concerning the control of personnel radioactive contamination are hereby incorporated as operational policy during standby activities.

IX Plant Operations **SOPs** **RWPs**

All employees who work within the the IX plant, or as required by a standard operating procedure (SOP) or a radiation work permit (RWP) shall perform one of the following before leaving the mill property at the end of the shift:

1. *Shower and change into clean street clothes. Self monitoring with the radiation detection instrument at the guard gate is not required. The individual is assumed to be free of contamination.*

2. If the individual does not shower, then that person shall wash potential areas of contamination (hands, arms, etc.) and change into clean street clothes. Prior to exiting the mill property, the individual will self monitor to confirm that they meet prescribed contamination levels. The radiation survey instrument at the guard gate where the employee exits the mill property shall be used. If monitoring results indicate levels above those prescribed, showering/decontamination is required prior to leaving the property.

Coveralls and/or work clothes exceeding prescribed contamination levels shall be decontaminated or disposed on-site.

This policy is being instituted to maintain radiation exposures ALARA. All employees shall be familiar with this procedure and cooperate to maintain good radiation protection practices to maintain radiation exposures ALARA.

Terry L Fletcher

Terry L. Fletcher
General Manager

Peter Luthiger
Radiation Safety Officer

APPENDIX G-3
RIO ALGOM MINING LLC, AMBROSIA LAKE FACILITY RESPIRATORY PROTECTION PROGRAM

RESPIRATORY PROTECTION PROGRAM

TABLE OF CONTENTS

I. Introduction

The primary objective of the Respirator Protection Program is to limit the inhalation of radioactive and non-radioactive airborne contaminants under abnormal conditions. This objective is normally accomplished through the utilization of engineering controls, including process, containment, and ventilation equipment. When such controls are not feasible or are malfunctioning the use of respiratory protection equipment may become necessary. Only MSHA and/or NIOSH approved respirators will be used.

Since the use of respirators entails a greater likelihood of accidental exposures and work in areas with possible increase in safety hazards, certain provisions must be set forth regarding the circumstances under which respiratory protection will be utilized. These provisions are outlined in the section entitled "Policy Statement".

This manual provides general guidance for the planned use of respirators to protect individuals from the inhalation of airborne materials in the work place. The areas covered include:

Determination of respirator requirements;
operational procedures;
fitting procedures;
maintenance procedures;
training;
medical limitations;
program administration and evaluation.

II. Definitions

Air-Line Respirator - An air-supplied respirator wherein respirable air is supplied to a respirable-inlet covering by means of a small diameter hose connected to a positive pressure supply of respirable air.

Air-Purifying Respirator - A respirator designed to remove contaminants from ambient air prior to its inhalation.

ALARA - As Low As Reasonably Achievable

Approved - Tested and listed as satisfactory by either National Institute for Occupational Safety & Health (NIOSH) Mine Safety and Health Administration (MSHA)

Canister (air-purifying) - A container with a filter, sorbent, or catalyst, or any combination thereof, which removes specific contaminants from the air drawn through it. Generally it is normally connected to the respirator at the chin.

Cartridge (air-purifying) - A small canister which normally fits on the side of respirators.

Confined Space - An enclosure such as a storage tank, process vessel, boiler, silo, tank car, pipeline, tube, duct, sewer, or pit having limited means of egress and poor natural ventilation which may be contain hazardous contaminants or be oxygen deficient.

Disposable Respirator - An air purifying respirator which removes particulate matter from ambient air prior to inhalation and which is designed to be discarded after a single use or after one day's use.

Emergency Respirator Use - Wearing a respirator when a hazardous atmosphere suddenly occurs that requires immediate use of a respirator either for escape from the hazardous atmosphere or for entry into the hazardous atmosphere to carry out maintenance or some other task.

Filter - a medium that removes particles as air passes through it.

Full Facepiece - A tight fitting device that covers the wearer's nose, mouth, eyes, and face which makes an airtight fit with an individual's face.

Half-Mask Facepiece - A tight fitting device that covers the wearer's nose and mouth which makes an airtight fit with an individual's face.

Oxygen Deficient Atmosphere - Ambient air corrected to standard temperature and pressure having less than 19.5 percent by volume of oxygen.

