STATE OF SOUTH DAKOTA
DEPARTMENT OF AGRICULTURE & NATURAL RESOURCES

BOARD OF MINERALS AND ENVIRONMENT

IN THE MATTER OF CLEAN	)	
NUCLEAR ENERGY CORP.	)	INTERVENOR LILIAS JONES JARDING
URANIUM EXPLORATON PERMIT	)	SUBMISSION OF ADDITIONAL
APPLICATION	)	EXHIBITS
	)	
	)	
EXNI 453	)	

COMES NOW Intervenor Lilias Jones Jarding and respectfully moves to file additional exhibits identified as of this date as evidence in this matter. Copies of this motion and the herein-referenced exhibits are being made available to all parties by postal mail and by electronic means.

Since the original filing date for exhibits in 2025, additional documents have become available and/or have become more relevant to the current matter, as it has been defined by the decisions of the Board of Mineral and Environment at their meeting of March 18, 2026.

The attached exhibits are:

1. Rowland L. Hall. 1982. Radiological and Environmental Assessment of Abandoned Uranium Mines in the Edgemont Mining District, South Dakota. A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science Geology. South Dakota School of Mines and Technology.
2. Mato Ohitika Analytics. October 1, 2025. Current Bureau of Land Management Mineral and Land Records System Active Mining Claims.

This Motion is not filed for any improper purpose or to cause delay. It is filed to ensure that issues in this matter receive proper and complete illumination and to ensure that the Board's decisions are fully informed by relevant information and are in the best interests of the State and the people of South Dakota.

Respectfully Submitted,

Lilias Jones Jarding, Ph.D.
Intervenor
Post Office Box 591
Rapid City, South Dakota 57709

March 23, 2026

CERTIFICATE OF SERVICE

The undersigned hereby certifies that the original of the Intervenor's Submission of Additional Exhibits was served electronically, and by via United States Mail, First Class, Postage Prepaid upon the following to be filed in the above captioned matter:

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Further, the undersigned certifies that true and correct copies of the above referenced documents were served via United States Mail, First Class, Postage Prepaid upon the following:

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Dated this 23rd day of March, 2026

Signature: Lilias Jones Jarding

RADIOLOGICAL AND ENVIRONMENTAL ASSESSMENT OF ABANDONED URANIUM MINES IN THE EDGEMONT MINING DISTRICT SOUTH DAKOTA

by

ROWLAND L. HALL

A thesis submitted in partial fulfillment
of the requirements for the degree of
MASTER OF SCIENCE
GEOLOGY
SOUTH DAKOTA SCHOOL OF MINES AND TECHNOLOGY
1982

Approved by:

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ACKNOWLEDGEMENTS

This research was sponsored by the USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Rapid City, South Dakota. The writer takes solé responsibility for the data and content of this report.

Among those who read the preliminary draft and made valuable suggestions are Dr. Perry Rahn (South Dakota School of Mines and Technology), Mr. Terry Yamamoto, and Dr. Ardel Bjugstad (Rocky Mountain Forest and Range Experiment Station). Each made valuable suggestions which significantly improved the work but none should be held responsible for shortcomings.

Additionally, Mr. Kenneth Fantone assisted with the initial field work, Mr. Douglas Beagle helped with the literature search, and Mr. Rick Kiel helped analyze spoils for radium-226.

Finally, I am grateful to my wife, Nancy, for her patience and time spent in typing this thesis.

ABSTRACT

This thesis is a site-specific evaluation of abandoned uranium mines in the southern Black Hills of South Dakota. The study, sponsored by the Rocky Mountain Forest and Range Experiment Station and the Black Hills National Forest, is an attempt to determine the present conditions within the abandoned mines of the Edgemont mining district.

The locations of 38 uranium mines covering greater than 490 acres (198 ha) were plotted on orthophotoquad maps and on 7½ minute quadrangle maps. The volume of spoils within the study area is estimated to be greater than 390,000 cubic yards (298,165 m^3).

Fifteen spoils samples from abandoned mine sites were analyzed for radium-226. Results from the analysis indicate isolated "hot spots" do exist, therefore, a potential hazard also exists from external radiation from uranium spoils, especially over long term exposure. Possible hazards to the occasional visitor would be minimal.

Air samples from selected adits analyzed for radon-222 indicate levels above the occupational exposure rates. Therefore, a potential hazardous condition does exist within the adits of the study area.

Many physical hazards and adverse environmental impacts were found in the study area. These include: open ventilation shafts; unplugged drill holes; stream erosion; and structurally unstable adits.

Based on the findings of this investigation, the following recommendations are made: (1) close all adits to eliminate possibilities of excessive radon gas exposure; (2) security fencing to be placed around mined areas and posted to warn against radiation and physical hazards; (3) reseed disturbed areas with native plant growth; (4) monitor the returning vegetation to measure its progress and (5) consult a health physicist to determine exposure rates for the occasional visitor.

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INTRODUCTION

Radioactive element mining and milling is becoming an issue in the Black Hills region. Strong feelings, both pro and con, concerning nuclear chemistry and its place in society make it an emotional as well as an economic issue.

A great deal of information is required before the U.S. Forest Service can properly redeem management responsibilities on public lands. What exactly will be the effects to the Black Hills region if large production radioactive ore mining and milling is initiated? What will happen to the ground water, to wildlife and the food chain, to the general population? What conditions exist in prospective mining areas now? (Mathers, 1979).

To answer there questions, a cooperative project between the Rocky Mountain Forest and Range Experiment Station, Rapid City, South Dakota and the Black Hills National Forest, Custer, South Dakota was started in June of 1979. This study is a part of this cooperative effort.

The purpose of this study is two-fold: (1) to determine the location, volume, and radiological status of all known uranium spoils and sites of mining disturbance in the southern Black Hills, and (2) to assess the present and future environmental impacts associated with these spoils.

The identification of these impacts is of great concern to the U.S. Forest Service (USFS) as well as to the general public. Much of the uranium mining in the Black Hills occurred on USFS land. It is not known if these abandoned spoils and mining operations are hazardous to wildlife, domestic animals or the general public.

Uranium was discovered in 1951 in the southern Black Hills by Jerry G. Brennan of Rapid City, South Dakota (Page and Redden, 1952). This discovery brought many prospectors and mining companies into the area. Within the next thirteen years, nearly one million tons (6.8×10^5 kg) of U_3O_8 were mined (Jackson, 1975). No mines are operating although Union Carbide Corporation and Tennessee Valley Authority(TVA) may resume mining in the near future.

Essentially no reclamation was done in the old mined areas (Figures 1,2,3, & 4). Numerous open pits, underground mines and associated dumps occur in the outcrop area of the Inyan Kara Group within 25 kilometers of Edgemont, South Dakota. Because no reclamation has been done on the mine sites, mine spoils are exposed to the biosphere. The mine spoils are potentially hazardous because they contain radioactive and toxic trace elements which may create health hazards to wildlife, domestic animals, or man.

There is no document which shows the location, size, and radioactivity of the abandoned uranium mines, spoils, and adits of the Edgemont mining district. The hazards to man, livestock, and wildlife cannot be evaluated until these data are acquired and evaluated. For this reason, a site-specific investigation is needed before the present conditions and environmental impact may accurately be assessed.

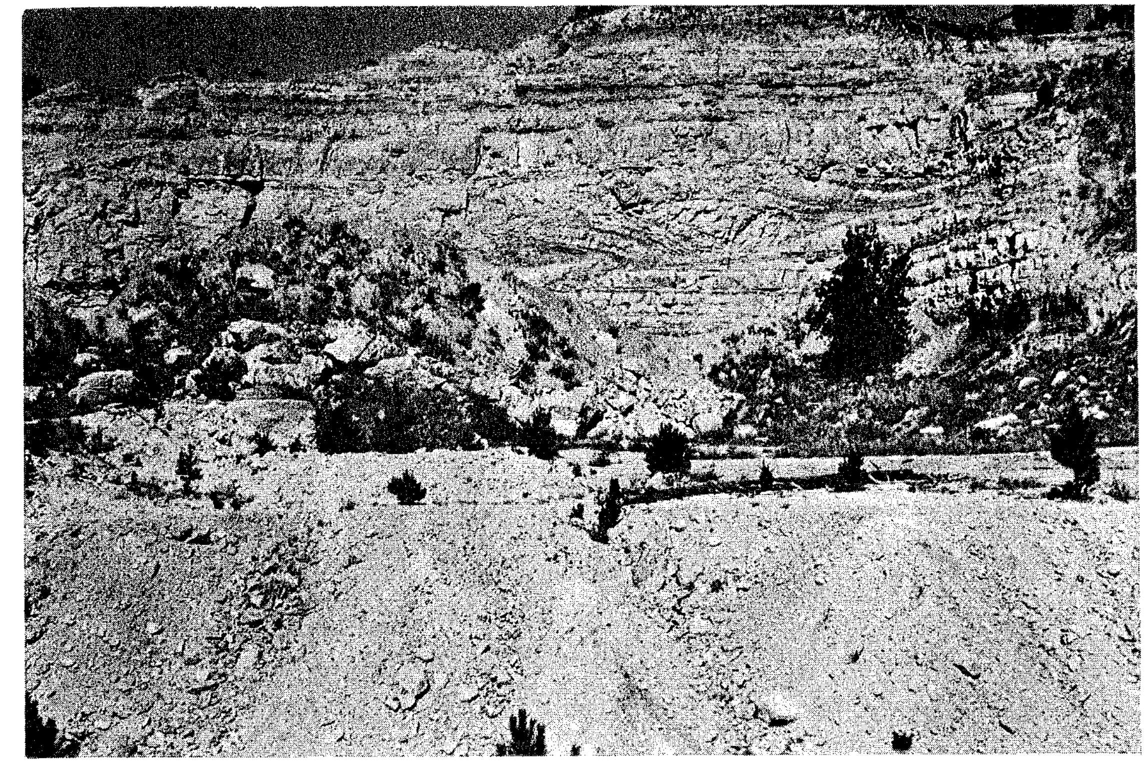

Figure 1 - Hay and Fay Mine, Showing Unreclaimed Condition of Open Pit Mines.

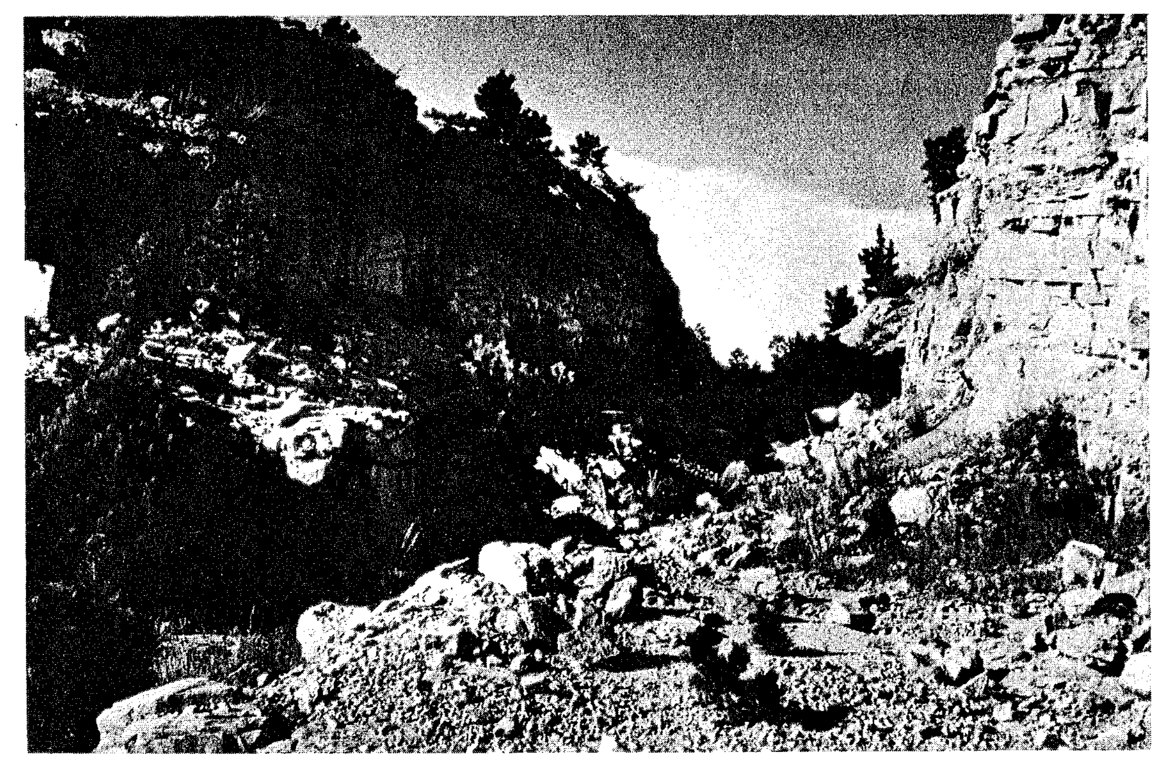

Figure 2 - Clarabelle Mine, Showing Unreclaimed Condition Typical of Most Uranium Mines Within the Study Area.

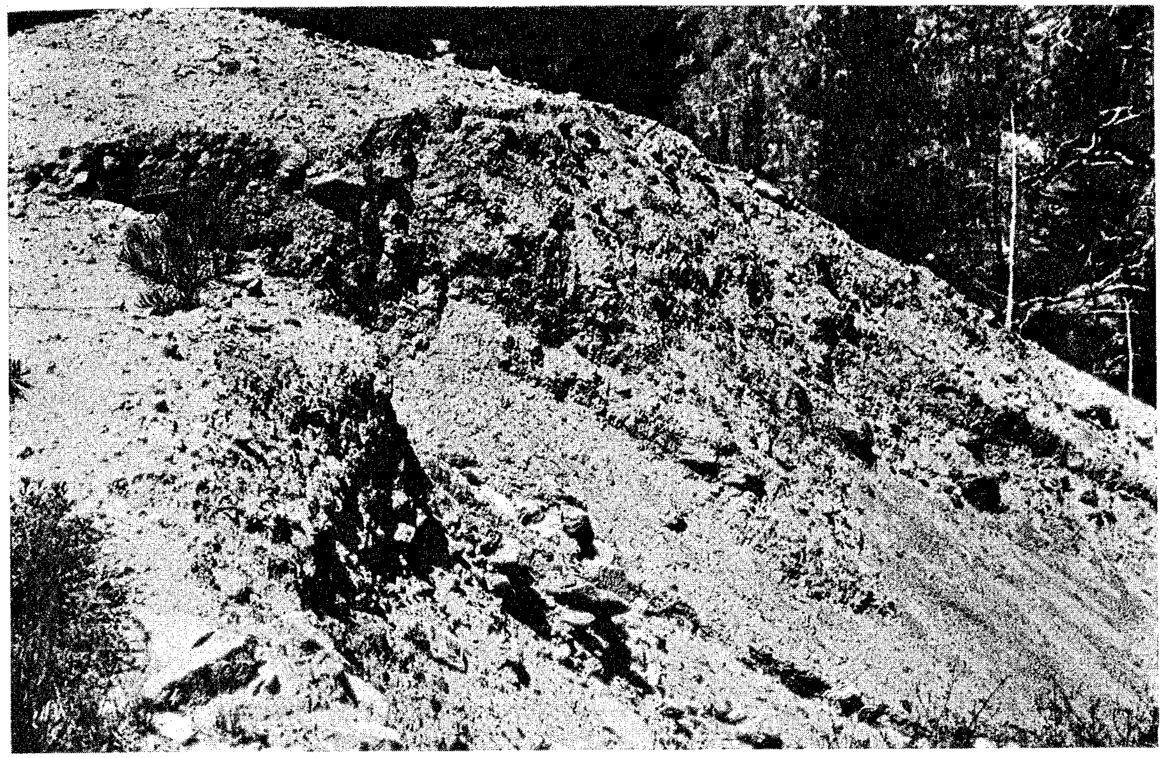

Figure 3 - Mine Spoils (Dumps and Possible Unused Ore Piles) from the Hot Point Group.

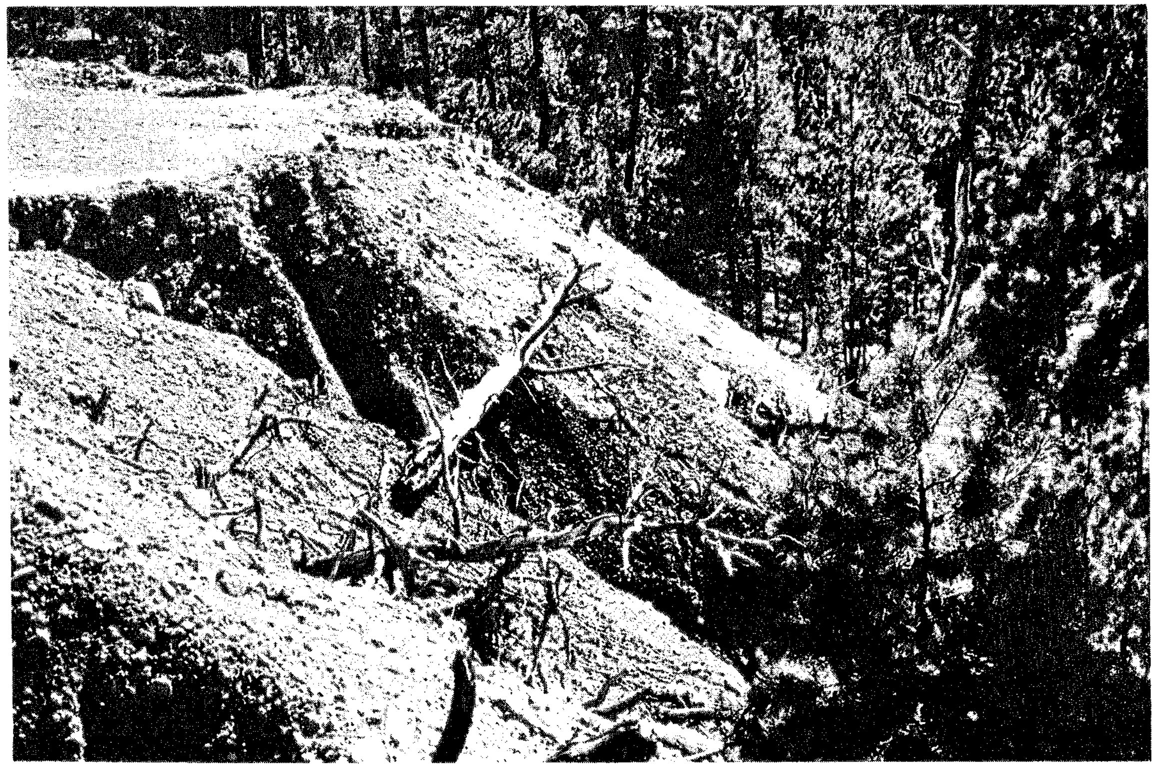

Figure 4 - Mine Spoils from the Ridge Runner Mine Showing Erosional Features and Lack of Vegetation.

The area encompassed by this study lies in Fall River and Custer counties in South Dakota and is almost entirely USFS property. Geographically, the study area lies south of the Dewey-Minnekahta road, north of Edgemont and the Burlington Northern Railroad, and west of Highway 18 (Figure 5).

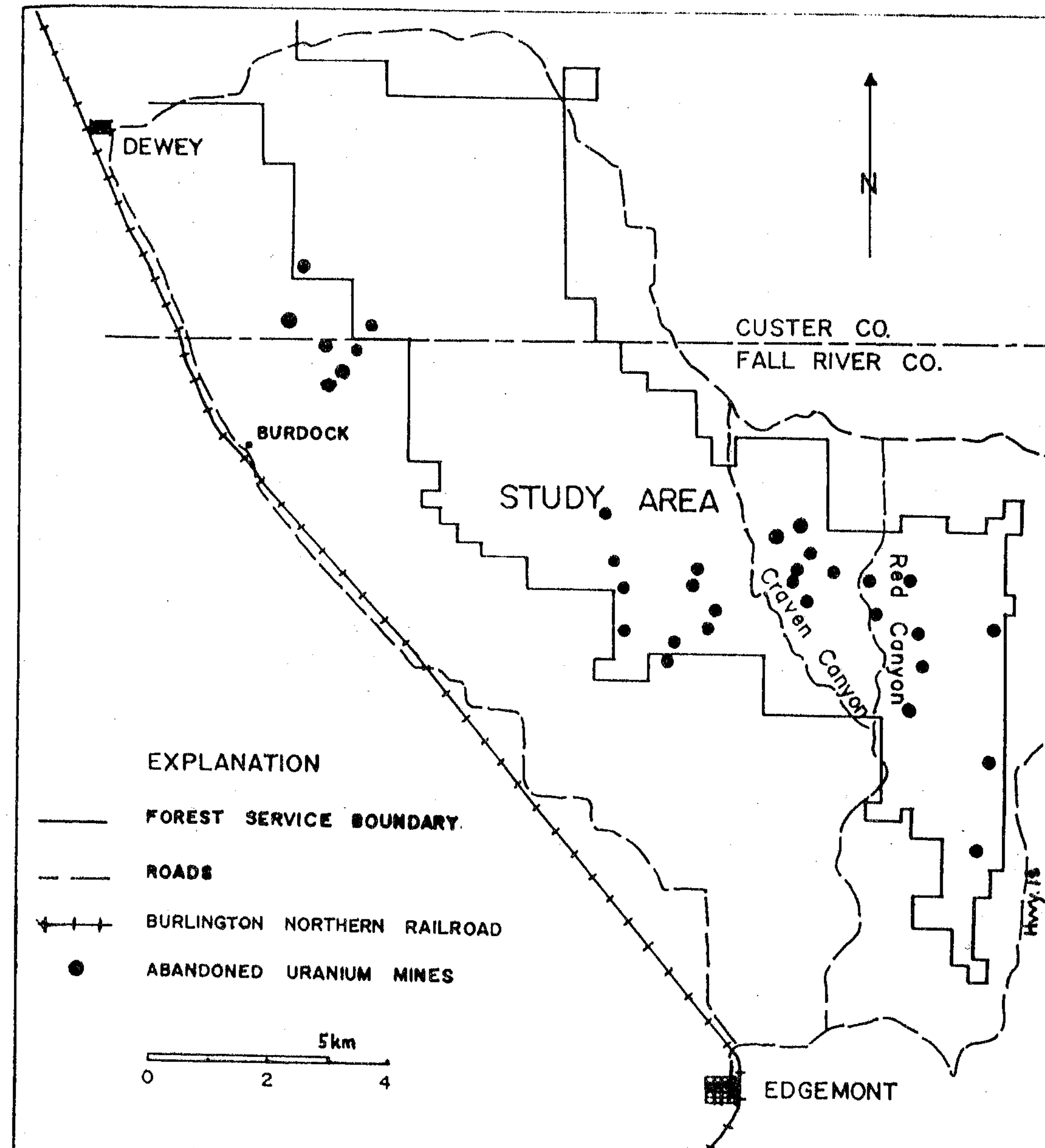

FIG. 5 — MAP SHOWING LOCATION OF STUDY AREA AND ABANDONED URANIUM MINES, EDGEMONT MINING DISTRICT, SOUTH DAKOTA

Chapter 1

METHODS

The first step in the accomplishment of the objectives of this study was to locate and map the individual sites of disturbance within the study area. All known mines in the Edgemont district were plotted from aerial photographs at a scale of 1: 12,000. The photographs were from four separate flight lines flown over the study area by Horizons Inc., Rapid City, South Dakota in 1978. The only area not covered by these flight lines was along Driftwood Canyon. Field reconnaissance has shown this area to be void of major mining. The resulting maps are presented in Figures 6 through 9. Distinctions were made on the basis of pits, spoils and areas with man-made disturbances. Finally, access roads were plotted. These roads, as evaluated from the photographs, were of unknown condition. A closer study by the author's field investigations has shown that these roads are mostly in poor condition.

The information from these maps was transferred to topographic maps and orthophotoquads at a scale of 1:24,000 (Figures 10 through 17). A listing of mines with township-section-range descriptions is located in Table 1. The volume of spoils and the area of disturbance, as estimated from aerial photographs and field measurements for each mine survey, are listed in Table 2.

A field reconnaissance of selected mine sites within the study area was then conducted by the author to evaluate the existing conditions and impacts associated with the abandoned

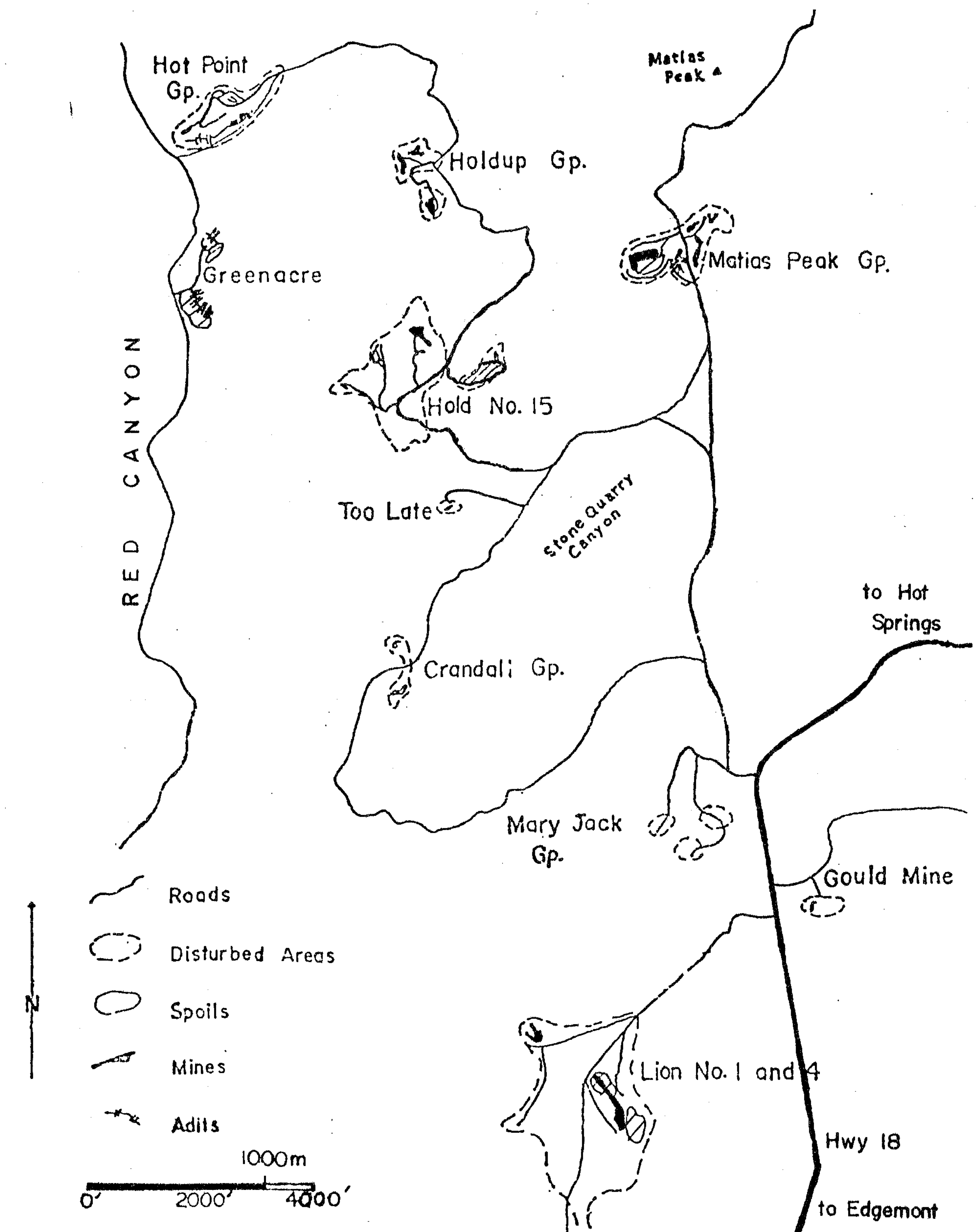

Figure 6 - Location of Abandoned Mines in Study Area.

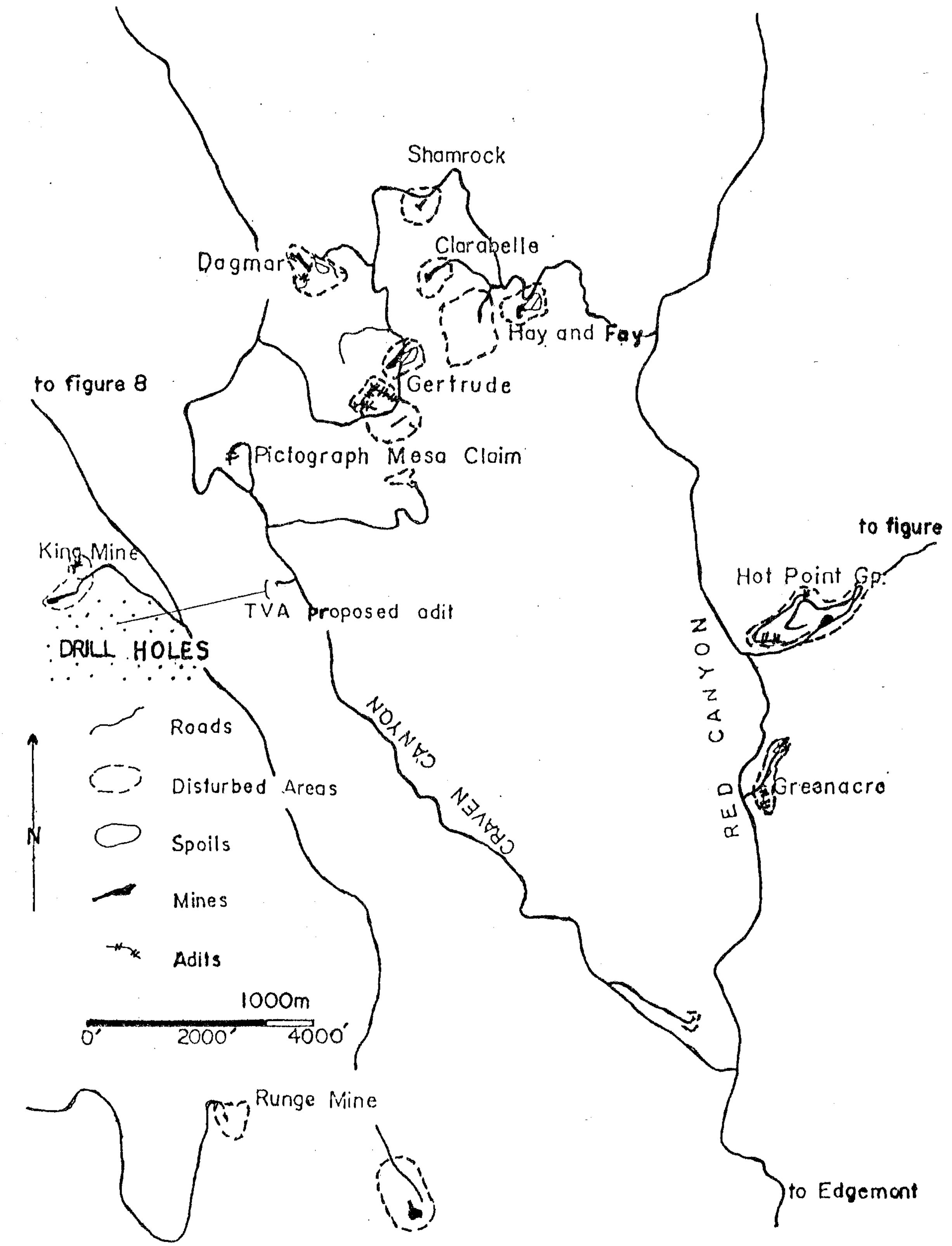

Figure 7 - Location of Abandoned Mines in Study Area.

