AD-A257 831

INSTALLATION RESTORATION PROGRAM
STAGE 2

REMEDIAL INVESTIGATION/FEASIBILITY STUDY

APPENDICES A THROUGH K
APPENDICES M THROUGH R

FOR

BOMARC MISSILE ACCIDENT SITE
MCGUIRE AIR FORCE BASE
NEW JERSEY

HEADQUARTERS MILITARY AIRLIFT COMMAND
SCOTT AIR FORCE BASE, ILLINOIS

MAY 1992

PREPARED BY

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ALEXANDRIA, VIRGINIA 22314

USAF CONTRACT NO. F33615-85-D-4533, DELIVERY ORDER NO. 10
CONTRACTOR CONTRACT NO. F33615-85-D-4533, DELIVERY ORDER NO. 10

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CURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

DTIC ELECTE NOV 10 1992 S B D

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS N/A
2a. SECURITY CLASSIFICATION AUTHORITY N/A	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) N/A	5. MONITORING ORGANIZATION REPORT NUMBER(S) N/A
6a. NAME OF PERFORMING ORGANIZATION The Earth Technology Corporation — 6b. OFFICE SYMBOL *(if applicable)*	7a. NAME OF MONITORING ORGANIZATION AFCEE ESO/ER
6c. ADDRESS *(City, State, and ZIP Code)* 300 N. Washington St., #700, Alexandria, VA 22314	7b. ADDRESS *(City, State, and ZIP Code)* Brooks AFB, Texas 78235-5501
8a. NAME OF FUNDING/SPONSORING ORGANIZATION AFCEE — 8b. OFFICE SYMBOL *(if applicable)* ESO/ER	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER F33615-90-D-4007
8c. ADDRESS *(City, State, and ZIP Code)* Brooks AFB, Texas 78235-5501	10. SOURCE OF FUNDING NUMBERS

Program Element No.	Project No.	Task No.	Work Unit Accession No.

11. TITLE *(Include Security Classification)*

IRP Stage 2 Remedial Investigation/Feasibility Study, Appendices A through K and M through R, for BOMARC Missile Site, McGuire AFB, New Jersey

12. PERSONAL AUTHOR(S)
Watts, Phillip and Collins, Donna

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT *(Year, Month, Day)*	15. PAGE COUNT
Final	FROM 89/11 to 92/5	1992 May 26	

16. SUPPLEMENTARY NOTATION

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS *(Continue on reverse if necessary and identify by block number)*
Remedial Investigation/Feasibility Study

19. ABSTRACT *(Continue on reverse if necessary and identify by block number)*
This document contains appendices to the final RI/FS report for the BOMARC Missile Site, McGuire AFB, New Jersey. The BOMARC site became contaminated in 1960 as the result of a fire which partially consumed a nuclear warhead-equipped BOMARC missile. The purpose of the RI/FS report is to document the extent and magnitude of environmental contamination at the site, to assess risks to human health and the environment, to determine the need for site remediation, and to evaluate feasible remedial alternatives. The appendices include borehole logs, analytical data, modeling information, etc.

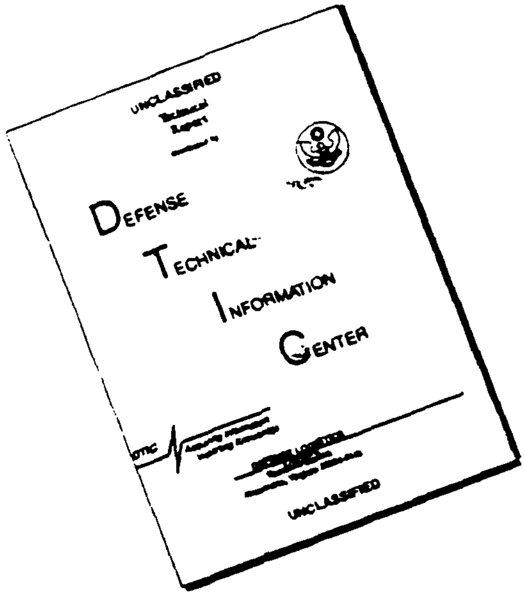
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT
[x] Unclassified/Unlimited ☐ Same As Rpt. ☐ DTIC Users

21. ABSTRACT SECURITY CLASSIFICATION
Unclassified

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE *(Include Area Code)*	22c. OFFICE SYMBOL
Major John M. Clegg, Jr. P.E.	(512)536-9001 (ext. 322)	AFCEE/ ESO/IR

DD Form 1473, JUN 86 *Previous editions are obsolete.*

SECURITY CLASSIFICATION OF THIS PAGE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APPENDIX A

Appendix A
Acronyms and Abbreviations

ADC	-	Analog to digital converter
AEC	-	Atomic Energy Commission
AFB	-	Air Force Base
AFLC	-	Air Force Logistics Command
AFR	-	Air Force Regulation
AFRAT	-	Air Force Radiation Assessment Team
ALARA	-	As Low As Reasonably Achievable
Am	-	Americium
Am-241	-	Americium-241, an isotope of americium
ANSI	-	American National Standard Institute
BEE	-	Bioenvironmental Engineer
BKG	-	Background
BOMARC	-	BOeing Michigan Aeronautical Research Center
bgs	-	Below ground surface
bls	-	Below land surface
C	-	Celsius
CE	-	Civil Engineer or Civil Engineering
CEEV	-	Civil Engineering Environmental Planning
CES	-	Civil Engineering Squadron
CFR	-	Code of Federal Regulations
Ci	-	Curie(s)
COE	-	U.S. Army Corps of Engineers
CDM	-	Camp, Dresser, McKee Federal Programs Corporation; contractors for EPA
cm	-	Centimeter(s)
cpm	-	Counts per minute
DEQPPM	-	Defense Environmental Quality Program Policy Memorandum
DEP	-	Department of Environmental Protection
DoD	-	Department of Defense
DOE	-	Department of Energy
DOT	-	Department of Transportation
dpm	-	Disintegrations per minute
dpm/100cm^2	-	Disintegrations per minute per 100 square centimeters
DU	-	Depleted Uranium
DQOs	-	Data quality objectives
EOD	-	Explosive Ordnance Disposal
EPA	-	U.S. Environmental Protection Agency
fCi	-	Femtocurie(s), 10^{-15} curies
FEMA	-	Federal Emergency Management Agency
FIDLER	-	Field Instrument to Detect Low Energy Radiation
ft	-	Foot, feet
g	-	Gram(s)
gal	-	Gallon(s)
GI	-	Gastrointestinal
GM	-	Geiger-Mueller
gpm	-	Gallons per minute
HE	-	High Explosive
HEPA	-	High Efficiency Particulate Airborne (filter)
HPG	-	Hyper-pure Germanium Detector

HNO_3	-	Nitric acid
HNu	-	Photo-ionization detector for organic vapors, manufactured by HNu
HSD	-	Human Systems Division
ICRP	-	International Commission on Radiological Protection
IRP	-	Installation Restoration Program
kev	-	Kiloelectron volts
kg	-	Kilogram(s)
km	-	Kilometer(s)
L	-	Liter(s)
LC_{50}	-	Median lethal concentration
LD_{50}	-	Median lethal dose
m	-	Meter(s)
MCA	-	Multichannel Analyzer
MCL	-	Maximum Contaminant Level
mCi	-	Millicurie(s) (10^{-3} curies)
MDL	-	Method Detection Limit
meV	-	Mega electron volt(s)
mg	-	Milligram(s)
mg/g	-	Milligrams per gram
mg/L	-	Milligrams per liter
mgd	-	Million gallons per day
min	-	Minute(s)
ml	-	Milliliter
MPC	-	Maximum Permissible Concentration
mR	-	Milliroentgens
mrad	-	Millirads
mR/hr	-	Milliroentgens per hour
MSL	-	Mean Sea Level
MPBB	-	Maximum Permissible Body Burden
MPC	-	Maximum Permissible Concentration
n	-	Neutron(s)
NAS	-	National Academy of Sciences
nCi	-	Nanocuries (10^{-9} curie), one billionth of a curie
NCRP	-	National Council on Radiation Protection and Measurement
NIM	-	Nuclear Instrumentation Module
NIST	-	National Institute of Standards and Technology
NJDEP	-	New Jersey Department of Environmental Protection
Np	-	Neptunium
NRC	-	Nuclear Regulatory Commission
OEHL	-	USAF Occupational and Environmental Health Laboratory
ORNL	-	Oak Ridge National Laboratory
OVA	-	Organic Vapor Analyzer
PAC-4G	-	Alpha radiation detection instrument, "G" designates gas proportion type
PAC-4S	-	Alpha radiation detection instrument, "S" designates scintillation type
PARCC	-	Precision, Accuracy, Representativeness, Completeness, and Comparability
pCi	-	Picocurie, one trillionth of a curie (10^{-12} curie)
pCi/gm	-	Picocuries per gram
pCi/L	-	Picocuries per liter

PF	-	Protection Factor
pH	-	A symbol for the degree of acidity/alkalinity of a solution
PNL	-	Pacific Northwest Laboratory; operated for DOE by Battelle Memorial Institute
ppb	-	Parts per billion (= micrograms per liter)
ppm	-	Parts per million (= milligrams per liter)
psi	-	Pounds per square inch, a measure of pressure
Pu	-	Plutonium
Pu-239	-	Plutonium-239, an isotope of plutonium
PVC	-	Polyvinyl chloride, a type of plastic material
QA	-	Quality Assurance
QAPP	-	Quality Assurance Project Plan
QC	-	Quality Control
R	-	Roentgens
R/hr	-	Roentgens per hour
RADCON	-	U.S. Army Radiological Control
RCA	-	Radiological Control Area
RCL	-	Radiological Control Line
rem	-	Roentgen equivalent man
RI/FS	-	Remedial Investigation/Feasibility Study
RMCL	-	Recommended Maximum Contaminant Level
RWSF	-	Retrievable waste storage facility
SCA	-	Single Channel Analyzer
SCBA	-	Self-Contained Breathing Apparatus
sec	-	second(s)
SOP	-	Standard Operating Procedure
SOW	-	Statement of Work
SSL	-	Soil Screening Level
TDS	-	Total Dissolved Solids
Th-232	-	Thorium-232
TLD	-	Thermoluminescence Dosimeter
U	-	Uranium
U-238	-	Uranium-238, the primary isotope of uranium (can also refer to Staballoy or Depleted Uranium)
μCi	-	Microcuries (10^{-6} curie), one millionth of a curie
μCi/m^2	-	Microcuries per square meter
μg	-	Micrograms (10^{-6}), one millionth of a gram
μ	-	Microns (10^{-6} meter)
μg/l	-	Micrograms per liter
μm	-	Micrometer (one millionth of a meter)
μmhos/cm	-	Micromhos per centimeter, measure of specific conductance in a solution
USAFOEHL	-	United States Air Force Occupational and Environmental Health Laboratories
VOA	-	Volatile Organic Analysis
WGP	-	Weapons Grade Plutonium
WIPP	-	Waste Isolation Pilot Plant

Definitions

Absorbed Dose	-	The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest. The unit of absorbed dose is the rad. One rad equals 100 ergs per gram.
Absorbed Fraction	-	A term used in internal dosimetry. It is that fraction of the photon energy (emitted within a specified volume of material) which is absorbed by the volume. The absorbed fraction depends on the source distribution, the photon energy, and the size, shape, and composition of the volume.
Absorption	-	The process by which radiation imparts some or all of its energy to any material through which it passes.
Absorption Coefficient	-	Fractional decrease in the intensity of a beam of x- or gamma radiation per unit thickness (linear absorption coefficient), per unit mass (mass absorption coefficient), or per atom (atomic absorption coefficient) of absorber, due to deposition of energy in the absorber. The total absorption coefficient is the sum of individual energy absorption process (Compton effect, photoelectric effect, and pair production).
Absorption Ratio	-	Ratio of concentration of a nuclide in a given organ or differential-tissue to the concentration that would be obtained if the same administered quantity of this nuclide were uniformly distributed throughout the body.
Actinides	-	Radioactive elements with atomic numbers larger than 88.
Activation	-	The process of making a material radioactive by bombardment with neutrons, protons, or other nuclear particles.
Activation	-	The process of inducing radioactivity by irradiation.
Activity	-	A measure of the rate at which radioactive material is emitting radiation; usually given in terms of the number of nuclear disintegrations occurring in a given quantity of material over a unit of time. The special unit of activity is the curie (Ci).
Acute Exposure	-	Radiation exposure of short duration.
Absorption	-	The adhesion of one substance to the surface of another.
Aging	-	Usually refers to time to permit decay of short-lived radionuclides.
A-horizon	-	Soil zone of maximum organic accumulation.

ALARA	-	As Low As Reasonably Achievable; ALARA refers to limiting release and exposure and is used by the NRC (10 CFR 50.34) in the context of "...as low as reasonably achievable taking into account the state of technology, and the economics of improvements in relation to benefits to the public health and safety and other societal and socioeconomic considerations..."
Alluvium	-	General term for clay, silt, sand, gravel, or other similar detrital material deposited by a body of running water.
Alpha Particles	-	A positively charged particle emitted by certain radioactive material. It is made up of two protons; hence, it is identical with the nucleus of a helium atom. It has a large mass, high charge (+2), short range (2-4 cm in air), and monoenergetic, discrete energies; alpha particles can be stopped by a sheet of paper, or the outer (dead) layers of human skin.
Alpha Radiation	-	Type of ionizing radioactivity consisting of emitted alpha particles.
Alveoli	-	The terminal air sacs of the lungs.
Americium-241 (Am)	-	Americium is a silvery, radioactive, somewhat malleable metal that melts at 987-1,001°C. Its density is 13.67 g/cm^3 at 4°C. Americium generally is found in the +3 valence state. It is easily disseminated over a wide area, and is difficult to remove from surfaces or the body once it has entered (Sax, 1984). It has a half life of 458 years. Beta decay of PU-241 yields Am-241. Americium-241 emits an alpha particle (5.49 MeV) and gamma rays during decay.
Amplification	-	As related to radiation detection instruments, the process (gas, electronic, or both) by which ionization effects are magnified to a degree suitable for their measurement.
Amplifier, Linear	-	A pulse amplifier in which the output pulse height is proportional to an input pulse height for a given pulse shape up to a point at which the amplifier overloads.
Amplifier, Pulse	-	An amplifier, designed specifically to amplify the intermittent signals of a nuclear detector, incorporating appropriate pulse-shaping characteristics.
Analyzer, Pulse Height	-	An electronic circuit which sorts and records the pulses according to height.
Anion	-	An ion that is negatively charged.

Aquiclude - A hydrogeologic unit which acts as a barrier to groundwater flow.

Aquifer - Geologic formation or water-bearing layer of permeable rock or soil that is capable of yielding usable quantities of water to a well or spring.

Aquitard - Geological formation or unit of low permeability which is stratigraphically adjacent to one or more aquifers and through which water movement is markedly retarded or impeded.

Area Monitoring - Routine monitoring of the radiation level or contamination of a particular area, building, room, or equipment. Some laboratories or operations distinguish between routine monitoring and survey activities.

Argillaceous - Containing or pertaining to clay.

Artisan - When pertaining to an aquifer, it is one that is confined so that its hydraulic head rises above the top of the aquifer unit; thus an artisan water body is one that is confined under hydraulic pressure.

Artificial Radioactivity - Manmade radioactivity produced by particle bombardment with neutrons or other particles. The resulting activity is "natural radioactivity" if formed by nuclear reactions occurring in nature, and "artificial radioactivity" if the reactions are caused by man.

Atom - The smallest particle into which an element can be divided and still retain its chemical properties. Each of the more than 100 elements has a different number of electrons, protons, and neutrons.

Atomic Absorption Coefficient - The linear absorption coefficient of a nuclide divided by the number of atoms per unit volume of the nuclide. It is equivalent to the nuclide's total cross section for the given radiation.

Atomic Mass - The mass of a neutral atom of a nuclide, usually expressed in terms of "atomic mass units." The "atomic mass unit" is one-twelfth the mass of one neutral atom of carbon-12; equivalent to 1.6604×10^{-24} gm.

Atomic Number - The number of protons in the nucleus of a neutral atom of a nuclide.

Atomic Weight - The mass of an atom relative to other atoms.

Attenuation - The process by which a beam of radiation is reduced in intensity when passing through some material. It is the combination of absorption and scattering processes and leads to a decrease in flux density of the beam when projected through matter.

Attenuation Factor - A measure of the opacity of a layer of material for radiation traversing it; the ratio of the incident intensity to the transmitted intensity.

Avalanche - The multiplicative process in which a single charged particle accelerated by a strong electric field produces additional charged particles through collision with neutral gas molecules. This cumulative increase of ions is also known as "Townsend ionization" or "Townsend avalanche."

Background Radiation - Radiation arising from radioactive material other than the one directly under consideration. Background radiation results from cosmic rays and from the naturally radioactive elements of the earth, including those from within the human body. There may also be background radiation due to the presence of radioactive substances in other parts of the building, in the building material itself, and so forth.

Backscattering - The deflection of radiation by scattering processes through angles greater than 90 degrees, with respect to the original direction of motion.

Barriers, Protective - Barriers of radiation-absorbing material, such as lead, concrete, and plaster, used to reduce radiation exposure.

Basement Rock - A complex of undifferentiated rocks that underlies the oldest identifiable rocks in the area.

Beam - A unidirectional or approximately unidirectional flow of electromagnetic radiation or of particles.

Bedrock - A solid rock formation usually underlying one or more other loose formations.

Bentonite - Expandable clay, a grouting material.

Beta Particles - Negatively charged electron given off during decay of some radioactive elements. Particles have a low mass, negative charge (-1), variable range (<2 cm in a solid, <500 cm in air), and a wide range of energies. A more-penetrating form of radiation than an alpha particle; can be stopped by thin metal.

Beta Radiation - Type of ionizing radiation consisting of beta particles.

Binary Scaler - A scaler whose scaling factor is two per stage.

Biological Half-life - Time required for half of a radioisotope to be eliminated from the body.

Biosphere - The part of the earth in which life can exist, including the lithosphere, hydrosphere, and atmosphere; living beings together with their environment.

Biota - The animal and plant life of a region.

Branching - The occurrence of two or more modes by which a radionuclide can undergo radioactive decay. For example, RaC can undergo α or β^-, β^+, or electron capture decay. An individual atom of a nuclide exhibiting branching disintegrates by one mode only. The fraction disintegrating by a particular mode is the "branching fraction" for that mode. The "branching ratio" is the ratio of two specified branching fractions (also called multiple disintegration).

Calibration - Determination of variation from standard, or accuracy, of a measuring instrument to ascertain necessary correction factors.

Capture, Radiative - The process by which a nucleus captures an incident particle and loses its excitation energy immediately by the emission of gamma radiation.

Carcinogenic - Capable of producing cancer.

Cation - An ion that is positively charged.

Chamber, Pocket - A small, pocket-sized ionization chamber used for monitoring radiation exposure of personnel. Before use, it is given a charge. Exposure to ionizing radiation causes discharge, so the amount of discharge is a measure of the radiation exposure.

Characteristic Radiation - Radiation originating from an atom after removal of an electron or from excitation of the nucleus. The wavelength of the emitted radiation is specific, depending only on the nuclide and particular energy levels involved.

Chronic Exposure - Radiation exposure of long duration.

Collimator - A devise for confining the elements of a beam within an assigned solid angle.

Compound - A distinct substance formed by a union of two or more ingredients in definite proportions by weight.

Compton Effect - An attenuation process observed for x- or gamma radiation in which an incident photon interacts with an orbital electron of an atom to produce a recoil electron and a scattered photon of energy less than the incident photon.

Compton Absorption Coefficient - That fractional decrease in the energy of a beam of x- or gamma radiation due to the deposition of the energy to electrons produced by Compton effect in an absorber.

Concentration Guide - The average concentration of a radionuclide in air or water to which a worker or member of the general public may be continuously exposed without exceeding radiation dose standards.

Condenser R-Meter - An instrument consisting of an "air-wall" ionization chamber together with auxiliary equipment for charging and measuring its voltage. It is used as an integrating instrument for measuring the exposure of x- or gamma radiation in roentgens (R).

Consolidated (Material) - In geology, natural materials that have been made firm, cohesive, and hard.

Contact-Handled Waste - Waste package having surface dose rate less than 0.2 R/hr. Such packages can be handled by workers without extensive shielding. Contact-handled wastes were termed low-level wastes in DOE/ET-0028 and DOE/ET-0029.

Containment - Confining the radioactive wastes within presented boundaries, e.g., within a waste package.

Contamination, Radioactive - Deposition of radioactive material in any place where it is not desired, particularly where its presence may be harmful. The harm may be in vitiating an experiment or a procedure, or in actually being a source of danger to personnel.

Controlled Area - A defined area in which the occupational exposure of personnel (to radiation) is under the supervision of the Radiation Protection Supervisor.

Cosmic Rays - High-energy particulate and electromagnetic radiations which originate outside the earth's atmosphere.

Count (Radiation Measurements) - The external indication of a device designed to enumerate ionizing events. It may refer to a single detected event or to the total number registered in a given period of time. The term often is erroneously used to designate a disintegration, ionizing event, or voltage pulse.

Counter, Gas Flow	-	A device in which an appropriate atmosphere is maintained in the counter tube by allowing a suitable gas to flow slowly through the sensitive volume.
Counter, Geiger Mueller	-	Highly sensitive, gas-filled radiation-measuring device, which operates at voltages sufficiently high to produce avalanche ionization.
Counter, Proportional	-	Gas-filled radiation detection device; the pulse produced is proportional to the number of ions formed in the gas by the primary ionizing particle.
Counter, Scintillation	-	The combination of phosphor, photomultiplier tube, and associated circuits for counting light emissions produced in the phosphors by an ionizing event.
Counting, Coincidence	-	A technique in which particular types of events are distinguished from background events by coincidence circuits which register coincidences caused by the type of events under consideration.
Counting Ratemeter	-	An instrument which gives a continuous indication of the average rate of ionizing events.
Critical	-	Capable of sustaining (at a constant level) a chain reaction. "Prompt critical" means sustaining a chain reaction without the aid of delayed neutrons.
Critical Mass	-	The minimum mass of fissile material which can be made critical with a specified geometrical arrangement and material composition.
Cumulative Dose Radiation	-	The total dose resulting from repeated exposures to radiation.
Curie (Ci)	-	Unit of measure of radioactivity; the radiation from one gram of radium during one second; or the equivalent amount of other material that produces 3.7×10^{10} disintegrations per second.
Daughter	-	In a decay chain, the element formed when its "parent" decays.
Daughter Nuclide	-	A nuclide formed upon disintegration of a parent radionuclide.
Decade Scaler	-	A scaler whose scaling factor is a power of ten.
Decay Chain	-	The series of elements that form sequentially as radioactive decay progresses.

Decay Constant	-	The fraction of the number of atoms of a radioactive nuclide which decays in unit time.
Decay Curve	-	A curve showing the relative amount of radioactive substance remaining after any time interval.
Decay Product	-	A nuclide resulting from the radioactive disintegration of a radionuclide, formed either directly or as the result of successive transformations in a radioactive series. A decay product may be either radioactive or stable.
Decay, Radioactive	-	Disintegration of the nucleus of an unstable nuclide by spontaneous emission of charged particles and/or photons.
Decontamination	-	The selective removal of radioactive material or other contaminant from a surface or from within another material.
Decontamination Factor (DF)	-	The ratio of the amount of undesired radioactive material initially present to the amount remaining after a suitable processing step has been completed. Decontamination factors may refer to the reduction of some particular type of radiation, or to the gross measurable radioactivity.
Depth Dose	-	The radiation dose delivered at a particular depth beneath the surface of the body; usually expressed as percentage of surface dose.
Detector, Radiation	-	Any device for converting radiant energy to a form more suitable for observation. An instrument used to determine the presence, and sometimes the amount, of radiation.
Devitrification	-	The process by which glassy substances lose their vitreous nature and become crystalline.
Discharge	-	In groundwater hydrology, water that issues naturally or is withdrawn from an aquifer.
Discriminator, Pulse Height	-	A circuit designed to select and pass voltage pulses of a certain specified amplitude.
Disintegration Constant	-	The fraction of the number of atoms of a radioactive nuclide which decays in unit time.
Disintegration Nuclear	-	A spontaneous nuclear transformation (radioactivity) characterized by the emission of energy and/or mass from the nucleus. When numbers of nuclei are involved, the process is characterized by a definite half-life.
Disposal (radioactive waste)	-	The planned confinement of radioactive waste in a manner which is considered permanent so that recovery is not provided.

Dolomite	-	A common rock-forming material (calcium-magnesium carbonate).
Dose	-	A general form denoting the quantity of radiation or energy absorbed. For special purposes it must be appropriately qualified. If unqualified, it refers to absorbed dose.
Dose Equivalent	-	A quantity used in radiation protection. It expresses all radiation on a common scale for calculating the effective absorbed dose. It is defined as the product of the absorbed dose in rads and certain modifying factors. (The unit of dose equivalent is the rem).
Dose Rate	-	Absorbed dose delivered per unit time.
Dose Ratemeter	-	Any instrument which measures radiation dose rate.
Dosimeter	-	Instrument to detect and measure accumulated radiation exposure. In common usage, a pencil-size ionization chamber with a self-reading electrometer, used for personnel monitoring.
Dry Storage	-	Storage of waste packages without liquid cooling.
Efficiency (Counters)	-	A measure of the probability that a count will be recorded when radiation is incident on a detector. Usage varies considerably, so it is well to ascertain which factors (window transmission, sensitive volume, energy dependence, etc.) are included in a given case.
Electron	-	Negatively charged particle that orbits an atom's nucleus.
Electron Volt (eV)	-	A unit of energy equivalent to the energy gained by an electron in passing through a potential difference of one volt. Larger multiple units of the electron volt are frequently used: keV for thousand or kilo electron volts; MeV for million or mega electron volts. 1 eV = 1.6×10^{-19} watt-seconds.
Element	-	A category of atoms all with the same atomic number, e.g., plutonium or gold.
Energy	-	Capacity for doing work. "Potential energy" is the energy inherent in a mass because of its spatial relation to other masses. "Kinetic energy" is the energy possessed by a mass because of its motion.
Enrichment	-	A process to increase the percentage of a desired isotope such as uranium-235.
Eolian	-	Applied to the erosive action of the wind and to deposits which are due to the transporting action of the wind.

Equilibrium, Radioactive	-	In a radioactive series, the state which prevails when the ratios between the amounts of successive members of the series remains constant.
Evapotranspiration	-	That portion of precipitation returned to the air through direct evaporation, or by transpiration from vegetation, or both.
Exposure	-	A measure of the ionization produced in air by x- or gamma radiation. It is the sum of the electrical charges on all ions of one sign produced in air when all electrons liberated by photons in a volume element of air are completely stopped in air, divided by the mass of the air in the volume element. The special unit of exposure is the roentgen.
External Radiation	-	Radiation from a source outside the body; the radiation must penetrate the skin.
Exit Dose	-	Dose of radiation at the surface of a body opposite to that on which the beam is incident.
Fallout	-	Radioactive debris from a nuclear detonation, which is airborne or has been deposited on the earth. Special forms of fallout are "Dry Fallout," "Rainout," and "Snowout."
Fault	-	A fracture or fracture zone along which there has been displacement of the sides relative to one another, parallel to the fracture.
Feldspar	-	Any of a group of common rock-forming minerals that are silicates of alumina and some other basic element, such as potassium, sodium, or calcium.
Fertile	-	A material that becomes fissile upon absorbing a neutron.
Fissile	-	Of a nuclide, capable of undergoing fission by interaction with slow neutrons.
Fission, Nuclear	-	A nuclear transformation characterized by the splitting of a nucleus into at least two other nuclei and the release of a relatively large amount of energy; usually limited to heavier nuclei such as isotopes of uranium, plutonium, and thorium.
Fission Product	-	Any radioactive or stable nuclide produced by fission, including both primary fission fragments and their radioactive decay products.
Fissionable Material	-	Actinides capable of undergoing fission by interaction with neutrons of all energies.

Fracture	-	Breaks in rocks caused by intense folding or faulting or the process of breaking fluid-bearing strata by injecting a fluid under such pressure as to cause partings in the rock.
Free-Air Ionization	-	An ionization chamber in which a delimited beam of radiation passes between the electrodes without striking them or other internal parts of the equipment. The electric field is maintained perpendicular to the electrodes in the collecting region. As a result, the ionized volume can be accurately determined from the dimensions of the collecting electrode and the limiting diaphragm. This is the basic standard instrument for x-ray dosimetry within the range of 5 to 1,400 kVp.
Fuel Cycle	-	Mining, refining, enrichment, and fabrication of fuel elements, use in a reactor, chemical processing to recover the fissionable material remaining in the spent fuel, re-enrichment of the fuel material, refabrication of new fuel elements, and management of radioactive waste.
Gamma Radiation	-	One form of electromagnetic energy (electromagnetic energy includes radio waves, infrared rays, visible light, ultraviolet rays, x-rays, gamma rays, cosmic rays) with no charge, no mass, long range (penetrates 4-10 cm of lead, 10-50 cm of soil), and several discrete energy levels. Gamma radiation, whose effects are similar to x-rays, is far more easily detected than alpha or beta radiation.
Gamma Ray	-	High-energy, short-wavelength electromagnetic radiation similar in nature to x-rays, emitted from the nucleus of an atom during decay of some radioactive elements. The most penetrating form of radiation; can be stopped by thick metal.
Gamma-ray Spectroscopy	-	Type of radiation analysis where the gamma energy is separated into discrete energy levels (spectrum) and then measured.
Gas Amplification	-	As applied to gas ionization radiation detecting instruments, the ratio of the charge collected to the charge produced by the initial ionizing event.
Geologic	-	Related to the study of the earth, its formation, and the changes it has undergone or is undergoing.
Geologic Isolation	-	Entombment of radioactive wastes deep underground in stable rock layers.
Geometry, Good	-	In nuclear physics measurements, an arrangement of source and detecting equipment such that the use of finite source size and finite detector aperture introduces little error.

Geometry, Poor - In nuclear physics measurements, an arrangement in which the angular aperture between the source and detector is large, introducing into the measurement a comparative large uncertainty for which a correction may be necessary.

Geomorphology - Study of the form of the earth, the general configuration of its surface, and the changes that take place in the evolution of landforms.

Germanium Detector - An instrument which uses a germanium metal core to detect gamma radiation.

Gross Alpha - A measure of total alpha radiation activity.

Gross Beta - A measure of total beta radiation activity.

Groundwater - Water that exists or flows within the zone of saturation beneath the land surface.

Grout - A mortar fluid combined with liquid waste to provide a matrix for isolation of the waste and to seal the waste from the environment.

Half-life - 1) Physical--the time required for a quantity of a radioactive substance to decay to one half of its original quantity. 2) Biological--time required for half of an ingested or inhaled substance to be eliminated from the body by natural processes. 3) Effective--time required for half of an ingested or inhaled radioactive substance to be eliminated from the body by the combination of radioactive decay and natural processes; mathematically equal to product of the physical and biological half-lives divided by the sum of the physical and biological half-lives.

Half-life, Radioactive - Time required for a radioactive substance to lose 50 percent of its activity by decay. Each radionuclide has a unique half-life.

Health Physics - A science and profession devoted to the protection of man and his environment from unnecessary radiation exposure.

HEPA - High Efficiency Particulate Airborne (filter). A high efficiency filter used to screen particulates from the air. Such filters are used on the personal respirators as protection against dust, fumes, mists, asbestos-containing dusts and mists, and radionuclides. Filters with the same composition are used on vacuum systems and building ventilation systems.

HNu Photoionizer - An instrument which detects organic and inorganic vapors and gases from liquids, landfills, soil samples, sediment samples, and potentially contaminated equipment.

Holocene Age	-	The period of time since the last ice age.
Hydrogeology	-	Relating to the science of groundwater and its geological relationship.
Hydraulic Gradient	-	The change in static head per unit of lateral distance in a given direction.
Hydrologic	-	Pertaining to the study of the properties, distribution, and circulation of water on the surface of the land, in the soil, and underlying rocks, and in the atmosphere.
Immobilization	-	Treatment and/or emplacement of wastes so as to impede their movement.
Induced Radioactivity	-	See "Artificial Radiation".
In-situ	-	In place.
Integral Dose (Volume Dose)	-	A measure of the total energy absorbed by a patient or object during exposure to radiation.
Interbeds	-	Thin beds of rock material alternating with thicker beds of rock.
Interfinger	-	To grade or pass from one rock material into another through a series of interlocking or overlapping wedge-shaped layers.
Interim Storage	-	Storage operations for which: a) monitoring and human control are provided and b) subsequent action involving treatment, transportation, or final disposition is expected.
Internal Radiation	-	Radiation from a source within the body (as a result of deposition of radionuclides in body tissues).
Ion	-	Atomic particle, atom, or chemical radical bearing an electrical charge, either negative or positive.
Ionization	-	The process by which a neutral atom or molecule acquires a positive or negative charge.
Ionizing Energy	-	The average energy lost by ionizing radiation in producing an ion pair in a gas. For air, it is about 33.73 eV.
Ionizing Event	-	Any occurrence or process in which an ion or group of ions is produced.
Ionizing Radiation	-	Any electromagnetic or particulate radiation (alpha, beta, gamma) capable of producing ions, directly or indirectly, in its passage through matter.

Irradiation	-	Exposure to radiation.
Isolation	-	Segregating wastes from the accessible environment (biosphere) to the extent required to meet applicable radiological performance objectives.
Isotopes	-	Nuclides having the same number of protons in their nuclei, and hence the same atomic number, but differing in the number of neutrons, and therefore in the mass number. Almost identical chemical properties exist between isotopes of a particular element. The term should be used as a synonym for nuclide.
Kiloelectron Volt (KeV)	-	Kiloelectron volts; energy equal to one thousand electron volts, 10^3 eV.
Leakage (Direct) Radiation	-	All radiation coming from the source housing except the useful beam.
Leachate	-	Fluid resulting from the separation or dissolving of soluble or particular constituents from solid waste or other man-placed media by the percolation of water through it.
Limonite	-	A field term for a group of brown, amorphous, naturally occurring, hydrous ferric oxides. May consist of the minerals goethite, hematite, and lepidocrocite.
Linear Absorption Coefficient	-	A factor expressing the fraction of a beam of x- or gamma radiation absorbed, in unit thickness of material.
Lithification	-	The conversion of unconsolidated sediment into solid rock by processes such as compaction, cementation, and crystallization.
Lithology	-	The study of rocks. Also, the character of a rock: its structure, color, mineral composition, grain size, and arrangement of its component parts.
Low Level Waste	-	Low-radioactivity waste such as contaminated clothing.
Magnetometer	-	Geophysical instrument that measures fluctuations in the earth's magnetic field.
Mass	-	The quantity of matter in a body as measured in its relation to inertia. The material equivalent of energy. Different from weight in that it neither increases nor decreases with gravitational force.

Mass Absorption Coefficient - The linear absorption coefficient per cm divided by the density of the absorber in grams per cubic cm. It is frequently expressed as μ/p, where μ is the linear absorption coefficient and p, the absorber density.

(MPD) Maximum Permissible Dose Equivalent - The greatest dose equivalent that a person or specified part thereof shall be allowed to receive in a given period of time.

Maximum-Exposed Individual - A person whose location and habits tend to maximize his radiation dose relative to other workers in the same area.

Median Lethal Dose (MLD) - Dose of radiation required to kill, within a specified period, 50 percent of the individuals in a large group of animals or organisms exposed. Also called the LD_{50}.

Microcurie (μCi) - One millionth of a curie; abbreviated μCi.

Micron - Unit of length equal to 10^{-6} meters (Symbol: μ).

Migration - Movement of oil or water through porous and permeable rock.

Millicurie - One thousandth of a curie (3.7×10^4 disintegrations per second); abbreviated mCi.

Milliroentgen - A submultiple of the roentgen, equal to one-thousandth of a roentgen; abbreviated mR.

Molecular Weight - The sum of the atomic weights of all the atoms in a molecule.

Molecule - Smallest quantity of a compound which can exist by itself and retain all properties of the original substance.

Monitoring - Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination present in an occupied region.

Monoenergetic Radiation - Electromagnetic radiation of a single wavelength, or radiation in which all the photons have the same energy.

Multibarrier - A system using the waste form, the container (canister), the overpack, the emplacement medium, and surrounding geologic media as multiple barriers to isolate the waste from the biosphere.

Natural Radioactivity - The property of radioactivity exhibited by more than fifty naturally occurring radionuclides.

Nuclide - A species of atom characterized by its mass number, atomic number, and nuclear energy state; to be regarded as a distinct nuclide, the atom must be capable of existing for a measurable lifetime in its nuclear energy state.

Neutron - Electrically neutral particle in the nucleus; of very slightly greater mass than a proton but without nuclear charge; can cause fission in uranium-235 and plutonium upon impact.

Neutron Absorption - Nuclear reaction in which uranium atoms absorb neutrons and transmute into heavier transuranic elements, such as plutonium.

Operations - Broad classification of waste management activities in terms of their basic function (e.g., waste storage, treatment, transportation, or disposal).

Outcrop - The exposure of bedrock or strata projecting through the overlying cover of detritus and soil.

Overpack - Secondary (or additional) external containment for packaged nuclear waste.

Parent - In a decay chain, the element which decays to produce a "daughter".

Parent Nuclide - A radionuclide that upon disintegration yields a specified nuclide, either directly or as a later member of a radioactive decay series.

Percentage Depth Dose - Dose of radiation delivered at a specified depth in tissue, expressed as a percentage of the skin dose.

Perched - Pertains to groundwater accumulation which is above and separate from the general water table of the area.

Permeability - The quality or state of being permeable. The relative ease with which a porous medium can transmit a liquid under a hydraulic gradient.

Permissible Dose - The dose of radiation which may be received by an individual within a specified period with expectation of no significantly harmful result.

Personnel Monitoring - Monitoring any part of an individual, his breath, excretions, or any part of his clothing.

Picocurie - One millionth of a microcurie (3.7×10^{-2} disintegrations per second or 2.22 disintegrations per minute); abbreviated pCi; replaces the term $\mu\mu c$.

Pleistocene Age - The earlier of the two epochs comprising the Quaternary; the age of glaciers.

Plutonium (Pu) - Manmade transuranic heavy element, formed by neutron absorption in uranium-238, which can be made to fission. It is a heavy (density 19.816 g/cm³ @ 4°C), radioactive, silvery white metal. Metallic plutonium has a melting point of 639.5°C and a boiling point of 3,232°C. It is chemically reactive, and after short exposure to air it oxidizes to a dark brown or black color. Plutonium may assume oxidation states of +3, +4, +5, or +6, depending on environmental conditions. Plutonium oxide (PuO_2) has a density of 11.46 gm/cm³ and a melting point of 2,200° to 2,400°C. It is relatively insoluble under most conditions. Plutonium is pyrophoric, meaning that it can ignite and self-sustain to complete oxidation. There are two regimes in the oxidation of plutonium: a kinetic-controlled regime, in which the oxidation rate is controlled by temperature and oxygen availability, and the diffusion-controlled regime, in which the oxidation is self-sustaining and is controlled by the diffusion of the oxygen through the oxide layer to the metal surface.

Porosity - The property of a rock or soil which enables the rock or soil to contain water in voids or interstices, usually expressed in percentage or as a decimal fraction of void volume as compared to total volume.

Potentiometric - Refers to the relief or elevation of the groundwater surface.

Primary Radiation - The useful beam of an x-ray tube.

Primary Wastes - Untreated initial wastes resulting from operation of fuel cycle facilities other than waste management facilities. (Wastes from operation of waste management facilities are secondary wastes).

Proportional Region - Voltage range in which the gas amplification is greater than one, and in which the charge collected is proportional to the charge produced by the initial ionizing event.

Proton - Positively charged particle in an atom's nucleus.

Rad - Radiation absorbed dose, the basic unit of absorbed dose of ionizing radiation. A dose of 1 rad is equivalent to the absorption of 100 ergs of radiation energy per gram of absorbing material.

Radiation - (1) The emission and propagation of energy through space or through a material medium in the form of waves; for instance, the emission and propagation of electromagnetic waves, or of sound and elastic waves. (2) The energy propagated through space or through a material medium as waves; for example, energy in the form of electromagnetic waves or of elastic waves. The term radiation or radiant energy, when unqualified, usually refers to electromagnetic radiation. Such radiation commonly is classified, according to frequency, as Hertzian, infrared, visible (light), ultraviolet, x-ray, and gamma ray. (3) By extension, corpuscular emissions, such as alpha and beta radiation, or rays of mixed or unknown type, as cosmic radiation.

Radiant Energy - The energy of electromagnetic radiation, such as radio waves, visible light, x- and gamma rays.

Radioactive Waste - Wastes from the nuclear fuel cycle and other activities using radioactive material (medical, industrial).

Radioactivity - Occurs when unstable atoms spontaneously expel particles, or bursts of energy. The particles and energy are invisible, odorless, tasteless, and soundless. The major types of ionizing radiation are alpha, beta, and gamma.

Radioisotope - A radioactive isotope.

Radionuclide - A species of atom that is radioactive.

Reaction Energy (Nuclear) - In the disintegration of a nucleus, it is equal to the sum of the kinetic or radiant energies of the reactants minus the sum of the kinetic or radiant energies of the products. If any product of a specified reaction is in an excited nuclear state, the energy of subsequently emitted gamma radiation is not included in the sum. The "ground-state nuclear reaction energy" is the reaction energy when all reactant and product nuclei are in their ground states (Symbol Q_o).

Recharge - In hydrology, a source or means for replenishment of water withdrawn or discharged from an aquifer by natural or artificial processes.

Rem - Roentgen equivalent man; a quantity used in radiation protection to express the effective dose equivalent for all forms of ionizing radiation. It is the product of the adsorbed dose in rads and factors related to relative biological effectiveness.

Remediation Measures - Actions necessary to clean up, remove, or treat a substance or location so hazardous effects are eliminated or reduced.

Remotely Handled Waste	-	Waste package having surface dose rate greater than 0.2 R/hr. Such packages require extensive shielding and/or remote handling to protect operating personnel. Remotely handled wastes were termed intermediate-level wastes in DOE/ET-0028 and DOE/ET-0029.
Repository (Federal)	-	A federally owned and operated facility for storage or disposal of specific types of waste from DOE sites and/or licensees.
Retrievability	-	Capability to remove waste from its place in isolation with approximately the same level of effort and radiation exposure as required to place the waste.
Risk (mathematical)	-	Product of the consequences and the probability of the event's occurrence.
Roentgen (R)	-	A unit for measuring gamma or x-ray radiation. The roentgen is defined by measuring the effect of the radiation on air. It is that amount of gamma or x-rays required to produce ions carrying 1 electrostatic unit of charge in 0.001293 g of dry air under standard conditions; 1 R = 2.58×10^{-4} coulomb/kg.
Scaler	-	An electronic device which registers current pulses received over a given time interval.
Scattered Radiation	-	Radiation which during its passage through a substance, has been deviated in direction. It may also have been modified by a decrease in energy.
Scattering	-	Change of direction of subatomic particles or photons as a result of a collision or interaction.
Sealed Source	-	A radioactive source sealed in an impervious container which has sufficient mechanical strength to prevent contact with, and dispersion of, the radioactive material under the conditions of use and wear for which it was designed.
Secondary Radiation	-	Radiation resulting from absorption of other radiation in matter. It may be either electromagnetic or particulate.
Secondary Wastes	-	Wastes that result from applying waste treatment technologies to primary wastes.
Secular Equilibrium	-	If a parent element has a very much longer half-life than the daughters (so there is no appreciable change in its amount in the time interval required for later products to attain equilibrium), then, after equilibrium is reached, equal numbers of atoms of all members of the series disintegrate in unit time. This condition is never actually attained, but is essentially established in such a case as

radium and its series to radium D. The half-life of radium is about 1,600 years; of radon, approximately 3.82 days; and of each of the subsequent members, a few minutes. After about a month, essentially the equilibrium amount of radon is present; then (and for a long time) all members of the series disintegrate the same number of atoms per unit time.

Selector, Pulse Height	-	A circuit designed to select and pass voltage pulses in a certain range of amplitudes.
Self-Absorption	-	Absorption of radiation (emitted by radioactive atoms) by the material in which the atoms are located; in particular, the absorption of radiation within a sample being assayed.
Series, Radioactive	-	A succession of nuclides, each of which transforms by radioactive disintegration into the next, until a stable nuclide results. The first member is called the "parent," the intermediate members are called "daughters," and the final stable member is called the "end product."
Shield	-	A body of material used to prevent or reduce the passage of particles or radiation. A shield may be designated according to what it is intended to absorb (i.e., as a gamma-ray shield or neutron shield), or according to the kind of protection it is intended to give (i.e., as a background, biological, or thermal shield). The shield of a nuclear reactor is a body of material surrounding the reactor to prevent the escape of neutrons and radiation into a protected area, which frequently is the entire space external to the reactor. It may be required for the safety of personnel or to reduce radiation enough to allow use of counting instruments for research or for locating contamination or airborne radioactivity.
Shielding	-	A material interposed between a source of radiation and personnel for protection against the danger of radiation. Commonly used shielding materials are concrete, water, and lead.
Shipping Cask	-	A specially designed container used for shipping radioactive materials.
Short-Lived Nuclides	-	Radioactive isotopes with relatively short half-lives. Usage for some isotopes varies with the concept being considered (e.g., isotopes with 5-50 year half-lives are short-lived in the context of geologic disposal but long lived in the context of predisposal operations).
Sigma (σ)	-	Greek letter refers to standard deviation, a statistical measure of dispersion.

Skin Dose (Radiology) - The dose of radiation which may be received by an individual within a specified period with expectation of no significantly harmful result.

Slurry - A fluid mixture or suspension of insoluble material.

Solidification - Conversion of liquid radioactive waste to a dry, stable solid.

Somatic - A direct effect (as of radiation) on the health of body tissue.

Source Term - The quantity of radioactive material (or other pollutant) released to the environment at its point of release (source).

Specific Activity - Total activity of a given nuclide per gram of a compound, element, or radioactive nuclide.

Spike - The known amount of an isotope added to a sample to determine the unknown amount present in analysis by isotope dilution.

Spurious Count - In a radiation counting device, a count caused by any agency other than ionizing radiation.

Split-Spoon Samples - Soil samples secured with a split-spoon sampling device.

Storage - Retention of waste in some type of manmade device in a manner permitting retrieval.

Stratigraphic - Refers to the sequence of soil and rock characteristics of an area.

Stratum - Sedimentary bed or layer, regardless of thickness, of homogeneous or gradational lithology.

Stray Radiation - The sum of leakage and scattered radiation.

Surficial Geology - Formed on, situated at, or occurring on the earth's surface.

Technologies - Specific methods for implementing concepts. An example is calcination of liquid high-level waste by using a spray calciner.

Thorium - Naturally occurring radioactive element.

Threshold Dose - The minimum absorbed dose that will produce a detectable degree of any given effect.

Tissue Dose	-	Absorbed dose received by tissue in the region of interest, expressed in rads.
Tracer	-	An isotope used to follow a process.
Transmissivity	-	Volume of water flowing through a 1-ft width of aquifer of given thickness under a unit gradient (1 ft vertically for each 1 ft laterally) and at the viscosity prevailing in the field. Mathematically, it is the product of permeability and aquifer thickness.
Transmutation	-	A nuclear process in which one nuclide is transformed into the nuclide of a different element. This can be accomplished by bombardment with neutrons (neutron absorption) or other nuclear particles.
Transportation	-	Movement of materials between sites. Intra-site movement is not considered. Includes alternative methods for packaging, handling, and transport of waste materials and plutonium compounds. Concepts include all conventional methods of land and water transport required by the waste management system.
Transuranic (TRU) Elements	-	Elements with an atomic number greater than 92. They include, among others, neptunium, plutonium, americium, and curium.
Transuranic Waste	-	Waste material measured or assumed to contain more than a specified concentration of transuranic elements.
Treatment	-	Operations intended to benefit safety or economy by changing the waste characteristics.
Tremie-grouted	-	Placing grout with a pipe in the annular space between the casing and boring wall.
Tube, Electron Multiplier	-	A tube in which small electron currents are amplified by a cascade process employing secondary emission.
Tube, Photomultiplier	-	An electron multiplier tube in which the electrons initiating the cascade originate by photoelectric emission.
Uranium	-	Natural radioactive element occurring in two main forms; uranium-235 and uranium-238.
Volatile	-	A substance which tends to evaporate into the air.
Waste Immobilization	-	Process of converting waste to a stable, solid, and relatively insoluble form.
Waste Isolation Pilot Plant	-	A Department of Defense repository proposed for a radioactive waste storage site in Southeastern New Mexico.

Waste Management - The planning, execution, and surveillance of essential functions related to the control of radioactive (and nonradioactive) waste, including treatment, transportation, storage, surveillance, and isolation.

Water Table - The upper surface of the zone of water saturation in the subsurface, at which the pressure is equal to atmospheric pressure; the upper surface of an unconfined aquifer.

Weapons-Grade Plutonium (WPG) - Approximately 93 percent Pu-239 and 7 percent Pu-240. Plutonium-239 is a neutron activation product of U-238 and has a half-life of 2.44 x 10^4 years. Plutonium-240 has a half-life of 6.58 x 10^3 years, and is formed by multiple neutron capture of U-238. Radioactive decay of Pu-239 and Pu-240 results in the release of alpha particles. A weak x-ray (gamma ray) is also associated with decay of Pu-239. Plutonium-241 (half-life 13.2 years) is formed through multiple neutron capture of U-238 or Pu-239, and decays to Am-241 with the release of beta radiation.

X-Rays - Penetrating electromagnetic radiations whose wave lengths are shorter than those of visible light. They are usually produced by bombarding a metallic target with fast electrons in a high vacuum. In nuclear reactions, it is customary to refer to photons originating in the nucleus as gamma rays, and those operating in the extranuclear part of the atom as x-rays. These rays are sometimes called roentgen rays after their discover, W. C. Roentgen.

Yellowcake - Partially refined uranium ore.

Definitions extracted, in part, from:

U.S. Department of Energy, 1980, Management of Commercially Generated Radioactive Waste, Final Environmental Impact Statement, DOE/EIS-0046F.

U.S. Department of Health, Education and Welfare, 1970, Radiological Health Handbook.

Electric Power Research Institute, 1976, Plutonium: Facts and Inferences: EPR, Special Report EA-43-SR.

APPENDIX B

STATEMENT OF WORK

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STATEMENT OF WORK (SOW)

THE INSTALLATION RESTORATION PROGRAM
REMEDIAL INVESTIGATION/FEASIBILITY STUDY (RI/FS)
AND ENVIRONMENTAL IMPACT STATEMENT (EIS)

STAGE 2 FOR

BOMARC MISSILE SITE, McGUIRE AFB NJ

I. DESCRIPTION OF WORK

1.1 **Scope.** The objective of the Air Force Installation Restoration Program (IRP) is to assess past hazardous waste disposal and spill sites on Air Force installations and develop remedial actions consistent with the National Contingency Plan (NCP) for those sites which pose a threat to human health and welfare or the environment. The intent of this effort is to conduct a Remedial Investigation and Feasibility Study (RI/FS) in parallel with an Environmental Impact Analysis Process (EIAP) which produces an Environmental Impact Statement (EIS) on the Air Force's Proposed Actions and Alternatives concerning the radioactive material from the 1960 fire at the BOMARC Missile Site at McGuire AFB NJ. Data concerning this fire will be mailed to contractor under separate cover. To meet this objective the contractor shall accomplish the following:

1.2 **Technical Requirement**

1.2.1 **RI/FS Work**

1.2.1.1 The objective of the RI/FS is to gather environmental data, screen for Applicable or Relevant and Appropriate Requirements (ARARs), determine potential health risks, and analyze remedial alternatives that will result in an Air Force decision document. The contractor shall comply with all requirements listed in the USAFOEHL/TS Handbook, Version 2.0, dated April 1988; and the BOMARC Missile Site Stage 2 Work Plan and Quality Assurance Project Plan (QAPP) (all mailed under separate cover). All references in this Statement Of Work to the "Handbook" refer to the above version of the USAFOEHL/TS Handbook. The Work Plan and Section 1 of the Handbook lists all documents relevant to supporting this Statement of Work (SOW) for the RI/FS.

