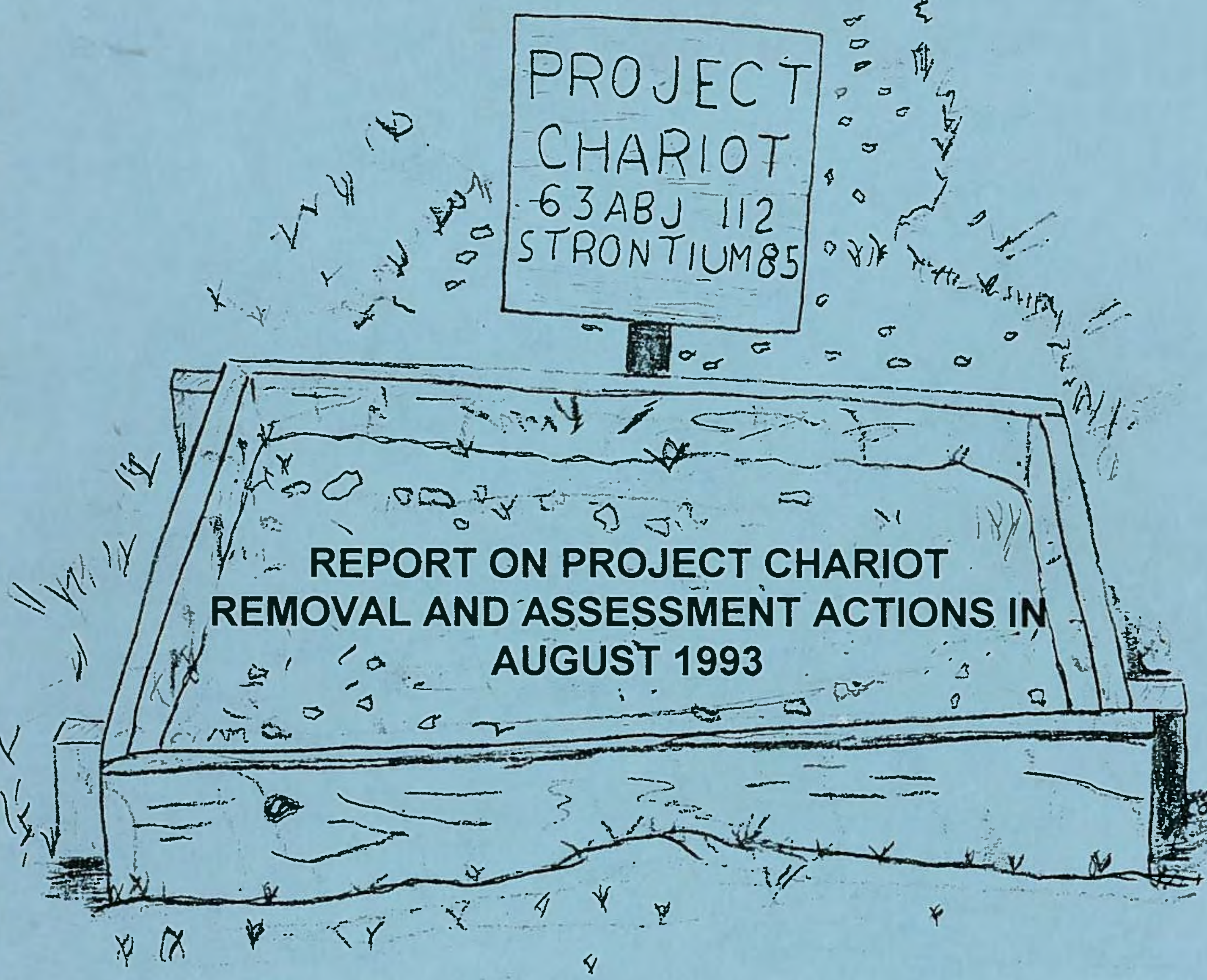
ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION NORTHERN REGIONAL OFFICE



REPORT ON PROJECT CHARIOT REMOVAL AND ASSESSMENT ACTIONS IN AUGUST 1993

Notice

This material was prepared with the support of the U.S. Department of Energy (DOE), Grant No. DE-FG08-93NV11433. However, any opinions, finding, conclusions, or recommendations expressed herein are those of the author(s) and do not necessarily reflect the view of DOE.

Executive Summary

Historical Background 1950's to 1960's

Project Chariot was a proposed nuclear excavation test intended to create a deep-water harbor near Cape Thompson, Alaska (Figure 1). This excavation, part of the AEC Plowshare Program, was to provide scientific and engineering data for future excavation projects.

From 1959 to 1963, a number of scientific studies were conducted at the Project Chariot site in Ogotoruk creek valley. These studies were to establish baseline environmental conditions at the site in order to evaluate the effects of the proposed nuclear detonations on the environment.

One of the studies conducted at the site was the United States Geological Survey (USGS) Tracer Study. In August of 1962 the USGS carried out a hydrologic tracer study with radionuclides at the Project Chariot site. This study evaluated the dispersal of radionuclides in the hydrologic environment. This data would be used to estimate the concentration of radionuclides that the proposed nuclear detonations would introduce into local water supplies. Twelve study sites were selected adjacent to or in Snowbank Creek. The radionuclides were applied to 10 soil plots, then water was sprayed over each plot in order to simulate rainfall. This runoff was collected and measured for each of the radionuclides. Another site consisted of a infiltration seepage pit on a sloping hillside. The final site was a section of Snowbank creek where sediment transport dispersal was evaluated.

Radionuclides used in the tracer experiment were Cesium 137 (Cs 137), Iodine 131 (I 131), Strontium 85 (Sr 85), and radioactive fallout from the Plowshare program's Project Sedan. Project Sedan was a underground nuclear detonation carried out at the AEC Nevada Test Site in 1962.

The USGS hydrologic tracer study took place in August 1962. Upon completion of the study, USGS personnel removed the contaminated soil from the test plots. The contaminated material was hauled in 55 gallon drums to lower Snowbank creek and dumped out of the drums and covered with 4 feet of uncontaminated soil excavated by a bull dozer. Figure 2 shows the material being buried in 1962.

Project Chariot was canceled by the AEC in 1963, and the planned nuclear detonations never took place. This was due in part to the opposition to the project from the indigenous people that used the region for their subsistence lifestyle, various scientists and environmental groups.

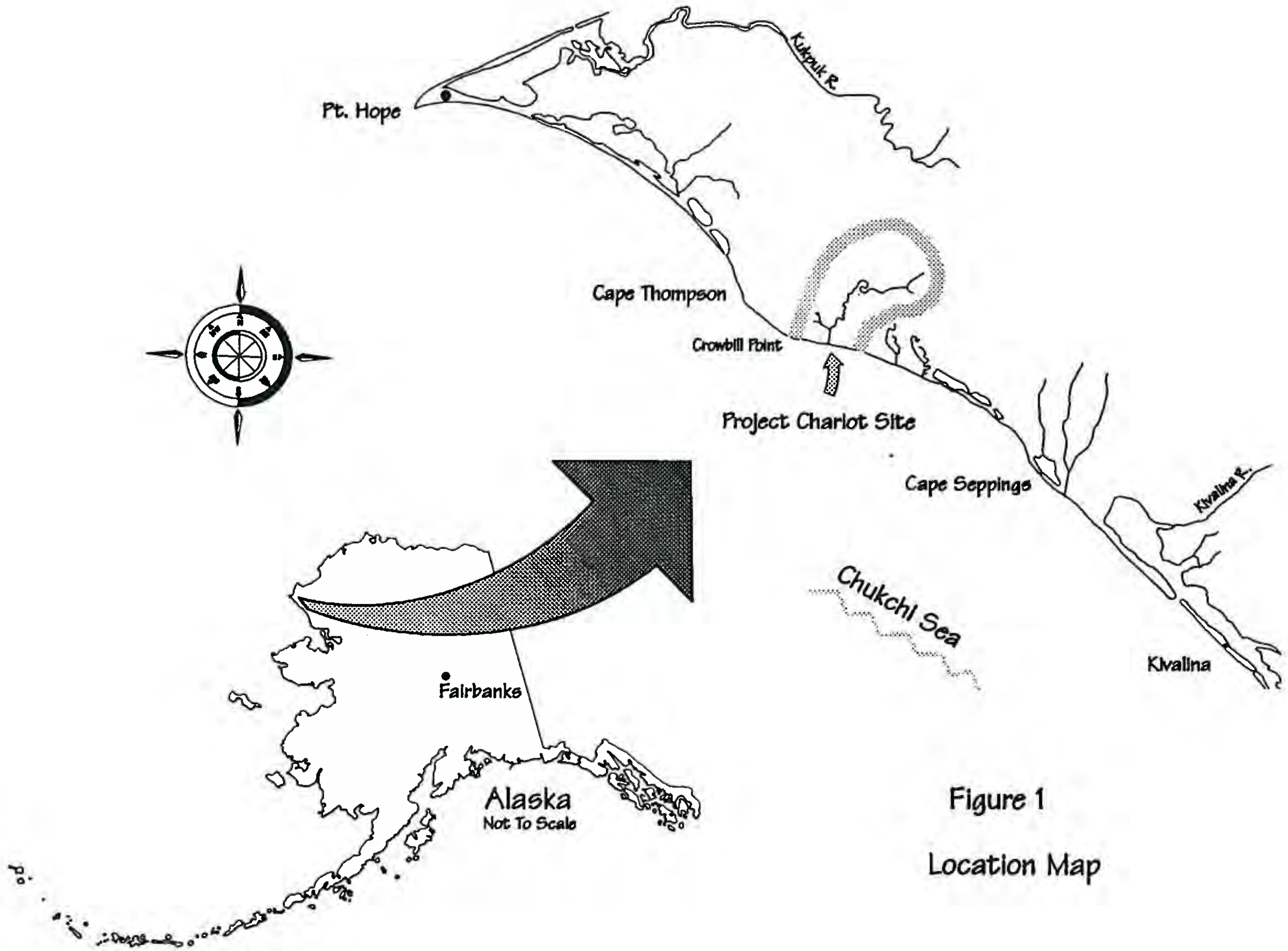

Pt. Hope
Kukpuk R.
Cape Thompson
Crowbill Point
Project Chariot Site
Cape Seppings
Kivalina R.
Chukchi Sea
Kivalina
Fairbanks
Alaska
Not To Scale
Figure 1
Location Map

FIGURE 1

Figure 2
Boards and Radioactive Tracer Material Being Buried Chariot Site - 1962

Figure 3
Excavator Removing the Surface Vegetation Getting Ready to Start the First Lift - 1993

Current Events 1992 to 1993

In 1991-92, Mr. Dan O'Neill, who was writing a book on Project Chariot, came across documentation indicating that the USGS had left the radioactive tracer material at the Project Chariot site. The USGS report on the experiment and actions taken in 1962 had been placed in the USGS files. AEC had decided not to require the removal of the buried tracer material. The revelation to the public of the tracer quantities of radioactive material left at the site came on the heels of the public concern over the Russian radiation pollution in the Arctic.

The Alaska Department of Environmental Conservation (ADEC) and the Army Corps of Engineers (COE) conducted a site visit on September 10 - 13, 1992. On surveying the ground surface in the area no elevated readings above background were observed. A single reading of 0.1 mR/hr, which could not be reproduced, was obtained off the bit of the soil auger used to drill a hole into the mound. Samples were also collected and sent to a laboratory. These preliminary results did not indicate that levels of radionuclides in the sampled water, sediment or soil represented a health hazard.

Later in September 1992, Governor Walter Hickel of Alaska, and U.S. Senator Frank Murkowski traveled to Point Hope to meet with the community, and discuss their concerns. They made a commitment to the people that a site investigation would be conducted and the radioactive tracer material would be removed. The Department of Energy (DOE) accepted responsibility and committed itself to the site investigation, and any remedial actions. ADEC was tasked with oversight of DOE activities. Many meetings were held with the villages involved and various agencies regarding the actions that should take place at the site. One concern was should a complete risk assessment be conducted of the area, letting the results determine if the mound should be excavated or left in place? Would the people in the local communities be comfortable with leaving the mound in place, even if the resulting site assessment indicated this was the reasonable action? Critical to this determination was a statement by the North Slope Borough Mayor Kaleak, "I would like to make it clear that the Borough continues to believe that only complete removal of the radioactive material buried at Cape Thompson will adequately address the concerns of our residents (Kaleak, 1993)". Finally it was decided that in addition to implementing an aerial survey, conducting soil and biota sampling activities, that the mound and any other contaminated soils found would be excavated and transported to the Nevada Test Site.

In July of 1993, EG&G Energy Measurements, a DOE contractor, conducted an aerial gamma radiological survey of the Project Chariot site. Results of the aerial survey were plotted on an aerial photograph. Radiation levels detected were within typical background levels, and varied principally with the site geological characteristics. No manmade, other than global fallout, radioactive anomalies were found by the aerial survey.

On-site field activities began on July 29, 1993. Water, soil, sediment and biota (mammal, bird and vegetation) samples were collected from the mound area, Ogotoruk Valley and the adjoining Kisimilok Valley. Samples were collected from these areas to establish background levels of radionuclides, which are naturally occurring or due to global fallout, and to evaluate if any artificial radionuclides had entered into the environment due to the USGS tracer study. In addition, samples were also collected from areas that the local villagers were concerned about.

An on-site gamma spectrum laboratory was setup for International Technologies (IT), the DOE contractor, and ADEC. This laboratory enabled IT and ADEC to run gamma spectrum analysis on soil samples, allowing for a fast turn around time.

On August 2, 1993, a representative of Foster Wheeler (North Slope Borough consultant) located a tracer plot site close to the mound area. Once this study plot site was found soil samples run in the on-site laboratory confirmed that Cs 137 was present at above background levels. Additional soil sampling was done to determine the depth and extent of Cs 137 levels above the 10 pCi/g cleanup level. Eventually an area of approximately 225 square feet was excavated to approximately one and a half feet below grade.

In addition, Plot 112 was located by using a 1962 USGS photo, and finding the original plot sign. No radiation levels were detected at this study plot site above background. Sr 85 was the radionuclide used at plot 112 and with a half-life of 63 days has decayed to undetectable levels by now.

For the DOE Snowbank creek radiological survey, sodium iodide detectors were used to locate any remaining contaminated soil from the tracer plot areas. Two detectors were mounted on a shoulder holder which a person would carry. That person would walk back and forth approximately 100 feet on either side of Snowbank creek along the whole length of it. These surveys again confirmed the location of the already identified plot contaminated with Cs 137. No other plots were identified by the survey instruments.

The mound was excavated in one foot lifts by using a large excavator (Figure 3). The surveys were accomplished by IT personnel walking the stockpiled excavated material with sodium iodide detectors, and surveying with tripod mounted sodium iodide detectors connected to multi-channel analyzers to identify specific gamma emitting radionuclides. Samples were also taken and analyzed in the on-site laboratory as well as sent off to the off-site laboratories for confirmation. Excavation continued in one foot lifts until the on-site laboratory sample results were below the Cs 137 cleanup level.

In late August 1993, excavations of the mound and the cesium 137 plot were completed. Soil verification then took place to see if the Cs 137 cleanup level had been reached. Initially samples were run in the on-site laboratory to check levels before sending the samples off-site to be run. Analysis run on the samples off-site included gross alpha, gross beta, a gamma spectrum which included Cs-137, and on some samples Sr 90, and Plutonium (Pu) 238, 239/240. ADEC's mound verification sample results for Sr 90 and Pu 238, Pu 239/240 were all below the laboratory detection limits. Results from the mound and study plot verification samples were below the Cs-137 10 pCi/g cleanup level. Therefore, DEC issued clean closure on both of the areas.

The excavated material was shipped by barge to Seattle, Washington. In Seattle it was placed on trucks and shipped to the Nevada Test Site. It is to be buried at one of the low specific activity waste sites at the NTS.

Conclusions

Results of the soil, sediment, and water sampling indicate that the variation in radiation within the Ogotoruk and Kisimilok valleys is principally naturally occurring, with the addition of manmade global fallout. Biota sampling results indicated that global fallout was still present in the food chain, but at lower levels than observed in the 1960's and 1970's. At the observed Cs 137 and Sr 90 levels the mammals and plants sampled do not represent an ingestion health hazard to humans. Based on the levels observed in the soil, water, and biota samples the department finds no reason to restrict use of this area because of radioactivity.

Future Actions

The State of Alaska Department of Health and Social Services, Division of Public Health will review the sampling data and revisit their preliminary health evaluation. In addition the Federal Agency for Toxic Substance and Disease Registry is conducting a health consultation for the North Slope Borough. As part to the ATSDR health consultation they will review the sampling data.

ADEC has obtained a real time gamma radiation monitoring instrument from DOE. As part of the State of Alaska Agreement in Principle with DOE this instrument will be installed in Pt. Hope in 1995 as part of an environmental monitoring station. This station will allow baseline gamma radiation data to be collected and data from other sites to be compared to Pt. Hope.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Preface

The staff of the Department of Environmental Conservation that worked on the Project Chariot Remedial Action are indebted to the people of the local communities of Pt. Hope and Kivalina, the North Slope Borough and the Northwest Arctic Borough, Non-governmental organizations, State and Federal agencies and numerous individuals for the comments, recommendations, criticisms, and constant questioning regarding the remedial activities. This input certainly resulted in a higher level of assessment, investigative and removal action than has ever been conducted before in Alaska for the level of contamination found at this site. It is the view of the Department that the results of the assessment, investigation and removal action in conjunction with the cancer epidemiological studies have addressed environmental and public health concerns raised by the USGS Tracer Study. Now through the cooperative effort of the local communities, Local, State and Federal government work needs to begin on the recommendations in this report, and on other recommendations brought forth by others involved in this project.

GLOSSARY

Becquerel:	(Bq) 1 Becquerel = 1 disintegration/second (dps) = 2.703×10^{-11} Ci
Curie:	(Ci) 1 Curie = 2.22×10^{12} disintegrations/minute (dpm) or 3.7×10^{10} disintegrations/second (dps)
Dose:	The deposition of energy into soft tissue (human body) by a specific form and energy level of radiation. This is normally measured in units of Rad (an acronym for Radiation Absorbed Dose).
Dose Equivalent:	The estimation of the biological risk associated with radiation exposure regardless of the type of radiation or its energy level. This is normally measured in units of Rem.
Exposure:	The measurement of radiation passing through air which an individual would be subjected to if they were to stand in that spot. This is normally measured in units of Roentgen (R).
Gray:	(Gy) The SI unit of absorbed dose. 1 Gy = 1 Joule kg^{-1} = 100 Rad
Half-Life:	The time for a quantity of radionuclide, i.e., its activity, to diminish by a factor of a half (because of nuclear decay events, biological elimination of the material, or both).
Ionizing Radiation:	Any radiation capable of displacing electrons from atoms or molecules, thereby producing ions.
Rad:	A measure of the dose of any ionizing radiation to body tissue in terms of the energy absorbed per unit mass of tissue. (1 Rad = 100 erg/gram of body tissue)
REM:	The amount of radiation which causes damage equivalent to the damage done by the absorption of 100 ergs X or gamma radiation per gram of soft body tissue.
Roentgen:	(R) The quantity of x-ray or gamma radiation producing one electrostatic unit of charge in one cubic centimeter of dry air at standard temperature and pressure.
Sievert:	(Sv) The special name for the SI unit of dose equivalent. 1 Sv = 100 REM

ACRONYMS, SYMBOLS, AND UNITS

ADEC	=	Alaska Department of Environmental Conservation
ADH&SS	=	Alaska Department of Health and Social Services
AEC	=	Atomic Energy Commission
ATSDR	=	Agency for Toxic Substance and Disease Registry
Bq	=	Becquerel
CFR	=	Code of Federal Regulations
Ci	=	Curie
COE	=	Army Corps of Engineers
Cs 137	=	Cesium 137
DOE	=	United States Department of Energy
DOT	=	Department of Transportation
EPA	=	United States Environmental Protection Agency
FW	=	Foster Wheeler Environmental Services
QA/QC	=	Qualtity Assurance / Quality Control
I 131	=	Iodine 131
IT	=	International Technology Corporation
K 40	=	Potassium 40
KV	=	Kisimilok Valley
MCL	=	Maximum Contaminant Levels
MDA	=	Minimal Detectable Activity
mREM	=	milli-rem
NSB	=	North Slope Borough
NTS	=	Nevada Test Site
Pb 210	=	Lead 210
pCi/g	=	picoCurie/gram (10^{-12} Ci/g)
pCi/L	=	picoCurie/Liter
Pu 239/240	=	Plutonium 239/240
Ra 226	=	Radium 226
SI	=	International System of Units
Sr 85	=	Strontium 85
Sv	=	Sievert
Th 232	=	Thorium 232
U 238	=	Uranium 238
USF&W	=	United States Fish & Wildlife Service
USGS	=	United States Geological Survey

RECOMMEND UNIT PREFIXES AND CONVERSIONS

UNIT CONVERSIONS

Quantity	SI Name & Symbol	Present Equivalent
Activity	Becquerel (Bq) disintegration/sec (dps)	2.703×10^{-11} Ci (27 pCi)
Absorbed dose	Gray (Gy)	100 Rad
Dose Equivalent Units	Sievert (Sv)	100 REM

RECOMMENDED UNIT PREFIXES

Multiple	Prefix	Symbol	Submultiple	Prefix	Symbol
10^{12}	tera	T	10^{-1}	deci	d
10^{9}	giga	G	10^{-2}	centi	c
10^{6}	mega	M	10^{-3}	milli	m
10^{3}	kilo	k	10^{-6}	micro	μ
10^{2}	hecto	h	10^{-9}	nano	n
10^{1}	deka	d	10^{-12}	pico	p
			10^{-15}	femto	f
			10^{-18}	atto	a

Chapter 1

Site Description and Project History

1.1 Project Chariot

In the 1950's researchers at Lawrence Radiation Laboratory, now Lawrence Livermore National Laboratory, in California conceived of the idea of using nuclear explosive devices for peaceful purposes. The idea was to use nuclear explosions to create excavations on a "geological scale." The Atomic Energy Commission (AEC) further developed this idea under the Plowshare program. In 1958 the AEC, as part of the Plowshare program, announced an operation called Project Chariot.

Project Chariot was a proposed nuclear excavation intended to create a deep-water harbor near Cape Thompson, Alaska. This excavation was to provide scientific and engineering data for future excavation projects. The Project Chariot site is located approximately 30 miles south of Point Hope, in the Ogotoruk Creek Valley. Figure 1-1 provides a location map.

Many environmental scientific studies were conducted at the Project Chariot site from 1959 to 1963. These studies were to establish baseline environmental conditions at the site to evaluate the effects of the proposed nuclear detonations on the environment. In addition engineering studies were undertaken to decide the configuration for the nuclear explosives. Results of many of these studies were published as *"Environment of the Cape Thompson Region, AK"* in 1966 by the AEC.

1.2 U.S. Geological Survey Tracer Study

In August of 1962 the United States Geological Survey (USGS) carried out a hydrologic tracer study with radionuclides at the Project Chariot site in Northwest Alaska (Janzer *et al.*, 1963; Piper, *et al.*, 1963). This study may not have been, at least directly, a part of the Project Chairot funded environmental studies (O'Neil, 1993). The purpose of this study was to evaluate the dispersal of radionuclides in the hydrologic environment. This data would be used in estimating the concentrations of radionuclides that the proposed nuclear detonations would introduce into local water supplies. Twelve study sites were selected adjacent to or in Snowbank Creek. The radionuclides were applied to 10 soil plots, then water was sprayed over each plot to simulate rainfall. This runoff was collected and measured for each radionuclide. Another site consisted of an infiltration seepage pit on a sloping hillside. The final site was a section of Snowbank Creek where sediment transport was evaluated. The radionuclides brought to the site for the tracer studies are listed in Table 1-1.

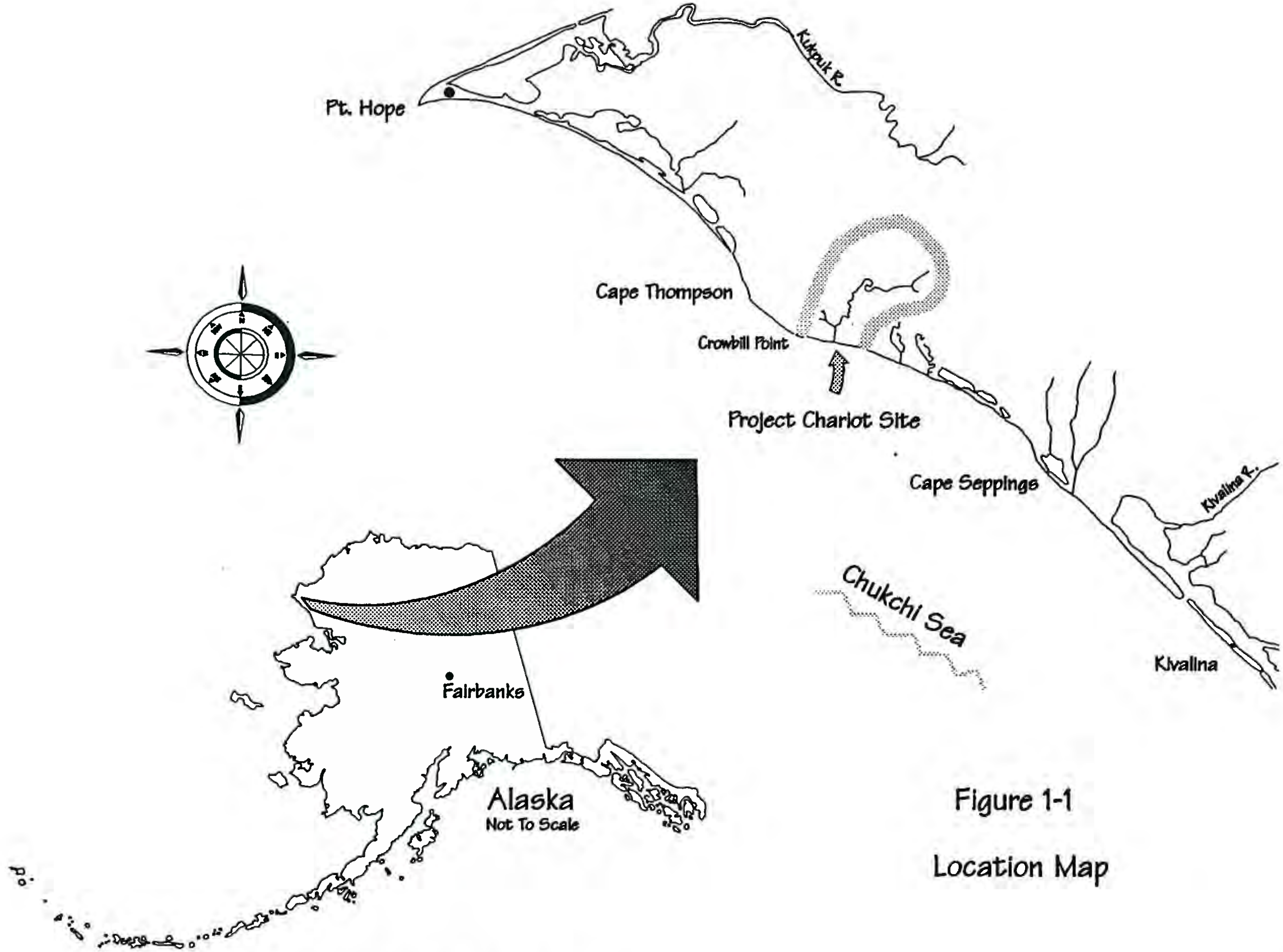


Figure 1-1

Location Map

Table 1-1

Radionuclides Used by USGS in the Hydrologic Tracer Study in 1962 (1)

Plot #	Plot Size (inches)	Radionuclides	mCi *	Weight pounds	Half-Life**	Chemical Composition	Remarks
105	30X63	Cs 137	2	4	30 years	CsCl	Soil plots
106	31X54	Cs 137	2	4	30 years	CsCl	Soil plots
107	32X31	Cs 137	2	4	30 years	CsCl	Soil plots
109	24X24	I 131	1.7	2	8 days	NaI	Soil plots
110	24X24	I 131	3.3	4	8 days	NaI	Soil plots
111	26X27	Sr 85	2.5	4	65 days	Sr(NO3)2	Soil plots
112	32X32	Sr 85	2.5	4	65 days	Sr(NO3)2	Soil plots
113	60X81	Sedan Fallout	1.7	3	***	Mixed Fission Prod.	Soil plots
114	58X59	Sedan Fallout	1.7	3	***	Mixed Fission Prod.	Soil plots
115	18X24	Sedan Fallout	1.7	3	***	Mixed Fission Prod.	Soil plots
116		Sedan Fallout	1.7	3	***	Mixed Fission Prod.	Infiltration study
117		Sedan Fallout	3.2	5.5	***	Mixed Fission Prod.	Stream dispersal study
		Total	26	43.5			

(1) October 9, 1962 USGS Letter from Arthur Piper to John Phillips of AEC.
* milliCurie. Curie is a unit that defines the rate at which atoms of radioactive materials disintegrate. A curie equals 37,000,000,000 disintegrations per second. A millicurie is one thousandth of a curie equal to 37,000,000 disintegrations per second.
** Half-life is the time it takes for half of the atoms in the radioactive material to disintegrate.
*** Mixed fission products contain many short-lived as well as long lived radionuclides.

The radionuclides of Cesium 137 (Cs 137), Iodine 131 (I 131), and Strontium 85 (Sr 85) were obtained from Oak Ridge National Laboratories (Woolsey, 1962). The radioactive fallout material came from the Plowshare program's Project Sedan. Project Sedan was the first nuclear excavation experiment conducted under the Plowshare program. On July 6, 1962 a 100 kiloton nuclear detonation was conducted at the AEC Nevada Test Site. The nuclear device was placed 635 feet below the land surface. Within seconds after the detonation the overlying earth for a radius of 300 to 400 feet was lifted skyward 290 feet. Roughly 7.5 million cubic yards or 12 million tons of earth was displaced by this explosion. Fallout was collected on metal trays positioned throughout the anticipated fallout area (AEC, 1963). USGS personnel collected fallout from these trays for use in their research. It was 15 pounds of this fallout material that USGS brought to the Project Chariot site.

The USGS hydrologic tracer studies took place between August 20-25, 1962. Upon completion of the studies, USGS personnel removed the contaminated soil from the test plots. They reported digging up all plots to a depth where the survey meter showed no reading greater than 0.1 milliRoentgen/hour(mR/hr). The excavated material was placed in 55 gallon drums and moved by a tracked vehicle to lower

Snowbank Creek. At this site the excavated material was dumped out of the drums and covered with 4 feet of uncontaminated soil excavated by a bull dozer (Woolsey, 1962). Figure's 1-2, 1-3, 1-4 and 1-5 document some USGS activities in August of 1962.

On September 7, 1962 an AEC radiation specialist inspected the site. The inspection included a visit to two of the "study plots" and burial site. Radiation surveys were made at the three locations. No radiation above background was detected at the burial site. The survey at one of the study plots indicated that one small area had radiation levels two to four times background at a distance of about two inches above the surface. The survey at the other plot disclosed one small piece of mud with levels of 1.2 mR/hr (open window) and 0.2 mR/hr (closed window) at a distance of about one inch above the surface. This piece of mud was buried so that no radiation could be detected at the ground level. These study plots were defined as plot 112 and 116 , respectively, in the September 10, 1962 field report from H. E. Book on the AEC inspection of the Project Chariot site on September 7, 1962.

During this inspection several violations of the AEC regulations were noted. AEC personnel noted in a memorandum that "I would point out that at this time that in my opinion, no problems involving health or safety existed during the experiment or presently exist at the Project Chariot site. While items of noncompliance were observed during the inspection, these were all of a technical nature, not affecting health and safety (Book, 1962)." Because of this noncompliance, a Notice of Violation was issued to the USGS by the AEC. Specifically AEC cited USGS for:

1) The quantities of strontium 85 and cesium 137 buried at the Cape Thompson, Alaska, site exceeded 1000 times the amounts specified in Appendix C of 10 CFR 20, contrary to 10 CFR 20.304(a), "Disposal by burial in soil."

2) No records were maintained of the byproduct materials disposed of by burial, contrary to 10 CFR 30.41 (a), "Records."

The AEC Notice of Violation required the USGS to supply additional data and evaluate the risk presented by leaving this material at the site (Price, 1963). The USGS addressed the AEC citations in a February 28, 1963 letter (Baker, 1963). Based on this information AEC stated, "However, we believe no further action is warranted. We plan no further correspondence with USGS regarding AEC inspection of Chariot site at Cape Thompson, Alaska and Notice to USGS dated January 23, 1963 (Page, 1963)."

Figure 1-2
USGS Researcher Simulating Rainfall on a Plot at the Chariot Site - 1962

Figure 1-3
USGS Researchers at a Plot Site Near Snowbank Creek - 1962

Figure 1-4
Bulldozer Covering the Radioactive Tracer Material at the Chariot Site - 1962

Figure 1-5
Boards and Radioactive Tracer Material Being Buried Chariot Site - 1962

Project Chariot was canceled by the AEC in 1963. This was due in part to the opposition to the project from the indigenous people that used the region for their subsistence lifestyle, various scientists and environmental groups. For the indigenous people of nearby Point Hope and Kivalina the negative impacts of the proposed Project Chariot nuclear detonations would have been substantial. It would have affected their subsistence lifestyle and could have affected their health.