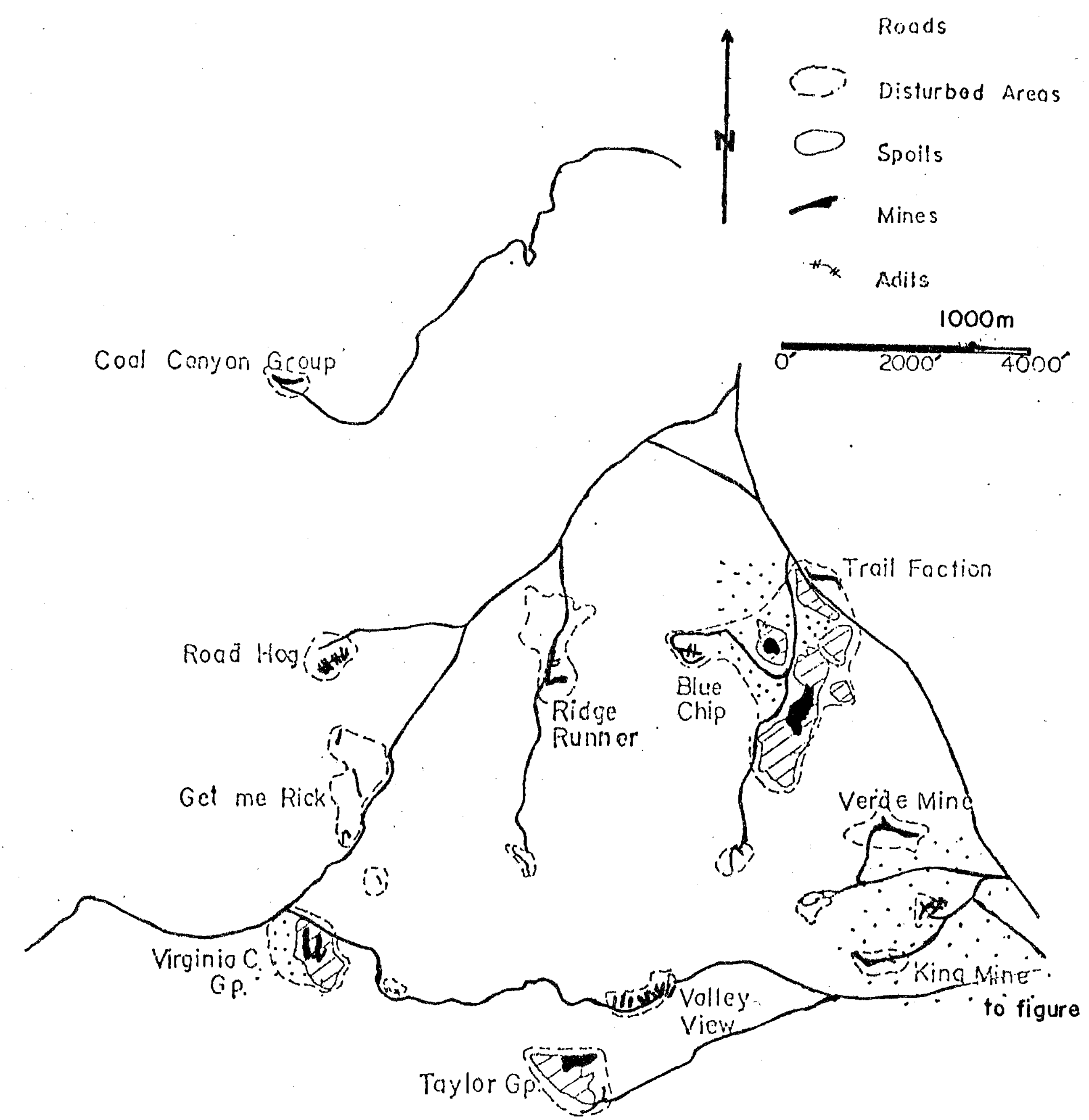

Figure 8 - Location of Abandoned Mines in Study Area.

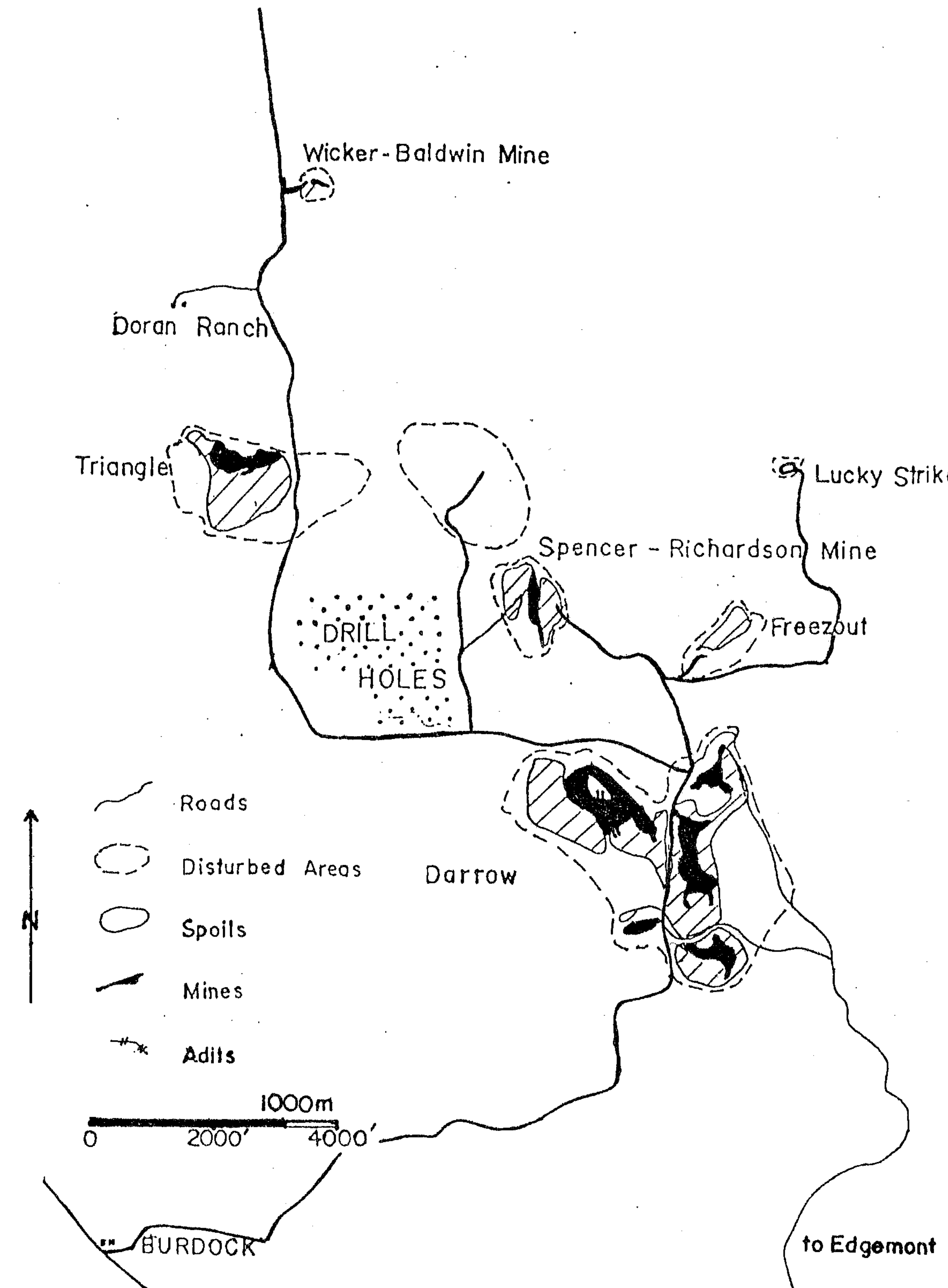

Figure 9 - Location of Abandoned Mines in Study Area.

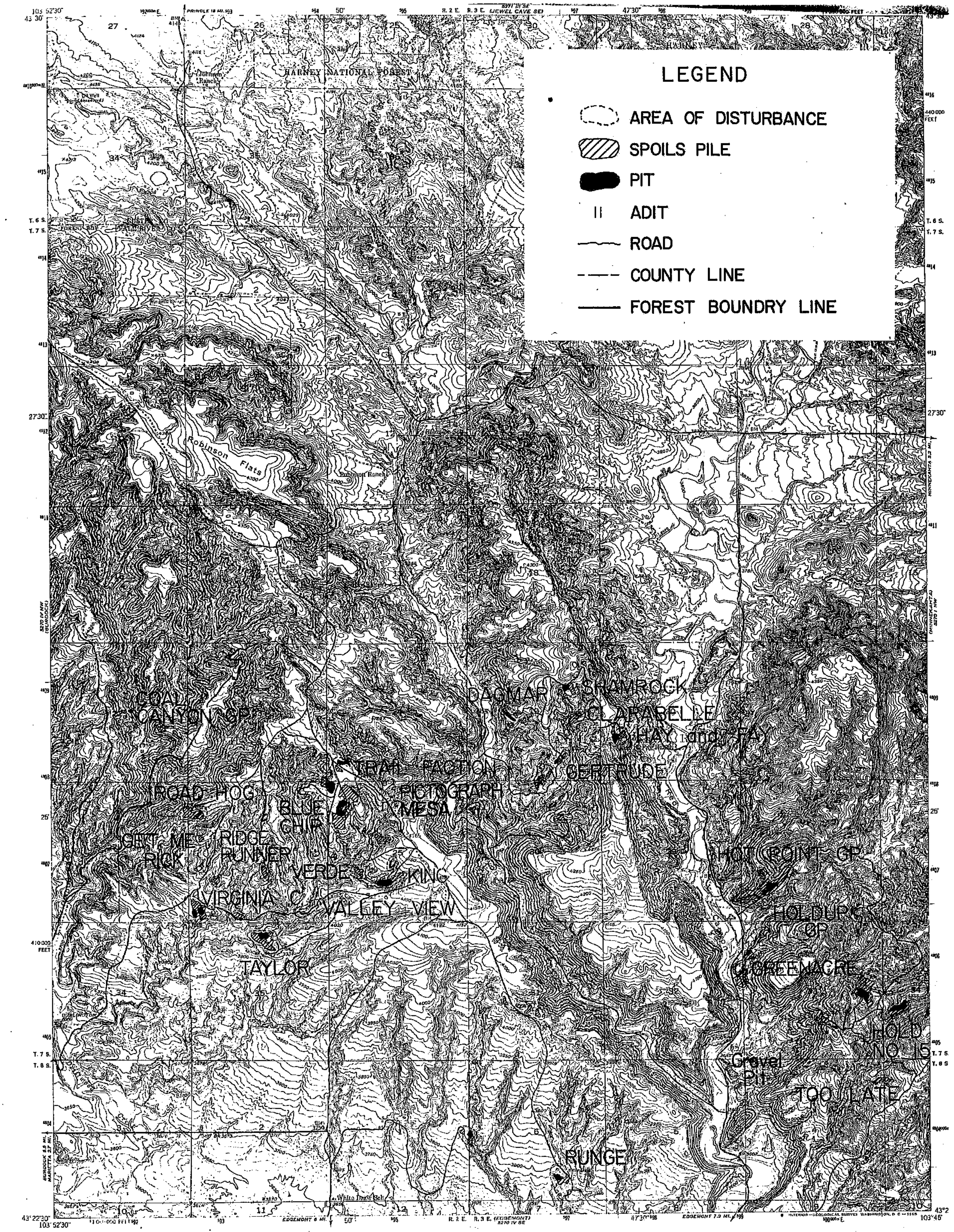

Figure 10 - Location of Mines Within Edgemont Northeast Topographic Quadrangle.

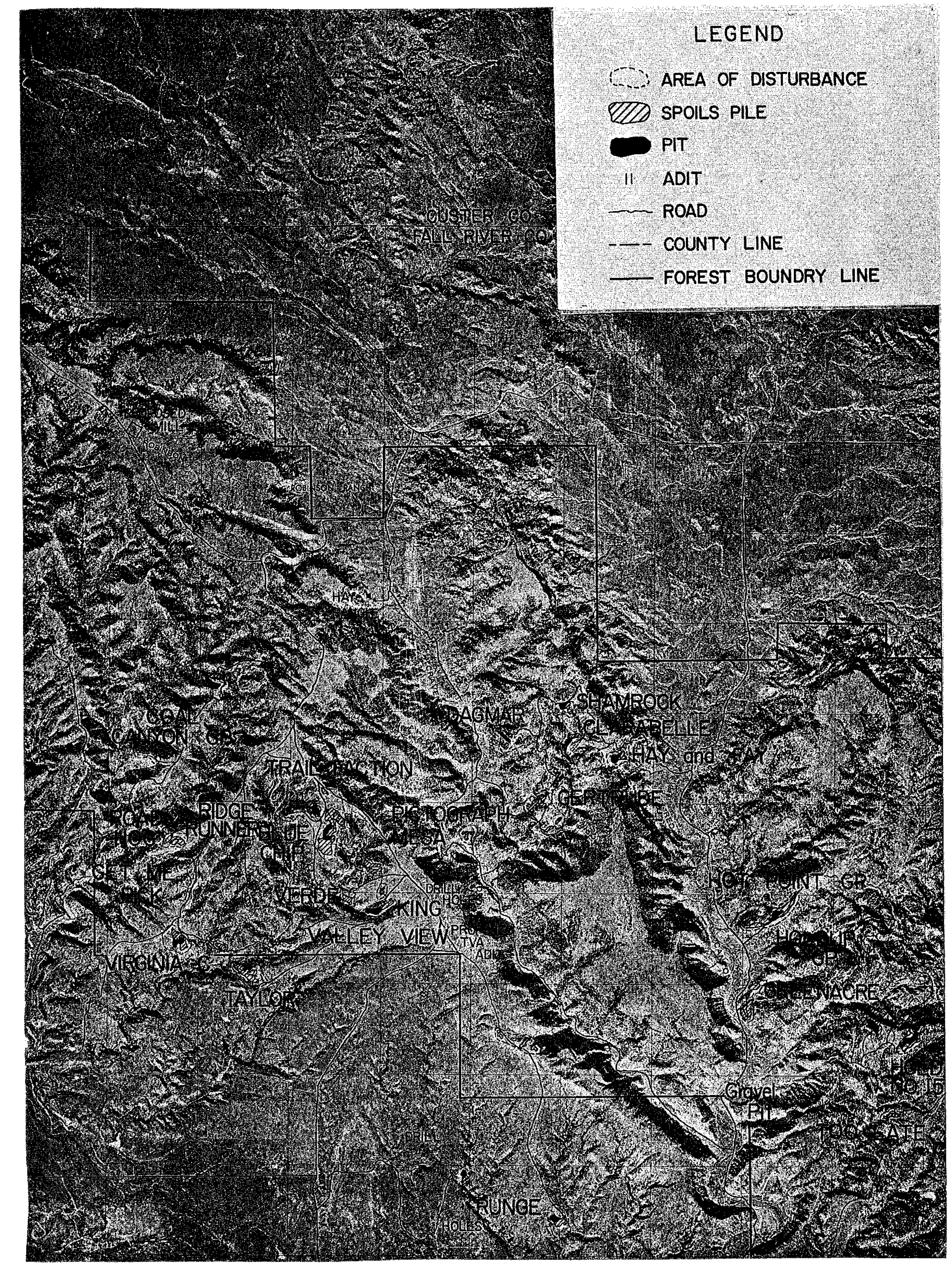

Figure 11 - Location of Mines Within Edgemont Northeast Orthophotoquad.

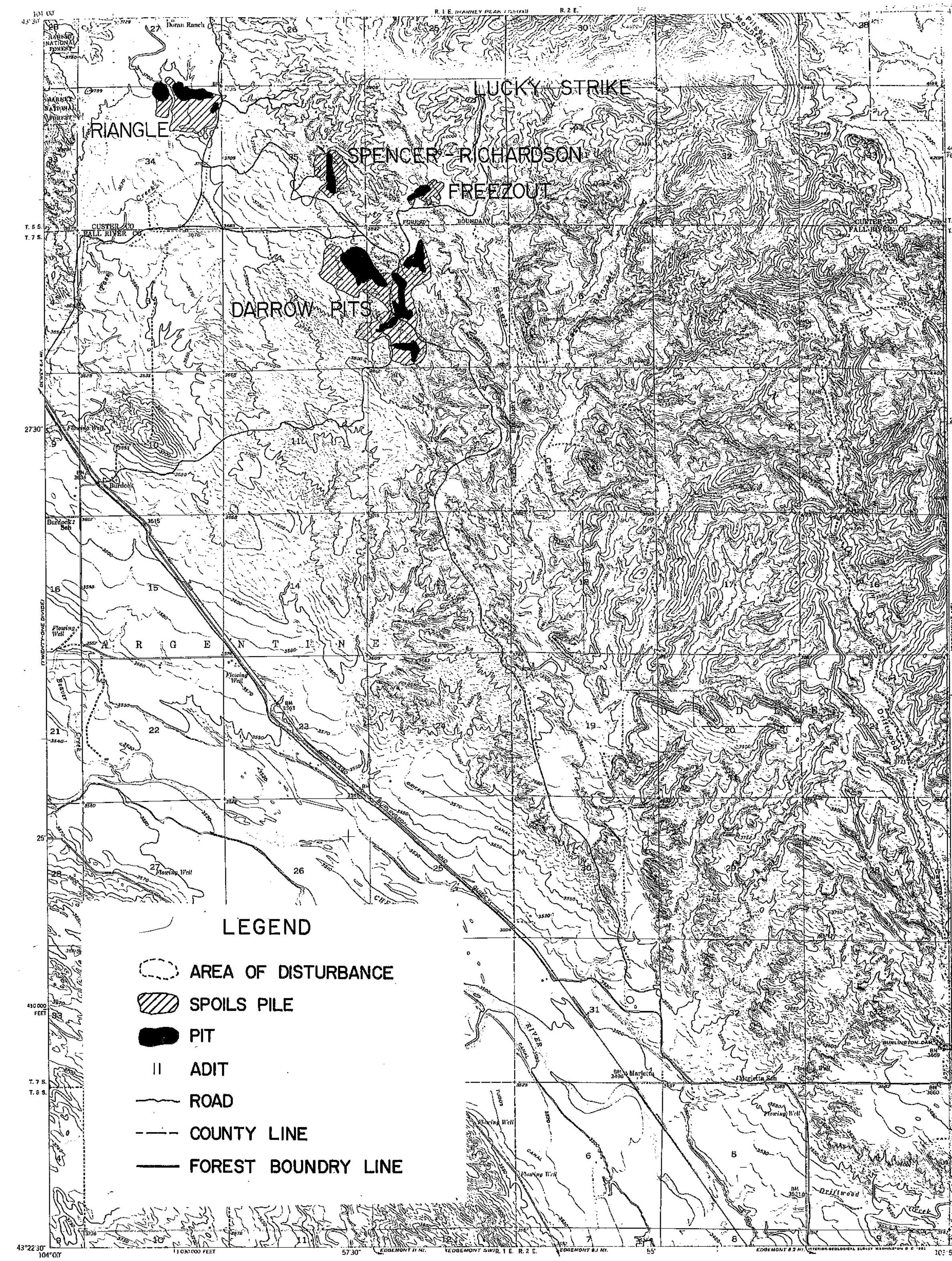

Figure 12 - Location of Mines Within Burdock Topographic Quadrangle.

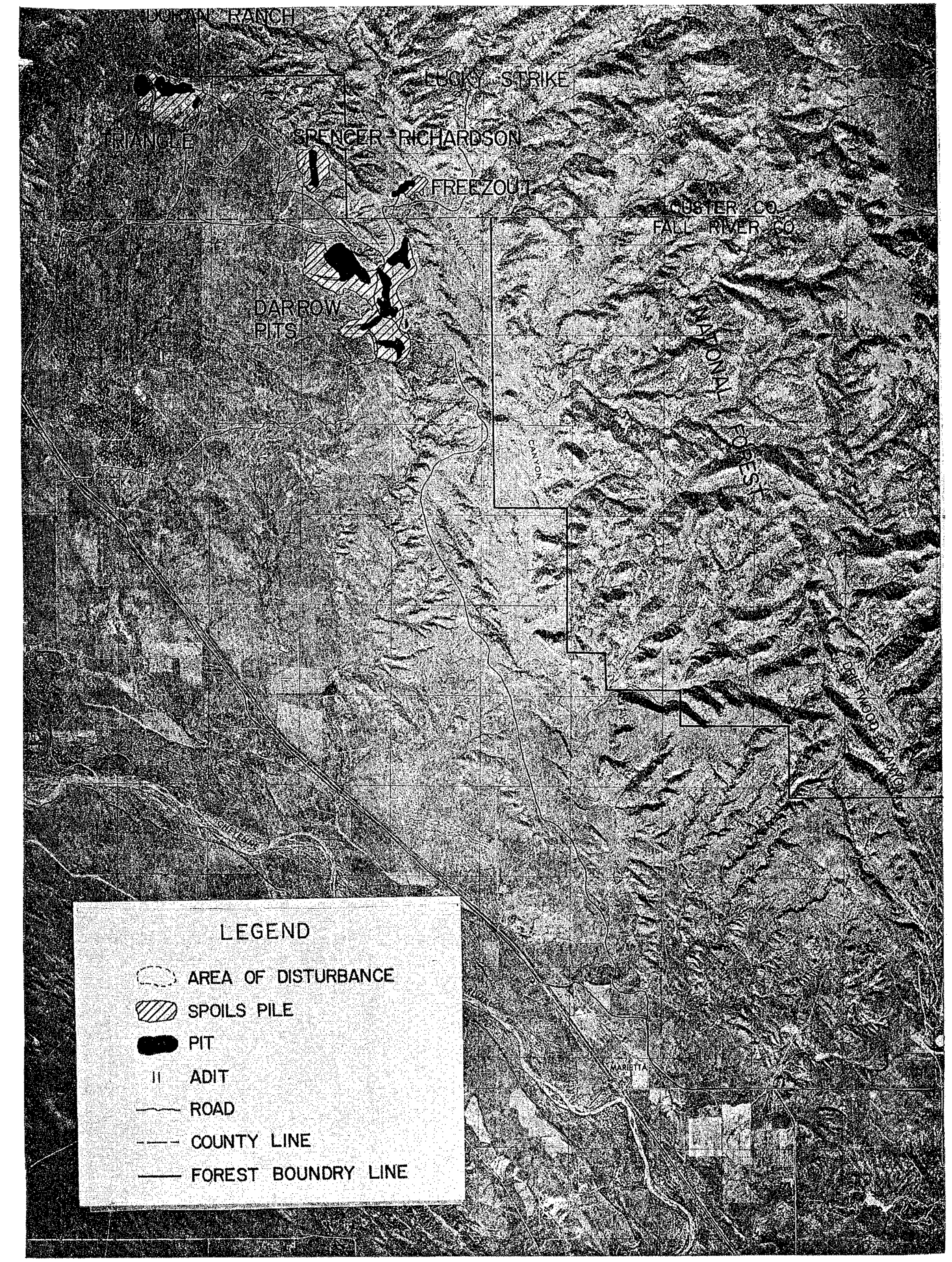

Figure 13 - Location of Mines Within Burdock Orthophotoquad.

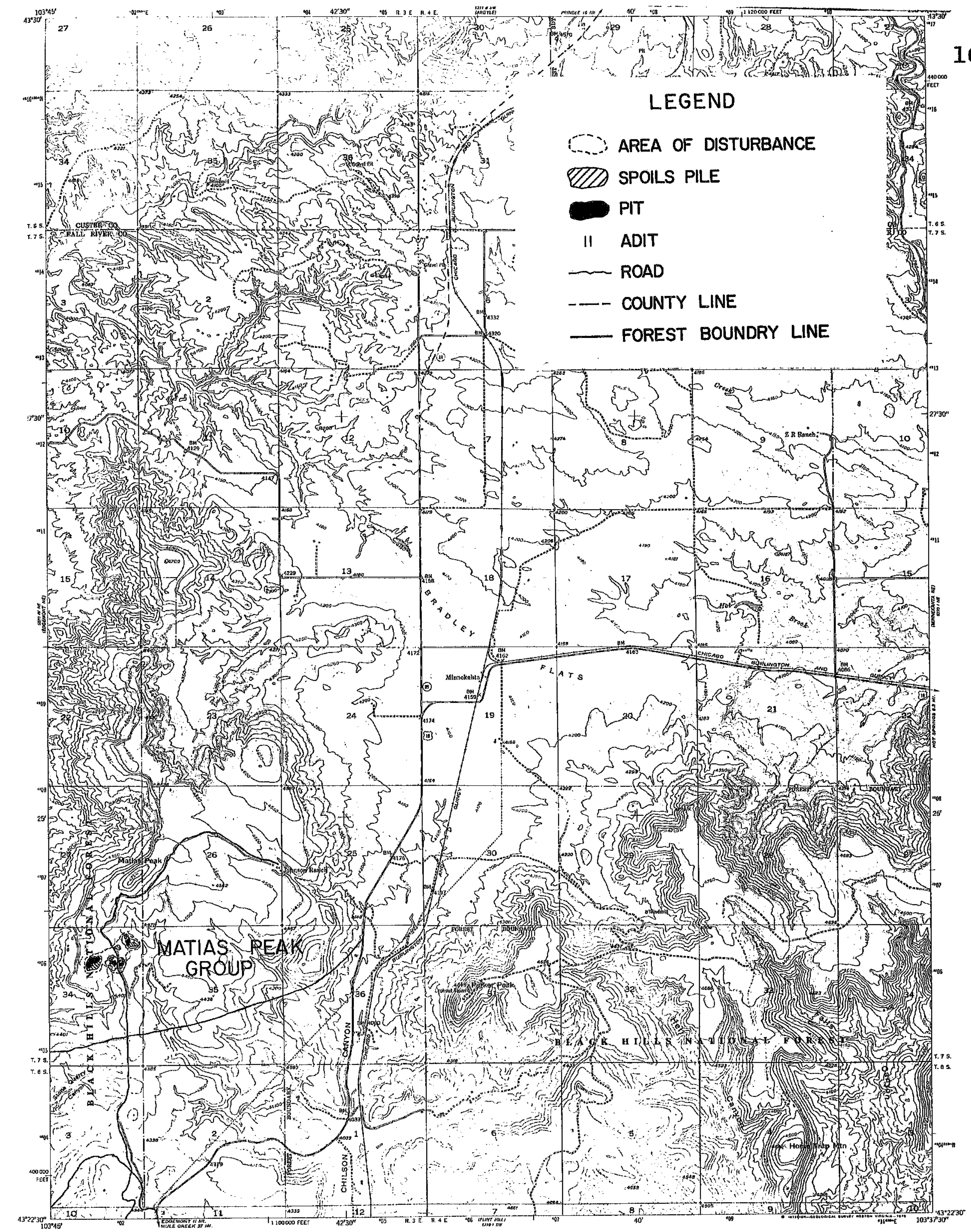

Figure 14 - Location of Mines Within Minnekahta Topographic Quadrangle.

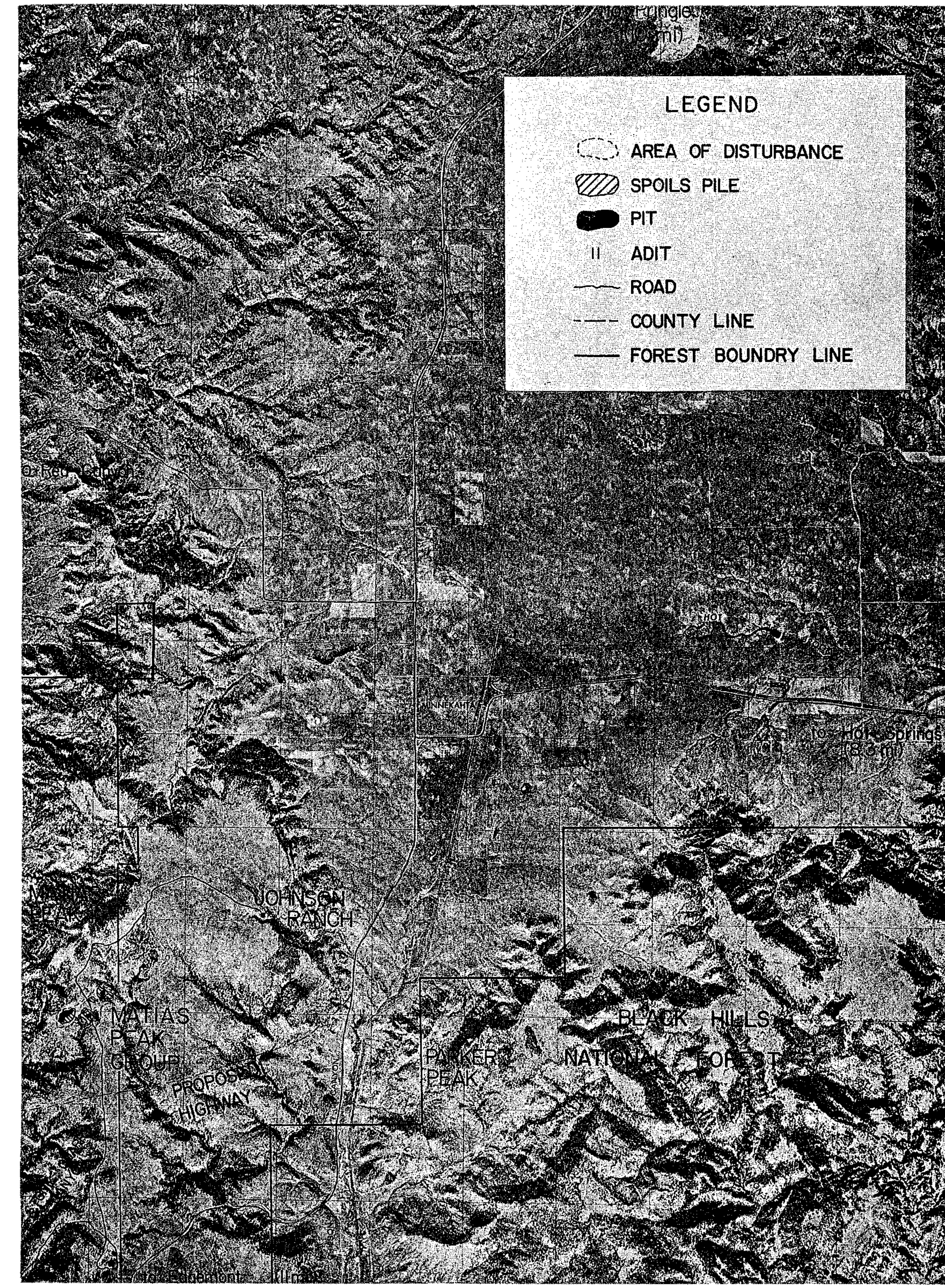

Figure 15 - Location of Mines Within Minnekahta Orthophotoquad.

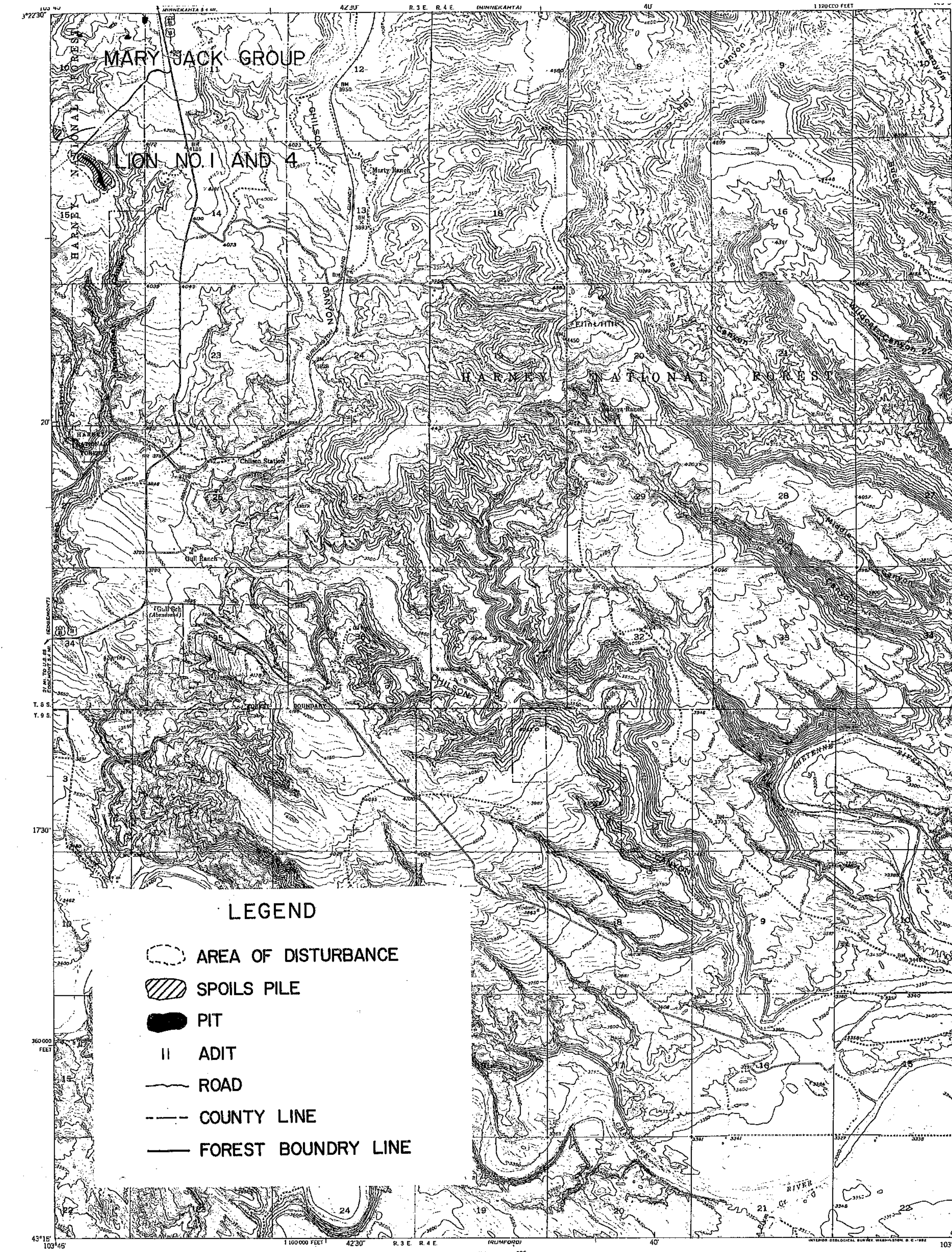

Figure 16 - Location of Mines Within Flint Hill Topographic Quadrangle.