1.2.2 **Literature Search.** Update literature search performed as part of RI/FS Work Plan to determine the radiological, geological, hydrogeological, social and environmental settings for this work effort. RI/FS Requirements are supplied under separate cover (see "Environmental Setting", Section II of the Report Format, Section 3, USAFOEHL/TS Handbook). When gathering information for the demographic setting and conducting the well inventory, consider only those populations and wells within one mile of the BOMARC site. Sources include: IRP Phase I Report, Federal and State geological agency reports, academic theses and related university research, municipality and county reports, and historical and current aerial photographs. Cite all bibliographic references reviewed, including personal communications, in the appropriate part of the report. The contractor shall not duplicate information gathered under any previous efforts (reports of previous efforts are provided under separate cover).

1.2.3 **Public Health and Environmental Requirements**

1.2.3.1 Develop the Data Quality Objectives (DQOs) to evaluate the threat of contaminants to public health and welfare or the environment. This effort shall satisfy the requirements contained in the Superfund Amendments and Reauthorization Act (SARA) of 1986 to identify all Applicable or Relevant and Appropriate Requirements (ARARs). Sources for ARARs are listed in the Handbook, Section 2 and Table 4-2 of the Work Plan.

1.2.3.2 Determine radioactive "hot" spots which may have occurred as a result of the 1960 fire by using post survey results (furnished under separate cover) and two models. Use this information to define the boundary for field work sampling grids for in-situ radiological analysis and soil borings, concrete coring, electrical conduit and manholes wipe sampling, and air monitoring of drilling locations. The boundary limit shall be defined as a significant amount/piece of radioactive material resulting in 0.2 micro curie per square meter of radioactivity.

1.2.3.2.1 Predict where these "hot" spots may occur by using historic data of the 1960 fire (sent under separate cover) and adapting two off-the-shelf computer models for air dispersion and sediment transport. Using the Nuclear Regulatory Commission (NRC)-approved Mesoscale, Version 2, (MEISO-2) model for air dispersion, determine the surface "footprint" from the airborne release during previous incident. Select an off-the-shelf, open channel flow sediment transport model to define the worst case condition for Pu-239 transport and dispersion into the drainage ditch and pond during the 1960 fire. Under present site conditions determine what frequency storm would cause erosion of the drainage ditch and further distribution of Pu-239 into the environment.

1.2.3.2.2 All documentation records for the models shall be maintained until a record of decision is issued.

1.2.4 **Site Preparation and Maintenance**

1.2.4.1 Establish a seven foot security fence boundary around the planned work area which shall include the launch shelters, concrete pad, and asphalt drainage ditch area. This area shall be known as the "Radiological Control Area" (RCA). Establish a sample and radiological waste holding areas within the RCA. Establish a contamination control area for decontamination and entry control. Establish a temporary area for logistical support with showering facilities and parking in an area free from radiation contamination.

1.2.4.2 Erect a temporary enclosure for Launch Shelter Building 204 to prevent the release of contaminated material into the environment during removal of loose debris and borehole field investigations.

1.2.4.3 **Radiological Waste** The contractor shall package all radioactive waste generated as a result of sampling and site characterization and maintain a complete inventory of the radiological waste placed in each container by chemical form, activity per gram of material, and description of contents. The Air Force will provide all containers and packaging instructions to the contractor, and provide for proper disposal by the Air Force Logistics Command. Coordinate with the Base POC and the USAFOEHL/TS TPM on the site for temporary storage of all radiological waste awaiting transfer to the Department of Defense radiological waste disposal contractor.

1.2.4.4 **Other Waste or Refuse** The contractor shall dispose of non-nuclear wastes in contractor furnished containers through a separate local waste disposal/refuse contractor.

1.2.4.5 **Quality Assurance/Quality Control (QA/QC).** A quality assurance/quality control (QA/QC) program shall be adhered to for ALL work specified in this Delivery Order. The USAFOEHL-approved QA/QC program is described in the IRP Stage 2 Quality Assurance Project Plan (QAPP). Data generated under the QA/QC program shall be used to evaluate the analytical results assembled for this site and to formulate conclusions and recommendations pertaining to the need for additional site investigations or remediation alternatives for EIS.

1.2.4.6 **Field Instrument sensitivity.** The contractor shall provide field instruments to monitor three regions (energy levels). Region One will be centered on the 17 KeV, Pu-239 x-rays, Region Two centered on the 60 KeV x-rays from Am-241, and Region Three at about 90 KeV for monitoring of natural background. A probe support shall be used to insure that all field measurements are collected at 2 feet heights above the ground. All data shall be recorded on standard field survey forms to record survey locations and results.

1.2.5 **Identification and Location of Radiological Waste From the the 1960 Fire:** Based on the literature search data the contractor shall determine the possible location of radiological materials which were removed from Launch Shelter 204 shortly after the fire. This debris consists of the launcher, associated support hardware, electrical hardware, possibly containerized earth drainage ditch dam and strippable paint used to fix the contamination in place. Use a ground-penetrating radar device to search for and identify the location of the buried material within the government property. A maximum of ten (10) days are authorized for ground-penetrating radar. Survey and mark the location with permanent survey monuments. Show the location on the project map.

1.2.6 **Field Investigation.** As used in this SOW, "field investigation" refers to the collection of all data, environmental and radiological samples, and subsequent laboratory analysis of samples. The purpose of data collection, sample collection and laboratory analysis is to determine whether any Pu-239, Am-241 contaminants generated from the 1960 fire are entering the environment or contained. The field investigation shall verify the extent of source, migration, potential pathways and the magnitude of contamination relative to ARARs. Define any naturally-occurring or background concentrations for transuranic compounds. Refer to Annex A for summary of field activities which defines the maximum number of field activities, and sample analysis (to include

QA/QC samples), and their respective analytical method or standard; and the maximum lengths,etc.

1.2.6.1 **IN-SITU RADIOLOGICAL SURVEYS**
The contractor shall conduct in-situ radiological surveys using hyper-pure Ge detectors with a field multi-channel analyzer to construct contamination contours and determine drilling locations. The site survey shall be performed using a radial and grid pattern described in the Work Plan. Model predictions developed in paragraph 1.2.3.2. shall also be used in conducting this survey. See Annex A for the maximum number of analyses for this survey.

1.2.6.2 **Soil Borings.** Drill 30 borings in the site for a maximum of 200 linear feet. Drill all borings using hollow-stem auger techniques. Obtain split-spoon samples for gamma radioanalysis in the field. Of the split spoon samples collected, a maximum of three (3) samples per boring shall be analyzed for Pu-239 by laboratory alpha spectroscopy. See Annex A for location, analytical methods maximum number of analysis. For those borings that will not be converted to test or monitoring wells; tremie-grout the borehole with a bentonite/cement slurry. The slurry shall be prepared by adding 3-5 pounds of bentonite and 6.5 gallons of clean water for each 94 pound sack of Type 1 Portland cement. Soil boring holes must be adequately resealed after the soil sample is replaced to the land surface to preclude future migration of contaminants. Soil that the site health physicist designates as being radioactively contaminated shall be disposed as radioactive waste.

1.2.6.3 **Concrete Coring.** Drill 6 cores inside Bldg 204 and 18 cores outside on the apron for a maximum of 50 linear feet. Core concrete and the soil below to collect samples to verify contaminant is sandwiched between concrete slabs and not migrating into the soil. Of the samples collected, a maximum of three (3) samples per coring shall be analyzed for Pu-239 by laboratory alpha spectroscopy. See Annex A for maximum number of analysis. Concrete core boreholes shall be filled to the land surface with the same slurry mix described in the above paragraph.

1.2.6.4 **Lithologic Samples.** For purposes of lithologic descriptions, obtain split-spoon or coring samples at five (5) foot maximum intervals, unless concurrence is obtained for a deviation by the USAFOEHL/TS TPM. Monitor all split-spoon or core samples and record radiation levels detected. Take laboratory samples as directed by field health physicist. As often as necessary, describe drill cuttings to indicate significant changes in lithology or characteristic properties that relate to the strata penetrated. Follow the standard identification practices detailed in ASTM D 2488. Correlate the materials encountered with local geologic formations as determined from the literature search. Include observations made by the driller and hydrogeologist during drilling such as depth to water, penetration rate, drill rig behavior, and other observations that might be indicative of changes in formation characteristics. If soil encountered during borehole drilling or test pit work is suspected to be contaminated because of high readings, containerize the soil cuttings in new, unused contractor furnished drums. Enter into the boring logs the depth(s) from which suspected contaminated soil cuttings were collected. Compile all of this information into standard boring or well logs. Indicate on the logs the intervals where discrete split-spoon/core samples were taken and the corresponding readings data.

1.2.6.5 **Air Monitoring During Drilling**. The contractor shall monitor continuously the ambient air during all drilling work, including all soil, concrete and asphalt boring/coring procedures. The air filters shall be counted to determine the gross alpha radioactivity both immediately upon stopping drilling activities, and 24 hours later to determine net alpha activity due to plutonium. In cases where alpha activity remains above 20 disintergrations per minute per 100 square centimeter (20 DPM/100 SQ CM), the filter paper shall be analyzed in the laboratory for plutonium-239 activity by alpha spectroscopy. See Annex A for the maximum number of analyses.

1.2.6.6 **Monitoring Wells**. Install a maximum of 10 new monitoring wells for a maximum of 1000 linear feet, 100 feet screening. These wells shall be installed at a specific location where concrete coring or soil borings indicate potential contaminant migration into groundwater which cannot be adequately monitored or assessed from existing on site monitoring wells. The USAFOEHL TPM shall coordinate on the installation of the new wells to determine the number of wells and their locations. All well water samples shall be analyzed for gross alpha/beta activity. The primary reference is "The Interim Radiological Methodology for Drinking Water:, EPA-600/4-75-008, March, 1976. Alternative methods must be approved by the Environmental Protection Agency (EPA) in accordance with 40 CFR 141.27. See Annex A for the maximum number of analysis.

1.2.6.7 **Water Sampling**

a. **BOMARC Underground Electrical/Communication Distribution System**. The concrete pad covering the manhole covers to the underground electrical and communications bunkers shall be removed to allow access for sampling. A water sample shall be taken from each bunker and analyzed. The remaining water standing in the communications bunkers shall be pumped out and properly disposed as radioactive waste. Any sludge remaining shall be sampled and analyzed for plutonium activity. Upon completion of the sampling, the manhole covers shall be replaced and the area resealed with portland cement concrete. See Annex A for the location for samples and the maximum number of analysis.

b. **Surface Water Samples**. Collect surface water samples in the drainage ditch if sufficient runoff is present to ensure an adequate sample volume. See Annex A for the maximum number of analysis.

c. **Ground Water Samples**. Ground water samples in either existing or newly installed monitoring wells shall be collected only if the results from concrete coring or soil borings show a potential groundwater contamination problem. Sampling locations must be coordinated with the USAFOEHL/TS TPM. See Annex A for the maximum number of analysis.

1.2.6.8 **Wells, Boreholes and Sampling Specification**. The contractor shall comply with the procedures described in Annex B as it pertains to wells, boreholes and groundwater sampling in this delivery order.

1.2.6.9 **Wipe Radiological Survey**.

a. When Shelter 204 is enclosed, take a maximum of 100 smear or wipe samples in Shelter 204. All the wipe samples shall be analyzed for a gross alpha activity determination with no more than ten (10) randomly selected for alpha spectroscopy analysis. See Annex A for location, analytical method, and the maximum number of analysis.

b. Select a maximum of twenty (20) launch shelters where wipe surveys shall be accomplished. No more than fifteen (15) shelters in the immediate area of Launch Shelter 204 shall be tested, and the remaining five (5) shelters outside the immediate vicinity of Shelter 204 shall be selected for wipe surveys. A maximum of twenty five (25) wipe samples shall be collected at each of the launch shelters selected for survey, for a total of no more than 500 wipe samples. Each wipe shall be analyzed for gross alpha activity to determine removeable contamination. See Annex A for location, analytical method and maximum number of analysis.

c. Those areas that show removable alpha contamination activity above the twenty disintergrations per minute per one hundred square centimeters (20 DPM/100 SQ CM) shall be resampled and counted. If the wipe still appears to be above the limit, a gray fixitive, strippable paint shall be applied to prevent the spread of contamination or at the discretion of the site health physicist removed and disposed as radioactive waste. See Annex A for maximum number of analysis.

1.2.7 **Baseline Risk Assessment.** After a thorough review of all data gathered during the field investigation and the determination of ARARs (paragraph I.2.3.1), determine the potential risk to human health and welfare or the environment from the contaminants identified at the site. The required elements of the baseline risk assessment are provided in the Handbook, Section 3 (Report Format Section IV). Include results of the baseline risk assessment in Section IV of the Final Report and the EIS.

1.2.8 **Preliminary Alternative Remedial Actions (FS Phase I)** Utilize the data and conclusions obtained from the field investigation and baseline risk assessment to develop preliminary alternative remedial actions. The required elements for the FS Phase I report are described in Section 3 of the Handbook and the Work Plan. Alternatives developed shall include the following categories:

a. Alternatives for off site treatment and/or disposal

b. Alternatives that attain ARARs

c. Alternatives that exceed ARARs

d. Alternatives that do not attain ARARs

e. No further action

f. Non-cleanup alternative

Documentation of the remedial alternative development process, including the decision rationale shall be provided as an Informal Technical Report (ITIR) and shall be included in Section V of the Final Report. (Item VI, paragraph 6.1, sequence 3)

1.2.9 **Initial Screening of Alternatives (FS Phase II).** The alternatives developed in paragraph I.1.2.8 shall be screened to eliminate those that are clearly infeasible or inappropriate, prior to undertaking detailed evaluation of the remaining alternatives. The required elements for the FS Phase II are provided in the Handbook, Section 3. An informal Technical Information Report shall be prepared detailing the screening process and identifying the alternatives remaining. (Item VI,paragraph 6.1,sequence 3) This decision process shall be included in Section V of the Final Report.

1.2.10 **Detailed Analysis of Alternatives (FS Phase III).** Perform a detailed analysis of the alternatives remaining after the initial screening. The required elements for the FS Phase II are provided in the Handbook, Section 3. Additional guidance can be found in EPA/540/G-85/003, Guidance on Feasibility Studies Under CERCLA. Provide an Informal Technical Information Report describing the analysis procedures, results and conclusions to the USAFOEHL/TS. (Item VI, paragraph 6.1, sequence 3) The detailed analysis of environmental pathways shall include the following:

a. Technical Analysis

b. Environmental Analysis

c. Public Health Analysis

d. Institutional Analysis

e. Cost Analysis

f. Evaluation of Alternatives

The analysis procedures, decision process, results and conclusions of the detailed analysis shall be included in Section V of the Final Report.

1.3 EIS WORK

1.3.1 The objective of the EIS is to be the decision documentation process that uses the results of the scientific analysis performed in the RI/FS to analyze the potential environmental impacts of the proposed actions and alternatives. The EIS uses those analysis in making decisions or recommendations on whether and how to proceed with those actions and alternatives. This process deliberately involves the public, other federal agencies,and state agencies to assure a clear understanding of the potential environmental consequences of proposed actions and alternatives. To meet this objective the contractor shall accomplish the following actions in addition to those actions listed for the RI/FS objectives at the BOMARC Missile Site, McGuire AFB NJ:

1.3.2 Synthesize the data collected for the RI/FS and incorporate it into the Environmental Impact Statement. Collect data to characterize the environmental setting for addressing the impacts of the proposed actions and alternatives on the human and natural environment. Include the collection of data required to assess the impact of proposed alternatives that may generate impacts that extend beyond the BOMARC site proper.

1.3.3 Identify potential contaminant pathways in air, water, and soil and assess their impact for the proposed actions and alternatives on the natural and human environment.

1.3.4 Identify issues and concerns that are raised by public participation in the EIAP. Address these issues in the appropriate section of the Draft EIS based on RI/FS data and independent data requirements from the preparation of the EIS.

1.3.5 **Environmental Review and Consultation Requirements**

1.3.5.1 Identify biological and archaeological/historical impacts of the proposed actions and alternatives. Conduct a survey for each category above through a literature review, verbal consultation with federal and state agency involved, and by site inspection. This survey shall be accomplished to meet the requirements of the Fish and Wildlife Coordination Act (16 V.S.C. Sec. 661 et seq), the National Historic Preservation Act of 1966 (U.S.C. Sec. 470 et seq.), the Endangered Species Act of 1983 (V.S.C. Sec. 1531 et seq.); and other environmental review laws and executive orders. Incorporate the survey into the EIS.

1.3.5.2 Define and list all federal permits, licenses, and other entitlements which must be obtained in implementing the proposal in the EIS.

1.3.6. **Public Hearings, (three) at McGuire AFB** The contractor shall prepare a EIS overview describing the proposed actions and alternatives of the subsequent impacts on the natural and human environment for presentation at the hearing Item VI, paragraph 6.1, sequence 9. The contractor shall provide a legal stenographer to record the proceedings and prepare a transcript of the hearing Item VI, paragraph 6.1, sequence 3. Three technical personnel 8 hours each, for two days, shall be available to respond to technical questions raised in the EIS. The contractor shall prepare a written response to all issues and questions raised during the hearing as recorded in the public hearing transcript Item VI, paragraph 6.1, sequence 3. Individual draft responses shall be made to each individual or agency raising a question and supplied to the Air Force. Final responses will be incorporated into the Final Environmental Impact Statement. (Item VI, paragraph 6.1, sequence 3)

1.3.7 Based on the scoping documents and the outcome of public hearing(s), update the significant issues or concerns to be addressed in the Final EIS. Utilizing the RI/FS data, rank the potential significance of each issue, and screen the alternatives and potential impacts to meet the requirements of 40CFR1500.4.

1.3.8 Develop mitigation options for the proposed actions and alternatives and discuss in the EIS.

1.3.9 **References.** The contractor shall comply with all requirements listed in Air Force Regulation 19-2, the EIAP process, the Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act (NEPA) the EIS scoping documents, and the BOMARC Missile Site Stage 2 Work Plan. (All documents are provided under separate cover). The Work Plan lists additional documents relevant to supporting this Statement of Work (SOW).

1.4 Decision Documents

1.4.1 **Technical Document to support EIS Record of Decision** The contractor shall prepare a Record of Decision in accordance with the requests stated in paragraph 1505.2, AFR 19-2, attachment 1. (provided under separate cover) (Item VI, paragraph 6.1, sequence 4)

1.4.2 **Technical Document to Support Remedial Action Alternatives** Prepare a decision document to the selection process. Use the format provided in the Handbook, Section 11. (Item VI, paragraph 6.1, sequence 4).

1.5 Reports

1.5.1 **Draft Reports.** Draft reports are considered "drafts" only in the sense that they have not been reviewed and approved by the Air Force. In all other respects, "drafts" must be complete, in the proper format, and free of grammatical and typographical errors. All draft reports shall be thoroughly screened through contractor in-house peer technical review before being released to USAFOEHL/TS.

1.5.2 **RI/FS Final Report.** Prepare a report delineating all findings from this investigative stage of the remedial investigation/feasibility study. Review the Results, Conclusions and Recommendations concerning the site listed in this task which was investigated during any previous IRP stage work effort. Use this information and data from previous efforts to establish trends and develop conclusions and recommendations. Integrate all investigative work done at the site to date so that the report reflects the total cumulative information for the site studied in this effort. Environmental sample results shall be analyzed with respect to QA/QC data unique to this project. Summary statistics shall be used and reported when justified by the amount and quality of data and incorporated only in the draft reports (ITIRs). This report must also include a detailed discussion of the recommended alternative. (Item VI, paragraph 6.1, sequence 4).

1.5.2.1 **RI/FS Report Format.** Strictly adhere to the USAFOEHL/TS Report Format (USAFOEHL/TS Handbook, Section 3) for preparation of draft and Final RI/FS Reports. This format is an integral part of this Delivery Order.

1.5.3 **Microfiche Copies of Final Report.** Provide three (3) microfiche copies of the approved Final Report (Item VI, paragraph 6.1, sequence 17).

1.5.4 **Environmental Impact Statement (EIS) Report.** Use the format and guidance provided in section 40 CFR 1502 for report preparation. (Item VI,paragraph 6.1, sequence 4). Incorporate by reference detailed information that is included in the RI/FS developed under this delivery order, especially the backup material (technical procedures and detailed data) that may be included as appendices to the RI/FS. Annotate a copy of the second draft report of the final impact statement indicating new information added to the EIS and provide to the Air Force to enhance security review at this stage of the process.

1.5.5 **Project Map.** Update an installation map which locates all sampling locations on a single sheet. Provide the map with the first draft RI/FS report following the field investigation. (Item VI, paragraph 6.1, sequence 3)

1.5.6 **Analytical Data.** Upon completion of all analyses, tabulate and incorporate all analytical data into an Informal Technical Information Report and forward the report to USAFOEHL/TS no later than three (3) weeks after all analyses have been completed. Use the format provided in the USAFOEHL/TS Handbook, Section 8. (Item VI, paragraph 6.2, sequence 3)

1.5.7 **Letter Report** The contractor shall provide a record of all conferences, informal meetings (other than those with a transcript), discussions, verbal directions, telephone conversations, etc. in which the contractor and his subcontractor personnel have participated on matters relative to direction of or planning for this SOW effort. These letter reports are called confirmation notices and are numbered sequentially. A maximum of 100 pages is authorized for this project. They shall fully identify participating personnel, subject discussed, and any guidance given and/or conclusions reached. Distribution will take place no more than five working days after the event occurred. Recipients of this Notice are key contractor personnel, USAFOEHL/TSS, and HQMAC/DEV. (Item VI, paragraph 6.1, sequence 16)

1.6 **Plans.**

1.6.1 **Health and Safety Plan.** Provide a revised written Health and Safety Plan (as provided under separate cover) within six (6) weeks after the Notice To Proceed (NTP). Comply with USAF, OSHA, EPA, NRC, State and local health and safety regulations regarding the work effort. Use NRC EPA guidelines for designating the appropriate levels of protection needed at the study sites. Coordinate the Health and Safety Plan directly with applicable regulatory agencies prior to submittal to USAFOEHL/TS. Provide the USAFOEHL/TS TPM with evidence of Health and Safety Plan approval prior to the start of field work. (Item VI,paragraph 6.1, sequence 3)

1.6.2 **Waste Management Plan..** Provide a written waste management plan within six (6) weeks after NTP. This plan shall detail the expected waste categories to be generated and approximate quantitites, define interium holding areas and contamination control procedures to be used. Comply with USAF, OSHA, NRC, EPA, state and local regulations for all categories of temporary waste storage and for disposal of wastes other than radioactive. (Item VI, paragraph 6.1,sequence 3)

1.7 **Meetings.** A maximum of 10 meetings with four (4) contractor personnel shall be attended at Mcguire AFB,NJ. Each meeting shall be a maximum of two 8 hour days in duration. All meetings shall be coordinated by the USAFOEHL/TS TPM and are required to support the EIS process.

1.8 **Special Notification .** Immediately report to the USAFOEHL/TS TPM or his/her supervisor, via telephone, any data/results generated during this investigation which may indicate an imminent health risk. Follow the telephone notification with a letter report within three (3) days. (Item VI, paragraph 6.1, sequence 16)

1.9 **R & D Status Reports.** Include all data as required by the USAFOEHL/TS Handbook, Section 6. Tabulated field and laboratory test results and QA/QC data shall be incorporated into the next monthly R & D Status Report as they become available and forwarded to the USAFOEHL/TS (Item VI, paragraph 6.1, sequence 1).

1.10 **Variations.** The above technical efforts which include maximum requirements are estimates only. Should the contractor determine technical efforts, including field work, require variation from these estimates, the contractor shall obtain a written concurrence from the contracting officer's technical representative at USAFOEHL/TS. This concurrence is required prior to proceeding with the variation. Under such circumstances, the ceiling price of this order shall remain unchanged. Should an increase in the ceiling amount be necessary, contracting officer authorization will be required prior to proceeding with the variation.

1.11 **Engineering Network Analysis.**— Provide within 10 days of NTP a computer generated network analysis, which is a detailed task plan for the integration of the RI/FS and EIS work efforts. The Network Analysis shall be in the form of a progress chart of suitable scale to indicate appropriately the percentage of work schedule for completion by any given date during the period of the delivery order. The Network Analysis will show both serial and parallel subtasks leading to a deliverable product or report. Show early and late start and completion data with float. Use the timeline, delivered under separate cover to obtain deliverable dates. This shall be updated quarterly. (Item VI, paragraph 6.1, sequence 2)

II. SITE LOCATION AND DATES:

BOMARC Site, McGuire AFB,NJ
Date to be established

III. BASE SUPPORT

The Base will:

3.1 Show location of underground utilities and issue digging or other appropriate permits to the IRP contractor prior to the commencement of digging or drilling operations.

3.2 Assign non-radioactive waste accumulation points within the installation for contract refuse pickup. The contractor is responsible for providing all necessary containers (55-gallon drums) and for transporting the containerized material.

3.3 Coordinate on a temporary radioactive waste storage area. Take custody of any radioactive materials in government furnished containers at storage area and transport government furnished containers off site.

3.4 Provide the contractor with existing engineering plans, drawings, diagrams, aerial photographs, etc., to facilitate evaluation of IRP site under investigation.

3.5 Arrange for the following services and have available prior to the start-up of field work:

a. Personnel identification badges, vehicle passes and/or entry permits.

b. A source for large quantities of potable water for borehole flushing, equipment cleaning, etc.

c. A set of keys to the locks on any existing test/monitoring wells at BOMARC Site. The keys shall be returned to the Base POC by the contractor when the survey has been completed.

d. Temporary construction barriers and parking/traffic control at the site.

3.6 Make paint color selections when requested.

3.7 Provide guidance on base standards as required for contractor interface.

IV. GOVERNMENT FURNISHED PROPERTY: None

V. GOVERNMENT POINTS OF CONTACT:

5.1 USAFOEHL/TS
Technical Program Manager (TPM)
Major John M. Clegg, Jr., PE
USAFOEHL/TSS
Brooks AFB TX 78235-5501
(512) 536-2158
AV 240-2158/2159
1-800-821-4528

5.2 Base Point of Contact (POC)
Marty Eisenhart
438 ABG/DEV
McGuire AFB, NJ 08641
(AC) 609-724-2770

5.3 HQ MAC/DEEV (POC)
Ms Calliott/Mr. Scott Edwards
Scott AFB IL 62225-5001
(AC) 618-256-5764

VI. DELIVERABLES

6.1 Attachment 1 of the basic contract. In addition to Sequence Numbers 1 and 5 listed in Attachment 1 to the basic contract which apply to all orders, the Sequence Numbers and dates listed below are applicable to this order:

Sequence No.	Para No.	Block 10	Block 11	Block 12	Block 13	Block 14
3 (Health & Safety Plan)	I.1.6.1	OTIME	89JAN13	89FEB24	-	10
3 (Waste Management Plan)	I.1.6.2	OTIME	89JAN13	89FEB24	-	4
3 (ITIR- PH I)	I.1.2.8	OTIME	89AUG31	**	-	3
3 (ITIR- PH II)	I.1.2.9	OTIME	89AUG31	**	-	3
3 (ITIR- PH III)	I.1.2.10	OTIME	89AUG31	**	-	3
9 (Public Hearing Support)	I.1.3.6	ONE/R	***	***	89DEC29	*
3 ITIR (Transscript	I.1.3.6	OTIME	****	****	-	*
3 ITIR (Response to Public Hearing)	I.1.3.6	OTIME	****	****	-	*
4 (Decision Document)	I.1.4.2	ONE/R	89AUG31	89OCT04	89DEC22	*****
4 (RI/FS Tech. Rpt)	I.1.5.2	ONE/R	89AUG31	89OCT04	89DEC22	*****
4 (EIS Document)	I.5.4	ONE/R	89APR26	89OCT04	89DEC29	******
17 (Microfiche)	I.1.5.3	OTIME	89DEC28	89DEC29	-	3
3 Project Map	I.1.5.5	OTIME	89APR26	89OCT04	-	1
3 ITIR Analytical	I.1.5.6	OTIME	**** ***	**** ***	-	1
16 (Letter Report)	I.1.5.7	OTIME	**** ****	**** ****		
4 (Decision Document)	I.1.4.1	ONE/R	89AUG31	89NOV30	89DEC22	*****
4 (Network Analysis)	I.1.11	ONE/R	89JAN17	89JAN27	***** ****	1

6.2 Notes:.

* Distribute 4 copies as shown USAFOEHL/TS(1),HQMAC/DEV(2),BASE(1). Retain public meeting transcript original for final EIS documentation.

** Upon completion of Phase but no later than 3 weeks of completion

*** No later than 10 days of notification of hearing

**** No later than 10 days after each hearing

***** One first draft report (15 copies), one second draft report (25 copies), and one Final Report (50 copies plus the original camera-ready copy) are required. Incorporate Air Force comments into the second draft and Final Reports as specified by USAFOEHL/TS. Supply USAFOEHL/TS with an advance copy of the first-draft, second draft, and Final Reports for acceptance prior to distribution. Distribute the remaining 14 copies of the first draft report, 24 copies of the second draft report, and 49 copies of the Final Report as specified by USAFOEHL/TS.

****** Four drafts and one final report shall be required. After acceptance of advanced copy by TPM, provide 20 copies to HQ USAF/LEEV, Bolling AFB, Washington DC 20331; 10 copies to HQMAC/DEV, Scott AFB IL, 62225-5001; 6 copies to USAFOEHL/TS and 2 copies to Base POC. Incorporate comments into all drafts and Final documents as specified by USAFOEHL/TS. Supply USAFOEHL/TS with an advance copy of the first draft, second draft, third draft and Final documents for acceptance prior to distribution.

******* Upon completion of analyses but no later than 3 weeks after all analyses have been completed

******** No later than 3 days of telephone notification with USAFOEHL.

********* Quarterly thereafter

SUMMARY OF FIELD ACTIVITIES
Annex A

TYPE WORK	OBJECTIVE	LOCATION(S)	SUPPORT	STANDARD OR ANALYTICAL METHOD	MAXIMUM NUMBER ANALYSIS/ACTIVITY
A. In-situ Survey	1. Gross Gamma Pu 239/Am 241 2. Alpha Spectroscopy PU 239	per survey grid	extent of contamination	1. portable (HPG) Hyper Pure GE detector 2. Surface barrier detector	1. 1000 analysis total 2. 200 analysis total
B. Soil boring (splitspoon auger) or concrete core (hollow auger)	lithological log	1.& 2. per survey grid 3. concrete cores in Bldg 204, Apron Bldg 204, 202 206, 200	soil class soil characteristics soil moisture or material class	1. standard penetration testing 2. ASTM D 1586 3. core drilling practice	1.& 2. 30 borings total for maximum 200 Linear feet total 3. 6 cores total inside Bldg 204 18 cores total outside apron, maximum 50 Linear feet
C. Soil boring sampling (split spoon auger) or concrete core sample	1. Gross Gamma Pu 239/Am 241 2. Alpha Spectroscopy Pu 239	per survey grid or core sample sites	extent of contamination	1. portable HPG 2. Surface barrier detector	1. 350 analysis total 2. 264 analysis total
D. Wipe Sampling	1. Gross Gamma Pu 239/Am 241 2. Gross Alpha/ Beta 3. Alpha Spectroscopy for Pu 239	1. Loose debris in Shelter 204 2. Structural members in shelters 3. Structural member in shelter 204	1. extent of contamination or cleanup 2. extent of contamination or cleanup 3. extent of removable contamination	1. High resolution Gamma/xray spectroscopy 2. Gas flow proportional detector/counter 3. Surface barrier detector	1. 100 analysis total 2. 600 analysis total 3. 40 analysis total
E. Water wells drilling 2" I.D..	Groundwater monitoring establish water table elevation if concrete core samples show penetration below lower slab		extent of groundwater contamination	standard practice	1. 10 wells maximum 2. 1000 Linear feet total 3. 100 feet max screening 5 foot minimum screening per well

TYPE WORK	OBJECTIVE	LOCATION(S)	SUPPORT	STANDARD OR ANALYTICAL METHOD	MAXIMUM NUMBER ANALYSIS/ACTIVITY
F. Water sampling	1. Gross Alpha/Beta (total, suspended and dissolved)	1. underground communication and electrical conduits and boxes in BOMARC site	extent of contamination	Interim Radiological Methodology for Drinking water, EPA-600/4-75-008 1. Gas flow proportional detector/counter	1. 60 analysis total
	2. Gross Alpha/Beta (total, suspended and dissolved)	2. Surface water from storm event in drainage ditch	extent of contamination	2. Gas flow proportional detector/counter	2. 20 analysis total
	3. Alpha Spectroscopy for Pu-239	3. Surface water from storm event in drainage ditch		3. Surface barrier detector	3. 10 analysis total
	4. Gross Alpha/Beta (total, suspended and dissolved)	4. Water wells, both new and existing from past IRP efforts	extent of contamination	4. Gas flow proportional detector/counter	4. 100 analysis total
	5. Alpha spectroscopy for Pu-239	5. Water wells, both new and existing from past IRP efforts	extent of contamination	5. Surface barrier detector	5. 20 analysis total
G. Air Monitoring	assure working protection in radioactive work area and from Gross Alpha/Beta radioactivity	wherever excavating removal, drilling or soil drilling/excavation is being performed	worker safety, hazard containment	Hi Volume air sampling for analysis by 1. gas-flow proportional counter for gross alpha/ 2. Surface barrier detector Pu 239 net alpha particles	1. 300 analysis total, one each at start and finish of daily work 2. 100 analysis total, one each 24 hours following daily work and sample
H. Ground penetrating radar	locate buried debris	BOMARC site adjacent government property	extent of containment	standard proration	1. 10 days (area survey)
I. Sludge Sampling	1. Gross gamma Pu-239/Am-241	1. Underground communication & Electrical systems in Bomarc Site	extent of contamination	1. High resolution Gamma/x-ray spectroscopy	1. 60 analysis total
	2. Alpha Spectroscopy Pu-239			2. Surface Barrier Detector	2. 10 analysis total

ANNEX B

WELLS, BOREHOLES AND SAMPLING SPECIFICATIONS

1. **Drilling Supervision.** The field investigation (including all coring, drilling, boring and sampling operations) shall be supervised by either a registered geologist, engineering geologist, hydrogeologist or Professional Engineer (PE) and a health physicist. (Provide 2 supervisors, one for drilling/boring work and the other for radiological sampling and site safety). A detailed log of the conditions and materials penetrated during the course of the work shall be maintained by the geologist/hydrogeologist/PE on site. Decisions on well coring and boring locations, depths, well screening intervals, and other construction details shall be made collectively by the USAFOEHL/TS TPM and the supervising geologist/hydrogeologist/PE and health physicist.

2. **Regulatory Requirements and Permits.** All well drilling, soil sampling, decontamination and/or purging, sampling methods, nuclear waste, nuclear material transport and other activities pertaining to this effort must conform to State and other applicable regulatory agency requirements. Cite references in an appendix to the Final Report. Complete permits, applications, and other documents which are required by local and/or State regulatory agencies for this work effort. File these documents with appropriate agencies and pay all applicable permitting and filing fees.

3. **Sealing Boreholes.** For those boreholes that will not be converted to test or monitoring wells; tremie-grout the borehole with a bentonite/cement slurry. The slurry shall be prepared by adding 3-5 pounds of bentonite and 6.5 gallons of clean water for each 94 pound sack of Type I Portland cement. Soil boreholes must be adequately resealed after the soil sample is replaced to the land surface to preclude future migration of contaminants. Soil that the site health physicist designates as being radioactively contaminated shall be disposed as radioactive waste. Concrete core boreholes shall be filled with the slurry to the land surface.

4. **Well Drilling.** Augers, temporary casings and/or boreholes shall be sufficiently large to provide a minimum of two (2) inch annular space on all sides of the well casing and screen during well completion. Ensure wells are installed straight, plumb, and centered in the borehole. Describe the lithology of materials encountered as described for borings in paragraph I.1.4.7.3. If possible, avoid installing wells in standing water. If wells must be installed in such areas, design the wells such that standing water does not leak into the top of the casing or cascade down the annular space from a 25 year flood.

5. **Well Casing Requirements.** Construct each shallow well with two (2) inch inside diameter (I.D.), Schedule 40, PCV casing. Use threaded screw-type joints only. Glued fittings are not permitted. Flush-thread all connections.

6. **Well Depth.** Install wells at a sufficient depth to collect representative

samples of aquifer quality.

7. **Well Screening Requirements.**

a. Screen each shallow well using two (2) inch I.D., Schedule 40, PVC screen having up to 0.020-inch openings. Screen opening size may be smaller based upon borehole geology or sieve analysis of aquifer materials. Each well screen shall be a maximum of ten (10) feet in length. Cap the bottom of the screen.

b. Screen all wells a minimum of five (5) feet.

c. Once the casing is in place, install the sand/gravel pack. If the formation is compatible with the screen opening size, allow the formation to collapse around the well screen. Supplement with washed and bagged, rounded silica sand or gravel with a grain size distribution compatible with the screen and the formation. Place the pack from the bottom of the borehole to at least 2 ft above the top of the screen. The sand/gravel pack should not extend into an overlying formation. Tremie at least a two (2) foot bentonite seal (granulated or pellets) above the sand/gravel pack. Ensure that the bentonite forms a complete seal. Grout the remainder of the annulus to the land surface with a Type I Portland cement/bentonite slurry. The slurry shall be prepared by adding 3-5 pounds of bentonite and 6.5 gallons of clean water for each 94 pound sack of Type I Portland cement. The bentonite used shall be free of additives that may affect water quality.

8. **Well Completion.** Complete all test wells using the following specifications:

a. Coordinate with the Base Point Of Contact (POC) to determine well completion (i.e., flush or projected above the ground surface) requirements.

(1) If well stick-up is of concern in an area, complete the well flush with the land surface. Cut the casing two to three inches below land surface, and install a protective locking lid consisting of a cast-iron valve box assembly. Center the lid assembly in a three (3) foot diameter concrete pad sloped away from the valve box. Ensure that free drainage is maintained within the valve box. Also, provide a screw-type casing cap to prevent infiltration of surface water. Maintain a minimum of one (1) foot clearance between the casing top and the bottom of the valve box. Clearly mark the well number on the valve box lid and well casing using an impact labeling method.

(2) If an above-ground-surface completion is used, extend the well casing two or three feet above land surface. Provide an end plug or casing cap for each well. Shield the extended casing with a steel guard pipe (sleeve) which is placed over the casing and cap and seated in a two-foot by two-foot by four-inch (2' X 2' X 4") concrete surface pad. Slope the pad away from the well sleeve. Install a lockable cap or lid on the guard pipe. Install three (3), three-inch diameter concrete-filled steel guard posts if the base POC determines the well is in an area which needs such protection. The guard posts shall be five (5) feet in total length and installed radially from each wellhead. Recess the guard posts approximately two (2) feet into the ground and set in concrete. Do not install the guard posts in the concrete pad placed at the well base. Fill each guard post with concrete. Clearly mark the well

number on the well protective sleeve exterior using paint and/or impact the base.

b. All wells shall be secured as soon as possible after drilling. Provide corrosion resistant locks for both flush and above-ground well assemblies. The locks must either have identical keys or be keyed for opening with one master key. Turn the lock keys over to the Base POC following completion of the field effort.

c. Include well completion summaries in the Final Report.

9. **Well Logs.** For each well, prepare a well completion log and schematic diagram showing well construction details. Lithologic descriptions and other information included in the well logs shall conform to the specifications of paragraph.

10. **Well Development.** Develop each well as soon as practical after well completion and grout curing with a dedicated submersible pump, bailer, and/or airlift method. Continue well development until the discharge water is clear and free of sediment to the fullest extent possible (ie., turbidity less than 5 NTU). Measure the rate of water production, pH, specific conductance, and water temperature during well development and include this information in the Final Report.

11. **Water Level Measurements.** Measure water levels at all test wells as feet below the measuring point elevation (usually top of casing) to the nearest 0.01 foot. Report as feet above mean sea level (MSL). Measure static water levels in wells prior to well development and before all well purging preceeding sampling events.

12. **Well Abandonment.** Recommend well abandonment method(s) or technique(s) which are applicable to the type of test wells installed and the geological conditions. Consider that these wells will be abandoned at some future date after the study objectives have been met. The actual process of well abandonment is not a part of this task order. Recommended method(s) shall be consistent with State and local well abandonment guidelines or regulations.

13. **Surveying.** Determine by certified land surveyor the elevations and locations of all newly installed test wells, soil borings, concrete coring sampling points. This shall be a "third order" survey. Notch the top of the riser casing where well elevations are established. Record the positions on project map. Bench marks used must have previously been established from, and be traceable to a US Coast and Geodetic Survey (USCGS) or US Geological Survey (USGS) survey marker. Clearly identify all bench mark locations on the project or a base map.

14. **Well and Borehole Cleanup.** Dispose of all uncontaminated well/borehole cuttings per direction of the Base Civil Engineer and clean the general area following the completion of each well/borehole. If approved by the Base Civil Engineer, uncontaminated cuttings may be spread over the general area in the vicinity of the well or borehole or shall be trucked to more suitable areas for disposal. Containerize and store cuttings suspected to be hazardous in accordance with paragraph I.1.4.4.2.

REF 68X (pn) 68X

AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT

1. PAGE 1 OF 11

2. PROC INSTRUMENT ID NO. (PIIN)	3. SPIIN	4. EFFECTIVE DATE	5. REQUISITION/PURCHASE REQUEST PROJECT NO.	6. DOC/DMS RATING
F33615-85-D-4533	001001	89JUN02	FY7624-89-01622	

7. ISSUED BY CODE FQ8419
DEPARTMENT OF THE AIR FORCE
AIR FORCE SYSTEMS COMMAND
AERONAUTICAL SYSTEMS DIV/PMRSC
WRIGHT-PATTERSON AFB, OH 45433-6503
NEGOTIATOR: JUDY S. CRACKEL
PHONE: (513) 255-3042

8. ADMINISTERED BY (IF OTHER THAN BLOCK 7) CODE S2101A
DCASMA BALTIMORE
200 TOWSONTOWN BLVD., WEST
TOWSON MD 21204-5299

9. CONTRACTOR NAME AND ADDRESS CODE 3J487 FACILITY CODE
IF "9" FOR MULTIPLE FACILITIES SEE SECT "K"
THE EARTH TECHNOLOGY CORPORATION
300 N. WASHINGTON STREET
SUITE 404
ALEXANDRIA VA 22314-2530

PHONE: (703) 549-8728
COUNTY: NONE

10. SECURITY CLAS U

11. DISCOUNT FOR PROMPT PAYMENT
1ST % DAYS NET DAYS
2ND % DAYS OTHER IF "9" SEE SECT "E"
3RD % DAYS

12. PURCHASE OFFICE POINT OF CONTACT
LSD/L05/LSD

13. THIS BLOCK APPLIES ONLY TO AMENDMENTS OF SOLICITATIONS

☐ The above numbered solicitation is amended as set forth in block 17. The hour and date specified for receipt of Offers ☐ is extended ☐ is not extended

Offers must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation, or as amended by one of the following methods:

(a) By signing and returning ______ copies of this amendment, (b) By acknowledging receipt of this amendment on each copy of the offer submitted, or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGEMENT TO BE RECEIVED AT THE ISSUING OFFICE PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter provided such telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

14. THIS BLOCK APPLIES ONLY TO MODIFICATIONS OF CONTRACTS

☐ THIS CHANGE IS ISSUED PURSUANT TO ______ THE CHANGES SET FORTH HEREIN ARE MADE TO THE ABOVE NUMBERED CONTRACT/ORDER.

☐ THE ABOVE NUMBERED CONTRACT IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES (SUCH AS CHANGES IN PAYING OFFICE, APPROPRIATION DATA, ETC.) SET FORTH HEREIN.

☐ THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF ______ IT MODIFIES THE ABOVE NUMBERED CONTRACT AS SET FORTH HEREIN.

☒ THIS MODIFICATION IS ISSUED PURSUANT TO "ORDERING" CLAUSE OF THE CONTRACT CLAUSES

15. CONTRACT ADMINISTRATION DATA

A. KIND OF MOD	B. MOD ABST RECIPIENT ADP PT	C. DATE OF SIGNATURE MODIFICATION	D. CHANGE IN CONTRACT AMOUNT INCREASE (+) DECREASE (-)	E. LOSING PO/CAO ON TRANSFER	F. GAINING PO/CAO ON TRANSFER	G. SVC/AGENCY USE
B			$ 149,843.00+			

16. ENTER ANY APPLICABLE CHANGES

A. PAY CODE	B. EFFECTIVE DATE OF AWARD	C. CONTRACT (1) TYPE (2) KIND	D. TYPE CONTR	E. SURV CRIT	F. SPL CONTR PROVISIONS	G. PAYING OFC CODE	H. DATE SIGNED	I. SECURITY (1) CLAS (2) DATE OF DD 254

17. REMARKS (Except as provided herein, all items and conditions of the contract, as heretofore changed, remain unchanged and in full force and effect.)

SUBJECT: REVISED TASK DESCRIPTION, ADD'L TIME, WORK & FUNDS WITHIN SCOPE OF BASIC ORDER
PROJECT ENGINEER: EMILE BALADI, USAFOEHL/TS, BROOKS AFB TX 78235-5501
FINANCE OFFICE: (S3910A) DCASR PHILADELPHIA, P.O. BOX 7730, PHILADELPHIA PA 19101-7478

18. ☒ CONTRACTOR/OFFEROR IS NOT REQUIRED TO SIGN THIS DOCUMENT ☐ CONTRACTOR/OFFEROR IS REQUIRED TO SIGN THIS DOCUMENT AND RETURN ______ COPIES TO ISSUING OFFICE

19. CONTRACTOR/OFFEROR (Signature of person authorized to sign)
BY

22. UNITED STATES OF AMERICA (Signature of Contracting Officer)
BY [signature]

20. NAME AND TITLE OF SIGNER (Type or print)

21. DATE SIGNED

23. NAME OF CONTRACTING OFFICER (Type or print)
JOHN M. LIPKER

24. DATE SIGNED
89 JUN 21

AFSC FORM 702 AUG 84 PREVIOUS EDITION WILL BE USED.

SCHEDULE OF CHANGES

FIRST: AFSC Form 700, Block 20, is amended by changing the dollar amount to read $2,097,061.00, an increase of $149,843.00.

SECOND: The Task Description, dated 7 Dec 88, is amended as shown on pages 3 through 9 herein.

THIRD: AFSC Form 706 (70H) is amended as shown on page 10 herein.

FOURTH: AFSC Form 703 (69K), Accounting Classification Data, is amended as shown on page 11 herein.

FIFTH: Contractor letters, dated 89 [illegible] and 89 Jun 15, are incorporated herein by reference.

SIXTH: This order further incorporates [illegible] reference ASD/PMRSC letters of authorization dated [illegible] Jun 12 & 89Jun16 and designated order no. F33615-[illegible]533/001001. Any costs incurred or payments [illegible] under the provision of the instrument referenced will be considered to have been made under this instrument.

SCHEDULE OF CHANGES

CONTRACT NUMBER: F33615-85-D-4533

DELIVERY ORDER NUMBER: 10

LOCATION: MCGUIRE AFB, NJ - RI/FS ,EIS STAGE 2 IRP

CONTRACTOR: EARTH TECHNOLOGY CORPORATION

MODIFICATION NUMBER: 01

DATE OF MODIFICATION: 16 MAY 89

Pen and Ink Changes follow:

PARAGRAPH	CHANGE
SECTION I	DESCRIPTION OF WORK
1.2.4.1	Replace the first two sentences with the following: Temporarily remove the concertina wire or erect a temporary bridge over it for Bldg. 204 access. Assure the wire barrier is replaced prior to demobilization in a manner acceptable to the base POC. Next,establish a seven foot security fence boundary for a maximum of 2500 feet of new fence around the work area. Utilize to the maximum extent practicable the existing fence and repair as necessary . Within this fenced area a temporary Radiological Control Area (RCA) shall be established by the on-site health physicist as soon as possible after site mobilization.
1.2.4.3	Add new paragraph: Subcontractors preforming the above site preparation work shall have the proper safety equipment and have attended the 40 hour OSHA certification required by 29 CFR 1910-120.
1.2.4.6	Replace paragraph with the following paragraph: **Field Instrument Sensitivity.** Prior to implementing the field work, the contractor shall determine the optimum model and geometry of the detection equipment. The equipment shall monitor at a minimum 17 keV to 1,500 keV spectrum of radioactivity with special attention to recognizing the 17 keV PU-239 x-rays,the 60 keV AM-241 x-rays, and the 90 keV x-rays from background radiation. Bench scale testing of the equipment on AM-241 is required to determine the optimum support height and

respective counting time for the different medias expected to be encountered in the field for accuracy ,reliability and overall sensitivity. The instrument sensitivity must be capable of meeting the EPA draft screening level of 0.2 micro curies per square meter with at least 95% confidence.

1.2.5 Replace paragraph with the following paragraph:

Identification and Location of Radiological Waste from the 1960 Fire. Based on the literature search data the contractor shall determine the possible location of radiological materials which were removed from the Launch Shelter 204 shortly after the fire. This debris consists of the launcher, associated support hardware, electrical hardware, possible containerized earth from drainage ditch dam, and strippable paint used to fix the contamination in place. Use magnetometry to survey the adjacent government property and then pin-point the site with a ground penetrating radar device. A maximum of ten (10) days are authorized for the search. Survey and mark the location with permanent survey monuments. Show the location on the project map.

1.2.6.2 Replace paragraph with the following title:

SOIL BORINGS FOR:

1.2.6.2a Add new paragraph:

Radiological Sampling. Drill 30 borings at the site for a maximum of 200 linear feet. Drill all borings using hollow-stem auger techniques. Obtain split spoon samples for field radioanalysis. Select a maximum of three samples per boring to be analyzed for PU-239 by laboratory alpha spectroscopy. See Annex A for location, analytical methods and maximum number of analyses.

1.2.6.2b Add new paragraph:

Chemical Sampling. Drive 4 borings on centerline of the drainage ditch for a maximum of 20 linear feet. Obtain split spoon samples with California Brass ring liners inside for chemical analysis. A sample shall be taken at the following locations along the drainage ditch: entry from concrete apron, upstream of old earthen dam location, midway from entry and dam, and at outlet depression on west side of Highway 539. For each sample collect the volatile organics portion between twelve and eighteen inches from the surface, and the remaining sample portions between six to twelve inches from the surface. Use the most recent EPA Contract Laboratory Program statement of work protocals to prefer the following analyses:

1) TCL Volatile Organic Compounds plus library search to determine the ten(10) nonsurrogate organic compounds of greatest concentration which are not listed on the TCL.
2) TCL Semivolatile Organic Compounds plus library search to determine the twenty (20) nonsurrogate organic compounds of greatest concentration which are not listed on the TCL.
3) Pesticides and PCBs.

Analyses must be preformed in a laboratory currently particpating in the EPA Contract Laboratory Program (CLP) for organics and state certified in New Jersey. The laboratory must adhere to all CLP holding times and QA/QC requirements. A complete CLP data package is required for each sample submitted. See Annex A for maximum number of analyses.

1.2.6.3 Replace paragraph with the following title:

CONCRETE CORINGS FOR:

1.2.6.3a Add new paragraph:

Radiological Sampling. Drill 6 cores inside Bldg. 204 and 18 cores outside on the apron for a maximum of 50 linear feet. Core concrete and the soil below to collect samples for field radioanalysis.
Select a maximum of three samples per coring to be analyzed for PU-239 by laboratory alpha spectroscopy. See Annex A for location, analytical methods and maximum number of analysis. Concrete core holes shall be filled with the same material as soil borings.

1.2.6.3b Add new paragraph:

Chemical Sampling. Drill 3 cores for a maximum of 9 linear feet in concrete and the soil below to collect samples for chemical analysis. A sample shall be taken at the following locations: within bldg. 204, and remaining on the apron. For each sample collect the sample portions between six to twelve inches from the surface of the soil/concrete interface. Use the most recent EPA Contract Laboratory Program statement of work protocals to prefer the following analyses:

1) TCL Volatile Organic Compounds plus library search to determine the ten(10)

nonsurrogate organic compounds of greatest concentration which are not listed on the TCL.

2) TCL Semivolatile Organic Compounds plus library search to determine the twenty (20) nonsurrogate organic compounds of greatest concentration which are not listed on the TCL.

3) Pesticides and PCBs.

Analyses must be preformed in a laboratory currently particpating in the EPA Contract Laboratory Program (CLP) for organics and state certified in New Jersey. The laboratory must adhere to all CLP holding times and QA/QC requirements. A complete CLP data package is required for each sample submitted. See Annex A for maximum number of analyses.