Particulate Matter - Finely divided solid or liquid particles suspended in air.

Powered Particulate-filter Respirator - An air purifying respirator that employs a blower to pass ambient air through a filter that removes particulate matter and supplies respirable air to a respiratory inlet covering.

Positive Pressure Respirator - A respirator in which the air pressure inside the respiratory inlet covering is positive in relation to the air pressure of the outside atmosphere during exhalation and inhalation.

Respirator - A device designed to protect the wearer from inhalation of harmful atmospheres.

Routine Respirator Use - Wearing a respirator as a normal procedure when carrying out a regular and frequently repeated task.

III. Policy Statement

A. Routine Operations

Routine operations include normal production activities which are generally repetitive and are carried out under acceptable conditions. For such operations, potential airborne hazards must be maintained at acceptable concentrations through the utilization of engineering controls. The use of respirators as a substitute for practicable engineering controls is not acceptable. Respirators may be used while engineering controls are being evaluated or instituted or on a voluntary basis.

B. Non-Routine Operations

Non-routine operations include non-production activities that occur infrequently or occur at times when engineering controls are impractical or inoperable. This includes maintenance activities which are required to maintain or regain control of normal production activities. For such operations, the use of respirators to avoid excessive exposure to airborne hazards are appropriate.

C. Emergency Operations

Emergencies are unexpected occurrences which may require the use of respirator protection to limit the inhalation of airborne material which may potentially pose hazardous health consequences. These situations include, but are not limited to shipping accidents, tailings failures, process releases, and ground failures.

D. Work Periods

The periods of time that respirators are worn continuously and the overall durations of use should be kept to a practicable minimum. Specific time limits on respirator use cannot be assigned because of variabilities in job requirements, physical capacities, and psychological attitudes of individuals.

Adequate provision must be made for the respirator users to leave areas where respirator use is required for periodic relief, depending on conditions and circumstances. The adequacy of such a relief period shall be determined by the immediate supervisor.

In order to limit the total time of respirator usage, rotation of maintenance work assignments shall be considered whenever practical.

E. Voluntary Respirator Use

When respirator use is not warranted, employees may request the use of a respirator to allow additional protection in an otherwise controlled environment. This is in keeping with the ALARA principle. However, voluntary use of approved respirators is not intended as a substitute for practicable engineering controls. Respirator protection credit shall not be given for voluntary use of respirators during normal work conditions.

F. Facial Hair

Individuals who have facial hair that interferes in the area where the respirator seals against the face, shall not be fitted with a tight-fitting respirator (half or full faced). This does not imply that all facial hair must be forbidden when respirators are worn, since moustaches or sideburns may be permitted provided they do not interfere with the sealing surface of the respirator. Each case must be considered individually. Additionally, the supervisor is obliged to ensure the respirator is both properly fitted and worn.

IV. Determination of Respirator Requirements

As part of the on-going health physics monitoring program implemented at the facility, air sampling is conducted in routine and non-routine areas throughout the year and when special work projects are scheduled. This extensive air sampling program identifies the extent of any potential airborne hazard thereby providing information into the potential exposure to individuals in the work area. Additionally, standard operating procedures have been developed for specific tasks where the potential exists for exposure to radioactive materials. These SOPs provide employees with time proven techniques to perform task so as to minimize their exposure and preclude the use of respiratory protective equipment.

The primary method to maintain exposures ALARA will be through the use of engineering controls such as ventilation. In the event that unwanted exposure potential still is possible with engineering controls in place, respirators may be used.

To provide additional information for use in evaluating actual intakes, additional air sampling may be performed while the work is in progress; and bioassay sample collection and analysis will be performed if exposure determinations warrant their use.

V. Operating Procedures - General

All respiratory protection equipment used in this program shall have MSHA/NIOSH approval. All such equipment shall be issued only from the Respirator Room which is located adjacent to the mill guard house. The Environmental department will be responsible for maintaining the equipment in proper working order.

A.. Mill Area

As a result of mill demolition work being conducted under RWPs, respiratory protection requirements will be described within the RWP, if needed. Other possible areas for respirator use may be the IX Plant or the Shop, depending on conditions.