1.3 Historical Controversy

The historical events concerning the USGS tracer study were condensed from a compilation of reports, memorandums, and current accounts from the original researchers. The reader should be aware that conflicting information exists in the historical documents regarding the USGS tracer study. This conflicting information raised major concerns with some reviewers. Examples of this were the proposed activity level of radioactive materials to be used, sample plot size and location, and dates of certain activities.

The department did not consider the historical document controversy significant enough to delay the site activities proposed for the summer of 1993 because:

1. Two of the original researchers indicated that they had carried out the study as described in the USGS Professional Paper 539 *POTENTIAL EFFECTS OF PROJECTS CHARIOT ON LOCAL WATER SUPPLIES NORTHWESTERN ALASKA* by Arthur M. Piper. A written response from one of the original researchers to our questions is presented in Appendix A.

2. The follow up AEC inspection reports, and interviews with one of the original researchers support the study procedures as described in the above paper (Book, 1962).

3. The proposed radiological aerial survey, ground survey, and biota sampling would detect any sources of radionuclides in the Ogotoruk creek drainage that would cause significant environmental problems.

1.4 Current Events 1992 - 1993

In 1991-92, Mr. Dan O'Neill, who was writing a book on Project Chariot, came across the documentation that the USGS had left the radioactive tracer material at the Project Chariot site (O'Neill, 1992). The USGS report on the experiment and actions taken in 1962 had been placed in the USGS files, and forgotten when Project Chariot was canceled. The revelation to the public of the tracer quantities of radioactive material left at the site occurred when public concern was heightened over the revelations of the Russian radiation pollution of the Arctic. Public concern over this revelation was high, especially in the local communities of Pt. Hope and Kivalina.

The people of Point Hope have long been concerned about the occurrences of cancer in their community. Epidemiological studies of the cancer rate among the local population have not found the types of cancers associated with radiation exposure. The small population size makes it difficult to statistically evaluate the cancer rate (Chandler, 1992).

Responding to the local communities' concerns, the Alaska Department of Environmental Conservation (ADEC) and the Army Corps of Engineers (COE) conducted a site visit on September 10 - 13, 1992 (COE, 1992). When surveying the ground surface in the area no elevated readings above background were observed. A single reading of 0.1 mR/hr, which could not be reproduced, was obtained off the bit of a soil auger used to drill a hole into the mound. The COE collected soil and water samples of the area. Later these same samples were tested for additional radionuclides by the US Department of Energy (DOE). These test results did not indicate any anomalous radioactivity levels. Further discussion of these sample results can be found in Chapter 6, Section 6.1.4.

Later in September 1992, Governor Walter Hickel of Alaska, and US Senator Frank Murkowski of Alaska traveled to Pt. Hope to meet with the community, and discuss their concerns. They made a commitment to the people that a site investigation would be conducted, and the radioactive tracer material would be removed. The DOE accepted responsibility and committed itself to the site investigation, and any remedial actions. ADEC was tasked with oversight of DOE activities. Over the months to follow, many teleconferences were held with the villagers, local governments, state agency representatives, DOE, US Fish and Wildlife Service, and many other interested parties to discuss these concerns. Meetings were held in Barrow, Point Hope, Kivalina, and Kotzebue to hear the communities' concerns and answer questions, provide radiation safety training and discuss the site investigation and proposed remedial action. Appendix B summarizes some of these events in the newsletters produced by ADEC during this project. A principal focus of these meetings were what type of study should take place, and what the resulting remedial action should be. Should a complete risk assessment be conducted of the area, letting the results determine if the mound should be excavated or left in place? Would the people in the local communities be comfortable with leaving the mound in place, even if the resulting site assessment showed this was the reasonable action? Critical to this determination was a statement by the North Slope Borough Mayor Kaleak, "I would like to make it clear that the Borough continues to believe that only complete removal of the radioactive material buried at Cape Thompson will adequately address the concerns of our residents

(Kaleak, 1993)." Because of these meetings it was determined that besides implementing an aerial survey, and conducting soil and biota sampling activities, that the mound and any other contaminated soils found would be excavated and transported to the Nevada Test Site (DOE, 1993).

Chapter 2

Alaska Department of Environmental Conservation Activities

2.1 ADEC's Role and Responsibilities

The mission of ADEC is to protect the public health from environmental threats, and to conserve, protect, and improve Alaska's environment for present and future generations. One of ADEC's responsibilities is to conduct oversight of a responsible party cleanup. In doing this oversight ADEC will decide if the proposed remedial actions are appropriate and, as necessary, conduct field oversight of the remedial actions to assure that they are adequate. Once DOE had stepped forward as the responsible party, ADEC had the responsibility to conduct oversight of the DOE activities.

2.1.1 Planning and Technical Review

The ADEC conducted the following planning and technical review activities:

a) ADEC searched for historical documents relating to the Project Chariot site at the University of Alaska Fairbanks library, obtained declassified documents related to Project Chariot from DOE, reviewed and commented on the historical documents about the activities at the Project Chariot site. This review is still ongoing as ADEC receives declassified documents from DOE. Once the review has been completed ADEC will provide a document summary paper to the local communities and interested parties. The documents will be placed on file with the University of Alaska Fairbanks library for access by the interested public.

In addition, ADEC staff are undergoing DOE security checks to obtain clearance to review any documents or sections of documents that remain classified.

b) ADEC reviewed and commented on the DOE remedial activities' plan for the radioactive tracer mound at the Project Chariot site; the water, sediment, soil and biota sampling plans; and the Cs 137 cleanup level environmental risk evaluation. Based on DOE's modifications to the initial remedial action plan after receiving ADEC and public comments, approval was granted.

c) The ADEC project manager and staff participated in interagency meetings for planning and review of all proposed activities. The project manager was also involved in first stages of any dispute resolution process. During this project, disputes were resolved during this first stage and did not require elevation.

d) ADEC helped DOE and its subcontractors in logistical planning for the site operations.

2.1.2 On-Site Activity

ADEC conducted spilt/independent sampling, and documented the following site activities:

a) ADEC personnel were on-site during the Project Chariot field operations from July 29 to August 28, 1993 to observe and document DOE field activities for compliance with the approved plans. During the field operations ADEC took 100 samples for analysis at its off-site contract laboratory, Lockheed Laboratories in Las Vegas, Nevada. ADEC staff operated the field laboratory and analyzed 66 soil samples for Cs 137.

b) During the field operations ADEC was involved with or worked with the involved parties to settle several concerns. There were concerns over the security of the on-site laboratory, DOE's contractors unwillingness to release preliminary data before full QA/QC, community representatives access to the freshly excavated lifts at the mound excavation site, split sampling procedures, field firearm procedures for bear protection, and all terrain vehicle use had to be resolved.

c) ADEC reviewed and evaluated the verification closeout sampling and results for the tracer mound and the Cs 137 contaminated study plot. Based upon ADEC's field and off-site laboratory results, DOE's field and off-site laboratory results, and the North Slope Borough's (NSB) off-site laboratory results being less than the 10 picoCurie/gram (pCi/g) cleanup level for Cs 137, ADEC issued closure approvals for these excavations.

2.1.3 Community Relations

ADEC helped in the coordination of community relations and helped in public education regarding all Project Chariot activities. This coordination entailed the assistance of other State of Alaska departments, such as Health and Social Services and Community and Regional Affairs.

a) ADEC provided a point of contact for the concerned local communities. To facilitate the exchange of information, ADEC developed a contact list of interested parties, published newsletters updating people on events, and established telephone conferences between the communities, local, state and federal agencies involved. In addition, ADEC also helped to coordinate the local public meetings.

b) In September of 1992, ADEC emergency response staff put on an 8-hour radiation training session in Pt. Hope. In addition, they provided radiation meters and instructions on their use at the request of the community.

c) During the field operations, due to health and safety requirements, only persons having the required safety training and medical monitoring could enter the exclusion zone around the tracer mound. To allow the on-site community monitors access to this area, ADEC funded training and medical monitoring for six community representatives in Fairbanks.

2.1.4 Health Consultation

ADEC is providing copies of its sampling results to Alaska Department of Health and Social Service Division of Public Health (ADH&SS), U.S. Agency for Toxic Substances and Disease Registry (ATSDR), or any other agency involved in conducting health assessments or consultations. In the future ADEC will, when its expertise is required, provide further assistance in evaluating environmental impacts from environmental threats.

Chapter 3

Field Activities Summer 1993 On-Site Activity

3.1 Aerial Survey

ADEC staff met with EG&G personnel in Kotzebue, AK in June 1993 to help with the logistical planning. In mid-July 1993 ADEC staff again journeyed to Kotzebue to meet with EG&G and view their operations base. Due to scheduling conflicts with a pre-field operations meeting, and an inspection of ADEC's contract laboratory, ADEC staff were unable to observe the actual aerial surveys.

In July of 1993 EG&G Energy Measurements, a DOE contractor, conducted an aerial gamma radiological survey of the Project Chariot site. The aerial survey included Ogotoruk Creek hydrologic drainage, except the peregrine falcon nesting exclusion area at Crowbill Point, and part of the Kisimilok Valley.

Results of the aerial survey were plotted on an aerial photo, found in Appendix B. Gamma radiation levels detected were within typical background levels, and varied principally with the site geological characteristics. No artificial, other than global fallout, radioactive anomalies were found by the aerial survey. Naturally occurring radioactive Potassium 40 (K 40), Uranium 238 (U 238) and Thorium 232 (Th 232) were identified as principal sources of this background radiation (EG&G, 1993).

3.2 Preliminary Field Visit

On June 22, 1993 ADEC staff conducted a Project Chariot site visit with DOE personnel, U.S. Fish and Wildlife (USF&W) personnel, IT personnel, Dr. Wayne Hanson, Arthur Beetem, and Walter Russell (representing Wilfred Lane). The purpose of this visit was 1) to conduct a site walkover with an original USGS researcher and try to identify the original study plot locations, 2) evaluate proposed creek equipment crossings and barge landing sites, 3) check on conditions of the airstrips, and 4) evaluate the proposed field camp location on Wilfred Lane's property.

3.3 Site Investigation and Remedial Actions July and August 1993

The ADEC began its oversight work of the DOE's field operations on July 29, 1993. Equipment was brought to the site by an ocean going tug and barge. The heavy equipment was then "walked" to the mound site via wooden platforms (Uni-mats) to limit the scarring of the tundra. Before excavation of the mound began, biota samples were collected by Foster Wheeler (FW), the North Slope Borough (NSB) consultant, and I T

Corporation (IT), DOE's contractor.

Water, soil, sediment and biota (mammal and vegetation) samples were collected from the mound area, Ogotoruk Valley and the adjoining Kisimilok Valley. Samples were collected from these areas to establish background levels of radionuclides, which are naturally occurring or due to global fallout, and evaluate if any artificial radionuclides had entered the environment due to the USGS tracer study. In addition, samples were also collected from areas that the local villagers were concerned about. ADEC took split samples from IT and FW. In addition, ADEC took several independent samples of soil and water.

An on-site gamma radiological laboratory was provided for IT and ADEC. This laboratory enabled IT and ADEC to run gamma spectrum analysis on soil samples, allowing for a fast turn around time. In addition, FW 's consultant, Dr. Bruce Honeycut, used the ADEC laboratory to run their on-site samples and verify ADEC procedures.

Besides removing the buried tracer material DOE conducted a radiological survey of Snowbank Creek for the USGS tracer study plots. Based on information provided in the USGS report and by the original researchers it appeared that, if any could be found, it would be the Cs 137 plots and the Project Sedan fallout plots. On August 2, 1993, a FW representative located a tracer plot site close to the mound area, before the DOE site survey began. Figure 3-1 shows the plot location that was found.

Once this study plot site was found soil samples analyzed in the on-site laboratory confirmed that Cs 137 was present above background levels. On-site laboratory results ranged from 928 pCi/g (ADEC) to 558 pCi/g (IT). Additional soil sampling was done to determine the depth and extent of Cs 137 levels above the 10 pCi/g cleanup level. Eventually an area of approximately 225 square feet was excavated to approximately one and a half feet below grade.

In addition, Plot 112 was located by using a 1962 USGS photo, and finding the original plot sign. No radiation levels were detected above background at this study plot site. Sr 85 was the radionuclide used at plot 112, and with a half-life of 63 days it would have decayed well beyond detectable levels by 1993.

For the DOE Snowbank Creek radiological survey, sodium iodide detectors were used to locate any remaining contaminated soil from the tracer plot areas. Two detectors were mounted on a shoulder yoke, which a person carried. That person would walk back and forth approximately 100 feet on either side of Snowbank Creek along its entire length. Figure 3-2 shows IT personnel conducting this survey. These surveys again confirmed the location of the already identified plot contaminated with Cs 137.

Figure 3-1
Site of the Suspected Cs 137 USGS 1962 Test Plot - 1993

Figure 3-2
IT Personnel Conducting the Snowbank Creek Radiological Survey - 1993

Figure 3-3
Excavator Removing the Surface Vegetation Getting Ready to Start the First Lift - 1993

No other plots were identified by the survey instruments.

The mound was excavated in one foot lifts by using a back hoe excavator. Figure 3-3 shows the excavator removing a lift. As the soil was removed, it was stockpiled on liners, surveyed with radiation equipment and sampled. The fresh open cut of the lift was also surveyed and sampled. The surveys were accomplished by IT personnel walking the stockpiled excavated material with sodium iodide detectors, and surveying with tripod mounted sodium iodide detectors connected to multi-channel analyzers to identify specific gamma emitting radionuclides. Figure 3-4 and 3-5 shows these activities. Soil samples were taken and analyzed in the on-site laboratory. The first four lift analyses were below the Cs 137 cleanup level of 10 pCi/g, approximating background levels. On the removal of lifts five and six, the old boards and plastic from the original plots were found. The contaminated soil was placed in B-25 Low Specific Activity containers, which are rectangular steel containers (73" x 47" x 52"), meeting US Department of Transportation (DOT) shipping requirements for transporting low specific activity wastes. Figure 3-6 shows a B-25 container being filled. After filling and weighing they were sealed. Paperwork documentation covering sampling, filling and handling of the B-25 containers were required as part of the Nevada Test Site waste certification procedures. Sampling of the containerized excavated material determined that the radioactivity level was below DOT's definition of a radioactive waste requiring special handling for shipping.

On August 23, 1993, excavation of the mound was completed and on-site approval by ADEC for final closure was given. Excavation of the cesium 137 study plot was completed and final closure was given by ADEC on August 26, 1993. For soil verification sampling on the mound and the tracer plot site, IT Corporation set up a hexagonal grid on which 37 sampling points were established. Figures 3-7 and 3-8 show the grids and sampling. IT took 37 discrete samples and composited each quadrant into four composite samples. ADEC took 13 splits of the discrete samples and one split of the composite samples. These were then run by ADEC and IT in the on-site laboratory. Based on the results of the on-site lab, confirmation samples were sent to ADEC's and IT's off-site laboratories. FW also took splits of the soil verification samples and analyzed them in ADEC's on-site laboratory and FW's off-site laboratory, Enseco Laboratory in Denver, CO. The on-site samples were analyzed for Cs 137. Off-site analyses on the samples included gross alpha, gross beta, a gamma spectrum, which included Cs 137, and on some samples Sr 90, Plutonium 238 (Pu 238), and Plutonium 239/240 (Pu 239/240). ADEC's mound verification results for Sr 90 and Pu 238, 239/240, were all below the laboratory detection limits. All the off-site laboratory results from the mound and study plot verification samples were also below the 10 pCi/g Cs 137 cleanup level. Therefore, DEC issued clean closure on both of the areas. A representative of the Native Village of Pt. Hope surveyed the excavation with his radiation meter before closure took place. Figure 3-9 shows him surveying the Cs

Figure 3-4
Sodium Iodide Detector and Multi-Channel Analyzer on a Mound Lift - 1993

Figure 3-5
IT Personnel Setting up to Sample Excavated Soil from the Mound - 1993

Figure 3-6
A B-25 Container Being Loaded with Contaminated Soil - 1993

Figure 3-7
Soil Verification Sampling Grid for Suspect Cs 137 Plot - 1993

Figure 3-8
Grid Being Laid out for Verification Soil Sampling at the Mound - 1993

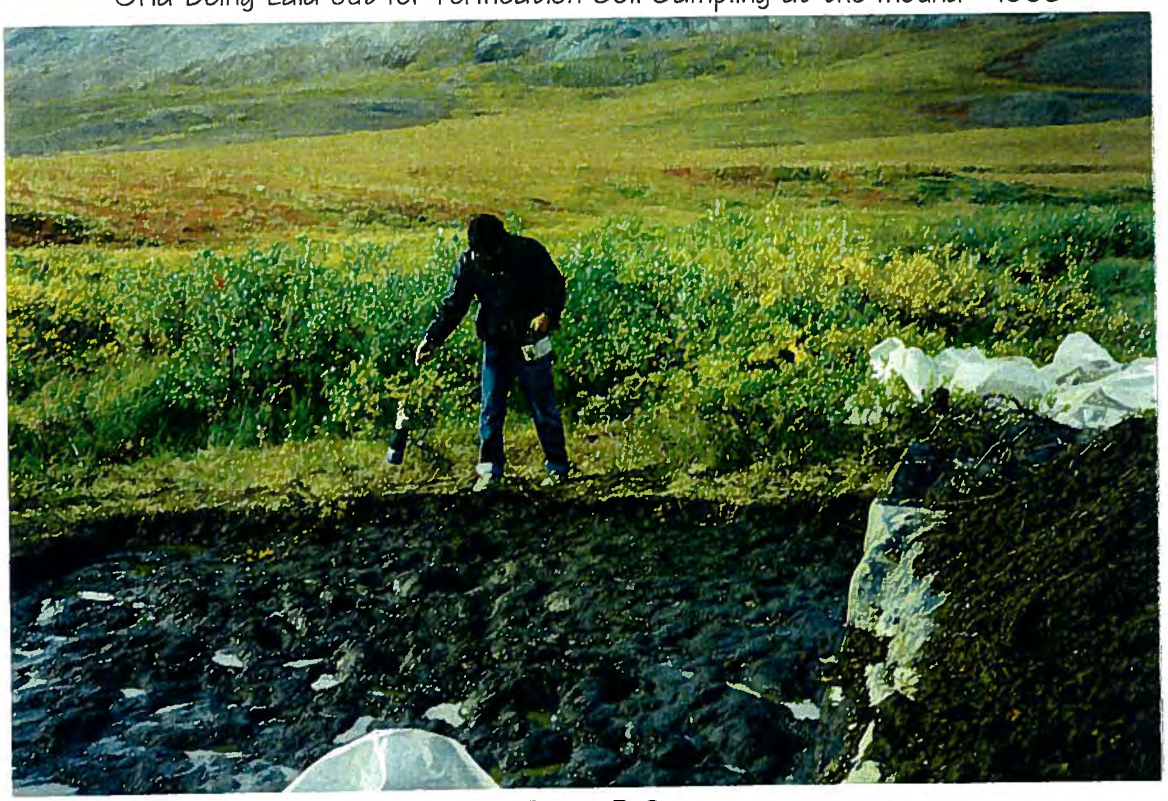


Figure 3-9
Native Village of Pt. Hope Representative Surveying the Cs 137 Plot After Cleanup - 1993

137 plot site. The excavations were filled in, regraded and seeded according to the DOE Remedial Action Plan approved by USF&W (USF&W, 1993).

Approximately 160 cubic yards of contaminated soil were placed in the B-25 containers. In addition dewatering water and protective clothing were also placed in B-25 containers. The containers were loaded on the barge on September 5, 1993 and shipped to Seattle, WA. In Seattle, the B-25 containers were off-loaded onto trucks and transported to the Nevada Test Site for disposal. Burial of these B-25 containers will be completed at the Nevada Test Site low specific activity site in 1994.

During the field operations, IT collected over 200 biota samples. These samples included lichen, sedges, willows, heather, birch, blueberries, mountain avens, cotton grass, Labrador tea, mushrooms, caribou, arctic ground squirrels, willow ptarmigan, grizzly bear, voles, and lemmings. Split samples were taken on various IT Corporation samples by ADEC and Foster Wheeler. In addition, ADEC and Foster-Wheeler took several independent samples. A discussion of ADEC sample results can be found in Chapter 6. Chapter 5, Section 5.6, contains a summary of the ADEC's on-site laboratory results. Appendix C contains the reports from ADEC's contract laboratory. The DOE and NSB reports should be referred to for a complete listing of their results.

Chapter 4

Sample Collection Activities For ADEC Quality Control Samples

4.1 Sediment and Water

4.1.1 Ogotoruk Valley

ADEC personnel documented IT's sampling procedures for several days when background sediment and water samples were taken in the Ogotoruk Valley. In general, the samples were collected at certain distances upstream from the mouth of either Ogotoruk Creek or Snowbank Creek. Snowbank Creek is a tributary of Ogotoruk Creek and had several unnamed tributaries itself. ADEC personnel were present when sediment and water sample splits for ADEC oversight were taken. Photographs with a 35-mm camera or videotapes were taken of the procedures.

Before samples were taken, a Horiba Water Checker, Model U-10, was placed in the stream water to stabilize. After water samples were taken, pH, conductivity, turbidity, dissolved oxygen, temperature, and salinity of the creek were obtained and noted.

Surface water samples were collected by rinsing a gallon freezer bag with creek water, then using a plastic measuring cup to fill the gallon bag placed in a plastic bucket for stabilization. The water was mixed, and the measuring cup was used to pour water into the sample containers. The samplers wore clean latex gloves for each sample. Figure 4-1 shows surface water sampling at Station Two, Tributary 3, of Snowbank creek.

After the first day of sediment sampling with the sediment corer, which was not usable in the mostly rocky substrate, sediment samples were collected into a stainless steel bowl with a stainless steel trowel. Figure 4-2 shows a sediment sample being taken using the sediment corer at Snowbank Creek site seven. The sediment/rocks were mixed in the bowl, then troweled into sample containers. The upper tributaries of Snowbank Creek flowed through fragmented rocks, which were collected as sediment. All samples were placed into a cooler for transport back to the base camp. Labels for both the surface water and sediment had been previously prepared and were placed on the sample bottles at the camp. After the sample was taken, the bottle was dried and the date and time were added to the label. The sample bottles were placed into Ziploc™ bags for transport. Chain of custody tape was not placed on the

Figure 4-1
Surface Water Sampling at Station 2, Tributary 3, Snowbank Creek - 1993

Figure 4-2
IT Personnel Sediment Sampling with Sediment Corer at Station 7 on Snowbank Creek - 1993

Figure 4-3
Vegetation Sampling in an Ephemeral Pond behind the Mound - 1993

water sample bottles, since they were checked to see if the pH was less than two back at the camp. Additional nitric acid was added if necessary, then the bottles were sealed. Clear plastic tape was placed over all labels on the sample bottles.

A Marsh-McBirney flowmeter was used to determine flow of the creek at the sample site, and the altitude of the site was obtained with an altimeter.

One field blank per day was taken for surface water and sediment. The water blank was distilled water carried to the site to rinse the Ziploc™ bag and measuring cup and then poured into a sample bottle. The sediment blank was clean sand carried to the site, poured into the bowl, which had been rinsed with distilled water and dried, mixed with a trowel, which had also been distilled water rinsed and dried, then placed into a sample bottle.

4.1.2 Kisimilok Valley

An ADEC person spent one day with the biota sampling team while they were in Kisimilok Valley collecting vegetation and mammal samples. The ADEC person collected surface water, sediment and soil samples from the three biota sampling sites (KV-1, KV-2, and KV-3). Photographs of the sample sites were taken with a 35-mm camera.

Surface water was collected into the sediment sampling bottle for that site after it had been rinsed three times with creek water. Single use vinyl gloves were worn by the sampler at each site. The water was poured into the water sample bottle that contained nitric acid as a preservative. Labels had not been prepared ahead of time and the bottles were marked with the site name. The sample time, method used and notes were written in a field notebook. A duplicate of surface water was taken at KV-2.

Sediment was collected using a clean stainless steel spoon. The spoon was used to move larger rocks from the creek bed and to scoop up the smaller rocks and sediment. Rocks larger than ½ inch were removed from the sediment sample before placing the sample into the 500-ml plastic bottle. The bottle was labeled with the site name and notes about the time, and method used were noted in a field notebook. A duplicate of creek sediment was taken at KV-2.

Most of the paperwork for the ADEC samples - labels, chain of custody forms - was completed while the biota team was collecting blueberries at KV-1. The sample bottles were sealed with ADEC evidence tape and the labels were covered with clear tape to protect them.

4.2 Soil

4.2.1 Ogotoruk Valley

The background soil samples were collected by IT personnel in Ogotoruk Valley during the first part of the field season. This operation was not observed by ADEC. Splits of various samples were obtained after the samples had been dried and crushed in the on-site lab. Several background samples were sent to Lockheed Laboratory for analyses. Additional samples were analyzed in the on-site lab by ADEC personnel.

4.2.2 Kisimilok Valley

Background soil samples from Kisimilok Valley were collected by ADEC personnel when sediment and water samples were collected. The two soil samples from KV-1 and KV-3 were 5:1 composites. Vegetation was removed from the surface of four corners approximately 1 meter apart and the center of the square meter. Soil from the five subsamples were mixed in a 1 gallon Ziploc™ freezer bag and labeled with the site name. Notes were taken in a field notebook. Labels were completed at KV-1 while the biota team was collecting vegetation samples.

4.2.3 Mound and Cesium Plot

ADEC personnel observed the collection and splitting of samples obtained for oversight and collected one sample from the mound after boards and plastic had been found. The sample collection procedures were usually photographed or videotaped by ADEC personnel. Figures 4-3 and 4-4 show these sampling activities.

The split samples for oversight were collected by IT personnel with clean stainless steel trowels from specified areas, typically as a 4:1 or 5:1 composite. The subsamples were mixed in a clean stainless steel bowl, then split into two or three samples and placed into Ziploc™ freezer bags.

One composite soil sample was collected by ADEC personnel from within the exclusion zone at the mound near the uncovered boards and plastic. Four corners and the center of one square meter created a 5:1 composite that was placed into a stainless steel bowl with a stainless steel spoon. Several rounds of the five subsample sites were taken to provide enough sample for a triplicate split. IT and FW requested splits. The ADEC sampler mixed the soil, then quartered it in the bowl, and took portions from each section to create each split. During the contamination survey before leaving the mound site, radiation readings for personnel footwear exceeded the release level (> 100 cpm) and were removed to be decontaminated. After brushing and washing to remove the soil, the boots were tested, declared clean and returned.

ADEC randomly chose 12 of 37 sample sites for clean closure sampling of the mound and Cesium plot. A split of one of the four composites taken was also obtained. IT was given the list of ADEC split sample requests before the collection of samples. The locations of the ADEC splits were marked with flags or stakes so IT personnel collecting the samples knew whether a split was required or not. The ADEC sample number and the closure site number was prewritten onto the freezer bag and it was given to the IT sampler before that sample was taken. Labels and chain of custody laboratory sheets for the samples were completed after the samples were obtained.

The clean closure samples were mixed in the Ziploc™ bags with clean stainless steel spoons by ADEC personnel, then a portion for the ADEC on-site lab was placed into a smaller Ziploc™ bag. Thirteen of the mound closure samples and five of the Cesium plot closure samples were sent to the contract lab for analyses. The ADEC on-site lab analyzed all 26 samples obtained of the closure samples.

4.3 Biota

4.3.1 Vegetation

The IT biota team collected vegetation samples consisting of several species of lichen (Cetraria delisei and others), willow (Salix alaxensis, Salix lanata), blueberry (Vaccinium uliginosum), heather (Cassiope tetragona), birch (Betula nana), mountain avens (Dryas octopetala), cotton grass (Eriophorum vaginatum), sedge (Carex aquatilis), Labrador tea (Ledum decumbens), and other specimens including fungi. Many vegetation samples were collected near former study sites of the early 1960's in Ogotoruk Creek valley. Vegetation samples were also collected from three sites in Kisimilok Creek valley. Figures 4-3 and 4-4 show the vegetation sampling.

ADEC personnel observed the sampling procedures of the biota team on several days. Photographs with a 35-mm camera and videotapes of the sampling procedures were taken. Samples of abundant species, such as willow, sedges, and blueberries, were collected from within a one square meter frame, while

Figure 4-4
Vegetation Samples in Labeled Sealed Ziploc™ Bags - 1993

Figure 4-5
Dried and Ground Vegetation Samples in On-site Biota Laboratory - 1993

some lichen species were collected on an "as found" basis from the same sample location. Often there was not the quantity of a single species within a square meter for an adequate sample.

The vegetation samples were placed into 1 gallon Ziploc™ freezer bags as they were collected. Once the bag was full, it was sealed with IT custody tape and labeled. One member of the biota team wrote notes concerning the sample collection while the other two members collected the samples. Travel between samples sites was by the Bombardier that could hold five persons, gear, sampling items, and samples.

At the Chariot camp, ADEC personnel observed the biota team air drying vegetation in cheesecloth bags, then oven drying vegetation samples. Splits of the samples were not obtained until they were milled in a Wiley mill. This machine cut the vegetation into very fine particles that were weighed and placed into Ziploc™ freezer bags to be sent to the lab for analysis. Figure 4-5 shows this being done. ADEC personnel observed the weighing and splitting of all the oversight samples. Minimum acceptable weight for the ADEC contract lab was approximately 100 grams oven dried weight. The ADEC split samples were labeled and sealed with ADEC evidence tape.

It was not possible for ADEC to receive splits of all requested samples due to the small amount of sample available at the sites. Several samples when dried, such as fungi and blueberries, weighed approximately 15% of their wet weight and the minimum amount for analysis was not reached. ADEC custody of the samples was not received until the IT chain of custody paperwork had been completed and signed by all parties involved. The ADEC samples were then sent to our off-site laboratory for analyses.

4.3.2 Animals

The IT biota sampling team collected small mammals and ptarmigan in both Ogotoruk Creek valley and Kisimilok Creek valley. Animals collected included arctic ground squirrels, voles, lemmings, caribou, grizzly bear and willow ptarmigan. The arctic ground squirrels were either caught in a Havahart live trap and/or shot on the ground. Voles were snap-trapped and ptarmigan were shot. The caribou samples of hind quarter muscle and bone were obtained in a frozen state from Pt. Hope and Kivalina residents. The grizzly bear sample was found on the beach approximately 5 miles from camp. Muscle and bone from a hind leg were removed from the carcass.

ADEC personnel accompanied the biota team on several days. The biota team collected vegetation and mammal samples on the same days from the same sample sites. Figures 4-6, and 4-7 show some mammal sampling.

The small mammals and ptarmigan were placed into Ziploc™ freezer bags that were labeled and sealed with IT custody tape. Ground squirrels and ptarmigan were refrigerated and later processed by removing skin and viscera, separating muscle from large bones and the rest of the carcass, then freezing the bones, muscle and carcass in separate freezer bags. Voles were left whole after skinning and eviscerating. The caribou and grizzly bear samples consisted of hind limbs. The muscle was separated from the bone and both were frozen in freezer bags. Figure 4-8 shows this being done.

The final processing of the mammal samples occurred by adding distilled water to the frozen carcass or muscle and blending with a heavy duty, explosion proof blender. The resulting semi-liquid was poured and/or spooned into sample containers and weighed. ADEC personnel were present when the selected ADEC mammal samples were split. The ADEC contract lab requested an approximate minimum sample of 150-200 grams. The mammal samples were refrozen in labeled sample bottles and sealed with ADEC evidence tape. The bone samples were processed by removing the muscle and marrow, then were cut with a saw to size. They were placed in a Ziploc™ freezer bag, labeled and sealed with ADEC evidence tape.

ADEC custody of the mammal splits was received after the IT chain of custody paperwork was completed and signed by the parties involved. An ADEC/IT sample number key was supplied to the biota team for the ADEC vegetation and mammal splits.

4.4 Shipment of Samples

All surface water, sediment, soil, mammal and vegetation samples were shipped in coolers to the contract lab. Only the mammal samples were shipped with blue ice so that they would remain frozen. Gross Alpha, Gross Beta, and Cs 137 were requested analyses for every sample. Pu 238, Pu 239/240, and Sr 90 were requested for several soil samples, which were collected from the mound area. Sr 90 analysis was also requested for all lichen samples and mammal samples with bone - arctic ground squirrel and ptarmigan carcasses, and caribou and grizzly bone.