1.2.6.5 Replace paragraph with the following paragraph:

Air Monitoring. The contractor shall monitor continuously the ambient air during all on-site work which involves distrubing the ambient conditions of the accident site and could result in resuspension of plutonium or Americum into the air. For worker safety realtime air monitoring is required concurrent with air filtration monitoring for quantifying the release of PU-239 during field operations. Air filters shall be counted for gross alpha radioactivity immediately upon completion of work and 15 days later to determine the net alpha activity of plutonium. In case where alpha activity remains above 4.4 disintergrations per minute per cubic meter of air sampled, the filters shall be analyzed in the laboratory for PU-239 activity by alpha spectroscopy. See Annex A for maximum number of samples and analytical methods.

1.2.6.7c Replace paragraph with the following paragraph:

Ground Water Sampling for Radioanalysis. Ground water samples shall be collected from existing monitoring well MW-47,MW-48 and MW-49, plus Pu-1,through 7. Use NJDEP protocols,provided under separate cover,to collect both filtered and unfiltered samples from each well. See Annex A for analytical methods and maximum number of analyses.

1.2.6.7d Add paragraph.

Ground Water Samples for Chemical Analyses. Ground water samples shall be collected from existing monitoring wells Pu-1,Pu-2,Pu-5 and Pu-7. Use the most recent EPA Contract Laboratory Program statement of work protocals to prefer the following analyses:

1) TCL Volatile Organic Compounds plus library search to determine the ten(10) nonsurrogate organic compounds of greatest concentration which are not listed on the TCL.
2) TCL Semivolatile Organic Compounds plus library search to determine the twenty (20) nonsurrogate organic compounds of greatest concentration which are not listed on the TCL.
3) Pesticides and PCBs.

Analyses must be preformed in a laboratory currently particpating in the EPA Contract Laboratory Program (CLP) for organics and state certified in New Jersey. The laboratory must adhere to all CLP holding times and QA/QC requirements. A complete CLP data package is required for each sample submitted. See Annex A for maximum number of analyses.

1.2.6.7e Add paragraph.

Ground Water Samples for New Monitoring Wells. Ground water samples in newly installed wells shall be collected and analyzed as referenced in paragraph 1.2.6.6 above. See Annex A for maximum number of analyses.

1.2.8 Change last sentence to read:

Documentation of the remedial alternative development process, including the decision rationale, shall be provided in Section V of the final report.

1.2.10 Delete fourth sentence and parenthetical statement following bold printed paragraph heading.

1.5.6 Replace paragraph with the following paragraph:

Analytical Data. The contractor shall validate all CLP data. Upon completion of all analyses, tabulate and incorporate all CLP data packages and radioanalysis, cross reference field and lab sample numbers,and include findings and discrepancies of data into an Informal Technical Information Report (ITIR). Forward this report to AFOEHL/TSS within five (5) weeks of completion of all analyses. Use the format provided in the Handbook, Section 8. (Item VI, Paragraph 6.2, sequence 3)

1.7 Change maximum number of meetings from 10 to read 14.

1.11 In last parenthetical statement change sequence 2 to read sequence 4.

SECTION VI DELIVERABLES

6.1 Delete sequence 3 (ITIR-PH I and III) deliverables.

6.1 Change sequence 3, paragraph I.1.2.9 BLK 11 to read 89 NOV 17.

6.1 Change sequence 4, paragraph I.1.4.2 BLK 12 and 13 to read 89 NOV 17 and 90 AUG 01.

6.1 Change sequence 4, paragraph I.1.5.2 BLK 12 and 13 to read 89 NOV 17 and 90 AUG 01 respectively.

6.1 Change sequence 4, paragraph I.5.4 BLK 12 and 13 to read paragraph I.1.5.4 89 NOV 17 and 90 AUG 01 respectively.

6.1 Change sequence 17, paragraph I.1.5.3 BLK 11 and BLK 12 to read 90 AUG 31 and 90 SEP 29 respectively.

6.1 Change sequence 3, paragraph I.1.5.5 BLK 11 and BLK 12 to read 90 AUG 31 and 90 SEP 29 respectively.

6.1 Change sequence 4, paragraph I.1.4.1 BLK 12 and 13 to read 89 NOV 17 and 90 AUG 01.

6.2 Change ******* to read:

Upon completion of analysis but not later than 5 weeks after all analysis have been completed. Furnish a complete CLP data package for each chemical analysis to AFOEHL/TSS with the ITIR.

ANNEX A SUMMARY OF FIELD ACTIVITIES

B. SOIL BORINGS Change maximum number of analyses/activity column to read:

1&2 a)30 borings for radiological sampling for a total of 200 linear feet.
b)4 borings for chemical sampling for a total of 20 linear feet.

3 a) 6 concrete cores for radiological sampling inside Bldg. 204 and 18 cores total outside on the concrete apron for a total of 50 linear feet.

b) 3 concrete cores for chemical sampling; one inside Bldg. 204 and the remainder on the apron for a total of 9 linear feet.

C.SOIL BORING SAMPLING...	ADD respectively to objective, standard and maximum number of analyses columns the following: 3. Volatile and Semivolatile organic compounds and pesticides and PCBs. 3. EPA Target Compound Lists(TCL) plus 30 NBS library search for most prominent non-listed compounds by CLP certified laboratory. 3. 11 analyses total.
F.WATER SAMPLING	ADD respectively to objective, standard and maximum number of analyses columns the following: 6. Volatile and Semivolatile organic compounds and pesticides and PCBs. 6. EPA Target Compound Lists(TCL) plus 30 NBS library search for most prominent non-listed compounds by CLP certified laboratory. 6. 10 analyses total.
G.AIR MONITORING	ADD to beginning of standard column paragraph the following phrase: In addition to realtime air monitoring,
H.GROUND ...RADAR	Change type work column to read "MAGNETOMETRY AND GROUND PENETRATING RADAR"

PART I SECTION F OF THE SCHEDULE SUPPLIES SCHEDULE DATA

1. PROC INSTRUMENT ID NO. (PIIN)	2. SPIIN	3. PAGE
F33615-85-D-4533	0010011	10 OF 11

4. ITEM NO.	5. ACRN	6. TSP PRI	7. MILSTRIP DOC NO. AND SUFFIX	8. CON ITEM SERIAL NO.	9. ENDING SERIAL NO. (WHEN APPL)	10. CLIN IDENT EXHIBIT
0001	AA					

11. DEL SCHED DATE	12. ENDING DATE (WHEN APPL)	13. DEL SCHEDULE QTY*	14. SCTY CLAS	15. SHIP TO	16. MARK FOR
A. 90DEC29	A.	A. 1	U	FY7624	
B.	B.	B.			
C.	C.	C.			

11. DEL SCHED DATE	12. ENDING DATE (WHEN APPL)	13. DEL SCHEDULE QTY*
D.	D.	D.
E.	E.	E.

17. DESCRIPTIVE DATA

SEE SECTION H OF THE BASIC CONTRACT FOR FY7624 ADDRESS. TECHNICAL EFFORT SHALL BE COMPLETED NO LATER THAN 90 AUG 31.

ALL DATA SHALL BE DELIVERED IAW ATTACHMENT #1 OF THE BASIC CONTRACT AS IMPLEMENTED BY PARAGRAPH VI OF THE TASK DESCRIPTION NO LATER THAN 90 SEP 29.

THE DATA SHALL BE ACCEPTED BY THE GOVERNMENT NOT LATER THAN THE DATE SHOWN IN BLOCK 11A.

4. ITEM NO.	5. ACRN	6. TSP PRI	7. MILSTRIP DOC NO. AND SUFFIX	8. CON ITEM SERIAL NO.	9. ENDING SERIAL NO. (WHEN APPL)	10. CLIN IDENT EXHIBIT
0002	AA					

11. DEL SCHED DATE	12. ENDING DATE (WHEN APPL)	13. DEL SCHEDULE QTY*	14. SCTY CLAS	15. SHIP TO	16. MARK FOR
A. 90DEC29	A.	A. 1	U	FY7624	
B.	B.	B.			
C.	C.	C.			

11. DEL SCHED DATE	12. ENDING DATE (WHEN APPL)	13. DEL SCHEDULE QTY*
D.		D.
E.		E.

17. DESCRIPTIVE DATA

SEE SECTION H OF THE BASIC CONTRACT FOR FY7624 ADDRESS. TECHNICAL EFFORT SHALL BE COMPLETED NO LATER THAN 90 AUG 31.

4. ITEM NO.	5. ACRN	6. TSP PRI	7. MILSTRIP DOC NO. AND SUFFIX	8. CON ITEM SERIAL NO.	9. ENDING SERIAL NO. (WHEN APPL)	10. CLIN IDENT EXHIBIT

11. DEL SCHED DATE	12. ENDING DATE (WHEN APPL)	13. DEL SCHEDULE QTY*	14. SCTY CLAS	15. SHIP TO	16. MARK FOR
A.	A.	A.			
B.	B.	B.			
C.	C.	C.			

11. DEL SCHED DATE	12. ENDING DATE (WHEN APPL)	13. DEL SCHEDULE QTY*
D.	D.	E.
E.	E.	E.

17. DESCRIPTIVE DATA

*REPRESENTS A NET INCREASE/DECREASE WHEN NO + OR − APPEARS AFTER THE ITEM NO.
E = ESTIMATED
− (IN QTY) = DECREASE
+ OR − (IN ITEM NO.) = ADDITION OR DELETION

PART I SECTION G OF THE SCHEDULE
ACCOUNTING CLASSIFICATION DATA

1. PROC INSTRUMENT ID NO. (PIIN): F33615-85-D-4533
2. SPIIN: 001001
3. PAGE 11 OF 11

4. APPROPRIATION AND ACCOUNTING DATA
A. SCTY CLAS: U B. ACRN: AA C. APPROPRIATION: 5793400
D. LIMIT SUBHEAD
E. SUPPLEMENTAL ACCTG CLASSIFICATION: 309 65NH 100705 000700 00000 534400 525300
F. CPN RECIPIENT DODAAD: F25300
G. OBLIGATION AMOUNT*: $149,843.00+
H. NON-CLIN/CLIN
I. PR/MIPR DATA: FY7624-89-01622+ (PR COMPLETE)
J. PAYING OFC CODE
K. DESCRIPTIVE DATA

AF FORM 616, HSA 89-506, ORIGINAL, DTD 89 MAY 17, EXPIRES 89 SEP 30

4. APPROPRIATION AND ACCOUNTING DATA
A. SCTY CLAS B. ACRN C. APPROPRIATION D. LIMIT SUBHEAD E. SUPPLEMENTAL ACCTG CLASSIFICATION
F. CPN RECIPIENT DODAAD G. OBLIGATION AMOUNT* $ H. NON-CLIN/CLIN I. PR/MIPR DATA J. PAYING OFC CODE
K. DESCRIPTIVE DATA

4. APPROPRIATION AND ACCOUNTING DATA
A. SCTY CLAS B. ACRN C. APPROPRIATION D. LIMIT SUBHEAD E. SUPPLEMENTAL ACCTG CLASSIFICATION
F. CPN RECIPIENT DODAAD G. OBLIGATION AMOUNT* $ H. NON-CLIN/CLIN I. PR/MIPR DATA J. PAYING OFC CODE
K. DESCRIPTIVE DATA

4. APPROPRIATION AND ACCOUNTING DATA
A. SCTY CLAS B. ACRN C. APPROPRIATION SUPPLEMENTAL ACCTG CLASSIFICATION
F. CPN RECIPIENT DODAAD G. OBLIGATION AMOUNT* $ H. NON-CLIN/CLIN I. PR/MIPR DATA J. PAYING OFC CODE
K. DESCRIPTIVE DATA

4. APPROPRIATION AND ACCOUNTING DATA
A. SCTY CLAS B. ACRN C. APPROPRIATION D. LIMIT SUBHEAD E. SUPPLEMENTAL ACCTG CLASSIFICATION
F. CPN RECIPIENT DODAAD G. OBLIGATION AMOUNT* $ H. NON-CLIN/CLIN I. PR/MIPR DATA J. PAYING OFC CODE
K. DESCRIPTIVE DATA

*REPRESENTS NET AMOUNT OF INCREASE DECREASE WHEN MODIFYING AN EXISTING ACRN.
+ OR - IN ACRN = ADDITION OR DELETION; - IN $ - DECREASE

NOTE TO CONTRACTOR: Submit invoices to paying office unless otherwise specified in the descriptive data item hereon.

AFSC FORM 703, JAN 80 — PREVIOUS EDITION WILL BE USED.

Phil

REF 68X (SD) 68X

AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT

1. PAGE 1 OF 8

2. PROC INSTRUMENT ID NO. (PIIN)	3. SPIIN	4. EFFECTIVE DATE	5. REQUISITION/PURCHASE REQUEST PROJECT NO.	6. DOC/DMS RATING
F33615-85-D-4533	001002	MAIL DATE	FY7624-89-01637	

7. ISSUED BY CODE FQ8419
DEPARTMENT OF THE AIR FORCE
AIR FORCE SYSTEMS COMMAND
AERONAUTICAL SYSTEMS DIV/PMRSA
WRIGHT-PATTERSON AFB, OH 45433-6503
NEGOTIATOR: JEFFREY H. MELLOTT
PHONE: (513) 255-3042

8. ADMINISTERED BY (IF OTHER THAN BLOCK 7) CODE S2101A
DCASMA BALTIMORE
200 TOWSONTOWN BLVD., WEST
TOWSON MD 21204-5299

9. CONTRACTOR NAME AND ADDRESS CODE 3J487 FACILITY CODE
IF "9" FOR MULTIPLE FACILITIES SEE SECT "K"

THE EARTH TECHNOLOGY CORPORATION
300 N. WASHINGTON STREET
SUITE 404
ALEXANDRIA VA 22314-2530

PHONE: (703) 549-8728
COUNTY: NONE

MAILING DATE SEP 07 1989
DUPLICATE ORIGINAL

10. SECURITY CLAS U

11. DISCOUNT FOR PROMPT PAYMENT
NET DAYS
1ST % DAYS
OTHER
2ND % DAYS IF "9" SEE SECT "E"
3RD % DAYS

12. PURCHASE OFFICE POINT OF CONTACT
LTA/L67/LTA

13. THIS BLOCK APPLIES ONLY TO AMENDMENTS OF SOLICITATIONS

☐ The above numbered solicitation is amended as set forth in block 17. The hour and date specified for receipt of Offers ☐ is extended ☐ is not extended

Offers must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation, or as amended by one of the following methods:

(a) By signing and returning ______ copies of this amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGEMENT TO BE RECEIVED AT THE ISSUING OFFICE PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter provided such telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

14. THIS BLOCK APPLIES ONLY TO MODIFICATIONS OF CONTRACTS

☐ THIS CHANGE IS ISSUED PURSUANT TO ______ THE CHANGES SET FORTH HEREIN ARE MADE TO THE ABOVE NUMBERED CONTRACT/ORDER.

☐ THE ABOVE NUMBERED CONTRACT IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES (SUCH AS CHANGES IN PAYING OFFICE, APPROPRIATION DATA, ETC.) SET FORTH HEREIN.

☐ THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF ______ IT MODIFIES THE ABOVE NUMBERED CONTRACT AS SET FORTH HEREIN.

☒ THIS MODIFICATION IS ISSUED PURSUANT TO THE "ORDERING" CLAUSE OF THE CONTRACT CLAUSES

15. CONTRACT ADMINISTRATION DATA

a. KIND OF MOD	b. MOD ABST RECIPIENT ADP PT	c. DATE OF SIGNATURE MODIFICATION	d. CHANGE IN CONTRACT AMOUNT INCREASE (+) DECREASE (-)	e. LOSING PO/CAO ON TRANSFER	f. GAINING PO/CAO ON TRANSFER	g. SVC/AGENCY USE
B			$159,317.00+			

16. ENTER ANY APPLICABLE CHANGES

a. PAY CODE	b. EFFECTIVE DATE OF AWARD	c. CONTRACT (1) TYPE (2) KIND	d. TYPE CONTR	e. SURV CRIT	f. SPL CONTR PROVISIONS	g. PAYING OFC CODE	h. DATE SIGNED	i. SECURITY (1) CLAS (2) DATE OF DD 254

17. REMARKS (Except as provided herein, all items and conditions of the contract, as heretofore changed, remain unchanged and in full force and effect.)

SUBJECT: ADDITIONAL TIME/WORK/FUNDS WITHIN SCOPE OF BASIC ORDER
PROJECT ENGINEER: LT COL RANDALL OSTRAAT, HSD/YAQI, BROOKS AFB TX 78235-5501
FINANCE OFFICE: (S3910A) DCASR PHILADELPHIA, P.O. BOX 7730, PHILADELPHIA PA 19101-7478

18. ☒ CONTRACTOR/OFFEROR IS NOT REQUIRED TO SIGN THIS DOCUMENT ☐ CONTRACTOR/OFFEROR IS REQUIRED TO SIGN THIS DOCUMENT AND RETURN ______ COPIES TO ISSUING OFFICE

19. CONTRACTOR/OFFEROR (Signature of person authorized to sign)		22. UNITED STATES OF AMERICA (Signature of Contracting Officer)	
BY		BY *Larry D. Haas*	
20. NAME AND TITLE OF SIGNER (Type or print)	21. DATE SIGNED	23. NAME OF CONTRACTING OFFICER (Type or print)	24. DATE SIGNED
		LARRY D. HAAS	89Aug29

AFSC FORM 702 AUG 84 PREVIOUS EDITION WILL BE USED.

SCHEDULE OF CHANGE

FIRST: Page 1 of the basic order, AFSC Form 700 (55X), block 20 is hereby revised to reflect the increase of the not-to-exceed ceiling amount of $159,317.00, for a revised ceiling amount of $2,256,378.00.

SECOND: The statement of work of the basic order, as amended by 001001, is hereby revised as set forth on pages 3 through 6 herein.

THIRD: Section F, Supplies Schedule Data, AFSC Form 706 (70H), is hereby revised as set forth on page 7 herein.

FOURTH: Section G, Accounting Classification Data, AFSC Form 703 (69K), is hereby revised as set forth on page 8 herein.

FIFTH: All other terms and conditions of the basic order, as amended, remain unchanged.

STATEMENT OF WORK 89 Aug 08

(Revision #2)

PARAGRAPH	CHANGE
SECTION I	**DESCRIPTION OF WORK**
1.2.6.2b	Replace paragraph with following new paragraph:

Chemical Sampling. Drive 4 borings on centerline of the drainage ditch for a maximum of 20 linear feet. Obtain split spoon samples with California Brass ring liners inside for chemical analysis.
A sample shall be taken at the following locations along the drainage ditch: entry from concrete apron, upstream of old earthen dam location, midway from entry and dam, and at outlet depression on west side of Highway 539. For Target Analyte List(TAL) two separate background samples shall be taken: one north of BOMARC site in woods and another besides the county road. For each sample collect the volatile organics portion between twelve and eighteen inches from the surface, and the remaining sample portions between six to twelve inches from the surface. Use the most recent EPA Contract Laboratory Program statement of work protocals to perform the following analyses:

1) TCL Volatile Organic Compounds plus library search to determine the ten(10) nonsurrogate organic compounds of greatest concentration which are not listed on the TCL.
2) TCL Semivolatile Organic Compounds plus library search to determine the twenty (20) nonsurrogate organic compounds of greatest concentration which are not listed on the TCL.
3) Pesticides and PCBs.
4) TAL metals only.

Analyses must be performed in a laboratory currently participating in the EPA Contract Laboratory Program (CLP) for TCL organics and state certified in New Jersey. TAL analysis does not have to be performed in a CLP lab. All laboratory analyses must adhere to CLP holding times and QA/QC requirements. A complete CLP data package is required for each sample submitted. A maximum of 10 percent of the samples will be split with the EPA.
See Annex A for maximum number of analyses.

1.2.6.3a Replace paragraph with following new paragraph:

Radiological Sampling. Drill 6 cores inside Bldg. 204 and 18 cores outside on the apron for a maximum of 50 linear feet. Core concrete and the soil below to collect samples for field radioanalysis.
Select a maximum of three samples per coring to be analyzed for PU-239 by laboratory alpha spectroscopy. See Annex A for location, analytical methods and maximum number of analyses. A maximum of 10 percent of the samples will be split with the EPA.
Concrete core holes shall be filled with the same material as soil borings.

1.2.6.3b Replace paragraph with following new paragraph:

Chemical Sampling. Drill 3 cores for a maximum of 9 linear feet in concrete and the soil below to collec samples for chemical analysis. A sample shall be taken at the following locations: within bldg. 204, and remaining on the apron. For each sample collect the sample portions between six to twelve inches from the surface of the soil/concrete interface. Use the most recent EPA Contract Laboratory Program statement of work protocals to perform the following analyses:

1) TCL Volatile Organic Compounds plus library search to determine the ten(10) nonsurrogate organic compounds of greatest concentration which are not listed on the TCL.
2) TCL Semivolatile Organic Compounds plus library search to determine the twenty (20) nonsurrogate organic compounds of greatest concentration which are not listed on the TCL.
3) Pesticides and PCBs.
4) TAL metals only.

Analyses must be performed in a laboratory currently participating in the EPA Contract Laboratory Program (CLP) for organics and state certified in New Jersey. TAL analysis does not have tc be performed in a CLP lab. All laboratory analyses must adhere to CLP holding times and QA/QC requirements. A complete CLP data package is required for each sample submitted. A maximum of 10 percent of the samples will be split with the EPA. See Annex A for maximum number of analyses.

1.2.6.7c Replace paragraph with the following paragraph:

Ground Water Sampling for Radioanalysis. Ground water samples shall be collected from existing monitoring well MW-47,MW-48 and MW-49, plus Pu-1,through 7. Use NJDEP protocols,provided under separate cover,to collect both filtered and unfiltered samples from each well. The EPA will take split samples at the same time. See Annex A for analytical methods and maximum number of analyses.

1.2.6.7d Replace paragraph with the following paragraph:

Ground Water Samples for Chemical Analyses. Ground water samples shall be collected from existing monitoring wells Pu-1,Pu-2,Pu-5 and Pu-7. The EPA will take split samples at the same time. Use the most recent EPA Contract Laboratory Program statement of work protocals to perform the following analyses:

1) TCL Volatile Organic Compounds plus library search to determine the ten(10) nonsurrogate organic compounds of greatest concentration which are not listed on the TCL.
2) TCL Semivolatile Organic Compounds plus library search to determine the twenty (20) nonsurrogate organic compounds of greatest concentration which are not listed on the TCL.
3) Pesticides and PCBs.
4) TAL metals only.

Analyses must be performed in a laboratory currently participating in the EPA Contract Laboratory Program (CLP) for organics and state certified in New Jersey. TAL analysis does not have to be performed in a CLP lab. All laboratory analyses must adherè to CLP holding times and QA/QC requirements. A complete CLP data package is required for each sample submitted. See Annex A for maximum number of analyses.

SECTION VI DELIVERABLES

6.1 Change sequence 3, paragraph I.1.2.9 BLK 11 to read 90 JAN 17.

6.1 Change sequence 4, paragraph I.1.4.2 BLK 12 and 13 to read 90 JAN 17 and 90 OCT 01 respectively.

6.1 Change sequence 4, paragraph I.1.5.2 BLK 12 and 13 to read 90 JAN 17 and 90 OCT 01 respectively.

6.1 Change sequence 4, paragraph I.1.5.4 BLK 12 and 13 to read, 90 FEB 17 and 90 NOV 01 respectively.

6.1 Change sequence 17, paragraph I.1.5.3 BLK 11 and BLK 12 to read 90 DEC 27 and 90 DEC 29 respectively.

6.1 Change sequence 3, paragraph I.1.5.5 BLK 11 and BLK 12 to read 90 OCT 31 and 90 NOV 29 respectively.

6.1 Change sequence 4, paragraph I.1.4.1 BLK 12 and 13 to read 90 JAN 17 and 90 OCT 29 respectively.

ANNEX A SUMMARY OF FIELD ACTIVITIES

B. SOIL BORINGS Change maximum number of analyses/activity column to read:

1&2 b)7 borings for chemical sampling for a total of 30 linear feet.

C.SOIL BORING SAMPLING... Replace respectively to objective, standard and maximum number of analyses columns the following:

3. Volatile and Semivolatile organic compounds, inorganic metals, pesticides and PCBs.

3. EPA Target Compound Lists(TCL) plus 30 NBS library search for most prominent non-listed compounds by CLP laboratory and TAL metals.

3. 11 TCL and 13 TAL analyses total.

C.SOIL BORING SAMPLING... Change maximum number of analyses column to the following:

2. 275 analysis total.

F.WATER SAMPLING Replace respectively to objective, standard and maximum number of analyses columns the following:

6. Volatile and Semivolatile organic compounds, inorganic metals, pesticides and PCBs.

6. EPA Target Compound Lists(TCL) plus 30 NBS library search for most prominent non-listed compounds by CLP laboratory and TAL metals.

6. 10 TCL and TAL analyses total.

PART I SECTION F OF THE SCHEDULE
SUPPLIES SCHEDULE DATA

1. PROC INSTRUMENT ID NO. (PIIN): F33615-85-D-4533
2. SPIIN: 001002
3. PAGE 7 OF 8

4. ITEM NO. 0001 — 5. ACRN AA — 6. TSP PRI — 7. MILSTRIP DOC NO. AND SUFFIX — 8. CON ITEM SERIAL NO. — 9. ENDING SERIAL NO. (WHEN APPL) — 10. CLIN IDENT EXHIBIT

11. DEL SCHED DATE A. 91APR30 — 12. ENDING DATE (WHEN APPL) A. — 13. DEL SCHEDULE QTY* A. 1 — 14. SCTY CLAS U — 15. SHIP TO FY7624 — 16. MARK FOR

B. B. B. D. D. D.
C. C. C. E. E. E.

17. DESCRIPTIVE DATA

SEE SECTION H OF THE BASIC CONTRACT FOR FY7624 ADDRESS. TECHNICAL EFFORT SHALL BE COMPLETED NO LATER THAN 90 OCT 31.

ALL DATA SHALL BE DELIVERED IAW ATTACHMENT #1 OF THE BASIC CONTRACT AS IMPLEMENTED BY PARAGRAPH VI OF THE TASK DESCRIPTION NO LATER THAN 90 DEC 29.

THE DATA SHALL BE ACCEPTED BY THE GOVERNMENT NOT LATER THAN THE DATE SHOWN IN BLOCK 11A.

4. ITEM NO. 0002 — 5. ACRN AA — 6. TSP PRI — 7. MILSTRIP DOC NO. AND SUFFIX — 8. CON ITEM SERIAL NO. — 9. ENDING SERIAL NO. (WHEN APPL) — 10. CLIN IDENT EXHIBIT

11. DEL SCHED DATE A. 91APR30 — 12. ENDING DATE (WHEN APPL) A. — 13. DEL SCHEDULE QTY* A. 1 — 14. SCTY CLAS U — 15. SHIP TO FY7624 — 16. MARK FOR

B. B. B. D. D. D.
C. C. C. E. E. E.

17. DESCRIPTIVE DATA

SEE SECTION H OF THE BASIC CONTRACT FOR FY7624 ADDRESS. TECHNICAL EFFORT SHALL BE COMPLETED NO LATER THAN 90 OCT 31.

4. ITEM NO. — 5. ACRN — 6. TSP PRI — 7. MILSTRIP DOC NO. AND SUFFIX — 8. CON ITEM SERIAL NO. — 9. ENDING SERIAL NO. (WHEN APPL) — 10. CLIN IDENT EXHIBIT

11. DEL SCHED DATE A. — 12. ENDING DATE (WHEN APPL) A. — 13. DEL SCHEDULE QTY* A. — 14. SCTY CLAS — 15. SHIP TO — 16. MARK FOR

B. B. B. D. D. E.
C. C. C. E. E. E.

17. DESCRIPTIVE DATA

*REPRESENTS A NET INCREASE/DECREASE WHEN NO + OR − APPEARS AFTER THE ITEM NO.
E = ESTIMATED
− (IN QTY) = DECREASE
+ OR − (IN ITEM NO.) = ADDITION OR DELETION

PART I SECTION G OF THE SCHEDULE
ACCOUNTING CLASSIFICATION DATA

1. PROC INSTRUMENT ID NO. (PIIN): F33615-85-D-4533
2. SPIIN: 001002
3. PAGE 8 OF 8

4. APPROPRIATION AND ACCOUNTING DATA
A. ACTY CLAS: U B. ACRN: AA C. APPROPRIATION: 5793400
D. LIMIT SUBHEAD:
E. SUPPLEMENTAL ACCTG CLASSIFICATION: 309 65NH 100705 000700 00000 534400 525300
F. CPN RECIPIENT DODAAD: F25300
G. OBLIGATION AMOUNT*: $159,317.00+
H. NON-CLIN/ELIN:
I. PR/MIPR DATA: FY7624-89-01637+ (PR COMPLETE)
8. PAYING OFC CODE:
9. DESCRIPTIVE DATA

AF FORM 616, HSA-752, DTD 89 JUL 27, EXPIRES 89 SEP 30.

4. APPROPRIATION AND ACCOUNTING DATA
A. ACTY CLAS B. ACRN C. APPROPRIATION D. LIMIT SUBHEAD E. SUPPLEMENTAL ACCTG CLASSIFICATION
F. CPN RECIPIENT DODAAD G. OBLIGATION AMOUNT* $ H. NON-CLIN/ELIN I. PR/MIPR DATA 8. PAYING OFC CODE
9. DESCRIPTIVE DATA

4. APPROPRIATION AND ACCOUNTING DATA
A. ACTY CLAS B. ACRN C. APPROPRIATION D. LIMIT SUBHEAD E. SUPPLEMENTAL ACCTG CLASSIFICATION
F. CPN RECIPIENT DODAAD G. OBLIGATION AMOUNT* $ H. NON-CLIN/ELIN I. PR/MIPR DATA 8. PAYING OFC CODE
9. DESCRIPTIVE DATA

4. APPROPRIATION AND ACCOUNTING DATA
A. ACTY CLAS B. ACRN C. APPROPRIATION D. LIMIT SUBHEAD E. SUPPLEMENTAL ACCTG CLASSIFICATION
F. CPN RECIPIENT DODAAD G. OBLIGATION AMOUNT* $ H. NON-CLIN/ELIN I. PR/MIPR DATA 8. PAYING OFC CODE
9. DESCRIPTIVE DATA

4. APPROPRIATION AND ACCOUNTING DATA
A. ACTY CLAS B. ACRN C. APPROPRIATION D. LIMIT SUBHEAD E. SUPPLEMENTAL ACCTG CLASSIFICATION
F. CPN RECIPIENT DODAAD G. OBLIGATION AMOUNT* $ H. NON-CLIN/ELIN I. PR/MIPR DATA 8. PAYING OFC CODE
9. DESCRIPTIVE DATA

*REPRESENTS NET AMOUNT OF INCREASE DECREASE WHEN MODIFYING AN EXISTING ACRN.
+ OR IN ACRN = ADDITION OR DELETION IN $ - DECREASE

NOTE TO CONTRACTOR: Submit invoices to paying office unless otherwise specified in the descriptive data item hereon.

RE68X (nl)

Phil, Pls check the changes
SL 68X

AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT

1. PAGE 1 OF 4

2. PROC INSTRUMENT ID NO. (PIIN): F33615-85-D-4533
3. SPIIN: 001003
4. EFFECTIVE DATE: MAIL DATE
5. REQUISITION/PURCHASE REQUEST PROJECT NO.: FY7624-90-15810
6. DOC/DMS RATING:

7. ISSUED BY CODE F08419
DEPARTMENT OF THE AIR FORCE
AIR FORCE SYSTEMS COMMAND
AERONAUTICAL SYSTEMS DIV/PKRSA
WRIGHT-PATTERSON AFB, OH 45433-6503
NEGOTIATOR: MARTY MCKALIP
PHONE: (513) 255-5633

8. ADMINISTERED BY (IF OTHER THAN BLOCK 7) CODE S2101A
DCASMA BALTIMORE
200 TOWSONTOWN BLVD., WEST
TOWSON, MD 21204-5299

9. CONTRACTOR NAME AND ADDRESS CODE 3J487 FACILITY CODE
THE EARTH TECHNOLOGY CORPORATION
300 N. WASHINGTON STREET
SUITE 404
ALEXANDRIA, VA 22314-2530

COUNTY: NONE
PHONE: (703) 549-8728

MAILING DATE
AUG 08 1990
DUPLICATE ORIGINAL

10. SECURITY CLAS U

11. DISCOUNT FOR PROMPT PAYMENT
NET DAYS
1ST % DAYS
OTHER
2ND % DAYS IF "9" SEE SECT "E"
3RD % DAYS

12. PURCHASE OFFICE POINT OF CONTACT: LTX/L66/LTX

13. THIS BLOCK APPLIES ONLY TO AMENDMENTS OF SOLICITATIONS

☐ The above numbered solicitation is amended as set forth in block 17. The hour and date specified for receipt of Offers ☐ is extended ☐ is not extended.

Offers must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation, or as amended by one of the following methods:

(a) By signing and returning ______ copies of this amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGMENT TO BE RECEIVED AT THE ISSUING OFFICE PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter provided each telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

14. THIS BLOCK APPLIES ONLY TO MODIFICATIONS OF CONTRACTS

☐ THIS CHANGE IS ISSUED PURSUANT TO ______ THE CHANGES SET FORTH HEREIN ARE MADE TO THE ABOVE NUMBERED CONTRACT/ORDER.

☐ THE ABOVE NUMBERED CONTRACT IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES (SUCH AS CHANGES IN PAYING OFFICE, APPROPRIATION DATA, ETC.) SET FORTH HEREIN.

☐ THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF ______ IT MODIFIES THE ABOVE NUMBERED CONTRACT AS SET FORTH HEREIN.

X THIS MODIFICATION IS ISSUED PURSUANT TO THE "CHANGES" CLAUSE OF THE CONTRACT CLAUSES

15. CONTRACT ADMINISTRATION DATA

A. KIND OF MOD	B. MOD ABST RECIPIENT ADD PT	C. DATE OF SIGNATURE MODIFICATION	D. CHANGE IN CONTRACT AMOUNT INCREASE (+) DECREASE (-)	E. LOSING PO/CAO ON TRANSFER	F. GAINING PO/CAO ON TRANSFER	G. SVC/AGENCY USE
B			$			

16. ENTER ANY APPLICABLE CHANGES

A. PAY CODE	B. EFFECTIVE DATE OF AWARD	C. CONTRACT (1) TYPE (2) KIND	D. TYPE CONTR	E. SURV CRIT	F. SPL CONTR PROVISIONS	G. PAYING OFC CODE	H. DATE SIGNED	I. SECURITY (1) CLAS (2) DATE OF DD 254
			B					

17. REMARKS (Except as provided herein, all items and conditions of the contract, as heretofore changed, remain unchanged and in full force and effect)

SUBJECT: REVISED TASK DESCRIPTION
PROJECT ENGINEER: LT COL OSTRAAT, HSD/YAQI, BROOKS AFB TX 78235-5501
FINANCE OFFICE: (S3910A) DCASR PHILADELPHIA, P.O. BOX 7730,
PHILADELPHIA, PA 19101-7478

18. X CONTRACTOR/OFFEROR IS NOT REQUIRED TO SIGN THIS DOCUMENT ☐ CONTRACTOR/OFFEROR IS REQUIRED TO SIGN THIS DOCUMENT AND RETURN ______ COPIES TO ISSUING OFFICE

19. CONTRACTOR/OFFEROR (Signature of person authorized to sign)
BY

22. UNITED STATES OF AMERICA (Signature of Contracting Officer)
BY [signature]

20. NAME AND TITLE OF SIGNER (Type or print)

21. DATE SIGNED

23. NAME OF CONTRACTING OFFICER (Type or print): RICHARD E. STEM

24. DATE SIGNED: 90 Aug 06

AFSC FORM 702 AUG 84 PREVIOUS EDITION WILL BE USED. *U.S. GPO: 1989-748-170/80044

90 Jun 15

Statement of Work

(Revision #3)

PARAGRAPH	CHANGE
SECTION I	DESCRIPTION OF WORK
1.3.6	Delete paragraph in its entirety.
1.3.7	Delete paragraph in its entirety.
1.3.8	Delete paragraph in its entirety.
1.4	Delete subsection in its entirety and replace with RESERVED. (This subsection includes 1.4.1 and 1.4.2)
1.5.1	Delete paragraph in its entirety.
1.5.2	Replace paragraph bold title with RI/FS DRAFT FINAL REPORT.
1.5.2.1	Replace paragraph with the following new paragraph:
	RI/FS Draft Final Report Format. Strictly adhere to the Handbook section 3 for preparation of RI/FS report.
1.5.3	Delete paragraph in its entirety.
1.5.4	Delete last sentence of paragraph.

SCHEDULE OF CHANGES

FIRST: The Statement of Work for the subject delivery order, dated 88 Dec 07 and amended by Revisions 1 and 2, is revised as shown on pages 3 and 4 herein.

SECOND: This modification will result in no increase or decrease in the not-to-exceed delivery order ceiling price.

THIRD: The contractor's letter dated 90 Jul 18, indicating concurrence with this action, is hereby incorporated by reference and made a part hereof.

FOURTH: All references to "ASD/PMRSA" are amended to read "ASD/PKRSA".

FIFTH: This modification constitutes full settlement of any claims of the contractor under the contract, including the clause entitled "Changes", arising out of or by reason of the changes effected hereby.

SECTION V GOVERNMENT POINTS OF CONTACT:

5.1 Change to read as follows:

HQ HSD
Contracting Officer's Technical Representative
Major John M. Clegg, Jr, (PE)
HQ HSD/YAQ
Brooks AFB, TX 78235 - 5501
(512) 536-9001
1-800-821-4528

5.2 Change to POC name to read as follows:

Mr Robert Panebianco

5.3 Change to POC name to read as follows:

Mr Mark Stafford

SECTION VI DELIVERABLES

6.1 Change sequence 3, paragraph I.1.2.9, Block 12 to read 90 Aug 31.

6.1 Delete sequence 9, paragraph I.1.3.6 all Blocks

6.1 Delete both sequence 3's, paragraph I.1.3.6 all Blocks

6.1 Delete sequence 4, paragraph I.1.4.1 all Blocks

6.1 Delete sequence 4, paragraph I.1.4.2 all Blocks

6.1 Change sequence 4, paragraph I.1.5.2 BLK 12 and 13 to read 90 Nov 01.

6.1 Change sequence 4, paragraph I.1.5.4 BLK 12 and 13 to read 90 NOV 01, and Block 14 to read *****.

6.1 Delete sequence 17, paragraph I.1.5.3 all Blocks.

6.1 Change sequence 3, paragraph I.1.5.5 BLK 12 to read 90 Nov 01.

6.1 Change sequence 3, paragraph I.1.5.6 BLK 12 to read 90 Jul 16.

6.2 Delete note ****** in its entirety.

6.2 Delete note ******* in its entirety.

6.2 Change note ***** to read as follows:

Prepare draft final reports in 15 copies plus a camera ready copy. Distribute copies as follows to Government Points of Contact in Section V:
HQ HSD/YAQ - 2 copies
HQ MAC/DEEV - 12 copies
438 ABG/DEV - 1 copy

REF 55X

55X

ORDER FOR SUPPLIES OR SERVICES

dmt/0026u

PAGE 1 OF

2. PROC. INSTRUMENT ID NO. (PIIN)	F33615-90-D-4007
3. CALL/ORDER NO.	0005
4. DATE OF ORDER*	29NOV 1990
5. REQUISITION/PURCHASE REQUEST PROJECT NO.	FY7624-91-15712
6. CERTIFIED FOR NATIONAL DEFENSE UNDER DOC REG 2/DMS REG 1 RATING	DO-C9

Mark all packages & papers with this number.

7. ISSUED BY CODE FQ2826

DEPARTMENT OF THE AIR FORCE
AIR FORCE SYSTEMS COMMAND
HUMAN SYSTEMS DIVISION/PK
BROOKS AFB TX 78235-5320

BUYER: J. LANGENDERFER, HSD/PKR
(512) 536-2158

8. ADMINISTERED BY CODE S2101A

DCAMO, Baltimore
300 East Joppa Road
Hampton Plaza Bldg. - Room 200,
Towson, MD 21204-3099

PAS: None

9. CONTRACTOR NAME AND ADDRESS CODE 3J487 FACILITY CODE

IF "9" FOR MULTIPLE FACILITIES SEE SECT "G"

The Earth Technology Corporation
300 N. Washington STreet
Suite 700
Alexandria, VA 22314

10. MAIL INVOICES TO

11. DISCOUNT FOR PROMPT PAYMENT

NET DAYS N

1ST ___ % ___ DAYS

OTHER IF "9" SEE SECT "G"

2ND ___ % ___ DAYS

3RD ___ % ___ DAYS

12A. PURCHASE OFFICE POINT OF CONTACT

MRA/MOR/MRA

12B. RESERVED FOR SERVICE/AGENCY USE

13. PAYMENT WILL BE MADE BY CODE S3910A IF "9" SEE SECT "G"

DCMR, Philadelphia
P.O. Box 7730
Philadelphia, PA 19101-7478

14. TYPE CONTRACTOR C

15. SECURITY A. CLAS U B. DATE OF DD 254

16. CONTRACT ADMINISTRATION DATA

A. FAST PAY	B. CONTRACT (1) KIND	(2) TYPE	C. ABSTRACT RECIP ADP POINT	D. SPL CONT PROVISIONS	E. CONT ADMIN FUNC LMT	17. (RESERVED)	18. SVC/AGENCY USE	19. SURV CRIT	20. TOTAL AMOUNT
	1	Y						C	Not-To-Exceed $ 499,377.00

21. APPROPRIATION AND ACCOUNTING DATA

A. CITY	B. AGENCY	C. APPROPRIATION	D. LIMIT SUBHEAD	E. SUPPLEMENTAL ACCOUNTING DATA
0	AA	5713400		301 65MB 244417 070000 53440 000000 528200

F. EPU RECIPIENT DODAAC	G. OBLIGATION AMOUNT	H. NON-CLIN/ELIN PAYMENT PROV	I. SVC AGENCY USE
F28200	499,377.00		FY7624-91-15712*

22A. TYPE OF ORDER

DELIVERY X — B. NON-DOD CONTRACT NO. This delivery order is subject to instructions contained on this side of form only and is issued in accordance with and subject to terms and conditions of above numbered contract, or Non-DOD Contract No.

PURCHASE — Reference your ___

Furnish the following on terms specified herein, including, for U.S. purchases, General Provisions of Purchase Order on DD Form 1155r (EXCEPT CLAUSE NO 13 APPLIES ONLY IF THIS BOX IS CHECKED, AND NO. 15 IF THIS BOX ☐ IS CHECKED), special provisions ___ and delivery as indicated. This purchase is negotiated under authority of 10 USC 2304(a)( ) or as specified in the schedule if within the U.S., its possessions or Puerto Rico; if otherwise, under 2304(a)(6).

☐ If checked, Additional General Provisions apply, supplier shall sign "Acceptance" on DD form 1155r and return ___ copies.

*If quantity accepted by the Government is same as quantity ordered, indicated by ✓ mark. If different enter actual quantity accepted below quantity ordered and encircle.

23. UNITED STATES OF AMERICA

Phyllis J Morse 90NOV29 (YYMMDD)

BY: NAME OF CONTRACTING/ORDERING OFFICER AND DATE

24. TOTAL

26. DIFFERENCES

25. QUANTITY ORDERED HAS BEEN

☐ INSPECTED ☐ RECEIVED ☐ ACCEPTED, AND CONFORMS TO THE CONTRACT EXCEPT AS STATED

26. SHIP NO. ☐ PARTIAL ☐ FINAL

27. D.O. VOUCHER NO.

28. INITIALS

DATE SIGNATURE OF AUTHORIZED GOVERNMENT REPRESENTATIVE

31. PAID BY

32. Amount Verified Correct For

30. PAYMENT ☐ COMPLETE ☐ PARTIAL ☐ FINAL

33. CHECK NUMBER

35. I CERTIFY THIS AMOUNT IS CORRECT AND PROPER FOR PAYMENT

SIGNATURE AND TITLE OF CERTIFYING OFFICER

34. BILL OF LADING NO.

36. RECEIVED AT	37. RECEIVED BY	38. DATE RECEIVED	39. TOTAL CONTAINERS	40. S/R ACCOUNT NUMBER	41. S/R VOUCHER NO.

PREVIOUS EDITION IS OBSOLETE.

AFSC FORM AUG 80 700

*When used as a formal contract this will be the effective date.

*Reference AF Form 616, HS-91-034, dated 18 Oct 90

SECTION B - Supplies and Services:

Item No	Supplies/Services		Quantity Purch Unit	Unit Price Total Item Amount
0001	CLIN	sec class: U	1 LO	N N

noun: SAMPLING, ANALYSIS AND DATA
acrn: AA nsn: N
site codes pqa: D acp: D fob: D
pr/mipr data: FY7624-91-15712
item proj mgr: FY7624

descriptive data:
Conduct work in accordance with the Statement of Work (SOW) of this order, dated 90 Oct 22, and Section C, The Description/Specifications of the basic contract. Submit data in accordance with attachment #1, the Contract Data Requirements List of the basic contract as implemented by paragraph VI of this order's SOW, dated 90 Oct 22.

Item No	Supplies/Services		Quantity Purch Unit	Unit Price Total Item Amount
0002	CLIN	sec class: U	1 LO	N N

noun: SUPPORT
acrn: AA nsn: N
site codes pqa: D acp: D fob: D
pr/mipr data: FY7624-91-15712
item proj mgr: FY7624

descriptive data:
Provide support in accordance with the Statement of Work of this order, dated 90 Oct 22, and Section C, The Description/Specifications of the basic contract.

<u>SECTION C - Description/Specifications</u>: See attached Statement of Work entitled "The "Installation Restoration Program Remedial Investigation/Feasibility Study (RI/FS) and Final Environmental Impact Statement (EIS)," for details.

<u>SECTION F - Schedule Data</u>:

Item No	Supplies Schedule Data		Delivery Schedule Quantity	Date
0001	CLIN Del Sch acrn: AA ship to: FY7624	Sec Class: U	1	92MAR31
	descriptive data: See Section H of the basic contract for FY7624 address. Technical effort shall be completed in accordance with the Statement of Work, dated 90 Oct 22 no later than 91 Jun 04. All data shall be delivered in accordance with attachment #1 of the basic contract as implemented by paragraph VI of the Statement of Work dated 90 Oct 22 no later than 91 Nov 15. The data shall be accepted by the government not later than 92 Mar 31.			
0002	CLIN Del Sch acrn: AA ship to: FY7624	Sec Class: U	1	92MAR31
	descriptive data: See Section H of the basic contract for FY7624 address. Technical effort shall be completed in accordance with the Statement of Work, dated 90 Oct 22 no later than 91 Jun 04.			

22 Oct 90

STATEMENT OF WORK (SOW)

THE INSTALLATION RESTORATION PROGRAM
REMEDIAL INVESTIGATION/FEASIBILITY STUDY (RI/FS)
AND FINAL ENVIRONMENTAL IMPACT STATEMENT (EIS)

STAGE 3 FOR

BOMARC MISSILE SITE, McGUIRE AFB, NJ

I. DESCRIPTION OF WORK

1.1 **Scope.** The objective of the Air Force Installation Restoration Program (IRP) is to assess past hazardous waste disposal and spill sites on Air Force installations and develop remedial actions consistent with the National Contingency Plan (NCP) for those sites which pose a threat to human health and welfare or the environment. The intent of this current work effort is to finalize a Remedial Investigation and Feasibility Study (RI/FS) in parallel with conducting an Environmental Impact Analysis Process (EIAP) which produces an Environmental Impact Statement (EIS) on the Air Force's Proposed Actions and Alternatives concerning the radioactive material from the 1960 fire at the BOMARC Missile Site at McGuire AFB, NJ.

1.1.1 **RI/FS Description of Work.**

1.1.1.1 The objective of the RI/FS is to gather environmental data, screen for Applicable or Relevant and Appropriate Requirements (ARARs), determine potential health risks, and analyze remedial alternatives that will result in a decision document for the Air Force and Environmental Regulators. To meet this objective the contractor shall finalize the stage 2 draft reports for the BOMARC Missile Site, McGuire AFB, NJ under contract F33615-85-D-4533/0010. (Herein referred to as the stage 2 report)

1.1.1.2 References. The contractor shall comply with all requirements listed in the USAFOEHL Handbook, Version 2.0, dated April, 1988; the BOMARC Missile Site Stage 2 Work Plan and Quality Quality Assurance Project Plan (QAPP), (Produced under stage 2 effort). All references in this Statement Of Work to the "Handbook" refer to the above version of the USAFOEHL Handbook. The Work Plan and Section 1 of the Handbook lists all documents relevant to supporting this Statement of Work (SOW).

1.1.2 **EIS Description of Work.**

1.1.2.1 The objective of the EIS is to be the decision documentation process that utilizes the results of the scientific analysis preformed in the RI/FS, and to analyze the potential environmental impacts of proposed actions and alternatives. The EIS uses these analyses in making decisions or recommendations on whether and how to proceed with these actions. This process deliberately involves the public, other Federal and State agencies to assure a clear understanding of the potential environmental consequences of proposed actions and alternatives. To meet this objective the contractor shall finalize the stage 2 reports under contract F33615-85-D-

4533/001003 to accomplish the following actions in addition to those actions listed for the RI/FS objectives at the BOMARC Missile Site, McGuire AFB NJ:

a. Identify any significant issues and conflicting concerns

b. Identify biological and archeological / historical impacts

c. Identify potential contaminant pathways

d. Identify reasonable and feasible alternatives or mitigation options; and their significant impacts on the environment and our society

e. Provide support to public and government meetings or hearings

f. Provide EIS documents for public and government agency review to aid in the decision making process

1.1.2.2 References. The contractor shall comply with all requirements listed in Air Force Regulation 19-2, the EIAP process, the Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act (NEPA), the EIS scoping documents, and the BOMARC Missile Site Stage 2 Work Plan. (Provided during stage 2 effort). The Work Plan lists additional documents relevant to supporting this Statement of Work (SOW).

1.2.2 **Public Hearing Support.** The contractor shall provide expert witness(es) testimony, a legal stenographer to take minutes, all technical illustrations and reference documents for the public hearing presentation. A maximum of two hearings will occur for a duration of two days. **(Item VI, Paragraph 6.1, Sequences 3 & 9).**

1.3 **Baseline Risk Assessment.** After a thorough review of all data in the stage 2 report finalize the potential risk to human health and welfare or the environment based on the contaminants identified at the site. The required elements of the baseline risk assessment are provided in the Handbook, Section 3 (Report Format Section IV). Include results of the baseline risk assessment in Section IV of the Final Report and the EIS.

1.4 **Analysis of Alternatives** Finalize the analysis of the alternatives from the stage 2 report. The analysis procedures, decision process, results and conclusions of the detailed analysis shall be included in Section V of the Final Report.

1.5 Environmental Impact Statement Developement.

1.5.1 Based on the outcome of public hearing update the significant issues or concerns in the Final EIS. Utilizing the RI/FS data, rank the potential significance of each issue, and screen the alternatives and potential impacts to meet the requirements of 40 CFR 1500.4.

1.5.2 Identify reasonable and feasible actions / alternatives or mitigating options for the significant issues. Define their significant impacts or consequences on the environment, the base mission and the society.

1.5.3 **Environmental Impact Statement** (EIS). Prepare in both draft and final forms the EIS meeting the requirements of AFR 19-2 and 40 CFR 1502. The maximum use of references shall be utilized, especially the supporting material for the RI/FS report. **(Item VI, Paragraph 6.1, Sequence 4)**

1.6 Reports

1.6.1 **RI/FS Final Report.** Prepare a report finalizing the stage 2 report. Forward the report to HSD/YAQ for Air Force and regulatory agency review **(Item VI, Paragraph 6.1, Sequence 4).**

1.6.1.1 **RI/FS Draft Reports.** Draft reports are considered "drafts" only in the sense that they have not been reviewed and approved by the Air Force. In all other respects, "drafts" must be complete, in the proper format, and free of grammatical and typographical errors. All draft reports shall be thoroughly screened through in-house peer technical review before being released to HSD/YAQ.

1.6.1.2 **RI/FS Report Format.** Strictly adhere to the Report Format (Handbook, Section 3) for preparation of Draft and Final RI/FS Reports.