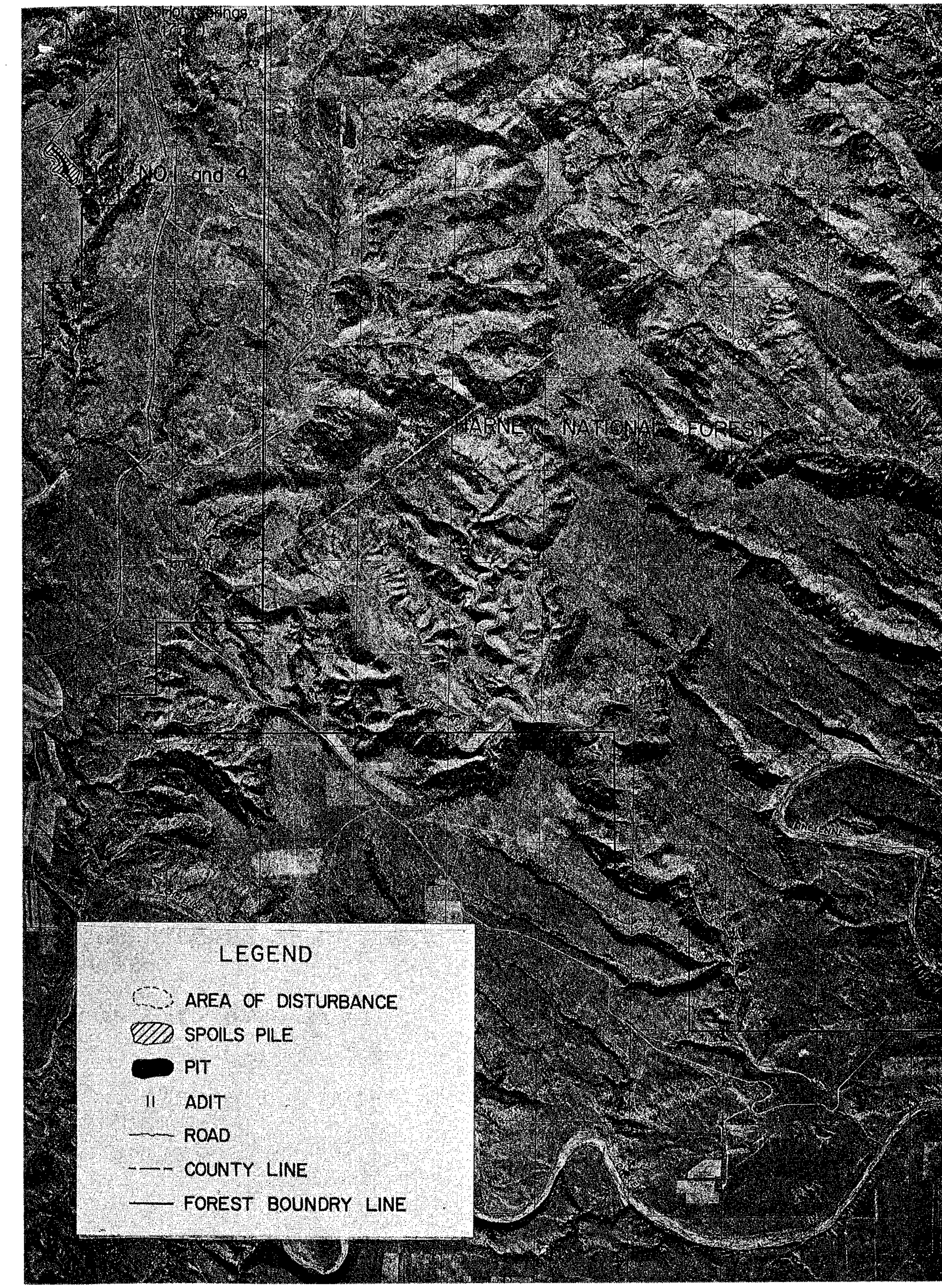

Figure 17 - Location of Mines Within Flint Hill Orthophotoquad.

MINE NAME	¼ Section	Section	TWSP-Range
Matias Peak	NE¼	34	7S-3E
Too Late	NW¼	4	8S-3E
Hold No. 15	SE¼	33	7S-3E
Holdup Group	SE¼	28	7S-3E
Hot Point Group	SW¼	28	7S-3E
Greenacre	NW¼	33	7S-3E
Hay & Fay	SW¼	20	7S-3E
Clarabelle	NE¼SE¼	19	7S-3E
Shamrock	NE¼	19	7S-3E
Dagmar	NE¼SW¼	19	7S-3E
Gertrude	SW¼SE¼	19	7S-3E
Pictograph Mesa	NW¼NW¼	30	7S-3E
King	NE¼SW¼	25	7S-2E
Verde	SE¼NW¼	25	7S-2E
Trail Faction	SW¼SW¼	24	7S-2E
Blue Chip	NW¼NW¼	25	7S-2E
Ridge Runner	NW¼NE¼	26	7S-2E
Road Hog	NW¼	26	7S-2E
Coal Canyon Group	NE¼SE¼	22	7S-2E
Get Me Rick	SW¼SW¼	26	7S-2E
Virginia C	SW¼SW¼	26	7S-2E
*Taylor	NW¼NE¼	35	7S-2E
Valley View	SE¼SE¼	26	7S-2E
Lion #1 & 4	NW¼NE¼	15	8S-3E
Mary Jack	NE¼NE¼	10	8S-3E
Freezeout	SE¼SW¼	36	6S-1E
Lucky Strike	NE¼NE¼	36	6S-1E
*Darrow	W½	1	7S-1E
*Spencer Richardson	SE¼	35	6S-1E
*Triangle	NW¼	34	6S-1E

* Not on USFS property

Table 1 - Location of Mines in Study Area

MINE NAME	VOL. OF SPOILS(yds^3)	AREA DISTURBED(acres)
Matias Peak	12,554	34.4
Mary Jack	440	10.0
Too Late	227	1.4
Hold No. 15	28,356	67.4
Hold up Group	407	12.9
Hot Point Group	2,722	28.7
Greenacre	12,889	6.5
Hay & Fay	16,944	2.8
Clarabelle	5,324	5.7
Shamrock	2,407	8.6
Dagmar	10,370	11.4
Gertrude	4,737	27.3
Pictograph Mesa	400	2.8
King	10,615	11.4
Verde	3,611	17.2
Trail Faction	7,645	2.0
Blue Chip	52,996	74.6
Ridge Runner	22,407	27.3
Road Hog	2,059	11.4
Coal Canyon Group	27,944	8.6
Get Me Rick	2,196	30.1
Virginia C	131,133	34.4
Taylor	30,437	24.4
Valley View	1,800	11.4
TOTALS	390,620 yds^3	490.6 acres

Table 2 -Mines in Study Area Located on USFS Property.

mines. A 35 mm camera was used along with field notes to record adits, places of erosion, spoils, and other areas of environmental interest.

Table 3 shows a listing of uranium prospects not examined. Many of these were never mined and exist only as scattered uranium prospects or occurrences. Most are outside the study area and were not inspected.

The second step in the accomplishment of the objectives of this study was to evaluate the radiation hazard potential within the study area. There are a variety of risks from radiation hazards that accompany all phases of the uranium industry. These risks may be classified on the basis of how they have been caused (Morrison, 1980). They are as follows: (1) radiation effects by the inhalation of radon and its daughters; (2) radiation effects through the external exposure to gamma rays: (3) radiation effects by ingestion of heavy metals.

To evaluate the first of these risks, long-term radon progeny measurements of eight adits within the study area were made using Track Etch[R] type F detectors. The Track Etch detectors were donated by Terradex Corporation, 460 North Wiget Lane, Walnut Creek, Californiz, 94598.

In addition to the Track Etch detectors placed in the adits, one Track Etch cup was placed on the surface of a spoils pile (Figure 18) and one was placed in a control area (the author's home). The cups were left in place for a period of greater than 30 days. They were sealed in an aluminum pouch provided by Terradex Corporation until placement in the adits.

MINE NAME	¼ Sec.	Sec.	TWSP-Range
Jim Rab Claim	S½	Sec 23	6S-3E
Unnamed	SW¼	Sec 21	5S-1E
Unnamed	NE¼	Sec 19	6S-2E
Unnamed	S½	Sec 23	6S-1E
Unnamed	NE¼	Sec 26	6S-1E
Elk Mountain	NE¼	Sec 9	6S-1E
Wolf Canyon		Sec 17 or 18	8S-6E
Unnamed	NW¼	Sec 7	8S-3E
Red Canyon	SE¼	Sec 29	7S-3E
Lucky Strike	NW¼	Sec 25	7S-2E
Trail Wind	NE¼	Sec 26	7S-2E
Walkan	W½	Sec 25	7S-2E
Western Edge	NE¼	Sec 25	7S-2E
Little Windy	SW¼	Sec 30	7S-3E
Lucky Toss	SW¼	Sec 30	7S-3E
Ophelia	NW¼	Sec 30	7S-3E
Blue Note	NE¼	Sec 24	7S-2E
Yellow Cat	NE¼	Sec 30	7S-2E
Carnotite Cave	SE¼	Sec 19	7S-3E
Lazyman	SE¼	Sec 20	7S-3E
Hipockets	W½	Sec 21	7S-3E
Eagle Eyrie	SW¼	Sec 4	8S-3E
Little Windy	SW¼	Sec 4	8S-3E
Acme	W¼	Sec 3	8S-3E
Cycad #1	NE¼	Sec 34	7S-3E
Schoonmaker	SE¼	Sec 34	7S-3E
Lakota Lodes	S¼	Sec 34	7S-3E
Amy	NE¼	Sec 12	9S-3E
Starlight	NW¼	Sec 25	8S-3E
Cheyenne Canyon	SE¼	Sec 11	9S-3E
Pabst #3	NW¼	Sec 1	8S-3E
Lo Ra	SE¼	Sec 2	9S-3E
Damsite Group	SW¼	Sec 31	8S-4E
Washboard	NW¼	Sec 31	8S-4E
Accidental	NE¼	Sec 30	8S-4E
Gould Mine	NE¼	Sec 11	8S-3E

Table 3-Uranium Prospects Not Examined

(from Elevatorski, 1977)

Figure 18 - Track Etch Detector Placed on Spoils Pile.

The cups were placed in adits selected on the basis of accessability to the general public.

To evaluate radiation effects through external exposure to gamma rays a radiometric survey which measured gamma exposure rates of the mines located on USFS property was completed in the summer of 1981 by the author. In this survey, a 100 ft. grid pattern was marked off by pacing. At each intersection, readings were taken allowing them to become stabilized by waiting one minute. The actual counter reading in counts per minute or mR/hr was then recorded on maps (Appendix A). Also included on these maps are the relative size and distribution of the spoils within the individual mine site.

The counter readings were used to find locations with the "hottest" spoils. These locations were then sampled. Due to time and money limitations, only fifteen samples were analyzed. Samples were chosen on the basis of accessability to the general public.

The fifteen samples were then analyzed for radium-226 using a sensitive gamma spectrometric procedure based on the measurement of bismuth-214 after sealing the sample in a metal can to prevent the loss of the radon-222, daughter of radium-226 (Perkins, 1981).

Radiation levels in ground water, surface water and vegetation, as recorded by TVA, were used to evaluate radiation effects by ingestion of heavy metals.

Finally, recommendations were made, based on the results to be discussed in the next chapter.

Chapter 2

RADIOACTIVITY

When evaluating the radiometric qualities of an area, the first question to arise is: "What constitutes a safe level of exposure?". In order to address this question, an examination of uranium and its daughter products is necessary. Figure 19 lists the radioactive isotopes of the uranium-238 decay series.

The uranium-238 decay series can be divided into four parts. They are as follows: (1) the long-lived isotopes, ^{238}U, which are considered to be in equalibrium in nature; (2) ^{226}Ra; (3) ^{222}Rn and its short-lived daughters; (4) the long-lived radon daughters, ^{210}Pb, ^{210}Bi, and ^{210}Po (EPA, 1976). These isotopes occur as coating on sand grains or as fillings or cement in interstitial spaces where it has accumulated by water deposition.

There are three types of ionizing radiation from the decay of uranium-238: (1) alpha particles, which are basically the nucleus of a helium atom; (2) beta particles, which are electrons, and positrons; (3) gamma radiation, which is a form of electromagnetic radiation of shorter wavelengths and therefore more penetrating (Morrison, 1980). The majority of the physiological hazards are due to the emission of gamma radiation and alpha radiation.

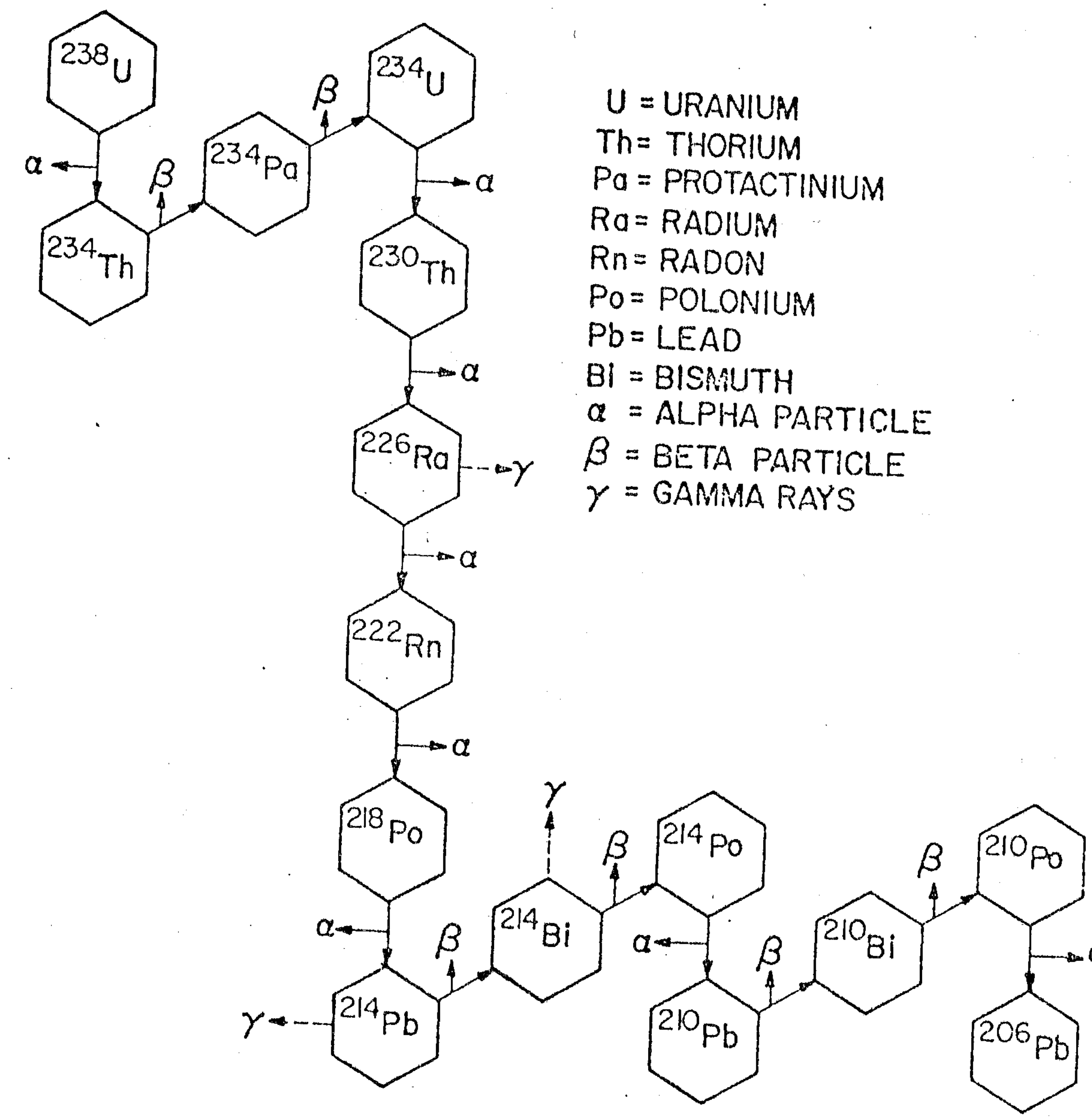

Figure 19 - Principal Branch of Uranium-238 Decay Series (DOE, 1979)

The uranium mining within the study area was done above-ground and in under-ground adits. The principal difference between under-ground and surface mining in terms of radiation hazard is in the types of radiation exposure. For above-ground, the major radiation exposure is from gamma rays. Underground, alpha radiation from ingestion and inhalation of short half-life radon daughters is the major source of radiation exposure.

Radium isotopes are present within all soils in varying states of equilibrium with its parents. Radium-226 decays by the emission of an alpha particle to radon-222, an inert gas with a half-life of 3.8 days. The atmospheric concentration of radon-222 depends upon: (1) the degree of air circulation; (2) the concentration of radon-226 in the soil, and; (3) the degree of equilibrium between radon and its daughter products. Because the daughter products are electrically charged, they tend to attach themselves to the dust particles within the atmosphere. Therefore, the primary source of contamination is through inhalation (EPA, 1978).

Since more than one radionuclide is involved, a total energy unit has been developed (Yamamoto, 1980). This unit, the working level (WL) is also designed to be a safe occupational level of exposure.

Ledbetter (1980) defines one WL as any mixture of short half-life radon daughters in a liter of air which will ultimately produce 1.3 x 10^5 million electronvolts (MeV) of alpha energy.

The WL was defined on the basis of the short-term alpha energy from 100 pCi/L of radon in equilibrium with its daughters. Disequilibrium is quite important to the relation between pCi/L of radon with an age of twenty minutes would be in about 30 per cent equilibrium. This would result in about .75 WL.

The problem of equilibrium arises because the radiation measured does not come primarily from the uranium but from its daughter elements. When uranium is disturbed or separated from its radioactive daughter elements, it immediately starts to decay and reform the elements until all of them in the decay series have accumulated in their original proportions. That is, each element is present in an amount so that it decays to the element below it in the series at the same rate as it is produced from the element above it. When this happens, an equilibrium is established. In equilibrium, no further change takes place in the quantity of any of the daughter elements until the sample is disturbed or subjected to a chemical change.

At the time of mine development, a uranium miner could work in an atmosphere containing one WL. This safe level has now been reduced by a factor of three (Yamamoto, 1980).

The radiation doses allowed for the general public have been 1/10th the occupational limits. This fraction is based on a philosophy that the general public represents a larger group at risk and that they are not being paid for taking the risk (Ledbetter, 1980).

For the purpose of this study the limit for "safe exposure levels" was set at 0.33 WL for alpha radiation. This corresponds to the recommended occupational exposure levels. For an occasional visitor to the study area, a maximum level of 1.0 WL was set by the author. These levels represent the authors opinion and should be used only as a relative guide.

It should be noted that as of March 1975, the Environmental Protection Agency has adopted the policy of assuming a linear relationship between population exposures to ionizing radiation and its biological effects. There is, therefore, some potential ill health attributable to any exposure to ionizing radiation and the magnitude of the potential ill health is directly proportional to the magnitude of the dose received (Yamamoto, 1980). Thus, there is some potential hazard in all radiation.

In the Federal Register's "Proposed Cleanup Standards for Inactive Uranium Processing Sites" (1980) a maximum limit of 25 mrem/yr for all releases, excluding radon and its daughters is recommended. This corresponds to only 5 pCi/gm of radium and is the maximum amount allowed without special treatment (CFR, 1980[a]). The long-used exposure dose limits of 2 mR/hr and 100 mR/wk are still the basic monitoring limits in the Texas Regulation (Ledbetter, 1980).

SAMPLE	FEDERAL STANDARDS	STUDY AREA
AIR	.003 WL	.003 WL
SOILS	5.0 pCi/g	5.0 pCi/g
WATER	5.0 μg/l	5.0 μg/l
OPEN LAND gamma exposure limit	20 μR above backround or 0.02 mR above backround	*45 counts/min. or .048 mR

Table 4 - General Public Radiation Standards

Values were taken from Federal Standards (40 CFR-192) for inactive mill tailings.

* Backround in the study area as measured by the author is 25 cpm or 0.028 mR

The Federal Register's proposed standards are quite low when compared to the Texas Regulation which are quite high. For the purpose of this study, an intermediate value of 100 pCi/g was chosen as an acceptable "safe limit" for gamma radiation. This value is lower than the Texas regulations for occupational safety, however, it is ten times higher than the maximum amount recommended by the Federal Register.

GAMMA RADIATION

Gamma radiation is measurable in spoils. The levels are usually a few tenth mR/hr. Samples for analysis of gamma radiation in the study area were obtained from spoils on the basis of their radioactivity as determined from field survey which measured gamma exposure rates.

There are three sources of gamma radiation that influence the reading obtained by the detectors used in this study: (1) cosmic radiation which originates from outer space and gives low-level high energy radiation; (2) radioactive nuclides which occur naturally in the atmosphere, namely radon-222 and bismuth-214, and (3) the natural radioactive nuclides present in the surficial layers of rock.

All persons are subject to low-level radiation exposure from natural sources occurring in the environment. The amount and type of this radiation varies from place to place and time to time (Henry, 1969). As a matter of fact, the southern Black Hills in a virgin condition 100 years ago, undoubtedly had higher than average background radiation due to the uranium deposits in the area (Redden, personal comm., 1982). Since the actual level of radiation varies, the actual background at any location can only be determined from direct measurements. Within the study area the background count is approximately 25 counts per minute, as measured with a simple Geiger-Mueller survey instrument, or .028 mR/hr as measured with a scintillometer-type survey instrument.

RADIOLOGICAL MAPPING

The basic part of a Geiger-Mueller survey instrument is a metal tube filled with an inert gas. A voltage from batteries is applied between a metal wire running the length of the tube and the tube wall. Then the counter is placed near a source of radioactivity, some of the radiations strike the tube filled with gas, creating a pulse of electric current which is then recorded. Alpha particles are stopped by the tube wall. Beta particles have a greater penetrating power, and some can enter the tube wall but most do not. Gamma rays penetrate the tube with much greater numbers, producing electrical pulses.

The scintillometer-type survey instrument, like the Geiger-Mueller type, records principally gamma rays. The radiation produces tiny flecks of light called scintillations in a potassium iodide crystal. The scintillation counter is of greater sensitivity due to the fact that the crystal reacts to a much larger proportion of gamma rays than does the Geiger tube. This means that the scintillometer can accurately detect a much smaller change in the amount of radioactivity.

Mass effect is probably the most important factor to consider when using these types of survey meters. The principal effect relates directly to the fact that a counter measures the total amount of radiation from a source. The total amount of radiation will vary with the size of the source as with the proportion and type of radioactive substances within the source. The source is defined as the material from which the radiation is emitting. This could be the walls of the adits, the spoils, or the ore body itself. The closer the source, the higher the readings. Efforts to compensate for mass effects were taken. All measurements were taken at approximately three feet (1 m) from the source. If the reading was greater than .06 mR/hr with the first meter or 200 counts per minute with the second meter, a second reading was taken. These readings are approximately four times background in the abandoned mine sites. This reading was taken as close to the source as possible the second time.

The scintillometer/Geiger counter readings obtained were then plotted on maps (Appendix A) and used to get a general profile of the radioactive conditions at each site. A summary of results of the radiometric survey are included in Table 5. Both survey instruments were calibrated before and after each use using a standard calibration disk.

SPOIL SAMPLING FOR Ra-226

The results from the spoil sampling analysis for ^{226}Ra are seen in Appendix A. The average spoil sample contained 382.1 pCi/g radium-226. The lowest concentration (2.660 pCi/g) was obtained from the Hot Point Group and the highest (1643.0 pCi/g)

PG.	Name of Mine	# Grid Location	Highest Reading	Lowest Reading	Mean	Std. Deviation
A-1	Matias Peak Group	55	.17 mR/hr	.028 mR/hr	.042 mR/hr	± .048 mR/hr
A-3	Mary Jack Group	16	.16 mR/hr	.028 mR/hr	.081 mR/hr	± .001 mR/hr
A-5	Lion No. 1 and 4	11	.20 mR/hr	.028 mR/hr	.057 mR/hr	± .005 mR/hr
A-6	Lion No. 1 and 4	32	.32 mR/hr	.028 mR/hr	.127 mR/hr	± .008 mR/hr
A-8	Too Late	6	700 cpm	150 cpm	329 cpm	± 416 cpm
A-9	Hold No. 15 (1)	29	.1 mR/hr	.028 mR/hr	.041 mR/hr	± .004 mR/hr
A-10	Hold No. 15 (2)	32	350 cpm	25 cpm	150.7 cpm	±176.5 cpm
A-11	Holdup Group	8	.1 mR/hr	.025 mR/hr	.054 mR/hr	± .062 mR/hr
A-12	Hot Point Group	13	.45 mR/hr	.032 mR/hr	.119 mR/hr	± .178 mR/hr
A-14	Greenacre	15	.35 mR/hr	.048 mR/hr	.09 mR/hr	± .125 mR/hr
A-16	Hay and Fay	11	.30 mR/hr	.028 mR/hr	.085 mR/hr	± .14 mR/hr
A-18	Clarabelle	12	400 cpm	50 cpm	139.6 cpm	± 179.7 cpm
A-19	Shamrock	22	275 cpm	50 cpm	102.2 cpm	± 120.9 cpm
A-21	Dagmar	13	300 cpm	50 cpm	101.9 cpm	± 166.7 cpm
A-22	Gertrude	18	200 cpm	25 cpm	86.1 cpm	± 98.02 cpm
A-24	Pictograph Mesa	4	400 cpm	100 cpm	193.75 cpm	± 259.0 cpm
A-25	King	20	250 cpm	25 cpm	88.75 cpm	± 153.07 cpm
A-28	Verde (1)	9	400 cpm	25 cpm	116.6 cpm	± 166.67 cpm
A-30	Verde (2)	7	100 cpm	50 cpm	71.42 cpm	± 79.6 cpm
A-31	Trail Faction	22	500 cpm	50 cpm	127.27 cpm	± 180.5 cpm
A-32	Blue Chip	33	450 cpm	50 cpm	107.57 cpm	± 139.0 cpm
A-33	Blue Chip	19	400 cpm	50 cpm	107.89 cpm	± 135.27 cpm
A-34	Blue Chip	5	400 cpm	50 cpm	200.00 cpm	± 267.86 cpm
A-35	Blue Chip	12	100 cpm	50 cpm	56.25 cpm	± 60.57 cpm
A-36	Ridge Runner	11	750 cpm	75 cpm	193.18 cpm	± 281.02 cpm
A-38	Taylor Group	27	300 cpm	25 cpm	156.48 cpm	± 173.5 cpm
A-39	Get Me Rick	13	400 cpm	25 cpm	169.20 cpm	± 210.0 cpm
A-41	Virginia C	28	1500 cpm	50 cpm	185.71 cpm	± 332.0 cpm
A-43	Coal Canyon	12	1000 cpm	25 cpm	166.66 cpm	± 320.0 cpm

Table 5 - Summary of Results From Radiometric Survey.

was obtined from the Virginia C Group. A summary of this data is given in Table 6.

AIR SAMPLING

The potential hazards within the study area, in terms of WL's which measure alpha radiation, can be measured within the confined adits. Potential hazards from this source are primarily from the inhalation of the short-term daughters of radon. Radon-222 is the radioactive isotope from the uranium-238 decay chain having a relatively long half-life of 3.8 days. A high probability exists that a person inhaling this gas directly would exhale the gas before the emission of an alpha particle. The main hazard comes from the short term daughters: ^{218}Pa; ^{214}Pb; ^{214}Bi; and ^{214}Po, which have a much shorter half-life and emit alpha particles within the lungs (EPA, 1978).

The amount of alpha particles emitted may be measured with Track Etch type F detectors donated by the Terradex Corporation.

Track Etch devices consist of thin sheets of alpha-sensitive material that are passively exposed to the atmosphere within the adit. Alpha particles from radon and radon daughters produce damage tracks in the sensitive material. These tracks were made visible by an etching technique, and then counted (Perkins, 1981).

The results expressed in pCi/L are shown in Table 7. The radon exposure rate was obtained from Terradex Corporation. The working levels were calculated from these exposure rates

PAGE	MINE NAME	^{226}Ra
A-2	Matias Peak Group	90.44 pCi/gm
A-4	Mary Jack Group	72.15 pCi/gm
A-7	Lion #1 and 4	123.8 pCi/gm
A-13	Hot Point Group	2.66 pCi/gm
A-15	Greenacre	$<$ 182.9 pCi/gm
A-17	Hay and Fay	$<$ 264.8 pCi/gm
A-20	Shamrock	144.8 pCi/gm
A-21	Gertrude	1075.0 pCi/gm
A-26	King	97.57 pCi/gm
A-27	King	126.5 pCi/gm
A-29	Verde	614.8 pCi/gm
A-37	Ridge Runner	357.8 pCi/gm
A-40	Get Me Rick	313.5 pCi/gm
A-42	Virginia C	1643.0 pCi/gm
A-44	Coal Canyon	619.9 pCi/gm

Table 6 - Results of Spoils Sampling for Radium-226.

MINE	RADON	WORKING LEVEL
MATIAS PEAK	46.82	0.4 WL
HOT POINT GP.	2422.27	21.8 WL
GREENACRE	2954.40	26.6 WL
GREENACRE	268.26	2.4 WL
BLUE CHIP	55.97	0.5 WL
DARROW	178.47	1.6 WL
DARROW	101.42	0.9 WL
CONTROL	6.25	0.06 WL

Table 7 - Track Etch Results

Radon exposure rates in pCi/liter
WL's at 90% equilibrium
1 pCi = 10^{-12} Ci
1 Ci = 1 curie = 3.7×10^{10} radioactive disintegrations/sec.

using the assumption that the degree of equilibrium between radon and its daughters is about 90 percent. One sealed cup containing 100 pCi/L of radon with an age of 10 days would be in about 90 percent equilibrium.

INGESTION OF RADIONUCLIDES

The last of the radiologic hazards to be evaluated, proposed by Morrison, 1980, is from ingestion of radioactive materials. To evaluate possible hazards from the ingestion of radioactive materials, radioactive levels from ground water and vegetation in the study area were needed. A search of the literature provided two tables from Tennessee Valley Authority (TVA) showing radioactive levels from ground water and vegetation within the study area. These are presented in Tables 8 and 9.

Uranium is present in minor amounts in all ground waters tested within the study area. The four wells listed are located in the vicinity of the Darrow Pits. Actual amounts of natural uranium-238 in the study area vary from 0.08 ug/L to 0.87 ug/L. TVA reports these values are well below the maximum permissible concentrations of uranium.

There are 133.2 pCi/L of dissolved radium-226 in the Burdock well B-2. This is the highest value reported by TVA and is not considered to be hazardous. The values represented by these wells are high, when compared to EPA maximum permissible concentrations as they are located in or very close to ore bodies.

Vegetation samples analyzed by TVA show only slight amounts of natural uranium and radium-226. These values are somewhat

Sampling Location	Natural U µg/l	^{230}Th pCi/l	^{226}Ra Dissolved pCi/l	^{210}Pb pCi/l	^{210}Po pCi/l
Burdock Well B-1	0.87	1.1 ± 0.2	0.55 ± 0.03	b	b
(Fall River)	0.25	0.04 ± 0.07	0.43 ± 0.03		
	0.25	0.3 ± 0.2	0.91 ± 0.04		
	0.41	0.4 ± 0.1	0.35 ± 0.03		
Burdock Well B-2	9.49	0.5 ± 0.1	133.2 ± 0.4	c	33.2 ± 0.2
(Lakota)	0.32	0.06 ± 0.07	80.6 ± 0.3		
	0.19	0.05 ± 0.10	33.2 ± 0.2		
Miles Spencer Ranch Well	0.08	0.04 ± 0.07	1.87 ± 0.05		
Preston Richardson Ranch Well	0.16	0.01 ± 0.07	4.42 ± 0.08		

b - Insufficient sample.
c - Sample lost during analysis.

Table 8 - Radioactivity Levels - Edgemont Project Area
Ground Water (Dissolved Activity) (from TVA, 1979)

Sampling Location	Gross α pCi/g	Gross β pCi/g	Natural U μg/g	^{230}Th pCi/g	^{226}Ra pCi/g	^{214}Bi[c] pCi/g	^{137}Cs[c] pCi/g
Burdock, Southeast; East Central Section 11	0.01 ± 0.01[b]	10.1 ± 0.1			0.30 ± 0.05[c]	0.30 ± 0.05	d
	0.5 ± 0.2	-	0.14	0.17 ± 0.02	0.11 ± 0.01	d	0.2 ± 0.03
	-	-	0.22	0.19 ± 0.03	0.28 ± 0.01	-	-
	-	-	e	e	0.08 ± 0.004	-	-
	-	-	0.14	0.19 ± 0.03	0.12 ± 0.01	-	-
	-	-	C.12	0.00 ± 0.01	0.17 ± 0.02	-	-
	-	-	C.15	-0.002 ± 0.004[f]	0.10 ± 0.001	-	-
Burdock, West; North Central Section 15	0.3 ± 0.2	-	0.07	0.13 ± 0.02	0.19 ± 0.01	d	0.2 ± 0.02
	-	-	0.21	0.19 ± 0.03	0.46 ± 0.02	-	-
	-	-	0.05	0.03 ± 0.01	0.15 ± 0.006	-	-
	-	-	0.17	0.01 ± 0.02	0.11 ± 0.01	-	-
	-	-	0.13	0.01 ± 0.01	1.01 ± 0.04	-	-
	-	-	0.13	0.03 ± 0.02	0.05 ± 0.001	-	-
Pit #6 Area; Northeast Section 32	0.9 ± 0.2	-	0.04	0.03 ± 0.01	0.15 ± 0.01	0.6 ± 0.07	0.2 ± 0.02
	-	-	0.03	0.10 ± 0.01	0.65 ± 0.01	-	-
	-	-	e	e	0.14 ± 0.007	-	-
	-	-	0.24	0.05 ± 0.14	0.17 ± 0.01	-	-
	-	-	0.21	0.01 ± 0.01	0.16 ± 0.02	-	-
	-	-	0.17	0.01 ± 0.02	0.22 ± 0.001	-	-
Runge, East; Central Section 31	1.0 ± 0.2	-	0.22	0.14 ± 0.02	0.26 ± 0.01	0.8[illegible] ± 0.1	0.4 ± 0.04
	-	-	0.02	0.01 ± 0.01	0.07 ± 0.004	-	-
	-	-	e	e	0.10 ± 0.007	-	-
	-	-	0.90	0.15 ± 0.03	0.34 ± 0.01	-	-
	-	-	0.42	0.01 ± 0.01	0.31 ± 0.02	-	-
	-	-	0.54	0.03 ± 0.01	0.24 ± 0.001	-	-

b - The error reported is the 1-sigma counting error.
c - Results obtained by gamma spectroscopy using a Ge(Li) detection system. Analysis for Ra-226 and Bi-214 using this method may produce results which are of questionable reliability.
d - None detected
e - Insufficient sample.
f - Negative value is an artifact of counting statistics and does not infer a negative activity.