Figure 4-6
Havahart Live Trap Setup for Ground Squirrels at the Mound - 1993

Figure 4-7
Snap Traps Setup for Voles and Lemmings next to Snowbank Creek - 1993

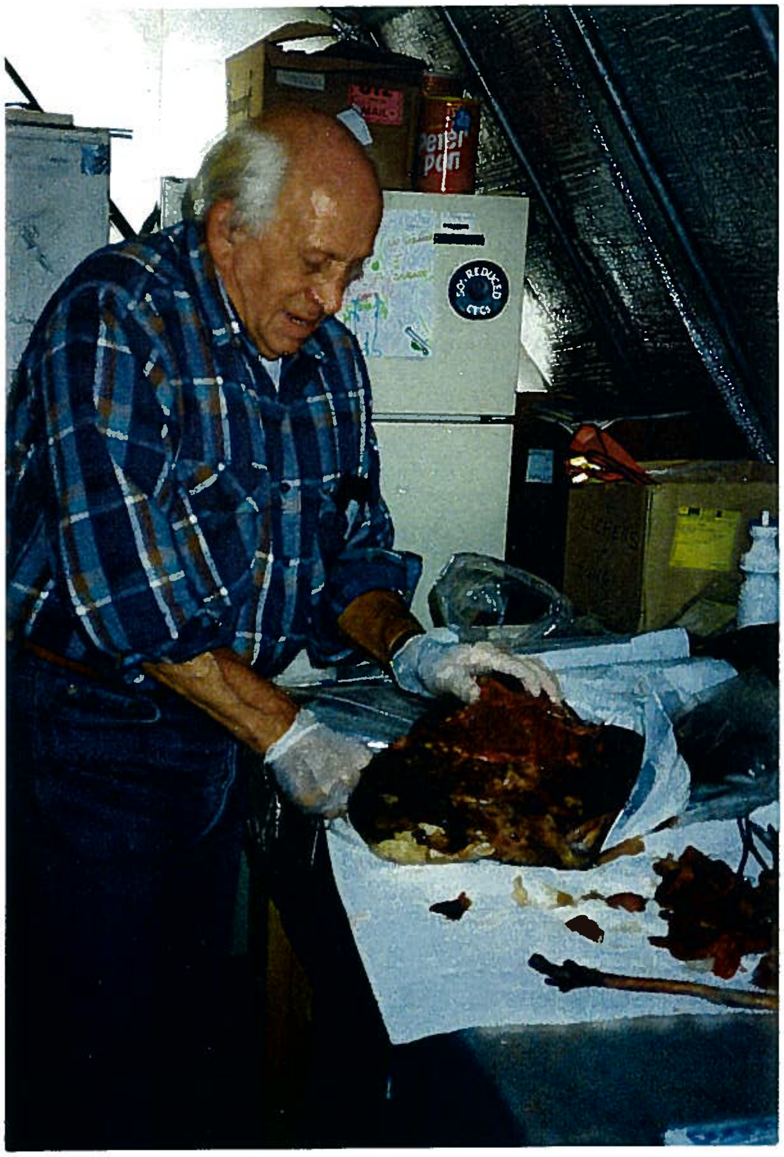


Figure 4-8
Caribou Sample being Cut Apart in On-site Biota Laboratory - 1993

ADEC's contract laboratory's Field Chain of Custody form was completed for each sample cooler, was copied, and then placed within the cooler. The cooler was sealed with strapping tape and ADEC evidence tape and addressed. An ADEC employee escorted the sample cooler to Kotzebue, where the cooler was placed on either Alaska Airlines Goldstreak or Federal Express. Goldstreak provided overnight service to Las Vegas from Kotzebue; however, the service was counter to counter. Twice an extra charge was paid to have the cooler delivered to the lab, but it was not delivered. The sample custodian of the lab once found the cooler in the baggage claim area and once at the counter of Alaska Airlines. Lockheed Laboratories reported that the ADEC custody seals remained intact. ADEC then switched to Federal Express two day service. The coolers were either kept at the air freight office or delivered to the contract lab. The mammal samples were shipped via Goldstreak service since they had to remain frozen.

Chapter 5

ADEC On-site Gamma Spectroscopy Laboratory

5.1 Purpose of Facility

Costs were very high for maintaining personnel and equipment at a site as remote as the Project Chariot location. These high costs made it imperative that everything possible be done to accelerate the completion of on-site activities. The on-site gamma spectroscopy laboratory's function was to make possible the on-site screening of soil samples from the mound and located study plots, with an approximate twelve-hour turn-around-time as opposed to the several days required for off-site laboratory determinations. Since the principal radionuclide contaminant present at the site, Cs 137, was easily detectable at concentrations well below the specified cleanup level of 10 pCi/g, this facility allowed rapid decisions to be made by IT, and reviewed by ADEC, concerning the segregation of contaminated from non-contaminated soil and whether further excavation was necessary.

In addition, this facility made it possible for ADEC to conduct rapid determinations at a minimal expense on additional samples, such as those submitted by area residents.

The laboratory building, sample preparation facilities, and standard sources were shared with IT personnel. However, although virtually identical hardware and software were used by ADEC and IT, sample determinations were made completely independently using different instrumentation. The representative of FW, who was acting in an oversight capacity for the NSB, did do a number of determinations using the same equipment as ADEC. Their October 5, 1993 report states "The analytical data from DOE's on-site laboratory that was reviewed in the field appear to be representative of site conditions. These data were also consistent with both Foster Wheeler and the State's on-site analysis."(FW, 1993).

It should be noted that for final closure of the mound and test plot, analytical determinations, including gross alpha and gross beta analyses along with gamma spectroscopy, were conducted at off-site laboratories.

5.2 Instrumentation

The spectroscopic instrumentation and software for the laboratory were purchased from Canberra Industries, Incorporated, and the model numbers shown in this report are those found in the Canberra Industries Nuclear Products Division Catalog, Edition Nine.

The detector used was a coaxial intrinsic germanium detector, # GC3019, with a relative efficiency of 30% and an absolute efficiency varying from nine to 1.0 % over the 100 to 2000 keV range, with the sample geometry used. A model 707 lead shield containing two inches of lead shielding in a steel jacket and lined with a tin/copper alloy was used to shield the detector from background sources of radiation.

The detector is powered by a Model 3106D 0-6 kV power supply with less than 3 mV noise or ripple and voltage drift not exceeding .01% per hour.

The detector was cooled by a Freolectric cryostat capable of maintaining a detector temperature of about 100 Kelvin.

The signal from the detector entered a Model 2002 preamplifier having a rise time of less than 20 nanoseconds and a count rate capability of 200,000 counts per second. This preamplifier was integrated into the detector assembly. Circuitry for monitoring the detector temperature was included in this unit.

The signal pulse passed next to a Model 2022 amplifier with filter shaping and baseline restorer capability.

An AccuSpec A Acquisition Interface Board installed in an IBM PS/Valuepoint computer accepted the signal from the amplifier. This board serves the function of a multichannel analyzer including pulse height analysis and analog to digital conversion. The spectral information obtained is stored in computer memory.

5.3 Software

Two computer software programs were used for the acquisition and analysis of spectral data.

The AccuSpec Display and Acquisition Software was used for controlling the acquisition of spectral data via the AccuSpec A Acquisition Interface Board. This included setting such key parameters as the number of channels in which data was to be collected, the range of gamma energies to be spanned in the collection, the duration of the counting, and the naming of the computer file to receive the acquired data.

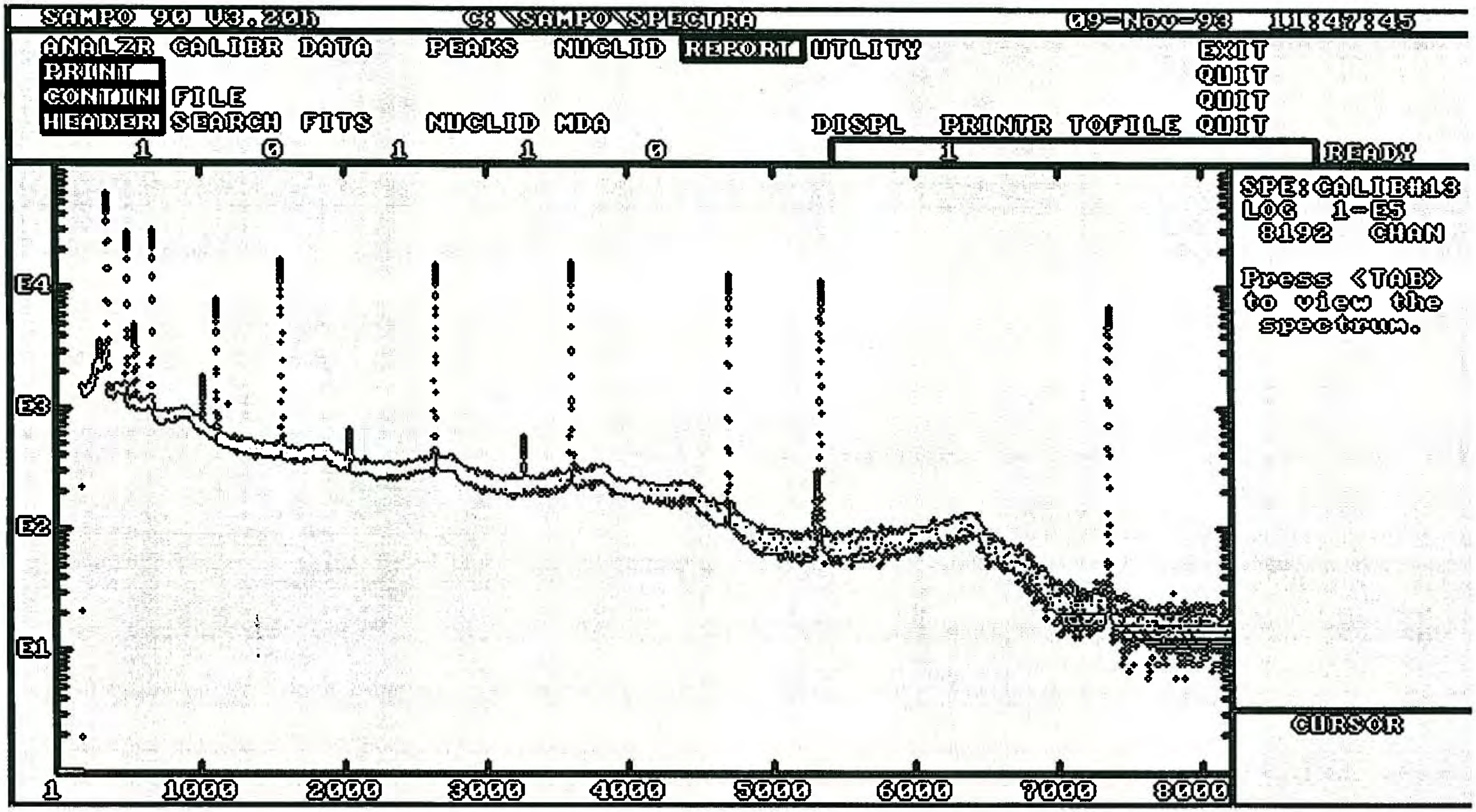
The data files created by the AccuSpec program were transferred to a spectral analysis program titled Sampo 90. This software package was used for calibration of the peak energy versus channel number, the detector efficiency calibration which is used to convert the number of observed counts to the actual activity of the sample, and for peak shape calibrations that allow the program's algorithms to compensate for varying peak widths and shapes. The program allowed the subtraction of both Compton scattering and peaked backgrounds from the observed spectra. The spectral data were compared to the information in a library file and the radionuclides responsible for the peaks were identified. Figure 5-1 provides an example of the spectral data display on the computer screen. The efficiency calibration data at each peaks' energy was used to evaluate the activity of the sample due to the observed radionuclide. A report was generated for each sample that indicated the observed peaks, the radionuclides present, and the activity of each. Sometimes included, especially for closure samples, were the results of an algorithmic calculation of the minimum detectable activity of each radionuclide in the library, which allowed the operator to decide if the count time was sufficient to positively identify any radionuclides present.

5.4 Sample Preparation

Samples were obtained from the field in labeled Ziploc™ plastic bags. The information on the bags label was transferred to aluminum foil pans (approximately 8 in. X 4 in. X 3 in.), and the sample was transferred to the aluminum pan. The samples were placed in an oven at a temperature of 105° C until they were thoroughly dry, usually about 12 hours. After the dry samples were allowed to cool, and were then crushed and homogenized, rocks and twigs were removed. A nominal 50 gram portion was transferred to a tared plastic petri dish and weighed to the nearest 0.01 gram on an electronic single pan balance. A lid containing the sample number and collection date was placed on the petri dish and the edges sealed with black electrical tape. The sample containers and sample weight and texture were close approximations to the configuration of the standard source used to calibrate the spectrometer. A clean pair of latex rubber gloves was worn for the preparation of each sample. A designated waste container was used for the disposal of the gloves and pans. Unused portions of the dried sample were returned to the Ziploc™ bags for disposal upon completion of all sampling activities, or for the preparation of future counting specimens if required.

Figure 5 -1

Example of Computer Screen Spectral Data Display



5.5 Quality Assurance

5.5.1 Calibration with Standard Sources

The standard radionuclide source used to do the energy, efficiency, and peak shape calibrations for the spectroscopy system was obtained from Analytics, Inc. of Atlanta, Georgia, which is a participant in a radioactivity measurements assurance program conducted by the National Institute of Standards and Technology, a division of the U.S. Department of Commerce. This source is numbered 46567-334 and was prepared by adding a gravimetrically measured aliquot of a master radionuclide solution to 50 grams of sand in a 2 3/4 inch plastic petri dish. The calibration date for the source is April 1, 1993. Specifications for the source are shown in Table 5-1.

Table 5-1

Master Radionuclide Source Specifications

ISOTOPE	GAMMA ENERGY	HALF-LIFE	GAMMA'S PER SECOND	TOTAL UNCERTAINTY
Cd-109	88	462.6 days	2023	4.7%
Co-57	122	271.7 days	975.7	4.6%
Ce-139	166	137.64 days	1647	4.8%
Hg-203	279	46.60 days	2467	4.8%
Sn-113	392	115.08 days	2221	4.5%
Cs-137	662	30.0 years	1565	4.9%
Y-88	898	106.61 days	5938	4.6%
Co-60	1173	5.2714 years	2852	4.8%
Co-60	1332	5.2714 years	2860	4.7%
Y-88	1836	106.61 days	6245	4.8%

The energy calibration, which creates a linear fit of the energy of the peaks in the standard to the channels in the multichannel analyzer, used all ten of the peaks in the standard source given above. The resulting fit had a maximum deviation from linearity of .089 keV. When contrasted to a channel width of 1/4 keV per channel, this shows a quite adequate energy calibration.

The efficiency calibration gave a typical efficiency versus peak energy curve with an efficiency of 0.086 at 122 keV and an efficiency of 0.010 at 1836 keV. The efficiency at the higher energies is quite good for this type of detector. The uncertainty in the efficiency determinations varied from 4.5 to 5.0%, which is comparable to the uncertainty in the count rates for the peaks of the standard source.

The shape calibration gave full width at half maximum values varying from 1.3 keV at low energies to 2.2 keV at the highest energy peak. These values are somewhat greater than optimal, but are still within normal parameters.

5.5.2 Calibration Checks

This system was used for the analysis of 91 samples, beginning on August 10, 1993 and concluding on August 23, 1993 (this includes analyses done by the FW representatives). During this period 18 calibration checks were done. The first check revealed an error in the input data and the system was recalibrated on the same day. A Canberra instrument representative was on-site for several days to help with the startup. The subsequent checks showed that for the three peaks monitored (Cd-109, Cs-137, and the 1332 keV peak of Co-60) the activities remained constant within a 3% range, and the peak centroid channel numbers varied by a maximum of three channels. There was some initial concern that temperature fluctuations within the tent housing the laboratory would affect the detector sensitivity, but this seems to have not been a problem.

5.5.3 Background Evaluation and Background Checks

The background counts for the peak background subtraction operation of the Sampo 90 program was obtained using a 50-gram sample of washed sea sand obtained from Malinkrodt Chemical corporation. The count time was 12 hours and 51 minutes. Three peaks were observed in excess of 1.0 pCi/g: K-40 at 14.4 pCi/g, Pb-210 at 8.03 pCi/g, and Th-234 at 1.18 pCi/g. These are all ubiquitous naturally occurring radionuclides, and the peak background subtraction operation did not affect the determination of any of the radionuclides contaminates at this site. Appendix E contains the ADEC on-site background evaluation checks.

5.5.4 Comparison of Bulk and Homogenized Sample Results

One split sample from the only identified plot site (JEK 0062) was randomly selected for an evaluation of the homogeneity of the samples collected. The bulk wet sample was divided into three portions designated A, B, and C. These were transferred to separate aluminum pans for drying. After drying the contents of each pan were separately crushed and mixed to produce a homogeneous mixture. Three 50 gram samples from each portion were then prepared for analysis. The only radionuclides identified in these samples were K-40 and Pb-212. Both were found at concentrations that are consistent with naturally occurring background levels. The results for each sample and the estimated errors are shown in Table 5-2.

Table 5-2

Comparison of Bulk and Homogenized Sample Results

SAMPLE	ACTIVITIES (pCi/g) K-40	Pb-212	ERROR (%)
A1	7.88	not found	14.5
A2	7.13	not found	18.2
A3	1.20	0.783	11.4, 16.2
	$\bar{X}$ = 5.4 σ = 3.6		
B1	1.03	0.574	10.6, 15.0
B2	1.04	not found	5.3
B3	9.35	0.861	9.9, 15.8
	$\bar{X}$ = 3.8 σ = 3.0		
C1	1.10	0.509	10.4, 18.4
C2	4.76	0.707	21.2, 12.4
C3	9.61	0.745	10.1, 14.7
	$\bar{X}$ = 5.2 σ = 4.3		

The mean values and the estimated standard deviation for the K-40 activities of the three samples from each portion of the original bulk sample are also given. Apparently obtaining truly homogeneous soil samples for the determination of trace levels of activity is not readily achieved. Nonetheless, it is also apparent that there is no significant difference between the mean of the determinations for the A, B, and C portions of the original bulk sample. This tends to support the quantity and redundancy of the sampling and analysis activities during this project, i.e., as the number of samples increases, the apparent differences between individual samples tend to shrink in significance.

5.6 Number and Type of Sample Determinations

A total of 66 determinations were made on soil samples by ADEC. Of these, 10 were background samples from areas thought to be free of radionuclide contaminates (except for fallout from atmospheric nuclear weapons tests); 10 were for samples of soil collected from soils excavated from the mound and test plot areas; 8 were from the surface of the excavations following the removal of the various lifts of soil; 15 were mound closure samples; and 23 were test plot closure samples.

Table 5-3 provides the sample locations and the results of ADEC on-site laboratory determinations for Cs-137 activities.

Table 5-3

ADEC On-site Laboratory Soil Sample Determinations

Samples SS-xxx	Analyzed FW	by DEC	Location	Cs-137 Activity (pCi/g)
002		X1	Cesium plot, Snowbank Creek	929
002		X	Cesium plot, Snowbank Creek	963
006		X2	Background Site A, 2 - 4"	ND
025		X3	Background Site D, 2 - 4"	ND
028		X4	Background Site D, 2 - 4", Blank dup, 200' west of excavation zone	ND
035		X5	Composite from 4 corners of excavated mound soil pile	ND
036		X6	Mound lift #3, excavated soil	ND
030		X7	Grab sample from excavated soil, lift #3	ND
039		X8	Mound after lift #4, 2 - 4"	ND
042		X9	Composite from lift #4 excavated soil pile	ND
043		X10	North side of mound, 5' from poss. rad area	ND
043	X		North side of mound, 5' from poss. rad area	
048		X11	Northeast corner of mound, from excavation surface 2 - 4" below grade	627
058		X	Center of dirt pile on north side of mound, composite	ND
058		X	SR381201 and 02, sequence numbers incorrect	ND
053	X		Composite from northwest portion of excavated soil from mound	
033	X		Grab sample from lift #2, mound excavation	
040	X		Middle of lift #4, excavated soil	
041	X		Middle of lift #4, excavated soil	
045		X22	Northwest corner of mound in lift #5	ND

056		X69	Excavation mound north pile east side on top of mound	<0.353
064		X21,67	Area west of mound, 0 - 2", assumed to be clean	ND
067 DLA036		X47	Surface composite, SE corner of mound	3.16
071		X20	East side of Cs plot, composite of 3 grabs, 0 - 4"	0.695
072		X68	South side of cesium plot, composite of 2 grabs, 0 -4"	1.28
079		X66	Southwest corner of excavated mound area, 2 - 4" grab	<0.445
080		X65	Southeast corner of excavated mound area, 2 - 4" grab	<0.295
083	X		Mound, 8-composite of excavated soil from trench	
083	X		Mound, 8-composite of excavated soil from trench	
JEKxxx				
025		X17	Four grabs from surface of soil in three B-25's, 12:1 composite, lift #6 soils	1.39
028		X18	Kisimilok Valley location KV-2, 5:1 composite at 0-2"	0.104
033		X19	Kisimilok Valley location KV-2, 5:1 composite at 0-2"	0.995
037		X23	8:1 composite of soil excavated from trench on the west side of the mound location.	ND
038		X25	Mound verification sample, grid #2	<0.470
039		X24	Mound verification sample, grid #9	0.721
040		X27	Mound verification sample, grid #11	0.818
041		X26	Mound verification sample, grid #13	3.98
042		X28	Mound verification sample, grid #14, first split	24
042		X29	Mound verification sample, grid #14, second split	1.68
042		X30	Mound verification sample, grid #14, third split	25.1
043		X31	Mound verification sample, grid #17	1.91
044		X32	Mound verification sample, grid #18	<0.333
045		X33	Mound verification sample, grid #23	0.571

046		X34	Mound verification sample, grid #26	<0.208
047		X35	Mound verification sample, grid #28	<0.402
048		X36	Mound verification sample, grid #35	<0.295
049		X37	Mound verification sample, grid #37	<0.366
050		X38	Mound verification sample, south quadrant composite	2.69
051		X41	Cesium test plot verification sample, grid #2	<0.318
052		X60	Cesium test plot verification sample, grid #3	<0.460
053		X43	Cesium test plot verification sample, grid #8	<0.303
054		X62	Cesium test plot verification sample, grid #11	3.56
054		X63	Cesium test plot verification sample, grid #11	3.21
055		X44	Cesium test plot verification sample, grid #15	<0.366
056		X58	Cesium test plot verification sample, grid #18	<0.455
057		X42	Cesium test plot verification sample, grid #22	1.03
058		X59	Cesium test plot verification sample, grid #23	<0.251
059		X40	Cesium test plot verification sample, grid #24	1.1
060		X45	Cesium test plot verification sample, grid #26	<0.419
061		X46	Cesium test plot verification sample, grid #28	on-site data lost
062 9 splits		X48 -57 skip 54	Cesium test plot verification sample, grid #31	<0.251
062			Cesium test plot verification sample, grid #31	<0.295
062			Cesium test plot verification sample, grid #31	<0.295
062			Cesium test plot verification sample, grid #31	<0.311
062			Cesium test plot verification sample, grid #31	<0.251
062			Cesium test plot verification sample, grid #31	<0.326
062			Cesium test plot verification sample, grid #31	<0.231
062			Cesium test plot verification sample, grid #31	<0.326
062			Cesium test plot verification sample, grid #31	<0.311

063		X61	Cesium test plot verification sample, west composite	<0.318
DHDxxx				
021		X13	5:1 surface soil composite 4300' upstream from mouth of Snowbank Creek	ND
021		X14	5:1 surface soil composite 4300' upstream from mouth of Snowbank Creek, second run	0.122
021		X14	5:1 surface soil composite 4300' upstream from mouth of Snowbank Creek, third run	0.121
022		X15	5:1 surface composite from NE quadrant of mound exclusion zone, August 12, 1993	127

There are also 11 samples with FWxxMD designations only, and two samples designated SCHAxxxx which were run by Bruce Honeyman of Foster Wheeler. The sample logs for these samples are currently unavailable, so they are not included in the table.

Sequence #12, 16, 39, and 54 were skipped; Sequence #64 was a calibration check; The sequence #'s for two SS058 runs were out of order (001 and 002 used twice), so the net number of DEC determinations is then = 69 - 5 + 2 = 66.
Background samples = 10
Excavated soil piles samples = 10
Excavation surface, nonclosure samples = 8
Mound closure samples = 15
Test plot closure samples = 23

Chapter 6

Discussion of Sampling Results

6.1 General Discussion

Results of the ADEC split and independent water, sediment, soil and biota sampling will be discussed in this chapter. Before reviewing the results of the radionuclide sampling, artificial radionuclides in the environment, natural radionuclides and decay chains, and laboratory detection limits will be discussed.

6.1.1 Global Fallout

In reviewing the results of sampling for radionuclides in the environment it is important to be aware of artificial radioactive fallout. Artificial radioactive fallout consists of particles released into the atmosphere from nuclear explosions or discharged from nuclear power plants during reactor operations or accidents.

Above ground testing of nuclear weapons by the United States, the former Union of Soviet Socialist Republics, United Kingdom, France and China from the 1940's through the 1970's injected large amounts of radionuclides into the atmosphere. For example it is estimated that 15 million curies of Sr 90 fell to the earth before 1970 (Shapiro, 1990). In 1963 the Limited Test Ban Treaty was signed and the United Kingdom, United States and the USSR halted their above ground testing. China and France, who were not treaty members, continued with above ground testing through the 1970's. Once the United States, USSR and the United Kingdom ceased their above ground testing in 1963 the levels of global fallout began to decline. Except for the input into the atmosphere from nuclear reactor incidents, such as Chernobyl, and venting from underground tests, worldwide levels of radioactive fallout continue to decline.

Fallout from nuclear explosions can be classified as local, tropospheric, or stratospheric. Local fallout, as defined by in a Report of the United Nations Scientific Committee on Effects of Atomic Radiation, 1982, is deposited within 100 miles of the test site. Material injected into the troposphere remains there on average for about 30 days. The bulk of the radioactive material from above ground testing of nuclear weapons has been injected into the stratosphere at altitudes of less than 12 miles (Faw, 1993). Once the radioactive material is injected into the stratosphere it may remain there several years before returning to the earth's surface as fallout. Because of this long retention time of the material in the stratosphere the many radionuclides with short half-live's of days or several months usually decay to levels that are not detectable, or are not considered a health concern. This radioactive material eventually deposits itself as fallout to the earth's surface mainly by being cleansed from the atmosphere by precipitation. Northern Alaska received about one-quarter as much fallout as the northern contiguous United States (Hanson, 1993). Distribution of fallout is dependent on the location of the nuclear detonation, deposition mechanisms, wind patterns and distance from the initial detonation.

Due to the northern Alaska's geographic location in relation to above ground testing sites, local fallout has not occurred with the exception of the 15 pounds of local fallout from Project Sedan carried to the Project Chariot site for the USGS 1962 tracer study. Principal radionuclides of concern from fallout in northern Alaska have been Cs 137 and Sr 90. These radionuclides have a long half-life and can be bioconcentrated through the food chain. Another radionuclide I 131, with a half-life of eight days, is of a short-term concern, generally just after the occurrence of local fallout. Sampling data suggests that in northern Alaska deposition of I 131 was lower than in the northern contiguous United States (Hanson, 1966). Other radionuclides deposited from fallout in northern Alaska may not enter environmental pathways that would affect the biota, or they may exist at levels that are not considered to pose a health threat to humans (Stutzman, 1986).

Samples taken during the Project Chariot field operations in July and August 1993, detected Cs 137 and Sr 90 that resulted from global fallout in background samples. The Cs 137 and other long lived radionuclides used by USGS in their tracer studies in 1962 were found in the disposal mound and in one or several of the study sites around Snowbank Creek. Appendix E contains the sample site location maps (IT, 1993).

6.1.2 Limits of Detection Values

In sampling for radionuclides in the environment, it is not unusual to find little or no activity. This frequently results in the laboratory reporting values as less than the measured limit of detection. This limit of detection may be defined as, "the lowest concentration that can be determined to be statistically different from a blank (a sample not containing any of the tested for material) (Gilbert, 1987)." In ADEC's contract laboratory results this may be represented by a "<" sign before the number, or by a "<" Minimal Detectable Activity (MDA). In this report ADEC's calculations of the mean, standard deviation and variance has been computed using all the reported values, including "<" numerical values. This allows for all the data to be evaluated statistically without an arbitrary cutoff of small or negative numbers. This follows the reporting rationale for radionuclides used by the US Environmental Protection Agency (EPA) for environmental data (EPA, 1992).

6.1.3 Naturally Occurring Radionuclides

Soil, sediment, water and biota samples taken during the Project Chariot field operations also detected naturally occurring radionuclides. These radionuclides, along with their decay products, are part of the earth's original composition. Table 6-1 shows the typical concentration of several natural occurring radionuclides in the ground. While these are typical values, it is not unusual to find much higher naturally occurring levels.

Table 6-1

Typical Levels for Naturally Occurring Radionuclides in the Ground
(Activity in pCi/g)

Type of Rock	Potassium 40	Uranium 238	Thorium 232
Igneous	21.6	1.6	1.31
Sandstone	9.1	0.50	0.65
Shale	22.5	1.2	1.09
Limestone	2.25	0.75	0.14
Granite	>29	>3.0	>3.9
World Average	10	0.7	0.6

Source: Faw, R.E., Shultis, J.K., RADIOLOGICAL ASSESSMENT SOURCES AND EXPOSURE, PTR Prentice-Hall, 1993
Shapiro, J., RADIATION PROTECTION A GUIDE FOR SCIENTISTS AND PHYSICIANS, 3rd Addition, Harvard University Press, 1990

Geologically the Ogotoruk Valley bedrock consists entirely of consolidated sediments, believed to have been deposited in marine environments. Bedrock typically consists of shaly sandstones, mudstone, limestone, and shaly silts. The principal bedrock underlying the Project Chariot site is a "grayish-black mudstone and siltstone, slaty to shaly, with gray to brown very fine to medium grained graywacke". This bedrock is covered by a thin layer of unconsolidated sediments consisting of peat, sand, silt, and gravel (Wilimovsky, 1966).

The soil and sediment sampling done found that Potassium 40 (K 40), Lead 210 (Pb 210), Lead 212 (Pb 212), Radium 224 (Ra 224), Radium 226 (Ra 226), Radium 228 (Ra 228), Bismuth 212 (Bi 212), Bismuth 214 (Bi 214), Uranium 235 (U 235), Actinium 228 (Ac 228), Thorium 228 (Th 228), Thorium 229 (Th 229) and Thallium 208 (Tl 208) were the principal naturally occurring radionuclides present. The radionuclides and the activity levels are consistent with the geologic make up of Ogotoruk Valley. These radionuclides are produced by three primordial decay chains originating with the parent radionuclides of U 235, U 238, and Th 232. Tables 6-2, 6-3, and 6-4 list three natural decay chains.

Table 6-2

Decay Series of Uranium 235

Isotope	Principle Particle emitted	Half-life
Uranium (U-235)	alpha	713,000,000 yr
Thorium (Th-231)	beta	25.6 hr
Protactinium (Pa-231)	alpha	34,300 yr
Actinium (Ac-227)	beta	22.0 yr
Thorium (Th-227)	alpha	18.6 hr
Radium (Ra-223)	alpha	11.2 days
Radon (Rn-219)	alpha	3.917 sec
Polonium (Po-215)	alpha	0.00183 sec
Lead (Pb-211)	beta	36.1 min
Bismuth (Bi-211)	alpha	2.16 min
Polonium (Po-211)	alpha	0.52 sec
Thallium (Tl-207)	beta	4.79 min
Lead (Pb-207)		Stable

Table 6-3

Decay Series of Uranium 238

Isotope	Principle Particle emitted	Half-life
Uranium (U-238)	alpha	4,500,000,000 yr
Thorium (Th-234)	beta	24.101 days
Protactinium (Pa-234)	beta	1.175 min
Uranium (U-234)	alpha	247,500 yr
Thorium (Th-230)	alpha	80,000 yr
Radium (Ra-226)	alpha	1,622.0 yr
Radon (Rn-222)	alpha	3.825 days
Polonium (Po-218)	alpha	3.05 min
Lead (Pb-214)	beta	26.8 min
Bismuth (Bi-214)	alpha 0.04% beta 99.96%	19.72 min
Polonium (Po-214)	alpha	163.7 usec
Thallium (Tl-210)	beta	1.32 min
Lead (Pb-210)	beta	22.5 yr
Bismuth (Bi-210)	beta	4.989 days
Polonium (Po-210)	alpha	138.374 days
Lead (Pb-206)		Stable

Table 6-4

Decay Series of Thorium 232

Isotope	Principle Particle emitted	Half-life
Thorium (Th-232)	alpha	13,900,000,000 yr
Radium (Ra-228)	beta	6.7 yr
Actinium (Ac-228)	beta	6.13 hr
Thorium (Th-228)	alpha	1.90 yr
Radium (Ra-224)	alpha	3.64 days
Radon (Rn-220)	alpha	54.53 sec
Polonium (Po-216)	alpha	0.158 sec
Lead (Pb-212)	beta	10.67 hr
Bismuth (Bi-212)	alpha 33.7%, beta 66.3 %	60.48 min
Polonium (Po-212)	alpha	0.29 sec
Thallium (Tl-208)	beta	3.1 min
Lead (Pb-208)		Stable

In addition to the radionuclides occurring from these decay chains Berilluym 7 (Be 7) and Potassium 40 (K 40) were also detected.

Be 7 has a half-life of 53 days. This radionuclide is ubiquitous in air samples taken worldwide and results from cosmic ray interaction in the earths atmosphere, with nitrogen and oxygen. Decay is principally by electron capture, resulting 10% of the time in gamma emissions. It may be removed from the atmosphere by precipitation and was detected in some soil and plant samples (Faw, 1993).