B. Hazardous Operations

Operations which require the use of supplied air respirators denote an environment which may be immediately hazardous to the wearer's health. Properly equipped personnel shall be available to monitor work and rescue the wearer in the event of equipment malfunction.

VI. Respirator Fitting Procedures - Qualitative

Either one of the following procedures should be performed as appropriate each time a respirator is issued and worn to ensure proper fitting of the respirator. These procedures do not apply to positive pressure or air supplied respirators which require fitting only as comfort dictates.

A. MSHA Respirator Negative Pressure Test (Particulate & Chemical Units)

Close off the inlet opening of the cartridges by covering with the palms of the hands. Inhale gently so that the facepiece collapses slightly (be careful not to create such a negative pressure as to break the seal due to warping of the facepiece. If the facepiece remains in its slightly collapsed condition and no inward leakage of air is detected, the fit is satisfactory.

B. Irritant Smoke Tube Test (Particulate Units)

Using a smoke tube with a squeeze bulb and instructing the wearer to keep his eyes closed, direct the smoke around the facepiece seal while the wearer breathes normally and moves his head in various motions simulating actual work movements. Leakage is indicated by irritation to the throat and lungs. Usually coughing is experienced. If there is no irritation, the fit is satisfactory.

C. Disposable Respirators (Particulate Units)

Using a smoke tube and squeeze bulb and instructing the wearer to keep his eyes closed, direct the smoke around the facepiece seal while the wearer breathes normally and moves his head in various motions simulating actual work movements. Leakage is indicated by irritation to the throat and lungs. Usually coughing is experienced. If there is no irritation, the fit is satisfactory.

VII. Cleaning and Maintenance

A. Cleaning and Sanitizing

The following guidelines should be used for proper maintenance of respiratory protective equipment.

1. MSA respirators should be cleaned and disinfected after each use or whenever the seal on the plastic bag has been broken.
2. Remove any filter, cartridges, or canisters and replace or clean and disinfect as necessary.
3. For air supplied respirators, wash facepiece and breathing tube in cleaner-disinfectant, using hand brush if necessary.
4. Rinse completely in clean water.
5. Place in dryer bin for drying.
6. After drying, a total gross alpha survey of a representative number (approximately 10 percent of the respirators) shall be conducted. If the activity exceeds 100 dpm per 100 square centimeters then a smear test shall be taken. If the activity still exceeds 100 dpm/100 cm^2, then the batch of respirators shall be recleaned.

7. Clean other respirator parts as recommended by the manufacturer.

8. Inspect valves, headstraps, facepiece, and other parts necessary for proper functioning and sealing of the respirator. Replace any defective parts.

9. Replacement parts used shall be only those supplied by the original manufacturer. Any modifications that are not authorized by MSHA/NIOSH to approved respirators shall not be performed.

10. Insert new or disinfected filters, cartridges, or canisters as required. Ensure a tight seal.

11. Place in a clean plastic bag and seal for storage for MSA respirators.

B. Inspection

Each respirator should be inspected after washing and prior to packaging for proper working condition. As a guideline, the following items are examples of what to look for:

1. Cracking or deterioration of rubber or plastic parts.

2. Elasticity and unity of holding straps.

3. Proper seating and unity of inhalation or exhalation values.

4. Proper tightness and correct fitting of connecting tubes.

5. Checking shelf-line date(s) where applicable.

6. Proper function of regulators and gauges.

7. Proper sealing and seating of cartridges and canisters.

In the event any defects are found, that piece of equipment will be immediately removed from service. It will be returned to service only when it has been repaired and meets the qualifications as outlined by the respirator's approval number.

C. Repairs

The replacement or repairs will be done only with parts designed for the respirator. No attempt will be made to replace components or make adjustments beyond the manufactures recommendations.

D. Storage

After the inspection, cleaning, surveying, maintenance, and repairs are completed, they shall be properly stored to protect against dust, temperature variants, sunlight, excessive moisture, or other contaminants which may interfere with the cleanliness or function of the respirator. The respirators will be stored in plastic bags and grouped together by type of respirator cartridge or canister.