Table 9 - Radioactivity Levels-Edgemont Mining District-Vegetation (from TVA, 1979)

less than those reported for ground water and are all below maximum permissible concentrations.

Chapter 3

NON-RADIOLOGIC HAZARDS

Following the initial discovery of uranium, prices rose sharply due to a great demand for nuclear power plants. The phase-out of the federal uranium procurement program in the early 1960's caused the prices to fall as sharply as they had risen. The decrease in the price of uranium was accompanied by the closure of many of the uranium mines all over the United States including those of the study area. Laws and regulations concerning reclamation of these mines were non-existant. The depressed prices put the original companies in a financial bind resulting in abandonment without concern for reclamation. The impacts observed by the author in field investigations are presented in the following sections.

FIELD INVESTIGATION OF IMPACTS

Uranium mining usually involves considerable disturbances of surface lands and associated biota. This is especially the case for open pit mines in which ore bodies are located less than 70 to 80 feet (21 to 24 m) below the surface, as they are in the study area (Figure 20). Large quantities of overburden and topsoil were removed during the mining process. Disturbed surface areas of up to 200 acres (81 ha) are located throughout the study area. Topsoil and overburden were not separated in the early mining operation and are now, in many

Figure 20 - Showing Present Condition of a Surface Mine in the Blue Chip Group.

cases, covered with spoils. The physical characteristics of each mine within the study area are listed in Table 9.

Unplugged drill holes are common in the area and are often obscure (Figure 21). They are up to 200 feet (61 m) deep and 6 to 8 inches (15 to 20 cm) in diameter. These holes represent a physical hazard to livestock, wildlife, and man. The drill pads that accompany these holes are, for the most part, unreclaimed and may be seen on aerial photographs.

Throughout the study area, numerous dozer scrapes, roads, and trenches are common. Natural vegetation has failed to reclaim these disturbances. Lack of vegetation has resulted in erosion which has left many of the roads impassable (Figure 22). Lack of vegetation is also a factor in the erosion of spoils (Figure 23).

Many of the sites appear to have been "dozer mined". These sites have numerous bulldozer slashes which range from 6 to 40 feet (1.8 to 12 m) in width and up to 150 feet (46 m) in length. Most are only 4 to 10 feet (1.2 to 3 m) in depth. Fourteen of these slashes were counted in the Valley View site. Radiometric survey showed only slight elevation of external radiation above backround. It is the opinion of the author that these "dozer mined" areas were only prospect trenches which were abandoned because no significant ore bodies were discovered.

Many of the mine sites are covered with the trash of

	Prospect trenches	Open pits	Bad access roads	Drill holes	Dozer damage	Extreme erosion	Stagnant ponds	Loose pit edges	Dangerous adits	Adits	Fenced	Mining refuse	Garbage dump	Ventilation shafts	Livestock	Track Etch (a)	Soil sample
Matias Peak		X		X				X	X	X					X	X	X
Mary Jack	X			X											X		
Lion No. 1 & 4	X	X		X	X	X	X	X				X	X		X		X
Crandall Group				X	X								X				
Too Late		X	X	X					X	X							
Hold No. 15	X	X		X	X	X	X			X		X					
Holdup Group	X			X	X	X											
Hot Point Group		X		X	X	X		X	X	X		X		X		X	X
Greenacre				X					X	X			X		X	X	X
Hay & Fay		X		X		X		X							X		X
Clarabelle		X		X		X		X	X	X					X		
Shamrock	X	X		X	X					X					X		X
Dagmar	X	X	X	X	X			X	X	X		X			X		
Gertrude	X	X		X	X			X	X	X		X			X		X
Pictograph Mesa				X						X		X	X				
King		X	X	X		X	X		X	X		X					X
Verde	X	X	X	X		X	X	X	X	X							X
Trail Faction		X		X		X		X			X	X	X				
Blue Chip	X	X		X	X	X	X	X	X	X		X				X	
Ridge Runner	X	X	X	X	X	X	X	X		X		X			X		X
Valley View	X	X	X	X	X		X										
Taylor		X	X	X		X	X	X				X	X				
Virginia C		X		X		X	X	X							X		X
Get Me Rick	X	X		X	X										X		X
Road Hog	X	X		X	X										X		
Coal Canyon Group			X	X	X				X	X		X					X
Lucky Strike	X	X	X												X		
Freezeout	X		X	X		X	X					X	X				
Darrow		X		X	X	X	X	X		X				X		X	
Triangle		X		X	X	X		X									
Spencer-Richardson		X		X	X			X									
Wicker-Baldwin		X			X												

Table 10 -Physical Characteristics of Mines Within the Study Area. Column (a)-Track-Etch-Alpha Sensitive Device Used to Measure Radon-222 Provided by Terradex Corporation.

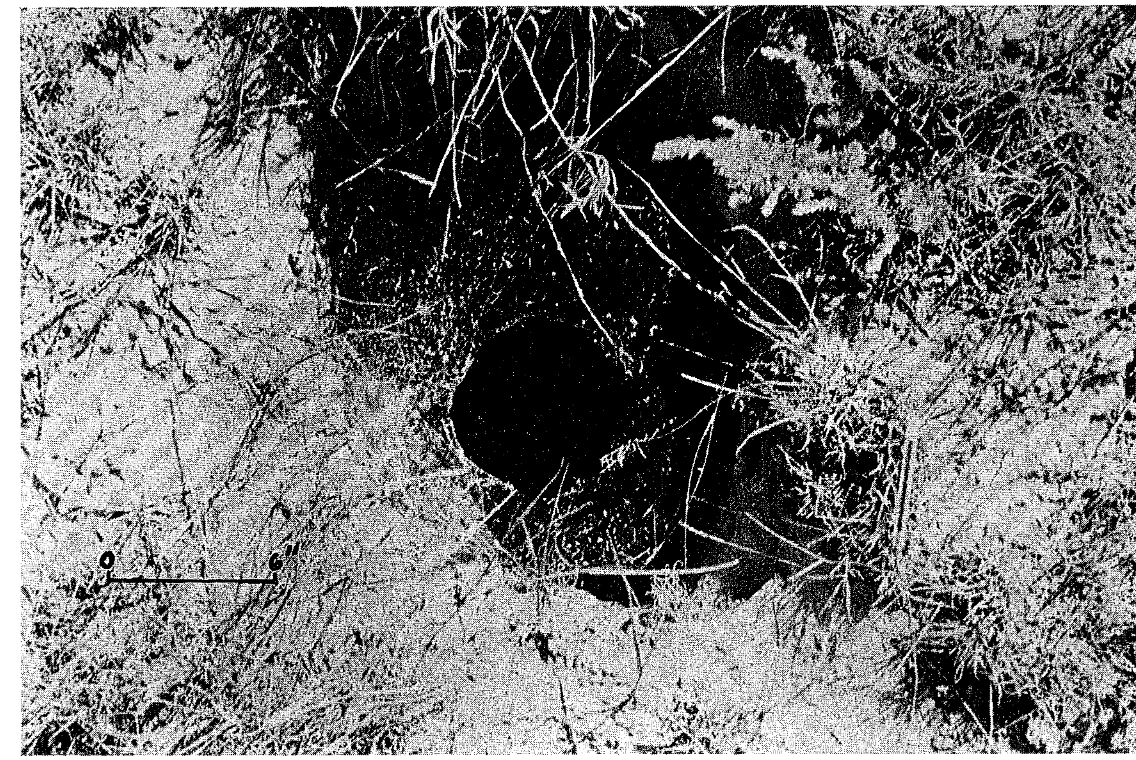

Figure 21 - Unplugged Drill Hole.

Figure 22 - Hold #15, Showing Poor Road Conditions.

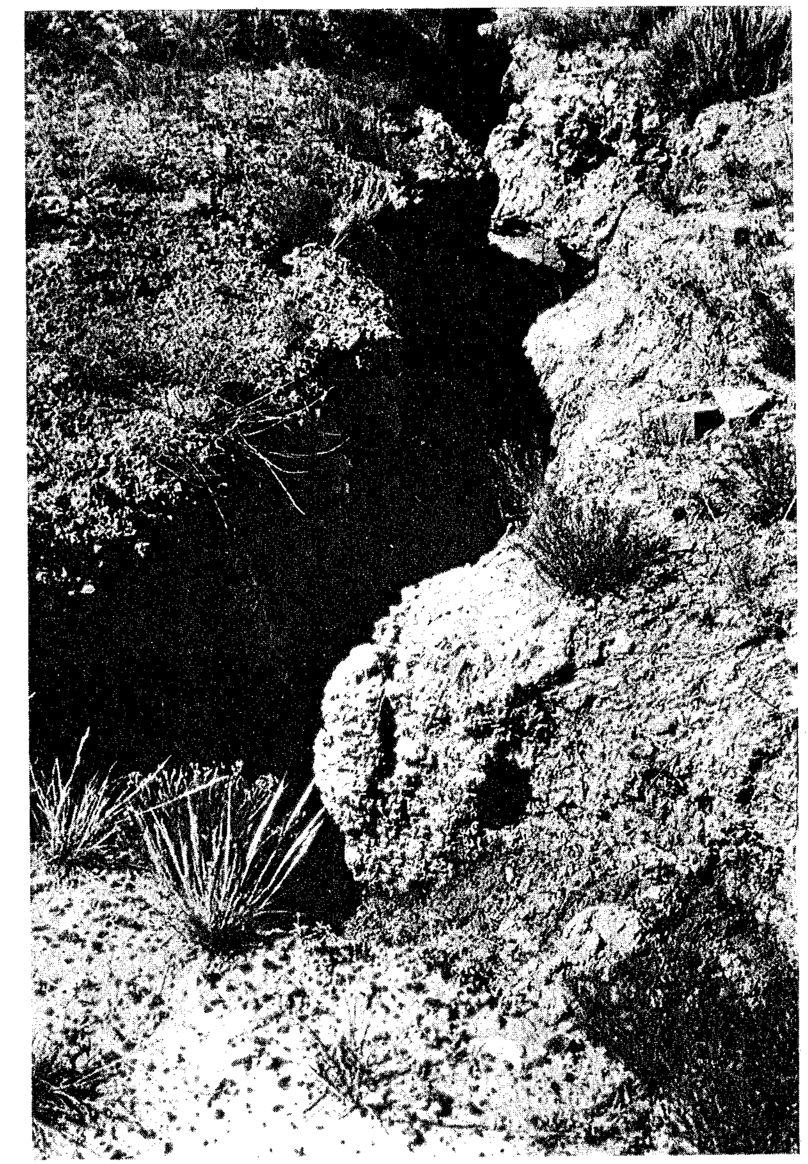

Figure 23 - Lion #1 and 4, Showing Spoils Erosion.

mining operations. Numerous items including blasting caps, wire, refrigerators, oil barrels, and a rusted-out bulldozer were left as these mines were abandoned. No mine site investigated in the study area was void of this trash.

The general public has developed an attitude of apathy toward these already disturbed lands. Many of the pits including those on USFS property have been used as garbage dumps. The wind has blown trash from these dumps to undisturbed lands. The mining roads have also been littered by trash from recreational users.

There are many physical hazards in the study area as a result of the unreclaimed condition of the mine sites. The rims of many of the pits are extremely unstable as evidenced by slumping. These rims are unmarked and many remain unseen as they are approached. At night one cannot see some of the pits until less than 25 feet (7.6 m) away from them. The Trail Faction and the Lion No. 1 and 4 could easily be driven into at night as a result of their obscure nature.

Adits also represent a physical hazard (Figures 24 and 25). Some of the adits are in fair condition, but most are quite dangerous. Cave-ins are common as evidenced by debris on the floor of the adits (Figure 26). Structural supports in many adits have been left standing but serve no purpose since the cave-ins. These adits are used and explored by the general public for recreation. Evidence of camping near the entrances

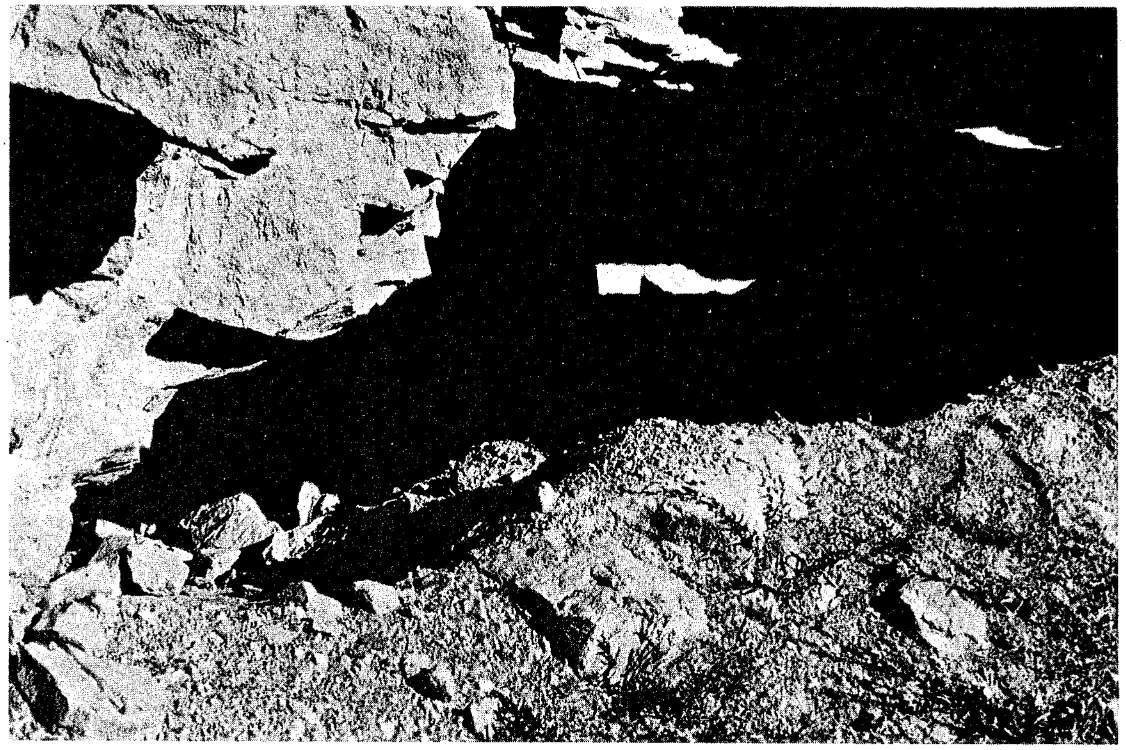

Figure 24 - Potentially Dangerous Adit (Clarabelle Mine)

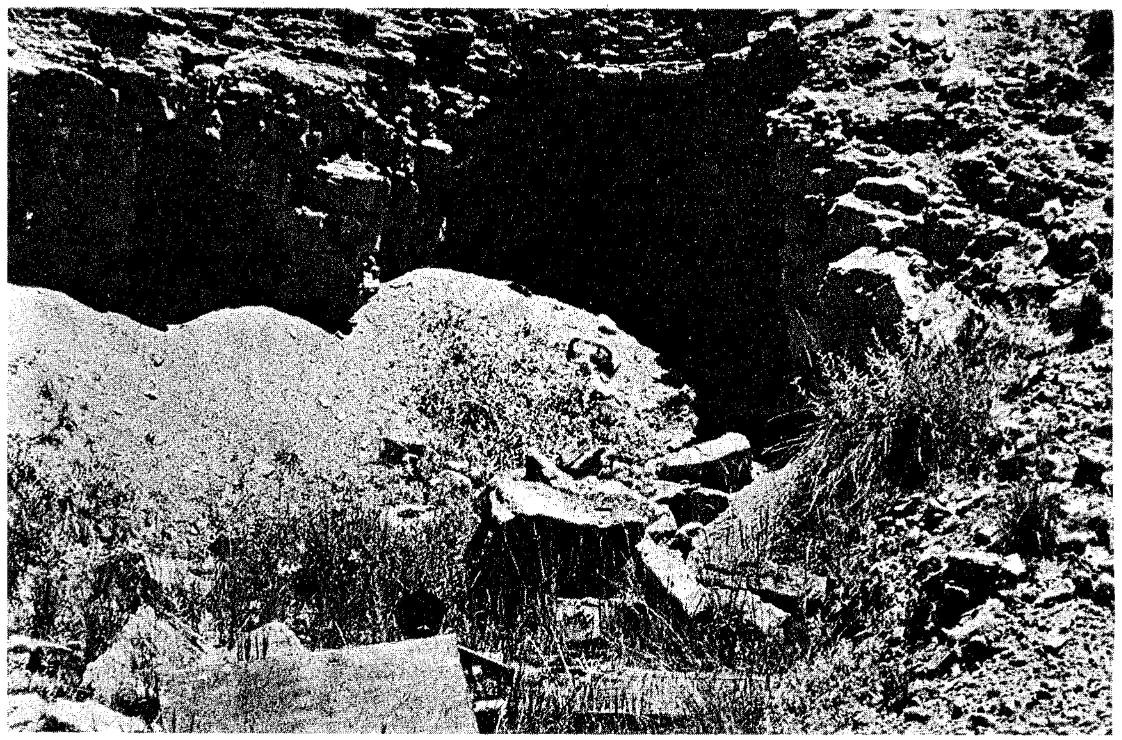

Figure 25 - Hot Point Group Showing Potentially Dangerous Adit.

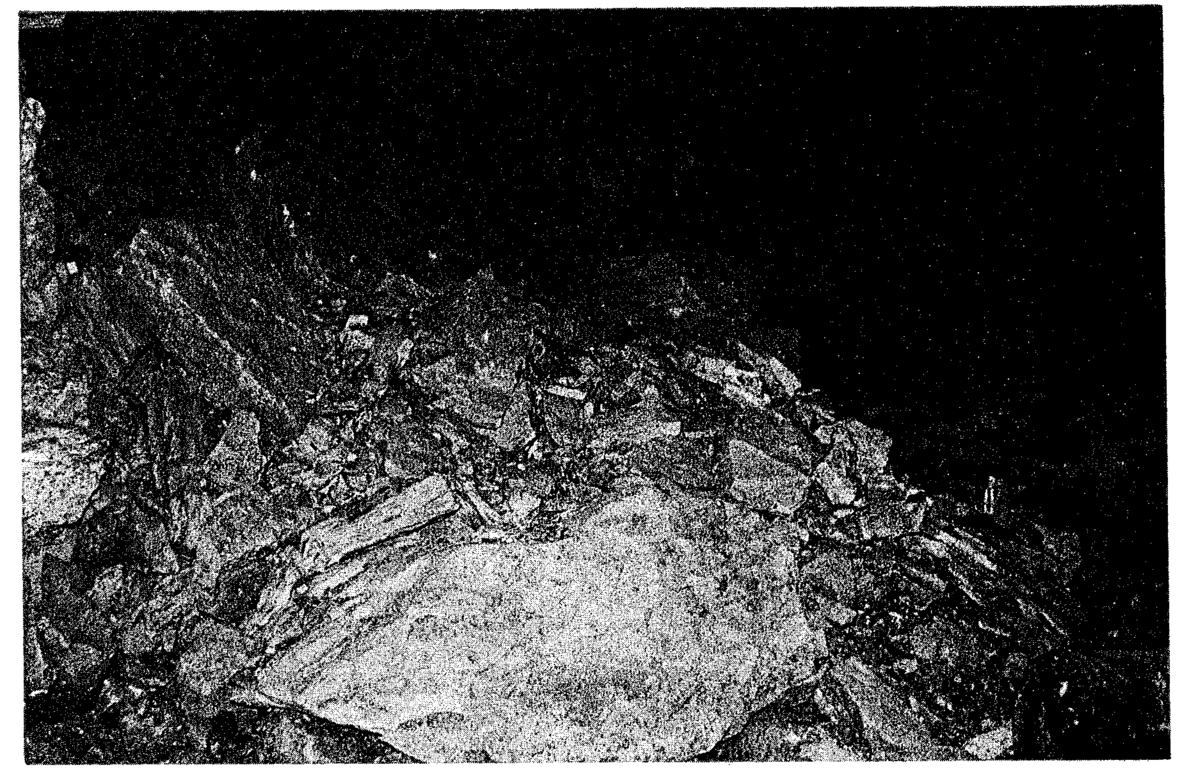

Figure 26 - Debris on Adit Floor Caused By a Cave-In.

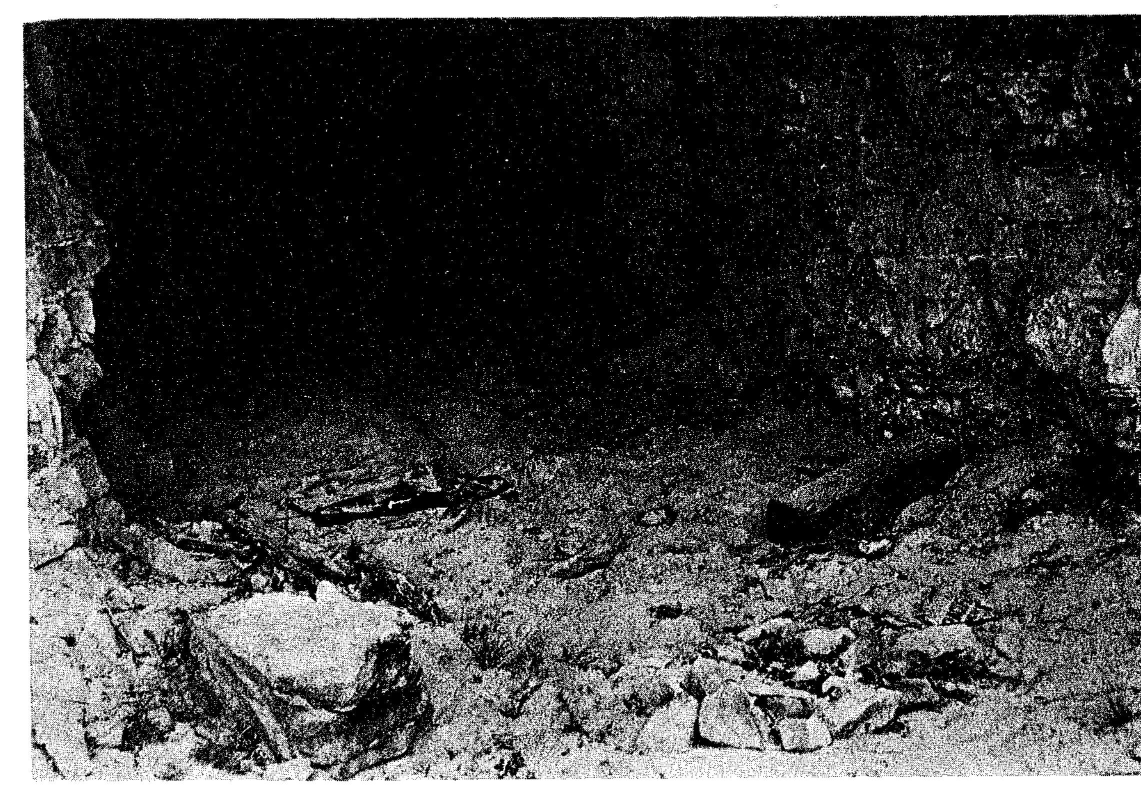

Figure 27 - Pictograph Mesa Claim, Showing Evidence of Camping Near Adit Entrance.

near the entrances of these adits was seen in many locations (Figure 27). The footprints of small children were also recognized on the floor of several adits. Local ranchers in the area are using some of these adits for cattle shelters.

The adits not only represent a physical hazards but also a radiological hazards.

Ventilation shafts have been left unmarked and are now covered by vegetation. Two shafts were found within the study area by the author (Figure 28). They are both about two feet (.6 m) wide and up to 60 feet (18 m) deep. Both are obscure and quite dangerous to man as well as domestic animals and wildlife.

SURFACE AND GROUND WATER

Surface runoff patterns, surface and ground water quality, and flow patterns may be adversely affected by open pit and under-ground mines (Goodier, 1978). No measures were taken in the study area to prevent degradation of water quality during the early mining operations.

Surface water runoff from the mine sites has increased due to the lack of vegetative cover. This resulted in the erosion of spoils, roads, and of the mines. Sediment loads in all areas of disturbance have increased, changing the microclimate at each location, however, dispersion of radio-nuclides, appears to be only local, visually estimated by the

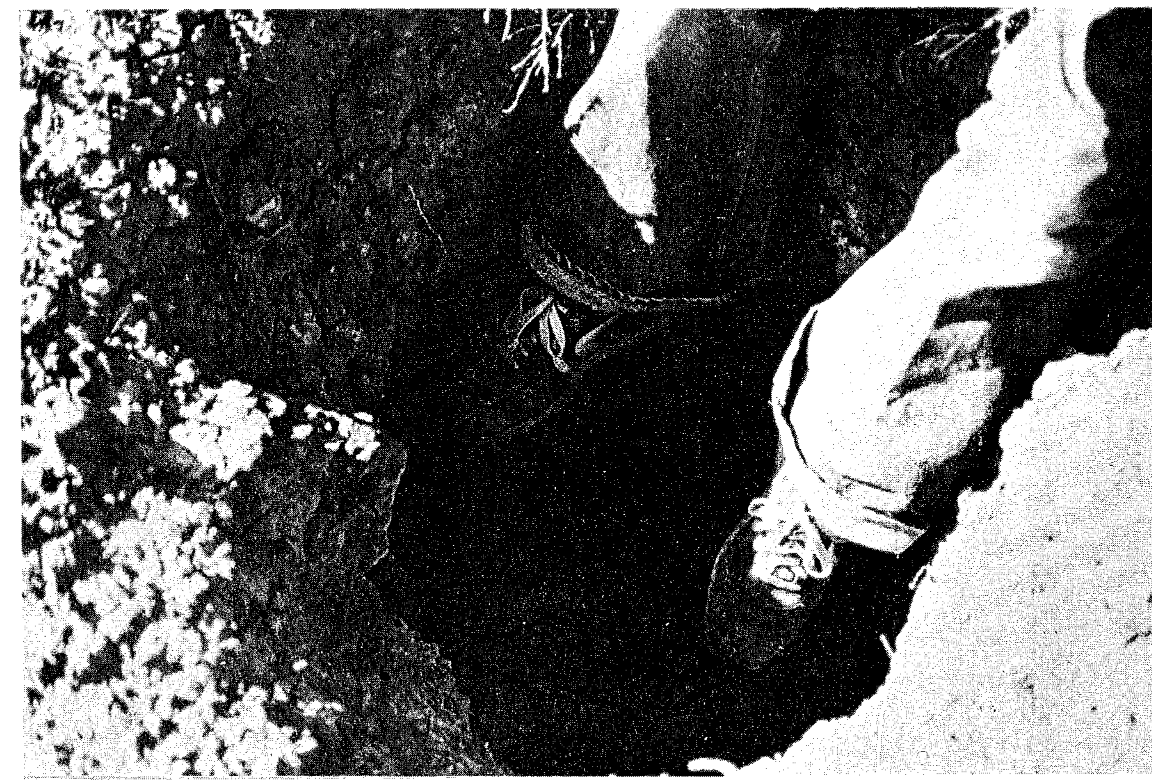

Figure 28 - Unmarked Ventilation Shaft in Study Area.

author at less than 100 m.

Most of the mines in the study area are above water table. As a result, the mines act as a sink to collect runoff and are naturally "silting in". Much of the runoff goes to stagnant ponds down-drainage from the mines or in the open pits. These stagnant ponds are used occasionally by livestock and wildlife as a source of water. This may possibly result in the ingestion of harmful trace elements. These stagnant ponds have also increased the presence of biting flies and mosquitoes as observed by the author.

Ground water quality has probably been little affected by the mine sites. Very little if any contamination is seen as a result of the early mining activities in the study area as most of the contaminantion appears to be natural.

TVA studies of surface waters draining the study area, and USGS data show that early mining has probably only slightly affected surface water quality, mostly in the amount of total dissolved solids. No increases or decreases in the amounts of contaminating elements above or below the mine sites are shown.

AIR QUALITY

The quality of air within the study area has only slightly been affected by the unreclaimed condition of the mines. Roads have caused an increase in fugitive dust resulting in depressed plant conditions along the roadways. Particulate matter from the spoils and pits increases as the velocity of the wind increases. The winds in the study area average approximately 9 miles per hour.

BIOLOGICAL IMPACTS

Alterations of the natural habitats for vaious native species of plants, aquatic life, and animals are inevitable in uranium mining areas. In these areas, toxic elements such as selenium may accumulate in plants which may be used as toxic element indicators (Rosenfeld and Beath, 1964). Selenium indicators such as asters (Aster adscendens Lindl.) and vetch (Astragalus racemousus Purch.) were identified by the author within the study area possibly indicating the migration of toxic elements.

The potential for vegetative climax on mine sites is not equivalent to the adjacent land. At best, 25 percent of the disturbed lands have vegetation returning to normal after 25 years. Most of the returning vegetation is in the form of noxious weeds and sages. The vegetation in the disturbed areas is not equivalent to adjacent land in terms of kinds or numbers of species of plants.

Game and animal populations are noticably less in the study area than in the Jewel Cave quadrangles to the north or the Hot Springs quadrangle to the east. This is possibly a result of man-made disturbances and roads as a result of past mining activity, giving hunters acess to the area, but probably is only due to the lack of moisture and food supporting wildlife and vegetation in the area.

Microclimates in the study area have been changed by sedimentation and chemical leaching from runoff, however, more habitats have been created by the mining activity than have been destroyed. Rocks, brush piles, and depressions, in which water may be stored, have all created habitats that are utilized by many species of rodents and small game. The increase in small game has resulted in an increase in populations of birds of prey.

LAND USE

Past mining activity in the study area has caused an increase in the recreational land use in the area. The number of roads on USFS property from mining activity has brought many people into the area. The increase in the number of people using the area also increases the exposure to potential hazards.

There are no water or recreational facilities within the study area to accommodate the increased recreational use.

The use of rangeland and cropland has not significantly been reduced because of mining in the study area.

Chapter 4

CONCLUSIONS

The purpose of this study has been two-fold (1) to determine the location, volume, and radiological status of all known uranium spoils and sites of mining disturbance in the southern Black Hills, and (2) to assess the present and future impacts associated with these spoils.

The location of 38 uranium mines covering greater than 490 acres (198 ha) were plotted on orthophotoquad maps and 7½ minute quadrangle maps. The volume of spoils within the study area is estimated by the author to be greater than 390,000 cubic yards (298,165 m^3).

Attempts have been made to determine the radiological status within the study area. There have been no known reported illnesses in the Edgemont area, such as cancer, as a result of mining activities. However, during the early 1950's, the connection between respiratory illness and radon gas may not have been realized. Therefore, if any illness resulted, it probably would not have been reported.

Possible dangers from radioactivity within the study area would be those classified by Morrison (1980). These dangers include: (1) radiation effects by inhalation of radon-222 and its short half-life daughters; (2) external exposure to gamma rays, and (3) radiation effects by injestion of radio-nuclides.

The first of these dangers was evaluated using Track Etch devices which measure the alpha radiation given off by the short half-life daughters of radon-222 gas. Results shown in Table 7 indicate that all the mines are above the .33 WL limit of occupational exposure, however, most people visiting the mine would not stay for an extended period of time. Therefore, an exposure limit of 1.0 WL was used by the author as approximate limit for occasional visitors. The Matias Peak, Blue Chip, and Darrow adits were the only adits below this limit.

The Hot Point Group and the Greenacre adits have noticeably higher WL's. This may possibly be due to a lack of circulation within the adits or possibly as a result of a higher concentration of radium-226 which would create an inequilibrium in the radon gas present. These values are probably isolated occurrences within the adits of the study area.

The author concludes from these results that there are possible hazards from the inhalation and ingestion of radon-222 and its short half-life daughters within the adits of the study area.

An evaluation of the second risk proposed by Morrison (1980) includes a radiometric survey which measures external exposure of gamma rays and spoils sampling for radium-226.

Results from the radiometric survey (Table 5) indicate that most of the spoils within the survey area are radioactive, however, large standard deviations indicate that the highest readings are from isolated locations within the disturbed areas.

Results from spoils sampling for radium-226 also seem to indicate a wide range of variability of radioactivity. Only four of the 15 spoils sampled were within the limit set by the author of 100 pCi/g, however, it must be noted that these samples were taken from isoloted locations within the mines.

It is concluded that dangers from external exposure to gamma rays within the study area are minimal to the occasional visitor. However, it should be noted that the potential hazard is directly proportional to the amount of time spent within the mine sites. Therefore, a potential hazard exists from external exposure to gamma rays from uranium spoils especially with long term exposure.

Uranium is present in trace or minor amounts in all ground water. The solubility of many uranium compounds in water is high enough to suggest that several ppm could occur in solution. Radioactivity levels in ground water within the study area are listed in Table 8. Actual amounts of natural uranium-238 in the study area vary from 0.08 μg/L to 0.87 μg/L (TVA, 1979). The maximum permissible concentration of uranium is well above the maximum value reported by TVA. Therefore, possible hazards from ingestion of the ground waters within the study area are considered to be minimal.