K 40 was the most abundant radionuclide found in ADEC samples. K 40 is a singular primordial radionuclide, having been present when the earth was formed, and not existing as part of a decay chain. It has a half-life of around 1,227,000,000 years. Decay is principally by beta emissions and electron capture, which results in a gamma emission about 10% of the time (Faw, 1993).

6.1.4 Sample results from September 1992

On September 10 - 13, 1992, the Alaska Department of Environmental Conservation (ADEC) and the Army Corps of Engineers (COE) conducted a site investigation of the Project Chariot site. A radiological survey of the ground surface was conducted in the area and no elevated readings above background were observed. A single reading of 0.1 mR/hr, which could not be reproduced, was obtained off the bit of a soil auger used to drill a hole into the mound. After the hole was back filled no elevated readings were observed at the ground surface. In addition to the radiological survey, several soil and water samples were collected and analyzed in a COE contract laboratory. The soil samples were later rerun at a DOE contract laboratory. Results are shown in Table 6-5.

Table 6-5

Sample Results from Sept. 10 - 13, 1992 site visit

Sample #	92CHA01	92CHA02	92CHA03	92CHA04
Lab #	K5811-1	K5811-2	K5811-3	K5811-4
Sample Type	Soil	Soil	Soil	Water
Gross Alpha (COE)	27.6 +/- 9.2	16.5 +/- 7.9	17.1 +/- 8.1	< 2**
Gross Alpha (DOE)	4.86	13.9	13.9	
Gross Beta (COE)	46.1 +/- 12.7	30.1 +/- 11.9	45.7 +/- 12.7	4 +/- 3***
Gross Beta (DOE)	1.56	10.2	10.9	
Sr 90 (DOE)	0.425	0.179	1.02	

* Results in picocuries per gram (pCi/g) for soil and picocuries per liter (pCi/L) for water.
** Laboratory detection limit 2 pCi/L
*** Laboratory detection limit 3 pCi/L

K5811-1 Pocket of relatively fine stream deposit confluence of Snowbank & Ogotoruk Creek, 9/11/92
K5811-2 Surface of "burial mound" southwest face 9/12/92
K5811-3 Approximately 3.5 feet into the burial mound southwest face
K5811-4 Water from Snowbank Creek approximately 45 yards below the burial mound

The DOE contract laboratory also reported the following naturally occurring radioisotopes: K 40, RA 226, TH 228, and TH 232.

Based on these results, the water samples do not exceed the Maximum Contaminant Levels for gross alpha and beta in the State of Alaska's Drinking Water Regulations (18 AAC 80). Soil sample results for gross alpha and beta were within the ranges observed in the later summer of 1993 field sampling. The DOE contract laboratory results were lower for gross alpha and beta, detected low levels of Sr 90 and only identified naturally occurring radionuclides in the gamma spectrogram. Due to sampling techniques, variation in laboratory QA/QC between laboratories, and sample size, these results are considered inconclusive.

6.2 Water and Sediment Sample Results

6.2.1 Cs 137 Results

All of the ADEC Cs 137 sample results for surface water samples were less than the measured limit of detection.

Ogotoruk Creek sediment sample results ranged from a low of 0.03 pCi/g to a high of 0.05 pCi/g, with a mean of 0.04 +/- 0.01 pCi/g. The lowest result occurred in a sample from the mouth of Ogotoruk Creek and the highest at site four, above the confluence with Snowbank Creek.

Snowbank Creek sediment sample results ranged from 0.04 pCi/g to 0.69 pCi/g, with a mean of 0.25 +/- 0.38 pCi/g. The lowest result occurring at sample Site 1, and the highest at Site 7. Site 7 was below the discovered Cs 137 plot and the mound. Sediments at Site 7 consisted of organic soil and fine-grain soil, and sediments from Site 1 and 2 consisted of a rocky substrate.

Organic fine grained soil, such as that at Site 7, generally has a greater ability to absorb and hold Cs 137 than does a rocky substrate. In addition the gentler gradient of this section allows for greater deposition of fine grained sediment. The finding of 0.688 pCi/g in the fine grain sediment is within the range of values in background surface soil. Our data do not show that the Cs 137 plot or the mound contributed to the difference in Cs 137 levels between sample sites on Snowbank Creek.

Sediment sample results from the adjacent Kisimilok Valley ranged from 0.03 pCi/g to 0.05 pCi/g, with a mean of 0.04 +/- 0.01 pCi/g. Again these are within observed background levels for Cs 137.

6.2.2 Sr 90 Results

ADEC did not run Sr 90 on water or sediment samples; previous tests run on the COE water and sediment samples by DOE did not detect Sr 90. Sr 90 did not make up a principal portion of any radioactive tracer material that USGS used, although there would have been minute quantities in the Project Sedan material. The mound verification samples and some biota samples were analyzed for Sr 90, where bioconcentration could occur.

6.2.3 Gross Alpha and Beta Results

6.2.3.1 Water

In ADEC surface water samples, gross alpha values were below the laboratory detection limit, except for the seepage water sample from Crowbill Point. The gross alpha level for the water sample from Crowbill Point was 4.4 pCi/L. This is within the State of Alaska Drinking Water Regulations Maximum Contaminant Level of 15 pCi/L (18 AAC 80, 1991). This water was the result of seepage from black shale-like rock parent material near the base of Crowbill Point. Figure 6-1 shows this sample location. A soil sample from Crowbill Point had a gross alpha level of 24 pCi/g.

Gross beta levels for all of ADEC samples were below the laboratories detection limit. Results of all water samples were well within the State of Alaska Drinking Water Regulations Maximum Contaminant Level of 50 pCi/L (18 AAC 80).

6.2.3.2 Sediment

Gross alpha sediment sample results for Ogotoruk and Snowbank Creeks ranged from 9.2 pCi/g to 26.4 pCi/g, with a mean of 16.2 +/- 5.9 pCi/g. Sediment samples from Kisimilok Creek ranged from 9 pCi/g to 15.3 pCi/g, with a mean of 11.6 +/- 2.8 pCi/g.

Sediment gross beta results for Ogotoruk and Snowbank Creeks ranged from 14.2 pCi/g to 29.6 pCi/g, with an average of 19.6 +/- 5.6 pCi/g. Kisimilok Creek sediment samples ranged from 15.7 pCi/g to 21.2 pCi/g, with an average of 19.6 +/- 2.6 pCi/g.

The observed ranges do not suggest any anomalies in sediment gross alpha or beta activities between the two valleys, or within the same valley. Variations in sample levels can be accounted for by the difference in parent geological materials.

Figure 6-1
Location for Sample 0023DHD93PC Near Crowbill Point

6.3 Soil Samples

6.3.1 Cs 137 Background Results

The highest Cs 137 soil background sample level obtained by ADEC was 1.48 pCi/g. This was a surface soil sample from Kisimilok Valley Site 3. The mean for all ADEC background soil samples was 0.19 +/- 0.39 pCi/g. The Kruskal-Wallis test, a non-parametric statistics test, was performed on the background Cs 137 data from Ogotoruk Creek, Snowbank Creek, and Kisimilok Valley to determine if there were differences in the means of the background data between each site. Test results suggest that there was no significant difference at the 95% confidence level between the three areas. Additional information on the analysis is included in Appendix D.

These sample results fall within the ranges of values for background Cs 137 levels found in soils in northern Alaska. In our review of two reports on Cs 137 levels in soil in northern Alaska the values for eight samples ranged from 0.1 pCi/g to 1.19 pCi/g, with a mean of 0.3 +/- 0.4 pCi/g (Baskaran, *et al.* 1988 and 1991). There is a great deal of variability in observed Cs 137 levels in soil, due to the nature of how it is deposited and transported. The results of these samples are consistent with Cs 137 levels deposited by global fallout in northern Alaska.

6.3.2 Cs 137 USGS Tracer Mound Results

Excavation of the mound was done in lifts, and composite samples were taken for the on-site laboratory. ADEC analyzed samples in the on-site laboratory and sent selected samples to Lockheed laboratories. Samples taken from the active thawed layer were within the range of background samples taken in Ogotoruk and Kisimilok Valleys. Permafrost was encountered within lift four. It was in lift five, in soils from the lower portion of the lift that radioactivity levels increased, indicating that the excavation was approaching the buried tracer material. This portion of lift five was containerized. In lift six the boards and plastic that had been buried with the radioactive contaminated dirt were encountered.

An ADEC off-site laboratory sample result from a lift where the original tracer material was buried was 127 pCi/g. The highest reading obtained from the lifts containing the original tracer material was 5,927 pCi/g by DOE's off-site laboratory. These ranges may appear extreme, but 3,000,000,000 pCi of Cs 137 was estimated to remain in the radioactive tracer contaminated soil.

Once the on-site laboratory results indicated that the original tracer contaminated soils had been excavated, verification samples were sent to ADEC's, IT's and FW's off-site laboratories. For ADEC's off-site laboratory's 13 samples, the values ranged from 0.05

pCi/g to 2.30 pCi/g, with an average of 0.65 +/- 0.64 pCi/g. For comparison the mean and standard deviation for 53 sample results from ADEC's and IT's on-site laboratory and off-site laboratory verification results was 1.28 +/- 3.31 pCi/g.

6.3.3 Cesium 137 Plot Results

This site or sites contained Cs 137 tracer material from the original USGS study in 1962. Cs 137 levels in initial soil samples from this site ranged from a high of 928 pCi/g (ADEC on-site lab) to 198 pCi/g (Foster-Wheeler). The mean for the two off-site laboratory samples (ADEC and IT) was 567.2+/- 18 pCi/g.

Limits to the Cs 137 plot site were determined by IT personnel using field instruments and by taking soil samples. ADEC and IT tested these samples in the on-site laboratory. Selected samples were sent to the off-site laboratories. Excavation was accomplished by hand, and occurred in the active layer. Once the on-site laboratory results indicated that the original tracer contaminated soil had been removed, verification samples were taken and shipped off to the outside laboratories. Results from five samples that ADEC sent to its lab ranged from a high of 3.37 pCi/g to less than 0.06 pCi/g, with a mean of 0.87 +/- 1.3 pCi/g. A mean of 0.74 +/- 0.89 pCi/g was obtained on the 12 samples run in the ADEC on-site lab.

6.3.4 USGS Tracer Mound Verification Sr 90 Results

All of ADEC's mound verification soil samples were less than the laboratory detection limit for Sr 90.

6.3.5 Gross Alpha

Background gross alpha levels for samples from Ogotoruk Valley ranged from 10.8 pCi/g to 35.2 pCi/g, with a mean of 20.1 +/- 7.6 pCi/g. The highest level was detected on Snowbank Creek at a site identified as a concern by the Native Village of Pt. Hope representative. Results of the gamma spectrum scan for the soil sample from Snowbank Creek is shown Table 6-6.

These levels are not unusual and may be found in areas that have a geological makeup, such as the "black shale material" at the Chariot site, containing such radionuclides. In our opinion the gross alpha level present in the sample is a result of naturally occurring radionuclides.

Kisimilok Valley gross alpha values for two samples were 12.2 pCi/g and 13.5 pCi/g. These are within the range of values observed in Ogotoruk Valley.

Table 6-6

Gamma Spectrum Results for Snowbank Creek Sample
(0023DHD93PC)

Radionuclide	pCi/g
Thorium 234 (Th-234)	2.311
Radium 226 (Ra-226)	2.754
Lead 214 (Pb-214)	2.437
Bismuth 214 (Bi-214)	2.239
Lead 210 (Pb-210)	2.537
Uranium 235 (U-235)	0.135
Actinium 228 (Ac-228)	0.974
Lead 212 (Pb-212)	1.004
Bismuth 212 (Bi-212)	0.988
Thallium 208 (Tl-208)	0.303
Potassium 40 (K-40)	21.882

6.3.6 Gross Beta

For Ogotoruk Valley the gross beta values ranged from 7.5 pCi/g to 36.4 pCi/g, with a mean of 21.6 +/- 8.5 pCi/g. The highest gross beta value again was for sample 0023DHD93PC. This value is within the range of what would be expected for this geological material.

Kisimilok Valley gross beta values for two samples were 21.1 pCi/g to 23 pCi/g. These are within the range of values observed in Ogotoruk Valley.

6.4 Biota Samples

6.4.1 Cs 137 Results

Results of ADEC splits on the plant samples for Cs 137 ranged from less than detectable to 2.909 pCi/g. The highest level was obtained on a sample of lichen (Cetraria delisei) taken from station seven in Ogotoruk Valley.

Lichens concentrate certain fallout radionuclides such as Cs 137 and Sr 90 into their tissue. This ability to concentrate fallout and their importance as a food source for caribou is a contributing factor for the bioconcentration of Cs 137 and Sr 90 in the Arctic foodchain (Hanson, 1993). In Figure 6-2 the mean values of Cs 137 in lichen samples taken over the years from within the Project Chariot vicinity are compared. Comparing the AEC 1960 - 62 years results with the 1993 results suggest a significant decrease in the mean Cs 137 level in lichens.

Caribou through their consumption of lichens and biochemical pathways in their bodies concentrate Cs 137 in the muscle tissues. Figure 6-3 presents the mean Cs 137 values observed in caribou muscle samples taken over the years from the Project Chariot vicinity. There is a sharp decline from the mean value observed in 1960-62 to the mean values obtained by ADEC, DOE and NSB in 1993.

Figure 6-2

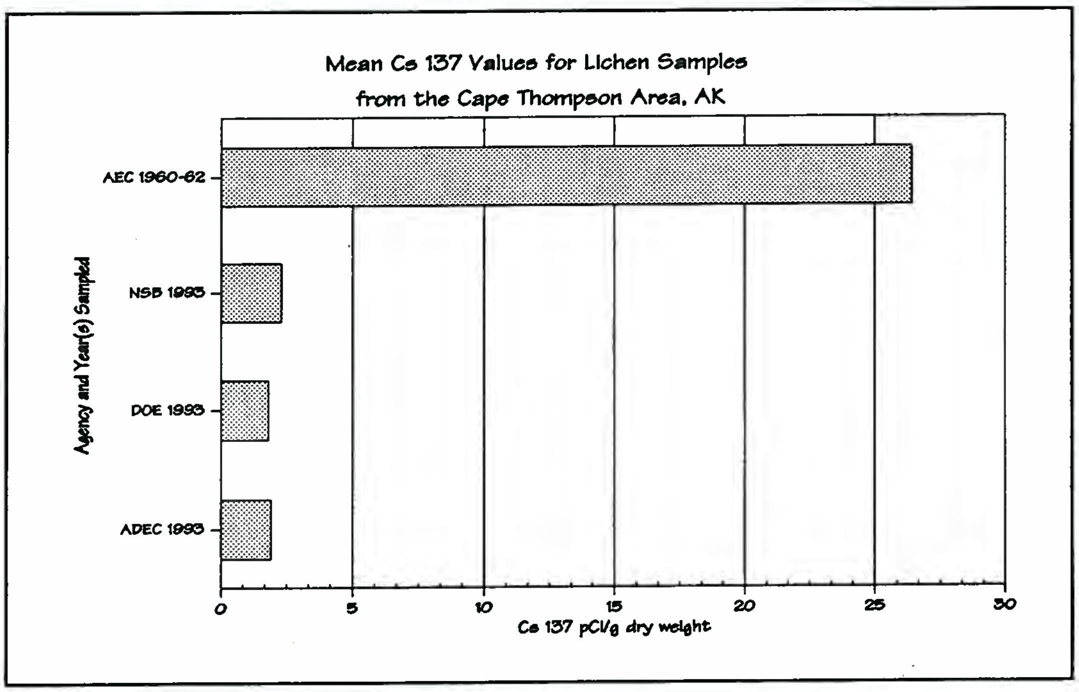
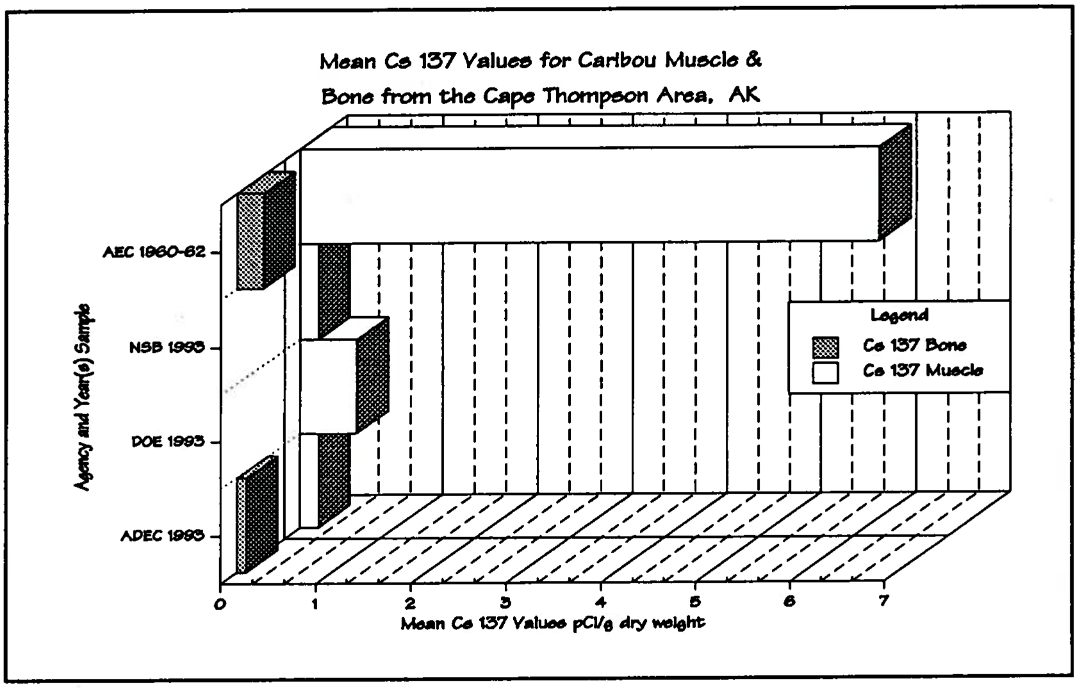


Figure 6-3



6.4.2 Sr 90 Results

In comparing ADEC's Sr 90 biota sampling results with IT Corporations significant differences were observed in the data. Due to this anomaly ADEC had some of its samples rerun. The analysis of the second comparative reruns compared well with the first analysis. IT Corporation's reanalyzed some of their Sr 90 biota samples. These resulted exhibited lower values and were comparable to the results ADEC observed.

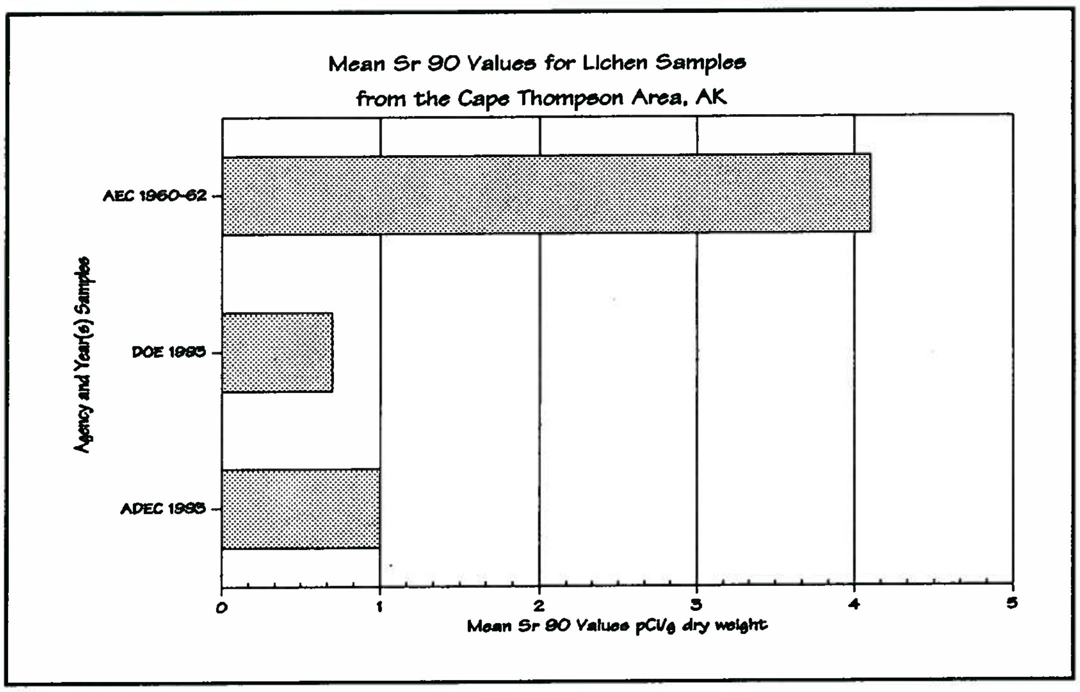
Sr 90 levels in lichen ranged from 0.58 pCi/g to 1.33 pCi/g, with a mean of 0.98+/-0.36 pCi/g. The highest level was found in a lichen (Cetraria delisei) sample taken from Site 10 in Ogotoruk creek valley. Figure 6-4 compares the mean Sr 90 found in lichens sampled in the Project Chariot area in the past with results from the 1993 field sampling.

The Sr 90 level in the mammal samples reflected values in line with the decline that has been occurring since the Limited Test Ban Treaty went into effect in 1963. Results for ground squirrel carcass ranged from less than 0.06 pCi/g to 0.49 pCi/g, with a mean of 0.14+/-0.14 pCi/g. For caribou muscle samples our results were less than the laboratory minimal detectable activity.

Levels of Sr 90 in the caribou bone and grizzly bear bone samples ranged from 1.41 pCi/g to 3.62 pCi/g, with a mean of 2.7 +/-1.2 pCi/g (n=3). Here again the results reflect a decline from the Sr 90 values observed in the 1960's. They also reflect the metabolic pathway, in which Sr 90 follows the calcium pathway in the body. Due to this pathway levels would be higher in the bone than muscle.

The Sr 90 levels in the mammal samples exhibited a similar trend as the lichen data with significant declines in the levels since the 1960's.

Figure 6-4



6.4.2.1 Other Radionuclides

The 15 pounds of soil brought up from the Project Sedan nuclear detonation contained other long lived radionuclides and activation products. Preliminary information from DOE, actual sample results from the edge of the Sedan crater, and other references suggested that they would be present at very low levels, if detectable at all. In addressing this concern some verification and biota samples were tested specifically for Pu 238, and 239/240. In addition, the gamma spectrum scans that were run on many samples could detect other gamma emitting artificial radionuclides, if above detection limits.

6.4.3.1 Pu 238 and 239/240

Plutonium is a radioactive metal and is recovered from irradiated, enriched uranium. Small amounts can occur naturally, and large quantities needed for nuclear weapons production must be concentrated from enriched uranium. The most common isotopes of plutonium are Pu 238 and Pu 239/240. Pu 239 and Pu 240 are two separate isotopes, but are usually combined for environmental monitoring. Half-life for Pu 238 is about 90 years and 24,000 years for Pu 239/240. Pu 238 is used as a power source for electric systems in some satellites, and Pu 239/240 is used in nuclear weapons. The plutonium is released to the environment through testing of nuclear weapons, accidents from weapon's facilities, nuclear reactors and satellite reentry. Plutonium 239/240 released by nuclear weapons testing returns to the earth's surface as fallout.

Analyses for Pu 239/240 and Pu 238 were run on soil samples from the tracer mound. Two samples were selected from an excavation lift that contained visual debris, such as the boards and plastic, from the 1962 burial. In addition, two samples were selected from our 13 mound verification samples for analysis of Pu 238 and Pu 239/240.

Results for Pu 238, and Pu 239/240 in the mound verification samples were less than the minimum detectable activity. Plutonium 239/240 concentration in fallout from nuclear weapons testing is lower than Cs 137 and Sr 90 concentrations. Pu 239/240 levels from global fallout are typically extremely small, and, if, deposited only by global fallout may be less than the detection limit. In the 1960's caribou bone sample only contained extremely minute amounts, in the 0.01 femtoCuries/gram (fCi/g) (0.00001 pCi/g) range (Hanson, 1993).

In the sample of the actual buried USGS tracer material, the results for Pu 238 were less than the detection limit. Pu 239/240 were detected at levels of 0.032 pCi/g and 0.011 pCi/g. Laboratory error for the first sample was 0.023 , with a Minimum Detectable Activity (MDA) of 0.012. For the second sample laboratory error was 0.013, with a MDA of 0.010. The second result is so close to the MDA, and statistically does not confirm the presence of Pu 239/240. The Pu 239/240 detected is likely from the Project Sedan soil. These Pu 239/240 levels are below average background levels in the contigous United States. The buried tracer material was placed in the B-25 containers and removed to the Nevada Test Site.

6.4.3.2 Other Artificial Radionuclides

The gamma scans did in several cases detect Antimony (Sb) 125 at 0.33 pCi/g and Cobalt (Co) 60 at 0.05 pCi/g. These levels were very low, but the material is present in global fallout . The gamma spectrum peaks for these ranges had bad shape, thus these results are inconclusive.

6.5 Comparison with IT and FW Laboratory Results

Except for the discrepancies in the original Sr 90, the results from ADEC's sampling did not exhibit any significant difference in comparisons with IT and FW results. The levels observed for the various radionuclides, outside of the Cs 137 study plot or the tracer material in the mound, were very low and representative of background levels observed in Northern Alaska. Sampling results did reflect the large variation exhibited in sampling for manmade radionuclides that have been distributed by worldwide fallout.

Chapter 7

Dose Assessment

7.1 Exposure Pathways

For people to be exposed to potential radiation doses from the radioactive tracer material left at the Project Chariot site there must be a viable pathway over which the exposure could occur. Pathways could be inhalation, direct exposure from radionuclides in the soil, ingestion of soil, water or biota containing the radionuclides.

Addressing any potential for past or present exposure from the radioactive tracer material used by USGS consists of two steps:

1) Determining an environmental pathway by which the radionuclides could migrate from the source to the human population.

2) Determine the migration potential along the identified environmental pathways.

Potential pathways for the radioactive tracer material used by USGS at the Chariot site are external radiation from the ground, inhalation, and ingestion.

7.2 Inhalation

This environmental pathway for the Project Chariot site would occur from the inhalation of contaminated dust. Inhalation of the radioactive tracer material used by USGS in 1962 is not considered a plausible exposure pathway for the following reasons:

1) The material was placed on the plots, wetted down and then removed with the soil when it was dug up.

2) The soil from the plots was buried in 1962, and it was uncovered in 1993 basically intact and in a frozen state.

Due to site conditions, limited activity of radioactive tracer material used, dispersion and dilution effects on any material that may have been suspended as dust before burial, inhalation is not considered a viable environmental pathway.

7.3 Direct Exposure from Soil Contamination

Direct exposure pathways from the radionuclides buried in the soil consists primarily of exposure to gamma radiation. Burial of the material under the 4 feet of soil cover attenuated the radiation levels at the mound surface to local background radiation levels. This was the case observed in 1992 and 1993 during actual on site monitoring at the burial site. In addition it was reported in 1962 that the burial of the material also resulted in radiation levels equivalent to background at the mound surface.

The Cs 137 study site was the only area with Cs 137 levels siginificantly above background. This site could have provided a radiation exposure level over background to a person or animal standing on the site. The test plot site apparently was not adequately excavated in 1962 . In evaluating the dose one receives from radiation, type of radiation, exposure level, and time one is exposed must be taken into account. Field measurements were made at the Cs 137 study site using the Pressurized Ion Chambers (PIC). A dose rate of approximately 18 uR/hr was observed in 1993 approximately 3 feet above the site. Using an average background gamma radiation dose rate of 8 uR/hr it is estimated that 10 uR/h additional dose rate was coming from the Cs 137 remaining in the soil. It is estimated that, based just on radioactive decay, the dose rate at the Cs 137 study site could have been 28 uR/hr in 1962.

These levels may be compared to those found in the United States. Dose rates from terrestrial gamma radiation sources range from 2 uR/hr to 230 uR/hr depending on geological conditions and elevation. Cosmic radiation dose rates may range from approximately 3 uR/hr to over 11uR/hr (Schiager, K. J., et al, 1994).

If a person were to stand on the site in 1962 for a week they would receive a dose of 3.36 mrem above background. Since that time, due to radioactive decay ,the dose rate has been decreasing. Today if someone were to stand on the site for 7 days they would be exposed to a dose of 1.68 mrem above background. The dose to someone passing across this site or even camping here for a short period of time would not be considered to represent an appreciable health hazard.

7.4 Ingestion

Several pathways exist for ingestion, 1) actual consumption of soil containing the radionuclides, 2) drinking the water containing radionuclides, and 3) consumption of biota contaminated with the radionuclides.

7.4.1 Soil Ingestion

Ingestion of soil is limited and generally is only considered significant in young children afflicted with pica(a compulsive craving for non-food objects) (EPA, 1984). The buried material would not represent the surface soil exposure typical of this pathway. Only the Cs 137 study site would represent such an area. Due to the pattern of human occupancy and subsistence use the ingestion of soil is not regarded as a pathway for human exposure.

7.4.2 Drinking Water

Current sampling of the water in Snowbank, Ogotoruk, and Kisimilok for Gross Alpha and Beta found that the levels were below the State of Alaska Drinking Water Maximum Contaminant Levels (18 AAC 80, 1991).

The small activity of the radioactive tracer material used, limited solubilities of the radioactive tracer material, and dilution occurring in Snowbank creek preclude the consumption of water from Ogotoruk creek as a pathway for human exposure.

7.4.3 Biota Consumption

One of the principal concerns expressed by people in the local communities was the potential for contamination of their subsistence food sources by the radioactive materials used in the USGS tracer study. A body of data exists on the lichen-caribou-human food chain concentration of radionuclides from the worldwide radionuclide fallout for this area. Due to the reported limited activity of the radionuclides used by USGS in the tracer study, and the small area impacted the reported study could not have contributed to bioconcentration through the lichen-caribou-human food chain.

Local concern, though, remained high due to conflicting statements in the historical documents regarding the activity level of radionuclides proposed to be used in 1962. In an effort to address this concern biota samples were taken. The two principal radionuclides in regards to food chain bioconcentration are Cs 137 and Sr 90. Table 7-1 summarizes the Cs 137 levels found in the biota that would be consumed by humans.

Table 7-1
Cs 137 Values for Biota Samples

Description	Mean+/-STD pCi/g dry wtg	Minimum Value pCi/g	Maximum Value pCi/g
Caribou muscle	0.37+/-.030	0.07	1.2
Blueberries	0.09+/-0.05	0.03	0.16

These values can be used in estimating the dose a person would receive over a one year period. Appendix G steps through this process. The results are shown in Table 7-2.

Table 7-2
Ingestion Pathway Dose

Description	Ingestion/year/ person/pounds	Dose Base on Mean mrem/yr	Dose Based on Minimum mrem/yr	Dose Based on Maximum mrem/yr
Caribou muscle	208	0.5	0.09	1.64
Blueberries	15	0.003	0.001	0.006

These dose levels are small and the maximum dose would constitute approximately 8% of an average persons yearly dose from food sources. On average a person in the United States receives a dose of 20 mrem from natural and manmade radioactive material in foods (DOE, 1991).

One may also compare this with past dose levels based on information from caribou muscle sampled for Cs 137 in the 1960's. A maximum value of 17 pCi/g dry weight of Cs 137 was found in caribou sampled in the Cape Thompson and Pt. Hope area in 1960 - 1962. Ingestion of 208 pounds of caribou at this level would result in a dose of 5.6 mrem/yr, or 25% of the average yearly dose from food sources.

7.5 Comparison with Levels In Norway After Chernobyl

In Norway after the accident at Chernobyl the Norwegian Directorate of Health established permissible radioactivity levels for Cs 137. These levels were 10 pCi/g for milk and baby food, a 16.2 pCi/g for most other foods, with the exception that levels for reindeer and wild game were increased to 162 pCi/g (Stand, P. et al, 1992). A person eating reindeer meat containing the maximum allowable level of 162 pCi/g would receive a dose of 77 mrem/yr. The goal was that the additional yearly intake levels for Cs 137 during the first year after the Chernobyl accident should not exceed 10,800,000 pCi/yr, and it should not exceed 2,160,000 pCi/yr in the following years.

The dose received by the people in Pt. Hope and Kivialina from the ingestion of caribou meat today and in the early 1960's did not approach those received in Norway after Chernobyl.

Chapter 8

Conclusions and Recommendations

8.1 Conclusions

Removal of the radioactive tracer material from the mound site and the Cs 137 study plot area was accomplished by DOE in a professional and conscientious manner. Sampling data showed a wide range in the concentration of radionuclides in the sediment, soil, and biota samples. This appears to be typical of sampling observations for radionuclides, whose concentrations are at natural background and global fallout levels.

The radioactive tracer material that was buried in the mound in 1962 remained in place, essentially immobile until it was excavated in 1993. Permafrost had been encountered during excavation of lift four, and the start of the radioactive tracer material was found in the lower portion of lift five. The silty and organic soils, that the material was buried in, have low hydraulic conductivity, and even lower in the frozen state. Also this soil has the ability to greatly retard the movement of radionuclides from the soil phase to the water phase (NSB, 1993). Results of sampling confirm that the radioactive tracer materials from the mound site did not enter into the local food chain through vegetation.