VIII. Training

The facility training program (new employee training, annual refresher) shall include a section on respiratory protection. The instruction in respiratory protection shall include the following:

1. The nature of the reasons why it becomes necessary to wear respirators in certain situations, and why engineering controls are not feasible.

2. An explanation of the reasons why it becomes necessary to wear respirators in certain situations, and why engineering controls are not feasible.

3. A discussion as to why a particular respirator is suitable for different types of contaminants.

4. A discussion of the respirators capabilities and limitations.

5. Instruction and demonstration concerning the types, operation, fitting, and correct use of a respirator.

6. Individual fitting and leak tests accompanied with appropriate documentation.

IX. Medical Limitations

A spirometer test is to be given to each employee to determine respiratory capacity. The frequency of such test for each employee shall be determined by a physician. This test shall be used in determining an employees ability to use respiratory protection equipment.

Upon evaluation of the spirometer test by the attending physician, a copy of the completed results shall be forwarded to the facility Radiation Safety Officer for reference.

The Radiation Safety Officer is then responsible for informing management and the affected employee that the employee is excluded from work requiring respiratory protection.

X. Qualifications of Administrator

Responsibility for the respiratory program shall be vested in one individual having experience in environmental engineering, and/or health physics, and/or industrial hygiene. The responsible individual must have the authority, ability, training, and experience to:

1. Evaluate the hazards pertaining to the job function.
2. Recommend engineering controls if feasible.
3. Specify respiratory protection if engineering controls are infeasible.
4. Forbid the use of improper respiratory protection equipment.

XI. Program Evaluation

The respiratory protection program will be reviewed as needed or at least annually. This review/audit will evaluate the effectiveness of the program in limiting exposures to individuals. The annual ALARA report will include an evaluation of the respiratory protection program.

A. Evaluation of Protection

The results of the air sampling program and bioassay program are an effective means of evaluating a respiratory protection program. Any evidence of a rise in exposure levels that could possibly be linked to respiratory protection shall be investigated immediately. The affected personnel shall be required to submit an immediate bioassay sample if one has not already been submitted subsequent to the incident.

B. Wearer Acceptance

Whenever possible, steps shall be taken to ensure that wearers can choose from a selection of models in order to enhance acceptability as long as the different models provide adequate protection. Before a new model is initiated into the program, a testing period will be conducted during which time comments from wearers are recorded and used in determining the feasibility of the models inclusion in this program.

C. Training and Fitting Records

Annual training and fitting records are required in order to provide documentation as to the adequacy of the program and to provide evidence of possible problems in fitting individuals with certain respiratory protection devices. As a minimum, the records should contain names, social security numbers, and dates of training or fitting.

D. Bioassay Program

Rio Algom Mining LLC's Bioassay Program is hereby referenced and made part of the Respiratory Protection Program.

The following table provides information regarding various respirators available at the facility. They are divided into section denoting a specific hazard. The user is cautioned that multiple hazards may be present and that consultation with the Environmental Department is advised if the user is not certain of the atmospheric conditions in the work area. See footnotes for specific information

TABLE 1

RESPIRATOR SELECTION TABLE

Particulate Radionuclides			
Respirator /Model	**Type**	**Approval Number**	**Limitations**
MSA Comfo-II - Type H canister	NP-HF-filter	TC-21C-135	19.5% oxygen
MSA UltraTwin - Type H canister	NP-FF-filter	TC-21C-155	19.5% oxygen
MSA Powered air particulate respirator	PP-FF-filter	TC-21C-186	19.5% oxygen
MSA Powered air particulate (RACAL)	PP-FF-filter	TC-21C-212	19.5% oxygen
MSA canister GMR-C	NP-FF	TC-14G-105	19.5% oxygen
MSA canister GMR-I	NP-FF	TC-14G-108	19.5% oxygen
MSA airline respirator	CF-(HF-FF)	TC-19C-78	Use with CO monitor
Radon Daughters			
Respirator /Model	**Type**	**Approval Number**	**Limitations**
3M - 9920 disposable	NP-HF-filter	TC-21C-202	19.5% oxygen
MSA Comfo-II - Type S canister	NP-HF-filter	TC-21C-134	19.5% oxygen
MSA UltraTwin - Type S canister	NP-FF-filter	TC-21C-187	19.5% oxygen