Uranium is also found in small amounts in vegetation within the study area and is not considered to be hazardous. It should be noted, however, that selenium indicator plants were found in several sites and may possibly indicate migration of toxic elements by diffusion (Rosenfeld and Beath, 1964).

Many adverse environmental impacts and physical hazards were also found within the study area. These include: (1) disturbed areas of up to 200 acres (81 ha); (2) unplugged drill holes; (3) numerous dozer scrapes, roads, and trenches; (4) stressed vegetation conditions; (5) open pits with loose edges; (6) extreme erosional features; (7) structurally unstable adits; (8) unmarked ventilation shafts, and (9) mine refuse.

RECOMMENDATIONS BASED ON CONCLUSIONS

It is the author's opinion that it is time to renew America's faith in the mining industry by correcting the mistakes of the past. A major problem seems to be one of avoidance whereby neither the United States government or the mining industry wants to accept the responsibility for corrective action. If these mistakes are not corrected, radical groups will have fuel to fight pro-mining legislation and the net loss of income as a result will be far greater than the cost of corrective action.

The U.S. Forest Service should not solely be responsible for corrective action. The U.S. Department of Energy and the NRC should work with congress for the appropriation of reclamation and clean-up funds.

There are three major functions of reclamation of the mines in the study area: (1) to stabilize erosion; (2) to improve esthetic appearance; (3) to eliminate possible hazards in the area. The problem lies in to what extent "complete" land reclamation should be accomplished. Minimum recommendations for the area studies include:

(1) close all adits

(2) place security fencing around all open pits

(3) post all potentially hazardous areas

(4) reseed disturbed areas with native plant species

(5) consult health physicist to set exposure limits for occasional visitors

The closure of all the adits would eliminate the possibility of excessive radon gas exposure. The physical hazard caused by adits with dangerous conditions would also be eliminated. Closure could either be permanent by the use of explosives, or temporary by security fencing.

Table 10 lists the species and rates of seeding recommended by TVA (1979). The species listed are adapted to climatic and soil conditions existing in the study area. These species may be used by grazing animals for food.

Drill seeding is to be used where possible. If slopes are too steep for drill equipment, other acceptable methods such as hydroseeding or aerial seeding could be used. Some areas may have to be seeded by hand (TVA, 1979). Ponderosa pine may also be planted in many of the disturbed areas.

A vegetation monitoring program to measure progress of reseeding should be implemented. Pictures could be taken and the upgrading of vegetation could be done every two years.

These recommendations will substantially reduce potential hazards, reduce erosion, increase stability of slopes, and improve the esthetic appearance of the mine sites in the study area.

To facilitate the growing number of recreational vehicles

Species	Ordinary Uplands	Heavy Soils Depressions	Sandy Soils	Wet or Subirrigated Areas
Agropyron smithii	4(4.5)	6(6.7)		4(4.5)
Rosana				
Agropyron dasystachyum	3(3.4)	3(3.4)		
Critana				
Agropyron riparium		2(2.2)	3(3.4)	3(3.4)
Sodar				
Bouteloua curtipendula	2(2.2)			
Pierre or Butte				
Calamovilfa longifolia			1(1.1)	
Schizachyrium scoparium	2(2.2)	2(2.2)	2(2.2)	
Blaze				
Oryzopsis hymenoides			3(3.4)	
Stipa viridula			2(2.2)	
Lodorm				
Agropyron elongatum				4(4.5)
Alkar or Orbit				
Astragalus cicer				3(3.4)
Atriplex canescens**			2(2.2)	

**Add to mixture if a palatable shrub is desired by landowner.

Table 11 - Recommended Seeding Rates of Pure Live Seed in Kg/ha (1 lb/acre) For Edgemont Uranium Mining District (from TVA, 1979).

in the area, a recreational picnic ground could be built. It has also been suggested that many of the individual mine roads be permanently closed to allow the land to revert back to its original condition.

A significant impact of the mining activities in the study area is the detrimental effect to the image of uranium mining in general. Environmental groups, such as the Black Hills Alliance, point to the present conditions of the uranium mines left behind by past mining practices, and fear that the Black Hills will become a "national sacrifice area" if mining is continued. These fears may never change unless the mistakes of the past are corrected.

These recommendations have been put forth as a minimum solution to the problems created by mistakes of the past. America suffers due to a deteriorating image of mining. Responsibilities must be accepted for the condition of these abandoned mines before this image can be improved. To do nothing would be the greatest mistake of all.

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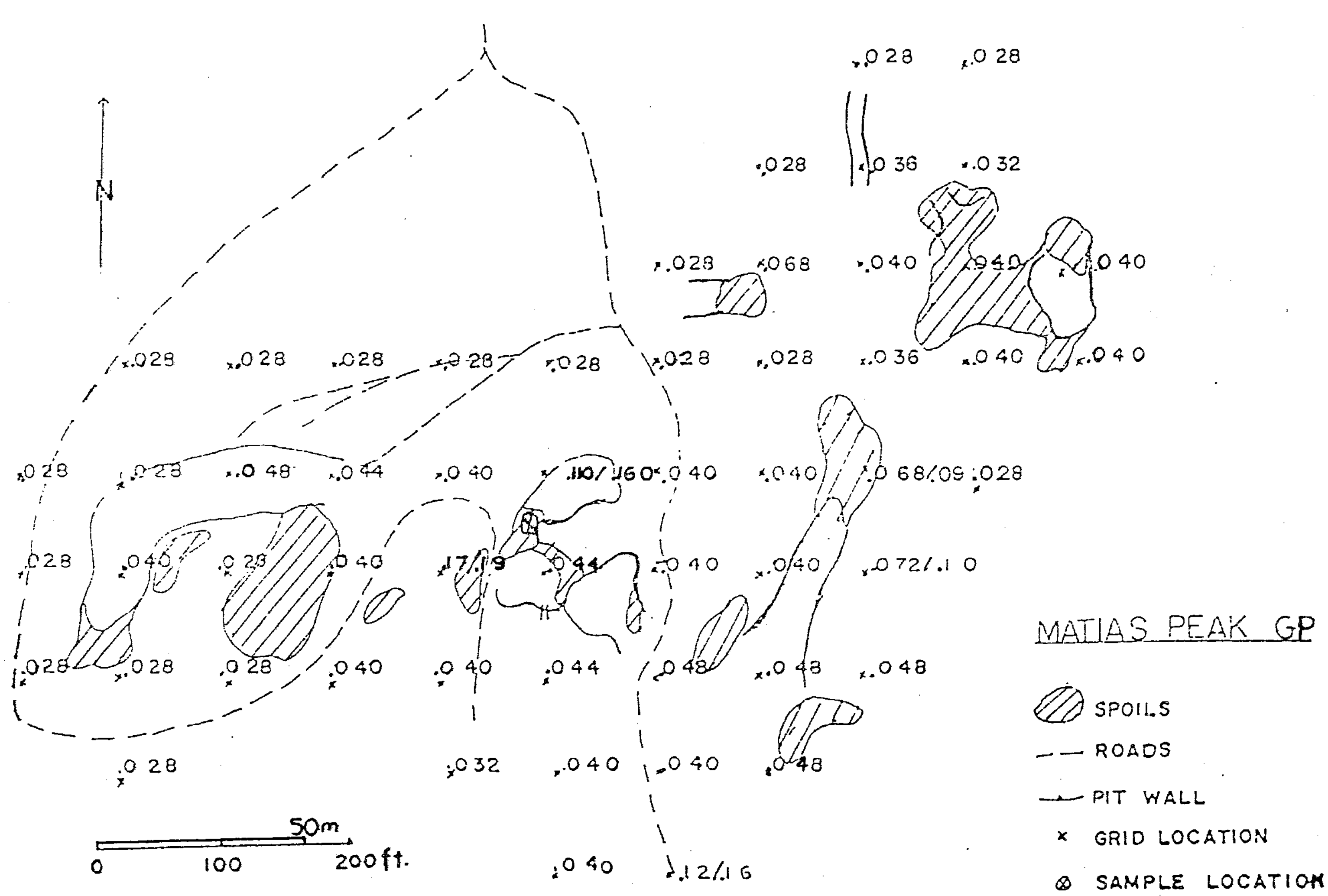
APPENDIX A

Radiologic Maps

and

Spoils Testing Results



RADIOMETRIC MAP (in mR/hr)

^{226}Radium in Soil

MATIAS PEAK

Sample No. Mine 1

Date Collected ____________

INPUT

(Computer Location)---STO

Total Count/Minute ^{226}Ra $\lesssim^{116}_{81}$ 209,555 /10 min.=20,955.5 (10)

Background Count/Minute distilled H_2O 2561 /10 min.=256.1(11)

Disintegrations/Count factor.................. 2.59 (12)

Sample Weight .... 594 gm.(13)

Count Time .... 22 hrs.(14)

Seal Time .... 18 hrs.(15)

Time Change correction factor .... 0 hr.(16)

Count Date 13 (17)

Elapsed Time addition factor .... 31 days(18)

Seal Date 6 (19)

Total Count/Minute ^{40}K $\lesssim^{77}_{67}$ ... 82,005 .... 8,200.5 (22)

Background Count/Minute ^{40}K $\lesssim^{77}_{67}$ ... 1,503 .... 150.3 (23)

OUTPUT

Net Count/Minute .... 20,732.

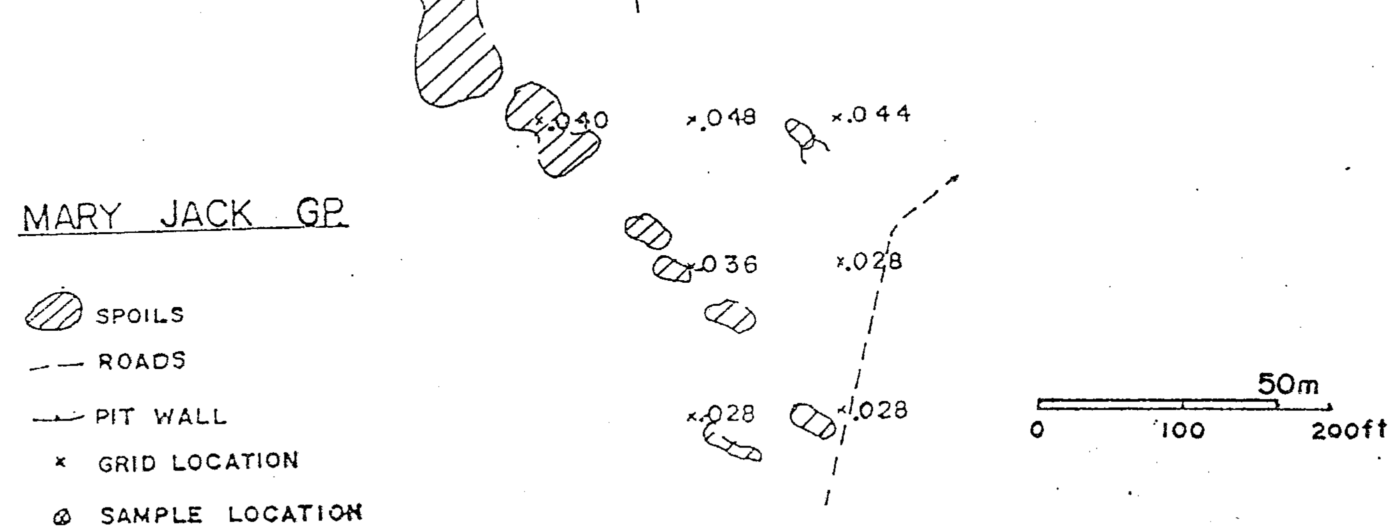
Net Disintegrations (Net Count x D/C per min.) 53,697.

Uncorrected ^{226}Ra Concentration (D/min/gm.)... 90.40

Ingrowth Time (T) .... 38.17 days

1-e $^{(-\lambda\Delta T')}$(-ΔT + 3.823) .... .9995

Corrected ^{226}Ra Concentration .... 90.44 pCi/gm.



RADIOMETRIC MAP (in mR/hr)

^{226}Radium in Soil — MARY JACK

Sample No. Mine 2

Date Collected ________

INPUT

(Computer Location)---STO

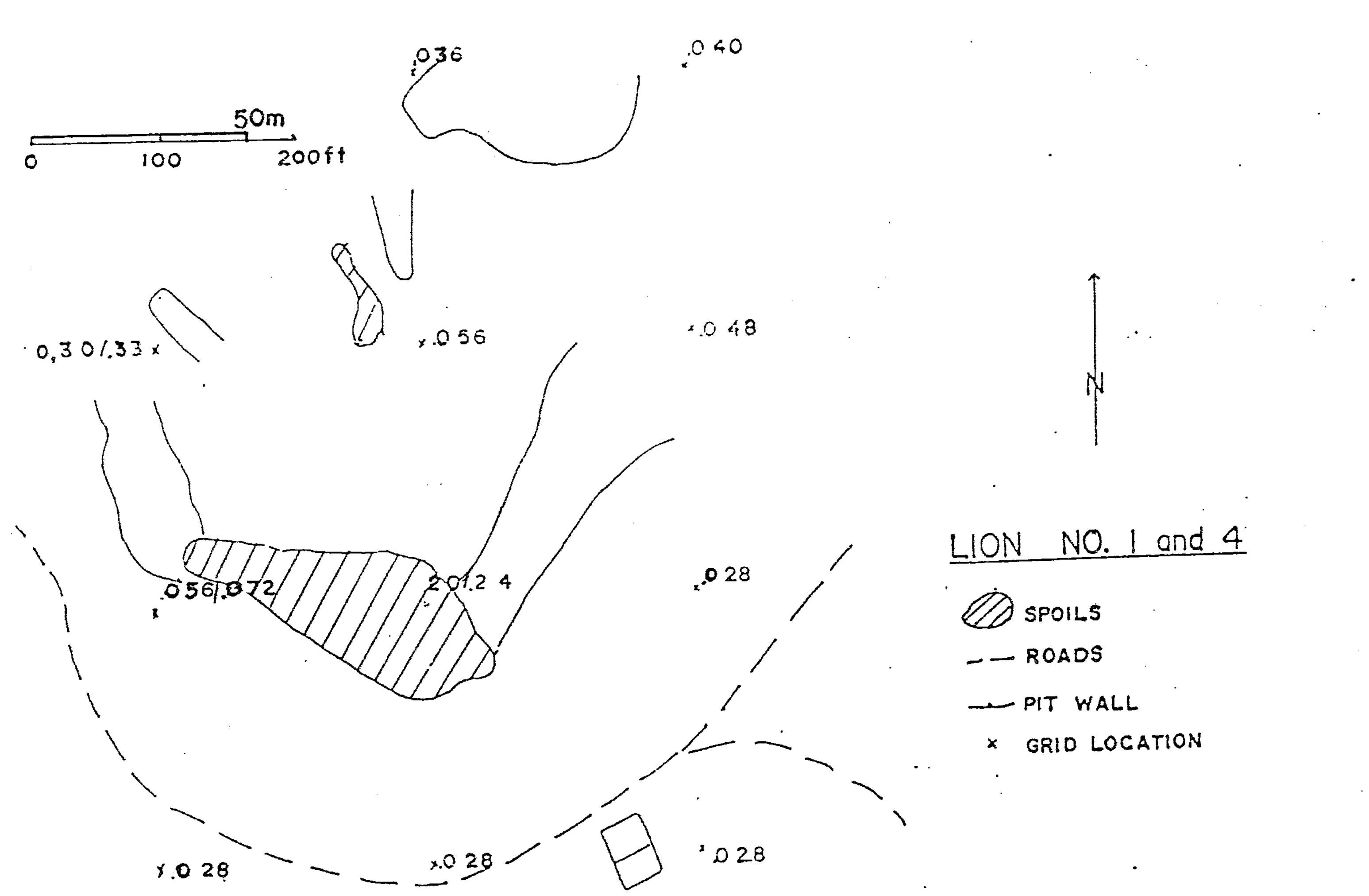
Total Count/Minute ^{226}Ra Σ_{81}^{116} 163,077 /10 min.= 16,307.7 (10)

Background Count/Minute distilled H_2O 2066 /10 min.= 206.6 (11)

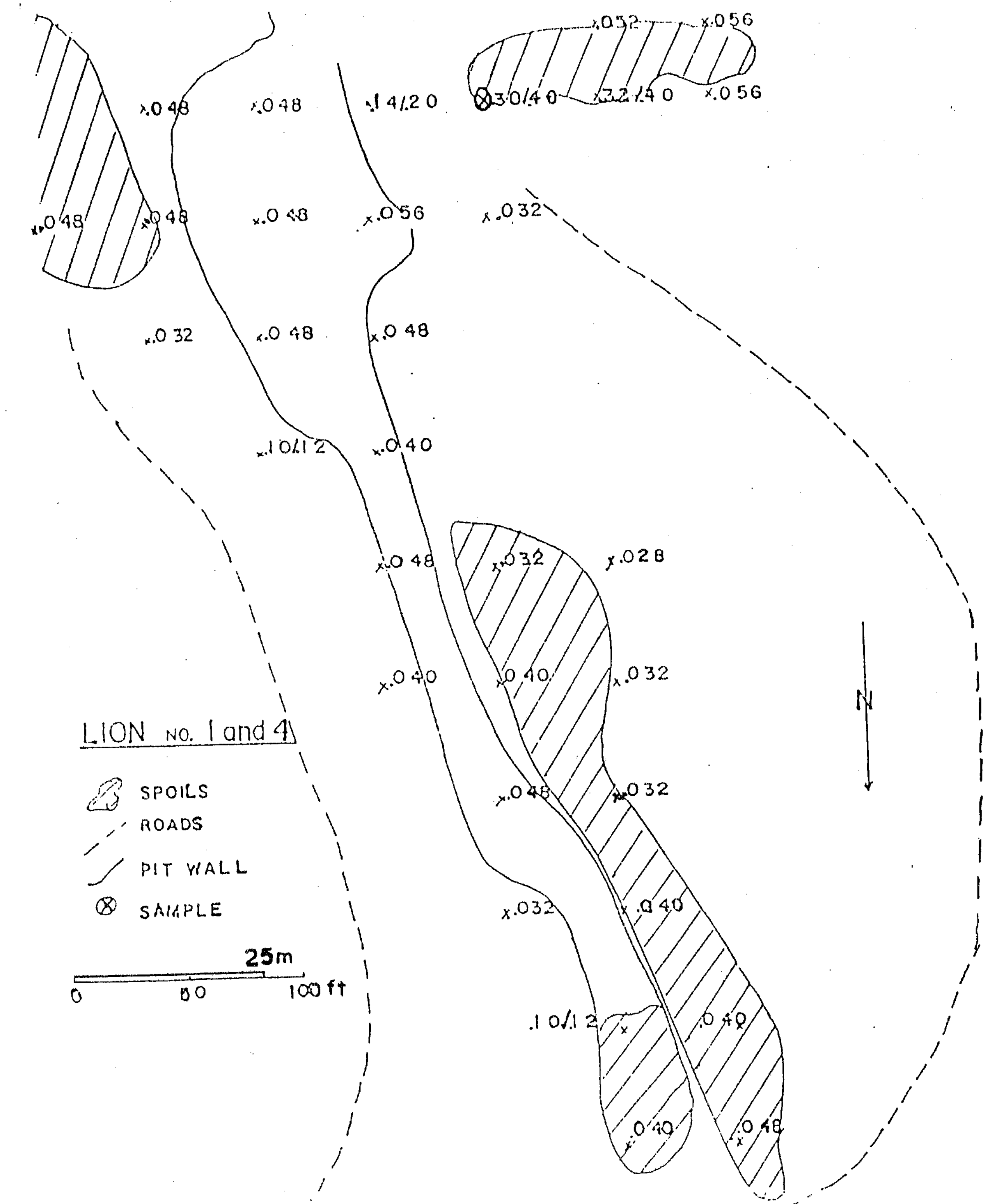
Disintegrations/Count factor	2.64	(12)
Sample Weight	590 gm.	(13)
Count Time	15 hrs.	(14)
Seal Time	18 hrs.	(15)
Time Change correction factor	0 hr.	(16)
Count Date	16	(17)
Elapsed Time addition factor	31 days	(18)
Seal Date	6	(19)
Total Count/Minute ^{40}K Σ_{67}^{77} 65,292	6,529.2	(22)
Background Count/Minute ^{40}K Σ_{67}^{77} 1278	127.8	(23)

OUTPUT

Net Count/Minute	16,118
Net Disintegrations (Net Count x D/C per min.)	42,554
Uncorrected ^{226}Ra Concentration (D/min/gm.)	72.13
Ingrowth Time (T)	40.88 days
$1-e^{(-\lambda \Delta T')}(-\Delta T + 3.823)$	.9997
Corrected ^{226}Ra Concentration	72.15 pCi/gm.



RADIOMETRIC MAP (in mR/hr)



RADIOMETRIC MAP (in mR/hr)

^{226}Radium in Soil — Lion #1 & 4

Sample No. Mine 3

Date Collected ________

INPUT

(Computer Location)---STO

Total Count/Minute ^{226}Ra $\lesssim^{116}_{81}$ 288,989 /10 min.= 28,898.9 (10)

Background Count/Minute distilled H_2O 2561 /10 min.= 256.1 (11)

Disintegrations/Count factor.................. 2.59 (12)

Sample Weight .... >600 gm. (13)

Count Time .... 22 hrs. (14)

Seal Time .... 18 hrs. (15)

Time Change correction factor .... 0 hr. (16)

Count Date 13 (17)

Elapsed Time addition factor .... 31 days (18)

Seal Date 6 (19)

Total Count/Minute ^{40}K $\lesssim^{77}_{67}$ ... 116,964 .... 11,696.4 (22)

Background Count/Minute ^{40}K $\lesssim^{77}_{67}$ 1503 .... 150.3 (23)

OUTPUT

Net Count/Minute 28,665

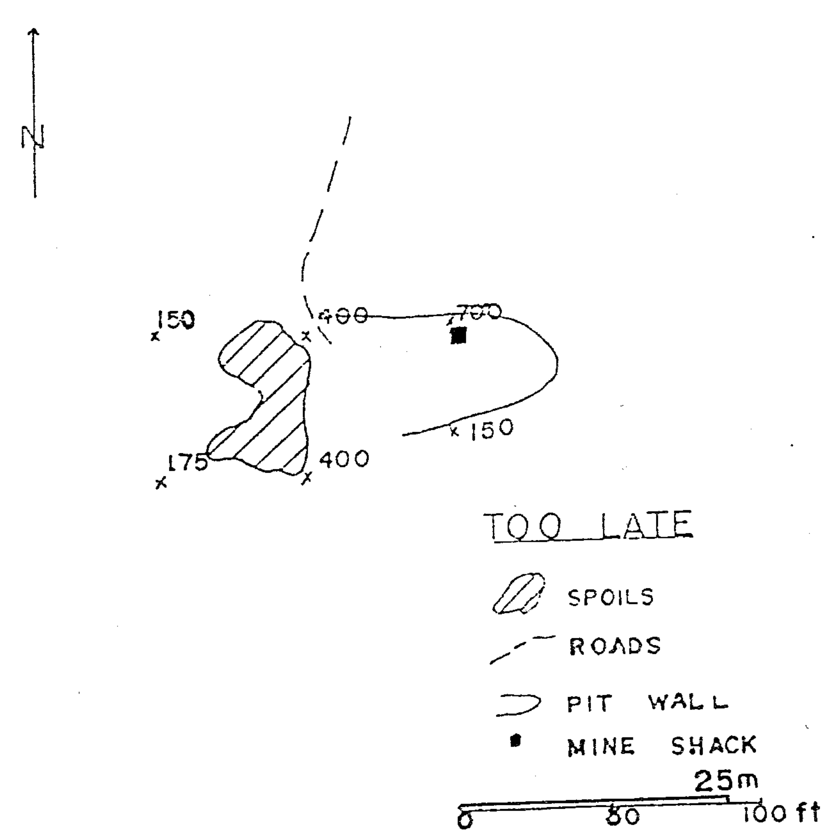
Net Disintegrations (Net Count x D/C per min.) 74,244

Uncorrected ^{226}Ra Concentration (D/min/gm.)... 123.7

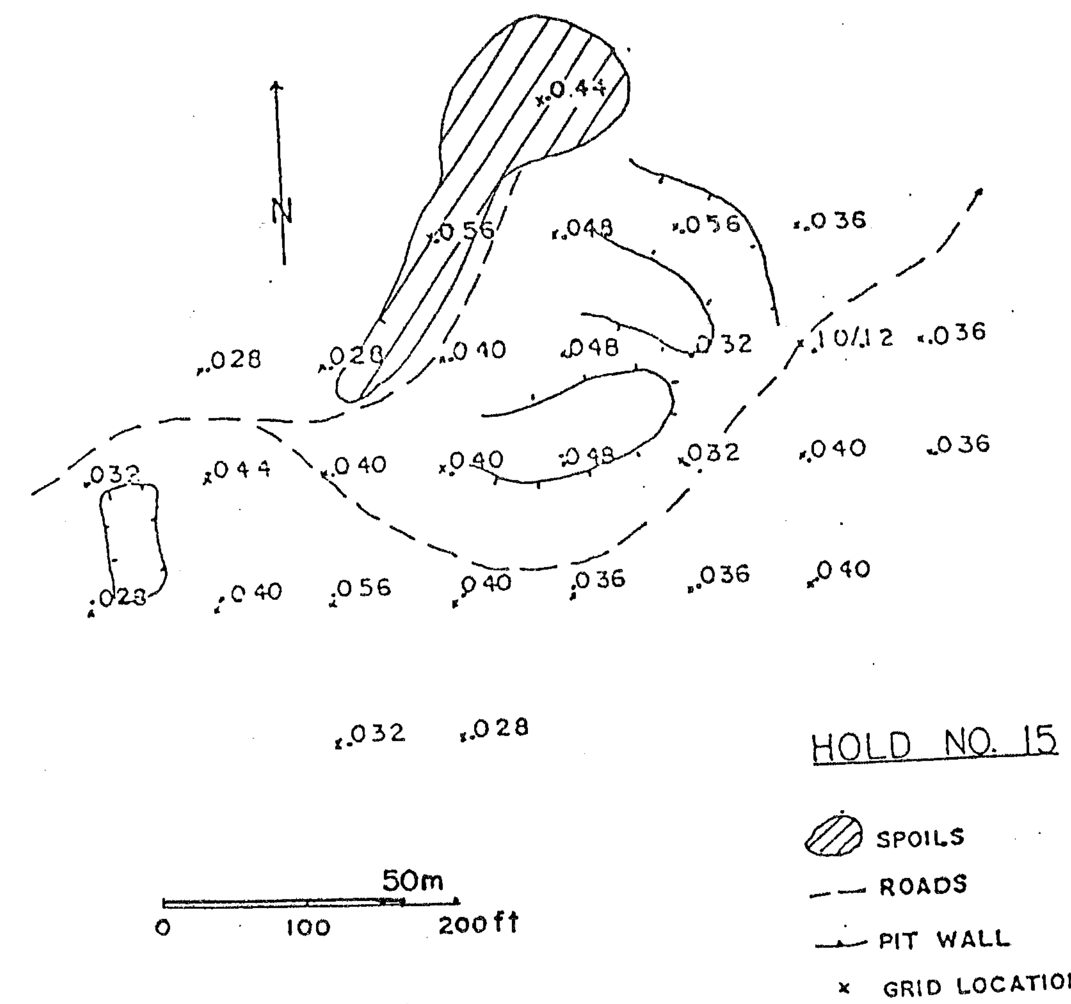
Ingrowth Time (T) .... 38.17 days

1-e $^{(-\lambda\Delta T')}$(-ΔT + 3.823) .... .9995

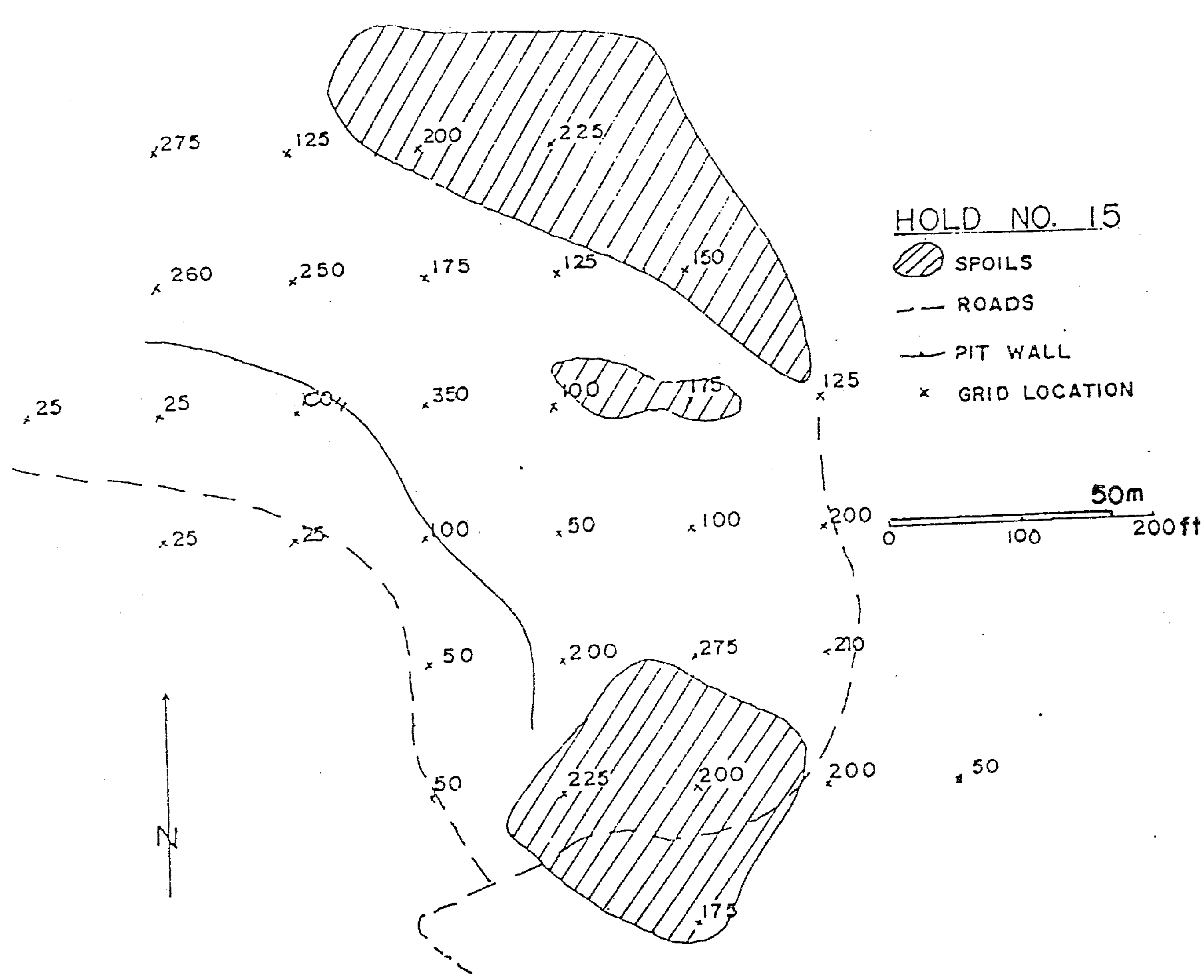
Corrected ^{226}Ra Concentration .... <123.8 pCi/gm.