At the Cs 137 study plot site the soils were not frozen, but consisted of silty organic soils. The principal radionuclide present at this site was Cs 137, and it tends to be held tightly by the soil preventing significant movement into the water phase. In effect the material prefers to remain in the soil. There did not appear to be any significant movement of the Cs 137 from this area into the surrounding environment. The Cs 137 study site was the only area located during the site investigations that could have provided a radiation exposure level over background to a person standing on the site. The dose rate at this site, as discussed in Chapter 7, was very low and does not now represent a hazard to someone passing across this site. Even camping here for a short period of time would not be considered to present a health hazard. Nonetheless, removal of the material assures the State that anyone using this site in the future will not be exposed to a dose rate above the locally naturally occurring background.

Results of the sampling by ADEC, DOE and the NSB did not find any anomalous radionuclide concentration levels that would indicate a significant artificial introduction of radionuclides into the Project Chariot environment, except that occurring from global fallout. Any radiation dose that a human would receive from animal ingestion of the radionuclide concentrations found in the biota samples is very small. The levels indicate that the decline in man-made fallout radionuclides is continuing. As discussed in Chapter 7 the levels of radionuclides found in the biota samples do not represent an appreciable health hazard to the local population.

In summary the department did not find any indication that people using this area for subsistence, in the present or the past, would receive a dose significantly above background to cause harm. *Based on the levels of radioactivity observed in the soil, water, air, and biota the department finds no reason to restrict use of this area because of radioactivity.*

8.2 Recommendations

The department is aware that the local people remain very concerned with the occurrence of cancer within their communities. One area of concern is anthropogenic pollution in the Arctic and it potential effects on their food sources. Action to address these concerns is being proposed under programs, such as the Arctic Monitoring and Assessment Program (AMAP). This type of monitoring will take time, and just what the impacts may be on the environment cannot be predicted. While the causes of cancer can be difficult to identify, people can take action against the cancers that are documented to be caused by lifestyle choices, such as smoking. The Department has the following recommendations:

1) A monitoring station be established in Pt. Hope, as discussed with DOE, to monitor for gamma radiation levels. This will document the variations in background gamma radiation for comparative purposes with other areas. This may help the people in Pt. Hope determine their dose from background gamma radiation and detect any anomalous levels. To complement the real time Pressurized Ion Chamber gamma radiation monitoring, a limited sampling program for radionuclides in precipitation and air is warranted.

2) A program be developed that will monitor radionuclides in the food chain to evaluate the possible influence on human exposure. Some studies are already underway, such as the National Oceanic Atmospheric Administrations (NOAA) marine mammal tissue bank. Any monitoring should be coordinated with these other efforts.

3) The community may want to coordinate through a representative with the Arctic Monitoring and Assessment Task Force (AMAP, 1993). This programs primary objective is to measure the levels of anthropogenic pollutants in the Arctic, and assess their effects on the Arctic environment. Representatives of the Inuit Circumpolar Conference are acting as observers in this process. (AMAP, 1993)

The communities need to be provided, in an understandable format, the results of past sampling of the biota in their area.

4) Continuing interaction of Federal, State and local health agencies is necessary to address the cancer concerns of the community. A strong educational program needs to be conducted to address the preventable lifestyle choices, such as smoking, which are one of the major cancer causes in the communities (PHS, 1994).

ADEC will assist the communities, when possible, in regards to establishing and achieving the recommendations.

References

18 AAC 80, "State of Alaska Drinking Water Regulations", Department of Environmental Conservation, 1991

AEC 1963 Plowshare Program Reprint from Annual Report to Congress for 1962 of the USAEC.

Baskaran, M., Kelley, J. J., Nadiv, A. S., & Holleman, D. F. "Environmental Radio cesium in Subarctic and Arctic Alaska Following Chernobyl", *Arctic* December 1991 Vol. 44 No. 4 p. 346 - 350.

Baskaran, M., Kelley, J. J., & Naidu, A. S. "Radiocesium & Radiopotassium Concentrations in Alaskan Arctic Soils, Plants & Animals", IMS 288-1.

Book, H. E. "AEC Memorandum to Ernest D. Campbell, Special Projects Division, SAN on Inspection of Licensed Operations of U.S. Geological Survey at Project Chariot site" November 2, 1962.

Chandler, B. M.D. MPH, Middaugh, J.P. M.D., Health Risk Assessment of Radioisotopes at Cape Thompson, Alaska, November 24, 1992, Department of Health and Social Services, Division of Public Health, Sec. of Epidemiology.

COE, "Final Report of Investigation for the Project Chariot Site at Cape Thompson, Alaska" December 11, 1992.

DOE, "Project Chariot - 1962 Tracer Study Site Assessment and Remedial Action Plan Summary Document", July 1993

EPA, Environmental Radiation Data - Report 65 January - March 1991.

Faw, R. E., Shultis, J. K. "Radiological Assessment Sources and Exposure" PJR Prentice-Hall 1993.

FW, "Report on Project Chariot Field Work - Reference No. 4-21-00-14002", October 5, 1993

Gilbert, R. O. "Statistical Methods for Environmental Pollution Monitoring" 1987 Van Nostrand Reinhold p. 177 - 178.

Hanson, W.C. "Radioactive Contamination in Arctic Tundra Ecosystems" Presented at

Workshop on Arctic Contamination May 2 - 7, 1993, Anchorage, Alaska. p. 5.

Hanson, W. C. "Fallout Radionuclides in Alaskan Food Chains", *American Journal Vet. Res.* January 1966 Vol. 27 No. 116 p. 359 - 366.

Kaleak, J. Mayor of North Slope Borough, "April 6, 1993 Letter to Thomas Gerusky (D.O.E.)"

NSB, A REVIEW of the "Project Chariot: Radiological Survey and Risk Analysis", NSB-SAC-OR-127, April 1993

O'Neill, D. , "February 17, 1993 Letter to Kevin Cabble (D.O.E.)"

Page, R. C. "AEC Memorandum on AEC Citation Letter form Price, E. R. January 23, 1962 & USGS Baker Letter February 28, 1963 Response" March 22, 1963.

Price, E. R. "AEC letter to USGS Denver office on License Compliance Regarding Chariot Site Activities" January 23, 1963.

Schiager, K.J., Goldman, M., Mossman, K.L., Massé, F.X., Genevieve, S.R., "Health Physics Society Positon Statement: Return to Background", Health Physcis Society Newsletter, February 1994, p. 10-12

Shapiro, J., Radiation Protection: a Guide for Scientists and Physicians - 3rd edition 1990 Harvard University Press. p. 387.

Strand, P., Selnaes, T.D., Bøe, E., Harbitz, O., Anderson-Sørile, "Chernobly Fallout: Internal Doses to the Norwegian Population and the Effect of Dietary Advice", Health Physics, 63(4):385-392; 1992

Stutzman, C. D. M.D., Nelson D. M. M.D., Lanier A. P. M.D. "Estimates of Cancer Incidence in Alaskan Natives Due to Exposure to Global Radioactive Fallout from Atmospheric Nuclear Weapons Testing", *Alaska Medicine* July/August/September 1986. p. 67 - 77

Taylor, H. W., Svoboda, J. , Henry, G. H. R., & Wein, R. W. "Post - Chernobly Cs-134 and Cs-137 Levels at Some Localities in Northern Canada", *Arctic* Vol. 41 No. 4 p 293 - 296.

Watson E., Chairman "Upgrading Environmental Radiation Data" Health Physics Society Committee Report HPSR-1 (1980) Office of Radiation Programs USEPA.
Baker, A. R. "USGS letter Responding to the AEC Citation letter from Price, E. R.

January 23, 1963" February 28, 1963.

Watson, D. G., Hanson, W. C., & Rickard, W. H. "Fallout Radionuclides in the Biota of the Cape Thompson Region, Alaska - A listing of Measurements", Battelle Northwest Laboratories, Richland, WA November 1965.

Woolsey, R. T. "AEC Memorandum to Eber R. Price, Assistant Director of Licensing and Regulation on USGS, Quality of Water Branch, Denver, CO - License# 5-1399-3" October 23, 1963.

APPENDIX A

BEETEM'S RESPONSE TO QUESTIONS

DOE Summary Notes of an Interview with W. Arthur Beetem

SUMMARY OF INTERVIEW WITH W. ARTHUR BEETEM

Arthur Beetem was one of the researchers who conducted the Project Chariot radioactive soil tracer experiments. We met with him in Florida on 11/11/92. Over the course of an approximately seven hour interview, the following is a summary of his recollections.

The study was conducted from August 20 through 25, 1962.

Radioactive tracers I-131 (5mCi), Cs-137 (6 mCi), and Sr-85 (5 mCi) were brought to the site in lead containers.

Sedan fallout was collected in fallout trays which were placed at regular distances from Sedan ground zero. The fallout tray material which was used at the Chariot site was located at the one-mile point (the radiation level at this location was 5 r/hr one day after the event). The Sedan fallout was transported to the Chariot site by plane. Level on contact with the sack was 0.1 mr/hr (10 mCi).

The Sedan fallout was considered classified and an armed security guard accompanied the team from Nevada to the Chariot site. He did not allow any other Chariot workers to come near the experimental area and actually had someone guarding the material 24 hours a day.

Between two to three experiments were carried out per day. Experimental areas from 4'x 4' to 4' x 12' were salted with the radioactive material, water from the nearby stream was sprayed onto the soil, and runoff was collected at a downslope spot for future analysis. The remaining contaminated soil was removed with shovels and placed in 55 gallon drums. There were 4 to 6 drums which were half full. (A full drum was too difficult to move.)

To satisfy the security agent, the Sedan soil was required to be mixed with the other contaminated soil to prevent anyone from being able to accurately analyze the isotopic content of the Sedan fallout.

To dispose of the contaminated soil, the surface soil was removed down to the permafrost line (approximately 40' x 30' to a depth of 14 to 16 inches). He estimated that the disposal site was approximately 100 feet from the stream. The contaminated soil from the barrels was placed in the center of the dug out area and thoroughly mixed. Then additional uncontaminated soil was added to the contaminated soil, and it was all mixed. The resultant dirt was very wet because the tundra contained a lot of moisture. Plastic sheets and four-foot wooden boards used during the experiment were also placed in the mixture.

Then an additional 4 to 6 feet of uncontaminated soil was placed over the mixture creating a mound. During the course of placing the soil on the mound, a C-9 CAT sunk in a few feet and had to be dragged out with another CAT.

He stated that the only real problem they had during this one-week stay at the Chariot site was one four-hour period when the wind died down. The mosquitoes were so bad that they all had to retreat to the mess hall.

Thomas M. Gerusky

Written Response from W. Arthur Beetem to Questions Provided by ADEC

Who took the photographs and who are the people in them?

Janzer took the 35 mm slides. A list accompanied the slides naming the individuals in the slides. Please review the list in order to answer the latter part of your question. Doug Dasher has a copy of the list.

How many curies on material were brought to the site?

Only fractions of a curie was brought to the site. The exact quantities of the different isotopes were published in Geological Survey Professional Paper 539 in 1966.

What was the experiment's operational sequence?

The experimental plots were built in one day. The following day, the experiments were performed. That same day, the plots were dismantled and the material moved to where plots 113 and 114 had been. At this locale, the different tracers were carefully stirred together. The mixing was performed for the purpose of preventing the measurements of isotopic ratios in the Sedan fallout. These measurements could possibly have provided information on the construction of the Sedan device.

What were the reasons behind the sampling notations?

Many laboratories start their numbering with 101, rather than one, to allow easier alphanumeric sorting by computers. Sixty-three shows the fiscal year that began July 1, 1962. Piper name his field samples AKd. A was for Alaska, and Kd was for distribution coefficient. Beetem chose ABJ for Alaska, Beetem, and Janzer. Breaks in plot numbers have no significance. Beginning with 106 had no significance.

Art Beetem transmitted the field notebooks and copies of the pictures to Dr. Arthur M. Piper. The field study supported Piper's evaluation of possible hydrologic effects of Project Chariot. Piper published his evaluations in Geological Survey Professional Paper 539. Piper lived near and worked out of Menlo Park, California. Beetem lived in and worked out of Denver. Beetem was not consulted on what to do with Piper's source material accumulated over more than 40 years on his retirement and later death. Consult the administrative offices in Menlo Park as to the disposition of Piper's field notes.

In the Sedan fallout plots, the soil was lighter in color. What is the reason for this?

Sedan was detonated in desert alluvium under Yucca Flats, Nevada. The desert alluvium is detritus of volcanic ash, volcanic flows and carbonates that form the Basin and Range topography of southern Nevada. The alluvium has almost no organic content and when pulverized and mixed is a very light gray in color. The other tracers were mixed with dried soil collected from the area around Project Chariot. It has a higher organic content and was much darker in color.

What was the selection criteria for the location of the plots along Ogotoruk/Snowbank Creeks?

There were no plots along Ogotoruk Creek. See Dr. Piper's Professional Paper for the objectives and criteria.

One photo depicts a man next to the headwaters of Snowbank Creek at the base of a hill. Is this the location where the infiltration gallery was set up? When the trench was dug for the infiltration gallery, were soil samples collected? If so, where would this information be found?

No. That was the location of the stream slug tests. A.M. Piper describes the percolation test in his Professional Paper 539. Based on the percolation study, Dr. Piper compared distribution coefficients (Kd) from percolation and distribution coefficients calculated from plot studies. The studies confirmed that sorption would be the dominant control on the movement of radioactive fallout by water in the Project Chariot vicinity. Please refer to Piper's Professional Paper 539.

Is this the only tracer experiment conducted in this area? Do they know of any other radioactive tracer experiment sites in Alaska (USGS or otherwise)?

Mr. Beetem states that this is too broad a question for him to answer. Obviously, he knows of this one at the Project Chariot site. He has no other knowledge of other tracers being used in Alaska.

What types of safety precautions were taken in handling the material? Was there any concern for safety precautions?

Standard laboratory radioactive material handling procedures were followed in preparation of the radioactive material in Denver. Negative pressure chemical hoods, glove boxes, film badges, dosimeters and smocks and gloves were used. Richard Johnson, the AEC courier, transported the material in a package with less that 0.1 milliroentgen/hr surface reading to the Project Chariot base camp. Mr. Johnson regularly wore a film badge to record his radiation exposure. Beetem and Janzer diluted the radioactive tracers as shown in the Piper paper by shaking the dried soils in taped plastic bags. Gloves and film badges were worn during the application of the tracers to the plots.
V.J. Janzer and W.A. Beetem worked in radiochemical laboratories for more than six years at that time. Their work involved analyzing environmental samples and using radioactive material in laboratory tracer studies. Both Janzer and Beetem had excellent laboratory safety records. Neither took undue risks, and always followed standard laboratory safety procedures in the field studies.
In order to have successfully measured field distribution coefficients, great care in the placement of the tracers had to be taken.

In the U.S. Department of Interior Geological Survey's letter dated October 9, 1962 addressed to Mr. John Philip, Director of Special Projects Division in the U.S. Atomic Energy Commission page number (1-3), there is a list of plot numbers and their corresponding information. Why is there no plot 63 ABJ 108?

No reason. There wa also no 63ABJ 104 or 63ABJ118.

What does "DO" in the remarks section stand for?

It is Do, not DO. In Suggestions to Authors of the US Geological Survey, Do. or do. means ditto. Webster's definition of ditto is: a thing mentioned previously or above-used to avoid repeating a word.

Excavation: etc.

Mr. Beetem answered similar questions in detail for DOE and IT Corp. representatives. To again respond would take too long and too many pages. Doug Dasher has received a copy of the DOE/IT interview with Mr. Beetem. Please refer to that transcript to obtain the answers to your questions. Mr. Beetem states that Plots 113 and 114 were dug up. Piper's Professional Paper reports that Sedan fallout was used on plots 113, 114, and 115. To meet the security requirements at that time, the Sedan fallout was mixed thoroughly with the other radioactive material. Thus, an isotopic analysis on the soil would not provide information on the device used for Project Sedan. The USGS employees dug and stirred up the material to achieve that objective.

This mixing also diluted the material until the tracer soil at the base of the mound was low-level radioactivity. See Piper's estimates. All wood and plastic were buried with the radioactive tracer soils. No wood or plastic was visible after the layer of radioactive soil was buried to a minimum depth of four feet. Mr. Beetem estimates that there was more than 150 times in volume of "clean" soil to the tracer soils transported to the burial mound. Examine Table 18 of Piper's Professional Paper for the probable radioactive levels of the "clean" soil.

The test plots were placed no further than 60 feet distance from Snowbank Creek. This distance was dictated by the length of hose and total head capacity of the pump, which were used to artificially add precipitation to the plots in order to perform the studies.

APPENDIX B

ADEC NEWSLETTERS

UPDATE: CHARIOT PROJECT SITE

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION

November 6, 1992

The Alaska Department of Environmental Conservation (ADEC) is providing this newsletter to all interested parties about the progress of activities for the Chariot site. This format will replace the situation reports used in the past. In the future, UPDATEs will include a "Current Situation" section along with a recent accomplishments section. The UPDATEs will be distributed to all interested parties and the news media as they are published. Modified UPDATEs containing only the "Current Situation" section will be generated as frequently as necessary and distributed to the Multi-Agency Committee (MAC) members. The MAC is listed in full in this report only. Changes to the MAC will be identified within the body of the appropriate future newsletter. Comments and questions about this newsletter may be directed to Doug Dasher at (907) 451-2172 or Leslie Simmons at (907) 451-2165.

ACCOMPLISHMENTS TO DATE

9/10 - 13/92 The Army Corps of Engineers (COE) and ADEC conducted a site investigation. Surface monitoring indicated no radiation hazards existed at the ground surface. The COE collected and analyzed soil and water samples from and near the mound. The mound is a waste pile from a 1962 radioactive tracer study. The COE expects to have a report with an explanation of the sample results around December 7, 1992. ADEC and the COE attended public meetings on September 11, 12, and 13, 1992.

9/25/92 ADEC, DOE, ADHSS, F&WS, the U.S. Geological Survey, and residents of Point Hope met via teleconference and discussed the following topics:

* Cape Thompson objectives
* Schedule for the tasks to be completed
* Site Safety Plan
* Funding

9/29 - 10/1/92 Tim Bigelow and Darren Mulkey, both from ADEC, presented radiation safety training in Point Hope. Attending were Luke Koonook, Caroline Nashookpuk, Rex Rock, Sr., George Kingik, Rex Tuzroyluk, Ray Koonuk, and Jack Shaeffer.

10/7 - 8/92 ADEC, DOE, FWS, COE, the North Slope Borough, and several consultants met to discuss both site operations and funding issues for assessment and remediation of the Chariot site.

10/8/92 DOE and ADEC met in Kotzebue with the Alaska Department of Community and Regional Affairs, the Mayors of the Northwest Arctic Borough and Kotzebue, the Coastal Zone Management Coordinator, and the Kotzebue City Manager to bring them up-to-date on the project progress.

10/9/92 DOE and ADEC addressed a public meeting in Point Hope about Chariot remediation plans. The objectives of the public meeting were to:

* Enable DOE and ADEC to present their respective agencies roles and obligations.
* Provide historical information about the original Project Chariot, including the rationale for the background radiation monitoring done between 1958 and 1962.
* Provide a forum for the general public to express their concerns about the radioactive tracer study and the materials buried in the Ogotoruk Valley.

10/12/92 A draft Agreement in Principle (AIP) between DOE and the State of Alaska was sent to DOE for review. The modified AIP will come back to the state for consideration and will go to the Multi-Agency Committee (MAC) for review and comment.

10/20/92 Mayor Jeslie Kaleak from the North Slope Borough, DOE, ADEC, and Dr. Wayne Hanson met by teleconference. They discussed the status of the sampling plan and a schedule for site assessment activities.

10/20/92 At the North Slope Borough's invitation, DOE and ADEC travelled to Point Hope to address a North Slope Borough assembly meeting. During this public meeting, ADEC and DOE gave the community detailed descriptions about the work done to date and the work and plans to come. A question and answer period followed.

10/20 - 21/92 ADEC and DOE attempted to fly into the Ogotoruk Valley, but were unable due to high winds. ADEC, DOE, and one representative each from Point Hope and the North Slope Borough did travel overland via 4-wheel All Terrain Vehicles to inspect the mound, runways, existing buildings, and one of the access trails.

* DOE mapped and surveyed the surface of the mound with radiological monitoring instruments and found no radiation above background. The site poses no risk for radiation exposure in its present undisturbed state.
* Three of the buildings on the native allotment are useable for storage with some repairs.
* An overland trail can be established for ground access to the site.
* The large airstrip in alignment with prevailing winds can be repaired to allow access by larger aircraft.
* Access to the Ogotoruk Valley by small aircraft is unreliable due to the predominantly high winds in the valley.

10/22/92 DOE and ADEC met in Anchorage to discuss details of the sampling and health and safety plans. The health and safety and the logistics plans and the schedule for activities will be developed after the sampling plan is approved.

10/26/92 ADEC sent two bibliographies to its list of interested parties. One bibliography is from the DOE-Nevada Technical Library; the other is from the BLM Alaska Resource Library. The DOE is in the process now of clearing the documents for public consumption. ADEC will work with DOE and the University of Alaska, Fairbanks Rasmuson Library to obtain a complete set of documents for the library. Once this is accomplished, people can obtain the documents through the regular inter-library loan process. ADEC will report progress as this project proceeds.

10/26-30/92 Susan Soule, ADHSS, lead a team of mental health professionals to Point Hope and Kivalina to meet with residents of both communities in groups and individually. At these meetings people discussed their feelings and concerns about Project Chariot and other issues which affect how people are feeling about themselves, their community, and the larger environment of regional, state and federal agencies in which their communities are located.

MULTI-AGENCY COMMITTEE REPRESENTATIVES:

Margaret Hansen, Alaska Department of Community and Regional Affairs
Dr. Peter Nakamura, Alaska Department of Health and Social Services
Susan Soule, ADHSS, Division of Mental Health
Kristina O'Connor, Alaska Department of Natural Resources
Richard Parrish, U.S. Army Corps of Engineers
John Martin, U.S. Fish and Wildlife Service
Larry Ethelbah, U.S. Bureau of Indian Affairs
Dr. Ward Hurlburt, U.S. Indian Health Service
Leo Kinneeveauk, Translator
Elijah Rock, Sr., Translator
Chuck Green, Northwest Arctic Borough
Caroline Nashookpuk, North Slope Borough
John Aiken, North Slope Borough
David Stone, City of Point Hope
Bert Adams, City of Kivalina
George Kingik, Native Village of Point Hope
David Swan, Native Village of Kivalina
Jack Schaefer, IRA Tribal Government Point Hope
Raymond Hawley, IRA Tribal Government Kivalina
Rex Rock, Sr., Tigara Corporation
Pete Schaeffer, NANA Corporation
Bill Thomas, Arctic Slope Regional Corporation
John Kelly, University of Alaska
Becky Norton, Kivalina Community Member
Rex Blazer, Northern Alaska Environmental Center
Mike Wenig, Trustees for Alaska

If the department has missed or misidentified any MAC member, please let us know. Thank-you.

UPDATE: CHARIOT RADIOACTIVE CLEANUP

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION

November 16, 1992

CURRENT SITUATION

During the week of December 14, 1992, the U.S. Department of Energy is planning a four-hour workshop on the background and history of Project Chariot radiation, what it is, and how it affects us. Weather permitting, the workshop will be held in the following four Alaska communities:

Dec. 15 in Barrow;
Dec. 16 in Point Hope;
Dec. 17 in Kivalina;
Dec. 18 in Kotzebue.

Presentations will be made by Dr. Wayne Hanson and Bama McKnight. Dr. Wayne Hanson, a radiation ecologist, will discuss the original Project Chariot and its successor studies which were conducted between 1959 - 1979. Bama McKnight will provide insight into what radiation is and the potential health effects from radiation. The workshop will be presented in non-technical terms and question and answer periods will be included. Simultaneous translation into Inupiaq will be provided.

FOR ADDITIONAL INFORMATION CONTACT:
Doug Dasher at 451-2172 or Leslie Simmons at 451-2165

PROJECT CHARIOT HISTORY
AND
THE ABCs OF RADIOLOGICAL SAFETY

Barrow:	12/15/92 at 1 pm in the Assembly Chambers
Pt. Hope:	12/16/92 at 1 pm in the Kalgai Center
Kivalina:	12/17/92 at 10:30 am in the Community Center
Kotzebue:	12/18/92 at 9 am in the Alaska Technical Center

AGENDA

PROJECT CHARIOT HISTORY — **WAYNE HANSON**
30 minutes
What was Project Chariot and its effects?

RADIOACTIVITY AND RADIATION — **BAMA McKNIGHT**
90 minutes
What is radioactivity; where did it come from? What is radiation and where does it come from? What can it do; does it go away?

BIOLOGICAL EFFECTS OF RADIATION — **ROGER STALEY**
30 minutes
How does radiation affect human beings? What are the good effects, the negative effects? What is necessary radiation and what is unnecessary radiation? How do we detect and measure it?

RADIATION PROTECTION — **BAMA McKNIGHT**, **ROGER STALEY**
30 minutes
How can we protect ourselves from unnecessary radiation?

Questions and answer periods will follow each section.
Breaks will be given throughout the session.
Sessions will be held in simultaneous translations.

UPDATE: CHARIOT RADIOACTIVE CLEANUP

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION

December 22, 1992

Current Situation:

The Alaska Department of Environmental Conservation (DEC) and the United States Department of Energy (DOE) met two weeks ago in Las Vegas, Nevada to discuss the schedule and preliminary plans for the cleanup of the radioactive waste buried at the Chariot site. At the request of the Point Hope and Kivalina Whaling Captains, the schedule for the site cleanup has been changed from March/April 1993 to a window of opportunity in July/August 1993. In phone calls and letters to DEC and DOE, the whaling captains and North Slope Borough representatives have asked that nothing be done at the site during March, April, May and June so that subsistence hunts for whale, seal, and walrus will not be disrupted. Also, for safety and logistical reasons, the July/August time frame is much better.

DOE will now revise the remediation, operations, and safety plans and will develop the test plot and background sampling plans. Both sets of plans will be presented in Point Hope and Kivalina during meetings which are tentatively scheduled for the last week in January or early in February 1993. At that time, the conceptual plans with details of the operations will be presented orally and written plans will be distributed for a 30-day public comment period. The general public and the local residents will be encouraged to review the documents and submit comments to DEC or DOE or give their comments to their respective representatives on the Multi-Agency Committee (MAC) and Citizen's Advisory Group (CAG). The MAC and CAG will meet in Point Hope at the end of the comment period to discuss comments received and possible resolutions to expressed concerns.

DOE has recently found pictures taken during the United States Geological Survey (USGS) tracer experiment and disposal process. The photographs (three of which are included with this newsletter) show several of the test plots, the wasted contaminated soil and boards, and the cover material. DOE presented the pictures at the Radiation Workshop held in Barrow on December 15, 1992. Bad weather caused cancellation of the workshops in Point Hope, Kivalina, and Kotzebue which were scheduled for later that week. The four and a half hour workshop was broadcast in Inupiaq by KBRW Radio and was videotaped in English and translated into Inupiaq for future distribution to the communities and other interested parties.

A letter dated November 24, 1992 from DOE Assistant Secretary for Environmental Restoration and Waste Management Leo P. Duffy to North Slope Borough Mayor Jeslie Kaleak, Sr. states that "DOE is committed to removing the low-level radioactive waste mound from the Project Chariot site." Mr. Duffy also states in the letter "We do not believe that any radiation exposure of the residents of the Cape Thompson area occurred as a result of the burial of the low-level radioactive waste."

Other Information: ADEC has received copies of several letters and reports which may be of interest to the public. Highlights of these documents are presented here.

The Environmental Protection Agency's Jim McCormick responded to a letter from Rebecca Friedenthal, a concerned citizen, in a letter dated November 2, 1992. The EPA states that "the material that was finally buried was dilute and not highly dangerous. With elapsed time, the remaining material has decayed and lost its radioactivity to the point that it is even less a problem....There isn't enough total radioactivity there to make this an acute hazard, no matter what activities were to occur on the site." He goes on to state that field studies were recently conducted, and no readings on the surface are any different than the natural background. "The radioactive material did not cause these cancers in that population. There is no reason to believe that the people of Point Hope have been exposed to any other dangers from this material. The most effective assistance to the people of Point Hope would be to identify the risk factors for the specific diseases in the community, and discover which factors are prevalent in that community."

Ms. Shirley A. Fry of the Oak Ridge Institute for Science and Education responded to Dr. Bruce Chandler's, M.D. inquires in a letter dated November 4, 1992. Ms. Fry states the following:

> "Given the information you provided about radionuclides buried in Alaska in 1962, it is my initial impression that they do not have the potential to cause acute clinical effects in the short term, nor to contribute to the overall risk of cancer among area residents....[T]here is no reason to suspect, based on the information I have, that the population in the area around the burial site could have been exposed to radiation from the buried materials at levels sufficiently high as to significantly increase their risk of developing or dying from radiogenic cancer, above that expected in the 'non exposed' populations at locations further away from the burial site."

Dr. Darrell Fisher gave a presentation at the University of Alaska, Fairbanks on November 13, 1992 on the Chariot site contamination. He stated in his presentation that "it would be less expensive to go in and remove the whole mound and transfer it somewhere than to do an extensive characterization on it." The greatest safety concern for those working on this operation is the danger from the environment, equipment and aircraft travel, rather than any radiation hazards. Dr. Fisher stated he had put a lot of thought into his recommendations with his principal consideration being the people in Pt. Hope. He feels that the Pt. Hope contamination does not represent a threat to human health. He recommends that the contamination be left "in place" below permafrost with a fence around the mound with appropriate posting. The DOE should allow the residual Cesium ^{137} to decay away to non-detect levels (which will take about 100 years) and to reallocate cleanup funds to medical research or to debt reduction. "I think if the cleanup process goes through, it would be the most expensive and least cost-effective radiation cleanup in the history of mankind."

Dr. Peter Nakamura, M.D., M.P.H. (Alaska Department of Health and Social Services) submitted on November 24, 1992 to the Multi Agency Committee (MAC) a report from Dr. Bruce Chandler, M.D., M.P.H. and Dr. John P. Middaugh, M.D. titled "Health Risk Assessment of Radioisotopes at Cape Thompson, Alaska." Some highlights of their report are as follows:

> "Mixed fission products and measured amounts of three specific radioisotopes totalling 26 millicuries of radioactive material were diluted in a total of 43.5 pounds of sand and soil and applied to the 12 test plots.
>
> "In a memorandum dated April 10, 1963, all activities regarding the status of the experimental site were summarized by the AEC, Division of Licensing and Regulation (DL&R). The AEC DL&R concluded, 'We believe no further action is warranted,' and '[i]n summary, we (at last) feel satisfied the radioactive waste mound at the Chariot site does not represent a health and safety problem and....it can be abandoned.' No further action regarding the materials at Cape Thompson was recommended."
>
> By using computer modeling, DOE has made the following calculated predictions of radiation exposures to individuals at Cape Thompson. "In a worst case scenario, if an individual were to have remained atop the burial site 24 hours per day for a full year, the most additional radiation he could receive from the site over and above background would be 10^{-5} milliRoentgen. This amount of radiation is equivalent to about one millionth of a routine chest x-ray or to the exposure a person receives in nine hundredths of a second in a jet plane at cruising altitude.
>
> "Matthew McKenna recently studied cancer in the North Slope from 1984 to 1989. He found that the age-adjusted cancer rate among North Slope residents was approximately 5 percent higher than the general cancer rate of the entire United States. When stratified by sex, male North Slope residents had a cancer rate 15 percent lower than the overall U.S. rate while female North Slope residents had a rate 25 percent higher than the U.S. rate. The age-adjusted cancer rate among residents of Point Hope was 38 percent higher than the overall U.S. rate; this difference was not statistically significant due to the small population of Point Hope residents. The eight cancers that were diagnosed in Point Hope residents from 1984 to 1989 included 2 cases of lung cancer, 2 cases of cervical cancer, and 1 case each of stomach, bone, colon and testicular cancer.

"The common types of cancers associated with radiation exposure among Hiroshima and Nagasaki bomb survivors and others with known radiation exposure have included thyroid cancers, leukemia, multiple myeloma, and breast cancer in females. None of these cancers was noted among Point Hope residents from 1984 to 1989.

"Concerns have been expressed that the buried radioisotope material may enter the food chain of Native subsistence hunters and their families through uptake by plants growing atop the burial site which are in turn eaten by caribou grazing at the site. Extensive research was done documenting the deposition of radionuclides in the arctic as a result of atmospheric nuclear tests in the 1950s. Cesium ^{137} was shown to enter the food chain and was detectable in very low amounts in lichens, caribou, and Alaska Natives. In the 1980s several detailed studies reviewed all available findings and concluded that levels were so low as to be of no public health concern."

The conclusions and recommendations of this Alaska Department of Health & Social Services report are quoted as follows:

1. The radioisotopes buried at Cape Thompson present no health risk to subsistence hunters in the area or to persons living in nearby villages. They have never presented a risk and will not present a risk if left in their present state. The small amount of radiation released by the remaining radioisotopes is completely attenuated by the soil mixed with the radioisotopes in the disposal material and by the overlying top cover. Individuals remaining atop the burial site indefinitely would experience absolutely no increased health risk of radiation-related cancer or other health problems. Given the low background radiation levels at Cape Thompson, the risk of radiation-related cancers is lower than most other places in the United States.