MSA canister GMR-I	NP-FF	TC-14G-108	19.5% oxygen

Ammonia / Amines

Respirator /Model	Type	Approval Number	Limitations
3M Model 8727 disposable	NP-HF-chemical	TC-23C-217	19.5% O_2, 300 ppm NH_3, 100 ppm methylamine
MSA Comfo-II - Type GMD canister With Type F prefilter	NP-HF-chemical	TC-23C-43 TC-21C-133	19.5% O_2 300 ppm NH_3, 100 ppm methylamine
MSA UltraTwin - Type GMD canister With Type F prefilter	NP-FF-chemical	TC-21C-147 TC-21C-133	19.5% O_2, 300 ppm NH_3, 100 ppm methylamine
MSA airline respirator	CF-(HF-FF)	TC-19C-78	Use with CO monitor

Acid Gases

Respirator /Model	Type	Approval Number	Limitations
MSA Comfo-II - GMB canister	NP-HF-filter	TC-23C-41	19.5% oxygen, 10 ppm Cl, 50 ppm HCL & SO_2
MSA UltraTwin - GMB canister	NP-FF-filter	TC-21C-145	19.5% oxygen, 10 ppm Cl, 50 ppm HCL & SO_2
MSA Comfo-II - GMC canister	NP-HF-filter	TC-23C-47	19.5% O_2, 10 ppm Cl, 50 ppm HCL & SO_2, .1% organics
MSA UltraTwin - GMC canister	NP-FF-filter	TC-21C-146	19.5% O_2, 10 ppm Cl, 50 ppm HCL & SO_2, .1% organics
UseType F prefilter for dusts/mists	filter	TC-21C-133	19.5% oxygen
MSA airline respirator	CF-(HF-FF)	TC-19C-78	Use with CO monitor

Asbestos

Respirator /Model	Type	Approval Number	Limitations
MSA Comfo-II - Type S canister	NP-HF-filter	TC-21C-134	19.5% oxygen
MSA UltraTwin - Type S canister	NP-FF-filter	TC-21C-187	19.5% oxygen
MSA canister GMR-I	NP-FF	TC-14G-108	19.5% oxygen
MSA airline respirator	CF-(HF-FF)	TC-19C-78	Use with CO monitor

Organic Vapors / Paint

Respirator /Model	Type	Approval Number	Limitations
MSA Comfo-II - Type GMA canister With MSA prefilter	NP-HF-chemical	TC-23C-40 TC-21C-133 / TC-23C-80	19.5% oxygen, 0.1% organic vapor
MSA UltraTwin - Type GMA canister With MSA prefilter	NP-FF-chemical	TC-21C-144 TC-21C-133/ TC-23C-80	19.5% oxygen, 0.1% organic vapor
MSA Comfo-II - Type GMC canister With MSA prefilter	NP-HF-chemical	TC-23C-47 TC-21C-133/ TC-23C-80	19.5% oxygen, 10 ppm Cl, 50 ppm HCL & SO_2, .1% organics
MSA UltraTwin - Type GMC canister With MSA prefilter	NP-FF-chemical	TC-21C-146 TC-21C-133/ TC-23C-80	19.5% oxygen, 10 ppm Cl, 50 ppm HCL & SO_2, .1% organics
MSA canister GMR-I	NP-FF	TC-14G-108	19.5% oxygen
MSA airline respirator	CF-(HF-FF)	TC-19C-78	Use with CO monitor

Welding Fumes			
3M - 9920 disposable	NP-HF-filter	TC-21C-202	19.5% oxygen
MSA Comfo-II - Type S canister	NP-HF-filter	TC-21C-134	19.5% oxygen
MSA UltraTwin - Type S canister	NP-FF-filter	TC-21C-187	19.5% oxygen
MSA airline respirator	CF-(HF-FF)	TC-19C-78	Use with CO monitor

Dust			
Any filter respirator	filter		19.5% oxygen
3M - 8710 disposable	NP-HF-filter	TC-21C-132	19.5% oxygen
3M - 8210 disposable (N95)	NP-HF-filter	TC-84A-0007	19.5% oxygen
3M - 9920 disposable	NP-HF-filter	TC-21C-202	19.5% oxygen

Foonotes:

1. See Appendix B for assigned protection factors for respirators.
2. Types:
    HF - half face
    FF - full face
    PP - positive pressure
    NP - negative pressure
    CF - continuous flow
3. Do not alter or modify any part of the respirator.