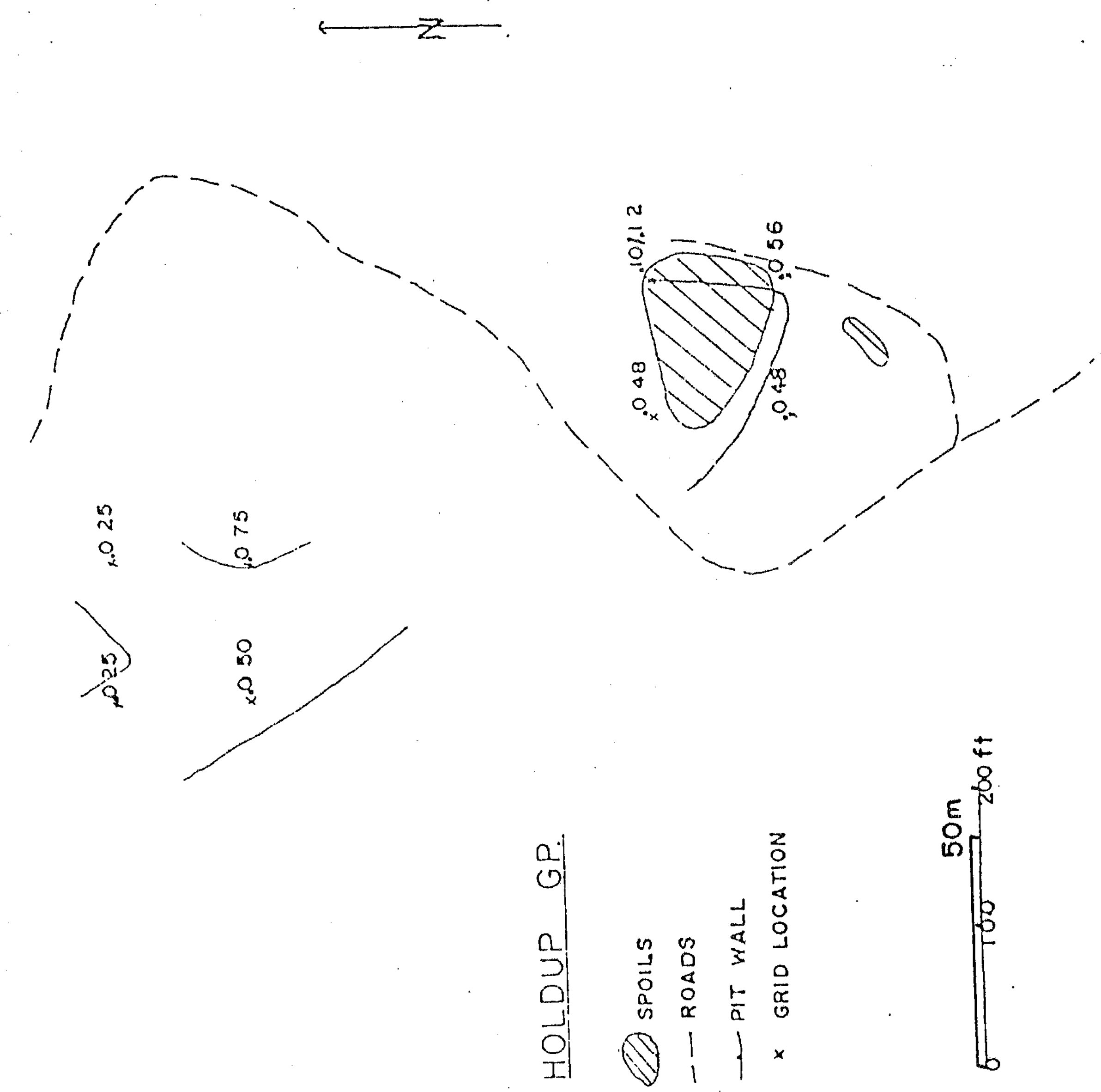
RADIOMETRIC MAP (in counts per minute)



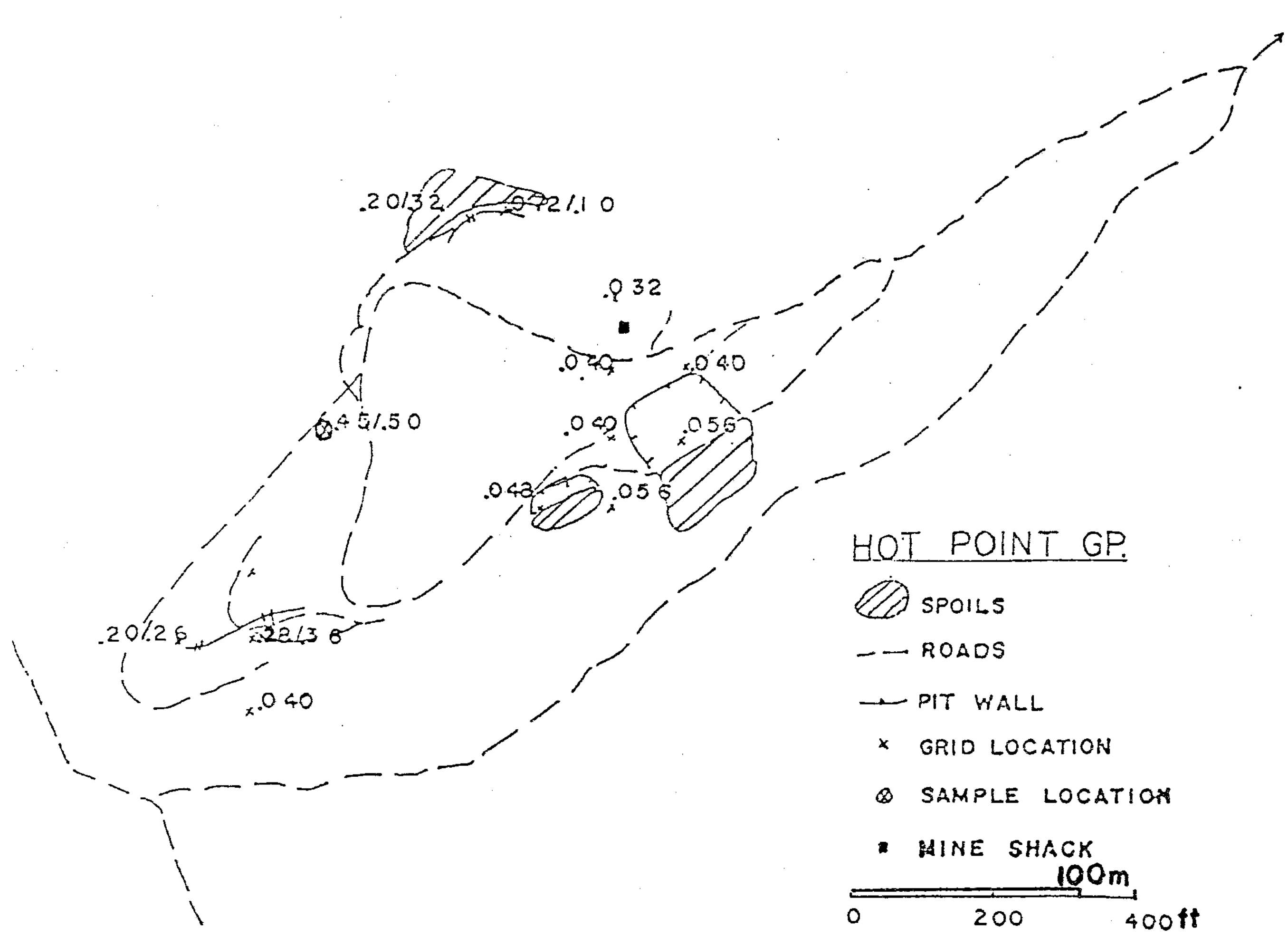
RADIOMETRIC MAP (in mR/hr)



RADIOMETRIC MAP (in counts per minute)



RADIOMETRIC MAP (in mR/hr)



RADIOMETRIC MAP (in mR/hr)

^{226}Radium in Soil

HOT POINT

Sample No. Mine 9

Date Collected ______

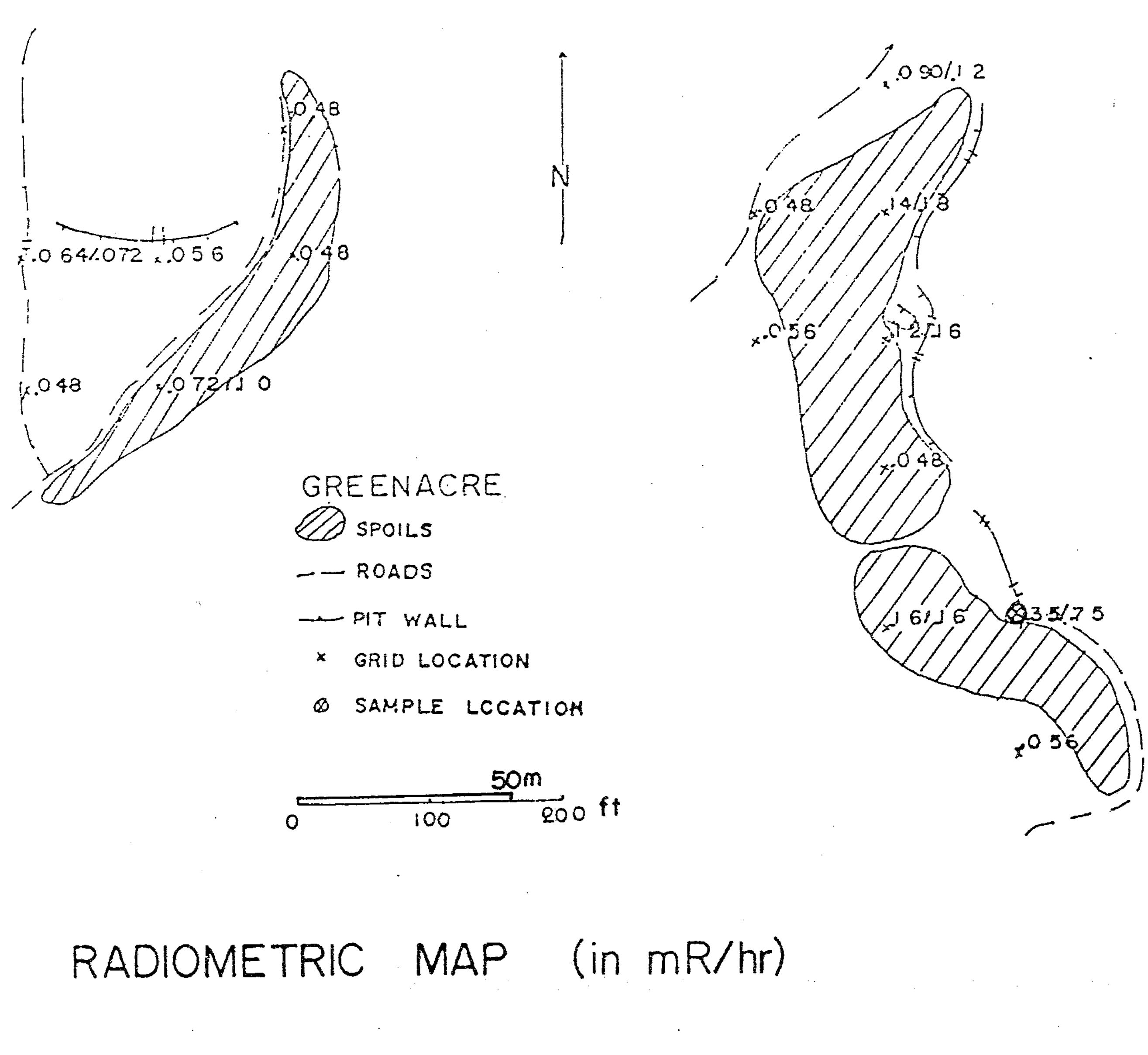
INPUT

(Computer Location)---STO

Total Count/Minute $^{226}Ra \lessgtr^{116}_{81}$ 8171 /10 min.=	817.1	(10)
Background Count/Minute distilled H_2O 2561 /10 min.=	256.1	(11)
Disintegrations/Count factor.................	2.59	(12)
Sample Weight	525 gm.	(13)
Count Time	22 hrs.	(14)
Seal Time	18 hrs.	(15)
Time Change correction factor	0 hr.	(16)
Count Date	13	(17)
Elapsed Time addition factor	31 days	(18)
Seal Date	6	(19)
Total Count/Minute $^{40}K \lessgtr^{77}_{67}$... 7,788	778.8	(22)
Background Count/Minute $^{40}K \lessgtr^{77}_{67}$... 1503	150.3	(23)

OUTPUT

Net Count/Minute	538.9
Net Disintegrations (Net Count x D/C per min.)	1396
Uncorrected ^{226}Ra Concentration (D/min/gm.)...	2.659
Ingrowth Time (T)	38.17 days
$1-e^{(-\lambda \Delta T')}(-\Delta T + 3.823)$	.9995
Corrected ^{226}Ra Concentration	2.660 pCi/gm.



RADIOMETRIC MAP (in mR/hr)

^{226}Radium in Soil

GREENACRE

Sample No. Mine 10

Date Collected ____________

INPUT

(Computer Location)---STO

Total Count/Minute ^{226}Ra $\lessgtr^{116}_{81}$ 425,838 /10 min.= 42,583.8 (10)

Background Count/Minute distilled H_2O 2561 /10 min.= 256.1 (11)

Disintegrations/Count factor 2.59 (12)

Sample Weight .... >600 gm. (13)

Count Time .... 15 hrs. (14)

Seal Time .... 18 hrs. (15)

Time Change correction factor .... 0 hr. (16)

Count Date 13 (17)

Elapsed Time addition factor .... 31 days (18)

Seal Date 6 (19)

Total Count/Minute ^{40}K $\lessgtr^{77}_{67}$ 172,941 .... 17,294.1 (22)

Background Count/Minute ^{40}K $\lessgtr^{77}_{67}$ 1503 .... 150.3 (23)

OUTPUT

Net Count/Minute 42,356

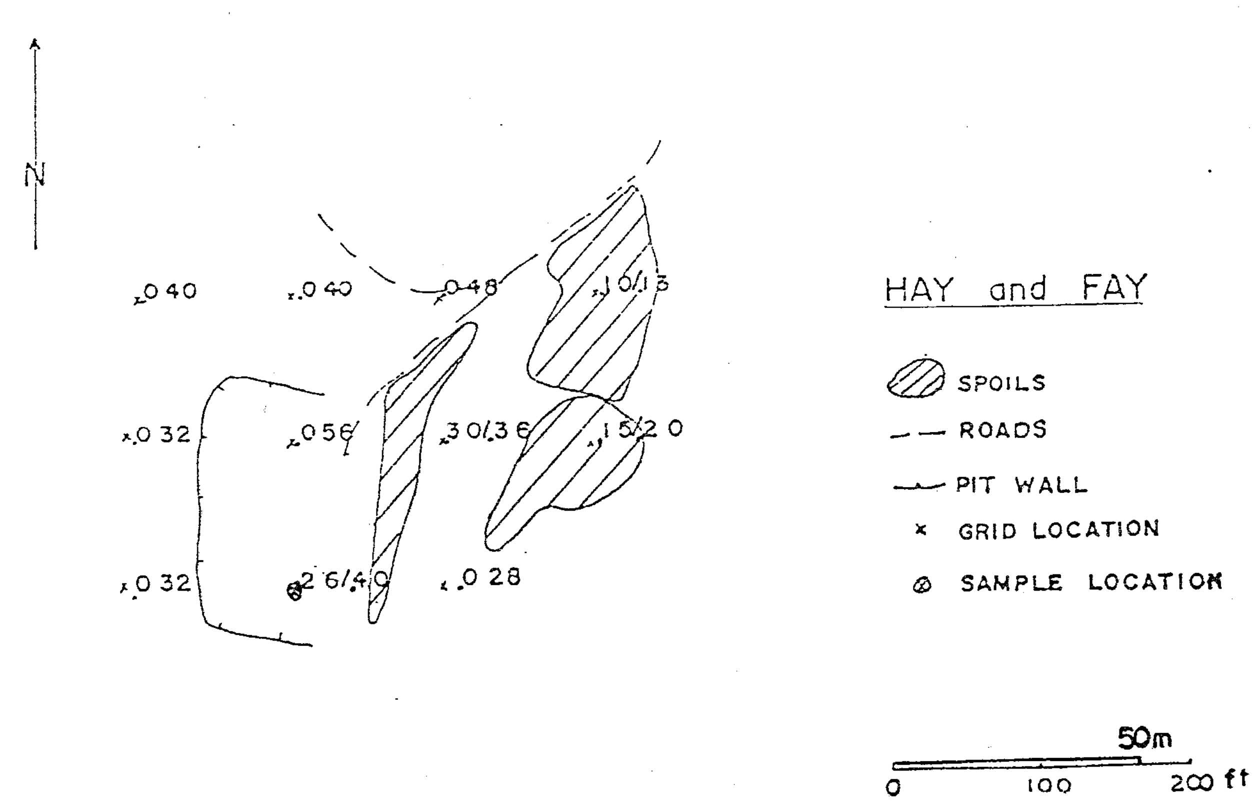
Net Disintegrations (Net Count x D/C per min.) 109,705

Uncorrected ^{226}Ra Concentration (D/min/gm.)... 182.8

Ingrowth Time (T) .... 37.88 days

$1-e^{(-\lambda \Delta T')}(-\Delta T + 3.823)$ .... .9994

Corrected ^{226}Ra Concentration .... < 182.9 pCi/gm.



RADIOMETRIC MAP (in mR/hr)

^{226}Radium in Soil

HAY & FAY

Sample No. Mine 12

Date Collected

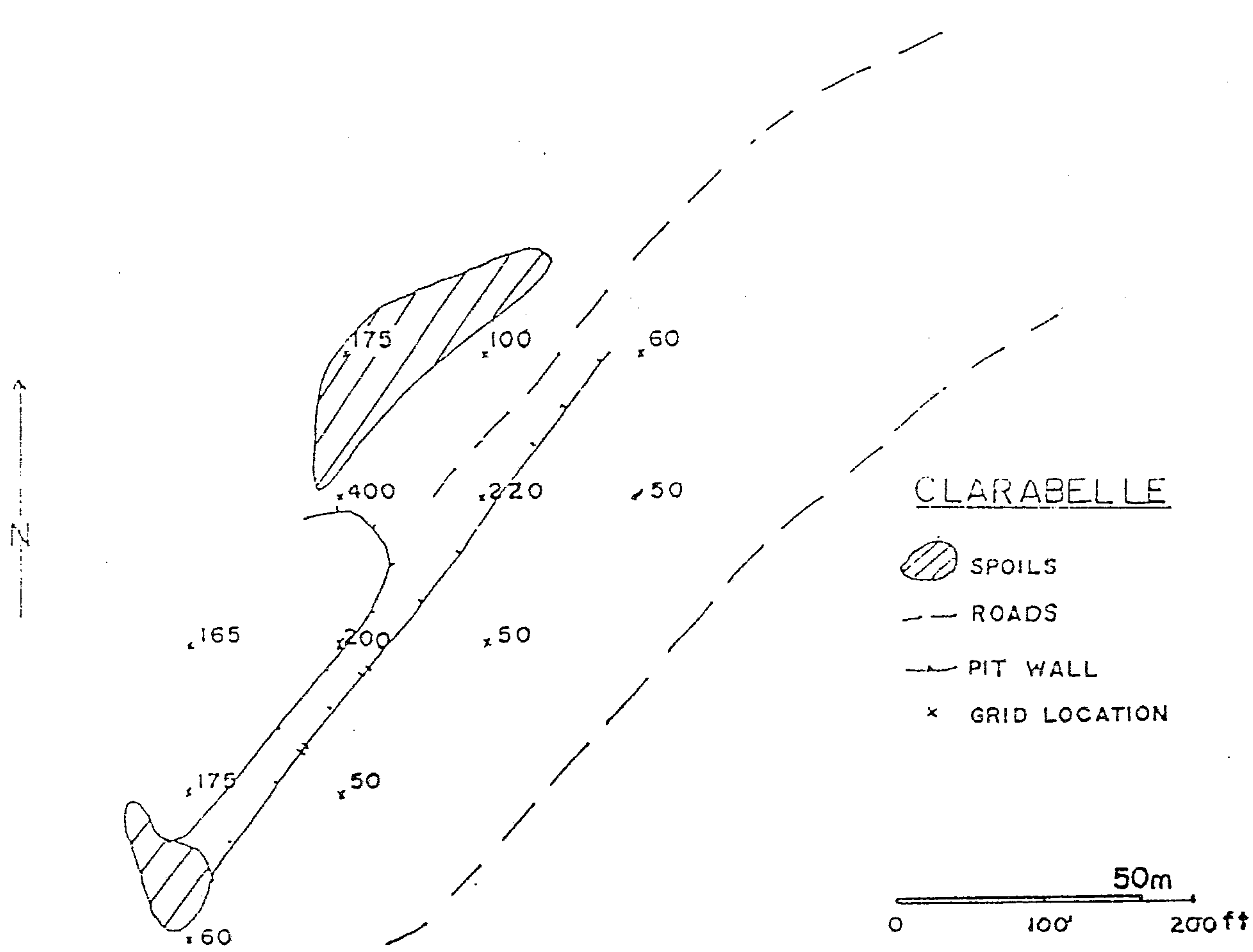
INPUT

(Computer Location)---STO

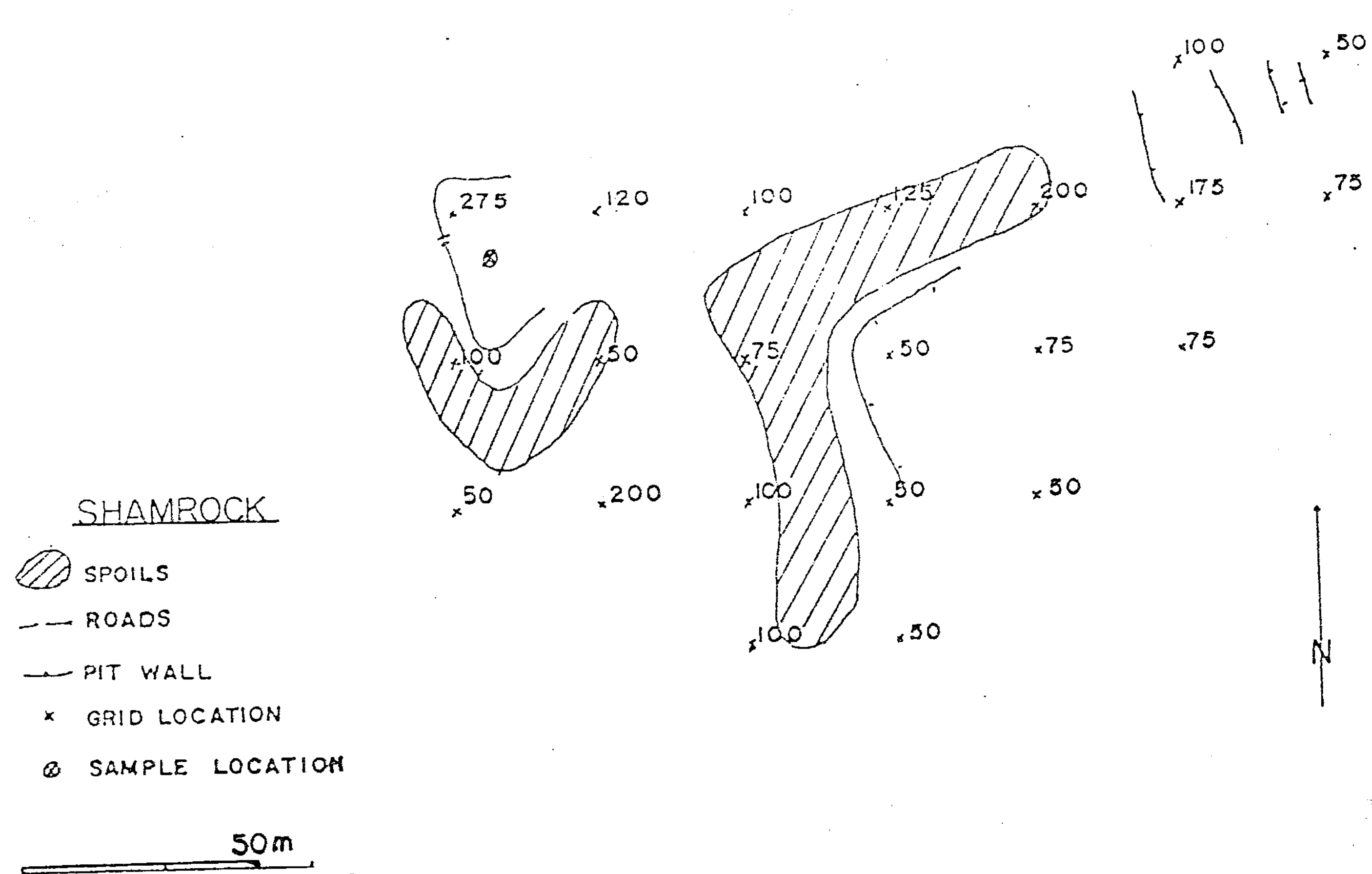
Total Count/Minute ^{226}Ra <116 <81 615,010 /10 min.=	61501.1	(10)
Background Count/Minute distilled H_2O 2561 /10 min.=	256.1	(11)
Disintegrations/Count factor..................	2.59	(12)
Sample Weight	>600 gm.	(13)
Count Time	15 hrs.	(14)
Seal Time	18 hrs.	(15)
Time Change correction factor	0 hr.	(16)
Count Date	13	(17)
Elapsed Time addition factor	31 days	(18)
Seal Date	6	(19)
Total Count/Minute ^{40}K <77 <67 ... 246,085	24,608.5	(22)
Background Count/Minute ^{40}K <77 <67 .. 1503	150.3	(23)

OUTPUT

Net Count/Minute	61,306	
Net Disintegrations (Net Count x D/C per min.)	158,784	
Uncorrected ^{226}Ra Concentration (D/min/gm.)...	264.6	
Ingrowth Time (T)	37.88	days
$1-e^{(-\lambda \Delta T')}(-\Delta T + 3.823)$	.9995	
Corrected ^{226}Ra Concentration	< 264.8	pCi/gm.



RADIOMETRIC MAP (in counts per minute)



RADIOMETRIC MAP (in counts per minute)

^{226}Radium in Soil

Sample No. SHAMROCK Mine 15

Date Collected________

INPUT

(Computer Location)---STO

Total Count/Minute ^{226}Ra $\leq^{116}_{81}$ 333,652 /10 min.= 33,65.2 (10)

Background Count/Minute distilled H_2O 2117 /10 min.=211.7(11)

Disintegrations/Count factor.................. 2.62 (12)

Sample Weight .... >600 gm.(13)

Count Time .... 17 hrs.(14)

Seal Time .... 18 hrs.(15)

Time Change correction factor .... 0 hr.(16)

Count Date 17 (17)

Elapsed Time addition factor .... 31 days(18)

Seal Date 6 (19)

Total Count/Minute ^{40}K $\leq^{77}_{67}$...138,140......... 13,814.0 (22)

Background Count/Minute ^{40}K $\leq^{77}_{67}$ 1241............ 124.1 (23)

OUTPUT

Net Count/Minute .... 33162.

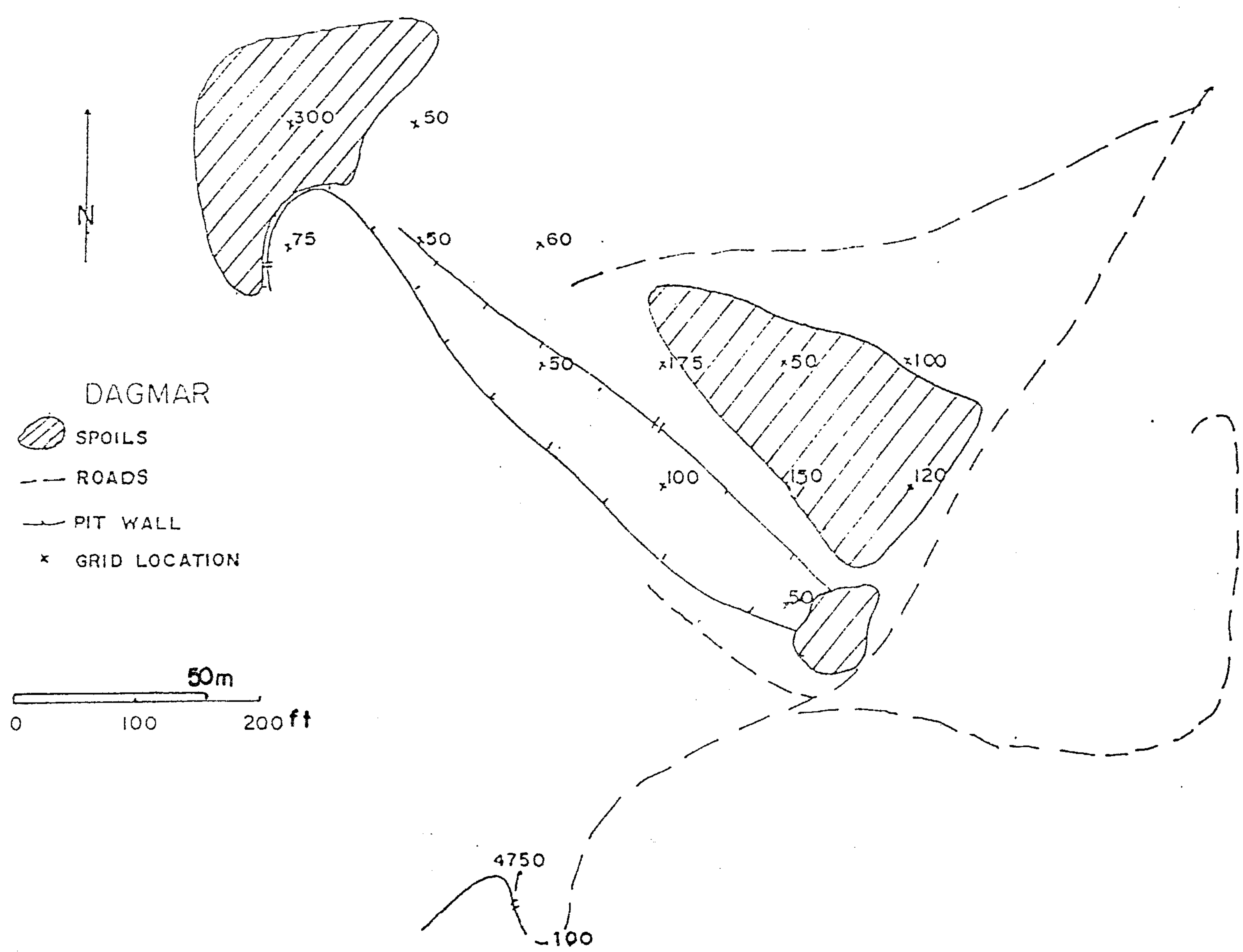
Net Disintegrations (Net Count x D/C per min.) 86884.

Uncorrected ^{226}Ra Concentration (D/min/gm.)... 144.8

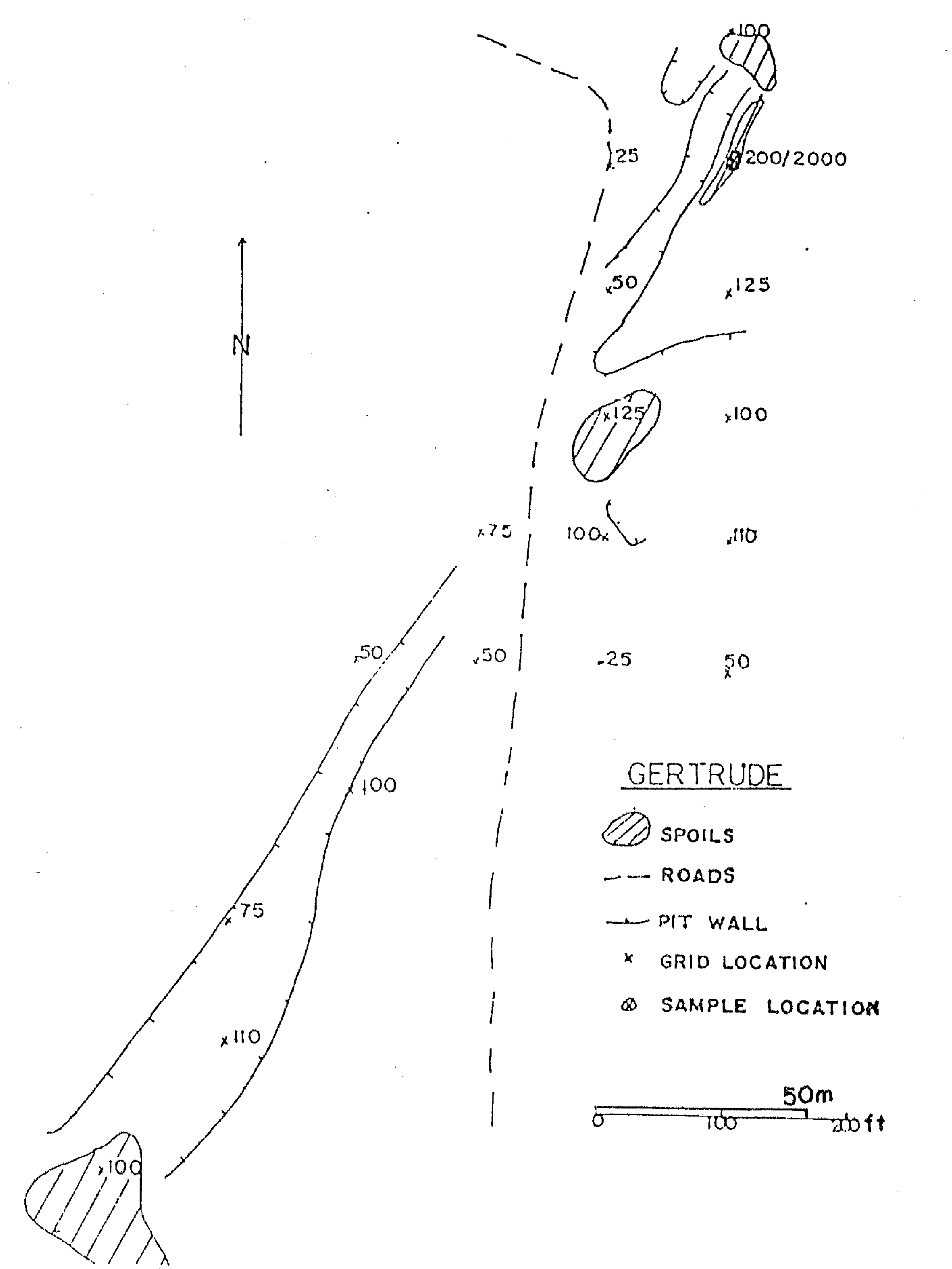
Ingrowth Time (T) .... 41.96 days

1-e $^{(-\lambda \Delta T')}$(-ΔT ÷ 3.823) .... .9998

Corrected ^{226}Ra Concentration .... 144.8 pCi/gm.