1.6.2 **Environmental Impact Statement (EIS) Report Format.** Utilize the format and guidance provided in section 40 CFR 1502 for both draft and final EIS documents. **(Item VI, Paragraph 6.1, Sequence 4).**

1.7 **Network Analysis.** Provide within 10 days of NTP a computer generated network analysis detailing the integration of the RI/FS and EIS work efforts. The Network analysis will show both serial and parallel subtasks leading to each deliverable product or report. Show early and late start and completion data with float. Utilize the latest timeline to establish deliverable dates. Provide the estimated manhours by categories to be used for each serial and parallel subtasks as computer back-up material. **(Item VI, Paragraph 6.1, Sequence 3).**

1.8 **Confirmation Notices.** The contractor shall provide a record of all conferences, meetings (other than those with a transcript), discussions, verbal directions, telephone conversations, etc. in which the contractor and his subcontractor personnel have participated on matters relative to this SOW effort. These records are called confirmation notices and are numbered sequentially. They shall fully identify participating personnel, subject discussed, and any guidance given and/ or conclusions reached. Distribution shall take place no more than five working days after the event occurred. Recipients of this Notice are key contractor personnel, HSD/YAQ, and HQMAC/DEV. A maximum of 100 pages shall be contracted for this effort. **(Item VI, Paragraph 6.1, Sequence 16).**

1.9 **Meetings.** A maximum of 10 meetings with a maximum of ten (10) contractor personnel shall attend public hearing(s) and government meetings at McGuire AFB,NJ. Each meeting shall be a minimum of two workdays in duration. All meetings shall be coordinated by the HSD/YAQ and are required to support the EIS process.

1.10 **R & D Status Reports.** Include all data as required by the Handbook, Section 6. **(Item VI, Paragraph 6.1, Sequence 1).**

1.11 **Variations.** The above technical efforts which include maximum requirements are estimates only. Should the contractor determine technical efforts, including field work, require variation from these estimates, the contractor shall obtain a written concurrence from the contracting officer's technical representative. This concurrence is required prior to proceeding with the variation. Under such circumstances, the ceiling price of this order shall remain unchanged. Should an increase in the ceiling amount be necessary, contracting officer authorization will be required prior to proceeding with the variation.

II. SITE LOCATION :

BOMARC Site, McGuire AFB, NJ

III. BASE SUPPORT: NONE.

IV. GOVERNMENT FURNISHED PROPERTY: NONE.

V. GOVERNMENT POINTS OF CONTACT (POC):

5.1 HSD/YAQ
Contracting Officer's Technical Representative
Major John M. Clegg, Jr., PE
Brooks AFB TX 78235-5501
(512) 536-9001
1-800-821-4528

5.2 MAJCOM POC
HQ MAC/DEEV
Mr. Mark Stafford
Scott AFB, IL 62225-5000
618-256-5764

5.3 BASE POC
Mr Robert Panebianco
438 ABG/DEV
McGuire AFB, NJ 08641-5005
609-724-2770

VI. DELIVERABLES

6.1 **Attachment 1 of the basic contract.** In addition to Sequence Numbers 1 and 5 listed in Attachment 1 to the basic contract which apply to all orders, the Sequence Numbers and dates listed below are applicable to this order:

Sequence No.	Para No.	Block 10	Block 11	Block 12	Block 13	Block 14
3 (Network Analysis)	I.1.7	QTRLY	10 DAC	a	-	4
3 Transcripts	I.1.2.2	OTIME	b	b	-	*
3 Transcripts	I.1.2.2	OTIME	b	b	-	*
4 (RI/FS Tech. Rpt)	I.1.6.1	ONE/2R	90 Nov 30	91 Feb 01	91 Nov 01	**
4 (EIS Documents)	I.1.6.2	ONE/3R	90 Nov 30	91 Feb 01	91 Nov 01	***
9 Public Hearing Support	I.1.2.2	As Req	91 Jun 04	91 Jun 04	91 Nov 15	*
16 Confirmation Notice- LTR report	I 1.8	As Req	c	c	-	4

6.3 Notes:.

a Quarterly thereafter

b Within 2 weeks after Public Hearing

c Distribution shall take place no more than 5 work days after event occurs

* Distribute 4 copies as shown to HSD/YAQ(1), HQMAC/DEV(2), BASE(1). Retain public meeting transcript original for final EIS documentation.

** One first draft report (15 copies), one second draft report (25 copies), and one Final Report (50 copies plus the original camera-ready copy) are required. Incorporate Air Force comments into the second draft and Final Reports as specified by HSD/YAQ. Supply HSD/YAQ with an advance copy of the first draft, second draft, and Final Reports for acceptance prior to distribution. Distribute the remaining 14 copies of the first draft report, 24 copies of the second draft report, and 49 copies of the Final Report as specified by HSD/YAQ.

*** For all draft and final EIS documents provide 20 copies to HQ USAF/LEEV, Bolling AFB, Washington DC 20331; 20 copies to HQMAC/DEV, Scott AFB IL, 62225-5001; 6 copies to HSD/YAQ and 5 copies to Base POC. Incorporate comments into all drafts and Final documents as specified by HSD/YAQ. Supply HSD/YAQ with an advance copy of the first draft, second draft, third draft and Final documents for acceptance prior to distribution. Provide a microfiche copy of each final document to HSD/YAQ within 1 month following final reports.

CERTIFICATE OF ESTABLISHED CATALOG OR MARKET PRICES

The undersigned, who represents that he/she is authorized to make such certification on behalf of the contractor indicated below, hereby certifies that the items listed below meet the following criteria:

(1) That the prices of the below-listed items are established catalog or market prices of commercial items sold in substantial quantities to the general public in an open market situation as such terms are defined in Paragraph 15.804-3(c) of the Federal Acquisition Regulation, and

(2) That any price or quantity discounts applied to such prices are at least as great as the largest discount offered to any other of the contractor's customers, government or commercial.

The items covered by the above certification are described as follows (use separate sheet, if necessary):

SIGNATURE

DATE

TYPED OR PRINTED NAME

TITLE

NAME OF FIRM

CITY, STATE

(CONTRACT/ORDER NUMBER
STAGE ___, BASE, _______)
state

FORMAT FOR PRICING SOW MODIFICATIONS

	CURRENT SOW	PROPOSED SOW MOD	AFTER MOD
DELIVERY ORDER LINE ITEMS (LI)	INCREASE/DECREASE	*ADDITIONAL SCOPE OF WORK	NEW LINE ITEM CEILINGS
LI0001: LABOR			
LI0002: SUPPORT			
Travel/Per Diem Reproduction Computer Usage Shipping Telephone Word Processing Sampling Bottles Editing Graphics Fed-X/Mail Equipment Rental Analyses Other Materials/ Supplies **Subcontract Overhead Costs			
LI0004: ANALYSES			
TOTAL:			

*ITEMIZE all labor, support and analytical costs ONLY FOR THE MODIFICATION. Be sure to attach all itemization for each line item.

**If contractor can certify adequate price competition was/will be obtained and selected/will select the lowest capable subcontractor, then use the attached example to price subcontractor costs.
If contractor cannot certify, then all subcontractor costs must be ITEMIZED IN DETAIL.
NOTE: ALL INCREASES/DECREASES (COLUMN 1) MUST CANCEL OUT PROPOSED ADDITIONAL SCOPE OF WORK (COLUMN 2) [illegible] REQUIREMENT FOR ADDITIONAL FUNDS.

APPENDIX C

BOREHOLE LOGS

The Earth Technology Corporation

BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.			
Project Number: 86013-11	Borehole Number: B01		Sheet 1 of 1
Borehole Location: BOMARC Missile Site		Elevation and Datum: Land: 174.00'	
Drilling Agency: John Mathes	Driller: Mike Dillon	Date Started: 10/10/89	Date Finished: 10/10/89
Drilling Equipment: Diedrich D-50		Total Depth (feet): 10.0	
Drilling Method: Hollow Stem Auger		Borehole Diameter (inches): 6	
Drilling Fluid: None			
Completion Information:		Logged By: Richard Bizub	Checked By: Phil Watts

Depth (feet)	Description	Lith-ology	OVA (ppm)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: PU-239 uCi/g	Remarks
	10 YR 6/8, brownish yellow, coarse-medium to fine sand, trace silt, trace fine gravel, roots, (SP-SM)	SP				6 1 1 2	4.42E-02	Started: 8:45 AM Fidler background: 150 cpm Sample taken: 001-SS-BO1-002 (sample from top 6" of spoon) HPG: 4.42E-02 uCi/sample Fidler: 110 cpm
	10YR 8/4, very Pale brown, medium to fine sand, little silt, iron staining bands, (SP-SM)	SP				6 1 1 2	ND	Tip Wet Sample taken: 001-SS-BO1-002 (sample from bottom of spoon) HPG: ND Fidler: 110 cpm
5	10YR 7/8, yellow to 10YR 8/3, very pale brown, medium to fine sand, trace clayey silt, iron staining, (SP-SC)	SP				5 6 7 11		Fidler: 110 cpm Generator for HEPA filter failed at 9:00 AM
	10YR 6/8, brownish yellow, medium to fine sand, little silt, (SP-SM)	SP				15 13 16 13		Fidler: 110 cpm Started Drilling again at 12:45 PM
	7.5 YR 6/8, reddish yellow, medium to fine sand, trace clayey silt, (SP-SC)	SP				6 11 12 10	ND	Sample taken: 001-SS-BO1-003 (sample from bottom of spoon) HPG: ND Fidler: 110 cpm
10								TD=10' Completed at 1:00 PM Grouted at 1:20 PM
15								

The Earth Technology Corporation

BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.			
Project Number: 86013-11	Borehole Number: B02		Sheet 1 of 1
Borehole Location: BOMARC Missile Site		Elevation and Datum: Land: 173.30'	
Drilling Agency: John Mathes	Driller: Mike Dillon	Date Started: 10/9/89	Date Finished: 10/9/89
Drilling Equipment: Diedrich D-50		Total Depth (feet): 10.0	
Drilling Method: Hollow Stem Auger		Borehole Diameter (inches): 6	
Drilling Fluid: None			
Completion Information:		Logged By: Richard Bizub	Checked By: Phil Watts

Depth (feet)	Description	Lith-ology	OVA (ppm)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: PU-239 uCi/g	Remarks
	10YR 6/8, brownish yellow, coarse to fine sand, little silt trace fine gravel, roots, (SP-SM)	SP				2 3 5 6	2.78E-02	Started: 2:30 PM Fidler: 90-110 cpm Drill rod broke
	10YR 7/8, yellow to 10YR 6/8, brownish yellow, medium to fine sand, trace silt, trace fine gravel, cinders, (SP-SM)	SP				5 6 8 8	ND	Fidler: 90-110 cpm
5	10YR 8/8, yellow to 10YR 6/8, medium to fine sand, little silt, iron stain (bands), (SP-SM)	SP				5 7 7 9		Fidler: 90-110 cpm
	7.5YR 6/8, reddish yellow to 10YR 8/8, yellow, medium to fine sand, little clayey silt, partings of dark minerals, (SP-SC)	SP				4 13 16 19		Fidler: 90-110 cpm
	10YR 8/3, very pale brown to 10 YR 8/8, brownish yellow, medium to fine sand, trace clayey silt, (SP-SC)	SP				11 18 19 17	ND	Fidler: 90-110 cpm
10								TD=10' Completed at 3:20 PM Grouted at 3:45 PM
15								

The Earth Technology Corporation

BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.		
Project Number: 86013-11	Borehole Number: B03	Sheet 1 of 1
Borehole Location: BOMARC Missile Site	Elevation and Datum: Land: 173.00'	
Drilling Agency: John Mathes / Driller: Mike Dillon	Date Started: 10/9/89	Date Finished: 10/9/89
Drilling Equipment: Diedrich D-50	Total Depth (feet): 10.0	
Drilling Method: Hollow Stem Auger	Borehole Diameter (inches): 6	
Drilling Fluid: None		
Completion Information:	Logged By: Richard Bizub	Checked By: Phil Watts

Depth (feet)	Description	Lith-ology	OVA (ppm)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: PU-239 uCi/g	Remarks
	10YR 7/8, yellow, coarse to fine sand, trace silt, trace fine gravel, roots, (SP-SM)	SP				2 6 11 12	5.65E+00	Started: 1:30 PM Fidler background: 90-110 cpm Fidler: 90-110 cpm
	10YR 6/8, brownish yellow, medium to fine sand, little silt, (SP-SM)	SP				6 12 14 14	ND	Fidler: 90-110 cpm Sample taken: 001-SS-BO3-002
5	10YR 7/8, yellow, fine sand, little silt, (SP-SM)	SP				3 7 10 12		Fidler: 90-110 cpm
	7.5YR 6/8, reddish yellow to 10YR 7/8, yellow, medium to fine sand, trace clayey silt, (SP-SC)	SP				7 14 16 20		Fidler: 90-110 cpm
	7.5YR 6/8, reddish yellow to 10YR 7/8, yellow, medium to fine sand, trace clayey silt, (SP-SC)	SP				11 19 15 14	ND	Fidler: 90-110 cpm Sample taken: 001-SS-BO3-003
10								TD=10' Completed at 2:00 PM Grouted at 2:20 PM
15								

The Earth Technology Corporation

BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.			
Project Number: 86013-11	Borehole Number: B04		Sheet 1 of 1
Borehole Location: BOMARC Missile Site		Elevation and Datum: Land: 174.70'	
Drilling Agency: John Mathes	Driller: Mike Dillon	Date Started: 10/9/89	Date Finished: 10/9/89
Drilling Equipment: Diedrich D-50		Total Depth (feet): 10.0	
Drilling Method: Hollow Stem Auger		Borehole Diameter (inches): 6	
Drilling Fluid: None			
Completion Information:		Logged By: Richard Bizub	Checked By: Phil Watts

Depth (feet)	Description	Lith-ology	OVA (ppm)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: PU-239 uCi/g	Remarks
	10YR 6/8, brownish yellow, coarse to fine sand, little silt, iron staining, roots, (SP-SM)	SP				3 6 8 7	6.66E+00	Started: 10:20 AM Fidler background: 100-120 cpm Fidler: 150 cpm (top 6" of spoon)
	10YR 7/6, yellow, medium to fine sand, trace silt, partings of dark minerals, mottling, (SP-SM)	SP				2 4 7 9	ND	Fidler: 100-120 cpm Sample taken: 001-SS-BO4-002
5	10YR 8/4, very pale brown, medium to fine sand, trace silt, mottling, (SP-SM)	SP				7 7 13 11		Fidler: 100-120 cpm
	10YR 8/2, fine sand, little silt, partings of dark minerals, mottling, (SP-SM)	SP				8 9 12 19		Fidler: 100-120 cpm
	10YR 8/3, very pale brown, medium to fine sand, trace silt, (SP-SM)	SP				9 11 13 14	ND	Fidler: 100-120 cpm Sample taken: 001-SS-BO4-003
10								TD=10' Completed at 10:45 AM Grouted at 11:05 AM
15								

The Earth Technology Corporation

BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.		
Project Number: 86013-11	Borehole Number: B05	Sheet 1 of 1
Borehole Location: BOMARC Missile Site	Elevation and Datum: Land: 173.20'	
Drilling Agency: John Mathes	Driller: Mike Dillon	Date Started: 10/5/89 / Date Finished: 10/5/89
Drilling Equipment: Diedrich D-50	Total Depth (feet): 6.0	
Drilling Method: Hollow Stem Auger	Borehole Diameter (inches): 6	
Drilling Fluid: None		
Completion Information:	Logged By: Richard Bizub	Checked By: Phil Watts

Depth (feet)	Description	Lith-ology	OVA (ppm)	Samples Number	Type	Blow Count	PU-239 uCi/g	Remarks
	10YR 8/3, very pale brown to 10YR 7/8, yellow, medium to fine sand, trace silt, mottling, roots, (SP-SM)	SP				1 2 4 7	1.05E+00	Started: 10:30 AM Fidler background: 60-90 cpm Fidler: 60-90 cpm
	10YR 6/6 to 10YR 7/4, very pale brown, medium to fine sand, trace silt, (SP-SM)	SP				4 4 6 7	ND	Fidler: 60-90 cpm Sample taken: 001-SS-BO5-002
5	10YR 8/2, white to 10YR 7/7, yellow, medium to fine sand, trace silt, (SP-SM)	SP				2 7 7 9	ND	Fidler: 60-90 cpm Sample taken: 001-SS-BO5-003
								TD=6' Completed at 10:45 AM Grouted at 11:00 AM
10								
15								

The Earth Technology Corporation

BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.	
Project Number: 86013-11	Borehole Number: B06
Sheet 1 of 1	
Borehole Location: BOMARC Missile Site	Elevation and Datum: Land: 174.90'
Drilling Agency: John Mathes	Driller: Mike Dillon
Date Started: 10/5/89	Date Finished: 10/5/89
Drilling Equipment: Diedrich D-50	Total Depth (feet): 10.0
Drilling Method: Hollow Stem Auger	Borehole Diameter (inches): 6
Drilling Fluid: None	
Completion Information:	Logged By: Richard Bizub
	Checked By: Phil Watts

Depth (feet)	Description	Lith-ology	OVA (ppm)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: PU-239 uCi/g	Remarks
	10YR 6/8, brownish yellow, medium to fine sand, trace silt, roots, (SP-SM)	SP				1 4 8 8	6.66E-00	Started: 11:15 Fidler background: 60-90 cpm Fidler: 2070 cpm (top 6" of spoon)
	10YR 6/6, brownish yellow, medium to fine sand, trace silt, some roots, (SP-SM)	SP				3 5 6 9	ND	Fidler: 60-90 cpm Sample taken: 001-SS-BO6-002
5	10YR 8/4, very pale brown to 10YR 6/6, brownish yellow, medium to fine sand, trace silt, mottling, partings of dark minerals, (SP-SM)	SP				6 8 9 14		Fidler: 60-90 cpm
	10YR 8/3, very pale brown with banding of 10YR 6/8, brownish yellow, medium to fine sand, trace clayey silt, mottling, (SP-SM)	SP				7 7 9 12		Fidler: 60-90 cpm
	10YR 8/3, very pale brown, medium to fine sand, trace silt, mottling, (SP-SM)	SP				6 8 8 12	ND	Fidler: 60-90 cpm Sample taken: 001-SS-BO6-003
10								TD=10' Completed at 11:30 AM Grouted at 11:55 AM
15								

The Earth Technology Corporation

BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.			
Project Number: 86013-11	Borehole Number: B07		Sheet 1 of 1
Borehole Location: BOMARC Missile Site		Elevation and Datum: Land: 174.70'	
Drilling Agency: John Mathes	Driller: Mike Dillon	Date Started: 10/4/89	Date Finished: 10/4/89
Drilling Equipment: Diedrich D-50		Total Depth (feet): 10.0	
Drilling Method: Hollow Stem Auger		Borehole Diameter (inches): 6	
Drilling Fluid: None			
Completion Information:		Logged By: Richard Bizub	Checked By: Phil Watts

Depth (feet)	Description	Lith-ology	OVA (ppm)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: PU-239 uCi/g	Remarks
	10YR 5/8, yellowish brown, medium to fine sand, trace silt, trace fine gravel, roots, (SP)	SP				2 4 6 8	1.08E+02	Started: 4:15 PM Fidler background: 60-80 cpm Fidler: 60-80 cpm
	10YR 5/8, yellowish brown, medium to fine sand, trace silt, trace fine gravel, (SP)	SP				3 3 4 6		Fidler: 60-80 cpm
5	10YR 6/8, brownish yellow to 7.5YR 6/6, reddish yellow, medium to fine sand, trace silt, mottling, (SP-SM)	SP				6 9 11 15	ND	Fidler: 60-80 cpm Sample taken: 001-SS-BO7-002
	10YR 7/6, yellow to 10YR 6/8, brownish yellow, fine sand, trace silt, (SP-SM)	SP				7 10 11 12		Fidler: 60-80 cpm
	10YR 8/2, white to 10YR 6/8, brownish yellow, medium to fine sand, trace silt, mottling, partings of dark minerals, (SP-SM)	SP				9 11 15 21	ND	Fidler: 60-80 cpm Sample taken: 001-SS-BO7-003
10								TD=10' Completed at 5:00 PM
15								

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BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.			
Project Number: 86013-11	Borehole Number: B08		Sheet 1 of 1
Borehole Location: BOMARC Missile Site		Elevation and Datum: Land: 174.60'	
Drilling Agency: John Mathes	Driller: Mike Dillon	Date Started: 10/4/89	Date Finished: 10/4/89
Drilling Equipment: Diedrich D-50		Total Depth (feet): 10.0	
Drilling Method: Hollow Stem Auger		Borehole Diameter (inches): 6	
Drilling Fluid: None			
Completion Information:		Logged By: Richard Bizub	Checked By: Phil Watts

Depth (feet)	Description	Lith-ology	OVA (ppm)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: PU-239 uCi/g	Remarks
	10YR 5/6, yellowish brown, coarse to fine sand, trace silt, trace fine gravel, roots, (SP)	SP				2 4 4 4		Started: 2:45 PM Fidler background: 60-80 cpm Fidler: 120 cpm (top 6" of spoon)
	10YR 5/8, yellowish brown, coarse-medium to fine sand, trace silt, trace fine gravel, (SP)	SP				2 2 2 1		Fidler: 60-80 cpm
5	10YR 8/3, very pale brown to 10YR 6/8, brown yellow, medium to fine sand, trace silt, (SP-SM)	SP				3 4 4 7		Fidler: 1200-1400 cpm (upper 6" of spoon) Sample taken: 001-SS-BO8-002 (center of spoon)
	10YR 8/4, very pale brown to 10YR 6/8, brownish yellow medium to fine sand, (SP-SM)	SP				8 15 16 16		Fidler: 250 cpm (upper 4" of spoon)
	10YR 6/8, brown yellow, medium to fine sand, trace silt, trace fine gravel, mottling, laminations of dark minerals, (SP-SM)	SP				11 11 12 19		Fidler: 180 cpm (upper 4" of spoon) Sample taken: 001-SS-BO8-003 (center of spoon)
10								TD=10'
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BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.			
Project Number: 86013-11	Borehole Number: B09		Sheet 1 of 1
Borehole Location: BOMARC Missile Site		Elevation and Datum: Land: 174.20'	
Drilling Agency: John Mathes	Driller: Mike Dillon	Date Started: 10/5/89	Date Finished: 10/5/89
Drilling Equipment: Diedrich D-50		Total Depth (feet): 6.0	
Drilling Method: Hollow Stem Auger		Borehole Diameter (inches): 6	
Drilling Fluid: None			
Completion Information:		Logged By: Richard Bizub	Checked By: Phil Watts

Depth (feet)	Description	Lith-ology	OVA (ppm)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: PU-239 uCi/g	Remarks
	10YR 7/8, to 10YR 8/8, yellow, medium to fine sand, trace silt, roots, (SP-SM)	SP				3 3 4 6		Started: 9:45 AM Fidler background: 60-90 cpm Fidler: 60-90 cpm
	10YR 6/6, brownish yellow, medium to fine sand, trace silt, mottling, (SP-SM)	SP				4 6 8 8		Fidler: 60-90 cpm Sample taken: 001-SS-BO9-002
5	10YR 8/2, white to 10YR 7/7, yellow, medium to fine sand, trace silt, mottling, partings of dark minerals, (SP-SM)	SP				4 8 8 10		Fidler: 60-90 cpm Sample taken: 001-SS-BO9-003
								TD=6' Completed at 10:00 AM
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BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.			
Project Number: 86013-11	Borehole Number: B10		Sheet 1 of 1
Borehole Location: BOMARC Missile Site		Elevation and Datum: Land: 171.10'	
Drilling Agency: John Mathes	Driller: Mike Dillon	Date Started: 10/11/89	Date Finished: 10/11/89
Drilling Equipment: Diedrich D-50		Total Depth (feet): 10.0	
Drilling Method: Hollow Stem Auger		Borehole Diameter (inches): 6	
Drilling Fluid: None			
Completion Information:		Logged By: Richard Bizub	Checked By: Phil Watts

Depth (feet)	Description	Lith-ology	OVA (ppm)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: PU-239 uCi/g	Remarks
	10YR 6/6 brownish yellow, coarse to fine sand, trace silt, trace, fine gravel, roots, (SP-SM)	SP				3 19 8 15		Started: 8:55 AM Fidler background: 130 cpm
	0.8'-1.1' asphalt and oil-soaked crushed stone	Asphalt						Fidler: 3800 cpm (from Asphalt & oil zone)
	10YR 7/6, yellow, medium to fine sand, little silt, (SP-SM)	SP				6 7 6 7		Fidler: 130 cpm Sample taken: 001-SS-BO10-002
5	10YR 8/8, yellow, medium to fine sand, little silt (SP-SM) same as above, little clayey silt (SP-SC)	SP				3 2 2 1		Fidler: 130 cpm
	10YR 8/3, very pale brown to 10YR 7/8 yellow medium to fine sand, and silty clay, (SP-SC)	SP				3 8 17 16		Fidler: 130 cpm PP-3.0 tons/square ft PP-2.5 tons/square ft
	10YR 8/2, white to 10YR 8/8, yellow, medium to fine sand, little clayey silt, iron staining (bands), (SP-SC)	SP				13 18 21 28		Fidler: 130 cpm Sample taken: 001-SS-BO10-003
10								TD=10' completed at 9:20 AM grouted at 9:40 AM
15								

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BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.			
Project Number: 86013-11	Borehole Number: B11		Sheet 1 of 1
Borehole Location: BOMARC Missile Site		Elevation and Datum: Land: 170.80'	
Drilling Agency: John Mathes	Driller: Mike Dillon	Date Started: 10/11/89	Date Finished: 10/11/89
Drilling Equipment: Diedrich D-50		Total Depth (feet): 6.0	
Drilling Method: Hollow Stem Auger		Borehole Diameter (inches): 6	
Drilling Fluid: None			
Completion Information:		Logged By: Richard Bizub	Checked By: Phil Watts

Depth (feet)	Description	Lithology	OVA (ppm)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: PU-239 uCi/g	Remarks
	Asphalt	Asphalt						Started: 10:45 AM Fidler background: 130 cpm
	10YR 7/8, yellow coarse to fine sand, trace silt, (SP-SM)	SP				7 15		
	0.8' to 1.1', asphalt and oil-stained crushed stone	Asphalt				13		Fidler: 540 cpm at asphalt zone
	10YR 8/8, yellow, medium to fine sand, little silt, mottling, iron staining (banding), (SP-SC)	SP SP				10 20 16 15		Fidler: 130 cpm Sample taken: 001-SS-BO11-002
	10YR 8/8, yellow, medium to fine sand, little silt, (SP-SM)	SP				5 5 5		Fidler: 130 cpm
5	7.5YR 7/8, reddish yellow, medium to fine sand, little silt, clay, (SP-SC)	SP				13		Sample taken: 001-SS-BO11-003
								TD=6' Completed at 10:15 AM Grouted at 10:30 AM
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BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.			
Project Number: 86013-11	Borehole Number: B12		Sheet 1 of 1
Borehole Location: BOMARC Missile Site		Elevation and Datum: Land: 170.80'	
Drilling Agency: John Mathes	Driller: Mike Dillon	Date Started: 10/11/89	Date Finished: 10/11/89
Drilling Equipment: Diedrich D-50		Total Depth (feet): 10.0	
Drilling Method: Hollow Stem Auger		Borehole Diameter (inches): 6	
Drilling Fluid: None			
Completion Information:		Logged By: Richar-l Bizub	Checked By: Phil Watts

Depth (feet)	Description	Lith-ology	OVA (ppm)	Samples: Number	Type	Blow Count	PU-239 uCi/g	Remarks
	Asphalt	Asphalt						Started: 1:00 PM Fidler background: 120 cpm Fidler: 1100 cpm (from Asphalt & oil zone)
	10YR 5/8, yellow brown, coarse-medium to fine sand, trace silt	SP				2 12 13		
	0.8' to 1.1', asphalt and oil-stained crushed stone	Asphalt						
	10YR 5/2, grayish medium fine sand	SP						
	10YR 8/6, yellow, medium to fine sand, little clayey silt, trace fine gravel, laminations of dark minerals, mottling, (SP-SC)	SP				15 13 20 23		Fidler: 120 cpm Sample taken: 001-SS-BO12-002
5	7.5YR 6/8, reddish yellow, medium to fine sand, little silt, mottling, laminations of dark minerals, (SP-SM)	SP				8 11 23 20		Fidler: 120 cpm
	10YR 8/4, very pale brown to 7.5 YR 6/8, reddish yellow medium to fine sand, some silty clay, mottling, (SP-SC)	SP				5 10 21 20		Fidler: 120 cpm
	10YR 8/4, very pale brown to 7.5 YR 6/8, reddish yellow, medium to fine sand, trace clayey silt, mottling, (SP-SC)	SP				10 20 27 30		Fidler: 120 cpm Sample taken: 001-SS-BO12-003
10								TD=10' completed at 1:45 PM
15								

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BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.			
Project Number: 86013-11	Borehole Number: B13		Sheet 1 of 1
Borehole Location: BOMARC Missile Site		Elevation and Datum: Land: 248.30'	
Drilling Agency: John Mathes	Driller: Mike Dillon	Date Started: 10/10/89	Date Finished: 10/10/89
Drilling Equipment: Diedrich D-50		Total Depth (feet): 6.0	
Drilling Method: Hollow Stem Auger		Borehole Diameter (inches): 6	
Drilling Fluid: None			
Completion Information:		Logged By: Richard Bizub	Checked By: Phil Watts

Depth (feet)	Description	Lithology	OVA (ppm)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: PU-239 uCi/g	Remarks
	Crushed stones	Stone				17		Started: 1:30 AM
						45		Fidler background: 110 cpm
						19		Fidler: 110 cpm
	10YR 6/8, brownish yellow, coarse to fine sand, trace silt, trace fine gravel, (SW-SM)	SW				16		
	7.5YR 6/8, reddish yellow, coarse to fine sand, trace clayey silt, trace fine gravel, (SW-SC)					10		
						10		Fidler: 110 cpm
						16		
		SW				20		Sample taken: 001-SS-PO13-002
	7.5YR 6/8, reddish yellow, coarse to fine sand, little clayey silt, (SW-SC)					9		
						10		Fidler: 110 cpm
5						5		
		SW				13		Sample taken: 001-SS-BO13-003
								TD=6'
								Completed at 2:00 PM
								Grouted at 1:50 PM
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BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.			
Project Number: 86013-11	Borehole Number: B14		Sheet 1 of 1
Borehole Location: BOMARC Missile Site		Elevation and Datum: Land: 172.90'	
Drilling Agency: John Mathes	Driller: Mike Dillon	Date Started: 10/10/89	Date Finished: 10/10/89
Drilling Equipment: Diedrich D-50		Total Depth (feet): 6.0	
Drilling Method: Hollow Stem Auger		Borehole Diameter (inches): 6	
Drilling Fluid: None			
Completion Information:		Logged By: Richard Bizub	Checked By: Phil Watts

Depth (feet)	Description	Lith-ology	OVA (ppm)	Samples: Number	Type	Blow Count	PU-239 uCi/g	Remarks
	10YR 6/8, brownish yellow, coarse medium-to-fine sand, trace silt, trace fine gravel, (SP-SM)	SP				1 6 19 13		Started: 2:10 PM Fidler background: 110 cpm Fidler: 110 cpm
	10YR 7/8 yellow, coarse-medium to fine sand, little silt, trace fine gravel, (SP-SM)	SP				7 7 9 9		Fidler: 110 cpm Sample taken: 001-SS-BO14-002
5	10YR 7/8, yellow, coarse-medium to fine sand, trace silt, trace fine gravel, (SP-SM)	SP				3 3 1 3		Fidler: 110 cpm Sample taken: 001-SS-BO14-003
10								TD=6' Completed at 2:30 PM
15								

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BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.		
Project Number: 86013-11	Borehole Number: B15	Sheet 1 of 1
Borehole Location: BOMARC Missile Site	Elevation and Datum: Land: 172.90'	
Drilling Agency: John Mathes / Driller: Mike Dillon	Date Started: 10/10/89	Date Finished: 10/10/89
Drilling Equipment: Diedrich D-50	Total Depth (feet): 6.0	
Drilling Method: Hollow Stem Auger	Borehole Diameter (inches): 6	
Drilling Fluid: None		
Completion Information:	Logged By: Richard Bizub	Checked By: Phil Watts

Depth (feet)	Description	Lith-ology	OVA (ppm)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: PU-239 uCi/g	Remarks
	10YR 6/8, brownish yellow, coarse-medium to fine sand, trace silt, trace fine gravel, roots, (SP-SM)	SP				1 2 3 5		Started: 2:45 PM Fidler background: 110 cpm Fidler: 110 cpm
	10YR 8/6, yellow, medium to fine sand, trace silt, iron staining (bands), (SP-SM)	SP				3 2 4 4		Fidler: 110 cpm Sample taken: 001-SS-BO15-002
5	10YR 8/2, white, medium to fine sand, little silt, dark mineral banding, (SP-SM)	SP				4 3 4 4		Fidler: 110 cpm Sample taken: 001-SS-BO15-003
								TD=6' Completed at 3:00 PM Grouted at 3:1[illegible] PM
10								
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BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.			
Project Number: 86013-11	Borehole Number: B16		Sheet 1 of 1
Borehole Location: BOMARC Missile Site		Elevation and Datum: Land: 171.20'	
Drilling Agency: John Mathes	Driller: Mike Dillon	Date Started: 10/10/89	Date Finished: 10/10/89
Drilling Equipment: Diedrich D-50		Total Depth (feet): 10.0	
Drilling Method: Hollow Stem Auger		Borehole Diameter (inches): 6	
Drilling Fluid: None			
Completion Information:		Logged By: Richard Bizub	Checked By: Phil Watts

Depth (feet)	Description	Lith-ology	OVA (ppm)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: PU-239 uCi/g	Remarks
	Asphalt, concrete	Asphalt						Started: 4:10 PM Fidler background: 100-120 cpm Fidler: 100-120 cpm Sample taken: 001-SS-BO16-001
	10YR 6/8, brownish yellow, coarse to fine sand, trace clayey silt, trace fine gravel, (SP-SC)	SP				7 15		
	10YR 8/6, yellow to 10YR 6/8, brownish yellow, medium to fine sand, trace clayey silt, trace fine gravel, (SP-SC)	SP				5 10 9 8		Fidler: 100-120 cpm Sample taken: 001-SS-BO16-002
5	4'-5' 7.5YR 6/8, coarse to fine sand, some clayey silt, (SW-SC)	SW				4 3 3		Fidler: 100-120 cpm
	10YR 8/3, very pale yellow medium to fine sand, trace silt, (SP-SM)	SP				7		
	10YR 8/2, white, medium to fine sand, little clayey silt, (SP-SC) 5YR 7/8, reddish yellow iron banding "iron stone"	SP				3 7 9 14		Fidler: 100-120 cpm
	10YR 7/1, light gray medium to fine sand, little clayey silt, iron staining (bands), (SP-SC)	SP				10 19 16 20		Fidler: 100-120 cpm Sample taken: 001-SS-BO10-003
10								TD=10' completed at 4:45 PM grouted at 5:00 PM
15								

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BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.			
Project Number: 86013-11	Borehole Number: B17		Sheet 1 of 1
Borehole Location: BOMARC Missile Site		Elevation and Datum: Land: 170.60'	
Drilling Agency: John Mathes	Driller: Mike Dillon	Date Started: 10/11/89	Date Finished: 10/11/89
Drilling Equipment: Diedrich D-50		Total Depth (feet): 6.0	
Drilling Method: Hollow Stem Auger		Borehole Diameter (inches): 6	
Drilling Fluid: None			
Completion Information:		Logged By: Richard Bizub	Checked By: Phil Watts

Depth (feet)	Description	Lith-ology	OVA (ppm)	Samples Number	Samples Type	Samples Blow Count	Samples PU-239 uCi/g	Remarks
	Asphalt	Asphalt						Started: 2:00 PM
	10YR 6/8, brownish yellow, coarse to fine sand, little silt, clay, mottling, (SP-SC)	SP				3 6 5		Fidler background: 120 cpm Fidler: 2300 cpm (top .6' of spoon)
	5YR 6/8, reddish yellow, medium to fine sand, some silty clay, mottling, (SP-SC)	SP				9 8 12 13		Fidler: 120 cpm Sample taken: 001-SS-BO17-002
5	7.5YR 6/2, reddish yellow to 10YR 8/3, very pale yellow, coarse to fine sand, trace silt, trace fine gravel, (SW-SM)	SW				7 9 13 20		Fidler: 120 cpm Sample taken: 001-SS-BO17-003
								TD=6' Completed at 2:20 PM Grouted at 2:35 PM
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BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.		
Project Number: 86013-11	Borehole Number: B18	Sheet 1 of 1
Borehole Location: BOMARC Missile Site	Elevation and Datum: Land: 170.20'	
Drilling Agency: John Mathes	Driller: Mike Dillon	Date Started: 10/12/89 / Date Finished: 10/12/89
Drilling Equipment: Diedrich D-50	Total Depth (feet): 6.0	
Drilling Method: Hollow Stem Auger	Borehole Diameter (inches): 6	
Drilling Fluid: None		
Completion Information:	Logged By: Richard Bizub	Checked By: Phil Watts

Depth (feet)	Description	Lith-ology	OVA (ppm)	Samples Number	Samples Type	Samples Blow Count	Samples PU-239 uCi/g	Remarks
	Asphalt	Asphalt						Started: 9:45 AM Fidler background: 100-120 cpm Fidler: 100-120 cpm
	10YR 6/8, brownish yellow, medium to fine sand, little silt (SP-SM)	SP				9 12 8		
	10YR 7/8, yellow, coarse to fine sand, trace silt, trace fine gravel (tip of spoon), (SW-SM)	SW						
	7.5YR 7/6, reddish yellow, coarse-medium to fine sand, trace silt, trace fine gravel (SP-SM)	SP				8 6 6 14		Fidler: 100-120 cpm Sample taken: 001-SS-BO18-002
5	7.5YR 6/8, reddish yellow, medium to fine sand, little clayey silt, mottling, (SP-SC)	SP				8 10 12 13		Fidler: 100-120 cpm Sample taken: 001-SS-BO18-003 Tip of spoon wet (saturated)
								TD=6' Completed at 10:10 PM Grouted at 10:20 PM
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BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.			
Project Number: 86013-11	Borehole Number: B19		Sheet 1 of 1
Borehole Location: BOMARC Missile Site		Elevation and Datum: Land: 175.20'	
Drilling Agency: John Mathes	Driller: Mike Dillon	Date Started: 10/12/89	Date Finished: 10/12/89
Drilling Equipment: Diedrich D-50		Total Depth (feet): 6.0	
Drilling Method: Hollow Stem Auger		Borehole Diameter (inches): 6	
Drilling Fluid: None			
Completion Information:		Logged By: Richard Bizub	Checked By: Phil Watts

Depth (feet)	Description	Lith-ology	OVA (ppm)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: PU-239 uCi/g	Remarks
	Asphalt	Asphalt						Started: 9:45 AM
	Oil-stained coarse to fine sand trace silt, trace fine gravel	Gravel				7 10 28		Fidler background: 120 cpm Fidler: 120 cpm
	10YR 8/8, yellow, medium to fine sand, trace silt, (SP-SM)	SP						
	10yr 6/8, brownish yellow, medium to fine sand, little silt, (SP-SM)	SP				9 18 24 23		Fidler: 120 cpm Sample taken: 001-SS-BO19-002
5	10YR 7/1, light gray to 10YR 7/8, yellow, coarse-medium to fine sand, litlle clayey silt, trace fine gravel, (SP-SC)	SP				9 14 19 16		Fidler: 120 cpm Sample taken: 001-SS-BO19-003
								TD=6' Completed at 10:50 AM Grouted at 11:00 AM
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BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.			
Project Number: 86013-11	Borehole Number: B20		Sheet 1 of 1
Borehole Location: BOMARC Missile Site		Elevation and Datum: Land: 175.20'	
Drilling Agency: John Mathes	Driller: Mike Dillon	Date Started: 10/12/89	Date Finished: 10/12/89
Drilling Equipment: Diedrich D-50		Total Depth (feet): 6.0	
Drilling Method: Hollow Stem Auger		Borehole Diameter (inches): 6	
Drilling Fluid: None			
Completion Information:		Logged By: Richard Bizub	Checked By: Phil Watts

Depth (feet)	Description	Lith-ology	OVA (ppm)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: PU-239 uCi/g	Remarks
	0'-.8' 10YR 5/2, grayish brown, medium to fine sand, trace silt 10YR 5/8, yellowish brown, medium to fine sand, trace silt, trace fine gravel	SP				2 3 3 6		Started: 3:30 PM Fidler background: 100 cpm Fidler: 100 cpm
	5YR 6/8 reddish yellow, coarse to fine sand, little silty clay, (SP-SC)	SP				10 10 12 12		Fidler: 100 cpm Sample taken: 001-SS-BO20-002
5	5YR 6/8, reddish yellow, coarse to fine sand, little silty clay, (SP-SC)	SP				10 13 24 18		Fidler: 100 cpm Sample taken: 001-SS-BO20-003
								TD=6' Completed at 3:55 PM Grouted at 4:05 PM
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BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.			
Project Number: 86013-11	Borehole Number: B21		Sheet 1 of 1
Borehole Location: BOMARC Missile Site		Elevation and Datum: Land: 175.20'	
Drilling Agency: John Mathes	Driller: Mike Dillon	Date Started: 10/12/89	Date Finished: 10/12/89
Drilling Equipment: Diedrich D-50		Total Depth (feet): 6.0	
Drilling Method: Hollow Stem Auger		Borehole Diameter (inches): 6	
Drilling Fluid: None			
Completion Information:		Logged By: Richard Bizub	Checked By: Phil Watts

Depth (feet)	Description	Lithology	OVA (ppm)	Samples Number	Samples Type	Samples Blow Count	Samples PU-239 uCi/g	Remarks
	10YR 6/8, brownish yellow, medium to fine sand, little silt, (SP-SM)	SP				3 4 5 6		Started: 4:15 PM Fidler background: 100 cpm Fidler: 100 cpm
	10YR 6/8, brownish yellow, coarse to fine sand, little silt, (SP-SM)	SP				4 4 6 8		Fidler: 100 cpm Sample taken: 001-SS-BO21-002
5	10YR 6/8, brownish yellow, coarse to fine sand, little silt, (SP-SM)	SP				8 10 11 14		Fidler: 100 cpm Sample taken: 001-SS-BO21-003
								TD=6' Completed at 4:30 PM
10								
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BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.			
Project Number: 86013-11	Borehole Number: B22		Sheet 1 of 1
Borehole Location: BOMARC Missile Site		Elevation and Datum: Land:	
Drilling Agency: John Mathes	Driller: Mike Dillon	Date Started: 10/12/89	Date Finished: 10/12/89
Drilling Equipment: Diedrich D-50		Total Depth (feet): 6.0	
Drilling Method: Hollow Stem Auger		Borehole Diameter (inches): 6	
Drilling Fluid: None			
Completion Information:		Logged By: Richard Bizub	Checked By: Phil Watts

Depth (feet)	Description	Lithology	OVA (ppm)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: PU-239 uCi/g	Remarks
	10YR 4/2, dark grayish brown, coarse to fine sand, some clayey silt, trace fine gravel, (SP-SC)	SP				7 8 9 11		Started: 4:20 PM Fidler background: 100 cpm Fidler: 100 cpm
	7.5YR 6/8, reddish yellow, coarse to fine sand, little clayey silt, (SP-SC)	SP						
	7.5YR 6/8, reddish yellow, medium to fine sand, little clayey silt, (SP-SC)	SP				7 10 11 12		Fidler: 100 cpm Sample taken: 001-SS-BO22-002
5	10YR 7/8, yellow, coarse to fine sand, little silt, trace fine gravel, (SW-SM)	SW				11 9 10 9		Fidler: 100 cpm Sample taken: 001-SS-BO22-003
								TD=6' Completed at 5:00 PM Grouted at 5:05 PM
10								
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BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.			
Project Number: 86013-11	Borehole Number: B23		Sheet 1 of 1
Borehole Location: BOMARC Missile Site		Elevation and Datum: Land: 157.90'	
Drilling Agency: John Mathes	Driller: Mike Dillon	Date Started: 10/12/89	Date Finished: 10/12/89
Drilling Equipment: Diedrich D-50		Total Depth (feet): 6.0	
Drilling Method: Hollow Stem Auger		Borehole Diameter (inches): 6	
Drilling Fluid: None			
Completion Information:		Logged By: Richard Bizub	Checked By: Phil Watts

Depth (feet)	Description	Lith-ology	OVA (ppm)	Samples Number	Samples Type	Samples Blow Count	Samples PU-239 uCi/g	Remarks
	10YR 6/3, pale brown, coarse to fine sand, trace silt, roots, (SP-SM)	SP				2 2 2 2		Started: 5:05 PM Fidler background: 100 cpm Fidler: 100 cpm
	7.5YR 5/6, brown, fine sand, little silt, (SP-SM)	SP						
	7.5YR, reddish yellow, medium to fine sand, little silt, (SP-SM)	SP				5 4 6 7		Fidler: 100 cpm Sample taken: 001-SS-BO23-002
5	7.5YR 7/8, reddish yellow, medium to fine sand, little silt, (SP-SM)	SP				6 7 10 13		Fidler: 100 cpm Sample taken: 001-SS-BO23-003
								TD=6' Completed at 5:15 PM
10								
15								

The Earth Technology Corporation

BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.		
Project Number: 86013-11	Borehole Number: B24	Sheet 1 of 1
Borehole Location: BOMARC Missile Site	Elevation and Datum: Land:	
Drilling Agency: John Mathes / Driller: Mike Dillon	Date Started: 10/12/89	Date Finished: 10/12/89
Drilling Equipment: Diedrich D-50	Total Depth (feet): 6.0	
Drilling Method: Hollow Stem Auger	Borehole Diameter (inches): 6	
Drilling Fluid: None		
Completion Information:	Logged By: Richard Bizub	Checked By: Phil Watts

Depth (feet)	Description	Lith-ology	OVA (ppm)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: PU-239 uCi/g	Remarks
	10YR 5/2, grayish brown, coarse to fine sand, trace silt, trace fine gravel, roots, (SP-SM)	SP				2, 3, 2, 1		Started: 5:30 PM Fidler background: 100 cpm Fidler: 100 cpm
	10YR 5/2, grayish brown, medium to fine sand, (SP-SM)	SP						
	7.5YR 6/8, reddish yellow, medium to fine sand, little silt, (SP-SM)	SP				3, 2, 2, 3		Fidler: 100 cpm Sample taken: 001-SS-BO24-002
5	2.5YR 5/6, red, medium to fine sand, little clayey silt, (SP-SC)	SP				4, 5, 4, 5		Fidler: 100 cpm Sample taken: 001-SS-BO24-003
								TD=6' Completed at 5:45 PM
10								
15								

The Earth Technology Corporation

BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.		
Project Number: 86013-11	Borehole Number: B25	Sheet 1 of 1
Borehole Location: BOMARC Missile Site	Elevation and Datum: Land: 147.50'	
Drilling Agency: John Mathes	Driller: Mike Dillon	Date Started: 10/16/89 / Date Finished: 10/16/89
Drilling Equipment: Diedrich D-50	Total Depth (feet): 6.0	
Drilling Method: Hollow Stem Auger	Borehole Diameter (inches): 6	
Drilling Fluid: None		
Completion Information:	Logged By: Phil Watts	Checked By: Phil Watts

Depth (feet)	Description	Lith-ology	OVA (ppm)	Samples Number	Samples Type	Samples Blow Count	Samples PU-239 uCi/g	Remarks
	0-1" Black organic material	SW				3		
	1"-3" 10YR 6/4, coarse sand to fine sand, (SW)	SM				2		Fidler background: 200 cpm
	10YR 4/1, fine-medium sand, little silt, trace clay, (SM)					2		Fidler: 200 cpm
	10YR 6/8, fine sand, little silt, small gravel, (SW)	SW				3		
	10YR 6/8, fine to medium sand, little silt with rounded quartz gravel (up to 0.5"), (SW)	SW				3, 2, 3, 4		Fidler: 200 cpm; Sample taken: 001-SS-BO25-002
	3.0' to 3.5' 10YR 7/6, fine to medium sand, trace to no fines	SM				4, 4		
5	3.5' to 6.0' 7.5YR 6/8, fine to very fine sand with silt and clay					6, 9		Fidler: 200 cpm; Sample taken: 001-SS-BO25-003
								TD=6'; Completed at 10:30 PM
10								
15								

The Earth Technology Corporation

BOREHOLE LOG

Project Name: BOMARC - McGuire AFB, Plumsted Twp., N.J.			
Project Number: 86013-11	Borehole Number: B26		Sheet 1 of 1
Borehole Location: BOMARC Missile Site		Elevation and Datum: Land: 139.50'	
Drilling Agency: John Mathes	Driller: Mike Dillon	Date Started: 10/16/89	Date Finished: 10/16/89
Drilling Equipment: Diedrich D-50		Total Depth (feet): 6.0	
Drilling Method: Hollow Stem Auger		Borehole Diameter (inches): 6	
Drilling Fluid: None			
Completion Information:		Logged By: Phil Watts	Checked By: Phil Watts

Depth (feet)	Description	Lith-ology	OVA (ppm)	Samples Number	Samples Type	Samples Blow Count	Samples PU-239 uCi/g	Remarks
	0-3" Black fine-medium sand, organic rich, (SP)	SP				1		
	3-9" 10YR 6/2, fine-medium sand, organics, (SP)	SP				3		Fidler background: 100 cpm
						2		Fidler: 100 cpm
	9-24" 10YR 6/8, fine-medium sand, little silt, trace small gravel, rounded quartz grains, (SM-SP)	SM				2		
	2.0-4.0' 10YR 8/6, fine-medium sand, trace small rounded quartz gravel, iron staining (banding), (SP)	SP				2, 4, 6, 7		Fidler: 100 cpm Sample taken: 001-SS-BO26-002
5	4.0-6.0' 10YR 7/8, fine to coarse sand, trace small rounded quartz gravel, (SW)	SW				4, 6, 8, 10		Fidler: 100 cpm Sample taken: 001-SS-BO26-003
								TD=6' Completed at 11:30 PM
10								
15								

APPENDIX D

RAW FIELD DATA

BASELINE AIR SAMPLING DATA
WELL PURGING AND SAMPLING DATA
FIELD DATA FROM SURFACE WATER SAMPLES

Baseline Air Sampling Data

TSP DATA SUMMARY/CALCULATIONS

Battelle Filter No. 096561 Sampler ID 9

Part A. Field Data (Vol. of air sampled)

Project No. BOMARC Date, on 6/4/89 off 6/5/89

Site McGuire AFB Location 1 Recorded by: MEB

	Sampler Time		Flow Readings			Temp.	B.P.	Comments
	Time clock setting	Elapsed time meter	Calibrator in. H2O	CMM	Dickson CMM	F	in. Hg	Time calibration
Stop	Ø1358	25 hrs 39 min	8.25	35	50	80	29.88	1407 (6/5/89)
Start	0830	0	7.3	47	40	60	29.80	0925 2025 (6/4/89)
Total, hr	29 hrs 23 min	25 hrs 38 min						sampler was not in operation between 0243 hrs and 0640 on 6/5/89
Avg.			7.8	41	45	70	29.84	

Weather Conditions During Sampling:

Wind			Visibility			Sky			Humidity			Temp., F		
Start		Stop	Start		Stop	Start		Stop	Start		Stop	Start		Stop
W	Direction	E	✓	Clear			Clear			Dry			< 20	
	Calm			Hazy	✓	✓	Scattered clouds		✓	Moderate	✓		21-40	
✓	Light	✓		Fog			Overcast	✓		Humid		✓	41-60	
	Gusty									Precip.			61-80	✓
													>81	

Unusual activities near site, (if any): None

Part B. Filter Data (Mass)

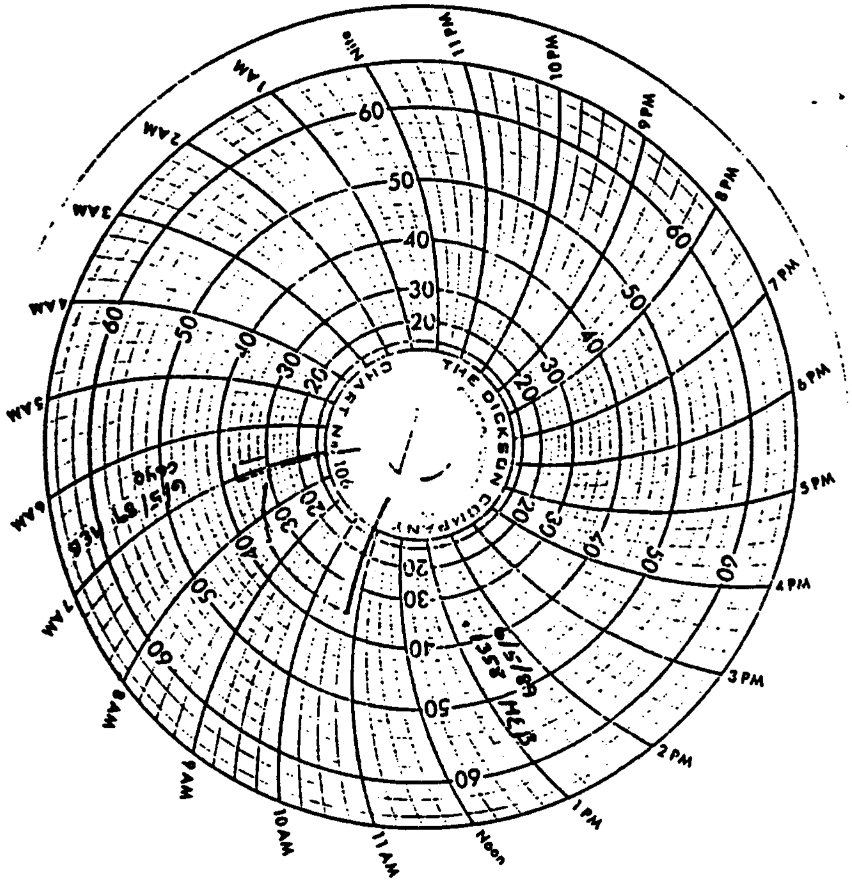
	Weight, g	Date	Recorded by:
Final			
Tare	4.1234	MAY 25 1989	WBayle
Net			

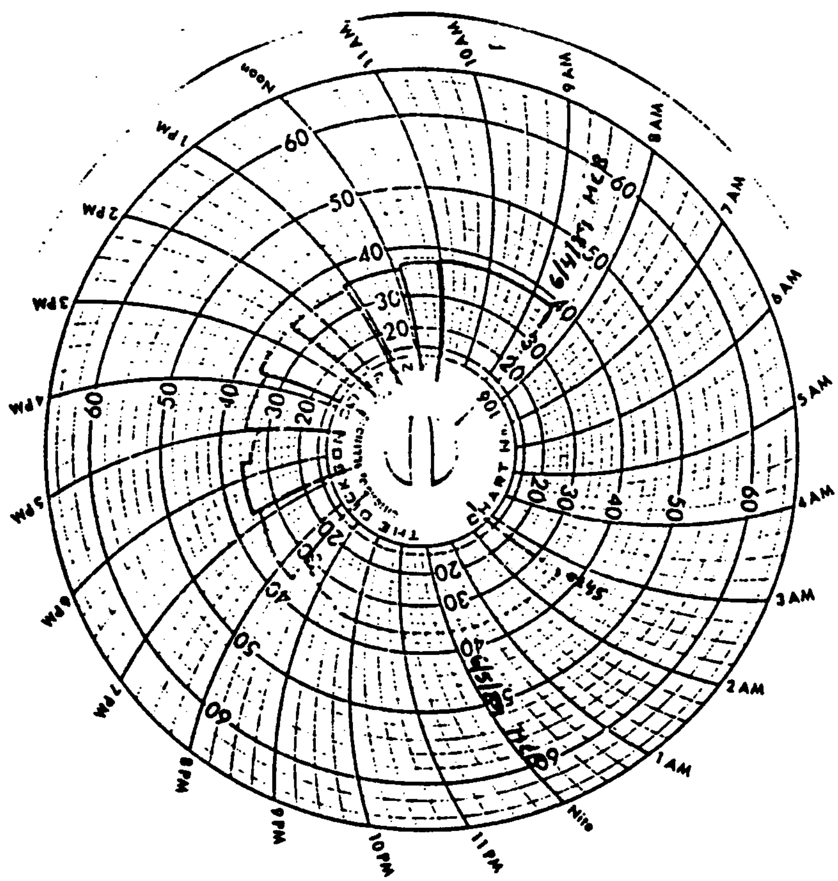
Part C. TSP Calculations:

TSP conc. ($\mu g/M^3$) = Mass ÷ Volume of air sampled
= Net weight ÷ Cubic Meters/min (CMM) x T_{min}
= ______ µg ÷ (________) x (________)
= ____________

Performed by:____________ Checked by:____________

Attach flow recorder chart here





6/4/89
McGuire AFB
TSP ID 9
Filter No. 96561 (continued)

DATE 6/4/89
SITE McGuire AFB
~~PM-10 ID~~ TSP 9
FILTER NO. 96561

TSP DATA SUMMARY/CALCULATIONS

Battelle Filter No. 096562 Sampler ID 4

Part A. Field Data (Vol. of air sampled)

Project No. BOMARC Date, on 6/4/89 off 6/6/89

Site McGuire AFB Location 2 Recorded by: MEB

	Sampler Time		Flow Readings			Temp.	B.P.	Comments
	Time clock setting	Elapsed time meter	Calibrator in. H2O	CMM CFM	Dickson CMM CFM	F	in. Hg	Time of calibration
Stop	0120	24hr 6min	6.75	46	43	65	29.83	0750 (6/6/89)
Start	0906	0	9.3	53	50	60	29.80	0855 (6/4/89)
Total, hr	40hr 14min	24hr 6min						
Avg.			8.0	49.5	46.5		29.82	

Weather Conditions During Sampling:

Wind Start	Wind	Wind Stop	Visibility Start	Visibility	Visibility Stop	Sky Start	Sky	Sky Stop	Humidity Start	Humidity	Humidity Stop	Temp., F Start	Temp., F	Temp., F Stop
W	Direction	E	✓	Clear			Clear			Dry			< 20	
	Calm	✓		Hazy	✓	✓	Scattered clouds		✓	Moderate			21-40	
✓	Light			Fog			Overcast	✓		Humid	✓	✓	41-60	✓
	Gusty									Precip.			61-80	
													>81	

Unusual activities near site, (if any): N/A, scattered showers occurred over the last 8 hours.