APPENDIX A

Radiation Safety Survey Form

Date: ______________________________

Work Request Number ______________________________

Employee Name ______________________________

Work Area ______________________________

Specific Job ______________________________

Pump Number ______________________________

Filter Number ______________________________

Time Started ______________________________

Time Completed ______________________________

Respirators: **Negative Pressure** _____ **Powered Air** _____ **Supplied Air** _____

Self Contained _____ **None** _____ **Other** _____

Employees Working on same job

1. ______________________ 3. ______________________

2. ______________________ 4. ______________________

Comments, Unusual Conditions, Etc. ______________________________

____

APPENDIX B

PROTECTION FACTORS FOR RESPIRATORS[a]

Description[b]	Protection Factors[d]		
	Modes[c]	Particulates Only	Particulates, Gases & Vapors[c]
I. Air-Purifying Respirators[f]			
Facepiece, half-mask[g]	**NP**	**10**	**-**
Facepiece, full	**NP**	**50**	**-**
Facepiece, half-mask full, or hood	**PP**	**1000**	**-**
II. Atmosphere-Supplying Respirators			
1. Air-line respirator			
Facepiece, half-mask	**CF**	**-**	**1000**
Facepiece, half-mask	**D**	**-**	**5**
Facepiece, full	**CF**	**-**	**2000**
Facepiece, full	**D**	**-**	**5**
Facepiece, full	**PD**	**-**	**2000**
Hood	**CF**	**-**	**(h)**
Suit	**CF**	**-**	**(i)(j)**
2. Self-contained breathing apparatus			
Facepiece, full	**D**	**-**	**50**
Facepiece, full	**PD**	**-**	**(k) 10000**
Facepiece, full	**RD**	**-**	**50**
Facepiece, full	**RP**	**-**	**(l) 5000**
III. Combination Respirators			
Any combination of air-purifying and atmosphere-supplying respirators		-	PF for type and mode of operation as listed above

Footnotes

a. For use in the selection of respiratory protective devices to be used only where the contaminants have been identified and the concentrations (or possible concentrations) are known.

b. Only for shaven faces and where nothing interferes with the seal of tight-fitting facepieces against the skin. (Hoods and suits are excepted.)

c. The mode symbols are defined as follows:
CF=continuous flow
D=demand
NP=negative pressure (i.e., negative phase during inhalation)
PD=pressure demand (i.e., always positive pressure)
PP=positive pressure

RD=demand, recirculating (closed circuit)
RP=pressure demand, recirculating (closed circuit)

d.

1. The protection factor is a measure of the degree of protection afforded by a respirator, defined as the ratio of the concentration of airborne radioactive material outside the respiratory protective equipment to that inside the equipment (usually inside the facepiece) under conditions of use. It is applied to the ambient airborne concentration to estimate the concentrations inhaled by the wearer according to the following formula:

$$\text{Concentration Inhaled} = \frac{\text{Ambient Airborne Concentration}}{\text{Protection Factor}}$$