2. All available evidence shows that past, current, and future potential health problems of residents of Point Hope are not related to radiation exposure at Cape Thompson. Epidemiologic studies of cancer among North Slope residents and Point Hope residents have not shown an excess of the types of cancers known from studies elsewhere to be associated with radiation exposure.

3. Given that the burial site presents absolutely no health risk, there is no indication for the site to be excavated or for the small amounts of remaining materials to be removed.

4. Potential exists for serious injuries or fatalities to occur if removal is attempted. Logistics are difficult. It would be tragic if anyone suffered an injury or fatality in an effort to clean up materials that pose no health threat to any living creature.

5. Removal of the material from the tundra at Cape Thompson would require the expenditure of millions of dollars. During this investigation the situation at Cape Thompson has been reviewed with a number of radiation physicists. When queried on whether the radioisotopes should be moved, the answer was uniformly and emphatically no. Money required for the Cape Thompson cleanup could be put to much better use studying health problems of North Slope residents and addressing the significant public health problems facing Point Hope and other Alaskan villages and communities, including problems of smoking, alcohol, and vaccine-preventible diseases.

6. Given the strength of scientific evidence, major efforts need to be focused on communicating existing information to local residents. Essential are efforts to identify credible individuals who are trusted by local residents and to support a process that enables local residents and all other Alaskans to examine all the evidence. Supplemental funds should be made available to empower the local communities to assess evidence now available so they can regain control over their lives.

If you would like a copy of any of these letters, please contact Deborah Alberg (DEC) at (907) 451-2175.

UPDATE: CHARIOT PROJECT SITE

February 10, 1993

North Slope Borough
City of Point Hope
City of Kivalina
Northwest Arctic Borough
Alaska Department of Environmental Conservation

The State of Alaska and the residents of the North Slope and Northwest Arctic Boroughs would like to inform everyone of the latest schedule of events involving the cleanup of the Chariot Project Site. At this time, the U.S. Department of Energy's (DOE) plan is to do the site remediation work during a window of opportunity in July/August. Comments and questions about this newsletter may be directed to Deborah Alberg at (907) 451-2175.

FEB 9: The U.S. Department of Energy (DOE) will meet with the Alaska Department of Environmental Conservation (DEC), the U.S. Fish and Wildlife Service (FWS), the North Slope Borough, the Northwest Arctic Borough, City of Kivalina, and the City of Point Hope, to present the draft work plan.

WEEK FEB 9th: The Project Chariot Site Remediation Plans will be distributed for comment. The remediation plans include the operational plan, the sampling plan, the quality assurance plan, the waste management plan, and the health and safety plan.

FEB 17: The North Slope Borough's contractor, Foster Wheeler Environmental Service will make a presentation in Point Hope.
Topics they will discuss include:

a. Basic Radiation
   (1) Background Radiation Information
      - Natural and Man-made Radioactivity; Radioactive Decay and Biological Removal; Radiation and Radioactivity Summary; Interaction of Radiation with the Environment; Behavior of Radioactivity: What does it Do?; and Alpha, Beta, Gamma Radiation, and X-Rays.
   (2) Radiation Monitoring and Effects on the Environment
      - Units of Radiation; Biological Effects of Radiation; Radiation Exposure Limits; Exposure Pathways for Humans; Regulatory Requirements for Monitoring the Environment; and Methods for Environmental Surveillance.

b. Project Chariot Site Information Review
   (1) General Overview and Objectives of Project Chariot Program
   (2) Overview of the original U.S. Geological Survey Tracer Experiment

WEEK FEB 23rd: Meetings will include discussions of the following: A work plan concept presentation by DOE; an explanation of the environmental assessment (EA) process by the Fish and Wildlife Service (FWS will be taking concerns from the villagers that will later be addressed in the EA); and, a health issues presentation by Department of Health and Social Services.

Tentative schedule:

Monday, 2/22 - Point Hope
   Meeting 2:00 pm - 5:00 pm (Kalgi Center)
Tuesday, 2/23 - 10:00 am - 2:00 pm (Kalgi Center)
Wednesday, 2/24 - Kotzebue
   Meeting 9:00 am - 3:00 pm (Army National Guard Drill Hall)
Thursday, 2/25 - Kivalina
   Meeting 10:30 am - 3:15 pm (Community Building)

LIST OF AGENCY REPRESENTATIVES

Joel Eacker, Westinghouse Corp.
Kevin Cabble, DOE-NV Field Office
Paul Gretsky, IT Corp.
Dr. Wayne Hanson, HERS
Doug Dasher, ADEC
Deborah Alberg, ADEC
Dr. Pete Nakamura, ADHSS
Dr. Jim Berner, USPHS-IHS
Gary Montoya, USFWS

FEB 12-MAR 12: Comment period on Project Chariot Site Remediation Plans. During this period, people should provide written comments to:

U.S. Department of Energy
Attn: Kevin Cabble
2765 South Highland, Suite 200
Las Vegas, NV 89109

WEEK MAR 22nd: (tentative date) DOE will hold a public meeting and meet with the Citizen's Advisory Committees in Point Hope to discuss comments and final Work plans.

JULY - AUG: Site Restoration Activities

UPDATE: CHARIOT PROJECT SITE

August 9, 1993

North Slope Borough
City of Point Hope
City of Kivalina
Northwest Arctic Borough
Alaska Department of Environmental Conservation

The State of Alaska and the residents of the North Slope and Northwest Arctic Boroughs would like to inform everyone of the latest restoration activities at the Chariot site.

On July 29, 1993, Project Chariot field operations started. A public meeting was held in Point Hope on July 30, 1993 at 7:00 pm. At this meeting the U.S. Department of Energy (DOE) and its contractors explained the field operations that are to take place this summer. Several people stated their concerns about the documents not yet being declassified, field locations that they felt needed to be sampled, long term monitoring, and biota sampling. No one requested that the field operations be halted.

Water, sediment and biota sampling is currently underway at the site. Vegetation and mammal samples are also being taken at this time. The Alaska Department of Environmental Conservation (DEC) has been and will continue to take splits of the above samples. The Department will be adding an additional person to it's field team so we can better provide oversight of the different DOE sampling teams.

Vegetation samples have been taken off of the mound site and traps have been placed to take mammal samples. Currently, the Pressurized Ion Chambers are being placed on and around the mound to obtain background readings. The one on the mound was reading approximately 6 uR/hr.

Grid lines are also being laid out along Snowbank Creek so that the ground survey can begin. This survey will look for the original 1962 soil test plots.

On August 2, 1993, Bill Turner of Foster Wheeler (North Slope contractor) located a tracer plot site. The plot located is to the south west and is approximately 200 feet from the mound. Preliminary analysis of the soil indicated that there was Cesium 137 present in the soil. It appears to be one of the USGS tracer study sites that used the Cesium 137 radioisotopes.

The barge had not been able to completely off-load due to sea conditions. On the morning of August 3, 1993, the barge was able to get in and off-loading was completed. Once this was completed the heavy equipment began to place the Unimats and travel to the mound.

On August 6, 1993 the heavy equipment made it to the mound. Unimats were placed and excavation of the mound began on August 7, 1993. As of August 8, 1993, several layers of the mound had been removed. Radiological soil analyses are currently be conducted in the field lab.

UPDATE: CHARIOT PROJECT SITE

September 2, 1993

North Slope Borough
City of Point Hope
City of Kivalina
Northwest Arctic Borough
Alaska Department of Environmental Conservation

The State of Alaska and the residents of the North Slope and Northwest Arctic Boroughs would like to inform everyone of the latest restoration activities at the Chariot site.

On August 26, 1993, excavations of the mound and a cesium 137 site were completed. For soil verification sampling on the mound and the site, International Technologies (IT) (U.S. Department of Energy's contractor) set up a hexagonal grid on which 37 sampling points were established. IT took 37 discrete samples to be analyzed on-site as well as compositing each quadrant into 4 samples to be sent off to their lab in St. Louis. The Department of Environmental Conservation (DEC) took 12 split samples of the 37 and 1 split of the 4 composites. These samples were analyzed both in DEC's on-site lab and contract lab, Lockheed, in Las Vegas. Foster Wheeler (North Slope Borough's consultant) also took splits of the soil verification samples that were run both on-site and off-site (Enseco Lab-Denver). The samples that were analyzed on-site were analyzed for cesium 137. Analysis run on the samples off-site included gross alpha, gross beta, a gamma spectrum which included cesium 137, and on some samples strontium 90 and plutonium 235. All the results from the verification samples were below 10 pCi/g cesium 137 (cleanup level). Therefore, DEC issued clean closure on both of the areas. Those areas have since been graded and revegetated.

Approximately 150 cubic yards of contaminated soil was placed in B-25s that will be placed on a barge and shipped to Seattle. In Seattle, the B-25s will be off loaded onto trucks and transported to the Nevada Test Site for disposal.

Extensive biota sampling was conducted of both Ogotoruk Valley and Kisimilok Valley. IT collected over 200 biota samples. These samples included lichen, sedges, willows, heather, birch, blueberries, mountain avens, cotton grass, Labrador tea, mushrooms, caribou, arctic ground squirrels, willow ptarmigan, grizzly bear, voles, and lemmings. DEC and Foster Wheeler collected split samples of these as well. In addition to the biota and soil verification sampling, background soil, water, and sediment sampling were also completed. Laboratory analysis of these samples are expected to be completed, including QA/QC review over the next several months. Currently, the barge is expected to arrive on September 2, 1993. Provided the weather cooperates, the Chariot camp should be closed down by early next week.

Public meetings were held in Point Hope on the 27th of August and on the 28th in Kivalina. At these meetings DOE and its contractors explained the cleanup operations that were completed during the summer. A majority of the local people were satisfied with the cleanup effort.

The final steps of this project still involve the QA/QC of the field and lab data, report preparation, review of DOE's report and a public presentation in late 1993 or early 1994 in Point Hope. In addition, the Agreement in Principal between DEC and DOE is being modified to include a PIC monitoring station in Point Hope, in conjunction with a grant request for fully funding Point Hope's PIC monitoring operation for a 5 year period.

DEC's activities in 1994 include PIC training for DEC and community operators, selection of community operators for the PIC station, installation of the PIC in Point Hope, the public meeting on Project Chariot cleanup and PIC operations, and an inspection of the revegetation project at the Project Chariot site.

APPENDIX C

AERIAL PHOTOGRAPHS

Aerial Radiological Survey

The following photos and contour lines represent the distribution of gamma radioactivity measured by EG&G in July 1993 at Ogotoruk and Kisimilok valley. Additional information on the aerial radiological survey can be found in the US Department of Energy Report DOE/NV-368 UC70 *Project Chariot Site Assessment and Remedial Action Final Report*.

APPENDIX D

SAMPLE RESULTS

draft 930901
rev. 940203

Gross Alpha Page 1 of 1

PROJECT CHARIOT REMEDIATION ANALYTICAL RESULTS
GROSS ALPHA

ADEC Sample #	IT Sample #	Foster Wheeler Sample #	Sample Site Location	Matrix	Lockheed Gross Alpha	Lockheed Number	IT-St.Louis Gross Alpha	Foster Wheeler Gross Alpha
					Results in pCi/L			
0003 DHD 93 PC	CHR OC SW 04		Ogotoruk Cr., site 04	Surface water	<0.92	L201	-0.29	
0005 DHD 93 PC	CHR OC SW 02		Ogotoruk Cr., site 02	Surface water	<0.97	L201	0.63	
0001 DHD 93 PC	CHR SBC SW 07 01		Snowbank Cr., site 07	Surface water	<2.5	L201		
0007 DHD 93 PC	CHR SBC SW 02		Snowbank Cr., site 02	Surface water	<1.9	L201	1.48	
0009 DHD 93 PC	CHR SBC SW 01		Snowbank Cr., site 01	Surface water	<2.5	L201	1.5	
0011 DHD 93 PC	CHR TR3 SW 06		Snowbank Cr., trib 3, site 06	Surface water	<1.6	L201	1.36	
0110 DHD 93 PC	N/A		Base of Crowbill Point	Surface water	4.4	L290	N/A	
0026 JEK 93 PC	N/A		Kisimilok Valley, station 1 (KV-1)	Surface water	<1.1	L235	N/A	
0029 JEK 93 PC	N/A		Kisimilok Valley, station 2 (KV-2)	Surface water	<0.94	L235	N/A	
0030 JEK 93 PC	N/A		Kisimilok Valley, station 2 (KV-2)	Surface water	<0.97	L235	N/A	
0034 JEK 93 PC	N/A		Kisimilok Valley, station 3 (KV-3)	Surface water	<1.0	L235	N/A	

Note: * Appears peak background has not been subtracted.
** All peaks for activity calculation had bad shape.
Where "<" appears, the result was less than the Minimum Detection Activity

draft 930901
rev. 940203

Gross Alpha Page 1 of 1

PROJECT CHARIOT REMEDIATION ANALYTICAL RESULTS
GROSS ALPHA

ADEC Sample #	IT Sample #	Foster Wheeler Sample #	Sample Site Location	Matrix	Results in pCi/g Lockheed Gross Alpha	Lockheed Number	IT-St.Louis Gross Alpha	Foster Wheeler Gross Alpha
0103 DLA 93 PC	N/A		Ogotoruk Cr., (mouth)	Sediment	9.2	L273	N/A	
0004 DHD 93 PC	CHR OC SD 04		Ogotoruk Cr., site 04	Sediment	12.9	L201	8.23	
0006 DHD 93 PC	CHR OC SD 02		Ogotoruk Cr., site 02	Sediment	13.6	L201	11.35	
0002 DHD 93 PC	CHR SBC SD 07 01		Snowbank Cr., site 07	Sediment	26.4	L201	28.59	
0008 DHD 93 PC	CHR SBC SD 02		Snowbank Cr., site 02	Sediment	18.2	L201	5.91	
0010 DHD 93 PC	CHR SBC SD 01		Snowbank Cr., site 01	Sediment	16.8	L201	5.51	
0027 JEK 93 PC	N/A		Kisimilok Valley, station 1 (KV-1)	Sediment	10.1	L234	N/A	
0031 JEK 93 PC	N/A		Kisimilok Valley, station 2 (KV-2)	Sediment	12.1	L234	N/A	
0032 JEK 93 PC	N/A		Kisimilok Valley, station 2 (KV-2)	Sediment	15.3	L234	N/A	
0035 JEK 93 PC	N/A		Kisimilok Valley, station 3 (KV-3)	Sediment	9	L234	N/A	

Note: * Appears peak background has not been subtracted.
** All peaks for activity calculation had bad shape.
Where "<" appears, the result was less than the Minimum Detection Activity

draft 930901
rev. 940203

PROJECT CHARIOT REMEDIATION ANALYTICAL RESULTS
GROSS ALPHA

ADEC Sample #	IT Sample #	Foster Wheeler Sample #	Sample Site Location	Matrix	Results in pCi/g Lockheed Gross Alpha	Lockheed Number	IT-St.Louis Gross Alpha	Foster Wheeler Gross Alpha
0046 JEK 93 PC	CHR CC 1.26		Mound verification sample 26	Soil	17.8	L233	N/A	
0047 JEK 93 PC	CHR CC 1.28		Mound verification sample 28	Soil	11.8	L233	N/A	
0048 JEK 93 PC	CHR CC 1.35		Mound verification sample 35	Soil	9	L233	N/A	
0049 JEK 93 PC	CHR CC 1.37		Mound verification sample 37	Soil	15.8	L233	N/A	
0050 JEK 93 PC	CHR CC 1-S		Mound verification - south comp.	Soil	12.8	L233	<4.74	
CESIUM PLOT SAMPLES								
0012 DHD 93 PC	SS 002	FW-23MD	Cesium plot, Snowbank Cr.	Soil	21.4	L201	N/A	31
0051 JEK 93 PC	CHR-CC-P-1.02		Cs plot verification sample 2	Soil	(not sent)		N/A	
0052 JEK 93 PC	CHR-CC-P-1.03		Cs plot verification sample 3	Soil	11.8	L245	N/A	
0053 JEK 93 PC	CHR-CC-P-1.08		Cs plot verification sample 8	Soil	(not sent)		N/A	
0054 JEK 93 PC	CHR-CC-P-1.11		Cs plot verification sample 11	Soil	<6.5	L245	N/A	
0055 JEK 93 PC	CHR-CC-P-1.15		Cs plot verification sample 15	Soil	(not sent)		N/A	
0056 JEK 93 PC	CHR-CC-P-1.18		Cs plot verification sample 18	Soil	16.7	L245	N/A	
0057 JEK 93 PC	CHR-CC-P-1.22		Cs plot verification sample 22	Soil	(not sent)		N/A	
0058 JEK 93 PC	CHR-CC-P-1.23		Cs plot verification sample 23	Soil	14.8	L245	N/A	
0059 JEK 93 PC	CHR-CC-P-1.24		Cs plot verification sample 24	Soil	(not sent)		N/A	
0060 JEK 93 PC	CHR-CC-P-1.26	FW-39PT	Cs plot verification sample 26	Soil	(not sent)		N/A	6
0061 JEK 93 PC	CHR-CC-P-1.28		Cs plot verification sample 28	Soil	(not sent)		N/A	
0062 JEK 93 PC	CHR-CC-P-1.31	FW-40PT	Cs plot verification sample 31	Soil	(not sent)		N/A	12
0063 JEK 93 PC	CHR-CC-P-W		Cs plot verification - west comp.	Soil	9.8	L245		

Note: * Appears peak background has not been subtracted.
** All peaks for activity calculation had bad shape.
Where "<" appears, the result was less than Minimum Detection Activity

draft 930901 | Gross Alpha | Page 1 of 1

rev. 940203

PROJECT CHARIOT REMEDIATION ANALYTICAL RESULTS
GROSS ALPHA

					Results in pCi/g			
ADEC Sample #	IT Sample #	Foster Wheeler Sample #	Sample Site Location	Matrix	Lockheed Gross Alpha	Lockheed Number	IT-St.Louis Gross Alpha	Foster Wheeler Gross Alpha
0064 JEK 93 PC	93-CH-43 & 44	93-CH-43/44	Station 10 (Cetraria delesei)	Biota - lichen	2.8	L274		21.4
0065 JEK 93 PC	93-CH-80 & 97		SRN & SRS (Cetraria delesei)	Biota - lichen	2.38	L274		
0066 JEK 93 PC	93-CH-103 & 105		Station 7 (Cetraria delesei)	Biota - lichen	7.09	L274		
0067 JEK 93 PC	93-CH-135 & 136		Station 4 (Cetraria delesei)	Biota - lichen	6.2	L274		
0069 JEK 93 PC	93-CH-66		Station 6 (Cassiope tetragona)	Biota - heather	1.1	L274		
0070 JEK 93 PC	93-CH-39		Station 10 (Cassiope tetragona)	Biota - heather	0.53	L274		
0071 JEK 93 PC	93-CH-147		Station 2 (Vaccinium ulignosom)	Biota - blueberry	0.5	L274		
0072 JEK 93 PC	93-KV-25 & 29		KV-1 (Vaccinium ulignosom)	Biota - blueberry	0.82	L274		
0068 JEK 93 PC	93-CH-70 & 71		Station 12 (Salix alexensis)	Biota - willow	<0.50	L274		
0073 JEK 93 PC	93-CH-85 & 86		Station 16 (Salix alexensis)	Biota - willow	<0.59	L274		
0074 JEK 93 PC	93-CH-82 & 83	93-CH-82/83/84	Station 13 (Salix alexensis)	Biota - willow	<0.50	L274		2.7
0075 JEK 93 PC	93-KV-17 & 18		KV-3 (Salix lonata)	Biota - willow	0.57	L274		
0076 JEK 93 PC	93-KV-10 & 11		KV-2 (Salix lonata)	Biota - willow	<0.39	L274		
0085 JEK 93 PC	93-CH-58B		Cesium plot (Salix spp.)	Biota - willow	<0.45	L274		
0077 JEK 93 PC	93-KV-30 & 31		KV-1 (Betula nana)	Biota - birch	0.59	L274		
0078 JEK 93 PC	93-CH-77, 78, & 79		SRN (Dryas octopetala)	Biota - mtn avens	0.88	L274		
0079 JEK 93 PC	93-CH-94 & 96		SRS (Dryas octopetala)	Biota - mtn avens	1.2	L274		
0081 JEK 93 PC	93-CH-137,138, & 139		Station 4 (Carex aquatius)	Biota - sedge	0.46	L274		
0082 JEK 93 PC	93-CH-115 & 116		Station 3 (Carex aquatius)	Biota - sedge	0.55	L274		
0083 JEK 93 PC	93-CH-145 & 146		Station 7 (Carex aquatius)	Biota - sedge	0.55	L274		
0084 JEK 93 PC	93-CH-60, 61, & 62	93-CH-60/61/62	Cesium plot (Carex aquatius)	Biota - sedge	0.98	L274		1.6
0080 JEK 93 PC	93-CH-28		Station 10 (Eriophorum vaginaton)	Biota - cottongrass	0.47	L274		
0086 JEK 93 PC	93-CH-29 & 31	93-CH-29/31	GS mound (Eriophorum vaginaton)	Biota - cottongrass	0.57	L274		9.1
0087 JEK 93 PC	93-CH-23 & 32		GS mound (Ledum decumbens)	Biota - Lab. tea	0.46	L274		
0088 JEK 93 PC	93-CH-8.3 & 9.3		Camp #8 (carcass)	Biota - gr. squirrel	<0.35	L262		
0089 JEK 93 PC	93-CH-152.3 & 153.3		Station 2 (carcass)	Biota - gr. squirrel	<0.48	L262		
0090 JEK 93 PC	93-KV-19.3 & 27.3		KV-1 (carcass)	Biota - gr. squirrel	<0.19	L262		
0091 JEK 93 PC	93-CH-132.3 & 133.3		MSP, Mammal Study Plot (carcass)	Biota - gr. squirrel	<0.15	L262		
0092 JEK 93 PC	93-CH-57.3 & 101.3		GS mound (carcass)	Biota - gr. squirrel	<0.14	L262		
0093 JEK 93 PC	93-CH-98.3 & 117.3		MSP & SRS (carcass)	Biota - gr. squirrel	<3.1	L262		
0094 JEK 93 PC	93-CH-63.3 & 64.3		Station 6 (carcass)	Biota - gr. squirrel	<5.3	L262		
0095 JEK 93 PC	93-CH-48.3 & 49.3		Snowbank Cr., 3500 feet (carcass)	Biota - ptarmigan	<0.36	L262		
0096 JEK 93 PC	93-CH-176.1	93-CH-176.1	Kivalina - Cape Thompson, Seppings	Biota - caribou (m)	<3.6	L262		0.07
0097 JEK 93 PC	93-CH-174.1	93-CH-174.1	Kivalina - Cape Thompson, Seppings	Biota - caribou (m)	<0.70	L262		0.047
0098 JEK 93 PC	93-CH-179.1	93-CH-179.1	Pt. Hope - Cape Thompson	Biota - caribou (m)	<0.47	L262		0.047
0101 JEK 93 PC	93-CH-180.1	93-CH-180.1	Pt. Hope - Singoalik River	Biota - caribou (m)	<0.19	L262		0.05
0099 JEK 93 PC	93-CH-179.2		Pt. Hope - Cape Thompson	Biota - caribou (b)	<0.91	L262		
0100 JEK 93 PC	93-CH-180.2		Pt. Hope - Singoalik River	Biota - caribou (b)	<0.85	L262		
0102 DLA 93 PC	93-CH-165.2		Beach - 5 miles east Chariot camp	Biota - grizzly (b)	<1.1	L262		

Note: * Appears peak background has not been subtracted.
** All peaks for activity calculation had bad shape.
Where "<" appears, the result was less than the Minimum Detection Activity

draft 930901
rev. 940203

Gross Beta Page 1 of 1

PROJECT CHARIOT REMEDIATION ANALYTICAL RESULTS
GROSS BETA

ADEC Sample #	IT Sample #	Foster Wheeler Sample #	Sample Site Location	Matrix	Results in pCi/L: Lockheed Gross Beta	Lockheed Number	IT-St.Louis Gross Beta	Foster Wheeler Gross Beta
0110 DHD 93 PC	N/A		Base of Crowbill Point	Surface water	<3.5	L290	N/A	
0003 DHD 93 PC	CHR OC SW 04		Ogotoruk Cr., site 04	Surface water	<2.1	L201	0.94	
0005 DHD 93 PC	CHR OC SW 02		Ogotoruk Cr., site 02	Surface water	<2.1	L201	0.76	
0001 DHD 93 PC	CHR SBC SW 07 01		Snowbank Cr., site 07	Surface water	<2.6	L201		
0007 DHD 93 PC	CHR SBC SW 02		Snowbank Cr., site 02	Surface water	<2.2	L201	0.2	
0009 DHD 93 PC	CHR SBC SW 01		Snowbank Cr., site 01	Surface water	<2.4	L201	1.08	
0011 DHD 93 PC	CHR TR3 SW 06		Snowbank Cr., trib 3, site 06	Surface water	<2.2	L201	0.52	
0026 JEK 93 PC	N/A		Kisimilok Valley, station 1 (KV-1)	Surface water	<2.0	L235	N/A	
0029 JEK 93 PC	N/A		Kisimilok Valley, station 2 (KV-2)	Surface water	<2.1	L235	N/A	
0030 JEK 93 PC	N/A		Kisimilok Valley, station 2 (KV-2)	Surface water	<2.1	L235	N/A	
0034 JEK 93 PC	N/A		Kisimilok Valley, station 3 (KV-3)	Surface water	<2.1	L235	N/A	

Note: * Appears peak background has not been subtracted.
** All peaks for activity calculation had bad shape.
Where "<" appears, the result was less than the Minimum Detection Activity

draft 930901
rev. 940203

Gross Beta   Page 1 of 1

PROJECT CHARIOT REMEDIATION ANALYTICAL RESULTS
GROSS BETA

ADEC Sample #	IT Sample #	Foster Wheeler Sample #	Sample Site Location	Matrix	Results in pCi/g Lockheed Gross Beta	Lockheed Number	IT-St.Louis Gross Beta	Foster Wheeler Gross Beta
0004 DHD 93 PC	CHR OC SD 04		Ogotoruk Cr., site 04	Sediment	22.3	L201	28.98	
0006 DHD 93 PC	CHR OC SD 02		Ogotoruk Cr., site 02	Sediment	17.3	L273	24.82	
0103 DLA 93 PC	N/A		Ogotoruk Creek (mouth)	Sediment	15.7	L201	N/A	
0002 DHD 93 PC	CHR SBC SD 07 01		Snowbank Cr., site 07	Sediment	29.6	L201	35.28	
0008 DHD 93 PC	CHR SBC SD 02		Snowbank Cr., site 02	Sediment	18.3	L201	27.45	
0010 DHD 93 PC	CHR SBC SD 01		Snowbank Cr., site 01	Sediment	14.2	L201	18.74	
0027 JEK 93 PC	N/A		Kisimilok Valley, station 1 (KV-1)	Sediment	15.7	L234	N/A	
0031 JEK 93 PC	N/A		Kisimilok Valley, station 2 (KV-2)	Sediment	21.1	L234	N/A	
0032 JEK 93 PC	N/A		Kisimilok Valley, station 2 (KV-2)	Sediment	20.4	L234	N/A	
0035 JEK 93 PC	N/A		Kisimilok Valley, station 3 (KV-3)	Sediment	21.2	L234	N/A	

Note: * Appears peak background has not been subtracted.
** All peaks for activity calculation had bad shape.
Where "<" appears, the result was less than the Minimum Detection Activity

draft 930901
rev. 940203

Gross Beta | Page 1 of 2

PROJECT CHARIOT REMEDIATION ANALYTICAL RESULTS
GROSS BETA

ADEC Sample #	IT Sample #	Foster Wheeler Sample #	Sample Site Location	Matrix	Lockheed Gross Beta (Results in pCi/g)	Lockheed Number	IT-St.Louis Gross Beta (Results in pCi/g)	Foster Wheeler Gross Beta (Results in pCi/g)
BACKGROUND SAMPLES								
0013 DHD 93 PC	SS 005		Background site A	Soil	14.5	L201	N/A	
0014 DHD 93 PC	SS 019		Background site B	Soil	17.7	L201	N/A	
0015 DHD 93 PC	SS 028		Background site D	Soil	13.7	L201	N/A	
0021 DHD 93 PC	N/A		Snowbank Cr. - 3500' - J.S. (comp.)	Soil	36.4	L201	N/A	
0023 DLA 93 PC	N/A		Snowbank Cr. - 3500' - J.S. (auger)	Soil	33.8	L201	N/A	
0028 JEK 93 PC	N/A		Kisimilok Valley, station 1 (KV-1)	Soil - upper l	21.1	L201	N/A	
0033 JEK 93 PC	N/A		Kisimilok Valley, station 3 (KV-3)	Soil - lowland	23	L234	N/A	
0104 DLA 93 PC	N/A		Borehole #1	Soil	7.5	L273	N/A	
0105 DLA 93 PC	N/A		East of Ogotoruk Cr. on beach	Soil - shale	25	L273	N/A	
0106 DLA 93 PC	N/A		Near Boreholes #3 and #4	soil - shale	25.8	L273	N/A	
0107 DLA 93 PC	N/A		Near Borehole #7	Soil	21.9	L273	N/A	
0108 DLA 93 PC	N/A		Cross on hill, east of Chariot camp	Soil	21.7	L273	N/A	
0109 DLA 93 PC	N/A		Crowbill Point	Soil	20.2	L273	N/A	
MOUND SAMPLES								
0025 JEK 93 PC	N/A		B-25s - waste characterization	Soil	(not sent)		N/A	
0024 SMR 93 PC	SS 058		Mound - center north dirt pile	Soil	13.1	L234	N/A	
0022 DHD 93 PC	SS 065		Mound - south west	Soil	132.3	L234	N/A	
0022 DHD 93 PCA	split w/0022DHD93PC		Mound - south west	Soil	121.1	L234	N/A	
0020 DHD 93 PC	SS 043		Mound - 5' from poss. rad area	Soil	16.6	L201	N/A	
0016 DHD 93 PC	SS 035		Mound - excavated dirt	Soil	16.4	L201	N/A	
0017 DHD 93 PC	SS 039		Mound excavation	Soil	16.2	L201	21.17	
0018 DHD 93 PC	SS 040		Mound - middle of lift 4	Soil	18.6	L201	N/A	
0019 DHD 93 PC	SS 042		Mound excavation	Soil	14.1	L201	N/A	
0036 DLA 93 PC	SS 067		Mound - south east corner	Soil	20.6	L245	N/A	
0037 JEK 93 PC	SS 083		Mound - trench composite	Soil	(not sent)		N/A	
0038 JEK 93 PC	CHR CC 1.02		Mound verification sample 2	Soil	19.9	L233	N/A	
0039 JEK 93 PC	CHR CC 1.09		Mound verification sample 9	Soil	18.1	L233	N/A	
0040 JEK 93 PC	CHR CC 1.11		Mound verification sample 11	Soil	19.5	L233	N/A	
0041 JEK 93 PC	CHR CC 1.13		Mound verification sample 13	Soil	17.3	L233	N/A	
0042 JEK 93 PC	CHR CC 1.14		Mound verification sample 14	Soil	13.3	L233	N/A	
0043 JEK 93 PC	CHR CC 1.17		Mound verification sample 17	Soil	18.5	L233	N/A	
0044 JEK 93 PC	CHR CC 1.18		Mound verification sample 18	Soil	14.8	L233	N/A	
0045 JEK 93 PC	CHR CC 1.23		Mound verification sample 23	Soil	16	L233	N/A	
0046 JEK 93 PC	CHR CC 1.26		Mound verification sample 26	Soil	14.3	L233	N/A	

draft 930901
rev. 940203

Gross Beta Page 2 of 2

PROJECT CHARIOT REMEDIATION ANALYTICAL RESULTS
GROSS BETA

ADEC Sample #	IT Sample #	Foster Wheeler Sample #	Sample Site Location	Matrix	Lockheed Gross Beta	Lockheed Number	IT-St.Louis Gross Beta	Foster Wheeler Gross Beta
					Results in pCi/g			
0047 JEK 93 PC	CHR CC 1.28		Mound verification sample 28	Soil	16.6	L233	N/A	
0048 JEK 93 PC	CHR CC 1.35		Mound verification sample 35	Soil	13.6	L233	N/A	
0049 JEK 93 PC	CHR CC 1.37		Mound verification sample 37	Soil	17.7	L233	N/A	
0050 JEK 93 PC	CHR CC 1-S		Mound verification - south comp.	Soil	18.2	L233	17.04	
CESIUM PLOT SAMPLES								
0051 JEK 93 PC	CHR-CC-P-1.02		Cs plot verification sample 2	Soil	(not sent)		N/A	
0052 JEK 93 PC	CHR-CC-P-1.03		Cs plot verification sample 3	Soil	17	L245	N/A	
0053 JEK 93 PC	CHR-CC-P-1.08		Cs plot verification sample 8	Soil	(not sent)		N/A	
0054 JEK 93 PC	CHR-CC-P-1.11		Cs plot verification sample 11	Soil	17.4	L245	N/A	
0055 JEK 93 PC	CHR-CC-P-1.15		Cs plot verification sample 15	Soil	(not sent)		N/A	
0056 JEK 93 PC	CHR-CC-P-1.18		Cs plot verification sample 18	Soil	15.2	L245	N/A	
0057 JEK 93 PC	CHR-CC-P-1.22		Cs plot verification sample 22	Soil	(not sent)		N/A	
0058 JEK 93 PC	CHR-CC-P-1.23		Cs plot verification sample 23	Soil	15.2	L245	N/A	
0059 JEK 93 PC	CHR-CC-P-1.24		Cs plot verification sample 24	Soil	(not sent)		N/A	
0060 JEK 93 PC	CHR-CC-P-1.26	FW-39PT	Cs plot verification sample 26	Soil	(not sent)		N/A	36
0061 JEK 93 PC	CHR-CC-P-1.28		Cs plot verification sample 28	Soil	(not sent)		N/A	
0062 JEK 93 PC	CHR-CC-P-1.31	FW-40PT	Cs plot verification sample 31	Soil	(not sent)		N/A	21
0063 JEK 93 PC	CHR-CC-P-W		Cs plot verification - west comp.	Soil	13.9	L245		
0012 DHD 93 PC	SS 002	FW-23MD	Cesium plot, Snowbank Cr.	Soil	346.4	L201	N/A	127