Part B. Filter Data (Mass)

	Weight, g	Date	Recorded by:
Final			
Tare	4.1350	MAY 25 1989	WBaylor
Net			

Part C. TSP Calculations:

TSP conc. ($\mu g/M^3$) = Mass ÷ Volume of air sampled
= Net weight ÷ Cubic Meters/min (CMM) x T_{min}
= ______ µg ÷ (________) x (________)
= ____________

Performed by:________________ Checked by:________________

Attach flow recorder chart here

6/5/89
McGuire AFB site 2
Inst. ID 4
Filter No. 96562 (continued)

DATE 6/4/89

SITE McGuire AFB site 2

Inst. ID ~~PM 10~~ 4

FILTER NO. 96562

TSP DATA SUMMARY/CALCULATIONS

Battelle Filter No. 096563 Sampler ID 10

Part A. Field Data (Vol. of air sampled)

Project No. BoMARC Date, on 6/4/89 off 6/6/89

Site McGuire AFB Location 3 Recorded by: MLB

	Sampler Time		Flow Readings			Temp.	B.P.	Comments
	Time Clock	Elapsed Time Meter	Calibrator in. H2O	CMM CMF	Dickson CMM CMF	F	in. Hg	Time Calibration
Stop	0310	27hr 9min	6.6	45	44	65	29.83	0715 (6/6/89)
Start	0938	0	7.0 ~~6.3~~	46.5 ~~44~~	48	60	29.80	0930 (6/4/89)
Total, hr	41hr 32min	27hr 9min						
Avg.			6.8	45.8	46		29.82	

Weather Conditions During Sampling:

Wind Start	Wind	Wind Stop	Visibility Start	Visibility	Visibility Stop	Sky Start	Sky	Sky Stop	Humidity Start	Humidity	Humidity Stop	Temp., F Start	Temp., F	Temp., F Stop
W	Direction	E	✓	Clear			Clear			Dry			< 20	
	Calm	✓		Hazy	✓	✓	Scattered clouds		✓	Moderate			21-40	
✓	Light			Fog			Overcast	✓		Humid	✓	✓	41-60	✓
	Gusty									Precip.			61-80	
													>81	

Unusual activities near site, (if any): N/A, Rain occurred on and off for the last 8 hours.

Part B. Filter Data (Mass)

	Weight, g	Date	Recorded by:
Final			
Tare	4.1366	MAY 25 1989	WBaylor
Net			

Part C. TSP Calculations:

TSP conc. ($\mu g/M^3$) = Mass ÷ Volume of air sampled

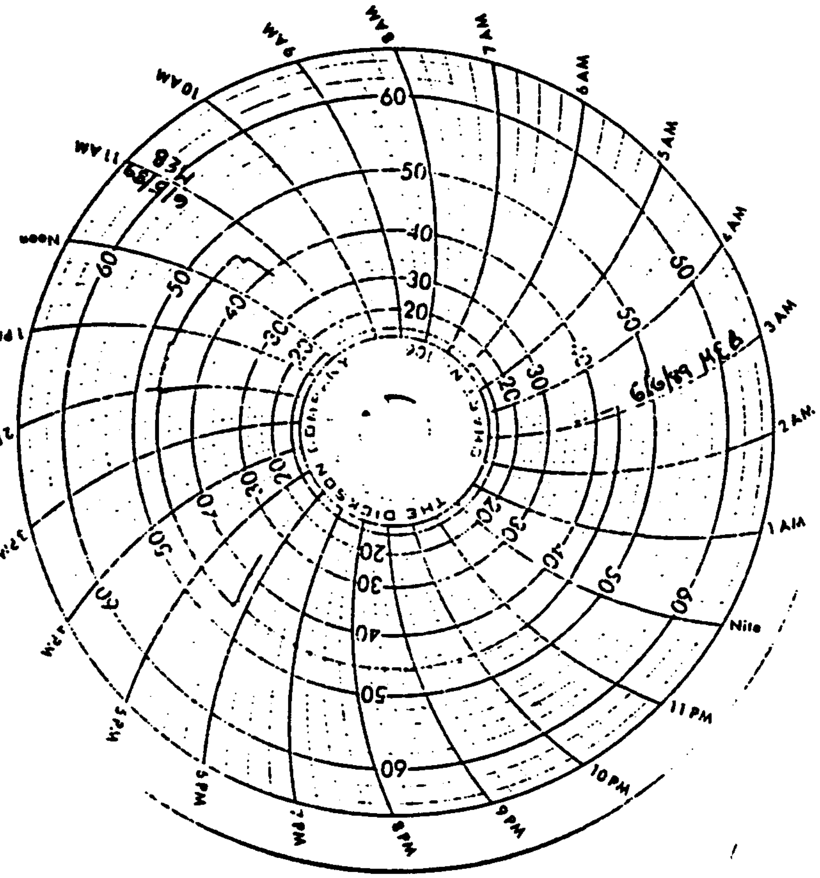
= Net weight ÷ Cubic Meters/min (CMM) x T_{min}

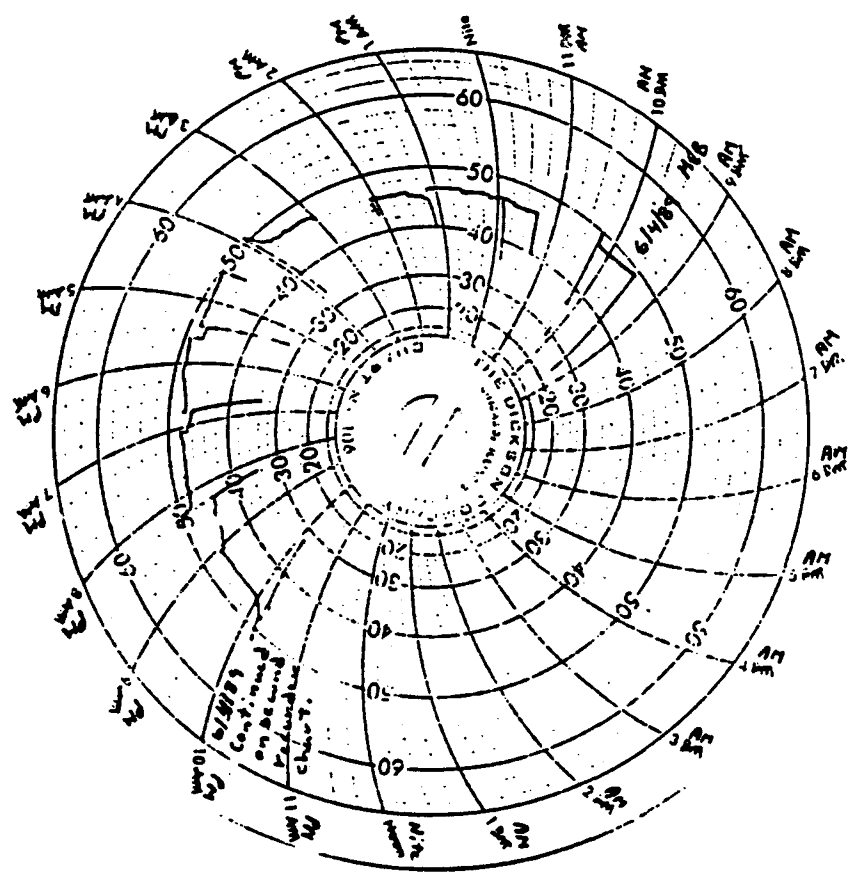
= ______ μg ÷ (________) x (________)

= ____________

Performed by: ____________ Checked by: ____________

Attach flow recorder chart here


6/5/89 HEB
6/6/89 HEB
THE DICKSON


6/4/89 HEB
THE DICKSON

6/4/89 McGuire AFB
Inst. ID 10
Filter No. 96563 (continued)

DATE 6/4/89
SITE McGuire AFB
Inst ~~PM-10~~ ID 10
FILTER NO. 96563

TSP DATA SUMMARY/CALCULATIONS

Battelle Filter No. 096564 Sampler ID 9

Part A. Field Data (Vol. of air sampled)

Project No. BOMARC Date, on 6/5/89 off 6/6/89

Site McGuire AFB Location 1 Recorded by: MEB

	Sampler Time		Flow Readings			Temp.	B.P.	Comments
	Time clock setting	Elapsed time meter	Calibrator in. H2O	Calibrator CMM	Dickson CMM	F	in. Hg	Time of calibration
Stop	0800	14 hr 20 min	7.8	49	33	67	29.85	0839 (6/6/89)
Start	1415	0	8.25	35	50	80	29.88	1407 (6/5/89)
Total, hr	17 hrs 45 min	14 hr 20 min						
Avg.			8.0	42	41.5	73.5	29.86	

Weather Conditions During Sampling:

Wind (Start)	Wind	Wind (Stop)	Visibility (Start)	Visibility	Visibility (Stop)	Sky (Start)	Sky	Sky (Stop)	Humidity (Start)	Humidity	Humidity (Stop)	Temp., F (Start)	Temp., F	Temp., F (Stop)
N	Direction	E	✓	Clear			Clear			Dry			< 20	
	Calm			Hazy	✓	✓	Scattered clouds		✓	Moderate	✓		21-40	
✓	Light	✓		Fog			Overcast	✓		Humid			41-60	
	Gusty									Precip.		✓	61-80	✓
													>81	

Unusual activities near site, (if any): NA, light rain for the last 8 hours

Part B. Filter Data (Mass)

	Weight, g	Date	Recorded by:
Final			
Tare	4.0975	MAY 25 1989	[signature]
Net			

Part C. TSP Calculations:

TSP conc. ($\mu g/M^3$) = Mass ÷ Volume of air sampled

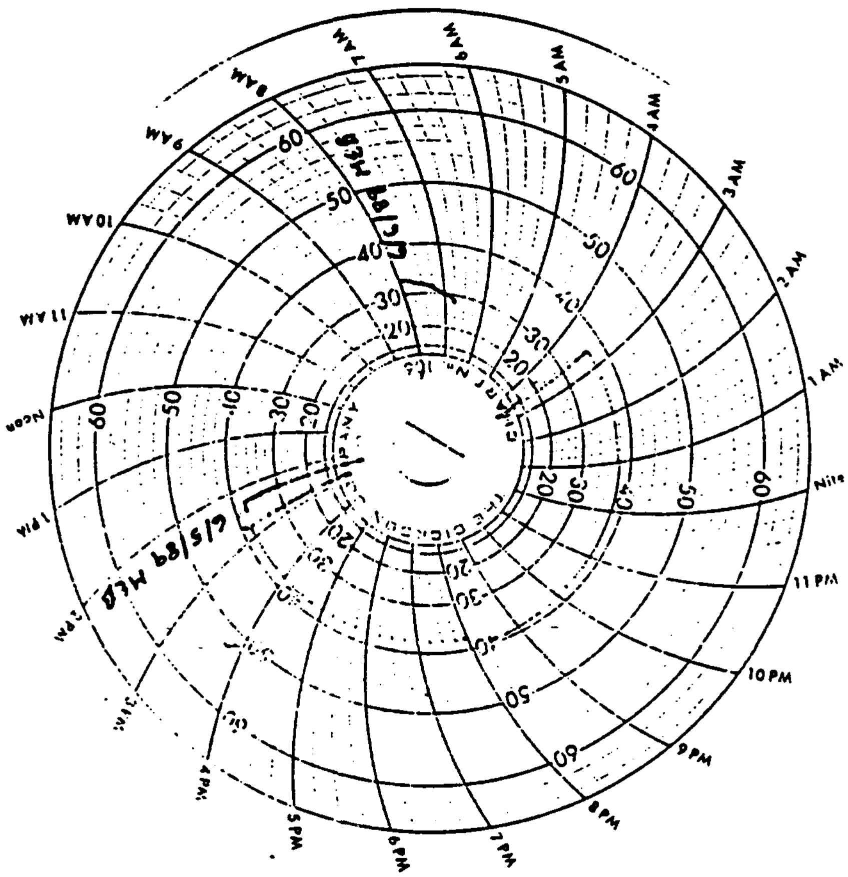
= Net weight ÷ Cubic Meters/min (CMM) x T_{min}

= ______ μg ÷ (________) x (________)

= __________

Performed by: ____________ Checked by: ____________

Attach flow recorder chart here



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6/5/89 MLB

Date 6/5/89
Site McGuire AFB
ID. 9
Filter# 96564

TSP DATA SUMMARY/CALCULATIONS

Battelle Filter No. 096565 Sampler ID 10

Part A. Field Data (Vol. of air sampled)

Project No. Bemarc Date, on 6/6/89 off 6/7/89

Site McGuire AFB Location 3 Recorded by: MEB

	Sampler Time		Flow Readings			Temp.	B.P.	Comments
	Time clock	Elapsed time meter	Calibrator in. H2O	CMM	Dickson CMM	F	in. Hg	Time of calibration
Stop	0930	26 hr 10 min	6.4	45	47	70	29.88	0940 (6/7/89)
Start	0720	0	6.6	45	44	65	29.83	0715 (6/6/89)
Total, hr	26 hr 10 min	26 hr 10 min						
Avg.			6.5	45	46	68	29.86	

Weather Conditions During Sampling:

Wind	Visibility	Sky	Humidity	Temp., F
Start E Direction Stop E	Start __ Clear __ Stop	Start __ Clear __ Stop	Start __ Dry __ Stop	Start __ < 20 __ Stop
✓ Calm __	✓ Hazy ✓	__ Scattered clouds __	__ Moderate __	__ 21-40 __
__ Light ✓	__ Fog __	✓ Overcast ✓	✓ Humid __	__ 41-60 __
__ Gusty __			__ Precip. ✓	✓ 61-80 ✓
				__ >81 __

Unusual activities near site, (if any): Heavy rain occurred on the morning of 6/7/89.

Part B. Filter Data (Mass)

	Weight, g	Date	Recorded by:
Final			
Tare	4.1207	MAY 25 1989	WBayton
Net			

Part C. TSP Calculations:

TSP conc. ($\mu g/M^3$) = Mass ÷ Volume of air sampled

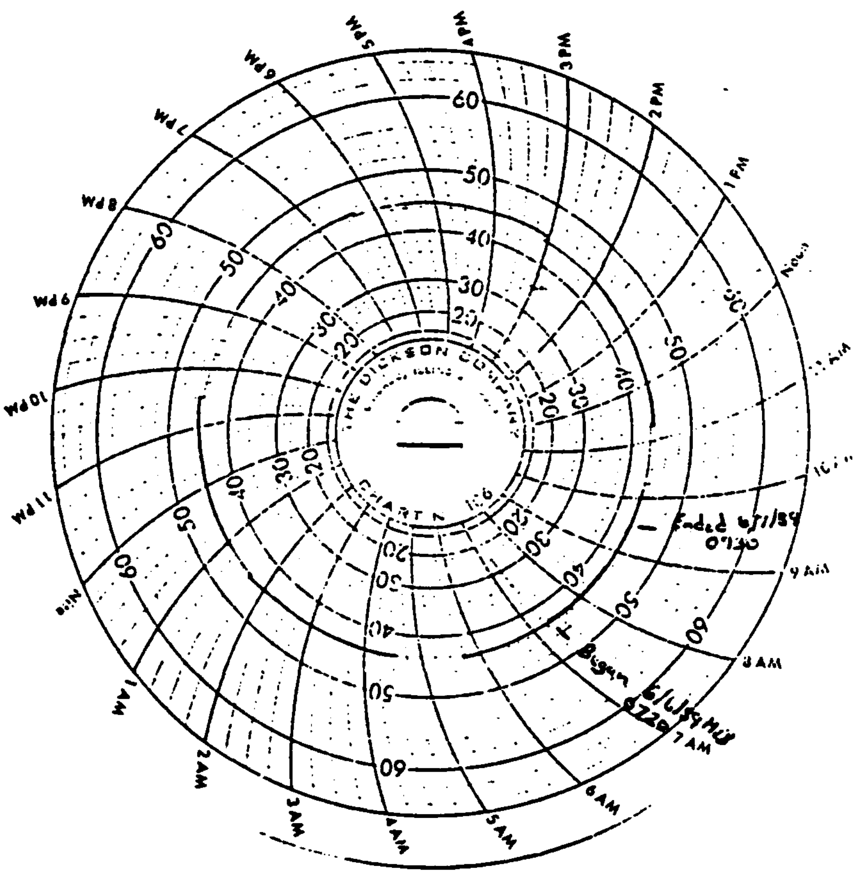
= Net weight ÷ Cubic Meters/min (CMM) x T_{min}

= ______ μg ÷ (________) x (________)

= ____________

Performed by: ____________ Checked by: ____________

Attach flow recorder chart here


THE DICKSON COMPANY
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Began
Ended

DATE 6/6/89
SITE McGuire AFB
PM-10 ID 10
FILTER NO. 96565

TSP DATA SUMMARY/CALCULATIONS

Battelle Filter No. 096566 Sampler ID 4

Part A. Field Data (Vol. of air sampled)

Project No. BOMARC Date, on 6/6/89 off 6/7/89

Site McGuire AFB Location 2 Recorded by: MEB

	Sampler Time		Flow Readings			Temp.	B.P.	Comments
	Time clock setting	Elapsed time meter	Calibrator in. H2O	Calibrator CMM	Dickson CMM	F	in. Hg	Time of calibration
Stop	1010	26hr 10min	7.0	46.5	42	70	29.38	1015 (6/7/89)
Start	0800	0	6.75	46	43	65	29.33	0750 (6/6/89)
Total, hr	26hr 10min	26hr 10min						
Avg.			6.9	46.3	43	68	29.36	

Weather Conditions During Sampling:

Wind Start	Wind	Wind Stop	Visibility Start	Visibility	Visibility Stop	Sky Start	Sky	Sky Stop	Humidity Start	Humidity	Humidity Stop	Temp., F Start	Temp., F	Temp., F Stop
E	Direction	E		Clear			Clear			Dry			< 20	
✓	Calm		✓	Hazy	✓		Scattered clouds			Moderate			21-40	
	Light			Fog		✓	Overcast	✓	✓	Humid		✓ (MEB)	41-60	
	Gusty	✓								Precip.	✓	✓	61-80	✓
													>81	

Unusual activities near site, (if any): Heavy rain occurred on the morning of 6/7/89

Part B. Filter Data (Mass)

	Weight, g	Date	Recorded by:
Final			
Tare	4.1445	MAY 25 1989	WDayton
Net			

Part C. TSP Calculations:

TSP conc. ($\mu g/M^3$) = Mass ÷ Volume of air sampled

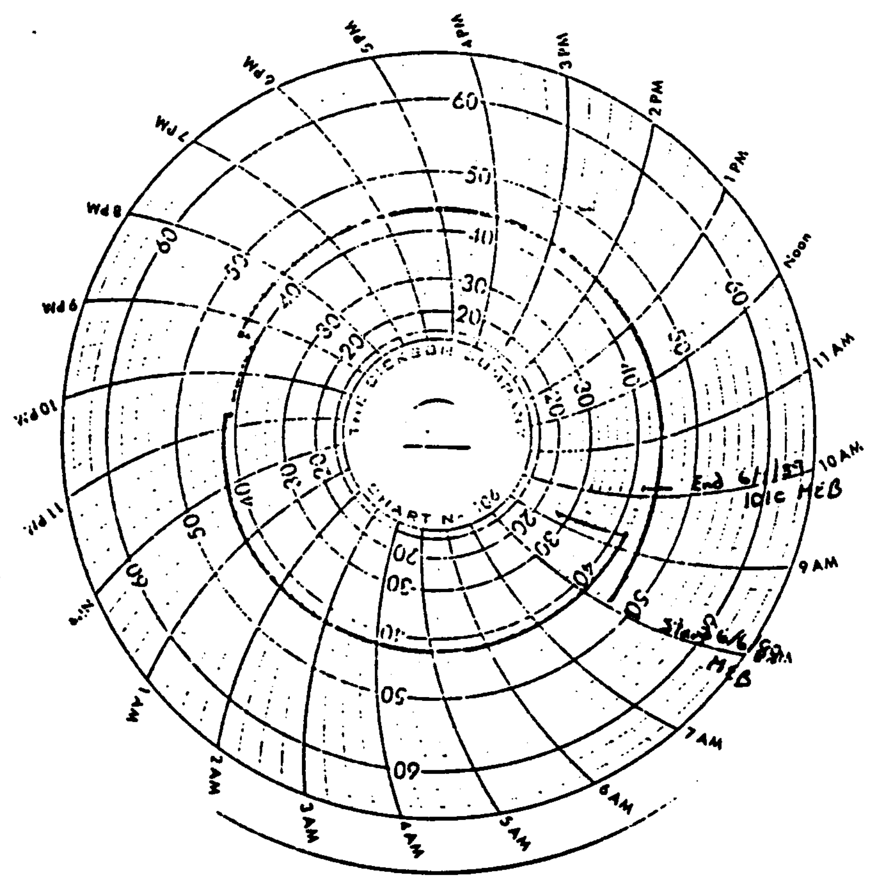
= Net weight ÷ Cubic Meters/min (CMM) x T_{min}

= ______ μg ÷ (________) x (________)

= ____________

Performed by:________________ Checked by:________________

Attach flow recorder chart here



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MCB
MCB

Date 6/6/89
Site McGuire AFB
I.D. 4
Filter# 96566

T S P - D A T A S U M M A R Y / C A L C U L A T I O N S

Battelle Filter No. 036567 Sampler ID 9

Part A. Field Data (Vol. of air sampled)

Project No. BOMARC Date, on 6/6/89 off 6/7/89

Site McGuire AFB Location 1 Recorded by: MEB

	Sampler Time		Flow Readings			Temp.	B.P.	Comments
	Time clock setting	Elapsed time meter	Calibrator in. H2O	Calibrator CFM	Dickson CMM	F	in. Hg	Time of calibration
Stop	1030	25hr 40min	8.4	50	34	70	29.88	1033 (6/7/89)
Start	0850	0	7.8	49	33	67	29.83	0834 (6/6/89)
Total, hr	25hr 40min	25hr 40min						
Avg.			8.1	50	34	69	29.86	

Weather Conditions During Sampling:

Wind Start	Wind	Wind Stop	Visibility Start	Visibility	Visibility Stop	Sky Start	Sky	Sky Stop	Humidity Start	Humidity	Humidity Stop	Temp., F Start	Temp., F	Temp., F Stop
E	Direction	E		Clear			Clear			Dry			< 20	
	Calm		✓	Hazy	✓		Scattered clouds		✓	Moderate			21-40	
✓	Light	✓		Fog		✓	Overcast	✓		Humid			41-60	
	Gusty									Precip.	✓	✓	61-80	✓
													>81	

Unusual activities near site, (if any): Heavy rain occurred on the morning of 6/7/89.

Part B. Filter Data (Mass)

	Weight, g	Date	Recorded by:
Final			
Tare	4.0850	MAY 25 1989	WBaytor
Net			

Part C. TSP Calculations:

TSP conc. ($\mu g/M^3$) = Mass ÷ Volume of air sampled

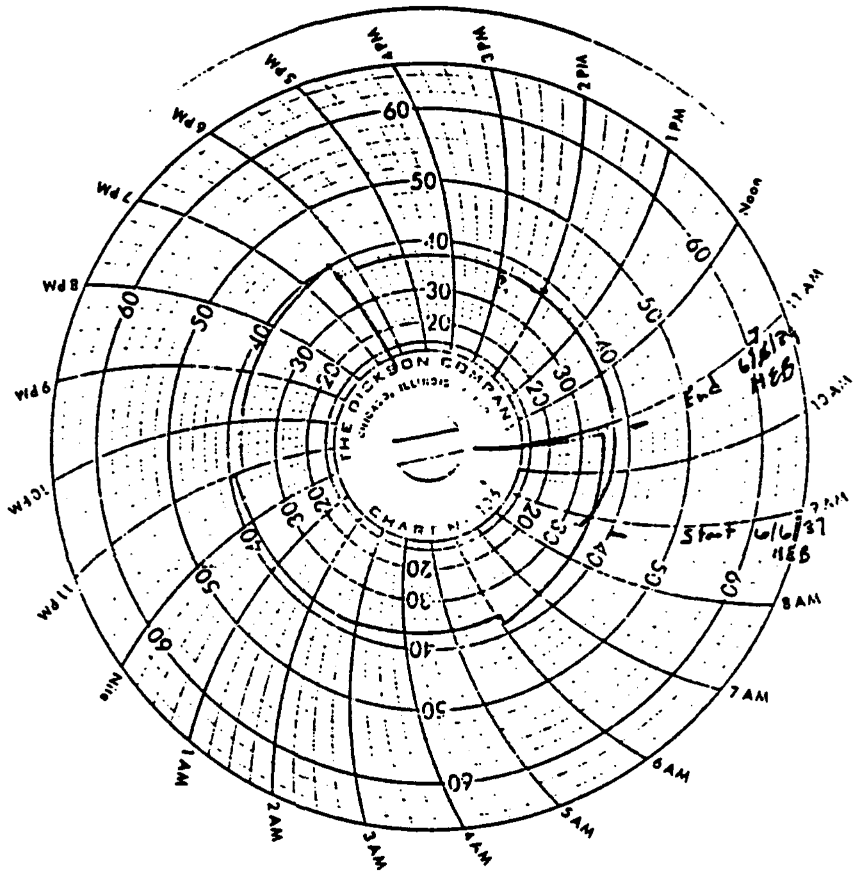
= Net weight ÷ Cubic Meters/min (CMM) x T_{min}

= ______ μg ÷ (__________) x (__________)

= ______________

Performed by:______________________ Checked by:______________________

Attach flow recorder chart here


THE DICKSON COMPANY
CHART No.
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Start 6/6/37
HEB
End
HEB

DATE 6/6/89
SITE McGuire AFB
PM-10 ID 9
FILTER NO. 96567

TSP DATA SUMMARY/CALCULATIONS

Battelle Filter No. 096568 Sampler ID 10

Part A. Field Data (Vol. of air sampled)

Project No. BOMARC Date, on 6/7/89 off 6/8/89

Site McGuire AFB Location 103 Recorded by: MEB

	Sampler Time		Flow Readings			Temp.	B.P.	Comments
	Timer clock setting	Elapsed time meter	Calibrator in. H2O	Calibrator CMM	Dickson CMM	F	in. Hg	Time of calibration
Stop	1052	24hr 46min	6.4	45	46	82	29.93	1104 (6/8/89)
Start	1006	0	6.4	45	47	70	29.88	0940 (6/7/89)
Total, hr	24hr 46min	24hr 46min						
Avg.			6.4	45	47	76	29.91	

Weather Conditions During Sampling:

Wind Start	Wind	Wind Stop	Visibility Start	Visibility	Visibility Stop	Sky Start	Sky	Sky Stop	Humidity Start	Humidity	Humidity Stop	Temp., F Start	Temp., F	Temp., F Stop
E	Direction	✓		Clear	✓		Clear			Dry			< 20	
	Calm	✓	✓	Hazy			Scattered clouds			Moderate	✓		21-40	
✓	Light			Fog		✓	Overcast	✓		Humid			41-60	
	Gusty								✓	Precip.		✓	61-80	
													>81	✓

Unusual activities near site, (if any): scattered light showers occurred throughout the early morning hours (6/8/89).

Part B. Filter Data (Mass)

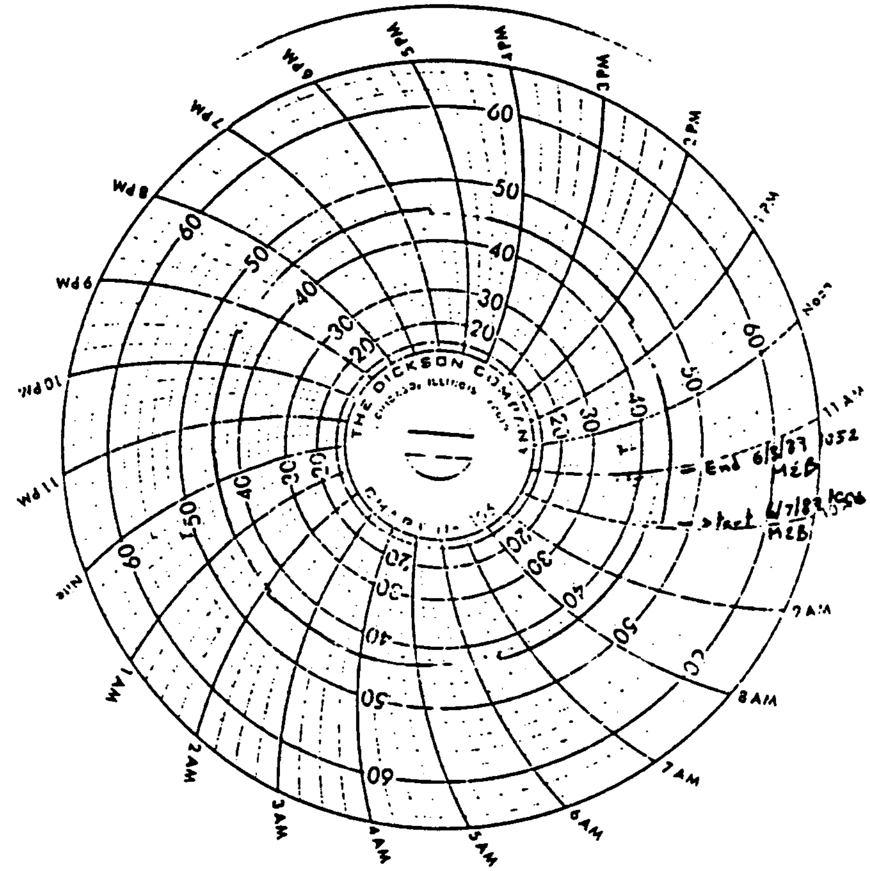
	Weight, g	Date	Recorded by:
Final			
Tare	4.1092	MAY 25 1989	[signature]
Net			

Part C. TSP Calculations:

TSP conc. ($\mu g/M^3$) = Mass ÷ Volume of air sampled
= Net weight ÷ Cubic Meters/min (CMM) x T_{min}
= ______ μg ÷ (________) x (________)
= ____________

Performed by: ____________ Checked by: ____________

Attach flow recorder chart here


THE DICKSON COMPANY
End 6/8/83 1052
MEB
Start 6/7/83 1056
MEB

DATE 6/7/89

SITE McGuire AFB

PM-10 ID 10

FILTER NO. 96568

TSP DATA SUMMARY/CALCULATIONS

Battelle Filter No. 096569 Sampler ID 4

Part A. Field Data (Vol. of air sampled)

Project No. BOMARC Date, on 6/7/89 off 6/8/89

Site McGuire AFB Location 2 Recorded by: HRB

	Sampler Time		Flow Readings			Temp.	B.P.	Comments
	Time, clock	Elapsed time meter	Calibrator in. H2O	Calibrator CMM	Dickson CMM	F	in. Hg	Time of calibration
Stop	~~1150~~ 0350	21 hr 42 min	6.5	45	44	82	29.93	1201 (6/8/89)
Start	1018	0	7.0	46.5	42	70	29.88	1015 (6/7/89)
Total, hr	~~25 hr 32 min~~ 21 hr 42 min	21 hr 42 min						
Avg.			6.8	46	43	76	29.91	

Weather Conditions During Sampling:

Wind (Start / Stop)	Visibility (Start / Stop)	Sky (Start / Stop)	Humidity (Start / Stop)	Temp., F (Start / Stop)
E Direction W	__ Clear ✓	__ Clear __	__ Dry __	__ < 20 __
__ Calm __	✓ Hazy __	__ Scattered clouds __	__ Moderate ✓	__ 21-40 __
✓ Light ✓	__ Fog __	✓ Overcast ✓	__ Humid __	__ 41-60 __
__ Gusty __			✓ Precip. __	✓ 61-80 __
				__ >81 ✓

Unusual activities near site, (if any): Scattered showers throughout early morning hours 6/8/89. Circuit breaker in generator was tripped for unknown reasons at 0350 hrs (6/8/89).

Part B. Filter Data (Mass)

	Weight, g	Date	Recorded by:
Final			
Tare	4.0963	MAY 25 1989	W Bayton
Net			

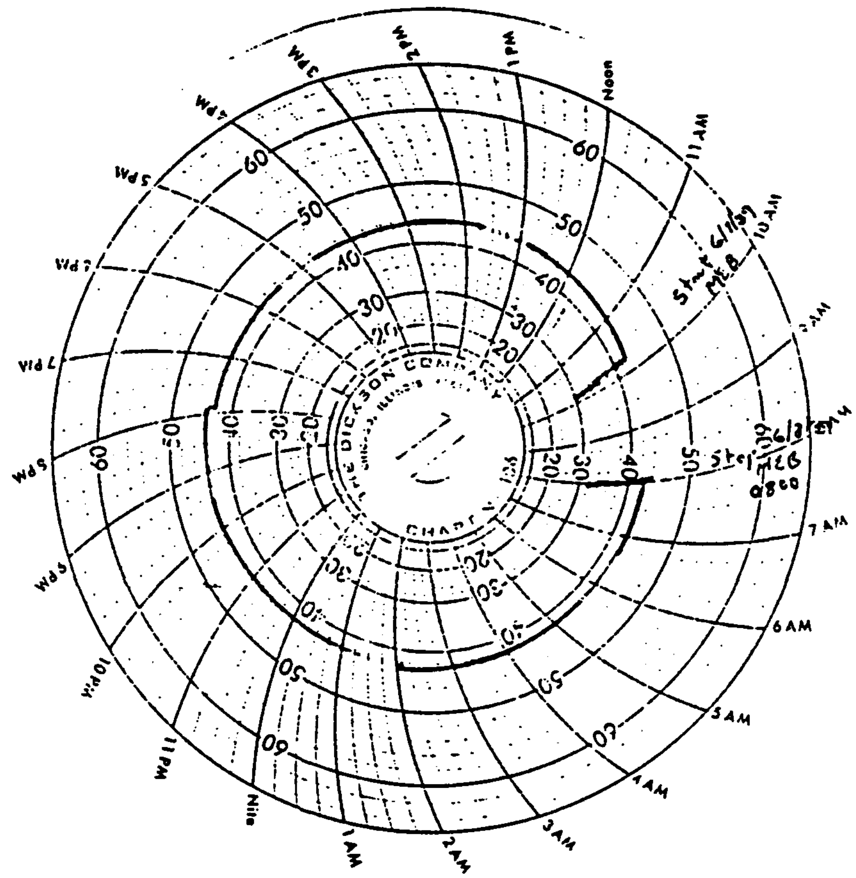
Part C. TSP Calculations:

TSP conc. ($\mu g/M^3$) = Mass ÷ Volume of air sampled
= Net weight ÷ Cubic Meters/min (CMM) x T_{min}
= _____ μg ÷ (_____) x (_____)
= _____

Attach flow recorder chart here

Performed by: _____ Checked by: _____

DATE 6/7/89
SITE McGuire AFB
PM-10 ID 4
FILTER NO. 96569


Noon
11 AM
10 AM
7 AM
6 AM
5 AM
4 AM
3 AM
2 AM
1 AM
Nite
11 PM
10 PM
1 PM
2 PM
3 PM
0800

TSP DATA SUMMARY/CALCULATIONS

Battelle Filter No. 098570 Sampler ID 4

Part A. Field Data (Vol. of air sampled)

Project No. BOMARC Date, on 6/7/89 off 6/8/89

Site McGuire AFB Location 1 Recorded by: MEB

	Sampler Time		Flow Readings			Temp.	B.P.	Comments
	Time clock	Elapsed time meter	Calibrator in. H2O	Calibrator CMM	Dickson CMM	F	in. Hg	Time of calibration
Stop	1238	26 hr 3 min	7.8	49	30	82	29.93	1247 (6/8/89)
Start	1035	0	8.4	50	34	70	29.83	1035 (6/7/89)
Total, hr	26 hr 3 min	26 hr 3 min						
Avg.			8.1	50	32	76	29.91	

Weather Conditions During Sampling:

Wind			Visibility			Sky			Humidity			Temp., F		
Start		Stop	Start		Stop	Start		Stop	Start		Stop	Start		Stop
E	Direction	✓		Clear	✓		Clear			Dry			< 20	
	Calm		✓	Hazy			Scattered clouds			Moderate	✓		21-40	
✓	Light	✓		Fog		✓	Overcast	✓		Humid			41-60	
	Gusty								✓	Precip.		✓	61-80	
													>81	✓

Unusual activities near site, (if any): scattered light showers occurred throughout the early morning hours (6/7/89).

Part B. Filter Data (Mass)

	Weight, g	Date	Recorded by:
Final			
Tare	4.0941	MAY 25 1989	MBaytor
Net			

Part C. TSP Calculations:

TSP conc. ($\mu g/M^3$) = Mass ÷ Volume of air sampled

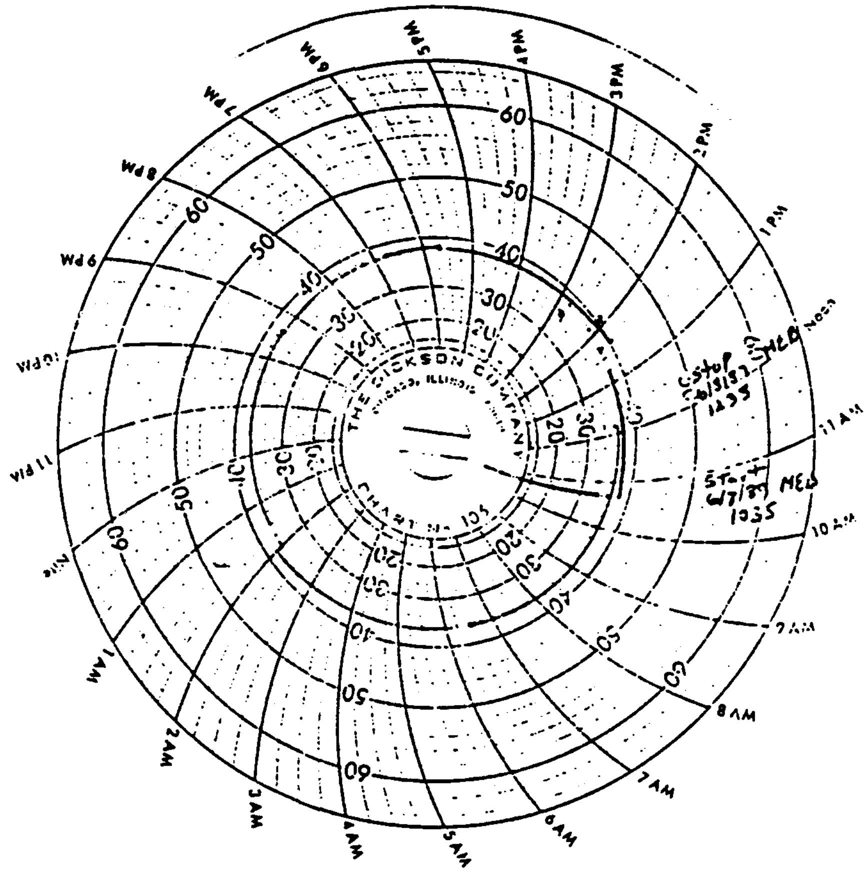
= Net weight ÷ Cubic Meters/min (CMM) x T_{min}

= ______ µg ÷ (________) x (________)

= ____________

Performed by:______________ Checked by:______________

Attach flow recorder chart here


THE DICKSON COMPANY
3 PM
2 PM
1 PM
11 AM
10 AM
8 AM
7 AM
6 AM
5 AM
4 AM
3 AM
2 AM
1 AM

DATE 6/7/89

SITE McGuire AFB

PM-10 ID 9

FILTER NO. 96570

T S P   D A T A   S U M M A R Y / C A L C U L A T I O N S

Battelle Filter No. 096571 Sampler ID 10

Part A. Field Data (Vol. of air sampled)

Project No. BOMARC Date, on 6/8/89 off 6/9/89

Site McGuire AFB Location 3 Recorded by: HEB

	Sampler Time		Flow Readings			Temp.	B.P.	Comments
	Time clock setting	Elapsed time meter	Calibrator in. H2O	CMM	Dickson CMM	F	in. Hg	Time of calibration
Stop	1145	24hr 15min	6.5	45	50	70	29.89	1200 (6/9/89)
Start	1130	0	6.4	45	46	82	29.93	1104 (6/8/89)
Total, hr	24hr 15min	24hr 15min						
Avg.			6.5	45	48		29.91	

Weather Conditions During Sampling:

Wind Start	Wind	Wind Stop	Visibility Start	Visibility	Visibility Stop	Sky Start	Sky	Sky Stop	Humidity Start	Humidity	Humidity Stop	Temp., F Start	Temp., F	Temp., F Stop
W	Direction	N	✓	Clear			Clear			Dry			< 20	
✓	Calm			Hazy	✓		Scattered clouds		✓	Moderate			21-40	
	Light	✓		Fog		✓	Overcast	✓		Humid			41-60	
	Gusty									Precip.	✓		61-80	✓
												✓	>81	

Unusual activities near site, (if any): Light rain throughout the early morning hours (6/9/89).

Part B. Filter Data (Mass)

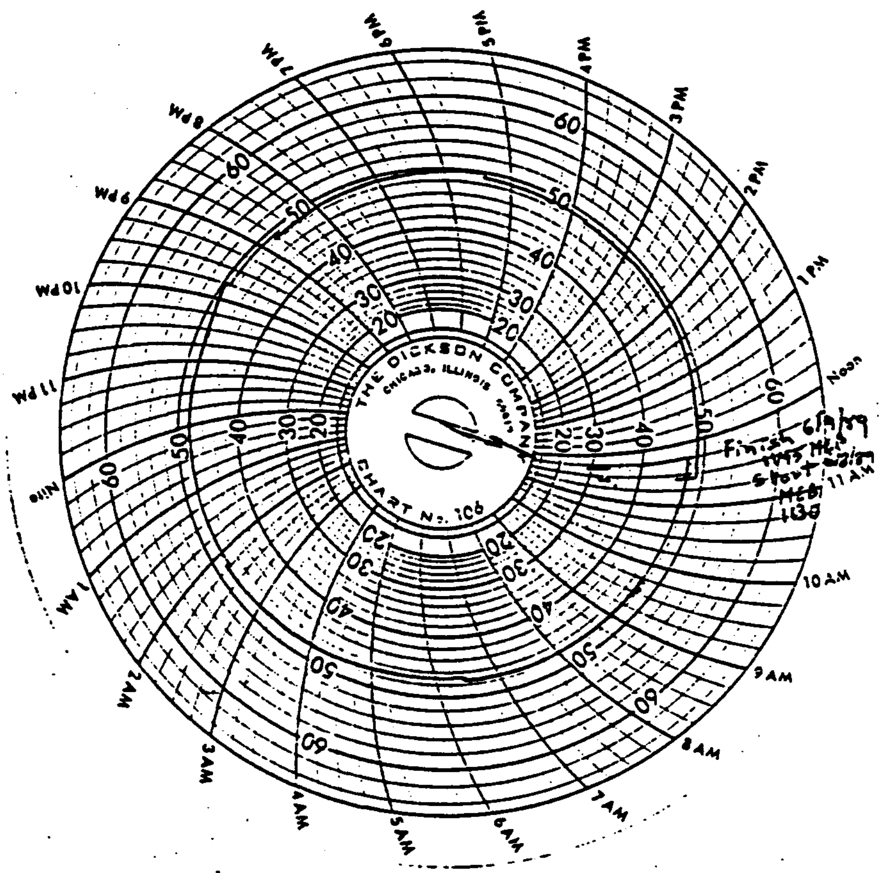
	Weight, g	Date	Recorded by:
Final			
Tare	4.0970	MAY 25 1989	WBaytor
Net			

Part C. TSP Calculations:

TSP conc. ($\mu g/M^3$) = Mass ÷ Volume of air sampled
= Net weight ÷ Cubic Meters/min (CMM) x T_{min}
= ______ µg ÷ (________) x (________)
= ________

Performed by: ________________ Checked by: ________________

Attach flow recorder chart here


THE DICKSON COMPANY
CHICAGO, ILLINOIS
CHART No. 106
Noon
1PM
2PM
3PM
4PM
5PM
6PM
7PM
8PM
9PM
10PM
11PM
Mid
1AM
2AM
3AM
4AM
5AM
6AM
7AM
8AM
9AM
10AM
20
30
40
50
60
Finish
Start
11 AM
1130

DATE 6/8/89
SITE McGuire AFB
PM-10 ID 10
~~FILTER~~ NO. 96571

TSP DATA SUMMARY/CALCULATIONS

Battelle Filter No. 096572 Sampler ID 4

Part A. Field Data (Vol. of air sampled)

Project No. SoMARC Date, on 6/8/89 off 6/9/89

Site McGuire AFB Location 2 Recorded by: MEB

	Sampler Time		Flow Readings			Temp.	B.P.	Comments
	Time clock setting	Elapsed time meter	Calibrator in. H2O	Calibrator CMM	Dickson CMM	F	in. Hg	Time of calibration
Stop	1235	24hr 0min	7.0	46.5	43	70	29.89	1250 (6/9/89)
Start	1235	0	6.5	45	44	82	29.93	1201 (6/8/89)
Total, hr	24hr 0min	24hr 0min						
Avg.								

Weather Conditions During Sampling:

Wind			Visibility			Sky			Humidity			Temp., F		
Start		Stop	Start		Stop	Start		Stop	Start		Stop	Start		Stop
W	Direction	N	✓	Clear			Clear			Dry			< 20	
	Calm			Hazy	✓		Scattered clouds		✓	Moderate			21-40	
✓	Light	✓		Fog		✓	Overcast	✓		Humid			41-60	
	Gusty									Precip.	✓		61-80	✓
												✓	>81	

Unusual activities near site, (if any): light rain occurred throughout early morning hours.