2. The protection factors apply:
   (a) Only for individuals trained in using respirators and wearing properly fitted espirators that are used and maintained under supervision in a well-planned respiratory protective program.
   (b) For air-purifying respirators only when high efficiency particulate filters (above 99.97% removal efficiency by thermally generated 0.3 mm dioctyl phthalate (DOP) test or equivalent) are used in atmospheres not deficient in oxygen and not containing radioactive gas or vapor respiratory hazards.
   (c) No adjustment is to be made for the use of sorbents against radioactive material in the form of gases or vapors.
   (d) For atmosphere-supplying respirators only when supplied with adequate respirable air. Respirable air shall be provided of the quality and quantity required in accordance with NIOSH/MSHA certification (described in 30 CFR part 11). Oxygen and air shall not be used in the same apparatus.
   (e) Excluding radioactive contaminants that present an absorption or submersion hazard. For tritium oxide, approximately one-third of the intake occurs by absorption through the skin so that an overall protection factor of less than 2 is appropriate when atmosphere-supplying respirators are used to protect against tritium oxide. If the protection factor for a device is 5 the effective protection factor for tritium is about 1.4; for devices with protection factors of 10 the effective factor for tritium oxide is about 1.7, and for devices with protection factors of 100 or more the effective factor for tritium oxide is about 1.9. Air-purifying respirators are not suitable for protection against tritium oxide. See also footnote i concerning supplied-air suits.
   (f) Canisters and cartridges shall not be used beyond service-life limitations.
   (g) Under-chin type only. This type of respirator is not satisfactory for use where it might be possible (e.g., if an accident or emergency were to occur) for the ambient airborne concentrations to reach instantaneous values greater than 10 times the pertinent values in table 1, column 3 of appendix B to §§ 20.1001—20.2401 of 10 CFR 20. This type of respirator is not suitable for protection against plutonium or other high toxicity materials. The mask is to be tested for fit prior to use, each time it is donned.

(h)

(1) Equipment shall be operated in a manner that ensures that proper air flow-rates are maintained. A protection factor of no more than 1000 may be utilized for tested-and-certified supplied-air hoods when a mini-mum air flow of 6 cubic feet (0.17 cubic meters) per minute is maintained and calibrated air–line pressure gauges or flow measuring devices are used. A protection factor of up to 2000 may be used for tested and certified hoods only when the air flow is maintained at the manufacturer's recommended maximum rate for the equipment, this rate is greater than 6 cubic feet (0.17 cubic meters) per minute, and calibrated air–line pressure gauges or flow measuring devices are used.

(2) The design of the supplied-air hood or helmet (with a minimum flow of 6 cfm (0.17 m^3 per minute) of air) may determine its overall efficiency and the protection it provides. For example, some hoods aspirate contaminated air into the breathing zone when the wearer works with hands-over-head. This aspiration may be overcome if a short cape-like extension to the hood is worn under a coat or overalls. Other limitations specified by the approval agency shall be considered before using a hood in certain types of atmospheres (see footnote i).

(i) Appropriate protection factors shall be determined, taking into account the design of the suit and its permeability to the contaminant under conditions of use. There shall be a standby rescue person equipped with a respirator or other apparatus appropriate for the potential hazards and communications equipment whenever supplied-air suits are used.

(j) No approval schedules are currently available for this equipment. Equipment is to be evaluated by testing or on the basis of reliable test information.

(k) This type of respirator may provide greater protection and be used as an emergency device in unknown concentrations for protection against inhalation hazards. External radiation hazards and other limitations to permitted exposure, such as skin absorption, must be taken into account in such circumstances.

(l) Quantitative fit testing shall be per-formed on each individual and no more than 0.02% leakage is allowed with this type of apparatus. Perceptible outward leakage of gas from this or any positive pressure self-contained breathing apparatus is unacceptable because service life will be reduced substantially. Special training in the use of this type of apparatus shall be provided to the wearer.