RADIOMETRIC MAP (in counts per minute)



RADIOMETRIC MAP (in counts per minute)

^{226}Radium in Soil

GERTRUDE

Sample No. Mine 17

Date Collected ______

INPUT

(Computer Location)---STO

Total Count/Minute ^{226}Ra $\sum_{81}^{116}$ 2,461,261/10 min.= 246,126.1(10)

Background Count/Minute distilled H_2O 2117 /10 min.=211.7 (11)

Disintegrations/Count factor.................. 2.62 (12)

Sample Weight .... >600 gm.(13)

Count Time .... 17 hrs.(14)

Seal Time .... 18 hrs.(15)

Time Change correction factor .... 0 hr.(16)

Count Date 17 (17)

Elapsed Time addition factor .... 31 days(18)

Seal Date 6 (19)

Total Count/Minute ^{40}K $\sum_{67}^{77}$ 985078 .... 98507.8 (22)

Background Count/Minute ^{40}K $\sum_{67}^{77}$ 1241 .... 124.1 (23)

OUTPUT

Net Count/Minute 246152

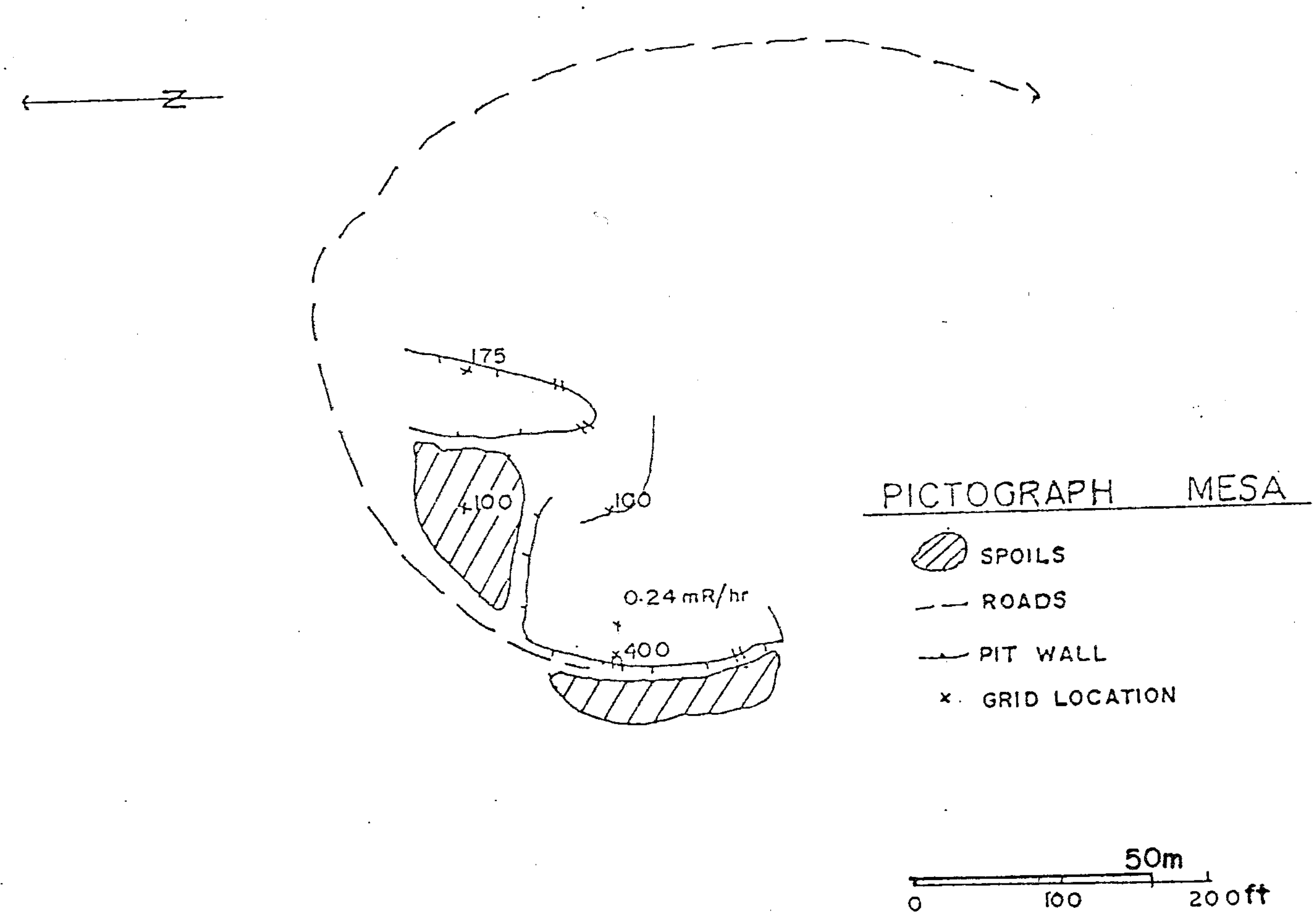
Net Disintegrations (Net Count x D/C per min.) 644919

Uncorrected ^{226}Ra Concentration (D/min/gm.)... 1075

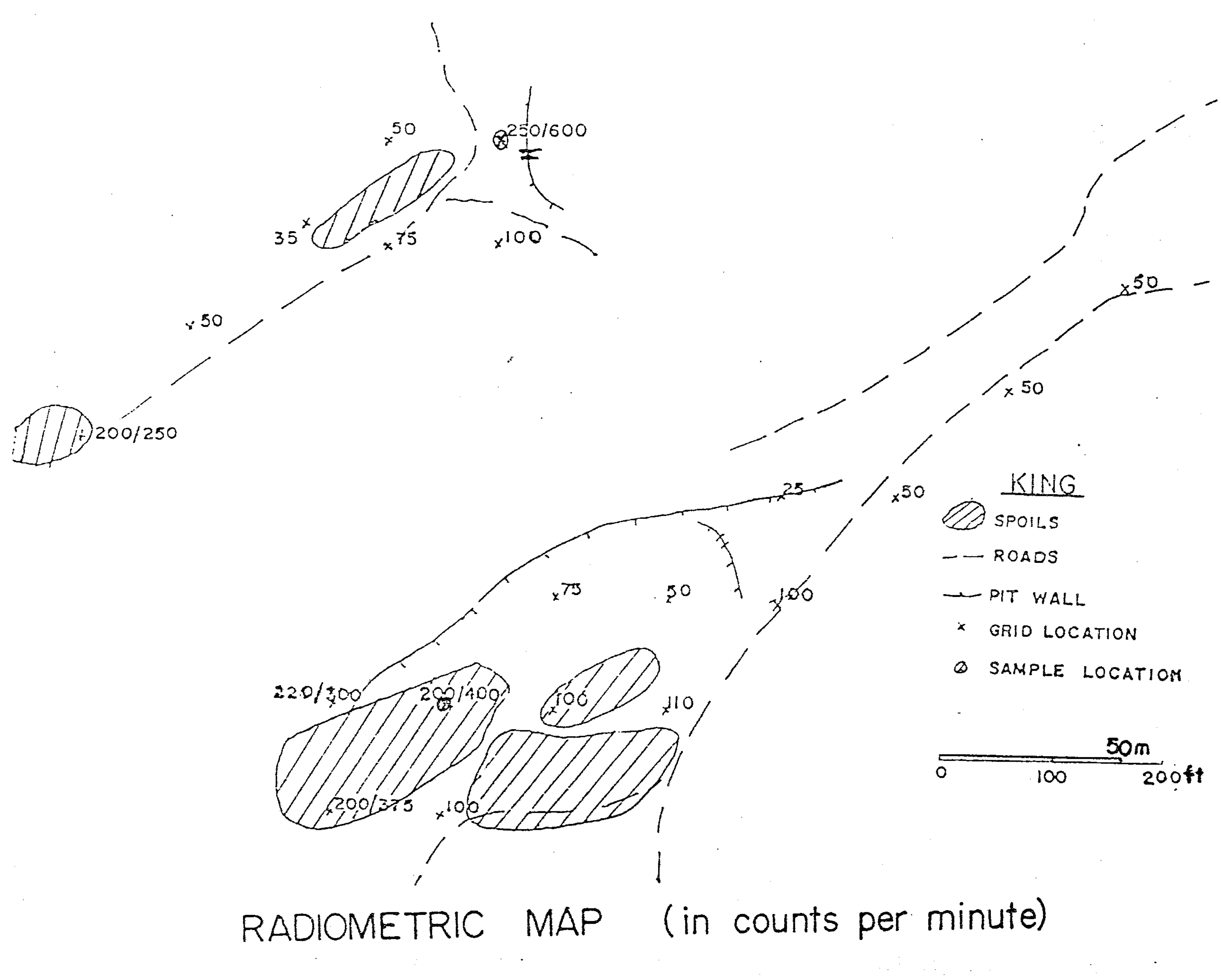
Ingrowth Time (T) .... 41.96 days

1-e $^{(-\lambda\Delta T')}$(-ΔT + 3.823) .... .9998

Corrected ^{226}Ra Concentration .... 1075. pCi/gm.



RADIOMETRIC MAP (in counts per minute)



RADIOMETRIC MAP (in counts per minute)

^{226}Radium in Soil

KING

Sample No. Mine 20

Date Collected ______

INPUT

(Computer Location)---STO

Total Count/Minute ^{226}Ra Σ_{81}^{116} 225,372 /10 min.=22,537.2 (10)

Background Count/Minute distilled H_2O 2117 /10 min.= 211.7 (11)

Disintegrations/Count factor................ 2.62 (12)

Sample Weight .... >600 gm.(13)

Count Time .... 17 hrs.(14)

Seal Time .... 17.5 hrs.(15)

Time Change correction factor .... 0 hr.(16)

Count Date 17 (17)

Elapsed Time addition factor .... 31 days(18)

Seal Date 6 (19)

Total Count/Minute ^{40}K Σ_{67}^{77}... 92098 .... 9209.8 (22)

Background Count/Minute ^{40}K Σ_{67}^{77}... 1241 .... 124.1 (23)

OUTPUT

Net Count/Minute .... 22,339.

Net Disintegrations (Net Count x D/C per min.) 58,527.

Uncorrected ^{226}Ra Concentration (D/min/gm.)... 97.54

Ingrowth Time (T) .... 41.96 days

$1-e^{(-\lambda\Delta T')}(-\Delta T + 3.823)$ .... .9998

Corrected ^{226}Ra Concentration .... 97.57 pCi/gm.

^{226}Radium in Soil

KING

Sample No. Mine 20.5

Date Collected ________

INPUT

(Computer Location)---STO

Total Count/Minute ^{226}Ra $\lessgtr^{116}_{81}$ 289,507 /10 min.=28950.7 (10)

Background Count/Minute distilled H_2O 2066 /10 min.=206.6 (11)

Disintegrations/Count factor.................. 2.64 (12)

Sample Weight .... >600 gm. (13)

Count Time .... 15 hrs. (14)

Seal Time .... 18 hrs. (15)

Time Change correction factor .... 0 hr. (16)

Count Date 16 (17)

Elapsed Time addition factor .... 31 days (18)

Seal Date 6 (19)

Total Count/Minute ^{40}K $\lessgtr^{77}_{67}$ 120,616 .... 12061.6 (22)

Background Count/Minute ^{40}K $\lessgtr^{77}_{67}$ 1278 ...... 127.8 (23)

OUTPUT

Net Count/Minute 28,747

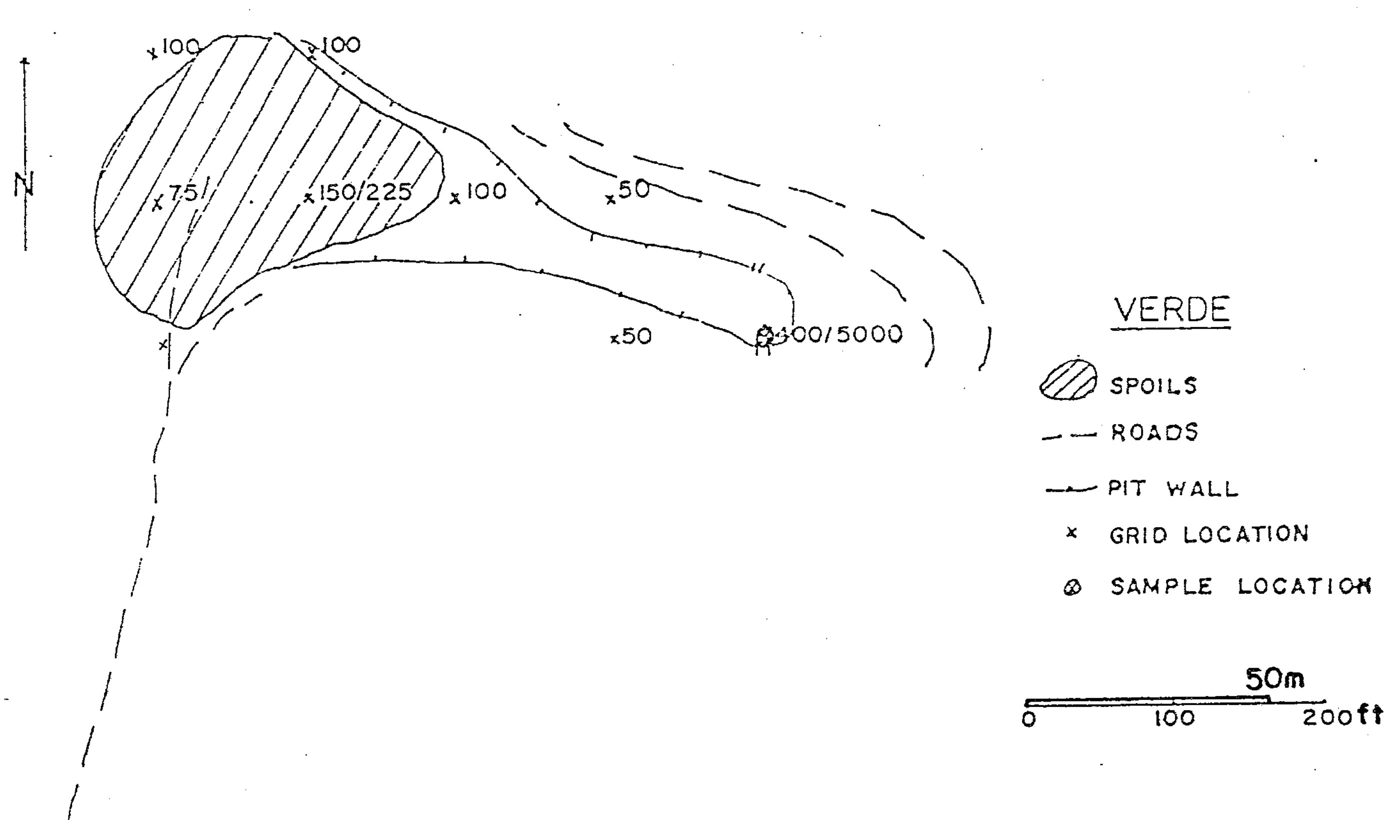
Net Disintegrations (Net Count x D/C per min.) 75,894

Uncorrected ^{226}Ra Concentration (D/min/gm.)... 126.5

Ingrowth Time (T) .... 40.92 days

$1-e^{(-\lambda\Delta T')}(-\Delta T + 3.823)$ .... .9997

Corrected ^{226}Ra Concentration .... 126.5 pCi/gm.



RADIOMETRIC MAP (in counts per minute)

^{226}Radium in Soil

Sample No. Mine VERDE 23

Date Collected __________

INPUT

(Computer Location)---STO

Total Count/Minute ^{226}Ra $\leq^{116}_{81}$ 1,408,599 /10 min.= 140,859.9(10)

Background Count/Minute distilled H_2O 2117 /10 min.= 211.7(11)

Disintegrations/Count factor.................. 2.62 (12)

Sample Weight .... 7600 gm.(13)

Count Time .... 17 hrs.(14)

Seal Time .... 18 hrs.(15)

Time Change correction factor .... 0 hr.(16)

Count Date 17 (17)

Elapsed Time addition factor .... 31 days(18)

Seal Date 6 (19)

Total Count/Minute ^{40}K $\leq^{77}_{67}$..... 568045 .... 56804.5 (22)

Background Count/Minute ^{40}K $\leq^{77}_{67}$ 1241 .... 124.1 (23)

OUTPUT

Net Count/Minute .... 140761.

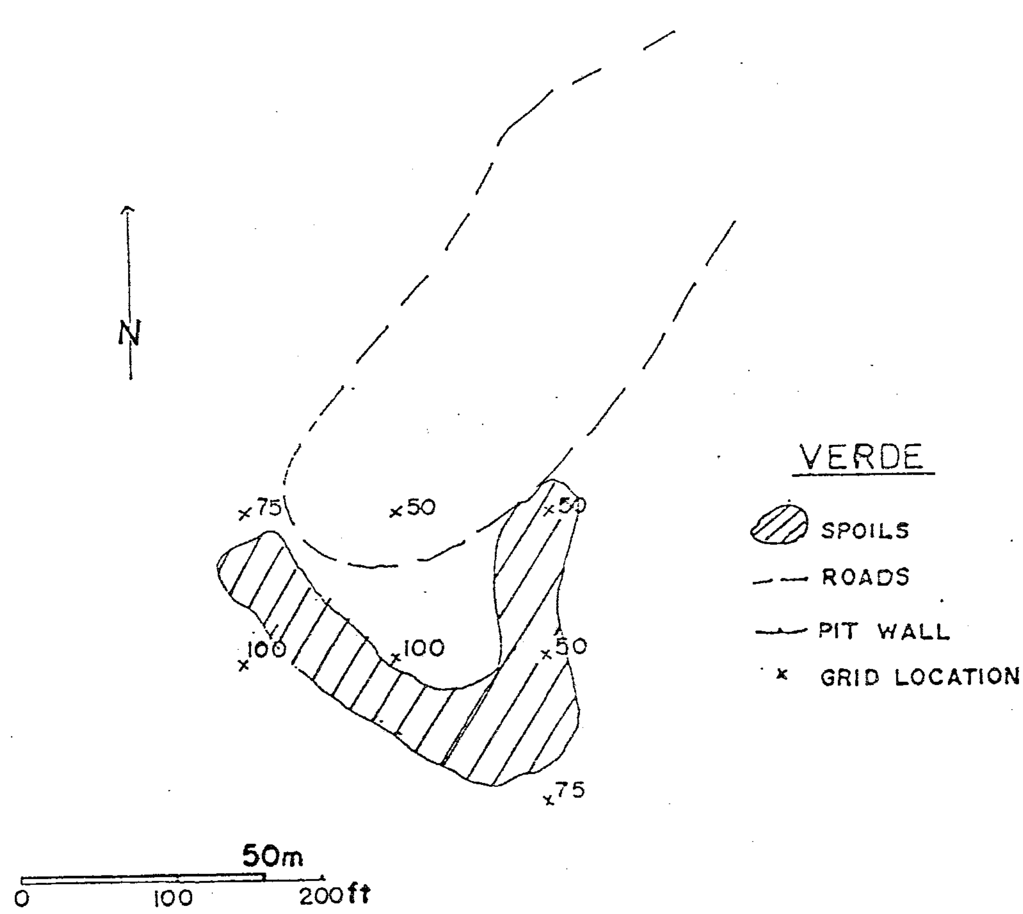
Net Disintegrations (Net Count x D/C per min.) 368795.

Uncorrected ^{226}Ra Concentration (D/min/gm.)... 614.7

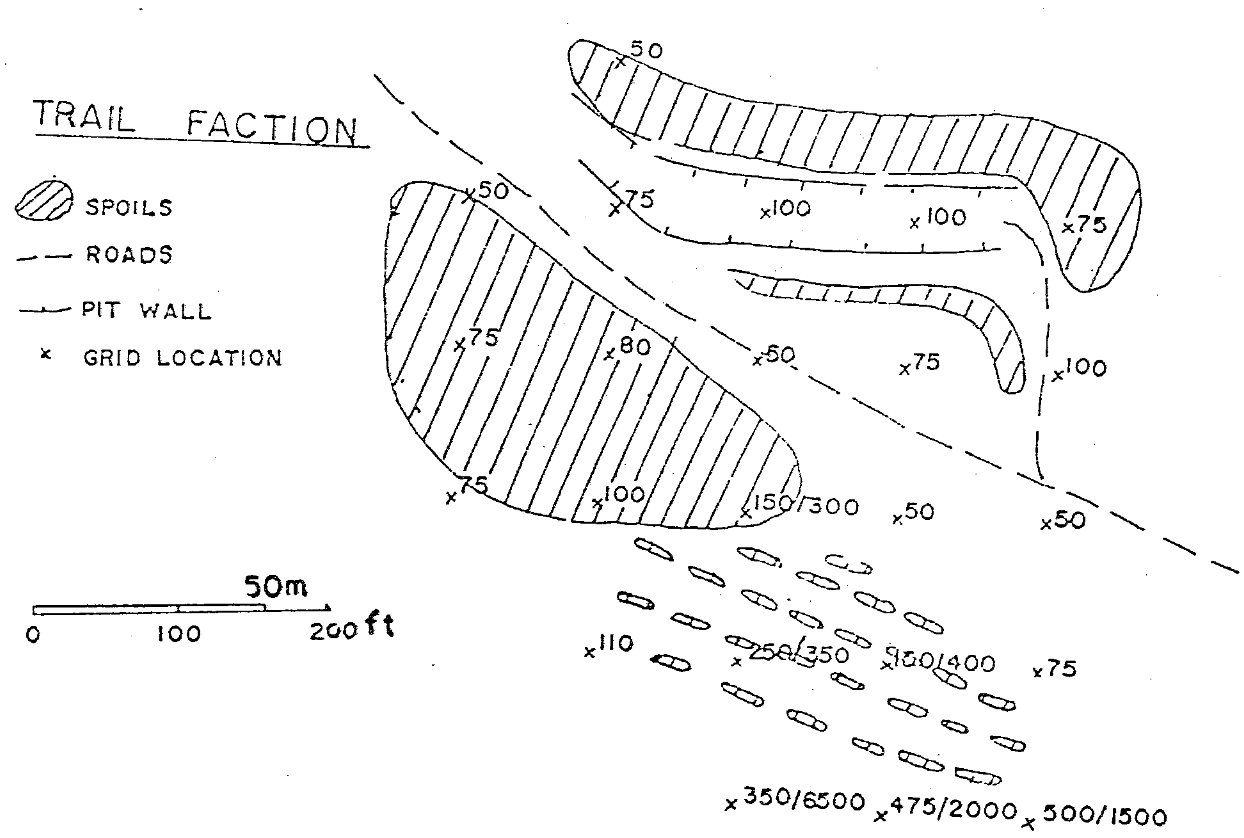
Ingrowth Time (T) .... 41.96 days

$1-e^{(-\lambda \Delta T')}(-\Delta T + 3.823)$ .... .9998

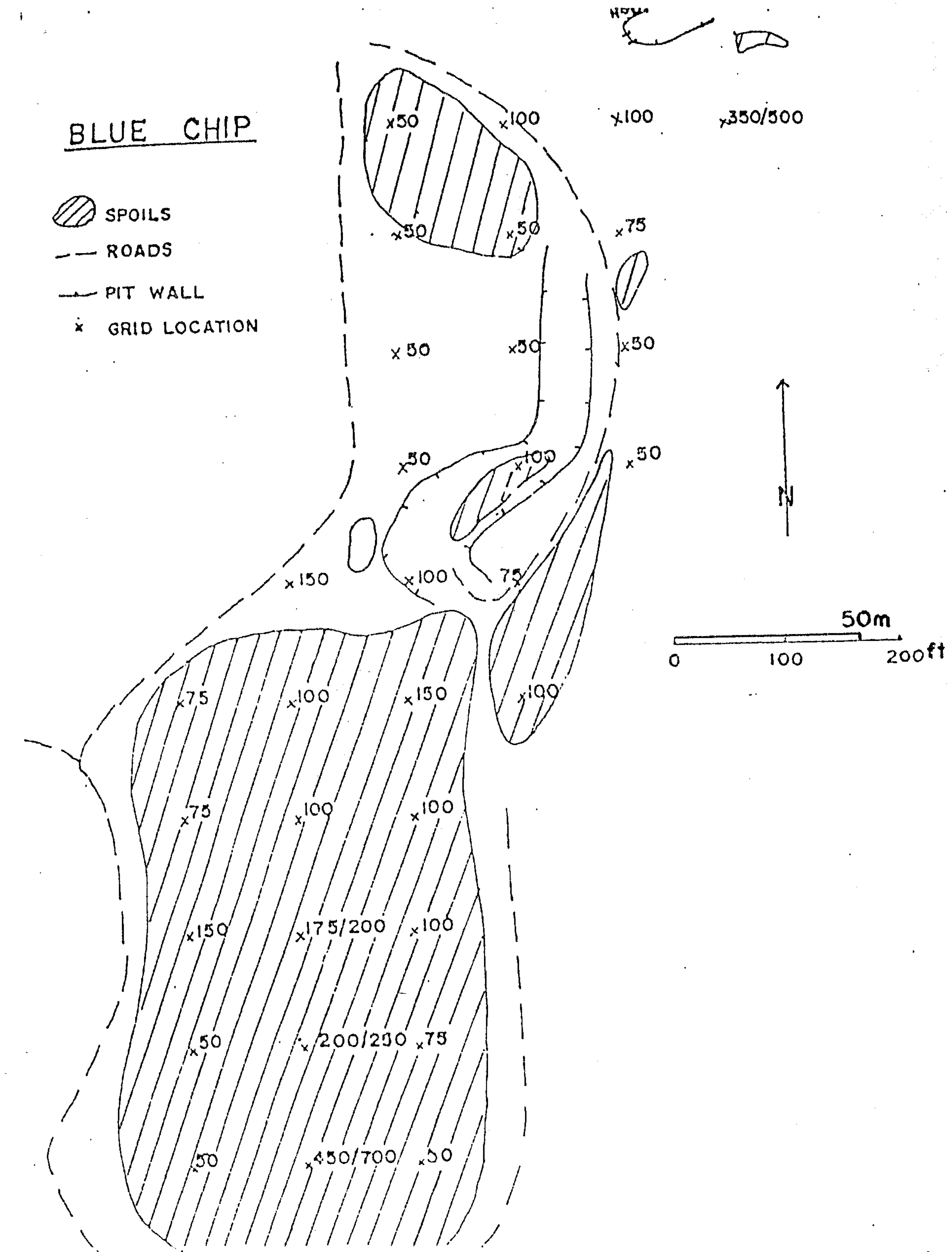
Corrected ^{226}Ra Concentration .... 614.8 pCi/gm.



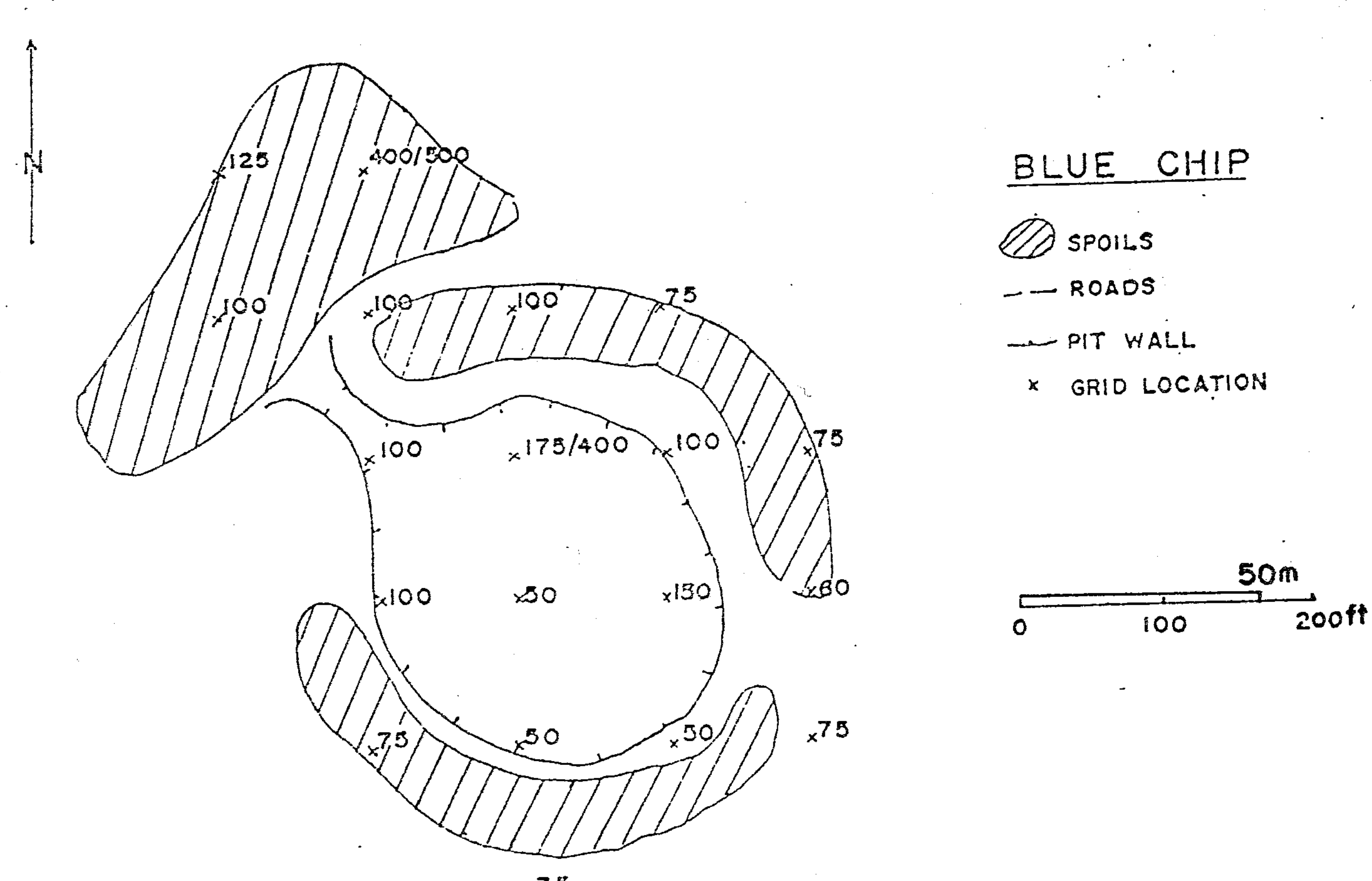
RADIOMETRIC MAP (in counts per minute)



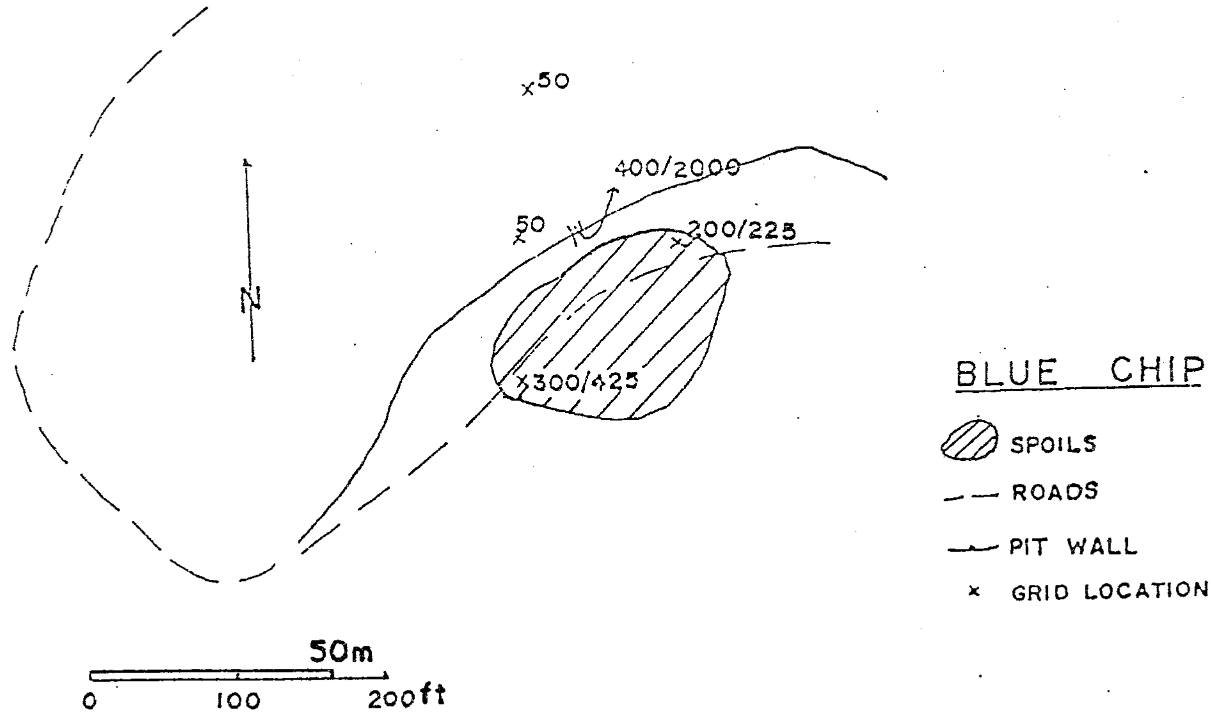
RADIOMETRIC MAP (in counts per minute)