Part B. Filter Data (Mass)

	Weight, g	Date	Recorded by:
Final			
Tare	4.0584	MAY 25 1989	WBayton
Net			

Part C. TSP Calculations:

TSP conc. ($\mu g/M^3$) = Mass ÷ Volume of air sampled

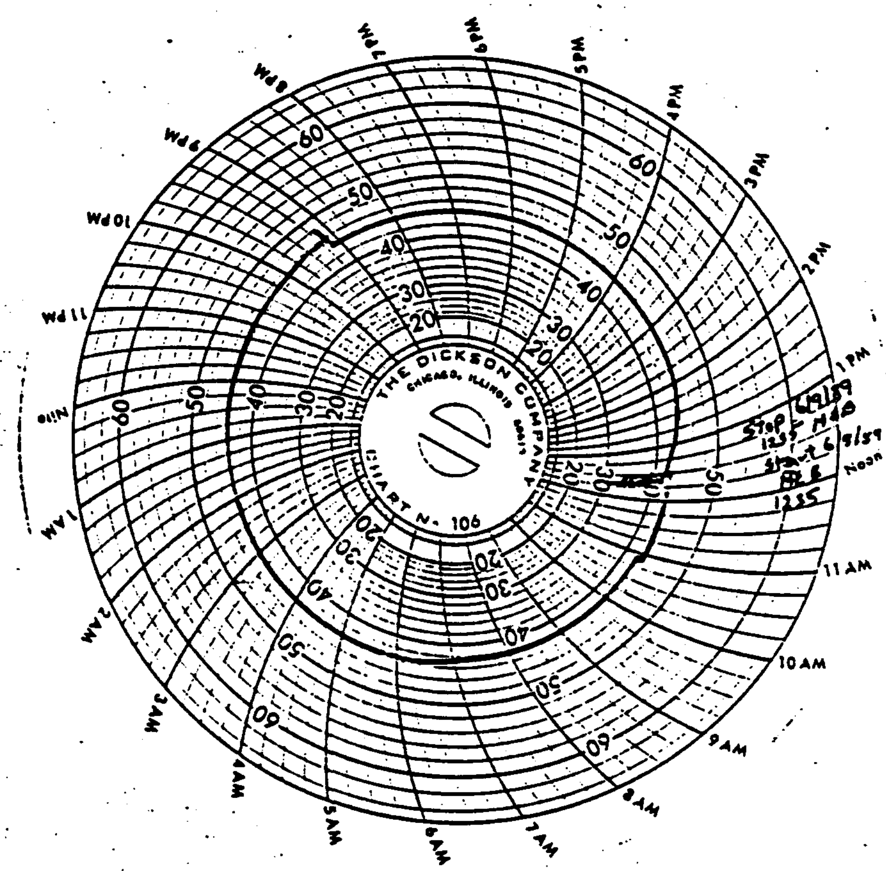
= Net weight ÷ Cubic Meters/min (CMM) x T_{min}

= ______ μg ÷ (________) x (________)

= ____________

Performed by:____________ Checked by:____________

Attach flow recorder chart here


THE DICKSON COMPANY
CHICAGO, ILLINOIS
CHART No. 106
Stop 6/9/59
1235
Start 6/9/59
1235
Noon
1 PM
2 PM
3 PM
4 PM
5 PM
6 PM
7 PM
8 PM
9 PM
10 PM
11 PM
Nite
1 AM
2 AM
3 AM
4 AM
5 AM
6 AM
7 AM
8 AM
9 AM
10 AM
11 AM

TSP DATA SUMMARY/CALCULATIONS

Battelle Filter No. 096573 Sampler ID 9

Part A. Field Data (Vol. of air sampled)

Project No. BCMARC Date, on 6/8/89 off 6/9/89

Site McGuire AFB Location 1 Recorded by: MEB

	Sampler Time: Time clock setting	Sampler Time: Elapsed time meter	Flow Readings: Calibrator in. H2O	Flow Readings: Calibrator CMM	Flow Readings: Dickson CMM	Temp. F	B.P. in. Hg	Comments: Time of calibration
Stop	1300	24 hrs 0 min	8.0	49	34	70	29.89	1310 (6/9/89)
Start	1300	0	7.8	49	30	82	29.93	1247 (6/8/89)
Total, hr	24 hrs 0 min	24 hrs 0 min						
Avg.			7.9	49	32		29.91	

Weather Conditions During Sampling:

Wind (Start)	Wind	Wind (Stop)	Visibility (Start)	Visibility	Visibility (Stop)	Sky (Start)	Sky	Sky (Stop)	Humidity (Start)	Humidity	Humidity (Stop)	Temp., F (Start)	Temp., F	Temp., F (Stop)
W	Direction		✓	Clear			Clear			Dry			< 20	
	Calm	✓		Hazy	✓		Scattered clouds		✓	Moderate			21-40	
✓	Light			Fog		✓	Overcast	✓		Humid	✓		41-60	
	Gusty									Precip.			61-80	✓
												✓	>81	

Unusual activities near site, (if any): Light rain throughout the morning hours (6/9/89)

Part B. Filter Data (Mass)

	Weight, g	Date	Recorded by:
Final			
Tare	4.0723	MAY 25 1989	WBayton
Net			

Part C. TSP Calculations:

TSP conc. ($\mu g/M^3$) = Mass ÷ Volume of air sampled

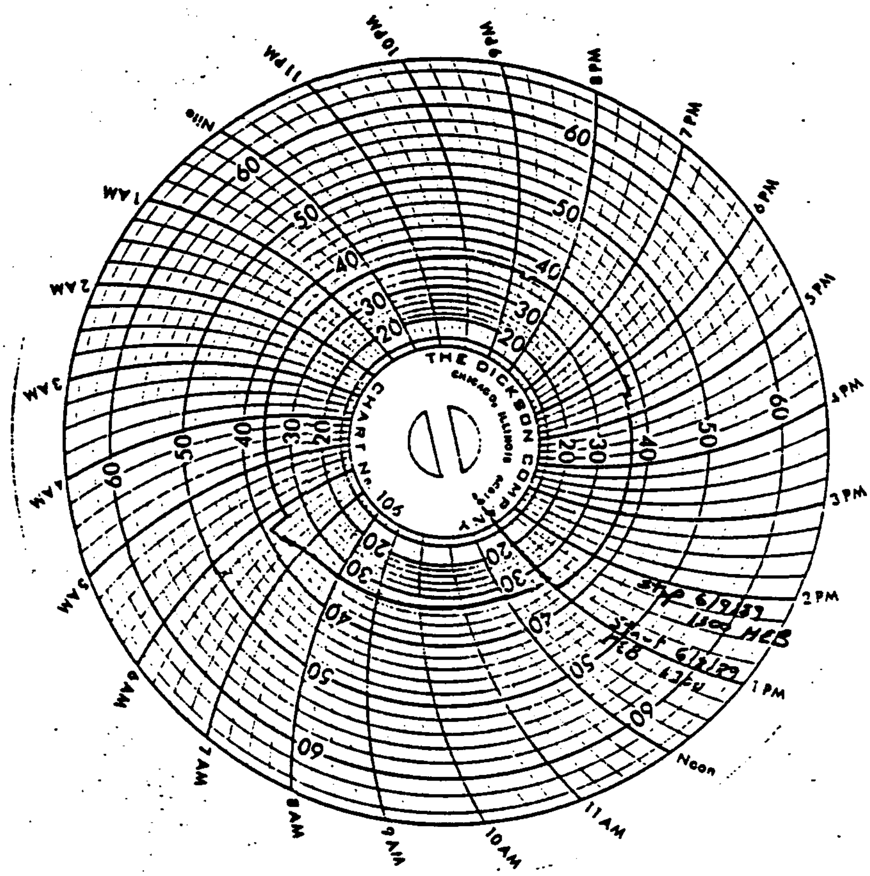
= Net weight ÷ Cubic Meters/min (CMM) x T_{min}

= ______ µg ÷ (________) x (________)

= ____________

Performed by:____________ Checked by:____________

Attach flow recorder chart here


THE DICKSON COMPANY
CHICAGO, ILLINOIS
CHART No. 105
Noon
1 PM
2 PM
3 PM
4 PM
5 PM
6 PM
7 PM
8 PM
9 PM
10 PM
11 PM
Nite
1 AM
2 AM
3 AM
4 AM
5 AM
6 AM
7 AM
8 AM
9 AM
10 AM
11 AM

DATE 6/8/89
SITE McGuire AFB
PM-10 ID 9
FILTER NO. 96573

Well Purging and Sampling Data

Well Purging and Sampling Data

Site: BOMARC FACILITY | Well No.: PU-3

Date(s): 7/7/89 | Geologist: Byrnes / Olsen

Purging Bailer: 1.5" stainless steel | Equipment Used: Tripod and Reel

Sampling Bailer: 1.5" teflon | Measurement Reference Datum: Top of Casing (TC

DATA FROM IMMEDIATELY BEFORE AND AFTER DEVELOPMENT

Depth to water measured from TOC (ft.): Before Purging: 48.67' | After Purging: 48.67' | After Sampling: 48.70'

Total purging time (min.): ______

Depth to sediment in well (ft.): Before Purging: 58.60' After Purging 58.60' 58.30'

	Time Since Purging Started (min)	Time	Cumulative Volume Removed (1)	Water Temp °C	pH of Water	Conductivity (µmhos/cm)	Water* Appearance	Primary** Particulates	OVA/HNu ~~Date~~
Before	0	1402	0	19.4	4.85	65	Cl	Cl	4.2/0
During	9	1411	1.5	15.6	4.39	60	CO/OG	ML	0/0
During	5	1416	3.0	14.4	4.35	55	CO/OG	ML	0/0
During	8	1424	4.5	14.7	4.41	60	CO/OG	ML	0.2/0
During	8	1432	6.0	14.8	4.45	60	CO/OG	ML	0.2/0
During	4	1436	7.5	14.6	4.37	60	CO/OG	ML	0.2/0
During	10	1446	8.5	14.5	[illegible]	50	[illegible]	[illegible]	[illegible]
After		1450	9.0	14.5	4.50	60	CO/TU	ML	0/0
		1535	9.5	16.9	4.59	62	CO/TU	ML	0/0
		1542	9.5	16.3	4.46	55	CO/TU	ML	0/0

*CL = clear, CO = cloudy, TU = turbid

**Particle: S = sand (Settle Time 1 min), ML = silt (1-2 hr), CL = clay (hrs)

Comments: 3 well Volumes = 4.86 gallons

~~Background~~ OVA Reading: 8.0 ppm

1.0	1558 ~~4.63~~	15.3 ~~14.6~~	4.63	55	0/0
1.5	1603	15.4	4.69	53	0/0

10 after taken

Field Water Quality Sampling and Analyses

Project: BOMARC
Pu-3

Instruments:
Temperature: Orion Research / 230 series
Conductivity: YSI / Model 33
pH: Orion Research / 230 series

General	Location		Pu-3	Pu-3	Pu-3	Pu-3	Pu-3
	Source		Well/GW				
	Sample ID		001-GW-PU3-001				
	Date		7-7-89				
	Clock Time or Pumping Time		1402	1411	1416	1424	1432
Sampling Conditions	Sampling Method		Bailing	Bailing	Bailing	Bailing	Bailing
	Depth Sample Taken		48.67	48.67	48.67	48.67	48.67
	Well Depth		58.60	58.60	58.60	58.60	58.60
	Water Height on Gauge or Staff						
	Discharge (cfs or gpm)						
	Weather		Sunny, 88°				
			V-humid				
Field Measurements and Analyses	Temperature (°C or ~~°F~~)		19.4°C	15.6°C	14.4°C	14.7°C	14.8°C
	Elec. Cond. (μmhos/cm)	Measured	65	60	55	60	60
		At 25°C					
	pH		4.85	4.39	4.35	4.41	4.45
	Eh						
Samples Collected and Treatment	~~Gross~~ Gross Beta	unfiltered HNO3 ~~unpreserved~~					
	~~Trace Metals~~ Gross Alpha	filtered HNO_3					
	Radiologics	unfiltered ~~HCl~~ HNO3					
	Nutrients	filtered HgCl					
	Gross Alpha	Unfiltered HNO3					
	Gross Beta	Unfiltered HNO3					
	Alpha Spec.	Unfiltered HNO3					
	Chain of Custody Y/N						
	Laboratory Sent To/Date						
Sample/Analyzed By							

Field Water Quality Sampling and Analyses

Project: BOMARC

Pu-3

Instruments:

Temperature: Orion 230

Conductivity: YSI 33

pH: Orion 230

General	Location		Pu-3	Pu-3	Pu-3		
	Source		groundwater	groundwater	groundwater		
	Sample ID		001-GW-PU3-001				
	Date		7-7-89	7-7-89	7-7-89	7-7-89	7-7-89
	Clock Time or Pumping Time		1436	1446	1457	1535	1542
Sampling Conditions	Sampling Method		Bailing	Bailing	Bailing		
	Depth Sample Taken		48.67'	48.67'	48.67'		
	Well Depth		58.60'	58.60'	58.60'		
	Water Height on Gauge or Staff						
	Discharge (cfs or gpm)						
	Weather		Sunny, ↑89°				
			V. humid				
Field Measurements and Analyses	Temperature (°C or ~~°F~~)		15.6	14.5	14.5	16.9	16.3
	Elec. Cond. (µmhos/cm)	Measured	60	59	60	62	55
		At 25°C					
	pH		4.37	4.34	4.50	4.59	4.46
	Eh						
Samples Collected and Treatment	Gross Alpha	unfiltered ~~unpreserved~~ HNO3			✓		
	~~Trace Metals~~ Pu 239 Alpha Spec	unfiltered HNO_3			✓		
	~~Radiologics~~ Gross Beta	unfiltered ~~HCl~~ HNO3			✓		
	Nutrients	filtered HgCl					
	Gross Alpha	filtered HNO3			✓		
	Gross Beta	filtered HNO3			✓		
	Pu239 Alpha Spec	filtered HNO3			✓		
	Chain of Custody Y/N				Y		
	Laboratory Sent To/Date						
Sample/Analyzed By							

Field Water Quality Sampling and Analyses

Project: Bomarc Missile Site

Pu-3

Instruments:

Temperature: Orion 230

Conductivity: YSI 33

pH: Orion 230

General	Location		Pu-3	Pu-3			
	Source		Groundwater	Groundwater			
	Sample ID		001-GW-	PU3-001			
	Date		7-7-89	7-7-89			
	Clock Time or Pumping Time		1558	1603			
Sampling Conditions	Sampling Method		Bailing	Bailing			
	Depth Sample Taken						
	Well Depth		58.60	58.60			
	Water Height on Gauge or Staff						
	Discharge (cfs or gpm)						
	Weather						
Field Measurements and Analyses	Temperature (°C or ~~°F~~)		15.3	15.4			
	Elec. Cond. (μmhos/cm)	Measured	55	53			
		At 25°C					
	pH		4.63	4.69			
	Eh						
Samples Collected and Treatment	Gross	unfiltered unpreserved					
	Trace Metals	filtered HNO_3					
	Radiologics	unfiltered HCl					
	Nutrients	filtered HgCl					
	Chain of Custody Y/N						
	Laboratory Sent To/Date						
Sample/Analyzed By							

Well Purging and Sampling Data

Site BOMARC FACILITY Well No. PU-4

Date(s) 7/8/89 Geologist Byrnes / Olsen

Purging Bailer 1.5" Stainless Steel Equipment Used Tripod and Reel

Sampling Bailer 1.5" teflon Measurement Reference Datum Top of Casing (TOC)

DATA FROM IMMEDIATELY BEFORE AND AFTER DEVELOPMENT

Depth to water measured from TOC (ft.): Before Purging: 48.13' After Purging: 48.70' After Sampling: ~~52.50~~ 48.15'

Total purging time (min.): 14

Depth to sediment in well (ft.): Before Purging: 52.50' After Purging 52.50'

	Time Since Purging Started (min)	Time	Cumulative Volume Removed (1)	Water Temp °C	pH of Water	Conductivity (µmhos/cm)	Water* Appear-ance	Primary** Particu-lates	OVA/HNu Date
Before	0	0635	0	14.2	3.40	120	Cl	CL	4.0/0
During	6	0641	1.0	12.8	3.40	119	Co/brn	ML	0/0
During	4	0644	2.0	12.8	3.53	121	co/brn	ML	0/0
During	5	0649	3.0	12.8	3.57	115	Co/brn	ML	0/0
During									
During									
During									
After		0708		13.5	3.43	120	co/brn	ML	0/0

*CL = clear	**Particle	Settle Time
CO = cloudy	S = sand	1 min
TU = turbid	ML = silt	1-2 hr
	CL = clay	hrs

Comments 3 Well Volumes : 2.14 gallons

Background OVA reading :

Initial Reading upon opening well :

OVA reading : 4.0

HNu reading : 0.0

Initial Breathing zone reading upon opening well :

OVA reading : 0.0

HNu reading : 0.0

Field Water Quality Sampling and Analyses

Project: Bomarc Missile Site

Pu-4·

Instruments:

Temperature: Orion 230

Conductivity: YSI Model 33

pH: Orion 230

General	Location		Pu-4	Pu-4			
	Source		Groundwater	Groundwater			
	Sample ID		001-GW-	PU4-001			
	Date		7-7-89	7-7-89			
	Clock Time or Pumping Time		1019	1045			
Sampling Conditions	Sampling Method		Bailing	Bailing			
	Depth Sample Taken		39.55	39.55			
	Well Depth		47.55	47.55			
	Water Height on Gauge or Staff						
	Discharge (cfs or gpm)						
	Weather		sunny, 90, humid				
Field Measurements and Analyses	Temperature (°C or °F)		18.0	16.1			
	Elec. Cond. (μmhos/cm)	Measured	35	35			
		At 25°C					
	pH		4.37	4.44			
	Eh						
Samples Collected and Treatment	Gross	unfiltered unpreserved		✓			
	Trace Metals	filtered HNO_3					
	Radiologics	unfiltered HCl					
	Nutrients	filtered HgCl					
				✓			
				✓			
				✓			
	Chain of Custody Y/N			Y			
	Laboratory Sent To/Date						
Sample/Analyzed By				CC, HB			

Field Water Quality Sampling and Analyses

Project: BOMARC Missile Site

PU-4

Instruments:
Temperature: Orion 230
Conductivity: YSI model 33
pH: Orion 230

General	Location	PU-4				
	Source	Groundwater				
	Sample ID	COL-GW-PU4-001				
	Date	7-8-89				
	Clock Time or Pumping Time	0635	0641	0644	0649	0708
Sampling Conditions	Sampling Method	Bailing				
	Depth Sample Taken	45.13				
	Well Depth	52.50				
	Water Height on Gauge or Staff					
	Discharge (cfs or gpm)					
	Weather	Sunny, ↓90's humid				
Field Measurements and Analyses	Temperature (°C or °F)	14.2	12.8	12.8	12.8	13.5
	Elec. Cond. (µmhos/cm) Measured	120	119	121	115	120
	Elec. Cond. (µmhos/cm) At 25°C					
	pH	3.40	3.40	3.53	3.57	3.43
	Eh					
Samples Collected and Treatment	Gross Alpha/Beta unfiltered ~~unpreserved~~ HNO3					✓
	Trace Metals filtered HNO_3					
	Radiologics unfiltered HCl					
	Nutrients filtered HgCl					
	Gross Alpha/Beta filtered HNO_3					✓
	Pu 239 Alpha Spec filtered HNO_3					✓
	Pu 239 Alpha Spec unfiltered HNO_3					✓
	Chain of Custody Y/N					Y
	Laboratory Sent To/Date					
	Sample/Analyzed By					

Well Purging and Sampling Data

Site BOMARC FACILITY

Well No. PU-6

Date(s) 7/7/89

Geologist Byrnes / Olsen

Purging Bailer 1.5" stainless steel

Equipment Used Tripod and Reel

Sampling Bailer 1.5" teflon

Measurement Reference Datum Top of Casing (TC

DATA FROM IMMEDIATELY BEFORE AND AFTER DEVELOPMENT

Depth to water measured from TOC (ft.): Before Purging: 39.55 After Purging: 39.55 After Sampling: 39.55

Total purging time (min.): 25

Depth to sediment in well (ft.): Before Purging: 47.55 After Purging 47.55

	Time Since Purging Started (min)	Time	Cumulative Volume Removed (l)	Water Temp °C	pH of Water	Conductivity (μmhos/cm)	Water* Appear-ance	Primary** Particu-lates	OVA/HNu ~~Date~~
Before	0	0950	0	17.9	6.76	40	Cl	Cl	0/1.0
During	10	1000	1.0	13.3	5.60	35	Co/orng	ML	0/0
During	7	1007	2.0	13.0	4.60	35	Co/orng	ML	0/0
During	4	1011	3.0	13.2	4.46	35	Co/orng	ML	0/0
During	4	1015	4.0	13.2	4.38	35	Co/orng	ML	0/0
During	4	1019	5.0	13.0	4.37	35	Co/orng	ML	0/0
During									
After	26	1045	6.0	16.1	4.44	35	Co/orng	ML	0/0

*Appearance	**Particle	Settle Time
CL = clear	S = sand	1 min
CO = cloudy	ML = silt	1-2 hr
TU = turbid	CL = clay	hrs

Comments 3 well Volumes =

Background OVA Reading :

Background HNu Reading :

Initial Readings upon First Opening Well :

OVA Reading :

HNu Reading :

Initial Breathing zone readings upon First opening well :

OVA Reading :

HNu Reading :

Well Purging and Sampling Data

Site BOMARC FACILITY

Well No. ~~PU~~ 60 MW-47

Date(s) 7/8/89

Geologist Byrnes / Olsen

Purging Bailer 1.5" Stainless Steel

Equipment Used Tripod and Reel

Sampling Bailer 1.5" teflon

Measurement Reference Datum Top of Casing (TOC)

DATA FROM IMMEDIATELY BEFORE AND AFTER DEVELOPMENT

Depth to water measured from TOC (ft.): Before Purging: 41.15' ; After Purging: 41.37' ; After Sampling: 41.30'

Total purging time (min.): 33

Depth to sediment in well (ft.): Before Purging: 53.80' After Purging 53.80'

	Time Since Purging Started (min)	Time	Cumulative Volume Removed (1)	Water Temp °C	pH of Water	Conductivity (μmhos/cm)	Water* Appear-ance	Primary** Particu-lates	OVA/HNu ~~Date~~
Before	0	0915	0	16.5	7.65	122	Cl	Cl	0/0
During	6	0921	2.0	14.3	6.54	112	Co/d.brn	ML	0/0
During	6	0927	4.0	14.3	6.48	115	Co/d.brn	ML	0/0
During	7	0934	6.0	14.5	5.80	113	CO/d.brn	ML	0/0
During	6	0940	8.0	14.1	5.23	102	Co/d.brn	ML	0/0
During	5	0945	9.0 –	14.4	4.38	102	Co/d.brn	ML	0/0
During	3	0948	10.0	14.4	4.39	100	CO/d.brn	ML	0/0
After	20	1008		14.8	4.43	95	Co/d.brn	ML	0/0

*CL = clear
CO = cloudy
TU = turbid

**Particle — Settle Time
S = sand — 1 min
ML = silt — 1-2 hr
CL = clay — hrs

Comments 3 well Volumes = 6.19 gallons
Background OVA reading: 4.5 ppm
Initial reading upon opening well:
OVA reading: 0.0 ppm
HNu reading: 0.0 ppm
Initial breathing zone reading upon opening well:
OVA reading: 0.0 ppm
HNu reading: 0.0 ppm

Well Development Data

Site BOMARC FACILITY　　Well No. MW-48

Date(s) 7/6/89　　Geologist Olsen / Byrnes / Collins

Rig NA　　Driller NA

Development Equipment 1.5" stainless steel Bailer / 1.5" teflon bailer　　Measurement Reference Datum Top PVC Casing

DATA FROM IMMEDIATELY BEFORE AND AFTER DEVELOPMENT

Depth to water (~~cm~~): Before 18.90' (TOC)　　Height above land surface ______

After 1 min NA　5 min NA　~~10~~ 38 min 18.95' (TOC)

Depth to sediment at well (~~cm~~): Before 32.50'　After 32.45'

	Time Since Development Started (min)	Time	Cumulative Volume Removed (1)	Water Temp °C	pH of Water	Conductivity (μmhos/cm)	Water* Appearance	Primary** Particulates	HNu (ppm) ~~Date~~
Before	0	1037	0	16.0	4.93	80	Cl	Cl	0.4
During	8	1045	1.5	15.5	4.87	86	Co/orng	ML	5.2
During	3	1048	3.0	15.0	5.02	88	Co/orng	ML	0.2
During	5	1053	4.5	15.0	5.03	85	Co/orng	ML	0.2
During	3	1056	6.0	15.4	5.07	81	Co/orng	ML	0.4
During	7	1103	7.5	15.5	5.20	81	Co/orng	ML	0
During	3	1106	9.0	15.0	5.08	83	Co/orng	ML	0
~~After~~ During	9	1115	10.5	15.0	5.10	81	Co/orng	ML	0
After	37	1152	10.5	15.0	5.10	81	Co/orng	ML	0

*CL = clear
CO = cloudy
TU = turbid

**Particle
S = sand
ML = silt
CL = clay

Settle Time
1 min
1-2 hr
hrs

Estimated volume fluid lost to aquifer during drilling (liters) na

No. of withdrawal periods, Date(s) na

Duration of each (hrs) na　　Method(s) na

Comments

3 Well Volumes = 6.6 gallons

Background HNu reading: 0.8 ppm

Initial Readings Upon First Opening well:

HNu reading: 0.4 ppm

Initial Breathing Zone Readings upon opening well:

HNu reading: 0.8 ppm

Well Purging and Sampling Data

Site BOMARC FACILITY
Well No. MW-49
Date(s) 7/6/89
Geologist Olsen / Byrnes
Purging Bailer 1.5" Stainless Steel
Equipment Used Tripod and Reel
Sampling Bailer 1.5" teflon
Measurement Reference Datum Top of Casing (TC

DATA FROM IMMEDIATELY BEFORE AND AFTER DEVELOPMENT

Depth to water measured from TOC (ft.): Before Purging: 39.10' After Purging: 39.10' After Sampling: 39.10'

Total purging time (min.): 31

Depth to sediment in well (ft.): Before Purging: 53.65' After Purging 53.45'

	Time Since Purging Started (min)	Time	Cumulative Volume Removed (1)	Water Temp °C	pH of Water	Conductivity (μmhos/cm)	Water* Appearance	Primary** Particulates	OVA (ppm) ~~Date~~
Before	0	1523	0	16.0	6.40	89	Cl	Cl	0.2
During	7	1530	1.5	15.3	7.18	80	Co/orange	ML	0
During	7	1537	3.0	15.0	6.96	80	Co/orng	ML	0
During	4	1541	4.5	14.5	7.00	80	Co/orng	ML	0
During	5	1546	6.0	15.0	6.97	79	Co/orng	ML	0
During	4	1550	7.5	14.9	7.01	79	Co/orng	ML	0
During	4	1554	9.0	14.5	7.05	80	Co/orng	ML	0.2
After	8	1602	10.5	15.0	6.90	79	Co/orng	ML	0

*Water appearance	**Particle	Settle Time
CL = clear	S = sand	1 min
CO = cloudy	ML = silt	1-2 hr
TU = turbid	CL = clay	hrs

Comments 3 Well Volumes =
Background OVA Reading: 0.2 ppm
Initial Readings Upon First Opening Well:
OVA Reading: 0.2 ppm
Initial Breathing Zone Readings upon opening Well:
OVA Reading: 0.2 ppm

Field Data From Surface Water Samples

Field Data From Surface Water Samples

	Unfiltered (UF) or Filtered (F)	ph	Temperature (°C)	Conductance (um hos)
001-SW-001-001	UF	NA	NA	NA
001-SW-001-002	F	NA	NA	NA
001-SW-002-001	UF	NA	NA	NA
001-SW-002-002	F	NA	NA	NA
001-SW-003-001	UF	NA	NA	NA
001-SW-003-002	F	NA	NA	NA
001-SW-004-001	UF	NA	NA	NA
001-SW-004-002	F	NA	NA	NA
001-SW-004-003	UF	5.15	27.3°C	132
001-SW-006-001	UF	8.48	27°C	49
001-SW-006-002	F	8.48	27°C	49
001-SW-007-001	UF	9.12	20°C	15
001-SW-007-002	F	9.12	20°C	15
001-SW-008-001	UF	3.61	23°C	8
001-SW-008-002	F	3.61	23°C	8
001-SW-009-001	UF	8.34	22°C	5
001-SW-009-002	F	8.34	22°C	5
001-SW-010-001	UF	9.65	21°C	10
001-SW-010-002	F	9.65	21°C	10
001-SW-011-001	UF	10.47	21.5°C	11
001-SW-011-002	F	10.47	21.5°C	11
001-SW-012-001	UF	NA	21°C	40
001-SW-012-002	F	NA	21°C	40

Field Data From Surface Water Samples
(Continued)

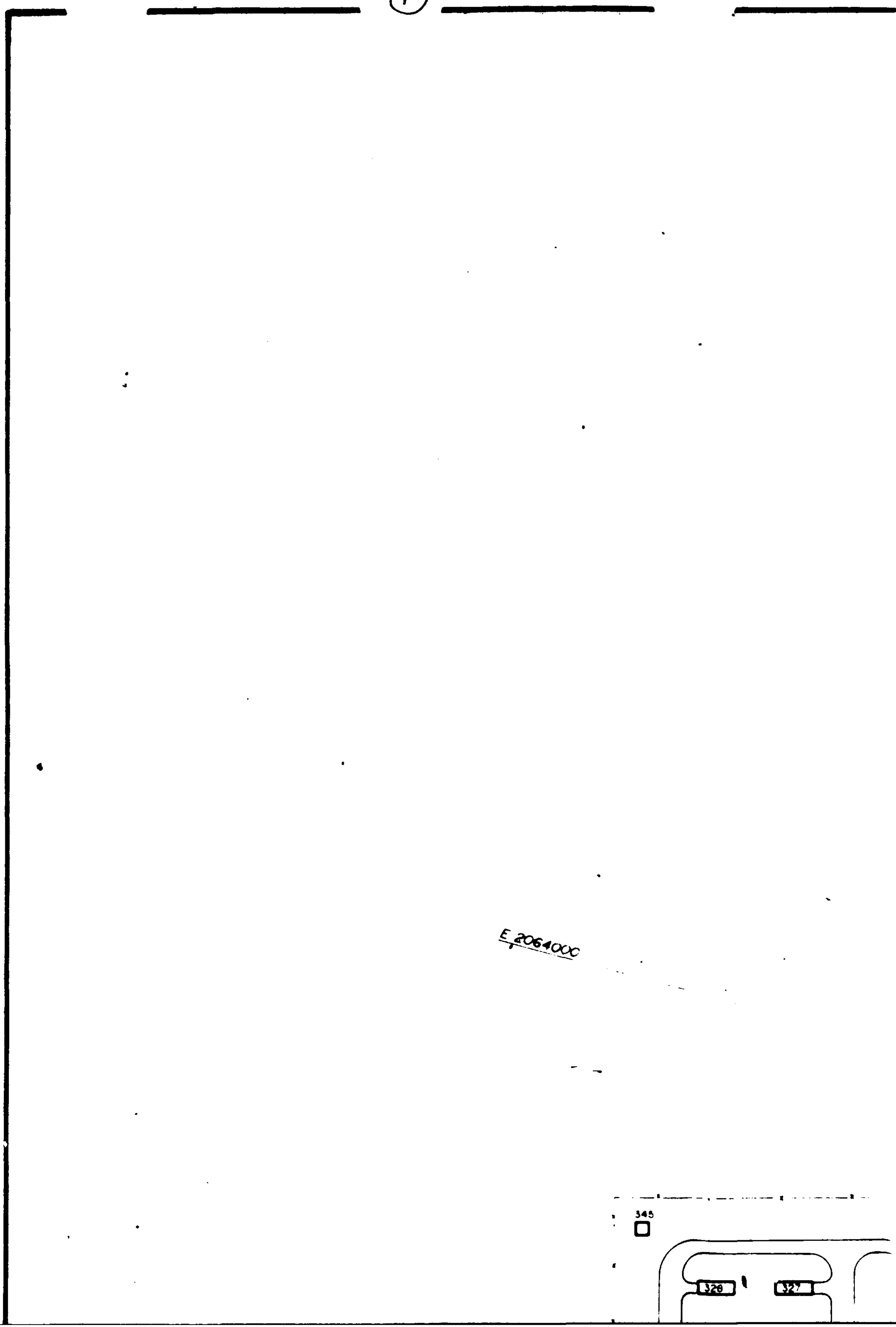
	Unfiltered (UF) or Filtered (F)	ph	Temperature (°C)	Conductance (um hos)
001-SW-013-001	UF	NA	21°C	40
001-SW-013-002	F	NA	21°C	40
001-SW-014-001	UF	NA	19°C	10
001-SW-014-002	F	NA	19°C	10
001-SW-015-001	UF	NA	NA	NA
001-SW-015-002	F	NA	NA	NA
001-SW-PB1-001	UF	NA	NA	NA
001-SW-PB1-002	UF	NA	NA	NA
001-SW-PB1-003	UF	NA	NA	NA
001-SW-PB1-004	UF	NA	NA	NA
001-SW-PB1-005	UF	NA	NA	NA
001-SW-PB1-006	UF	NA	NA	NA
001-SW-CB1-001	UF	NA	NA	NA
001-SW-CB1-002	UF	NA	NA	NA
001-SW-CB1-003	UF	NA	NA	NA
001-SW-CB1-004	UF	NA	NA	NA
001-SW-CB1-005	UF	NA	NA	NA
001-SW-CB1-006	UF	NA	NA	NA

NA = Not available.

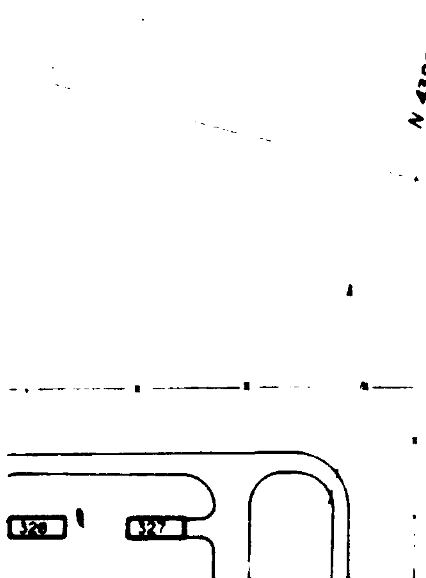
APPENDIX E

SURVEYING DATA

(1)

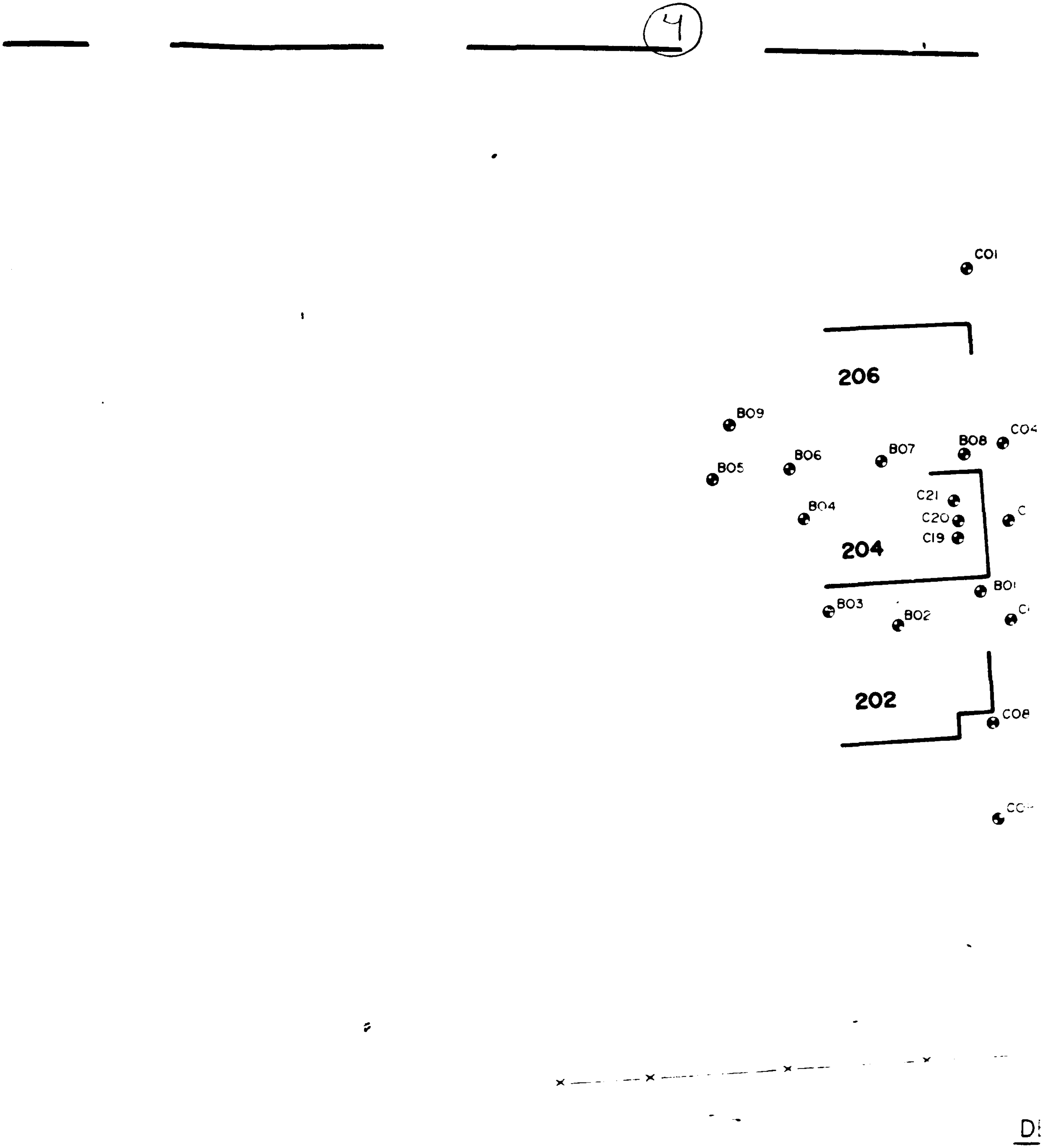


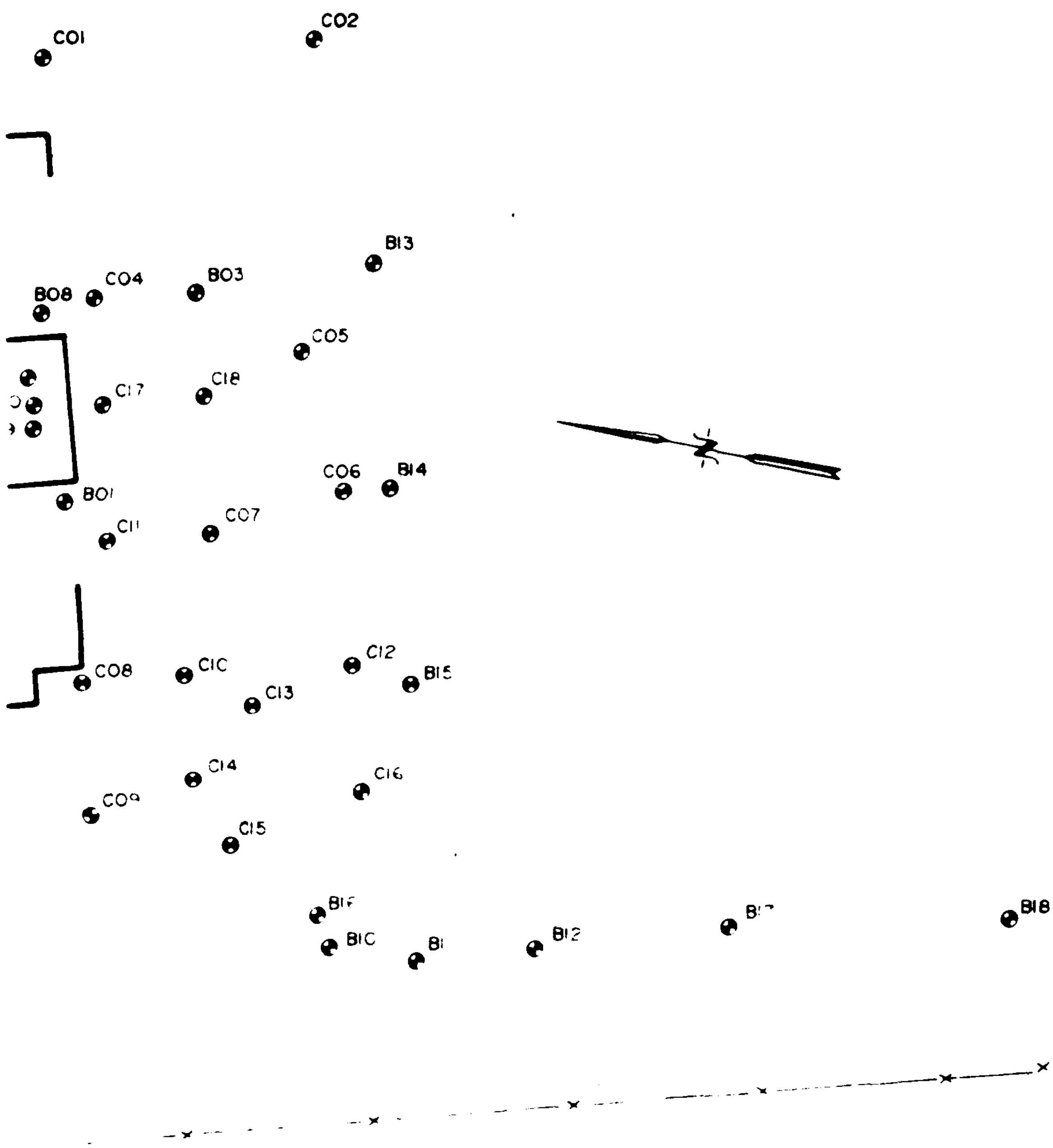
(2)



3

N.J. PLANE COORDINATE SYSTEM

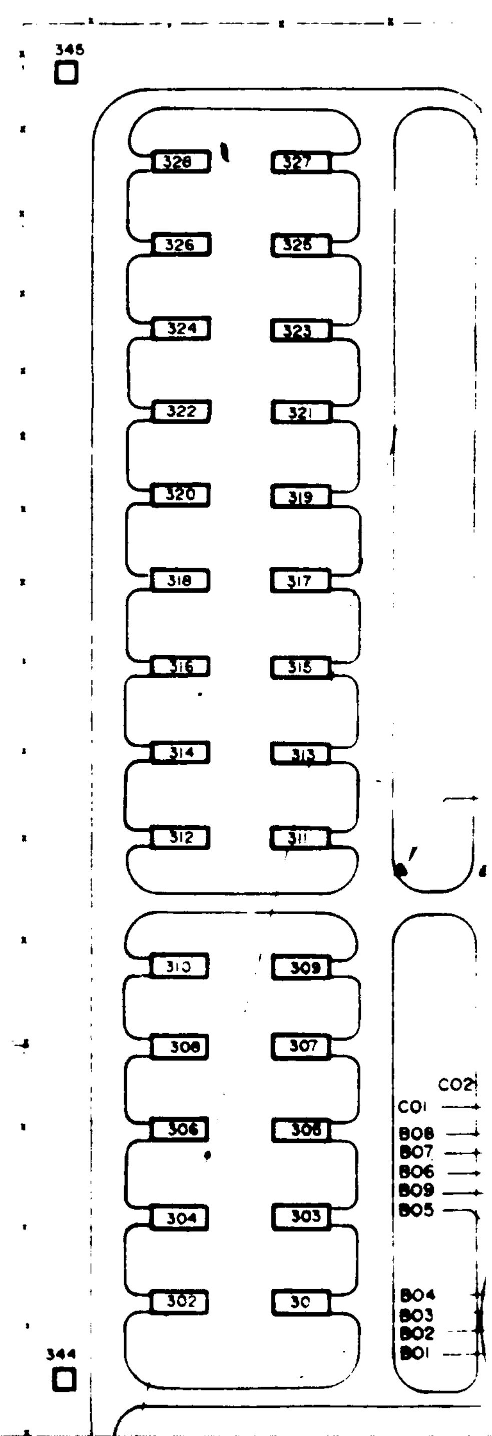

4
C01
206
B09
B05
B06
B07
B08
C21
C20
C19
204
B04
B03
B02
202
C08


CO1
CO2
B13
BO8
CO4
BO3
CO5
C17
C18
CO6
B14
BO1
C11
CO7
CO8
C1C
C13
C12
B15
C14
C16
CO9
C15
B16
B1C
B1
B12
B17
B18

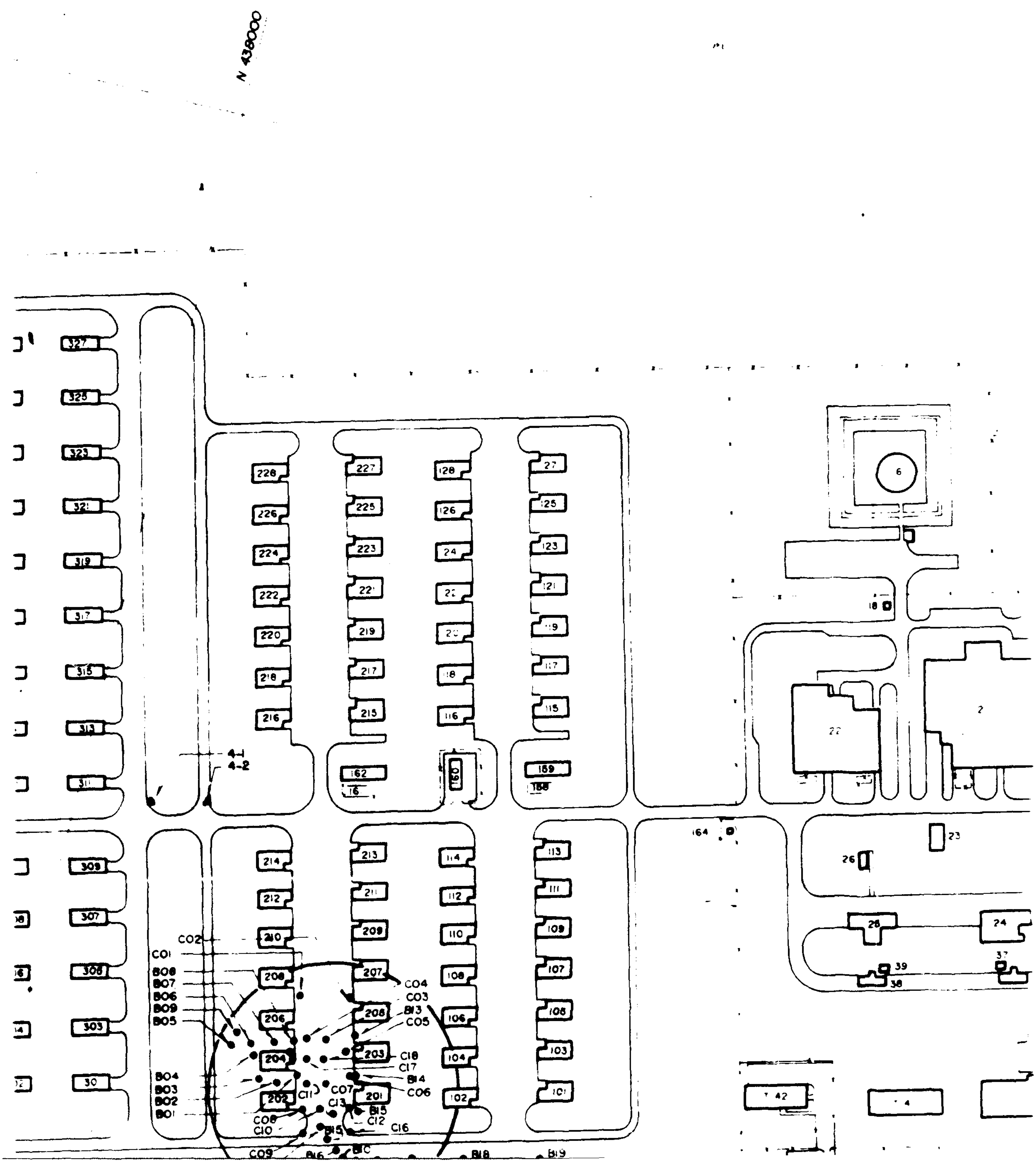
DETAIL 'A'
1" = 50'

(6)

E 2064000


345
328
327
326
325
324
323
322
321
320
319
318
317
316
315
314
313
312
311
310
309
308
307
306
305
304
303
302
CO2
CO1
BO8
BO7
BO6
BO9
BO5
BO4
BO3
BO2
BO1
344

7



N 438000
327
325
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217
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123
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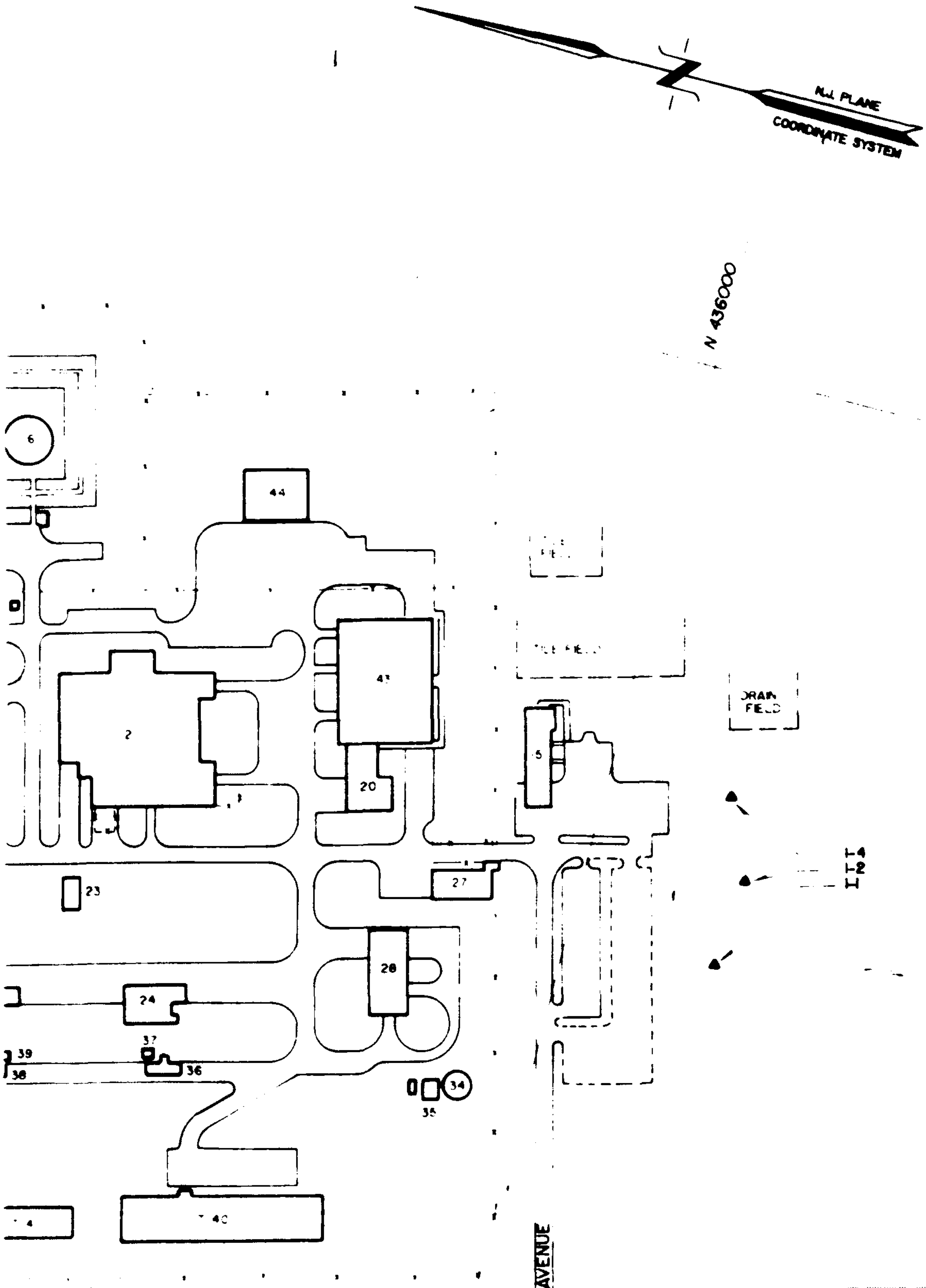
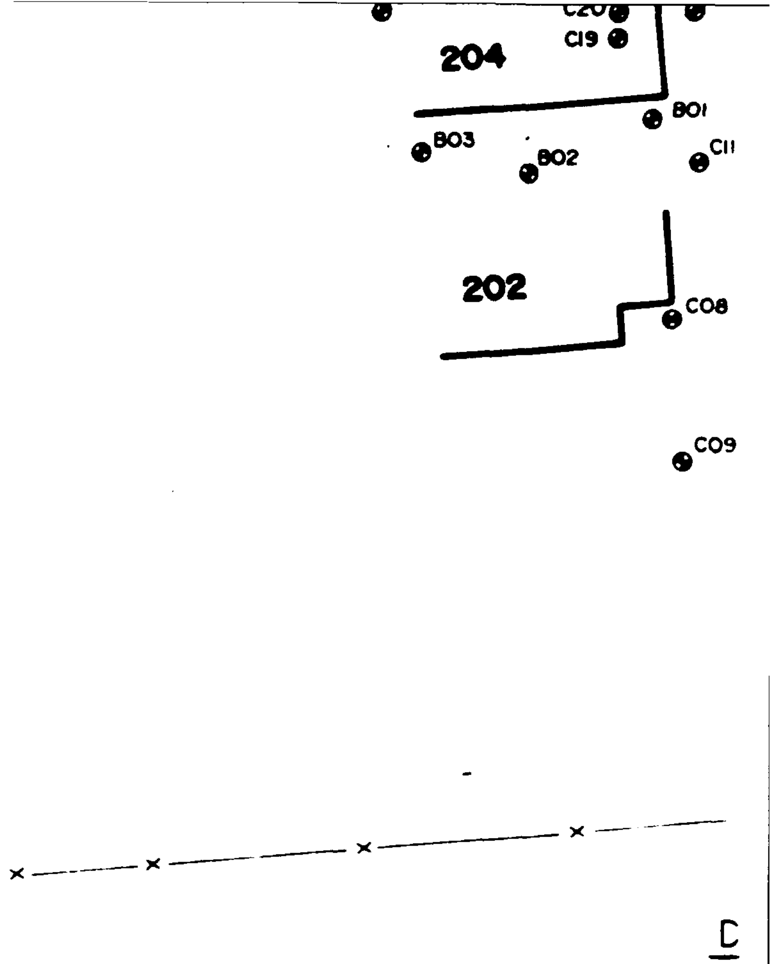
117
115
162
16
160
189
188
6
18
22
2
4-1
4-2
214
212
210
208
206
204
202
213
211
209
207
205
203
201
114
112
110
108
106
104
102
113
111
109
107
105
103
101
164
23
26
28
24
39
38
37
42
CO1
CO2
BO8
BO7
BO6
BO9
BO5
BO4
BO3
BO2
BO1
CO4
CO3
B13
CO5
C18
C17
B14
CO6
C11
CO7
C13
B15
C12
C16
CO8
C10
CO9
B16
B18
B19