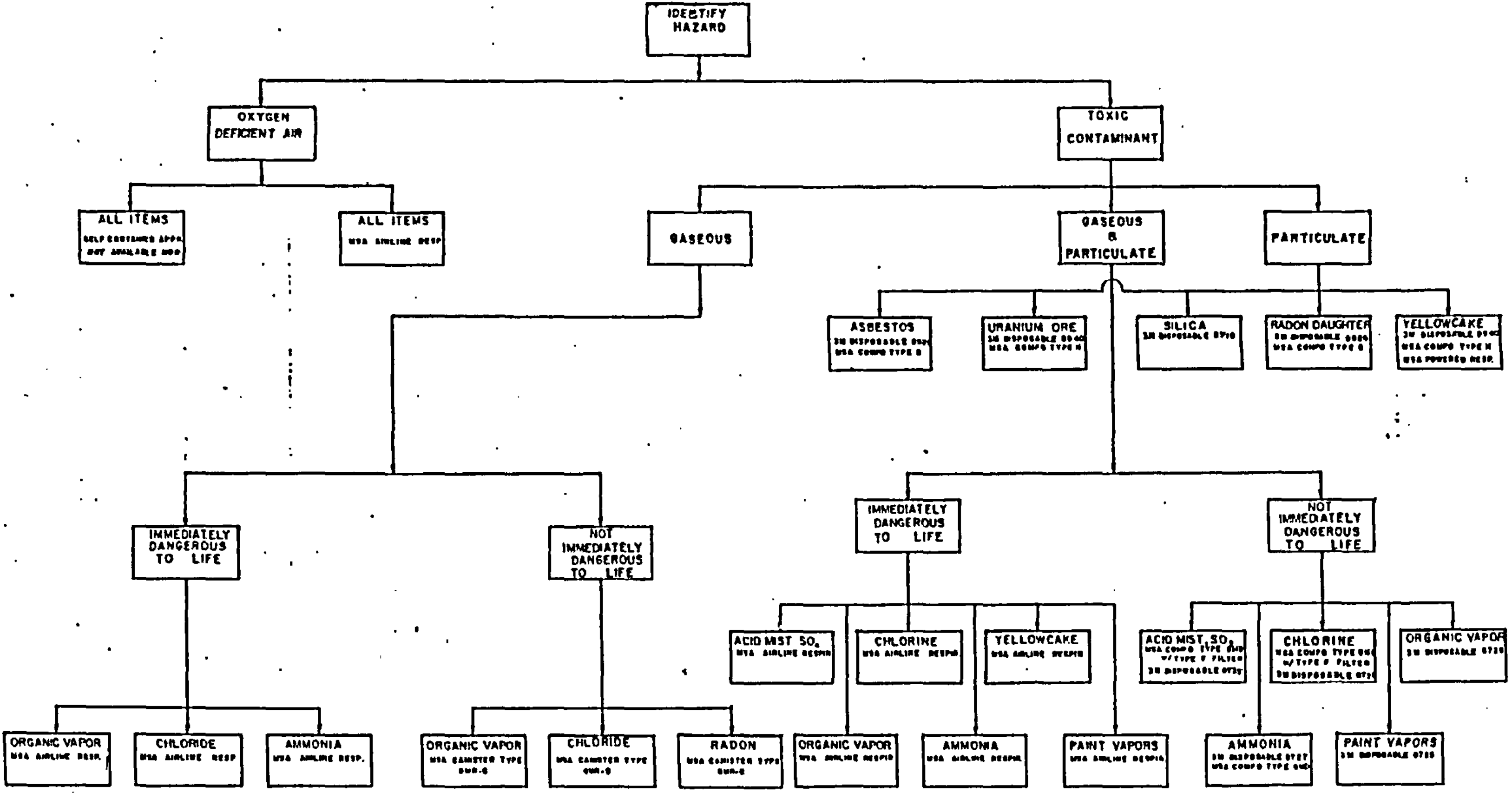


FIGURE-1
NON LISTED AREAS SELECTION CHART

RIO ALGOM MINING LLC
Ambrosia Lake Facility

RESPIRATORY PROTECTION PROGRAM

Approval: ______________________________ Date: ______________
General Manager

Approval: ______________________________ Date: ______________
Radiation Safety Officer

Approval: ______________________________ Date: ______________
Supervisor Mill Operations

Approval: ______________________________ Date: ______________
General Maintenance Foreman

Approval: ______________________________ Date: ______________
Reclamation Engineer

Approval: ______________________________ Date: ______________
Supervisor, Personnel and Administration

Approval: ______________________________ Date: ______________
Reclamation Foreman

RIO ALGOM MINING LLC
Ambrosia Lake Facility

RESPIRATORY PROTECTION PROGRAM

Original: October 1978

Reviewed/Revised:
November 1979
December 1980
November 1981
April 1982
January 1983
February 1984
August 1985
May 1986
June 1987
May 1988
May 1989
October 1990
June 1991
January 1992
June 1992
June 1993
December 1993
June 1994
August 1994
June 1995
June 1996
August 1996
January 1997
January 1998
January 1999
January 2000
January 2001
January 2002
January 2003
November 2003