Note: * Appears peak background has not been subtracted.
** All peaks for activity calculation had bad shape.
Where "<" appears, the result was less than the Minimum Detection Activity

draft 930901 | Gross Beta | Page 1 of 1

rev. 940203

PROJECT CHARIOT REMEDIATION ANALYTICAL RESULTS
GROSS BETA

ADEC Sample #	IT Sample #	Foster Wheeler Sample #	Sample Site Location	Matrix	Results in pCi/g: Lockheed Gross Beta	Lockheed Number	IT-St.Louis Gross Beta	Foster Wheeler Gross Beta
0064 JEK 93 PC	93-CH-43 & 44	93-CH-43/44	Station 10 (Cetraria delesei)	Biota - lichen	27.3	L274		32.1
0065 JEK 93 PC	93-CH-80 & 97		SRN & SRS (Cetraria delesei)	Biota - lichen	17.5	L274		
0066 JEK 93 PC	93-CH-103 & 105		Station 7 (Cetraria delesei)	Biota - lichen	29.37	L274		
0067 JEK 93 PC	93-CH-135 & 136		Station 4 (Cetraria delesei)	Biota - lichen	30.8	L274		
0069 JEK 93 PC	93-CH-66		Station 6 (Cassiope tetragona)	Biota - heather	10.97	L274		
0070 JEK 93 PC	93-CH-39		Station 10 (Cassiope tetragona)	Biota - heather	6.79	L274		
0071 JEK 93 PC	93-CH-147		Station 2 (Vaccinium ulignosom)	Biota - blueberry	5.14	L274		
0072 JEK 93 PC	93-KV-25 & 29		KV-1 (Vaccinium ulignosom)	Biota - blueberry	6.41	L274		
0085 JEK 93 PC	93-CH-58B		Cesium plot (Salix spp.)	Biota - willow	6.78	L274		
0068 JEK 93 PC	93-CH-70 & 71		Station 12 (Salix alexensis)	Biota - willow	8.32	L274		
0073 JEK 93 PC	93-CH-85 & 86		Station 16 (Salix alexensis)	Biota - willow	13.95	L274		
0074 JEK 93 PC	93-CH-82 & 83	93-CH-82/83/84	Station 13 (Salix alexensis)	Biota - willow	9.79	L274		22
0075 JEK 93 PC	93-KV-17 & 18		KV-3 (Salix lonata)	Biota - willow	6.59	L274		
0076 JEK 93 PC	93-KV-10 & 11		KV-2 (Salix lonata)	Biota - willow	6.32	L274		
0077 JEK 93 PC	93-KV-30 & 31		KV-1 (Betula nana)	Biota - birch	6.31	L274		
0078 JEK 93 PC	93-CH-77, 78, & 79		SRN (Dryas octopetala)	Biota - mtn avens	7.36	L274		
0079 JEK 93 PC	93-CH-94 & 96		SRS (Dryas octopetala)	Biota - mtn avens	6.6	L274		
0080 JEK 93 PC	93-CH-28		Station 10 (Eriophorum vaginaton)	Biota - cottongrass	8.27	L274		
0086 JEK 93 PC	93-CH-29 & 31	93-CH-29/31	GS mound (Eriophorum vaginaton)	Biota - cottongrass	9.27	L274		14.2
0081 JEK 93 PC	93-CH-137,138, & 139		Station 4 (Carex aquatius)	Biota - sedge	8.35	L274		
0082 JEK 93 PC	93-CH-115 & 116		Station 3 (Carex aquatius)	Biota - sedge	9.52	L274		
0083 JEK 93 PC	93-CH-145 & 146		Station 7 (Carex aquatius)	Biota - sedge	10.91	L274		
0084 JEK 93 PC	93-CH-60, 61, & 62	93-CH-60/61/62	Cesium plot (Carex aquatius)	Biota - sedge	13.55	L274		15.9
0087 JEK 93 PC	93-CH-23 & 32		GS mound (Ledum decumbens)	Biota - Lab. tea	7.05	L274		
0088 JEK 93 PC	93-CH-8.3 & 9.3		Camp #8 (carcass)	Biota - gr. squirrel	6.47	L262		
0089 JEK 93 PC	93-CH-152.3 & 153.3		Station 2 (carcass)	Biota - gr. squirrel	14.95	L262		
0090 JEK 93 PC	93-KV-19.3 & 27.3		KV-1 (carcass)	Biota - gr. squirrel	6.36	L262		
0091 JEK 93 PC	93-CH-132.3 & 133.3		MSP, Mammal Study Plot (carcass)	Biota - gr. squirrel	7.85	L262		
0092 JEK 93 PC	93-CH-57.3 & 101.3		GS mound (carcass)	Biota - gr. squirrel	4.08	L262		
0093 JEK 93 PC	93-CH-98.3 & 117.3		MSP & SRS (carcass)	Biota - gr. squirrel	9.9	L262		
0094 JEK 93 PC	93-CH-63.3 & 64.3		Station 6 (carcass)	Biota - gr. squirrel	15.4	L262		
0095 JEK 93 PC	93-CH-48.3 & 49.3		Snowbank Cr., 3500 feet (carcass)	Biota - ptarmigan	17.07	L262		
0096 JEK 93 PC	93-CH-176.1	93-CH-176.1	Kivalina - Cape Thompson, Seppings	Biota - caribou (m)	13.7	L262		2.39
0097 JEK 93 PC	93-CH-174.1	93-CH-174.1	Kivalina - Cape Thompson, Seppings	Biota - caribou (m)	10.07	L262		1.14
0098 JEK 93 PC	93-CH-179.1	93-CH-179.1	Pt. Hope - Cape Thompson	Biota - caribou (m)	7.37	L262		1.33
0101 JEK 93 PC	93-CH-180.1	93-CH-180.1	Pt. Hope - Singoalik River	Biota - caribou (m)	3.56	L262		1.49
0099 JEK 93 PC	93-CH-179.2		Pt. Hope - Cape Thompson	Biota - caribou (b)	21.4	L262		
0100 JEK 93 PC	93-CH-180.2		Pt. Hope - Singoalik River	Biota - caribou (b)	19.6	L262		
0102 DLA 93 PC	93-CH-165.2		Beach - 5 miles east Chariot camp	Biota - grizzly (b)	26.6	L262		

Note: * Appears peak background has not been subtracted.
** All peaks for activity calculation had bad shape.
Where "<" appears, the result was less than the Minimum Detection Activity

draft 930827 | Cesium 137 | Page 1 of 1

rev. 940203

PROJECT CHARIOT REMEDIATION ANALYTICAL RESULTS

CESIUM 137

				Results in pCi/L					
ADEC Sample #	IT Sample #	Sample Site Location	Matrix	Lockheed result	Lockheed Number	ADEC on-site	IT on-site	IT-St.Louis result	Foster-Wheeler
0003 DHD 93 PC	CHR OC SW 04	Ogotoruk Cr., site 04	Surface water	<5.77	L201	N/A	N/A	<9.83	
0005 DHD 93 PC	CHR OC SW 02	Ogotoruk Cr., site 02	Surface water	<5.49	L201	N/A	N/A	<5.76	
0001 DHD 93 PC	CHR SBC SW 07 01	Snowbank Cr., site 07	Surface water	<11.9	L201	N/A	N/A		
0007 DHD 93 PC	CHR SBC SW 02	Snowbank Cr., site 02	Surface water	<5.84	L201	N/A	N/A	<9.13	
0009 DHD 93 PC	CHR SBC SW 01	Snowbank Cr., site 01	Surface water	<5.26	L201	N/A	N/A	<8.45	
0011 DHD 93 PC	CHR TR3 SW 06	Snowbank Cr., trib 3, site 06	Surface water	<4.64	L201	N/A	N/A	<8.12	
0110 DHD 93 PC	N/A	Base of Crowbill Point	Surface water	<17.6	L290	N/A	N/A	N/A	N/A
0026 JEK 93 PC	N/A	Kisimilok Valley, station 1 (KV-1)	Surface water	<7.22	L290	N/A	N/A	N/A	
0029 JEK 93 PC	N/A	Kisimilok Valley, station 2 (KV-2)	Surface water	<6.45	L235	N/A	N/A	N/A	
0030 JEK 93 PC	N/A	Kisimilok Valley, station 2 (KV-2)	Surface water	<4.38	L235	N/A	N/A	N/A	
0034 JEK 93 PC	N/A	Kisimilok Valley, station 3 (KV-3)	Surface water	<5.30	L235	N/A	N/A	N/A	

Note: * Appears peak background has not been subtracted.
** All peaks for activity calculation had bad shape.
Where "<" appears, the result was less than the Minimum Detection Activity

draft 930827
rev. 940203

PROJECT CHARIOT REMEDIATION ANALYTICAL RESULTS
CESIUM 137

ADEC Sample #	IT Sample #	Sample Site Location	Matrix	Lockheed result	Lockheed Number	ADEC on-site	IT on-site	IT-St.Louis result	Foster-Wheeler
				Results in pCi/g					
0103 DLA 93 PC	N/A	Ogotoruk Cr., (mouth)	Sediment	0.029	L273	N/A	N/A	N/A	N/A
0004 DHD 93 PC	CHR OC SD 04	Ogotoruk Cr., site 04	Sediment	0.054	L201	N/A	N/A	0.06	
0006 DHD 93 PC	CHR OC SD 02	Ogotoruk Cr., site 02	Sediment	0.049	L201	N/A	N/A	<0.06	
0002 DHD 93 PC	CHR SBC SD 07 01	Snowbank Cr., site 07	Sediment	0.688	L201	N/A	N/A	1.49	
0008 DHD 93 PC	CHR SBC SD 02	Snowbank Cr., site 02	Sediment	0.038	L201	N/A	N/A	0.06	
0010 DHD 93 PC	CHR SBC SD 01	Snowbank Cr., site 01	Sediment	0.035	L201	N/A	N/A	<0.03	
0027 JEK 93 PC	N/A	Kisimilok Valley, station 1 (KV-1)	Sediment	0.026	L234	N/A	N/A	N/A	
0031 JEK 93 PC	N/A	Kisimilok Valley, station 2 (KV-2)	Sediment	0.033	L234	N/A	N/A	N/A	
0032 JEK 93 PC	N/A	Kisimilok Valley, station 2 (KV-2)	Sediment	0.043	L234	N/A	N/A	N/A	
0035 JEK 93 PC	N/A	Kisimilok Valley, station 3 (KV-3)	Sediment	0.045**	L234	N/A	N/A	N/A	

Note: * Appears peak background has not been subtracted.
** All peaks for activity calculation had bad shape.
Where "<" appears, the result was less than the Minimum Detection Activity

draft 930827
rev. 940203

Cesium 137 Page 1 of 2

PROJECT CHARIOT REMEDIATION ANALYTICAL RESULTS
CESIUM 137

ADEC Sample #	IT Sample #	Sample Site Location	Matrix	Results in pCi/g: Lockheed result	Lockheed Number	ADEC on-site	IT on-site	IT-St.Louis result	Foster-Wheeler
BACKGROUND SAMPLES									
0021 DHD 93 PC	N/A	Snowbank Cr. - 3500' - J.S. (comp.)	Soil	0.117	L234	<0.122	N/A	N/A	<1
0023 DLA 93 PC	N/A	Snowbank Cr. - 3500' - J.S. (auger)	Soil	<0.039	L234		N/A	N/A	
0013 DHD 93 PC	SS 005	Background site A	Soil	0.036	L201		<0.40	<0.40	
0014 DHD 93 PC	SS 019	Background site B	Soil	<0.034	L201		<0.42	<0.42	
0015 DHD 93 PC	SS 028	Background site D	Soil	0.029	L201	<MDA	<0.38	<0.38	
0104 DLA 93 PC	N/A	Borehole #1	Soil	0.196	L273	N/A	N/A	N/A	N/A
0105 DLA 93 PC	N/A	East of Ogotoruk Cr. on beach	Soil - shale	<0.041	L273	N/A	N/A	N/A	N/A
0106 DLA 93 PC	N/A	Near Boreholes #3 and #4	soil - shale	0.03	L273	N/A	N/A	N/A	N/A
0107 DLA 93 PC	N/A	Near Borehole #7	Soil	0.05	L273	N/A	N/A	N/A	N/A
0108 DLA 93 PC	N/A	Cross on hill, east of Chariot camp	Soil	0.117	L273	N/A	N/A	N/A	<1.0
0109 DLA 93 PC	N/A	Crowbill Point	Soil	0.179	L273	N/A	N/A	N/A	N/A
0028 JEK 93 PC	N/A	Kisimilok Valley, station 1 (KV-1)	Soil - upper lowland	0.168	L234	0.104	N/A	N/A	
0033 JEK 93 PC	N/A	Kisimilok Valley, station 3 (KV-3)	Soil - lowland	1.484	L234	0.995	N/A	N/A	
MOUND SAMPLES									
0016 DHD 93 PC	SS 035	Mound - excavated dirt	Soil	0.053	L201				
0017 DHD 93 PC	SS 039	Mound excavation	Soil	0.031	L201	<MDA	<0.34	<0.36	
0018 DHD 93 PC	SS 040	Mound - middle of lift 4	Soil	0.029	L201		<0.42	<0.42	
0019 DHD 93 PC	SS 042	Mound excavation	Soil	0.053	L201	<MDA	<0.41	<0.41	
0020 DHD 93 PC	SS 043	Mound - 5' from poss. rad area	Soil	0.047	L201	<MDA	<0.59	<0.59	
0024 SMR 93 PC	SS 058	Mound - center north dirt pile	Soil	<0.08	L234	<MDA	<0.63	<0.63	
0022 DHD 93 PC	SS 065	Mound - south west	Soil	117.19	L234	127	127.6+/-7.1	127.6+/-7.1	
0022 DHD 93 PCA	split w/0022DHD93PC	Mound - south west	Soil	75.78	L234	N/A	N/A	N/A	
0025 JEK 93 PC	N/A	B-25s - waste characterization	Soil	(not sent)		1.39	N/A	N/A	
0036 DLA 93 PC	SS 067	Mound - south east corner	Soil	2.797	L245	3.16		N/A	
0037 JEK 93 PC	SS 083	Mound - trench composite	Soil	(not sent)		<MDA		<0.63	
0038 JEK 93 PC	CHR CC 1.02	Mound verification sample 2	Soil	0.255	L233	<0.470	<0.50	<0.50	
0039 JEK 93 PC	CHR CC 1.09	Mound verification sample 9	Soil	0.896	L233	0.721*	0.99+/-0.21	0.99+/-0.21	
0040 JEK 93 PC	CHR CC 1.11	Mound verification sample 11	Soil	1.169	L233	0.818*	1.79+/-0.31	1.79+/-0.31	
0041 JEK 93 PC	CHR CC 1.13	Mound verification sample 13	Soil	1.194	L233	3.98*	0.49+/-0.08	0.49+/-0.08	
0042 JEK 93 PC	CHR CC 1.14	Mound verification sample 14	Soil	0.503	L233	24.0*	<0.45	<0.45	
0043 JEK 93 PC	CHR CC 1.17	Mound verification sample 17	Soil	1.213	L233	1.91*	2.35+/-0.27	2.05+/-0.27	
0044 JEK 93 PC	CHR CC 1.18	Mound verification sample 18	Soil	0.046	L233	<0.333	<0.52	<0.52	
0045 JEK 93 PC	CHR CC 1.23	Mound verification sample 23	Soil	0.389	L233	0.571*	1.87+/-0.28	1.87+/-0.28	
0046 JEK 93 PC	CHR CC 1.26	Mound verification sample 26	Soil	0.056**	L233	<0.208	<0.38	<0.38	

draft 930827

rev. 940203

PROJECT CHARIOT REMEDIATION ANALYTICAL RESULTS

CESIUM 137

ADEC Sample #	IT Sample #	Sample Site Location	Matrix	Results in pCi/g: Lockheed result	Lockheed Number	ADEC on-site	IT on-site	IT-St.Louis result	Foster-Wheeler
0047 JEK 93 PC	CHR CC 1.28	Mound verification sample 28	Soil	0.145	L233	<0.402	<0.31	<0.31	<MDA(0nsite)
0048 JEK 93 PC	CHR CC 1.35	Mound verification sample 35	Soil	0.203	L233	<0.295	<0.42	<0.42	<MDA(0nsite)
0049 JEK 93 PC	CHR CC 1.37	Mound verification sample 37	Soil	0.134	L233	<0.366	<0.34	<0.34	
0050 JEK 93 PC	CHR CC 1-S	Mound verification - south comp.	Soil	2.304	L233	2.69*		0.6	
CESIUM PLOT SAMPLES									
0012 DHD 93 PC	SS 002	Cesium plot, Snowbank Cr.	Soil	579.62	L201	928	?500?	554.7+/-51.9	198
0012 DHD 93 PC		Cesium plot, Snowbank Cr.	Soil			963			
0051 JEK 93 PC	CHR-CC-P-1.02	Cs plot verification sample 2	Soil	(not sent)		<0.318		<0.38	
0052 JEK 93 PC	CHR-CC-P-1.03	Cs plot verification sample 3	Soil	0.423	L245	<0.460		<0.60	
0053 JEK 93 PC	CHR-CC-P-1.08	Cs plot verification sample 8	Soil	(not sent)		<0.303		<0.38	
0054 JEK 93 PC	CHR-CC-P-1.11	Cs plot verification sample 11	Soil	3.369	L245	3.56		2.55+/-0.35	
0054 JEK 93 PC		Cs plot verification sample 11	Soil			3.21			
0055 JEK 93 PC	CHR-CC-P-1.15	Cs plot verification sample 15	Soil	(not sent)		<0.366		<0.42	
0056 JEK 93 PC	CHR-CC-P-1.18	Cs plot verification sample 18	Soil	0.271	L245	<0.455		<0.44	
0057 JEK 93 PC	CHR-CC-P-1.22	Cs plot verification sample 22	Soil	(not sent)		1.03		1.8+/-0.30	
0058 JEK 93 PC	CHR-CC-P-1.23	Cs plot verification sample 23	Soil	<0.059	L245	<0.251		<0.41	
0059 JEK 93 PC	CHR-CC-P-1.24	Cs plot verification sample 24	Soil	(not sent)		1.1		1.27+/-0.22	
0060 JEK 93 PC	CHR-CC-P-1.26	Cs plot verification sample 26	Soil	(not sent)		<0.419		<0.45	0.87
0061 JEK 93 PC	CHR-CC-P-1.28	Cs plot verification sample 28	Soil	(not sent)				<0.77	
0062 JEK 93 PC	CHR-CC-P-1.31	Cs plot verification sample 31	Soil	(not sent)		<0.251		<0.57	<0.08
0062 JEK 93 PC		Cs plot verification sample 31	Soil			<0.295			
0062 JEK 93 PC		Cs plot verification sample 31	Soil			<0.295			
0062 JEK 93 PC		Cs plot verification sample 31	Soil			<0.311			
0062 JEK 93 PC		Cs plot verification sample 31	Soil			<0.251			
0062 JEK 93 PC		Cs plot verification sample 31	Soil			<0.326			
0062 JEK 93 PC		Cs plot verification sample 31	Soil			<0.231			
0062 JEK 93 PC		Cs plot verification sample 31	Soil			<0.326			
0062 JEK 93 PC		Cs plot verification sample 31	Soil			<0.311			
0063 JEK 93 PC	CHR-CC-P-W	Cs plot verification - west comp.	Soil	0.208	L245	<0.318			

Note: * Appears peak background has not been subtracted.
** All peaks for activity calculation had bad shape.
Where "<" appears, the result was less than the Minimum Detection Activity

draft 930827
rev. 940203

PROJECT CHARIOT REMEDIATION ANALYTICAL RESULTS
CESIUM 137

Cesium 137 Page 1 of 1

ADEC Sample #	IT Sample #	Sample Site Location	Matrix	Results in pCi/g Lockheed result	Lockheed Number	ADEC on-site	IT on-site	IT-St.Louis result	Foster-Wheeler
0064 JEK 93 PC	93-CH-43 & 44	Station 10 (Cetraria delesei)	Biota - lichen	1.759	L274	N/A	N/A	1.5	2.29
0065 JEK 93 PC	93-CH-80 & 97	SRN & SRS (Cetraria delesei)	Biota - lichen	0.881	L274	N/A	N/A	0.95	
0066 JEK 93 PC	93-CH-103 & 105	Station 7 (Cetraria delesei)	Biota - lichen	2.909	L274	N/A	N/A	2.8	
0067 JEK 93 PC	93-CH-135 & 136	Station 4 (Cetraria delesei)	Biota - lichen	2.107	L274	N/A	N/A	1.8	
0069 JEK 93 PC	93-CH-66	Station 6 (Cassiope tetragona)	Biota - heather	0.026	L274	N/A	N/A	<0.12	
0070 JEK 93 PC	93-CH-39	Station 10 (Cassiope tetragona)	Biota - heather	<0.078	L274	N/A	N/A	<0.13	
0071 JEK 93 PC	93-CH-147	Station 2 (Vaccinium ulignosom)	Biota - blueberry	0.033	L274	N/A	N/A	<0.16	
0072 JEK 93 PC	93-KV-25 & 29	KV-1 (Vaccinium ulignosom)	Biota - blueberry	<0.052	L274	N/A	N/A	<0.12	
0068 JEK 93 PC	93-CH-70 & 71	Station 12 (Salix alexensis)	Biota - willow	<0.059	L274	N/A	N/A	<0.08	
0073 JEK 93 PC	93-CH-85 & 86	Station 16 (Salix alexensis)	Biota - willow	<0.148	L274	N/A	N/A	<0.12	
0074 JEK 93 PC	93-CH-82 & 83	Station 13 (Salix alexensis)	Biota - willow	<0.146	L274	N/A	N/A	<0.07	<0.47
0075 JEK 93 PC	93-KV-17 & 18	KV-3 (Salix lonata)	Biota - willow	<0.05	L274	N/A	N/A	<0.10	
0076 JEK 93 PC	93-KV-10 & 11	KV-2 (Salix lonata)	Biota - willow	<0.086	L274	N/A	N/A	<0.08	
0085 JEK 93 PC	93-CH-58B	Cesium plot (Salix spp.)	Biota - willow	0.178**	L274	N/A	N/A	<0.12	
0077 JEK 93 PC	93-KV-30 & 31	KV-1 (Betula nana)	Biota - birch	<0.053	L274	N/A	N/A	<0.11	
0078 JEK 93 PC	93-CH-77, 78, & 79	SRN (Dryas octopetala)	Biota - mtn avens	0.188	L274	N/A	N/A	0.18	
0079 JEK 93 PC	93-CH-94 & 96	SRS (Dryas octopetala)	Biota - mtn avens	0.129	L274	N/A	N/A	<0.25	
0080 JEK 93 PC	93-CH-28	Station 10 (Eriophorum vaginaton)	Biota - cottongrass	0.123	L274	N/A	N/A	<0.18	
0081 JEK 93 PC	93-CH-137,138, & 139	Station 4 (Carex aquatius)	Biota - sedge	0.036	L274	N/A	N/A	<0.10	
0082 JEK 93 PC	93-CH-115 & 116	Station 3 (Carex aquatius)	Biota - sedge	0.284	L274	N/A	N/A	<0.13	
0083 JEK 93 PC	93-CH-145 & 146	Station 7 (Carex aquatius)	Biota - sedge	<0.065	L274	N/A	N/A	<0.10	
0084 JEK 93 PC	93-CH-60, 61, & 62	Cesium plot (Carex aquatius)	Biota - sedge	<0.067	L274	N/A	N/A	<0.19	<3.65
0086 JEK 93 PC	93-CH-29 & 31	GS mound (Eriophorum vaginaton)	Biota - cottongrass	0.112	L274	N/A	N/A	<0.12	<0.54
0087 JEK 93 PC	93-CH-23 & 32	GS mound (Ledum decumbens)	Biota - Lab. tea	0.139	L274	N/A	N/A	<0.09	
0088 JEK 93 PC	93-CH-8.3 & 9.3	Camp #8 (carcass)	Biota - gr. squirrel	<0.038	L262	N/A	N/A	<0.59	
0089 JEK 93 PC	93-CH-152.3 & 153.3	Station 2 (carcass)	Biota - gr. squirrel	<0.032	L262	N/A	N/A	<0.39	
0090 JEK 93 PC	93-KV-19.3 & 27.3	KV-1 (carcass)	Biota - gr. squirrel	<0.026	L262	N/A	N/A	<0.93	
0091 JEK 93 PC	93-CH-132.3 & 133.3	MSP, Mammal Study Plot (carcass)	Biota - gr. squirrel	<0.02	L262	N/A	N/A	<0.72	
0092 JEK 93 PC	93-CH-57.3 & 101.3	GS mound (carcass)	Biota - gr. squirrel	<0.049	L262	N/A	N/A	<0.54,<0.30	
0093 JEK 93 PC	93-CH-98.3 & 117.3	MSP & SRS (carcass)	Biota - gr. squirrel	0.133	L262	N/A	N/A	<0.41	
0094 JEK 93 PC	93-CH-63.3 & 64.3	Station 6 (carcass)	Biota - gr. squirrel	<0.028	L262	N/A	N/A	<0.30	
0095 JEK 93 PC	93-CH-48.3 & 49.3	Snowbank Cr., 3500 feet (carcass)	Biota - ptarmigan	<0.042	L262	N/A	N/A	<0.93	
0096 JEK 93 PC	93-CH-176.1	Kivalina - Cape Thompson, Seppings	Biota - caribou (m)	0.191	L262	N/A	N/A	0.39	0.33
0097 JEK 93 PC	93-CH-174.1	Kivalina - Cape Thompson, Seppings	Biota - caribou (m)	0.154	L262	N/A	N/A	0.58	<0.085
0098 JEK 93 PC	93-CH-179.1	Pt. Hope - Cape Thompson	Biota - caribou (m)	0.336	L262	N/A	N/A	1.2	0.39
0101 JEK 93 PC	93-CH-180.1	Pt. Hope - Singoalik River	Biota - caribou (m)	0.066	L262	N/A	N/A	<0.32	<0.08
0099 JEK 93 PC	93-CH-179.2	Pt. Hope - Cape Thompson	Biota - caribou (b)	<0.136	L262	N/A	N/A		
0100 JEK 93 PC	93-CH-180.2	Pt. Hope - Singoalik River	Biota - caribou (b)	<0.14	L262	N/A	N/A		
0102 DLA 93 PC	93-CH-165.2	Beach - 5 miles east Chariot camp	Biota - grizzly (b)	<0.147	L262	N/A	N/A		

Note: * Appears peak background has not been subtracted.
** All peaks for activity calculation had bad shape.
Where "<" appears, the result was less than the Minimum Detection Activity

draft 930901
rev. 930915

Pu 238, 239/40; Sr 90

PROJECT CHARIOT REMEDIATION ANALYTICAL RESULTS
PLUTONIUM 238, 239/40 AND STRONTIUM 90

ADEC Sample #	IT Sample #	Sample Site Location	Matrix	Results in pCi/L				
				Lockheed Pu 238	Lockheed Pu 239/40	IT-St.Louis Pu 238	Lockheed Sr 90	IT-St.Louis Sr 90
0001 DHD 93 PC	CHR SBC SW 07 01	Snowbank Cr., site 07	Surface water	N/A	N/A		N/A	
0003 DHD 93 PC	CHR OC SW 04	Ogotoruk Cr., site 04	Surface water	N/A	N/A		N/A	
0005 DHD 93 PC	CHR OC SW 02	Ogotoruk Cr., site 02	Surface water	N/A	N/A		N/A	
0007 DHD 93 PC	CHR SBC SW 02	Snowbank Cr., site 02	Surface water	N/A	N/A		N/A	
0009 DHD 93 PC	CHR SBC SW 01	Snowbank Cr., site 01	Surface water	N/A	N/A		N/A	
0011 DHD 93 PC	CHR TR3 SW 06	Snowbank Cr., trib 3, site 06	Surface water	N/A	N/A		N/A	
0026 JEK 93 PC	N/A	Kisimilok Valley, station 1 (KV-1)	Surface water	N/A	N/A		N/A	
0029 JEK 93 PC	N/A	Kisimilok Valley, station 2 (KV-2)	Surface water	N/A	N/A		N/A	
0030 JEK 93 PC	N/A	Kisimilok Valley, station 2 (KV-2)	Surface water	N/A	N/A		N/A	
0034 JEK 93 PC	N/A	Kisimilok Valley, station 3 (KV-3)	Surface water	N/A	N/A		N/A	
0110 DHD 93 PC	N/A	Base of Crowbill Point	Surface water	N/A	N/A		N/A	

draft 930901
rev. 930915

PROJECT CHARIOT REMEDIATION ANALYTICAL RESULTS
PLUTONIUM 238, 239/40 AND STRONTIUM 90

				Results in pCi/g				
ADEC Sample #	IT Sample #	Sample Site Location	Matrix	Lockheed Pu 238	Lockheed Pu 239/40	IT-St.Louis Pu 238	Lockheed Sr 90	IT-St.Louis Sr 90
0002 DHD 93 PC	CHR SBC SD 07 01	Snowbank Cr., site 07	Sediment	N/A	N/A		N/A	
0004 DHD 93 PC	CHR OC SD 04	Ogotoruk Cr., site 04	Sediment	N/A	N/A		N/A	
0006 DHD 93 PC	CHR OC SD 02	Ogotoruk Cr., site 02	Sediment	N/A	N/A		N/A	
0008 DHD 93 PC	CHR SBC SD 02	Snowbank Cr., site 02	Sediment	N/A	N/A		N/A	
0010 DHD 93 PC	CHR SBC SD 01	Snowbank Cr., site 01	Sediment	N/A	N/A		N/A	
0027 JEK 93 PC	N/A	Kisimilok Valley, station 1 (KV-1)	Sediment	N/A	N/A		N/A	
0031 JEK 93 PC	N/A	Kisimilok Valley, station 2 (KV-2)	Sediment	N/A	N/A		N/A	
0032 JEK 93 PC	N/A	Kisimilok Valley, station 2 (KV-2)	Sediment	N/A	N/A		N/A	
0035 JEK 93 PC	N/A	Kisimilok Valley, station 3 (KV-3)	Sediment	N/A	N/A		N/A	
0103 DLA 93 PC	N/A	Mouth of Ogotoruk Creek	Sediment	N/A	N/A		N/A	