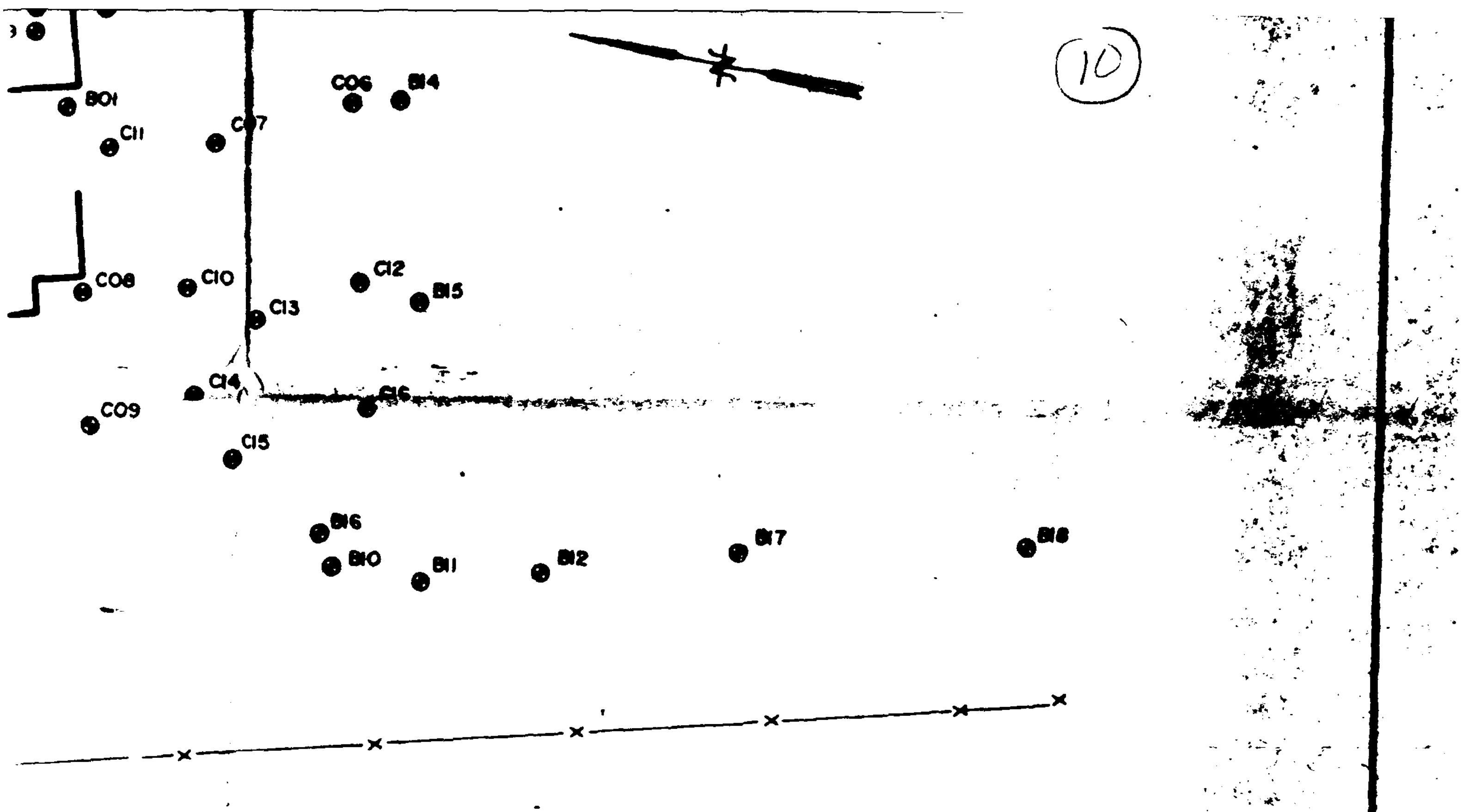
8



N.J. PLANE
COORDINATE SYSTEM
N 436000
6
44
43
2
20
5
DRAIN FIELD
27
23
28
24
37
39
38
36
34
35
AVENUE



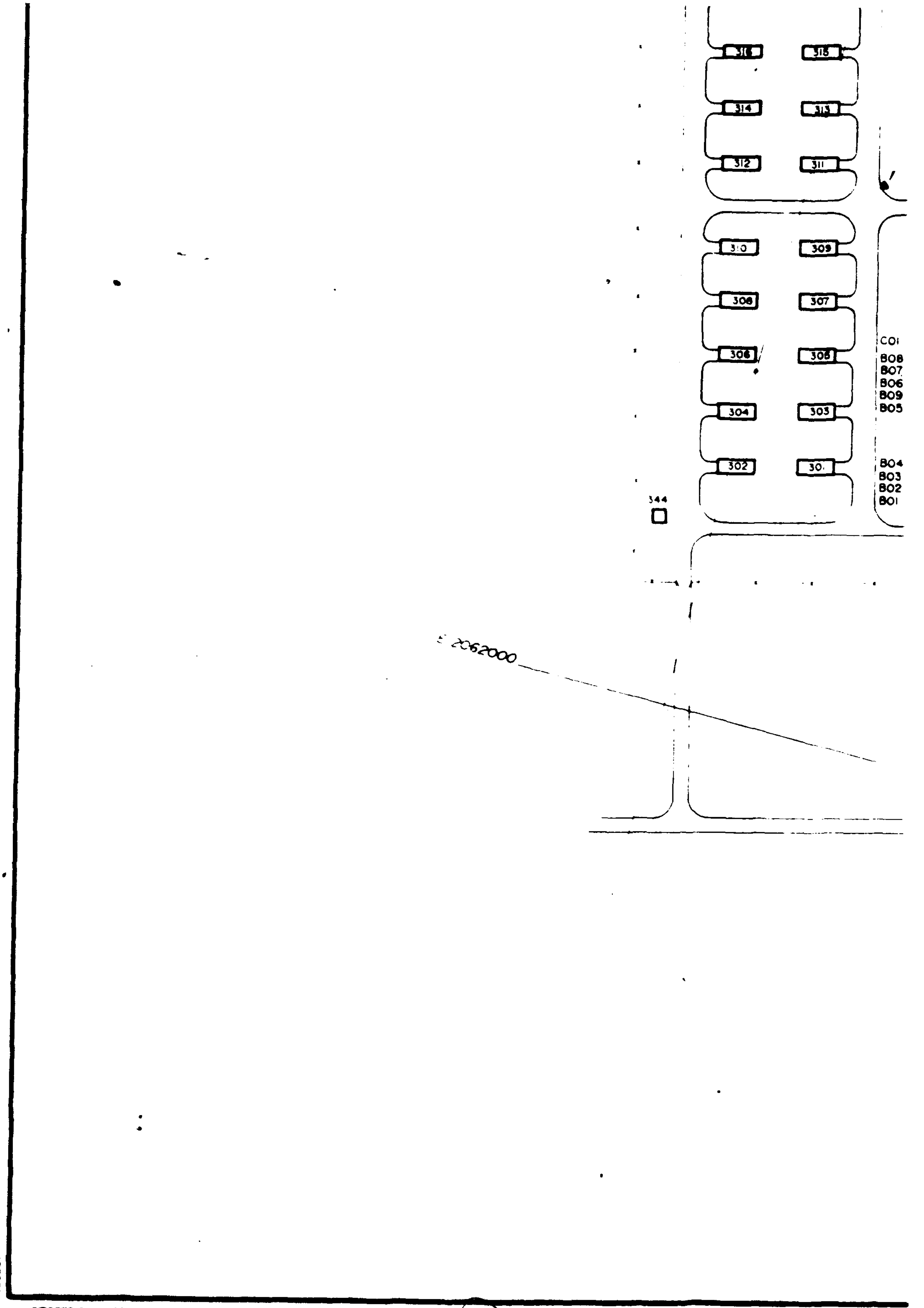
BOREHOLE PT.	NORTH	EAST	ELEV
B01	437547.56	2062513.18	1
B02	437576.43	2062493.25	1
B03	437604.89	2062493.07	1
B04	437622.12	2062527.27	1
B05	437661.00	2062535.39	1
B06	437631.30	2062545.23	1
B07	437595.81	2062555.56	1
B08	437564.67	2062564.99	1
B09	437658.45	2062557.66	1
B10	437447.74	2062401.46	1
B11	437521.93	2062402.06	1
B12	437388.87	2062411.22	1
B13	437472.33	2062596.60	24
B14	437455.52	2062534.35	1
B15	437438.38	2062480.90	1
B16	437452.87	2062409.51	1
B17	437335.42	2062428.45	1
B18	437255.91	2062445.20	[illegible]
B19	437137.65	2062475.10	16
B20	437092.65	2062381.04	17
B21	436964.77	2062413.93	17
[illegible]	[illegible]	[illegible]	17



DETAIL 'A'
1" = 50'

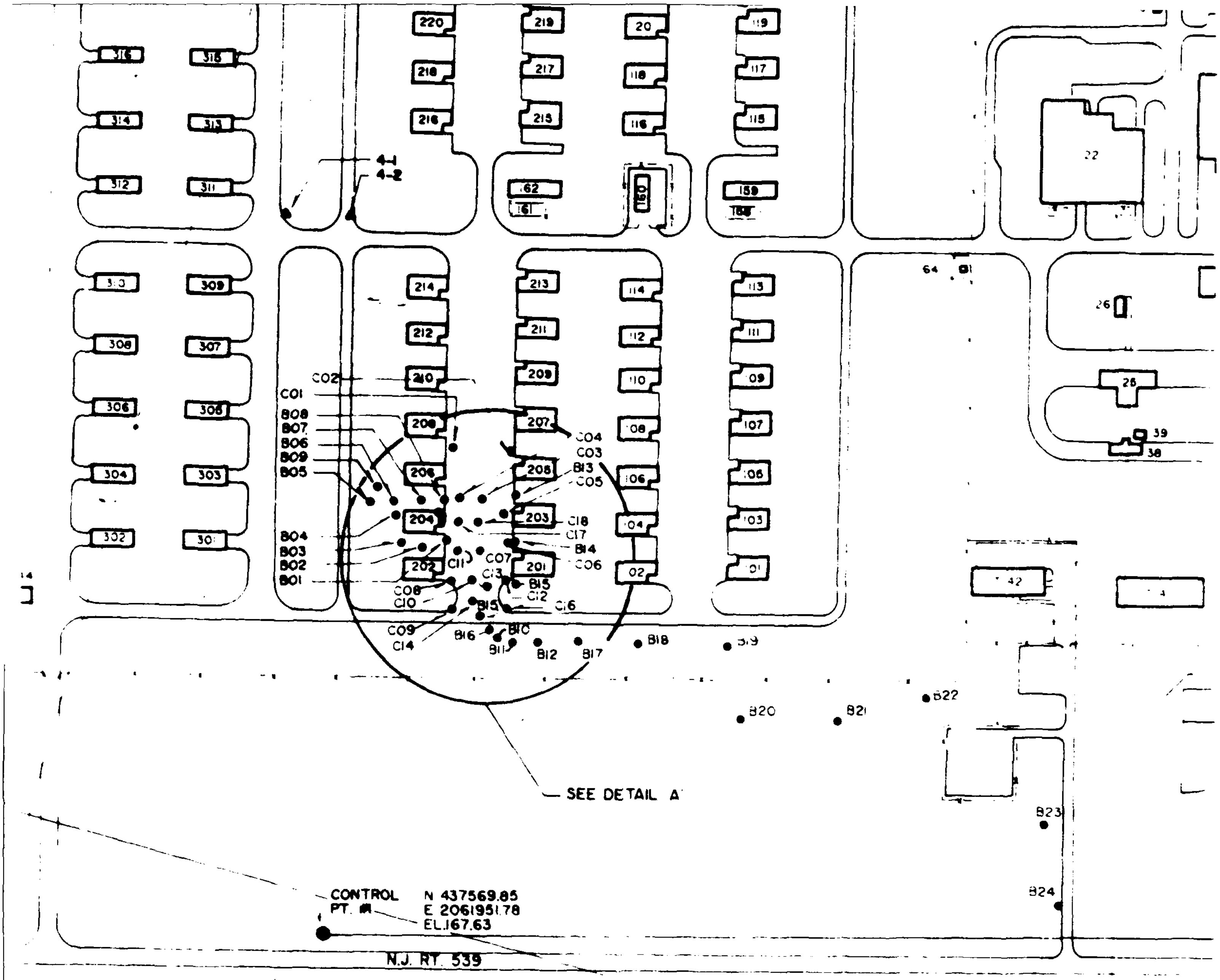
ELEVATION
174.0
173.3
173.0
174.7
173.2
174.9
174.7
174.6
174.2
171.1
170.8
170.8
248.3
172.9
172.9
171.2
170.6
170.2
168.4
173.9
[illegible]

CORING PT.	NORTH	EAST	ELEVATION
C01	437577.62	2062636.87	176.7
C02	437501.29	2062656.98	176.4
C03	437521.69	2062579.26	174.7
C04	437550.40	2062572.09	175.4
C05	437488.20	2062568.22	174.7
C06	437468.37	2062531.97	174.0
C07	437504.10	2062512.28	173.5
C08	437531.84	2062463.28	173.5
C09	437522.41	2062426.26	172.6
C10	437503.20	2062471.03	172.9
C11	437532.71	2062504.26	173.9
C12	437455.22	2062683.00	173.4
C13	637481.53	2062466.14	172.6
C14	437495.35	2062461.99	172.5
C15	437480.91	[illegible]	172.3
C16	437446.94	[illegible]	172.3
C17	437542.08	2062562.52	174.9
C18	437514.12	2062550.55	174.3
C19	437560.61	2062532.07	175.2
C20	[illegible]	[illegible]	175.2
[illegible]	[illegible]	[illegible]	[illegible]



188227

DIETTERICH CORPORATION

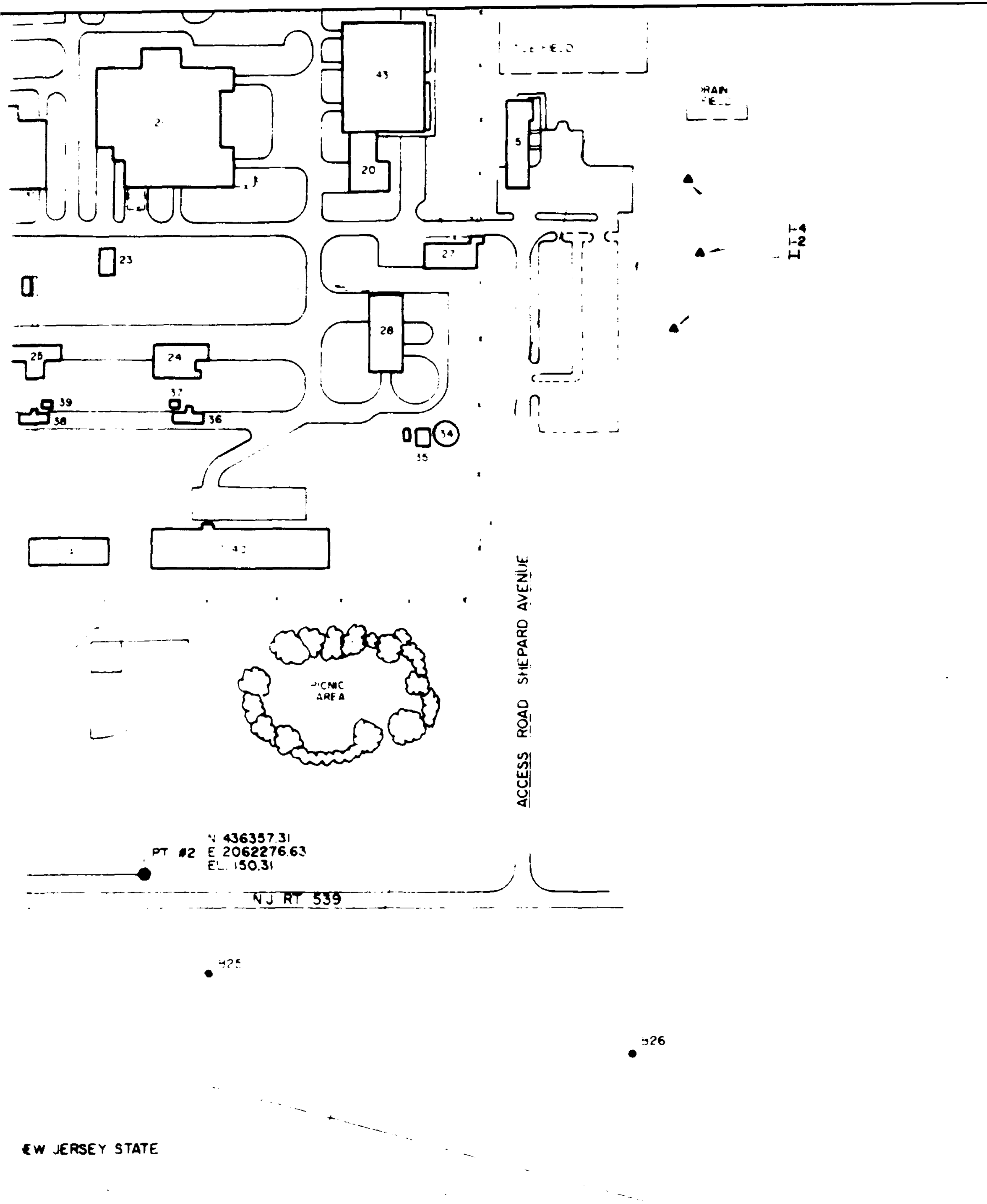


NOTES:

1. HORIZONTAL AND VERTICAL DATUM TIED INTO THE NEW JERSEY S
PLANE COORDINATE SYSTEM.

2. FIELD SURVEY PERFORMED AUGUST, 29, 1990.

3. ANOMALIES ARE MARKED BY AN IRON PIPE SET IN CONCRETE.



EW JERSEY STATE

ONCRETE.

I HEREBY CERTIFY
IN ACCORDANCE W
PROFESSIONAL LA

THIS PLAN HAS BEE
PREPARED BY GILM
BE ALTERED IN ANY
GILMORE AND ASSO

B09	[illegible]	[illegible]	[illegible]
B10	437447.[illegible]	[illegible]	[illegible]
B11	[illegible]37521.[illegible]	[illegible]	[illegible]
B12	437388.87	[illegible]	[illegible]
B13	437472.33	[illegible]	249.[illegible]
B14	437455.52	[illegible]	[illegible]
B15	437438.38	[illegible]	[illegible]
B16	437452.87	2062409.[illegible]	[illegible]
B17	437335.42	2062428.[illegible]	[illegible]
B18	437255.[illegible]	[illegible]	[illegible]
B19	437137.[illegible]	[illegible]	[illegible]
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B26	435592.[illegible]	[illegible]	132.5

* SOIL BORING HOLES WERE TAKEN FROM "SOIL BORING AND SPOT ELEVATIONS & LOCATION PLAN" SHEET [illegible] of [illegible] [illegible] [illegible]MORE AND ASSOCIATES INC., NEW BRITAIN, PA [illegible]

SUB SURFACE ANOMALY LOCATIONS

4 1	437885.94	206288[illegible]
4 2	437798.47	206290[illegible]
[illegible] 1	435810.83	206324[illegible]
[illegible] 2	435800.05	2063363
[illegible] 4	435846.06	2063463

POINTS LOCATED BY FIELD SURVEY, PERFORMED GILMORE AND ASSOCIATES, INC 8-29-90

[illegible]	REVISED
REV.	
DES BY	
DRN BY	G.K.
CHK BY	J.S.C.
ERV BY	
GRV BY	
APP BY	

[I] HEREBY CERTIFY THAT THIS MAP AND SURVEY WERE PERFORMED [I]N ACCORDANCE WITH THE MINIMUM STANDARDS OF PRACTICE FOR PROFESSIONAL LAND SURVEYORS IN THE STATE OF NEW JERSEY.

BRUCE W. FLORA

N.J. LICENSE # GS-31667

[T]HIS PLAN HAS BEEN REPRODUCED FROM AN ORIGINAL DRAWING AS PREPARED BY GILMORE AND ASSOCIATES, INC. THIS PLAN IS NOT TO BE ALTERED IN ANY WAY WITHOUT THE WRITTEN CONSENT OF GILMORE AND ASSOCIATES, INC.

GILMORE & ASSOCIATES
CONSULTING ENGINEERS
& LAND SURVEYORS
331 BUTLER AVENUE,
NEW BRITAIN, PA 18901
[illegible] MAIN STREET, TRAPPE, PA 19426

DATE

THE EARTH[illegible]
CORPORATI[illegible]

[illegible]	C09	437522.41	2062426.26	172.[illegible]
[illegible]	C10	437503.20	2062471.03	172.9
[illegible]	C11	437532.71	2062504.26	173.9
[illegible]	C12	437455.22	2062483.80	173.[illegible]
[illegible]	C13	437481.53	2062466.14	172.6
[illegible]	C14	437495.35	2062441.99	172.5
[illegible]	C15	437480.91	2062425.00	172.3
[illegible]	C16	437446.94	2062446.60	172.3
[illegible]	C17	437542.08	2062542.52	174.9
[illegible]	C18	437514.12	2062550.55	174.3
[illegible]	C19	437560.61	2062532.97	175.2
[illegible]	C20	437561.97	2062538.75	175.2
[illegible]	C21	437565.04	2062546.17	175.2
[illegible]				
[illegible]				
156.[illegible]				
[illegible]				
[illegible]				

POINTS LOCATED BY FIELD SURVEY, PERFORMED BY GILMORE AND ASSOCIATES, INC 8-29-90

AN[illegible] SHEET [illegible]
TAIN FA [illegible]-90

ANOMAL[illegible] [illegible]CATIONS

[illegible]7885.9[illegible]	[illegible]62887.49
[illegible]7798.[illegible]	2062[illegible]8.71
[illegible]58[illegible].83	2063246.65
[illegible]5800.05	2063363.51
[illegible]5846.06	2063463.96

[illegible]IELD SURVEY, PERFORMED BY
ATES, INC 8-29-90

REV	DESCRIPTION	DATE	BY
	REVISED COODINATE NUMBERING SYSTEM AS PER REVIEW LETTER DATED 10-9-90	*10-18-90*	*G.K.*

ES

		DATE	
DES BY			PROJECT No. 89-310-03 — SCALE: 1" = 200'
DRN BY	G.K.	9-14-90	PROJECT: **BOMARC MISSILE SITE** McGUIRE AIRFORCE BASE, OCEAN COUNTY, N.J.
CHK BY	J.S.C.		SHEET TITLE: **SOIL BORING LOCATIONS**
ERV BY			
GRV BY			
APP BY			

426

THE EARTH TECHNOLOGY CORPORATION

SHEET 1 OF 1

DRAWING No.

APPENDIX F

CHAIN-OF-CUSTODY FORMS

CHAIN OF CUSTODY RECORD

SAIC
An Employee Owned Company

Science Applications International Corporation
4224 Campus Point Court, MS # 210
San Diego, California 92121
Attn: Sample Custodian, Environmental Chemistry Laboratory

Shipment #: ______
Field Charge #: ______
Lab Charge #: ______

SHIP TO	CLIENT/PROJECT INFORMATION	SAMPLING INFORMATION
Name: Teledyne Isotopes	Client: SAIC	Location: POMARC
Address: [illegible]	Project: POMARC	
Contact:	Contact: [illegible]	Sampler:
Phone #: [illegible]	Phone #: [illegible] 278 [illegible]	Phone #:

Lab Sample ID	Client Sample ID	Sampling Date	Sampling Time	# of Containers	Sample Description/Remarks	[illegible]	Metals [illegible]-32	Received 04-09-90	Samples Intact Upon Receipt? (Y/N)
				1	201-WP-021-001	X	X	✓	
				1	206-WP-022-001	X	X	✓	
				1	203-WP-016-001	X	X		
				1	204-WP-014-001	X	X		
				1	204-WP-023-001	X	X		
				1	204-WP-026-001	X	X		
				1	204-WP-028-001	X	X		
				1	201-WP-056-001	X	X		
				1	201-WP-086-001	X	X	✓	
				1	201-WP-099-001	X	X	✓	
				1	201-WP-111-001	X	X	✓	

Possible Hazards:

Total Containers: 11

Comments, Observations, Special Instructions:

(Signature and Company Name)

Relinquished by:	Date / Time	Received by/Location:	Relinquished by:	Date / Time	Received by/Location:
[illegible]	[illegible]/89				

Distribution: Original Accompanies Shipment. Canary Laboratory Retains. Pink Project Manager File (Sent with Report). Goldenrod Sampler Retains

Rev 1/89

CHAIN OF CUSTODY RECORD

SAIC
An Employee Owned Company

Science Applications International Corporation
4224 Campus Point Court, MS # 210
San Diego, California 92121
Attn: Sample Custodian, Environmental Chemistry Laboratory

Shipment #:
Field Charge #:
Lab Charge #:

SHIP TO
Name: TMA/Eberline
Address: 7021 [illegible] NE Albuquerque, NM 87109
Contact:
Phone #:

CLIENT/PROJECT INFORMATION
Client: SAIC
Project: Portland
Contact: [illegible] Collins
Phone #: 202-278-2480

SAMPLING INFORMATION
Location: Portland
Sampler: [illegible]
Phone #: 202-278-2480

Lab Sample ID	Client Sample ID	Sampling Date	Sampling Time	# of Containers	Sample Description/Remarks	Total metals/HNO3	Gross alpha	Gross beta		received results	Samples Intact Upon Receipt? (Y/N)
		9-11-89		2	001-SW-006-001	X	X	X		✓	
				2	001-SW-006-002	X	X	X		✓	
		9-16-89		2	001-SW-007-001	X	X	X		✓	
				2	001-SW-007-002	X	X	X		✓	
		9-19-89		2	001-SW-008-001	X	X	X		✓	
				2	001-SW-008-002	X	X	X		✓	
		9-11-89		2	001-SW-009-001	X	X	X		✓	
				2	001-SW-009-002	X	X	X		✓	
		9-11-89		2	001-SW-010-001	X	X	X		✓	
				2	001-SW-010-002	X	X	X		✓	
		9-11-89		2	001-SW-011-001	X	X	X		✓	
		9-11-89		2	001-SW-012-001	X	X	X		✓	
				2	001-SW-012-002	X	X	X		✓	
		9-11-89		2	001-SW-013-001	X	X	X		✓	
				2	001-SW-013-002	X	X	X		✓	
		9-11-89		2	001-SW-014-001	X	X	X		✓	
				2	001-SW-014-002	X	X	X		✓	
				2	001-SW-015-001	X	X	X		✓	
				2	001-SW-015-002	X	X	X		✓	
		9-11-89		2	001-SW-011-002	X	X	X		✓	

Possible Hazards:

Total Containers: 40

Comments, Observations, Special Instructions:

(Signature and Company Name)

Relinquished by:	Date / Time	Received by/Location:	Relinquished by:	Date / Time	Received by/Location:
[illegible]	[illegible]	[illegible]			

Distribution: Original Accompanies Shipment, Canary Laboratory Retains, Pink Project Manager File (Sent with Report), Goldenrod Sampler Retains

Rev 1/89

CHAIN OF CUS. .OY RECORD

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Page 1 of 1

Science Applications International Corporation
4224 Campus Point Court, MS # 210
San Diego, California 92121
Attn: Sample Custodian, Environmental Chemistry Laboratory

Shipment #:
Field Charge #:
Lab Charge #:

SHIP TO	CLIENT/PROJECT INFORMATION	SAMPLING INFORMATION
Name: Teledyne Isotopes	Client: [illegible]	Location: ROMARSC
Address: [illegible] Ave. Westwood, NJ	Project: [illegible]	[illegible], NJ
Contact: ---	Contact: [illegible]	Sampler: CD, GD
Phone #: 201 664-7070	Phone #: 303 278 8980	Phone #: 303 278 8980

Lab Sample ID	Client Sample ID	Sampling Date	Sampling Time	# of Containers	Sample Description/Remarks	500 mL plastic/HNO3	Method [illegible] -27	1 L glass/HNO3		Received 11-17-89	Samples Intact Upon Receipt? (Y/N)
	500 mL H2O			1	001-SW-[illegible]-001	X	X			✓	
	500 mL H2O			1	001-SW-[illegible]-005	X	X			✓	
	1 L H2O			1	001-GW-PW10-001		X	X		✓	
	1 L H2O			1	001-GW-PW10-001 F		X	X		✓	
	1 L H2O			1	001-GW-PW7-001		X	X		✓	
	1 L H2O			1	001-GW-PW7-001 F		X	X		✓	
	1 L H2O			1	001-GW-PW3-001		X	X		✓	
	1 L H2O			1	001-GW-PW3-001 F		X	X		✓	
	2-500 mL	7-6-89	1555	2	001-GW-MW49-001	X	X			✓	
	2-500 mL	7-6-89	1555	2	001-GW-MW49-001F	X	X			✓	

Possible Hazards:

Total Containers: 12

Comments, Observations, Special Instructions:

(Signature and Company Name)

Relinquished by:	Date / Time	Received by/Location:	Relinquished by:	Date / Time	Received by/Location:
[illegible]	10/20/89 1630				

Distribution: Original Accompanies Shipment, Canary Laboratory Retains, Pink Project Manager File (Sent with Report), Goldenrod Sampler Retains

Rev 1/89

Science Applications International Corporation
4224 Campus Point Court, MS # 210
San Diego, California 92121
Attn: Sample Custodian, Environmental Chemistry Laboratory

CHAIN OF CUSTODY RECORD

SAIC
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Shipment #:
Field Charge #:
Lab Charge #:

SHIP TO	CLIENT/PROJECT INFORMATION	SAMPLING INFORMATION
Name: Teledyne Isotopes	Client: SAIC	Location: BOMARC Missile Site
Address: 50 Van Buren Ave, Westwood, NJ	Project: BOMARC	
Contact: Dave Martin	Contact: Donna Collins	Sampler: CO, GD
Phone #: 201-664-7070	Phone #: 303-278-8480	Phone #: 303-278-8480

Lab Sample ID	Client Sample ID	Sampling Date	Sampling Time	# of Containers	Sample Description/Remarks	250 ml glass/None/Alpha Spec Pu 239	Method FRO-052-32	Received 2/28/90	Samples Intact Upon Receipt? (Y/N)
	001-SL-TS2-001	10-7-89	0839	1	Shallow Soil 0-1"	X	X	✓	
	001-SL-TS3-005	10-7-89	0917	1	Shallow Soil 7-8"	X	X	✓	
	001-SL-TS7-001	10-7-89	1602	1	Shallow Soil 1-2"	X	X	✓	
	001-SL-TS4-005	10-7-89	1033	1	Shallow Soil 2-3"	X	X	✓	
	001-SL-TS5-005	10-7-89	1101	1	Shallow Soil 2-3"	X	X	✓	
	001-SL-TS6-002	10-7-89	1525	1	Shallow Soil 0-1"	X	X	✓	
	001-SL-TS4-006	10-7-89	1035	1	Shallow Soil 2-3"	X	X	✓	
	001-SL-TS2-002	10-7-89	0842	1	~~Sediment~~ Shallow Soil 0-1"	X	X	✓	
	001-SL-TS2-005	10-7-89	0849	1	Shallow Soil 2-3"	X	X	✓	
	~~001-SD-CB1-005~~	— CO 10/19						✓	
	~~001-SD-CB1-003~~	— CO 10/19						✓	
	~~001-SD-CB1-001~~	~~10-8-89~~	~~1205~~	~~1~~	~~Sediment~~ CO 10/19			✓	
	001-SD-CB1-002	10-8-89	1207	1	Sediment from Comm. Bunker	X	X	✓	
	001-SL-TS2-008	10-7-89	0852	1	Shallow Soil 3-6"	X	X	✓	
	001-SL-TS3-002	10-7-89	0910	1	Shallow Soil 0-6"	X	X	✓	
	001-SL-TS3-007	10-7-89	0955	1	Shallow Soil 8-9"	X	X	✓	
	001-SL-TS3-008	10-7-89	0957	1	Shallow Soil 8-9"	X	X	✓	
	001-SL-TS3-009	10-7-89	0959	1	Shallow Soil 9-12"	X	X	✓	
	001-SL-TS3-010	10-7-89	1000	1	Shallow Soil 9-12"	X	X	✓	
	001-SL-TS4-001	10-7-89	1021	1	Shallow Soil 0-1"	X	X	✓	

Possible Hazards:

Total Containers: Cont

Comments, Observations, Special Instructions:

(Signature and Company Name)

Relinquished by:	Date / Time	Received by/Location:	Relinquished by:	Date / Time	Received by/Location:
[illegible]	[illegible]			[illegible]	[illegible]

SAIC

Distribution: Original Accompanies Shipment, Canary: Laboratory Retains; Pink: Project Manager File (Sent with Report), Goldenrod: Sampler Retains

Rev 1/89

CHAIN OF CUSTODY RECORD

SAIC

Page 2 of 2

Science Applications International Corporation
4224 Campus Point Court, MS # 210
San Diego, California 92121
Attn: Sample Custodian, Environmental Chemistry Laboratory

Shipment #:
Field Charge #:
Lab Charge #:

SHIP TO	CLIENT/PROJECT INFORMATION	SAMPLING INFORMATION
Name: Teledyne Isotopes	Client: SAIC	Location: BOMARC
Address: 50 Van Buren Ave, Westwood, NJ	Project: BOMARC	Missile Site
Contact: Dave Martin	Contact: Donna Collins	Sampler: CO, GD
Phone #: 201-664-7070	Phone #: 202-278-8480	Phone #: 202-278-8480

Lab Sample ID	Client Sample ID	Sampling Date	Sampling Time	# of Containers	Sample Description/Remarks	250 ml plastic/None/Alpha Spec Pu 239	Method PRO-052-32	Received 1-5-90	Samples Intact Upon Receipt? (Y/N)
	001-SL-C10-001	9-15-89	1605	1	Shallow Soil 0-6"	X	X	✓	
	001-SL-C20-002	9-28-89	1615	1	Shallow Soil 6-12"	X	X	✓	
	001-SL-C14-001	10-3-89	0846	1	Shallow Soil 0-6"	X	X	✓	
	001-SL-C20-001	9-28-89	1615	1	Shallow Soil 0-6"	X	X	✓	

Possible Hazards:

Total Containers: 21

Comments, Observations, Special Instructions:

(Signature and Company Name)

Relinquished by:	Date / Time	Received by/Location:	Relinquished by:	Date / Time	Received by/Location:
[illegible]	10/20/89 / 1630			[illegible]	[illegible]

SAIC Distribution: Original Accompanies Shipment, Canary Laboratory Retains; Pink Project Manager File (Sent with Report), Goldenrod Sampler Retains

Rev 1/89

CHAIN OF CUSTODY RECORD

Science Applications International Corporation
4224 Campus Point Court, MS # 210
San Diego, California 92121
Attn: Sample Custodian, Environmental Chemistry Laboratory

SAIC — An Employee Owned Company

Shipment #: ____
Field Charge #: ____
Lab Charge #: ____

SHIP TO
Name: Teledyne Isotopes
Address: 50 Van Buren Ave
Westwood, NJ
Contact: ——
Phone #: 201-664-7070

CLIENT/PROJECT INFORMATION
Client: SAIC
Project: BOMARC
Contact: Donna Collins
Phone #: 202-278-8780

SAMPLING INFORMATION
Location: BOMARC
Sampler: CO, GD
Phone #: 202-278-8780

Lab Sample ID	Client Sample ID	Sampling Date	Sampling Time	# of Containers	Sample Description/Remarks	Soil glass/none/Gamma Alpha Spec	Method LRO-057-32	Received 2-27-89	Samples Intact Upon Receipt? (Y/N)
	01-SS-B26-001	10-1-89	1?23	1	Shallow Soil 0-1"	X	X	✓	
	01-SS-TS6-004	10-1-89	1?27	1	1-2"	X	X	✓	
	01-SS-TS4-007	10-1-89	1036	1	2-6"	X	X	✓	
	01-SS-TS3-002	10-1-89	0942	1	6-7"	X	X	✓	
	01-SS-TS7-006	10-1-89	1606	1	2-3"	X	X	✓	
	01-SS-TS7-008	10-7-89	1611	1	2-6"	X	X	✓	
	01-SS-TS7-007	10-7-89	1608	1	2-6"	X	X	✓	
	01-SS-TS7-005	10-7-89	1603	1	2-3"	X	X	✓	
	01-SS-TS5-009	10-7-89	1106	1	6-12"	X	X	✓	
✓	01-SS-B20-001	10-11-89	1105	1	0-6"	X	X	✓	
✓	01-SS-B19-002	10-12-89	—	1	2-4'	X	X	✓	
✓	01-SS-B24-002	10-12-89	—	1	[illegible]-4'	X	X	✓	
	01-SS-B16-003	10-10-89	—	1	8-10'	X	X	✓	
	01-SS-B13-004	10-10-89	—	1	4-6'	X	X	✓	
	01-SS-B16-001	10-10-89	—	1	1-2'	X	X	✓	
	01-SS-B21-002	10-12-89	—	1	2-4'	X	X	✓	
	01-SS-B19-002	10-12-89	—	1	4-6'	X	X	✓	
	01-SS-B18-003	10-12-89	—	1	4-6'	X	X	✓	
	01-SS-B23-001	10-11-89		1	0-6"	X	X		
	01-SS-B18-002	10-12-89	—	6	2-4'	X	X	✓	

Possible Hazards:
Total Containers: Cont.
Comments, Observations, Special Instructions:

re and Company Name)

Relinquished by:	Date / Time	Received by/Location:	Relinquished by:	Date / Time	Received by/Location:
[illegible]	[illegible]			[illegible]	[illegible]

Distribution: Original Accompanies Shipment, Canary · Laboratory Retains, Pink · Project Manager File (Sent with Report), Goldenrod · Sampler Retains

Rev 1/89

CHAIN OF CUSTODY RECORD

SAIC. An Employee Owned Company

Science Applications International Corporation
4224 Campus Point Court, MS # 210
San Diego, California 92121
Attn: Sample Custodian, Environmental Chemistry Laboratory

Shipment #:
Field Charge #:
Lab Charge #:

SHIP TO	CLIENT/PROJECT INFORMATION	SAMPLING INFORMATION
Name: Teledyne Isotopes	Client: SAIC	Location: BOMARC
Address: 50 Van Buren Ave, Westwood, NJ	Project: BOMARC	
Contact: —	Contact: Donna Collins	Sampler: CD, GD
Phone #: 201-664-7070	Phone #: 303-278-8480	Phone #: 303-278-8480

Sample Type (Container/Preservative/Parameter Type): 250 ml glass/none/Pu 239 Alpha Spec; Method PRO-057-32; Received - 1-5-90

Lab Sample ID	Client Sample ID	Sampling Date	Sampling Time	# of Containers	Sample Description/Remarks	250 ml glass/none/Pu 239 Alpha Spec	Method PRO-057-32	Received - 1-5-90	Samples Intact Upon Receipt? (Y/N)
	001-SS-B11-003	10-10-89	—	1	Split-spoon sample 4-6'	X	X	✓	
	001-SS-B13-002	10-10-89	—	1	2-4'	X	X	✓	
	001-SS-B20-002	10-12-89	—	1	2-4'	X	X	✓	
	001-SS-B21-002	10-12-89	—	1	4-6'	X	X	✓	

Possible Hazards:

Total Containers: 4

Comments, Observations, Special Instructions:

ure and Company Name)

Relinquished by:	Date / Time	Received by/Location:	Relinquished by:	Date / Time	Received by/Location:
[illegible]	12/28/89 1630			[illegible] 1630	[illegible]

Distribution: Original Accompanies Shipment, Canary · Laboratory Retains, Pink · Project Manager File (Sent with Report), Goldenrod · Sampler Retains

CHAIN OF CUSTODY RECORD

SAIC
An Employee Owned Company

Science Applications International Corporation
4224 Campus Point Court, MS # 210
San Diego, California 92121
Attn: Sample Custodian, Environmental Chemistry Laboratory

Shipment #:
Field Charge #:
Lab Charge #:

SHIP TO	CLIENT/PROJECT INFORMATION	SAMPLING INFORMATION
Name: Teledyne Isotopes	Client: SAIC	Location: [illegible]
Address: 50 Van Buren Ave. Westwood, NJ	Project: [illegible]	
Contact: —	Contact: Laura Collins	Sampler: [illegible]
Phone #: 201-664-7070	Phone #: 303-278-8480	Phone #: 303-278-8480

Lab Sample ID	Client Sample ID	Sampling Date	Sampling Time	# of Containers	Sample Description/Remarks		250 ml glass/none/Pu239 Alpha spec	Method PRO-052-32	Received 2-13-90	Samples Intact Upon Receipt? (Y/N)
	01-SL-TS6-003	10-7-89	1526	1	Hollow Soil	1-3"	X	X	✓	
	01-SL-TS5-006	10-7-89	1102	1		2-3"	X	X	✓	
	01-SL-TS6-008	10-7-89	1545	1		3-6"	X	X	✓	
	01-SL-TS5-003	10-7-89	1059	1		1-2"	X	X	✓	
	01-SL-TS6-010	10-7-89	1540	1		6-12"	X	X	✓	
	01-SL-TS7-003	10-7-89	1100	1		1-3"	X	X	✓	
	01-SL-TS6-005	10-7-89	1529	1		2-3"	X	X	✓	
	01-SL-TS6-006	10-7-89	1530	1		2-3"	X	X	✓	
	01-SL-TS7-010	10-7-89	1118	1		6-12"	X	X	✓	
	01-SL-TS7-001	10-7-89	1555	1		0-1"	X	X	✓	
	01-SL-TS6-007	10-7-89	1522	1		3-6"	X	X	✓	
	01-SL-TS5-001	10-7-89	1055	1		0-1"	X	X	✓	
	01-SL-TS6-009	10-7-89	1526	1		6-12"	X	X	✓	
	01-SL-TS7-009	10-7-89	1119	1		6-12"	X	X	✓	
	01-SL-TS2-010	10-7-89	0859	1		6-12"	X	X	✓	
	01-SL-TS3-001	10-7-89	1522	1		0-6"	X	X	✓	
	01-SL-TS4-010	10-7-89	1042	1		6-12"	X	X	✓	
	01-SL-TS4-009	10-7-89	1041	1		6-12"	X	X	✓	
	01-SL-TS2-009	10-7-89	0853	1		6-12"	X	X	✓	
	01-SL-TS4-008	10-7-89	1038	1		3-6"	X	X	✓	

Possible Hazards:

Total Containers: [illegible]

Comments, Observations, Special Instructions:

(Signature and Company Name)

Relinquished by:	Date / Time	Received by/Location:	Relinquished by:	Date / Time	Received by/Location:
[illegible]	[illegible]			[illegible]	[illegible]

Distribution: Original Accompanies Shipment; Canary Laboratory Retains; Pink Project Manager File (Sent with Report); Goldenrod Sampler Retains

CHAIN OF CUS /Y RECORD

SAIC
An Employee-Owned Company

Science Applications International Corporation
4224 Campus Point Court, MS # 210
San Diego, California 92121
Attn: Sample Custodian, Environmental Chemistry Laboratory

Shipment #:
Field Charge #:
Lab Charge #:

SHIP TO
Name: Teledyne Isotopes
Address: 50 Van Buren Ave.
Westwood, NJ
Contact: —
Phone #: 201-644-7070

CLIENT/PROJECT INFORMATION
Client: SAIC
Project: BOMARC
Contact: Donna Collins
Phone #: 203-278-8480

SAMPLING INFORMATION
Location: BOMARC
Sampler: Co, GD
Phone #: 203-278-8480

Sample Type (Container/Preservative/Parameter Type): 250 mL glass/none/Pu239 Alpha Spec; Method FRO-052-32; Received 2-13-90

Lab Sample ID	Client Sample ID	Sampling Date	Sampling Time	# of Containers	Sample Description/Remarks	250 mL glass/none/Pu239 Alpha Spec	Method FRO-052-32	Received 2-13-90	Samples Intact Upon Receipt? (Y/N)
	001-SL-I55-008	10-7-89	1105	1	✓ Shallow Soil 3-6"	X	X	✓	
	001-SL-I55-010	10-7-89	1107	1	✓ Shallow soil 6-12"	X	X	✓	
	001-SL-I55-007	10-7-89	1104	1	✓ Shallow soil 3-6"	X	X	✓	
	001-SL-I55-002	10-7-89	1057	1	✓ Shallow soil 0-1"	X	X	✓	

Possible Hazards:

Total Containers: 24

Comments, Observations, Special Instructions:

(Signature and Company Name)

Relinquished by:	Date / Time	Received by/Location:	Relinquished by:	Date / Time	Received by/Location:
Catherine M. Olson	10/20/89 1630			[illegible]	[illegible]

HIC

Distribution: Original Accompanies Shipment. Canary – Laboratory Retains. Pink Project Manager File (Sent with Report). Goldenrod Sampler Retains

Rev 1/89

CHAIN OF CUSTODY RECORD

SAIC
An Employee Owned Company

Science Applications International Corporation
4224 Campus Point Court, MS # 210
San Diego, California 92121
Attn: Sample Custodian, Environmental Chemistry Laboratory

Shipment #:
Field Charge #:
Lab Charge #:

SHIP TO	CLIENT/PROJECT INFORMATION	SAMPLING INFORMATION
Name: Teledyne Isotopes	Client: SAIC	Location: BOMARC
Address: 50 Van Buren Ave.	Project: BOMARC	
Contact: —	Contact: Donna Collins	Sampler: CG, GD
Phone #: 201-664-7070	Phone #: 303-278-8980	Phone #: 303-278-8980

Lab Sample ID	Client Sample ID	Sampling Date	Sampling Time	# of Containers	Sample Description/Remarks	250 ml plastic/none/Full Gamma Scan	Method PRO-052-32	Received 1-19-90	Samples Intact Upon Receipt? (Y/N)
	001-SL-TSI-061	10-8-89	1111	1	Shallow Soil 0-6"	X	X	✓	
	001-SL-TSI-070	10-8-89	1223	1		X	X	✓	
	001-SL-TSI-058	10-8-89	1059	1		X	X	✓	
	001-SL-TSI-077	10-8-89	1602	1		X	X	✓	
	001-SL-TSI-078	10-8-89	1610	1		X	X	✓	
	001-SL-TSI-074	10-8-89	1525	1		X	X	✓	
	001-SL-TSI-073	10-8-89	1518	1		X	X	✓	
	001-SL-TSI-068	10-8-89	1214	1		X	X	✓	
	001-SL-TSI-069	10-8-89	1219	1		X	X	✓	
	001-SL-TSI-063	10-8-89	1128	1		X	X	✓	
	001-SL-TSI-072	10-8-89	1512	1		X	X	✓	
	001-SL-TSI-079	10-8-89	1617	1		X	X	✓	
	001-SL-TSI-065	10-8-89	1146	1		X	X	✓	
	001-SL-TSI-080	10-8-89	1707	1		X	X	✓	
	001-SL-TSI-060	10-8-89	1107	1		X	X	✓	
	001-SL-TSI-085	10-8-89	1756	1		X	X	✓	
	001-SL-TSI-081	10-8-89	1723	1		X	X	✓	
	001-SL-TSI-082	10-8-89	1729	1		X	X	✓	
	001-SL-TSI-071	10-8-89	1500	1		X	X	✓	
	001-SL-TSI-066	10-8-89	1111	1		X	X	✓	
		Total Containers		[illegible]					

Possible Hazards:

Comments, Observations, Special Instructions:

(Signature and Company Name)

Relinquished by:	Date / Time	Received by/Location:	Relinquished by:	Date / Time	Received by/Location:
Catherine H. Moore	10/10/89 1630				

Distribution: Original Accompanies Shipment; Canary Laboratory Retains; Pink Project Manager File (Sent with Report); Goldenrod Sampler Retains

Rev 1 89

CHAIN OF CUSTODY RECORD

SAIC
An Employee-Owned Company

Science Applications International Corporation
4224 Campus Point Court, MS # 210
San Diego, California 92121
Attn: Sample Custodian, Environmental Chemistry Laboratory

Shipment #: ____
Field Charge #: ____
Lab Charge #: ____

SHIP TO
Name: Teledyne Isotopes
Address: 50 Van Buren Ave, Westwood, NJ
Contact: —
Phone #: 201-664-7070

CLIENT/PROJECT INFORMATION
Client: SAIC
Project: LOMAUC
Contact: [illegible] Collins
Phone #: 303-278-8980

SAMPLING INFORMATION
Location: LOMAUC
Sampler: CC, GD
Phone #: 303-278-8980

Lab Sample ID	Client Sample ID	Sampling Date	Sampling Time	# of Containers	Sample Description/Remarks	125 ml plastic/none/[illegible]	Method PRC-052-32	Received 1-19-90	Received 1-26-89	Samples Intact Upon Receipt? (Y/N)
	001-SL-TSI-064	10-8-89	1137	1	Shallow Soil 0-6"	X	X	✓		
	001-SL-TSI-076	10-8-89	1557	1	0-6"	X	X	✓		
	001-SL-TSI-075	10-8-89	1527	1	0-6"	X	X	✓		
	001-SL-TSI-084	10-8-89	1748	1	0-6"	X	X	✓		
	001-SL-TSI-067	10-8-89	1209	1	0-6"	X	X	✓		
	001-SL-TSI-082	10-8-89	1741	1	0-6"	X	X	✓		
	001-SL-TSI-062	10-8-89	1122	1	0-6"	X	X	✓		
	001-SL-C19-003	9-28-89	1640	1	12-18"	X	X	✓		
	001-SL-C21-002	9-28-89	1305	1	6-12"	X	X	✓		
	001-SL-C21-003	9-28-89	1205	1	12-18"	X	X		✓	
	001-SL-C19-002	9-28-89	1640	1	6-12"	X	X		✓	
	001-SL-C02-001	8-11-89	0853	1	0-6"	X	X		✓	
	001-SL-C12-002	9-15-89	1501	1	6-12"	X	X		✓	
	001-SL-C12-003	9-15-89	1501	1	12-18"	X	X		✓	
	001-SL-C10-002	9-15-89	1605	1	6-12"	X	X		✓	
	001-SL-C12-001	9-15-89	1501	1	0-6"	X	X		✓	
	001-SL-C19-001	9-28-89	1640	1	0-6"	X	X		✓	
	001-SL-C11-002	9-15-89	0910	1	6-12"	X	X		✓	
	001-SL-C20-003	9-28-89	1615	1	12-18"	X	X		✓	
	001-SL-C11-001	9-15-89	0910	1	0-6"	X	X		✓	