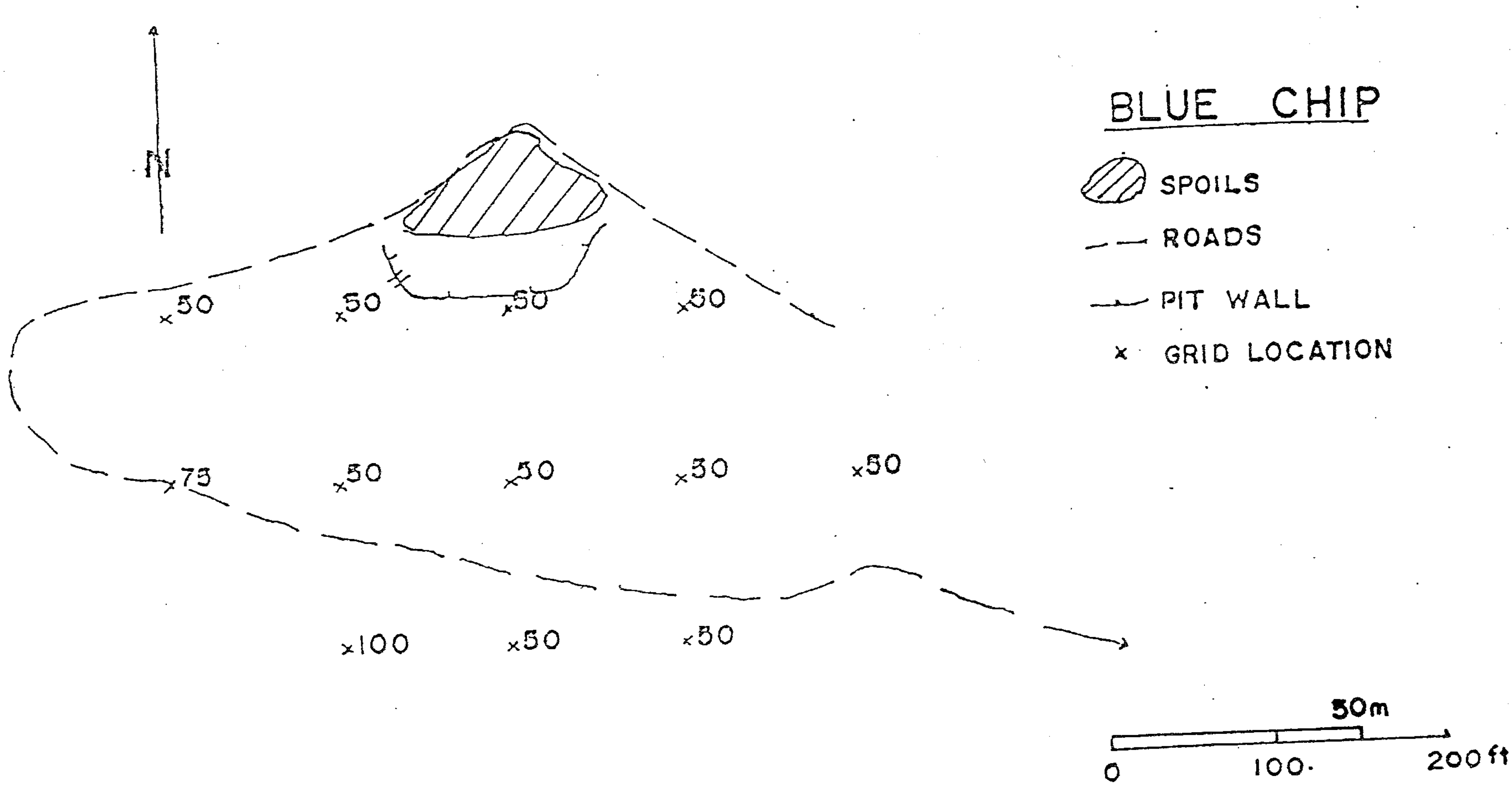
RADIOMETRIC MAP (in counts per minute)



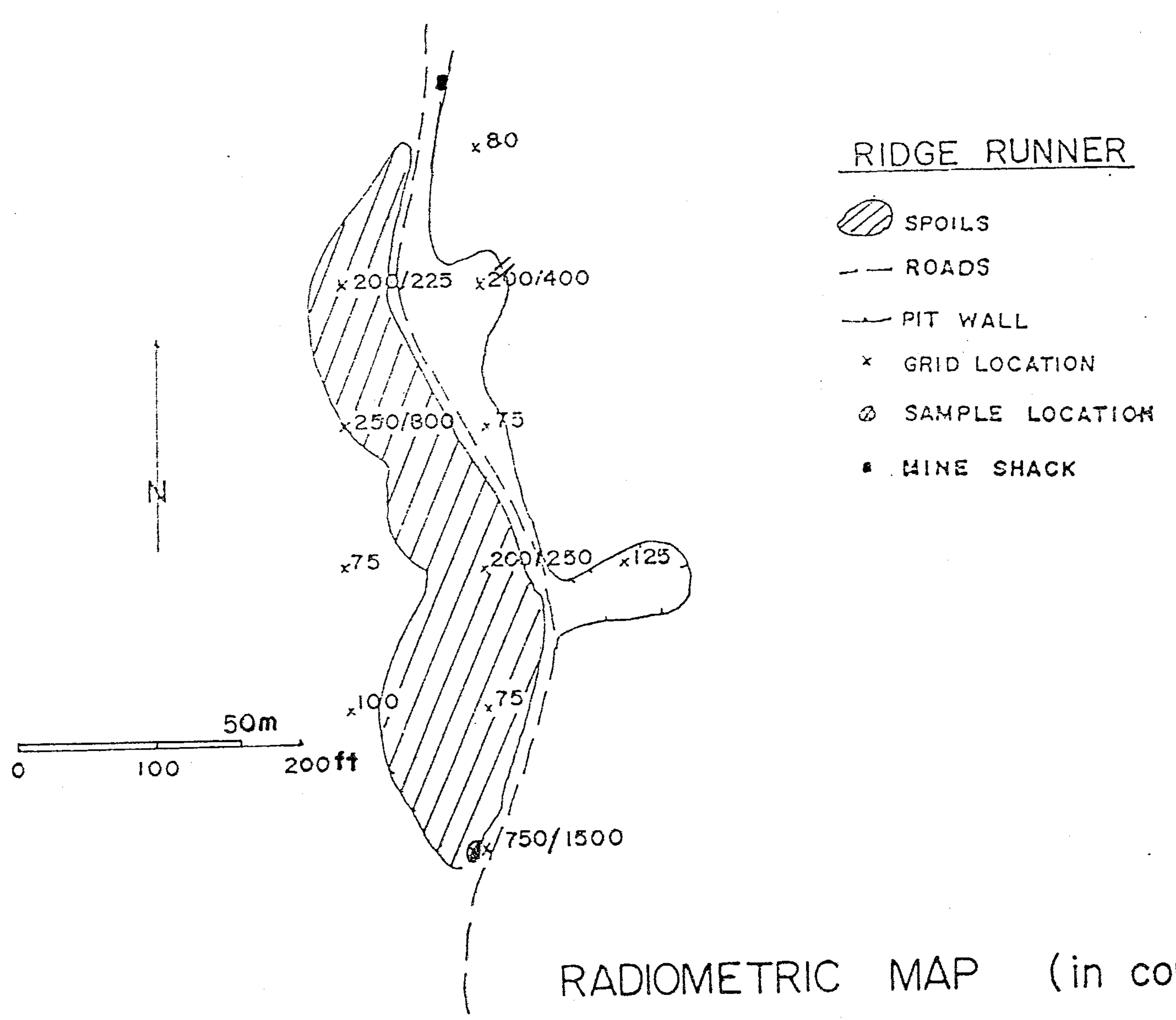
RADIOMETRIC MAP (in counts per minute)



RADIOMETRIC MAP (in counts per minute)



RADIOMETRIC MAP (in counts per minute)



RADIOMETRIC MAP (in counts per minute)

^{226}Radium in Soil RIDGE RUNNER

Sample No. Mine 33

Date Collected ____

INPUT

(Computer Location)---STO

Total Count/Minute ^{226}Ra $\sum_{81}^{116}$ 817,153 /10 min.= 81,715.3 (10)

Background Count/Minute distilled H_2O 2561 /10 min.= 256.1 (11)

Disintegrations/Count factor 2.59 (12)

Sample Weight .... 592 gm. (13)

Count Time .... 14 hrs. (14)

Seal Time .... 17.5 hrs. (15)

Time Change correction factor .... 0 hr. (16)

Count Date 13 (17)

Elapsed Time addition factor .... 31 days (18)

Seal Date 6 (19)

Total Count/Minute ^{40}K $\sum_{67}^{77}$ 292,402 .... 29,240.2 (22)

Background Count/Minute ^{40}K $\sum_{67}^{77}$ 1503 .... 150.3 (23)

OUTPUT

Net Count/Minute 81,733

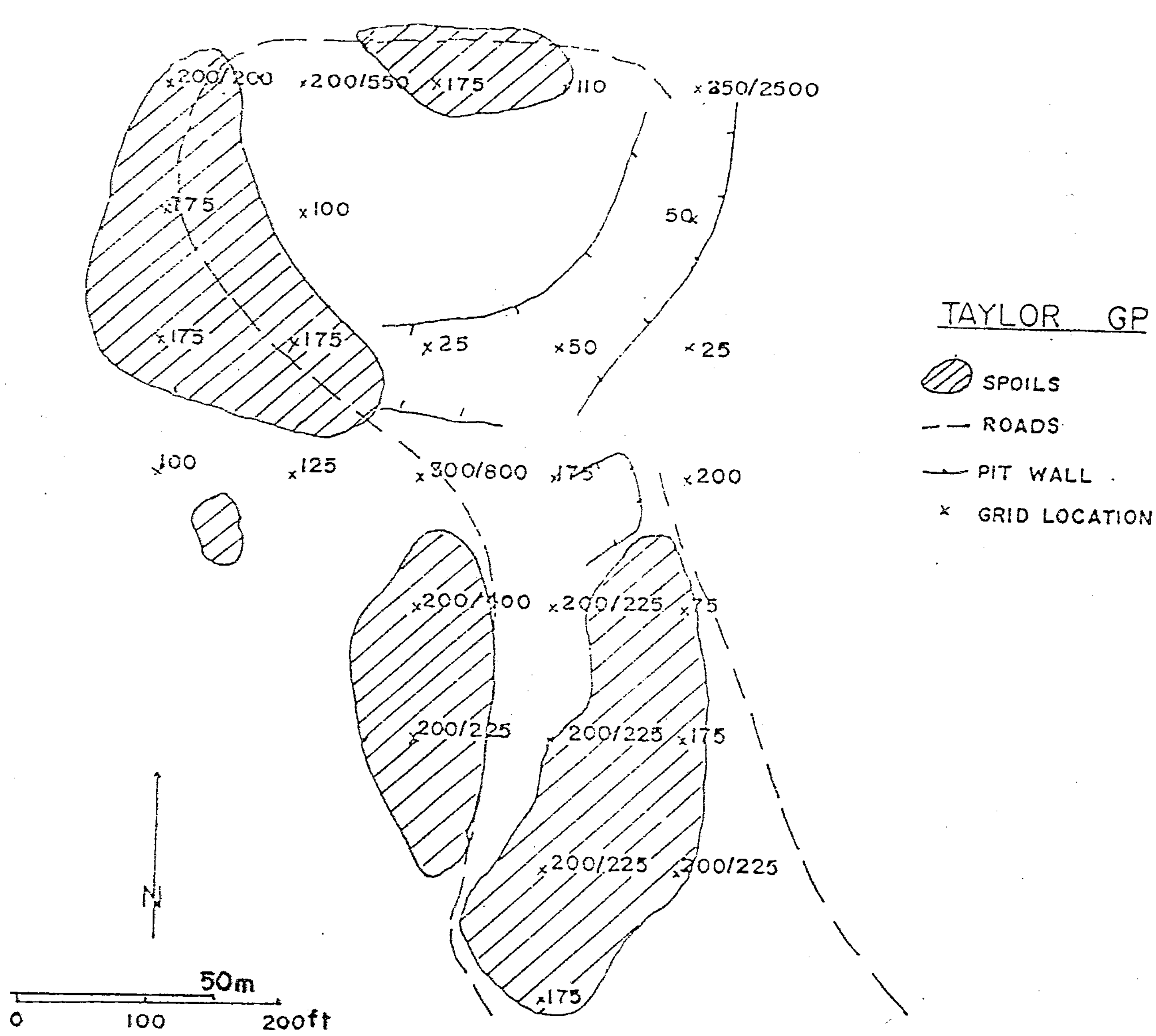
Net Disintegrations (Net Count x D/C per min.) 211,690

Uncorrected ^{226}Ra Concentration (D/min/gm.)... 357.6

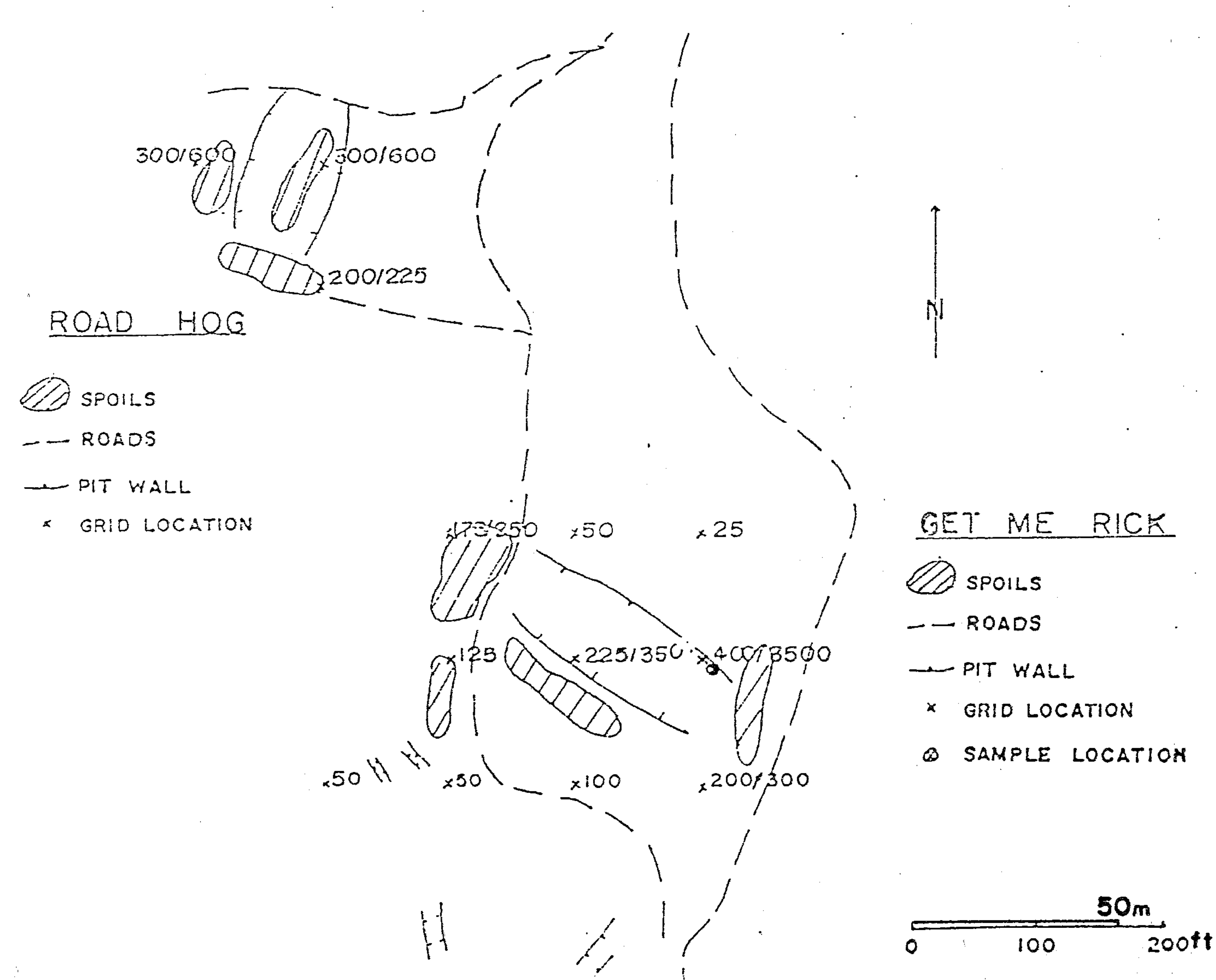
Ingrowth Time (T) .... 37.84 days

$1-e^{(-\lambda\Delta T')}(-\Delta T + 3.823)$ .... .9995

Corrected ^{226}Ra Concentration .... 357.8 pCi/gm.



RADIOMETRIC MAP (in counts per minute)



RADIOMETRIC MAP (in counts per minute)

^{226}Radium in Soil

GET ME RICK

Sample No. Mine 27

Date Collected ____________

INPUT

(Computer Location)---STO

Total Count/Minute ^{226}Ra $\lessgtr^{116}_{81}$ ~~713,017~~ /10 min.= 71,301.7 (10)

Background Count/Minute distilled H_2O 2561 /10 min.= 256.1 (11)

Disintegrations/Count factor.................. 2.59 (12)

Sample Weight .... 588 gm. (13)

Count Time .... 15 hrs. (14)

Seal Time .... 17.5 hrs. (15)

Time Change correction factor .... 0 hr. (16)

Count Date 13 (17)

Elapsed Time addition factor .... 31 days (18)

Seal Date 6 (19)

Total Count/Minute ^{40}K $\lessgtr^{77}_{67}$ 280,478 .... 28,047.8 (22)

Background Count/Minute ^{40}K $\lessgtr^{77}_{67}$ 1503 .... 150.3 (23)

OUTPUT

Net Count/Minute 71,144

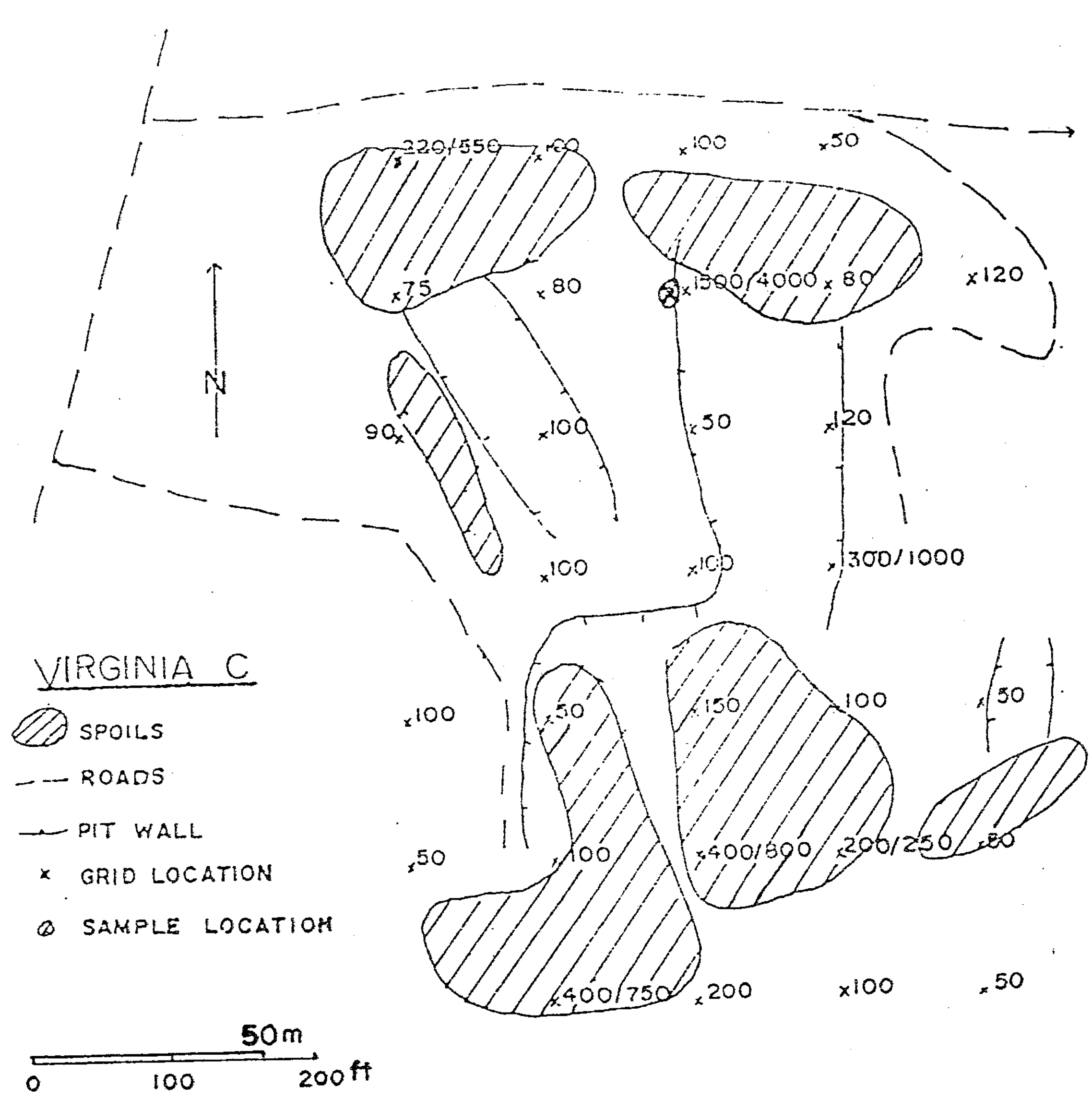
Net Disintegrations (Net Count x D/C per min.) 184,262

Uncorrected ^{226}Ra Concentration (D/min/gm.)... 313.4

Ingrowth Time (T) .... 37.88 days

$1-e^{(-\lambda \Delta T')}(-\Delta T + 3.823)$ .... .9995

Corrected ^{226}Ra Concentration .... 313.5 pCi/gm.



RADIOMETRIC MAP (in counts per minute)

^{226}Radium in Soil

VIRGINIA C

Sample No. Mine 25

Date Collected ______

INPUT

(Computer Location)---STO

Total Count/Minute ^{226}Ra $<^{116}_{81}$ 3,723,485 /10 min.= 372,348.5 (10)

Background Count/Minute distilled H_2O 2561 /10 min.= 256.1 (11)

Disintegrations/Count factor 2.59 (12)

Sample Weight .... 588 gm. (13)

Count Time 15hrs. (14)

Seal Time 18hrs. (15)

Time Change correction factor .... 0 hr. (16)

Count Date 13 (17)

Elapsed Time addition factor .... 31 days (18)

Seal Date 6 (19)

Total Count/Minute ^{40}K $<^{77}_{67}$ 1442115 .... 144,211.5 (22)

Background Count/Minute ^{40}K $<^{77}_{67}$ 1503 .... 150.3 (23)

OUTPUT

Net Count/Minute .... 372720.

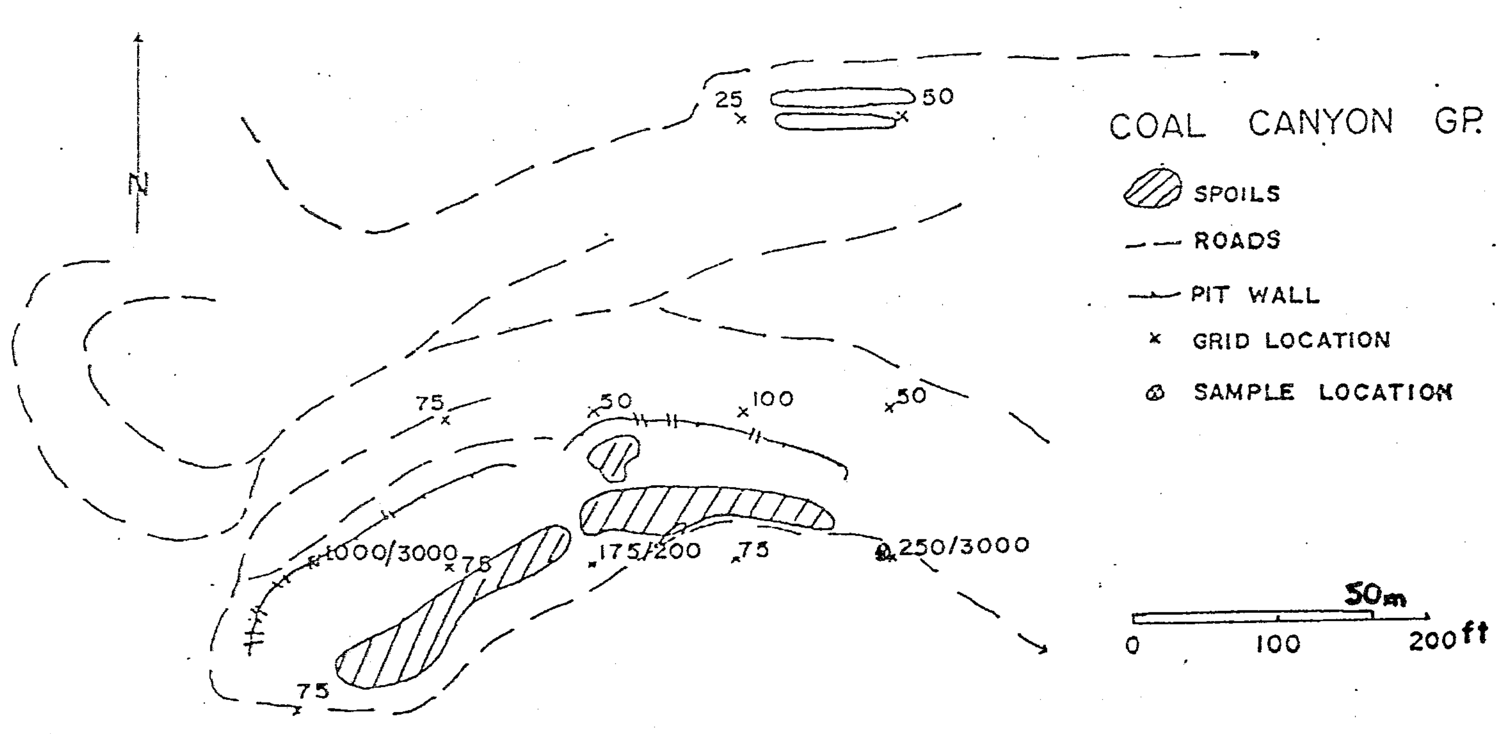
Net Disintegrations (Net Count x D/C per min.) 965346.

Uncorrected ^{226}Ra Concentration (D/min/gm.)... 1641.

Ingrowth Time (T) .... 37.88 days

1-e $^{(-\lambda \Delta T')}$(-ΔT + 3.823) .... .9995

Corrected ^{226}Ra Concentration .... 1643. pCi/gm.



RADIOMETRIC MAP (in counts per minute)

^{226}Radium in Soil

COAL CANYON

Sample No. Mine 30

Date Collected ______

INPUT

(Computer Location)---STO

Total Count/Minute ^{226}Ra $\leq^{116}_{81}$ 1,408,759 /10 min.= 140,875.9 (10)

Background Count/Minute distilled H_2O 2066 /10 min.= 206.6 (11)

Disintegrations/Count factor.................. 2.64 (12)

Sample Weight .... >600 gm. (13)

Count Time .... 16 hrs. (14)

Seal Time .... 18 hrs. (15)

Time Change correction factor .... 0 hr. (16)

Count Date 16 (17)

Elapsed Time addition factor .... 31 days (18)

Seal Date 6 (19)

Total Count/Minute ^{40}K $\leq^{77}_{67}$ 555,803 .... 55,580.3 (22)

Background Count/Minute ^{40}K $\leq^{77}_{67}$ 1278 .... 127.8 (23)

OUTPUT

Net Count/Minute 140,851

Net Disintegrations (Net Count x D/C per min.) 371,848

Uncorrected ^{226}Ra Concentration (D/min/gm.)... 619.7

Ingrowth Time (T) .... 40.92 days

$1-e^{(-\lambda \Delta T')}(-\Delta T + 3.823)$ .... .9997

Corrected ^{226}Ra Concentration .... 619.9 pCi/gm.

VITA Rowland L. Hall
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(605) 343-5583

Personal Background

Born: Chadron, Nebraska, November 15, 1952
Marital Status: Married, no children

Education

B.A. - (Earth Science & Biology) - Chadron State College Chadron, Nebraska, 1980.

M.S. - (Geology) - South Dakota School of Mines and Technology, Rapid City, South Dakota, 1982.

Honors

Beta Beta Beta - Biology Honorary Fraternity
Sigma Gamma Epsilon - Earth Science Honorary Fraternity

Work Experience

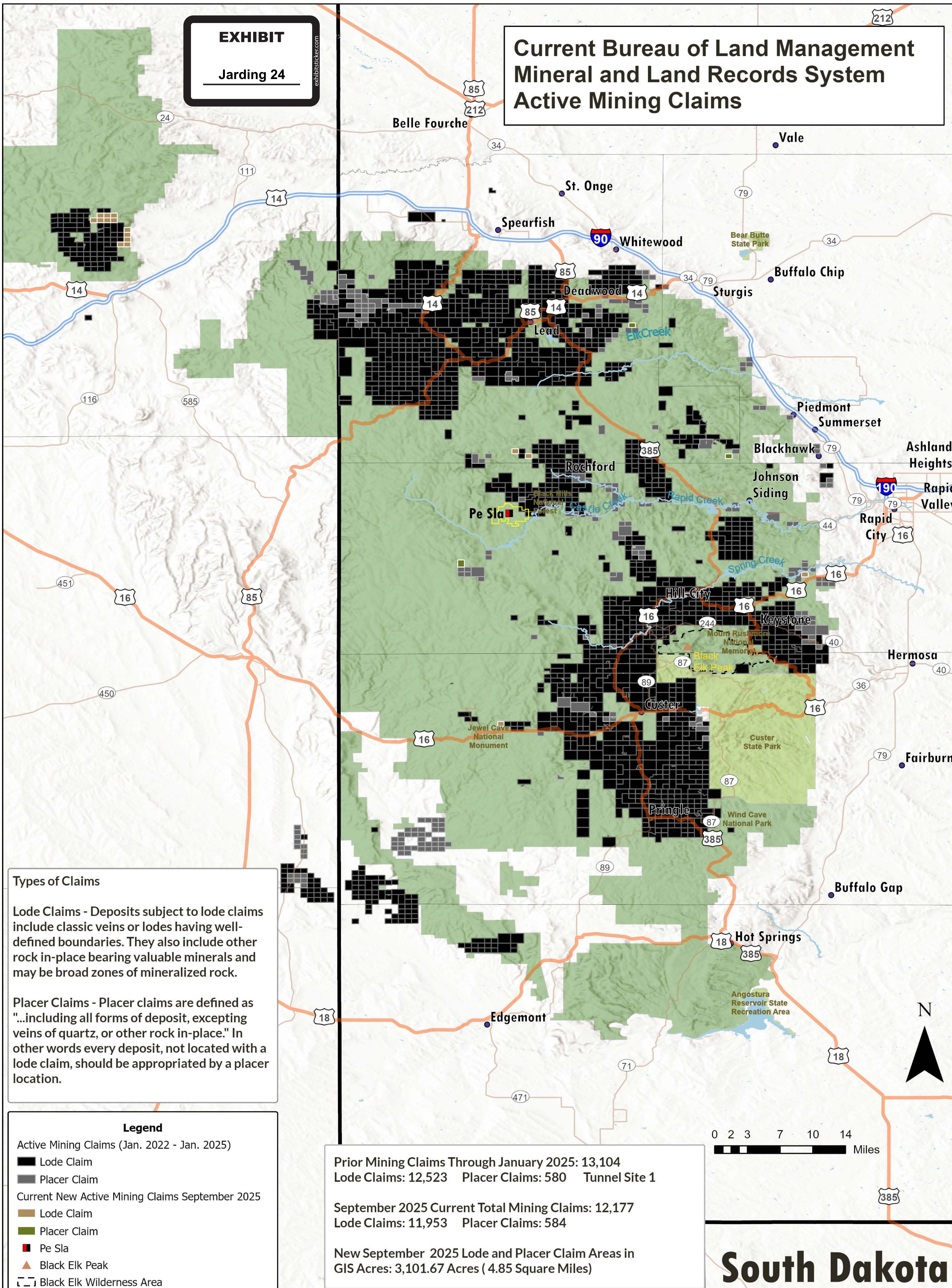
1982 Teaching Assistant, 1982 Remote Sensing Short Course for Minerals and Mineral Fuels. South Dakota School of Mines and Technology, Rapid City, SD. Assisted in the organization of seminar.

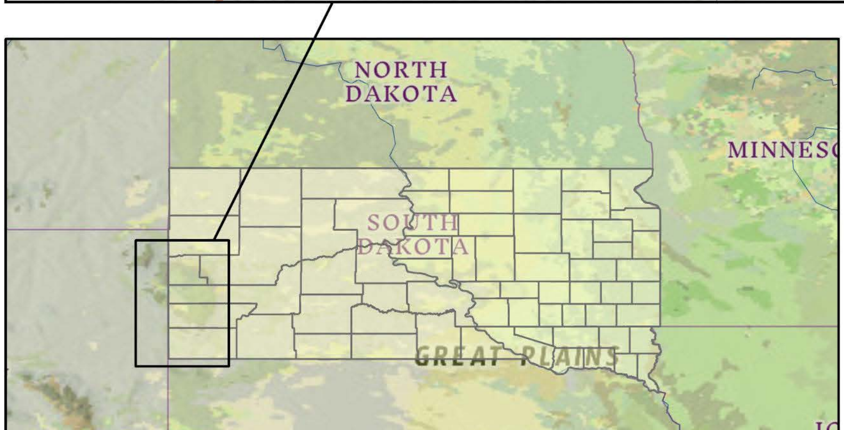
1980-81 Research Assistant, USFS, Rocky Mountain Range and Forest Experiment Station, SDSM&T, Rapid City, SD. Evaluated and identified mine sites. Recommended corrective measures concerning hazards of sites.

1975-80 Contractor, self-employed, Chadron, NE. Constructed residential housing and many major construction projects. Supervised four full-time employees. Responsible for all aspects of business. Financed education at Chadron State College.

1977 Salesman, Lampert Building Center, Chadron, NE. Responsible for sales, record keeping, drafting and developing materials lists.

1972-75 Medic, U. S. Army.





Strategic Mapping Provided by:	South Dakota Study Area BLM Mining Claims Paha Sapa (Black Hills, South Dakota) October 1, 2025
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Black Hills Clean Water Alliance www.bhcleanwateralliance.org	MAPBOOK BLM Mining Claims Lode Claims / Placer Claim Updated Claims Q4 2025