draft 930901
rev. 940203

PROJECT CHARIOT REMEDIATION ANALYTICAL RESULTS
PLUTONIUM 238, 239/40 AND STRONTIUM 90

Pu 238, 239/240; Sr 90

ADEC Sample #	IT Sample #	Sample Site Location	Matrix	Results in pCi/g: Lockheed Pu 238	Lockheed Pu 239/40	IT-St.Louis Pu 238	Lockheed Sr 90	Lockheed Number	IT-St.Louis Sr 90
BACKGROUND SAMPLES									
0013 DHD 93 PC	SS 005	Background site A	Soil	N/A	N/A		N/A		
0014 DHD 93 PC	SS 019	Background site B	Soil	N/A	N/A		N/A		
0015 DHD 93 PC	SS 028	Background site D	Soil	N/A	N/A		N/A		
0021 DHD 93 PC	N/A	Snowbank Cr. - 3500' - J.S. (comp.)	Soil	N/A	N/A		N/A		
0023 DLA 93 PC	N/A	Snowbank Cr. - 3500' - J.S. (auger)	Soil	N/A	N/A		N/A		
0104 DLA 93 PC	N/A	Borehole #1	Soil	N/A	N/A		N/A		
0105 DLA 93 PC	N/A	East of Ogotoruk Cr. on beach	Soil - shale	N/A	N/A		N/A		
0106 DLA 93 PC	N/A	Near Boreholes #3 and #4	Soil - shale	N/A	N/A		N/A		
0107 DLA 93 PC	N/A	Near Borehole #7	Soil	N/A	N/A		N/A		
0108 DLA 93 PC	N/A	Cross on hill, east of Chariot camp	Soil	N/A	N/A		N/A		
0109 DLA 93 PC	N/A	Crowbill Point	Soil	N/A	N/A		N/A		
0028 JEK 93 PC	N/A	Kisimilok Valley, station 1 (KV-1)	Soil - upper lowland	N/A	N/A		N/A		
0033 JEK 93 PC	N/A	Kisimilok Valley, station 3 (KV-3)	Soil - lowland	N/A	N/A		N/A		
MOUND SAMPLES									
0025 JEK 93 PC	N/A	B-25s - waste characterization	Soil	(not sent)	(not sent)		(not sent)		
0024 SMR 93 PC	SS 058	Mound - center north dirt pile	Soil	N/A	N/A		N/A		
0022 DHD 93 PC	SS 065	Mound - south west	Soil	<0.012	0.032		N/A	L234	
0022 DHD 93 PCA	split w/0022DHD93PC	Mound - south west	Soil	<0.021	0.011		N/A	L234	
0016 DHD 93 PC	SS 035	Mound - excavated dirt	Soil	N/A	N/A		N/A		
0017 DHD 93 PC	SS 039	Mound excavation	Soil	N/A	N/A		N/A		
0018 DHD 93 PC	SS 040	Mound - middle of lift 4	Soil	N/A	N/A		N/A		
0019 DHD 93 PC	SS 042	Mound excavation	Soil	N/A	N/A		N/A		
0020 DHD 93 PC	SS 043	Mound - 5' from poss. rad area	Soil	N/A	N/A		N/A		
0036 DLA 93 PC	SS 067	Mound - south east corner	Soil	N/A	N/A		N/A		
0037 JEK 93 PC	SS 083	Mound - trench composite	Soil	(not sent)	(not sent)		(not sent)		
0038 JEK 93 PC	CHR CC 1.02	Mound verification sample 2	Soil	N/A	N/A		<0.38	L233	
0039 JEK 93 PC	CHR CC 1.09	Mound verification sample 9	Soil	N/A	N/A		<0.38	L233	
0040 JEK 93 PC	CHR CC 1.11	Mound verification sample 11	Soil	N/A	N/A		<0.36	L233	
0041 JEK 93 PC	CHR CC 1.13	Mound verification sample 13	Soil	N/A	N/A		<0.39	L233	
0042 JEK 93 PC	CHR CC 1.14	Mound verification sample 14	Soil	N/A	N/A		<0.41	L233	
0043 JEK 93 PC	CHR CC 1.17	Mound verification sample 17	Soil	<0.028	<0.019		<0.43	L233	
0044 JEK 93 PC	CHR CC 1.18	Mound verification sample 18	Soil	<0.018	<0.022		<0.50	L233	
0045 JEK 93 PC	CHR CC 1.23	Mound verification sample 23	Soil	N/A	N/A		<0.55	L233	
0046 JEK 93 PC	CHR CC 1.26	Mound verification sample 26	Soil	N/A	N/A		<0.49	L233	
0047 JEK 93 PC	CHR CC 1.28	Mound verification sample 28	Soil	N/A	N/A		<0.36	L233	
0048 JEK 93 PC	CHR CC 1.35	Mound verification sample 35	Soil	N/A	N/A		<0.35	L233	
0049 JEK 93 PC	CHR CC 1.37	Mound verification sample 37	Soil	N/A	N/A		<0.35	L233	

draft 930901
rev. 940203

Pu 238, 239/240; Sr 90

PROJECT CHARIOT REMEDIATION ANALYTICAL RESULTS
PLUTONIUM 238, 239/40 AND STRONTIUM 90

				Results in pCi/g					
ADEC Sample #	IT Sample #	Sample Site Location	Matrix	Lockheed Pu 238	Lockheed Pu 239/40	IT-St.Louis Pu 238	Lockheed Sr 90	Lockheed Number	IT-St.Louis Sr 90
0050 JEK 93 PC	CHR CC 1-S	Mound verification - south comp.	Soil	<0.020	0.018		<0.37	L233	
CESIUM PLOT SAMPLES									
0012 DHD 93 PC	SS 002	Cesium plot, Snowbank Cr.	Soil	N/A	N/A		N/A		
0051 JEK 93 PC	CHR-CC-P-1.02	Cs plot verification sample 2	Soil	(not sent)	(not sent)		(not sent)		
0052 JEK 93 PC	CHR-CC-P-1.03	Cs plot verification sample 3	Soil	N/A	N/A		<0.47	L245	
0053 JEK 93 PC	CHR-CC-P-1.08	Cs plot verification sample 8	Soil	(not sent)	(not sent)		(not sent)		
0054 JEK 93 PC	CHR-CC-P-1.11	Cs plot verification sample 11	Soil	N/A	N/A		<0.51	L245	
0055 JEK 93 PC	CHR-CC-P-1.15	Cs plot verification sample 15	Soil	(not sent)	(not sent)		(not sent)		
0056 JEK 93 PC	CHR-CC-P-1.18	Cs plot verification sample 18	Soil	N/A	N/A		<0.50	L245	
0057 JEK 93 PC	CHR-CC-P-1.22	Cs plot verification sample 22	Soil	(not sent)	(not sent)		(not sent)		
0058 JEK 93 PC	CHR-CC-P-1.23	Cs plot verification sample 23	Soil	N/A	N/A		<0.49	L245	
0059 JEK 93 PC	CHR-CC-P-1.24	Cs plot verification sample 24	Soil	(not sent)	(not sent)		(not sent)		
0060 JEK 93 PC	CHR-CC-P-1.26	Cs plot verification sample 26	Soil	(not sent)	(not sent)		(not sent)		
0061 JEK 93 PC	CHR-CC-P-1.28	Cs plot verification sample 28	Soil	(not sent)	(not sent)		(not sent)		
0062 JEK 93 PC	CHR-CC-P-1.31	Cs plot verification sample 31	Soil	(not sent)	(not sent)		(not sent)		
0063 JEK 93 PC	CHR-CC-P-W	Cs plot verification - west comp.	Soil	N/A	N/A		<0.59	L245	

Note: * Appears peaks background has not been subtracted.
** All peaks for activity calculation had bad shape.
Where "<" appears, the result was less than the Minimum Detection Activity

draft 930901
rev. 940203

Pu 238, 239/240; Sr 90 — Page 1 of 1

PROJECT CHARIOT REMEDIATION ANALYTICAL RESULTS
PLUTONIUM 238, 239/40 AND STRONTIUM 90

ADEC Sample #	IT Sample #	Sample Site Location	Matrix	Results in pCi/g Lockheed Pu 238	Lockheed Pu 239/40	IT-St.Louis Pu 238	Lockheed Sr 90	Lockheed Number	IT-St.Louis Sr 90
0064 JEK 93 PC	93-CH-43 & 44	Station 10 (Cetraria delesei)	Biota - lichen	N/A	N/A		1.33	L274	0.5
0065 JEK 93 PC	93-CH-80 & 97	SRN & SRS (Cetraria delesei)	Biota - lichen	N/A	N/A		0.58	L274	0.69
0066 JEK 93 PC	93-CH-103 & 105	Station 7 (Cetraria delesei)	Biota - lichen	N/A	N/A		0.77	L274	0.78
0067 JEK 93 PC	93-CH-135 & 136	Station 4 (Cetraria delesei)	Biota - lichen	N/A	N/A		1.25	L274	
0069 JEK 93 PC	93-CH-66	Station 6 (Cassiope tetragona)	Biota - heather	N/A	N/A		N/A		
0070 JEK 93 PC	93-CH-39	Station 10 (Cassiope tetragona)	Biota - heather	N/A	N/A		N/A		
0071 JEK 93 PC	93-CH-147	Station 2 (Vaccinium ulignosom)	Biota - blueberry	N/A	N/A		N/A		
0072 JEK 93 PC	93-KV-25 & 29	KV-1 (Vaccinium ulignosom)	Biota - blueberry	N/A	N/A		N/A		
0068 JEK 93 PC	93-CH-70 & 71	Station 12 (Salix alexensis)	Biota - willow	N/A	N/A		N/A		
0073 JEK 93 PC	93-CH-85 & 86	Station 16 (Salix alexensis)	Biota - willow	N/A	N/A		N/A		
0074 JEK 93 PC	93-CH-82 & 83	Station 13 (Salix alexensis)	Biota - willow	N/A	N/A		N/A		
0075 JEK 93 PC	93-KV-17 & 18	KV-3 (Salix lonata)	Biota - willow	N/A	N/A		N/A		
0076 JEK 93 PC	93-KV-10 & 11	KV-2 (Salix lonata)	Biota - willow	N/A	N/A		N/A		
0085 JEK 93 PC	93-CH-58B	Cesium plot (Salix spp.)	Biota - willow	N/A	N/A		N/A		
0077 JEK 93 PC	93-KV-30 & 31	KV-1 (Betula nana)	Biota - birch	N/A	N/A		N/A		
0078 JEK 93 PC	93-CH-77, 78, & 79	SRN (Dryas octopetala)	Biota - mtn avens	N/A	N/A		N/A		
0079 JEK 93 PC	93-CH-94 & 96	SRS (Dryas octopetala)	Biota - mtn avens	N/A	N/A		N/A		
0081 JEK 93 PC	93-CH-137,138, & 139	Station 4 (Carex aquatius)	Biota - sedge	N/A	N/A		N/A		
0082 JEK 93 PC	93-CH-115 & 116	Station 3 (Carex aquatius)	Biota - sedge	N/A	N/A		N/A		
0083 JEK 93 PC	93-CH-145 & 146	Station 7 (Carex aquatius)	Biota - sedge	N/A	N/A		N/A		
0084 JEK 93 PC	93-CH-60, 61, & 62	Cesium plot (Carex aquatius)	Biota - sedge	N/A	N/A		N/A		
0080 JEK 93 PC	93-CH-28	Station 10 (Eriophorum vaginaton)	Biota - cottongrass	N/A	N/A		N/A		
0086 JEK 93 PC	93-CH-29 & 31	GS mound (Eriophorum vaginaton)	Biota - cottongrass	N/A	N/A		N/A		
0087 JEK 93 PC	93-CH-23 & 32	GS mound (Ledum decumbens)	Biota - Lab. tea	N/A	N/A		N/A		
0088 JEK 93 PC	93-CH-8.3 & 9.3	Camp #8 (carcass)	Biota - gr. squirrel	N/A	N/A		0.08	L262	
0089 JEK 93 PC	93-CH-152.3 & 153.3	Station 2 (carcass)	Biota - gr. squirrel	N/A	N/A		0.49	L262	4.4
0090 JEK 93 PC	93-KV-19.3 & 27.3	KV-1 (carcass)	Biota - gr. squirrel	N/A	N/A		0.13	L262	6
0091 JEK 93 PC	93-CH-132.3 & 133.3	MSP, Mammal Study Plot (carcass)	Biota - gr. squirrel	N/A	N/A		<0.080	L262	1.6
0092 JEK 93 PC	93-CH-57.3 & 101.3	GS mound (carcass)	Biota - gr. squirrel	N/A	N/A		<0.090	L262	6.3,1.3
0093 JEK 93 PC	93-CH-98.3 & 117.3	MSP & SRS (carcass)	Biota - gr. squirrel	N/A	N/A		0.09	L262	18
0094 JEK 93 PC	93-CH-63.3 & 64.3	Station 6 (carcass)	Biota - gr. squirrel	N/A	N/A		<0.12	L262	5.2
0095 JEK 93 PC	93-CH-48.3 & 49.3	Snowbank Cr., 3500 feet (carcass)	Biota - ptarmigan	N/A	N/A		<0.16	L262	11
0096 JEK 93 PC	93-CH-176.1	Kivalina - Cape Thompson, Seppings	Biota - caribou (m)	N/A	N/A		<0.090	L262	4.9
0097 JEK 93 PC	93-CH-174.1	Kivalina - Cape Thompson, Seppings	Biota - caribou (m)	N/A	N/A		<0.10	L262	2
0098 JEK 93 PC	93-CH-179.1	Pt. Hope - Cape Thompson	Biota - caribou (m)	N/A	N/A		N/A		
0101 JEK 93 PC	93-CH-180.1	Pt. Hope - Singoalik River	Biota - caribou (m)	N/A	N/A		N/A		
0099 JEK 93 PC	93-CH-179.2	Pt. Hope - Cape Thompson	Biota - caribou (b)	N/A	N/A		3.62	L262	
0100 JEK 93 PC	93-CH-180.2	Pt. Hope - Singoalik River	Biota - caribou (b)	N/A	N/A		3.08	L262	
0102 DLA 93 PC	93-CH-165.2	Beach - 5 miles east Chariot camp	Biota - grizzly (b)	N/A	N/A		1.41	L262	1.6

Note: * Appears peak background has not been subtracted.
** All peaks for activity calculation had bad shape.
Where "<" appears, the result was less than the Minimum Detection Activity

rev. 940321

PROJECT CHARIOT REMEDIATION ANALYTICAL RESULTS
STRONTIUM 90

ADEC Sample #	IT Sample #	Sample Site Location	Matrix	Results in pCi/g		
				Lockheed number	Lockheed 1st sample	Lockheed 2nd sample
0052JEK93PC	CHR-CC-P-1.03	Cs plot verification sample 3	Soil	L1169-9	<0.47	<0.29
0054JEK93PC	CHR-CC-P-1.11	Cs plot verification sample 11	Soil	L1169-10	<0.51	<0.29
0056JEK93PC	CHR-CC-P-1.18	Cs plot verification sample 18	Soil	L1169-11	<0.50	<0.31
0088JEK93PC	93-CH-8.3 & 9.3	Camp #8 (carcass)	Biota - gr. squirrel	L1169-1	0.08	0.08
0089JEK93PC	93-CH-152.3 & 153.3	Station 2 (carcass)	Biota - gr. squirrel	L1169-2	0.49	0.188
0090JEK93PC	93-KV-19.3 & 27.3	KV-1 (carcass)	Biota - gr. squirrel	L1169-3	0.13	0.096
0093JEK93PC	93-CH-98.3 & 117.3	MSP & SRS (carcass)	Biota - gr. squirrel	L1169-4	0.09	<0.07
0094JEK93PC	93-CH-63.3 & 64.3	Station 6 (carcass)	Biota - gr. squirrel	L1169-5	<0.12	<0.061
0096JEK93PC	93-CH-176.1	Kivalina - Cape Thompson, Seppings	Biota - caribou (m)	L1169-7	<0.09	<0.069
0097JEK93PC	93-CH-174.1	Kivalina - Cape Thompson, Seppings	Biota - caribou (m)	L1169-8	<0.10	<0.073

APPENDIX E

ADEC ON-SITE LABORATORY BACKGROUND GAMMA ANALYSIS

SAMPO 90. 1993 PA,MN,JR.   Version 3.20h   1993-Aug-12   10:33:17

```
*****************************************************************************
*                                                                           *
*     G A M M A   S P E C T R U M   A N A L Y S I S   R E P O R T          *
*                                                                           *
*****************************************************************************
```

ADEC FIELD LAB --- PROJECT CHARIOT
Sample description:BACKGROUND, 8 HOUR
Spectrum file name:BKGD811
Sample identifier :BACKGROUND
Sample geometry :PETRI
Sample type :SOLID
Sample size : 5.000E+01 G
Measured by :SR

#1

[signature] 8/12/93

```
Start of irradiation           :1993-Aug-01    at 08:53:06
End of irradiation             :1993-Aug-01    at 08:53:06
Collect started on             :1993-Aug-10    at 22:21:01
Collect ended on               :1993-Aug-11    at 06:21:06
Predecay date                  :1993-Aug-11    at 08:53:06

Irradiation/sampling time      :0 years 0 days 0 hours 0 minutes
Decay time                     :0 years 9 days 13 hours 27 minutes
Predecay time                  :0 years 0 days 10 hours 32 minutes

Live time: 2.88E+004 s real time: 2.88E+004 s   dead time: 1.74E-002 %

Shape calibration requested      :DETECT1
Shape calibration used           :DETECT1
                        Created  :1993-Aug-09     15:43:49
                        Modified :1993-Aug-11     11:59:06

Energy calibration requested     :DETECT1
Energy calibration used          :DETECT1
                        Created  :01-Jan-01       00:00:00
                        Modified :1993-Aug-11     11:50:06

Efficiency calibration requested :DETECT1
Efficiency calibration used      :DETECT1
                        Created  :1993-Aug-09     16:07:08
                        Modified :1993-Aug-11     12:01:23

Last search  discrimination level:    4.00
Last search     FROM channel 14 TO channel 8178
Last fitting discrimination level:    4.00
Last fit        FROM channel 1 TO channel 16384
Identification energy tolerance  :    1.00
Minimum acceptable confidence    :    0.10
Gamma reference library          :..\LIBRARY\MAIN.ILF
with 64 isotopes and 151 gamma lines.
```

******************** P E A K   F I T   R E P O R T ********************

peak no	centroid channel	energy keV	area counts	error %	background counts	intensity gps	error %	gfit
1	369.95	92.86	3.38E+002	7.0	7.21E+002	1.49E-001	7.9	0.6
2	741.36	185.77	2.12E+002	11.1	6.96E+002	9.80E-002	11.5	0.9
3	952.73	238.59	3.04E+002	7.5	5.34E+002	1.64E-001	7.9	0.9
4	1180.19	295.43	6.85E+001	30.7	3.88E+002	4.39E-002	30.8	1.3
5	2043.13	511.01	5.14E+002	6.9	3.47E+002	5.47E-001	7.4	2.3
6	2332.04	583.17	1.82E+002	7.9	1.74E+002	2.20E-001	8.3	0.9
7	2437.60	609.54	1.07E+002	19.6	1.70E+002	1.35E-001	19.7	1.7
8	3644.33	910.96	1.15E+002	13.4	7.91E+001	2.13E-001	13.6	1.5
9	4480.93	1119.95	1.00E+002	10.1	6.28E+001	2.23E-001	10.4	1.0
10	5843.58	1460.44	9.82E+002	2.4	2.99E+001	2.76E+000	3.4	1.0
11	7058.77	1764.12	1.09E+002	7.4	0.00E+000	3.60E-001	8.4	1.1

Flags: m = a peak in a multiplet, M = last peak in a multiplet, ? = bad fit
B = backround peak - will be subtracted from the peak above.

********* R A D I O N U C L I D E   A N A L Y S I S   R E P O R T ***********

Un det set	Nuc lid #	Nuclide name	Confid	Sample	Decay corrected	Predecayed	Saturation	Total sampled	Error %
				activity (pCi/G)					
	1	K-40	0.98	1.40E+001	1.40E+001	1.40E+001	0.00E+000	0.00E+000	3.38
	2	TL-208	0.72	1.57E-001	1.57E-001	1.57E-001	0.00E+000	0.00E+000	7.41
	3	PB-212	0.15	1.99E-001	2.01E-001	1.99E-001	0.00E+000	0.00E+000	7.94
	4	BI214	0.99	1.12E-001	1.12E-001	1.12E-001	0.00E+000	0.00E+000	42.70
	5	RA-226	0.36	1.24E-001	1.24E-001	1.24E-001	0.00E+000	0.00E+000	30.77
	6	TH-234	0.26	1.49E+000	1.49E+000	1.49E+000	0.00E+000	0.00E+000	7.85

These peaks were not identified:

Peak	Channel	Energy	Intensity	SE Cand.	DE Cand.	Error
2	741.36	185.77	9.80E-002	696.77	1207.77	11.48
8	3644.33	910.96	2.13E-001	1421.96	1932.96	13.65
11	7058.77	1764.12	3.60E-001	2275.12	2786.12	8.37

************** P E A K   A S S O C I A T I O N   R E P O R T **************

Under deter set #	Nuc lide #	Nuclide	Peak #	Peak channel	Peak energy	Peak usage %
	1	K-40				
			10	5843.58	1460.44	100.00
	2	TL-208				
			5	2043.13	511.01	11.49
			6	2332.04	583.17	111.38
	3	PB-212				
			3	952.73	238.59	100.00
	4	BI214				
			7	2437.60	609.54	71.26
			9	4480.93	1119.95	14.02
	5	RA-226				
			4	1180.19	295.43	100.00
			7	2437.60	609.54	78.62
			9	4480.93	1119.95	15.47
	6	TH-234				
			1	369.95	92.86	100.00

APPENDIX F

STATISTICAL ANALYSIS - NONPARAMETRIC TEST

Kruskal-Wallis NonParametric Test

The Kruskal-Wallis test is an extension of the Mann-Whitney test for $k \geq 2$ populations or data sets. This test is a nonparametric test which ranks the data allowing for a moderate number of tied data and ND (non detect) values to be accommodated. This test is also good for small sets of data. According to EPA's manual titled "Environmental Radiation Data - Report 65", the present system of laboratory reporting eliminates the use of ND values. In other words, the present reporting procedure allows all the data to be reported and evaluated statistically without an arbitrary cutoff of small or negative numbers. Therefore, the less than values, formerly ND values because the data was below the minimum detection limit, are used in the Kruskal-Wallis test (Gilbert, 1987).

The Kruskal-Wallis test was performed on the limited background data from Ogotoruk Creek, Snowbank Creek, and Kisimilok Valley. The test indicated that there is no significant difference between the three locations at a 95% confidence level. The following data were used in the calculations:

Ogotoruk Creek (pCi/g)	Snowbank Creek (pCi/g)	Kisimilok Valley (pCi/g)
0.036	0.117	0.168
< 0.40	< 0.122	1.484
< 0.40	< 0.039	0.104
< 0.34	< 1	0.995
< 0.42		
< 0.42		
0.029		
< 0.38		
< 0.38		
0.196		
< 0.041		
0.03		
0.05		
0.117		
< 1		
0.179		
< 0.169		
< 0.08		

```
Grouping variable = LOCATION  Observation variable = CESIUM137

ruskal-Wallis H =     1.47

For number of groups <= 3, look up p-value in text such as Siegel

Rank sum group OGOT =  228.0    N =    18  Mean Rank =  12.67
Rank sum group SNOW =   52.0    N =     4  Mean Rank =  13.00
ank sum group KISI =   71.0    N =     4  Mean Rank =  17.75

Press Enter  to see multiple comparisons (based on mean ranks):
'Reference Zar, p. 200)

                                                             q CRITICAL
Newman-Keuls Multiple Comparisons                  P     Q    VALUE(0.05)
-----------------------------------------------------------------------
    Rank(KISIMILO) -Rank(OGOTORUK) =
                                        5.0833   3    3.215       3.310
    Rank(KISIMILO) -Rank(SNOWBANK) =
                                        4.7500   2    4.398       2.770
    Rank(SNOWBANK) -Rank(OGOTORUK) =
                                        0.3333   2    0.309       2.770

Press Enter
```


```
-----------------------------------------------------------------------
    Rank(KISIMILO) -Rank(OGOTORUK) =
                                        5.0833   3    3.215       3.310
    Rank(KISIMILO) -Rank(SNOWBANK) =
                                        4.7500   2    4.398       2.770
    Rank(SNOWBANK) -Rank(OGOTORUK) =
                                        0.3333   2    0.309       2.770
```


```
Homogeneous Populations, groups ranked

Gp  1  refers to LOCATION=OGOTORUK
Gp  2  refers to LOCATION=SNOWBANK
Gp  3  refers to LOCATION=KISIMILO

                Gp Gp Gp
                 1  2  3
Population  1   ---------

This is a graphical representation of the Newman-Keuls multiple comparisons
test. At the 0.05 significance level, the Ranks of any two groups underscored
by the same line are not significantly different.

Press Enter
```

APPENDIX G

DOSE ASSESSMENT CALCULATIONS

Cs 137 in Caribou Muscle Sampling Years 1960-62

Year	Day	Location	Cs 137 pCi/g wet wt	Cs 137 pCi/g dry wt	Wet wt/Dry Wt Ratio
1960	243	Cape Thompson	0.789	2.92	0.27
1960	243	Cape Thompson	0.656	2.4	0.27
1960	243	Cape Thompson	0.852	3.14	0.27
1960	243	Cape Thompson	0.545	2.01	0.27
1960	243	Cape Thompson	0.599	2.2	0.27
1960	243	Cape Thompson	0.699	0.259	2.70
1960	243	Cape Thompson	0.859	3.36	0.26
1960	243	Cape Thompson	0.969	3.79	0.26
1960	243	Cape Thompson	0.844	3.26	0.26
1960	243	Cape Thompson	0.575	2.2	0.26
1960	243	Cape Thompson	0.624	2.37	0.26
1960	243	Cape Thompson	0.65	2.47	0.26
1960	243	Cape Thompson	0.705	2.64	0.27
1960	243	Cape Thompson	0.651	2.46	0.26
1960	243	Cape Thompson	0.626	2.37	0.26
1960	319	Cape Thompson	3.71	13.4	0.28
1960	319	Cape Thompson	3.72	13.4	0.28
1961	53	Cape Thompson	1.67	6.53	0.26
1961	53	Cape Thompson	1.58	6.23	0.25
1961	70	Cape Thompson	0.468	1.92	0.24
1961	70	Cape Thompson	0.465	1.92	0.24
1961	70	Cape Thompson	0.492	1.96	0.25
1961	70	Cape Thompson	0.492	1.96	0.25
1961	70	Cape Thompson	0.479	1.89	0.25
1961	72	Cape Thompson	1.52	6.04	0.25
1961	72	Cape Thompson	1.68	6.37	0.26
1961	72	Cape Thompson	1.19	4.87	0.24
1961	72	Cape Thompson	1.32	5.36	0.25
1961	72	Cape Thompson	1.41	5.74	0.25
1961	72	Cape Thompson	1.4	5.62	0.25
1961	72	Cape Thompson	1.41	5.61	0.25
1961	77	Cape Thompson	0.584	2.8	0.21
1961	77	Cape Thompson	0.596	2.92	0.20
1961	81	Cape Thompson	0.942	3.44	0.27
1961	81	Cape Thompson	1.06	3.79	0.28
1961	81	Cape Thompson	0.978	3.51	0.28
1961	85	Cape Thompson	0.997	3.76	0.27
1961	85	Cape Thompson	1.04	3.9	0.27
1961	85	Cape Thompson	4.03	15.4	0.26
1961	93	Cape Thompson	0.702	2.98	0.24
1961	93	Cape Thompson	0.778	3.18	0.24
1961	93	Cape Thompson	1.02	4.24	0.24
1961	110	Cape Thompson	0.725	3.04	0.24
1961	110	Cape Thompson	0.603	2.49	0.24
1961	217	Cape Thompson	1.28	4.77	0.27
1961	217	Cape Thompson	1.22	4.58	0.27
1961	217	Cape Thompson	1.15	4.3	0.27
1961	239	Cape Thompson	1.4	5.48	0.26
1961	239	Cape Thompson	1.49	5.66	0.26
1961	239	Cape Thompson	1.38	5.31	0.26
1962	200	Cape Thompson	1.92	8.06	0.24
1962	224	Pt. Hope	2.88	11	0.26

Cs 137 Analytical Results for Caribou Muscle & Blueberries
Summer 1993 Samples

Description of Matrix	Sampler	ID #	Cs 137 Result pCi/g dry wt
Caribou Muscle	ADEC	0096 JEK 93 PC	0.19
Caribou Muscle	IT	93-CH-176.1	0.39
Caribou Muscle	FW	93-CH-176.1	0.33
Caribou Muscle	ADEC	0097 JEK 93 PC	0.15
Caribou Muscle	IT	93-CH-174.1	0.58
Caribou Muscle	FW	93-CH-174.1	***0.09***
Caribou Muscle	ADEC	0098 JEK 93 PC	0.34
Caribou Muscle	IT	93-CH-179.1	1.20
Caribou Muscle	FW	93-CH-179.1	0.39
Caribou Muscle	ADEC	0101 JEK 93 PC	0.07
Caribou Muscle	IT	93-CH-180.1	***0.32***
Caribou Muscle	FW	93-CH-180.1	***0.08***
Caribou Muscle	FW	93-CH-185.1	0.65
Blueberry	ADEC	0071 JEK 93 PC	0.03
Blueberry	IT	93-CH-147	***0.16***
Blueberry	ADEC	0072 JEK 93 PC	***0.05***
Blueberry	IT	93-KV-25 &29	***0.12***

ADEC - Alaska Department of Environmental Conservaiton
IT - International Technologies Coporation Department of Energy Contractor
FW - Foster-Wheeler North Slope Boroughs Consultant

Note: Numbers in bold italics indicates they were reported by the analytical laboratory as less than values.

Description of Matrix	Minimum Value pCi/g dry wt	Maximum Value pCi/g dry wt	Mean Value pCi/g dry wt	Standard Deviation
Caribou Muscle	0.07	1.20	***0.37***	***0.30***
Blueberry	0.03	0.16	***0.09***	***0.05***

Note: Mean and standard deviation values calculated from data including less than values. Actual mean values will be less than the above computed means.

C:\Chariotf\Spreadsheets\biota93.wb1

Cs 137 in Caribou Muscle Sampling Years 1960-62

Year	Day	Location	Cs 137 pCi/g wet wt	Cs 137 pCi/g dry wt	Wet wt/Dry Wt Ratio
1962	224	Pt. Hope	2.61	10.2	0.26
1962	224	Pt. Hope	2.62	9.89	0.26
1962	224	Pt. Hope	2.82	10.9	0.26
1962	224	Pt. Hope	2.43	9	0.27
1962	224	Pt. Hope	2.63	9.93	0.26
1962	224	Pt. Hope	2.02	6.91	0.29
1962	224	Pt. Hope	2.5	9.11	0.27
1962	224	Pt. Hope	2.49	9.5	0.26
1962	224	Pt. Hope	2.15	7.75	0.28
1962	224	Pt. Hope	2.58	9.38	0.28
1962	224	Pt. Hope	3.08	11.8	0.26
1962	224	Pt. Hope	2.25	8.11	0.28
1962	224	Pt. Hope	2.5	9.34	0.27
1962	224	Pt. Hope	2.49	8.47	0.29
1962	224	Pt. Hope	2.46	8.68	0.28
1962	224	Pt. Hope	4.11	17	0.24
1962	224	Pt. Hope	3.35	12.6	0.27
1962	224	Pt. Hope	3.16	12	0.26
1962	224	Pt. Hope	4.08	16.9	0.24
1962	224	Pt. Hope	3.32	11.2	0.30
		Mean	1.61	6.11	0.29
		Standard Deviation	1.04	3.95	0.29
		Variance	1.08	15.62	0.08
		Minimum Value	0.465	0.259	0.20
		Maximum Value	4.11	17	2.70
		Number of Samples	72	72	72

(1) Watson, D.G., Hanson, W.C., Rickard, W.H., "Fallout Radionuclides in the Biota of The Cape Thompson Region, Alaska - A Listing of Measurements" November 1965, Battelle Northwest Laboratories, Richland , Wasington

C:\chariotf\spreadsheets\biota.wb1

Radiological Dose Calculations (1)

Description of Matrix	Estimated Weekly Consumption, lbs	Dose @Mean Value, mrem/yr	Dose @Minimum Value, mrem/yr	Dose @Maximum Value, mrem/yr	Dose@Maximum 1960-62 Value mrem/yr
Caribou	4	0.50	0.09	1.64	5.63
Blueberry	0.3 ****	0.0032	0.0012	0.006	

Sources & Comments

(1) Calculation*: pCi/g (wet wt)** x lb/yr ingestedx454g/lbxEffective Dose Conversion Factor mrem/pCi)***

*Ingestion calculations use Federal Guidance Report 11, Limiting Values for Radioncluide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestions, EPA - 502/1-88-020

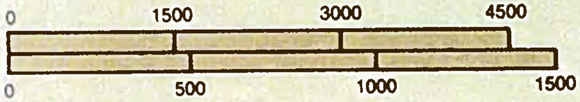
** Wet wt - Dry weight results must be converted to wet weight as consumed. A mean wet wt/dry wt ratio of 0.29 (Caribou) is used based on 1960-1962 sampling results. A wet wt/dry wt ratio of 0.10 is used for the blueberries.

*** For Cs 137 a value of 5.00E-5 mrem/pCi is used. Source is the above referenced Federal Guidance Report 11 and the DOE Residual Radioactive Material Guidelines RESRAD.

**** Estimate of 15 pounds per year blueberry consumption obtained from Ray Koonuk of Pt. Hope

Note: Normal preparation and cooking of food can reduce the radionuclide concentration in the ingested food. Special precautions can be taken in preparing foods to reduce the radiocesium content. (Stand, P., et al, 1992)

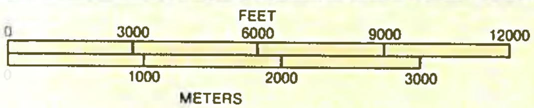
C:\chariot\spreadsheets\biota.wb1



Kisimilok Valley

CONVERSION SCALE		
LETTER LABEL	TERRESTRIAL EXPOSURE RATE (μR/h)	TOTAL EXPOSURE RATE* (μR/h)
A	0 - 1	4 - 5
B	1 - 3	5 - 7
C	3 - 5	7 - 9
D	5 - 7	9 - 11
E	7 - 9	11 - 13

*Includes an estimated 4 μR/h due to cosmic ray contributions.



Ogotoruk Valley

CONVERSION SCALE		
LETTER LABEL	TERRESTRIAL EXPOSURE RATE (μR/h)	TOTAL EXPOSURE RATE* (μR/h)
A	0 - 1	4 - 5
B	1 - 3	5 - 7
C	3 - 5	7 - 9
D	5 - 7	9 - 11
E	7 - 9	11 - 13

*Includes an estimated 4μR/h due to cosmic ray contributions