Total Containers: [illegible]

Possible Hazards:

Comments, Observations, Special Instructions:

(Signature and Company Name)

Relinquished by:	Date / Time	Received by/Location:	Relinquished by:	Date / Time	Received by/Location:
[illegible]	[illegible]			[illegible]	[illegible]

CHAIN OF CUSTODY RECORD

SAIC
An Employee Owned Company

Science Applications International Corporation
4224 Campus Point Court, MS # 210
San Diego, California 92121
Attn: Sample Custodian, Environmental Chemistry Laboratory

Shipment #: ______
Field Charge #: ______
Lab Charge #: ______

SHIP TO	CLIENT/PROJECT INFORMATION	SAMPLING INFORMATION
Name: Teledyne Isotopes	Client: SAIC	Location: [illegible] Missile Site
Address: [illegible] Westwood, NJ	Project: [illegible]	
Contact: —	Contact: [illegible]	Sampler: CO, GD
Phone #: 201-664-7070	Phone #: [illegible]	Phone #: 303-278-8480

Lab Sample ID	Client Sample ID	Sampling Date	Sampling Time	# of Containers	Sample Description/Remarks	250 mL plastic / none / [illegible]	Method PRO-052-32	Received 1-26-89	Received 2-6-90															Samples Intact Upon Receipt? (Y/N)
	001-SL-C13-003	9-15-89	1545	1	Shallow Soil 12-18"	X	X	✓																
	001-SL-C17-003	9-15-89	0910	1	12-18"	X	X	✓																
	001-SL-C16-003	9-15-89	1130	1	12-18"	X	X	✓																
	001-SL-C16-002	9-15-89	1120	1	6-12"	X	X	✓																
	001-SL-C13-001	9-15-89	1545	1	0-6"	X	X	✓																
	001-SL-C11-001	9-15-89	1122	1	0-6"	X	X	✓																
	001-SL-C13-002	9-15-89	1545	1	6-12"	X	X	✓																
	001-SL-C11-002	9-15-89	1122	1	6-12"	X	X	✓																
	001-SL-C03-003	9-13-89	0853	1	12-18"	X	X		✓															
	001-SL-C03-002	9-13-89	1535	1	6-12"	X	X	✓																
	001-SL-C02-002	8-11-89	0853	1	6-12"	X	X	✓																
	001-SL-C01-003	8-9-89	1120	1	12-18"	X	X	✓																
	001-SL-C18-001	9-15-89	0830	1	0-6"	X	X	✓																
	001-SL-C18-002	9-15-89	0830	1	6-12"	X	X	✓																
	001-SL-C18-003	9-15-89	0830	1	12-18"	X	X	✓																
	001-SL-C10-003	9-15-89	1605	1	12-18"	X	X	✓																
	001-SL-C02-001	9-13-89	1535	1	0-6"	X	X	✓																
	001-SL-C05-002	9-13-89	1100	1	6-12"	X	X	✓																
	001-SL-C05-003	9-13-89	1700	1	12-18"	X	X	✓																
	001-SL-C01-002	8-9-89	1120	1	6-12"	X	·	✓																

Possible Hazards:

Total Containers: [illegible]

Comments, Observations, Special Instructions:

(Signature and Company Name)

Relinquished by:	Date / Time	Received by/Location:	Relinquished by:	Date / Time	Received by/Location:
[illegible]	[illegible]			[illegible]	[illegible]

CHAIN OF CUSTODY RECORD

SAIC
An Employee Owned Company

Science Applications International Corporation
4224 Campus Point Court, MS # 210
San Diego, California 92121
Attn: Sample Custodian, Environmental Chemistry Laboratory

Shipment #:
Field Charge #: 1
Lab Charge #:

SHIP TO	CLIENT/PROJECT INFORMATION	SAMPLING INFORMATION
Name: Teledyne Isotopes	Client: [illegible]	Location: [illegible]
Address: [illegible]	Project: [illegible]	
Contact: [illegible]	Contact: [illegible] Collins	Sampler: [illegible]
Phone #: [illegible]	Phone #: 202-[illegible]	Phone #: [illegible]-3480

Lab Sample ID	Client Sample ID	Sampling Date	Sampling Time	# of Containers	Sample Description/Remarks		Glass/plastic/None/[illegible]	Method [illegible]-GS7-32	90 Received 1-26-90	Received 2-6-90	Samples Intact Upon Receipt? (Y/N)
	001-SL-C07-003	9-13-89	1150	1	Shallow Soil	12-18"	X	X	✓		
	001-SL-C15-001	10-1-89	1110	1	Shallow Soil	0-6"	X	X	✓		
	001-SL-C15-002	10-1-89	1110	1	Shallow Soil	6-12"	X	X	✓		
	001-SL-C01-001	8-4-89	1120	1	Shallow Soil	0-6"	X	X	✓		
	001-SL-C14-003	10-3-89	0846	1	Shallow Soil	12-18"	X	X	✓		
	001-SL-C15-003	10-1-89	1110	1	Shallow Soil	12-18"	X	X	✓		
	001-SL-C07-003	9-15-89	1101	1	Shallow Soil	12-18"	X	X	✓		
	001-SL-C04-001	9-13-89	1150	1	Shallow Soil	0-6"	X	X	✓		
	001-SL-C08-001	9-15-89	1115	1	Shallow Soil	0-6"	X	X	✓		
	~~001-SO-204-002~~	~~9-3-89~~	~~1540~~	~~1~~	[illegible] 10/19						
	~~001-SO-204-003~~	~~9-3-89~~	~~1541~~	~~1~~	[illegible] 10/19						
	001-SL-C07-002	9-15-89	1101	1	Shallow Soil	6-12"	X	X	✓		
	001-SL-C14-002	10-3-89	0846	1	Shallow Soil	6-12"	X	X	✓		
	001-SL-C04-002	9-13-89	1150	1	Shallow Soil	6-12"	X	X	✓		
	001-SL-C06-002	9-15-89	1035	1	Shallow Soil	6-12"	X	X	✓		
	~~001-SO-204-001~~	~~9-2-89~~	~~1537~~	~~1~~	[illegible] 10/19						
	001-SL-C08-002	9-15-89	1115	1	Shallow Soil	6-12"	X	X		✓	
	~~001-SO-204-003~~	~~9-3-89~~	~~1542~~	~~1~~	[illegible] 10/19						
	001-SL-C06-001	9-15-89	1035	1	Shallow Soil	0-6"	X	X		✓	
	001-SL-[illegible]-059	10-9-89	1105	1	Shallow Soil	0-6"	X	X		✓	

Possible Hazards:

Total Containers: [illegible]

Comments, Observations, Special Instructions:

(Signature and Company Name)

Relinquished by:	Date / Time	Received by/Location:	Relinquished by:	Date / Time	Received by/Location:
[illegible]	[illegible] 11:30			[illegible]	[illegible]

CHAIN OF CUSTODY RECORD

SAIC An Employee Owned Company

Science Applications International Corporation
4224 Campus Point Court, MS # 210
San Diego, California 92121
Attn: Sample Custodian, Environmental Chemistry Laboratory

Shipment #:
Field Charge #:
Lab Charge #:

SHIP TO
Name: Teledyne Isotopes
Address: 50 Van Buren Ave
Westwood, NJ
Contact: Dave Martin
Phone #: 201-6

CLIENT/PROJECT INFORMATION
Client: SAIC
Project: BOMARC
Contact: Donna Collins
Phone #: 203-278-8480

SAMPLING INFORMATION
Location: BOMARC Missile Site
Sampler: GO, GD
Phone #: 203-278-8480

Lab Sample ID	Client Sample ID	Sampling Date	Sampling Time	# of Containers	Sample Description/Remarks	[illegible]	Method FRO-052-32		Received 2-6-90	Samples Intact Upon Receipt? (Y/N)
	101-SL-C05-001	9-13-89	1700	1	0-6"	X	X		✓	
	101-SL-C11-003	9-15-89	1122	1	12-18"	X	X		✓	
	101-SL-C06-003	9-15-89	1035	1	12-18"	X	X		✓	
	101-SL-C07-001	9-15-89	1101	1	0-6"	X	X		✓	
	101-SL-C08-003	9-15-89	1115	1	12-18"	X	X		✓	
	~~101-SD-204-005~~	~~9-3-89~~	~~1545~~	~~1~~	GO [illegible]					

Possible Hazards:

Total Containers: 5

Comments, Observations, Special Instructions:

(Signature and Company Name)

Relinquished by:	Date / Time	Received by/Location:	Relinquished by:	Date / Time	Received by/Location:
[illegible]	[illegible]			[illegible]	[illegible]

Distribution: Original Accompanies Shipment, Canary Laboratory Retains, Pink Project Manager File (Sent with Report), Goldenrod Sampler Retains

CHAIN OF CUSTODY RECORD

SAIC. An Employee Owned Company

Science Applications International Corporation
4224 Campus Point Court, MS # 210
San Diego, California 92121
Attn: Sample Custodian, Environmental Chemistry Laboratory

Shipment #:
Field Charge #:
Lab Charge #:

SHIP TO	CLIENT/PROJECT INFORMATION	SAMPLING INFORMATION
Name: Teledyne Isotopes	Client: SAIC	Location: BOMARC Missile Site
Address: 50 Van Buren Ave Westwood, NJ	Project: BOMARC Missile Site	
Contact: Dave Martin	Contact: [illegible] Collins	Sampler: [illegible]
Phone #: 201-664-7070	Phone #: 202-278-8480	Phone #: 202-278-8480

Lab Sample ID	Client Sample ID	Sampling Date	Sampling Time	# of Containers	Sample Description/Remarks		250 ml. glass/none/Alpha Spec/Gamma Spec	Method DRO-052-32	Received 1-5-90	Received 1-18-90	Samples Intact Upon Receipt? (Y/N)
✓	001-SL-TS2-003	10-7-89	0845	1	Shallow Surface Soil	1-2"	X	X	✓		
✓	001-SL-TS2-004	10-7-89	0818	1	Shallow Surface Soil	1-2"	X	X	✓		
✓	001-SL-TS2-006	10-7-89	0840	1	Shallow Surface Soil	2-3"	X	X	✓		
✓	001-SL-TS2-007	10-7-89	0851	1	Shallow Surface Soil	3-6"	X	X		✓	
✓	~~001-SL-TS3-004~~	~~10-7-89~~	~~0944~~	~~1~~	~~Shallow Soil~~	~~6-7"~~	X	X		✓	
✓	001-SL-TS3-006	10-7-89	0951	1	Shallow Soil	7-8"	X	X		✓	
✓	001-SL-TS3-0011	10-7-89	1003	1	Shallow Soil	12-18"	X	X		✓	
✓	001-SL-TS3-0012	10-7-89	1004	1	Shallow Soil	12-18"	X	X		✓	
✓	001-SL-TS4-002	10-7-89	1028	1	Shallow Soil	0-1"	X	X	✓		
✓	001-SL-TS4-003	10-7-89	1030	1	Shallow Soil	1-2"	X	X	✓		
✓	001-SL-TS4-004	10-7-89	1031	1	Shallow Soil	1-2"	X	X	✓		
✓	001-SL-TS5-004	10-7-89	1100	1	Shallow Soil	1-2"	X	X	✓		
✓	001-SL-TS7-002	10-7-89	1558	1	Shallow Soil	0-1"	X	X		✓	
	~~001-SL-B03-001~~										
	~~001-SL-B04-001~~										
✓	001-SL-B05-001	10-2-89	1605	1	Shallow Soil	0-6"	X	X	✓		
✓	001-SL-B06-001	10-2-89	1612	1	Shallow Soil	0-6"	X	X	✓		
✓	001-SL-B08-001	10-2-89	1628	1	Shallow Soil	0-6"	X	X	✓		
✓	001-SL-B14-001	10-6-89	1103	1	Shallow Soil	0-6"	X	X	✓		

Possible Hazards:

Total Containers: 17

Comments, Observations, Special Instructions:

(Signature and Company Name)

Relinquished by:	Date / Time	Received by/Location:	Relinquished by:	Date / Time	Received by/Location:
[illegible]	[illegible]			[illegible]	[illegible]

Distribution: Original Accompanies Shipment, Canary Laboratory Retains, Pink Project Manager File (Sent with Report), Goldenrod Sampler Retains

Rev 1 89

CHAIN OF CUSTODY RECORD

SAIC
An Employee Owned Company

Science Applications International Corporation
4224 Campus Point Court, MS # 210
San Diego, California 92121
Attn: Sample Custodian, Environmental Chemistry Laboratory

Shipment #:
Field Charge #:
Lab Charge #:

SHIP TO	CLIENT/PROJECT INFORMATION	SAMPLING INFORMATION
Name: Teledyne Isotopes	Client: SAIC	Location: COMARC
Address: 50 Van Buren Ave. Westwood, NJ	Project: COMARC	
Contact: —	Contact: Donna Collins	Sampler: CD, GD
Phone #: 201-664-7070	Phone #: 303-278-8480	Phone #: 303-278-8480

Sample Type (Container/Preservative/Parameter Type)

Lab Sample ID	Client Sample ID	Sampling Date	Sampling Time	# of Containers	Sample Description/Remarks	[illegible] FU 229	Method PPO-NE7-37			Received 1-2-90	Received 1-8-90	Samples Intact Upon Receipt? (Y/N)
	001-SS-B08-002	10-4-89	1530	1	Split spoon samples 4-6'	X	X				X	
	001-SS-B05-003	10-5-89	1040	1	4-6'	X	X				X	
	001-SS-B08-003	10-4-89	1530	1	8-10'	X	X				X	
	001-SS-B05-002	10-5-89	1040	1	2-4'	X	X				X	
	001-SL-B13-001	10-6-89	1657	1	Shallow soil 0-0.5'	X	X				X	
	001-SL-B12-001	10-3-89	1619	1	Split-Spoon Samples 0-0.5'	X	X				X	
	001-SS-B01-003	10-4-89	1620	1	4-6'	X	X				X	
	001-SS-B01-003	10-5-89	1000	1	4-6'	X	X				X	
	001-SL-B11-001	10-3-89	1612	1	Shallow Soil samples 0-0.5'	X	X				X	
	001-SS-B09-002	10-5-89	1000	1	Split-Spoon Samples 2-4'	X	X				X	
	001-SL-B10-001	10-3-89	1601	1	Shallow Soil samples 0-0.5'	X	X				X	
	001-SS-B06-002	10-5-89	1155	1	Split-Spoon samples 0-2'	X	X				X	
	001-SL-B02-001	10-3-89	1540	1	Shallow Soil sample 0-0.5'	X	X				X	
	001-SL-B01-001	10-3-89	1527	1	" " 0-0.5' ~~8-10'~~	X	X			✓		
	001-SS-B02-002	10-4-89	—	1	Split Spoon Samples 8-10'	X	X			✓		
	001-SS-B04-002	10-4-89	—	1	2-4'	X	X			✓		
	001-SS-B02-002	10-4-89	—	1	2-4'	X	X			✓		
	001-SS-B04-00[illegible]	10-4-89	—	1	8-10'	X	X			✓		
	001-SS-B03-002	10-4-89	—	1	2-4'	X	X			✓		
	001-SS-B07-002	10-4-89	1630	1	4-6'	X	X			✓		

Possible [illegible]: | Total Containers: [illegible] | Comments, Observations, Special Instructions:

(Signature and Company Name)

Relinquished by:	Date / Time	Received by/Location:	Relinquished by:	Date / Time	Received by/Location:
[illegible]	[illegible]			[illegible]	[illegible]

Science Applications International Corporation
4224 Campus Point Court, MS # 210
San Diego, California 92121
Attn: Sample Custodian, Environmental Chemistry Laboratory

CHAIN OF CUSTODY RECORD

SAIC. An Employee Owned Company

Shipment #: ____
Field Charge #: 11
Lab Charge #: ____

SHIP TO
Name: Teledyne Isotopes
Address: 50 Van Buren, Westwood, NJ
Contact: ---
Phone #: 201-664-7070

CLIENT/PROJECT INFORMATION
Client: SAIC
Project: FORMRC
Contact: Donna Collins
Phone #: 303-278-8480

SAMPLING INFORMATION
Location: FORMRC
Sampler: Co, GD
Phone #: 303-278-8480

Lab Sample ID	Client Sample ID	Sampling Date	Sampling Time	# of Containers	Sample Description/Remarks	250 ml glass/none/ PIC 234 Alpha Spec	Method ORO-052-R2	Received 1-2-90	Received 1-8-90	Samples Intact Upon Receipt? (Y/N)
	001-SL-[illegible]-002	8-8-89	1112	1	Shallow Soils 6-12"	X	Y	✓	✓	
	001-SL-001-001	8-8-89	0923	1	0-6"	X	X	✓		
	001-SL-001-002	8-8-89	1100	1	6-12"	X	X	✓		
	001-SL-004-001	8-8-89	1418	1	0-6"	X	Y			
	001-SL-002-002	8-8-89	1057	1	6-12"	X	X	✓		
	001-SL-002-001	8-8-89	1055	1	0-6"	X	X	✓		
	001-SL-003-001	8-8-89	1525	1	0-6"	X	Y		X	
	001-SL-003-002	8-8-89	1517	1	6-12"	X	X		X	
	001-SS-B25-003	10-16-89	1000	1	Split-Spoon Samples 4-6'	X	X		X	
	001-SS-B26-002	10-16-89	1100	1	Split-Spoon Samples 2-4'	X	X		X	
	001-SS-B26-003	10-11-89	1110	1	Split-Spoon Samples 4-6'	X	Y		X	
	001-SS-B06-003	10-5-89	1155	1	Split-Spoon Samples 8-10'	X	X		X	

Possible Hazards:

Total Containers: 32

Comments, Observations, Special Instructions:

(Signature and Company Name)

Relinquished by:	Date / Time	Received by/Location:	Relinquished by:	Date / Time	Received by/Location:
[illegible]	12/20/89 [illegible]			[illegible]	[illegible]

Distribution: Original Accompanies Shipment, Canary Laboratory Retains; Pink Project Manager File (Sent with Report), Goldenrod Sampler Retains

Rev 1/89

CHAIN OF CUSTODY RECORD

SAIC. An Employee Owned Company

Science Applications International Corporation
4224 Campus Point Court, MS # 210
San Diego, California 92121
Attn: Sample Custodian, Environmental Chemistry Laboratory

Shipment #:
Field Charge #:
Lab Charge #:

SHIP TO
Name: Teledyne Isotopes
Address: 50 Van Buren Ave
Westwood, NJ
Contact: Dave Martin
Phone #: 201-664-7070

CLIENT/PROJECT INFORMATION
Client: SAIC
Project: BOMARC
Contact: Donna Collins
Phone #: 303.278.8480

SAMPLING INFORMATION
Location: BOMARC Missile Site
Sampler: CO, GD
Phone #: 202.278.8480

Sample Type (Container/Preservative/Parameter Type): 250ml Plastic/none/PU239 Alpha Spec; Method PRO-052-32; Received 12-13-89

Lab Sample ID	Client Sample ID	Sampling Date	Sampling Time	# of Containers	Sample Description/Remarks	250ml Plastic/none/PU239 Alpha Spec	Method PRO-052-32		Received 12-13-89	Samples Intact Upon Receipt? (Y/N)
✓	001-SL-TSI-032	9-29-89	1121	1	Shallow Soil 0-6"	X	X		✓	
✓	001-SL-TSI-031	9-29-89	1114	1		X	X		✓	
✓	001-SL-TSI-029	9-29-89	1041	1		X	X		✓	
✓	001-SL-TSI-039	10-6-89	1133	1		X	X		✓	
✓	001-SL-TSI-018	9-16-89	—	1		X	X		✓	
✓	001-SL-TSI-030	9-29-89	1054	1		X	X		✓	
✓	001-SL-TSI-017	9-16-89	—	1		X	X		✓	
✓	001-SL-TSI-016	9-16-89	—	1		X	X		✓	
✓	001-SL-TSI-033	9-29-89	1128	1		X	X		✓	
✓	001-SL-TSI-038	10-6-89	1116	1		X	X		✓	
✓	001-SL-TSI-010	10-8-89	0826	1		X	X		✓	
✓	001-SL-TSI-011	9-16-89	—	1		X	X		✓	
✓	001-SL-TSI-014	10-8-89	0843	1		X	X		✓	
✓	001-SL-TSI-023	9-29-89	0858	1		X	X		✓	
✓	001-SL-TSI-022	9-29-89	0851	1		X	X		✓	
✓	001-SL-TSI-007	9-16-89	—	1		X	X		✓	
✓	001-SL-TSI-002	9-16-89	—	1		X	X		✓	
✓	001-SL-TSI-024	9-29-89	0904	1		X	X		✓	
✓	001-SL-TSI-008	9-16-89	—	1		X	X		✓	
✓	001-SL-TSI-006	10-8-89	0815	1		X	X		✓	

Po... Hazards:

Total Containers: Con't

Comments, Observations, Special Instructions:

...ture and Company Name)

...nquished by:	Date / Time	Received by/Location:	Relinquished by:	Date / Time	Received by/Location:
[illegible]	[illegible]			[illegible]	[illegible]

Distribution: Original Accompanies Shipment, Canary Laboratory Retains, Pink Project Manager File (Sent with Report), Goldenrod Sampler Retains

Rev 1/89

CHAIN OF CUSTODY RECORD

SAIC
An Employee Owned Company

Science Applications International Corporation
4224 Campus Point Court, MS # 210
San Diego, California 92121
Attn: Sample Custodian, Environmental Chemistry Laboratory

Shipment #:
Field Charge #:
Lab Charge #:

SHIP TO
Name: Teledyne Isotopes
Address: 50 Van Buren
Westwood, NJ
Contact: —
Phone #: 201-664-7070

CLIENT/PROJECT INFORMATION
Client: SAIC
Project: POHAKC
Contact: Leona Collins
Phone #: 202-278-8980

SAMPLING INFORMATION
Location: POHAKULOA Missile Site
Sampler: CO, GD
Phone #: 202-278-8980

Lab Sample ID	Client Sample ID	Sampling Date	Sampling Time	# of Containers	Sample Description/Remarks	250ml plastic/none/Puzzs Aldo Sp	Method Opn-AE7-27	Received 12-13-89	Received 12-26-89	Samples Intact Upon Receipt? (Y/N)
✓	001-SL-TSI-003	9-16-89	—	1	Shallow Soil 0-6"	X	X	✓		
✓	001-SL-TSI-028	9-29-89	1024	1	↓	X	X	✓		
✓	001-SL-TSI-020	9-16-89	—	1		X	X	✓		
✓	001-SL-TSI-004	9-16-89	—	1		X	X	✓		
✓	001-SL-TSI-001	9-16-89	—	1		X	X	✓		
✓	001-SL-TSI-037	10-6-89	1100	1		X	X	✓		
✓	001-SL-TSI-012	10-8-89	0835	1		X	X	✓		
✓	001-SL-TSI-044	10-6-89	1234	1		X	X	✓		
✓	001-SL-TSI-054	10-7-89	1657	1		X	X	✓		
✓	001-SL-TSI-043	10-6-89	1226	1		X	X		✓	
✓	001-SL-TSI-025	9-29-89	0926	1		X	X		✓	
✓	001-SL-TSI-013	10-8-89	0838	1		X	X		✓	
✓	001-SL-TSI-042	10-6-89	1204	1		X	X		✓	
✓	001-SL-TSI-041	10-6-89	1200	1		X	X		✓	
✓	001-SL-TSI-052	10-7-89	1652	1		X	X		✓	
✓	001-SL-TSI-035	9-29-89	1149	1		X	X		✓	
✓	001-SL-TSI-026	9-29-89	0938	1		X	X		✓	
✓	001-SL-TSI-050	10-6-89	1658	1		X	X		✓	
✓	001-SL-TSI-009	10-8-89	0821	1		X	X		✓	
✓	001-SL-TSI-015	10-8-89	0817	1	↓	X	X		✓	

Possible Hazards:

Total Containers: [illegible]

Comments, Observations, Special Instructions:

(Signature and Company Name)

Relinquished by:	Date / Time	Received by/Location:	Relinquished by:	Date / Time	Received by/Location:
[illegible]	[illegible]			[illegible]	[illegible]

Distribution: Original Accompanies Shipment; Canary - Laboratory Retains; Pink - Project Manager File (Sent with Report); Goldenrod - Sampler Retains

Rev 1/89

CHAIN OF CUSTODY RECORD

SAIC. An Employee Owned Company

Science Applications International Corporation
4224 Campus Point Court, MS # 210
San Diego, California 92121
Attn: Sample Custodian, Environmental Chemistry Laboratory

Shipment #:
Field Charge #:
Lab Charge #:

SHIP TO
Name: [illegible]
Address: [illegible] Ave, [illegible], NJ
Contact: ---
Phone #: 201-649-7070

CLIENT/PROJECT INFORMATION
Client: SAIC
Project: BOMARC
Contact:
Phone #: 202-278-8980

SAMPLING INFORMATION
Location: BOMARC
Sampler: CO, GD
Phone #: 202-278-8980

Sample Type (Container/Preservative/Parameter Type): 250 ml plastic/None/[illegible]; Method FRO-052-32; Received 12-13-89; Received 12-26-89

Lab Sample ID	Client Sample ID	Sampling Date	Sampling Time	# of Containers	Sample Description/Remarks	250 ml plastic/None	Method FRO-052-32	Received 12-13-89	Received 12-26-89	Samples Intact Upon Receipt? (Y/N)
✓	001-SL-TSI-057	10-7-89	1059	1 ✓	Shallow Soil 0-6"	X	X		✓	
✓	001-SL-TSI-048	10-6-89	1612	1 ✓	↓	X	X	✓		
✓	001-SL-TSI-047	10-6-89	1602	1 ✓	↓	X	X	✓		
✓	001-SL-TSI-051	10-7-89	1616	1 ✓	↓	X	X		✓	
✓	001-SL-TSI-052	10-7-89	1648	1 ✓	↓	X	X		✓	
✓	001-SL-TSI-046	10-6-89	1552	1	↓	X	X		✓	
✓	001-SL-TSI-045	10-6-89	1253	1	↓	X	X		✓	

Possible Hazards:

Total Containers: 7

Comments, Observations, Special Instructions:

(Signature and Company Name)

Relinquished by:	Date / Time	Received by/Location:	Relinquished by:	Date / Time	Received by/Location:
[illegible]	[illegible] 1630			[illegible]	[illegible]

Distribution: Original Accompanies Shipment. Canary Laboratory Retains. Pink Project Manager File (Sent with Report). Goldenrod Sampler Retains.

CHAIN OF CUS RECORD

SAIC

Science Applications International Corporation
4224 Campus Point Court, MS # 210
San Diego, California 92121
Attn: Sample Custodian, Environmental Chemistry Laboratory

Shipment #:
Field Charge #:
Lab Charge #:

SHIP TO	CLIENT/PROJECT INFORMATION	SAMPLING INFORMATION
Name: Teledyne Isotopes	Client: SAIC	Location: [illegible]
Address: 50 Van Buren Ave. Westwood, NJ	Project: BOMARC	
Contact: —	Contact: Donna Collins	Sampler: [illegible]
Phone #: 201 664 7070	Phone #: 303-278 8480	Phone #: 303-278-8480

Lab Sample ID	Client Sample ID	Sampling Date	Sampling Time	# of Containers	Sample Description/Remarks	[illegible]	Normal GRO-057-27	Received 12-19-89	Samples Intact Upon Receipt? (Y/N)
✓	001-SS-B16-002	10-10-89	—	1	Shallow Soil 1-6'	X	X	X	
✓	001-SL-B25-001	10-11-89	1226	1	0-0.5'	X	X	✓	
✓	001-SL-B24-001	10-11-89	1201	1	0-0.5'	X	X	✓	
✓	001-SL-B21-001	10-11-89	1118	1	0-0.5'	X	X	✓	
✓	001-SS-B23-002	10-12-89	—	1	2-4'	X	X	✓	
✓	001-SS-B22-002	10-12-89	—	1	2-4'	X	X	✓	
✓	001-SS-B17-003	10-11-89	—	1	4-6'	X	X	✓	
✓	001-SL-B17-001	10-11-89	1000	1	0-0.5'	X	X	✓	
✓	001-SS-B20-003	10-12-89	—	1	4-6'	X	X	✓	
✓	001-SS-B24-003	10-17-89	—	1	4-6'	X	X	✓	
✓	001-SS-B11-002	10-11-89	—	1	2-4'	X	X	✓	
✓	001-SS-B12-003	10-11-89	—	1	8-10'	X	X	✓	
✓	001-SS-B15-002	10-10-89	—	1	2-4'	X	X	✓	
✓	001-SS-B10-003	10-11-89	—	1	8-10'	X	X	✓	
✓	001-SS-B15-003	10-10-89	—	1	4-6' ~~2-4'~~	X	X	✓	
✓	001-SS-B11-002	10-11-89	—	1	2-4' ~~4-6'~~	X	X	✓	
✓	001-SS-B11-003	10-11-89	—	1	4-6' ~~2-4'~~	X	X	✓	
✓	001-SS-B12-002	10-11-89	—	1	2-4' ~~0-0.5'~~	X	X	✓	
✓	001-SL-B12-001	10-11-89	1138	1	0-0.5'	X	X	✓	
✓	001-SL-B26-001	10-11-89	—	1	0-0.5'	X	X	✓	

Possible Hazards: [illegible]

Total Containers: [illegible]

Comments, Observations, Special Instructions:

(Signature and Company Name)

Relinquished by:	Date / Time	Received by/Location:	Relinquished by:	Date / Time	Received by/Location:
[illegible signature]	12/20/89 1630			12/21/89 10:30	[illegible signature]

Distribution: Original Accompanies Shipment, Canary Laboratory Retains, Pink Project Manager File (Sent with Report), Goldenrod Sampler Retains

Rev. 1.89

Science Applications International Corporation
4224 Campus Point Court, MS # 210
San Diego, California 92121
Attn: Sample Custodian, Environmental Chemistry Laboratory

CHAIN OF CUS. _ / RECORD

SAIC

Shipment #: ______
Field Charge #: ______
Lab Charge #: ______

SHIP TO	CLIENT/PROJECT INFORMATION	SAMPLING INFORMATION
Name: Teledyne Isotopes	Client: SAIC	Location: BOMARC
Address: 50 Van Buren Ave Westwood, NJ	Project: BOMARC	
Contact: —	Contact: Donna Collins	Sampler: CO, GD
Phone #: 201 664 7070	Phone #: 303 399 2780	Phone #: 303 399 2780

Lab Sample ID	Client Sample ID	Sampling Date	Sampling Time	# of Containers	Sample Description/Remarks	Sample Type: [illegible] glass/none/[illegible]		Sample Type: Received 12-19-89	Samples Intact Upon Receipt? (Y/N)
✓	01-SS-818-001	10-11-89	1030	1	Shallow Soil 0-0.5'	X		X	
✓	01-SS-819-001	10-11-89	1015	1	Shallow soil 0-0.5'	X		X	
✓	01-SS-822-003	10-12-89	—	1	Shallow Soil 4-6'	X		X	
✓	01-SS-823-003	10-12-89	—	1	Shallow Soil 4-6'	X		X	

Possible Hazards:

Total Containers: 21

Comments, Observations, Special Instructions:

(Signature and Company Name)

Relinquished by:	Date / Time	Received by/Location:	Relinquished by:	Date / Time	Received by/Location:
[illegible signature]	10/20/89 1630			[illegible]	[illegible signature]

SAIC Distribution: Original Accompanies Shipment, Canary Laboratory Retains, Pink Project Manager File (Sent with Report), Goldenrod Sampler Retains

Rev 1/89

CHAIN OF CUSTODY RECORD

BC Log Number ____________

Client name: SAIC / BOMARC

Job number or Purchase Order number:

Project name: BOMARC

Project manager: Neil Botts

Sampler(s): CD, ME, DC, NB

Analyses required

Sample number	Date sampled	Time sampled	Matrix Type	Sample description	Number of containers	Gross Alpha	Gross Beta	Gross Alpha (F)	Gross Beta (F)				Hazardous sample / Special handling required	Remarks
	7/6/89	1200	Water	001-GW-MW48-001	2	X	X							Method 900
	7/6/89	1200	Water	001-GW-MW48-001 (F)	2			X	X					EPA-600/4-80-032
	7/6/89	1555	Water	001-GW-MW49-001	2	X	X							
	7/6/89	1555	Water	001-GW-MW49-001 (F)	2			X	X					Rush
	7/8/89	1000	Water	001-GW-MW47-001	2	X	X							Analysis
	7/8/89	1000	Water	001-GW-MW47-001 (F)	2			X	X					
	6/29/89	1615	Water	001-GW-PU7-001	1	X	X							Note: 2 samples
	6/29/89	1615	Water	001-GW-PU7-001 (F)	1			X	X					with same
	6/29/89	1100	Water	001-GW-PU5-001	1	X	X							ID - one is filtered
	6/~~30~~ 29/89	~~0915~~ 1100	Water	001-GW-PU5-001 (F)	1			X	X					one is NOT.
	6/30/89	0915	Water	001-GW-PU2-001	1	X	X							↓
	6/30/89	0915	Water	001-GW-PU2-001 (F)	1			X	X					

	Signature	Company	Date	Time
Relinquished by	[signature]	SAIC	5-30-89	1400
Receive by				
Relinquished by				
Received by				
Relinquished by				
Received by				

BROWN AND CALDWELL Analytical Laboratories

☐ 1255 Powell Street, Emeryville, CA 94608 (415) 428-2300
☐ 373 South Fair Oaks Avenue, Pasadena, CA 91105 (213) 681-4655

Note: Samples are discarded 30 days after results are reported unless other arrangements are made.
Hazardous samples will be returned to client or disposed of at client expense.

CHAIN OF CUSTODY RECORD

BC Log Number ______

Client name: SAIC / BOMARC

Job number or Purchase Order number:

Project name: BOMARC

Project manager: Neil Botts

Sampler(s): CO, ME, DC, NB

Sample number	Date sampled	Time sampled	Matrix Type	Sample description	Number of containers	Gross Alpha	Gross Beta	Gross Alpha (F)	Gross Beta (F)				Hazardous sample / Special handling required	Remarks
	6/28/89	1730	Water	001-GW-PU1-001	1	X	X							Method 900
	6/28/89	1730	Water	001-GW-PU1-001 (F)	1			X	X					EPA-600/4-80-032
	6/29/89	1630	Water	001-GW-PU10-001	1	X	X							
	6/29/89	1630	Water	001-GW-PU10-001 (F)	1			X	X					

	Signature	Company	Date	Time
Relinquished by	[signature]	SAIC	6-30-89	1400
Received by				
Relinquished by				
Received by				
Relinquished by				
Received by				

BROWN-AND-CALDWELL—Analytical Laboratories

☐ 1255 Powell Street, Emeryville, CA 94608 (415) 428-2300
☐ 373 South Fair Oaks Avenue, Pasadena, CA 91105 (213) 681-4655

Note: Samples are discarded 30 days after results are reported unless other arrangements are made.
Hazardous samples will be returned to client or disposed of at client expense.

CHAIN OF CUSTODY RECORD

BC Log Number 1

Client name: SAIC / BOMARC	Job number or Purchase Order number:
Project name: BOMARC	
Project manager: Neil Eotts	Sampler(s): CO, ME, DC, NB

Sample number	Date sampled	Time sampled	Matrix Type	Sample description	Number of containers	Gross Alpha	Gross Beta	Gross Alpha (F)	Gross Beta (F)				Hazardous sample / Special handling required	Remarks
	7/7/89	1615	Water	001-GW-PU3-001	1 l	X	X							Method 900
	7/7/89	1615	Water	001-GW-PU3-001 (F)	1 l			X	X					EPA-600/4-80-032
	7/8/89	0700	Water	001-GW-PU4-001	1 l	X	X							
	7/8/89	0700	Water	001-GW-PU4-001 (F)	1 l			X	X					
	7/7/89	1100	Water	001-GW-PU6-001	1 l	X	X							Rush
	7/7/89	1100	Water	001-GW-PU6-001 (F)	1 l			X	X					Analysis
	10/30/89	0945	Water	001-EQB-PU7-001	1 l	X	X							
	10/30/89	0945	Water	001-EQB-PU7-001 (F)	1 l			X	X					
														Note: 2 samples ea
														with same ID. one
														is filtered 1 NOT

	Signature	Company	Date	Time
Relinquished by	Catherine M. Olsen	SAIC	8-31-89	1400
Received by				
Relinquished by				
Received by				
Relinquished by				
Received by				

BROWN-AND-CALDWELL Analytical Laboratories

☐ 1255 Powell Street, Emeryville, CA 94608 (415) 428-2300

☐ 373 South Fair Oaks Avenue, Pasadena, CA 91105 (213) 681-4655

Note: Samples are discarded 30 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.

-metaTR[illegible], Inc

CC1

Page 2 of 2

Chain-of-Custody

Client: SAIC / Bomarc

Project No: BOMARC

Due Date:

Report To: Neil Botts

Date Received:

Received By:

Sample Location:

Item No.	Sample No.	Sample ID	Matrix	Analysis Required	Sample Date	Comments	Preservative
1.	001-SW-001-001		W	Gross α-β		Method 900	HNO_3 ≤2
2.	001-SW-001-002		W	↓		EPA-600/4-80-032	
3.	001-SW-002-001		↓	↓			
4.	001-SW-002-002		↓	↓		Rush	
5.	001-SW-003-001		↓	↓		Analysis	
6.	001-SW-003-002		↓	↓			
7.	001-SW-004-001		↓	↓			
8.	001-SW-004-002		↓	↓			
9.							
10.							
11.							
12.							
13.	Shipped	by	(NL)	8-31-89	1400 hrs		

Items	Date	Signature Received	Analysis	Relinquished By	Returned By	Date	Received By

metal [illegible], Inc.

Chain-of-Custody

Client: Earth Technology
Project No: Bomarc
Due Date:
Report To:

Relinquished [illegible] 6-29-89 - 13:00

Date Received: 6-30-89
Received By: Mary Piken
Sample Location: BOMARC

Item No.	Sample No.	Sample ID	Matrix	Analysis Required	Sample Date	Comments	Preservative
1.	001-GW-PU1	001	aqueous	BNA PEST/PCB	6/28/89	Perform full TCL	ice
2.	001-GW-PU1	001	aqueous	VOA	6/29/89	QA/QC	ice
3.	trip blank	001	aqueous	VOA		Procedure	↓
4.	001-GW-PU5	001	aqueous	VOA	6/29/89	↓	↓
5.	001-GW-PU5	-001 Dup	aq	BNA PEST/PCB	6/29/89	↓	↓
6.	001-GW-PU1	-001 Dup	aq	VOA	6/28/89	↓	↓
7.	001-GW-PU1	-001 Dup	aq	BNA PCB/PEST	6/28/89	↓	↓
8.	001-GW-PU1	-001 Dup	aq	VOA	6/28/89	↓	↓
9.	001-GW-PU1	001 Dup	aq	PEST/PCB/BNA	6/28/89	↓	↓
10.							
11.							
12.							
13.							

Items	Date	Signature Received	Analysis	Relinquished By	Returned By	Date	Received By
BOMARC Organic [illegible] sample	6/29/89	Mary Piken	Above				

[illegible], Inc.

Chain-of-Custody

Client: Earth Technology
Project No: BOMARC
Due Date: ______ Report To: ______

Date Received: ______
Received By: ______
Sample Location: ______

Item No.	Sample No.	Sample ID	Matrix	Analysis Required	Sample Date	Comments	Preservative
1.	001-EQU-PU2-001		aq	VOA	6/30/89	Perform full	ice
2.	001-EQU-PU2-001		aq	BNA/PEST/PCB	↓	TCL QA/QC	ice
3.	001-GW-PU2-001		aq	VOA	↓	procedure	↓
4.	001-GW-PU2-001		aq	BNA/PEST/PCB	↓	↓	↓
5.	001-AMB-PU2-001		aq	VOA	6/30/89	↓	↓
6.	001-GW-PU7-001		aq	VOA	6/29/89	↓	↓
7.	001-GW-PU7-001		aq	BNA	↓	↓	↓
8.	001-GW-PU10-001		aq	VOA	↓	↓	↓
9.	001-GW-PU10-001		aq	BNA	↓	↓	↓
10.	Trip Blank		aq	VOA	↓	↓	↓
11.							
12.							
13.							

Items	Date	Signature Received	Analysis	Relinquished By	Returned By	Date	Received By
ALL	7-1-89	Mary P[illegible]					

Chain-of-Cu[redacted]dy

Client: Earth Technology Corp.
Project No: 86013 -11
Due Date: ______ **Report To:** P. Watts

Date Received: ______
Received By: ______
Sample Location: ______

Item No.	Sample No.	Sample ID	Matrix	Analysis Required	Sample Date	Comments	Preservative
1.	001-GW-PU1-	001	GW	TAL Total + Diss. Metals	6-28-89	Two Containers	HNO_3 . pH<2
2.	001-GW-PU2	-001	GW	TAL Total + Diss Metals	6-30-89	DP QC ~~Two~~ Three Containers	"
3.	001-GW-PU5	-001	GW	TAL Tot. + Diss Metals	6-29-89	Two Containers	"
4.	001-GW-PU7	-001	GW	TAL Tot. + Diss Metals	6-29-89	Two Containers	"
5.	001-GW-PU10	-001	GW	TAL Tot. + Diss Metals	6-29-89	Two Containers	"
6.	001-AMB-	PU2-001	GW	TAL Dissolved Metals	6-30-89	One Container	"
7.	001-EQU-P	U2-001	GW	TAL Total ~~Total~~ P.O.W. Metals	6-30-89	One Container	"
8.							
9.							
10.							
11.							
12.							
13.							

Items	Date	Signature Received	Analysis	Relinquished By	Returned By	Date	Received By
Samples Listed Above	8-17-89	Relinquished By: Mehin J. Tipe					

metaTRACE, Inc.

Chain-of-Custody

Client: O.F. H.L. (Air Force)

Project No: 86013-11

Due Date: ASAP

Report To: Phil Watts, The Earth Technol. Corp. 300 N. Washington St., Suite 900 Alexandria, VA 22314

Date Received:

Received By:

Sample Location: Asphalt drainage ditch (AP1 - AP5)

Item No.	Sample No.	Sample ID	Matrix	Analysis Required	Sample Date	Comments	Preservative
1.	AP-1	001-SL-AP1-002	Soil	TCL Semivolatiles	8/8/84	Soil samples	None
2.	AP-1	001-SL-AP1-002	Soil	Pesticides and PCBs	8/8/89	taken 6" to 12"	↓
3.	AP-1	001-SL-AP1-002	Soil	TAL inorganic metals	↓	below surface	↓
4.	AP-2	001-SL-AP2-002	↓	TCL Semivolatiles	↓	↓	↓
5.	AP-2	001-SL-AP2-002	↓	Pesticides and PCBs	↓	↓	↓
6.	AP-2	001-SL-AP2-002	↓	TAL inorganic metals	↓	↓	↓
7.	AP-3	001-SL-AP3-002	↓	TCL Semivolatiles	↓	↓	↓
8.	AP-3	001-SL-AP3-002	↓	Pesticides and PCBs	↓	↓	↓
9.	AP-3	001-SL-AP3-002	↓	TAL inorganic metals	↓	↓	↓
10.	AP-4	001-SL-AP4-002	↓	TCL Semivolatiles	↓	↓	↓
11.	AP-4	001-SL-AP4-002	↓	Pesticides and PCBs	↓	↓	↓
12.	AP-4	001-SL-AP4-002	↓	TAL inorganic metals	↓	↓	↓
13.			↓		↓	↓	↓

Items	Date	Signature Received	Analysis	Relinquished By	Returned By	Date	Received By
18 Full	8/10/89	[signature]	See above	[signature]		8/11/89	[signature]
+4 spiked							
Matrix							
bottles							
(empty)							

Chain-of-Custody

Page 2 of 2

Client: O.E.HL (Air Force)

Project No: 86013-11

Due Date: ASAP

Report To: Phil Watts, The Earth Technol. Corp. 300 N. Washington St., Suite 700 Alexandria VA 22314

Date Received:

Received By:

Sample Location: Asphalt Drainage Ditch (AP1-AP5) and Concrete Apron (CC1-CC2)

dup

Item No.	Sample No.	Sample ID	Matrix	Analysis Required	Sample Date	Comments	Preservative
1.	AP-5	001-SL-AP5-002	Soil	TCL Semivolatiles	8/8/89	6"-12" below soil	None
2.	AP-5	001-SL-AP5-002	Soil	Pesticides and PCBs	8/8/89	surface. AP5 is	↓
3.	AP-5	001-SL-AP5-002	Soil	TAL inorganic metals	8/8/89	duplicate of AP3	↓
4.	CC-1	001-SL-CC1-003	↓	VOA	8/10/89	location	↓
5.	CC-1	001-SL-CC1-003	↓	VOA	8/10/89	6"-12" below	↓
6.	CC-1	001-SL-CC1-003	↓	TCL Semivolatiles	8/10/89	soil surface	↓
7.	CC-1	001-SL-CC1-003	↓	Pesticides and PCBs	↓	↓	↓
8.	CC-1	001-SL-CC1-003	↓	TAL inorganics metals	↓	0-6" below surface	↓
9.	CC-2	001-SL-CC2-003	↓	VOA	↓	↓	↓
10.	CC-2	001-SL-CC2-003	↓	VOA	↓	↓	↓
11.	CC-2	001-SL-CC2-003	↓	TCL Semivolatiles	↓	↓	↓
12.	CC-2	001-SL-CC2-003	↓	Pesticides and PCBs	↓	↓	↓
13.	CC-2	001-SL-CC2-003	↓	TAL inorganic metals	↓	↓	↓

Items	Date	Signature Received	Analysis	Relinquished By	Returned By	Date	Received By
	8/11/89	Theodore Feller					

SAIC Bomarc RIFS
McGuire AFB NJ
August 10, 1989

Metatrace Inc
13715 Rider Trail North
Earth City MO 63045

Gentleman & Ladies

This is the second shipment of soil samples sent for analysis for the paramators indicated.

These samples were collected from a site known to be contaminated with Pu-239 and Am-241. The samples have been screened by gamma spectrometry and the quantities in each sample are shown in the enclosed table.

These samples are shipped as limited quantity per 49 CFR 173.421

Very truly yours,

Stanley J. Waligora

Stanley J. Waligora Jr.
Health Physicist

Sample ID		Am-241 (µCi)	Pu (µCi)
001-SL-AP1-002	A	4.743E-2 +/- 10%	2.846E-1
	B	1.710E-1 +/- 10%	1.026E+00
001-SL-AP2-002	A	2.442E-3 +/- 39%	1.465E-2
	B	1.349E-3 +/- 60%	8.094E-3
001-SL-AP3-002	A	1.800E-3 +/- 53%	1.080E-2
	B	< 1.724E-4	< 1.034E-3
001-SL-AP4-002	A	< 5.508E-4	< 3.305E-3
	B	< 5.458E-4	< 3.275E-3
001-SL-AP5-002	A	1.250E-3 +/- 65%	7.500E-3
	B	< 1.139E-4	< 6.834E-4
001-SL-CC1-002		< 2.416E-1	< 1.450E+00
001-SL-CC1-003		< 5.83E-4	< 3.498E-3
001-SL-CC2-002	A	< 1.031E-3	< 6.186E-3
	B	< 1.023E-3	< 6.138E-3
001-SL-CC2-003	A	< 3.332E-4	< 1.999E-3
	B	< 3.187E-4	< 1.912E-3

metaTRAC Inc.

Chain-of-Custody

CC1 : Page 1 of 1

Client: OEHL (Air Force)

Project No: 86013-11

Due Date: ASAP

Report To: Phil Watts, The Earth Tech. Corp. 300 N. Washington Street, Suite 700 Alexandria VA. 22314

Date Received:

Received By:

Sample Location:

Item No.	Sample No.	API Sample ID	Matrix	Analysis Required	Sample Date	Comments	Preservative
1.	AP-1	001-SL-AP1-003	Soil	VOA	8/8/89	Soil, 12-18" below	None
2.	"	001-SL-AP1-003	Soil	VOA	8/8/89	surface	None
3.	AP-2	001-SL-AP2-003	↓	VOA	8/8/89	↓	None
4.	"	001-SL-AP2-003		VOA	8/8/89		"
5.	AP-3	001-SL-AP3-003		VOA	8/8/89		"
6.	"	001-SL-AP3-003		VOA	8/8/89		"
7.	AP-4	001-SL-AP4-003		VOA	8/8/89		"
8.	"	001-SL-AP4-003		VOA	8/8/89		"
Dup→ 9.	AP-5	001-SL-AP5-003		VOA	8/8/89	Duplicate at AP-3	"
10.	"	001-SL-AP5-003	↓	VOA	8/8/89	location	"
11.				~~VOA~~			
12.							
13.							

Items	Date	Signature Received	Analysis	Relinquished By	Returned By	Date	Received By
10	8/8/89	K Cameli	VOA	Melvin J. Snyder			

SAIC - GCL
EARTH TECHNOLOGY
BOMARC PITS
McGUIRE AFB, N.J.
AUG. 8, 1989

METATRACE, INC.
13715 RIDER TRAIL NORTH
EARTH CITY, MO. 63045

GENTLEMEN & LADIES:

THE ENCLOSED SAMPLES ARE SENT FOR ANALYSES INDICATED ON THE CHAIN OF CUSTODY FORM.

ORIGINAL ARRANGEMENTS WERE MADE BY NEIL BOTTS AT SAIC IN GOLDEN CO. (303) 278-8480.

THESE SAMPLES ARE ASSOCIATED WITH KNOWN PU-239 AND AM-241 CONTAMINATION AND THEY HAVE BEEN ASSAYED BY GAMMA SPECTROMETRY.

THESE SAMPLES ARE SHIPPED UNDER 49 CFR 173.421 AS A LIMITED QUANTITY. THE DIRT ON THE OUTSIDE OF THE JARS AND VIALS MAY BE SLIGHTLY CONTAMINATED BUT IN NO CASE AS MUCH AS 1000 dpm/cm². THE OUTER BAGS ARE NOT CONTAMINATED. THE PAINT CAN IS ALSO CLEAN.

IF YOU HAVE ANY QUESTIONS PLEASE CALL NEIL BOTTS. WE ARE IN THE FIELD WITH NO PHONE. HOWEVER YOU MAY LEAVE A MESSAGE AT NU MOTEL AT (609) 723-6500.

VERY TRULY YOURS,

[signature]

STANLEY J. WALICZRA JR
HEALTH PHYSICIST

APPENDIX G

PLUTONIUM TRANSPORT MODEL
BOMARC SITE, McGUIRE AIR FORCE BASE

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

PLUTONIUM TRANSPORT MODEL
BOMARC SITE, McGUIRE AIR FORCE BASE

JULY 1990

Burgess & Niple, Limited

Engineers and Architects

5085 Reed Road • Columbus, OH 43220 • (614) 459-2050

b&n 1912

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
BOMARC SITE, McGUIRE AIR FORCE BASE
PLUTONIUM TRANSPORT MODEL

JULY 1990

BURGESS & NIPLE, LIMITED
Engineers and Architects
5085 Reed Road
Columbus, OH 43220

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INTRODUCTION

Science Applications International Corporation (SAIC) is completing a remedial investigation and feasibility study (RI/FS) of a plutonium contaminated site (BOeing-Michigan Aeronautical Research Center [BOMARC] Site) near McGuire Air Force Base in Ocean County, New Jersey.

The BOMARC Site was subjected to an accidental release of plutonium to the environment on June 7, 1960 caused by an explosion of rocket fuel and subsequent fire of a BOMARC missile. The fire melted the plutonium warhead and as a result of the firefighting activities, plutonium-contaminated water flowed outside the missile shelter (No. 204) down the asphalt apron and street and into a drainage ditch leading to a ponding area outside the site boundary.

As part of the RI/FS, SAIC has requested that mathemathical modeling be performed by Burgess & Niple, Limited to define plutonium transport and dispersion into the drainage ditch and ponding area.

This report describes the site, the model selection and testing, the modeling goals and assumptions, the input data used, the modeling scenarios and their results, and provides a preliminary prediction of the transport path and fate of plutonium released into the drainage ditch.

SITE DESCRIPTION

General Topography

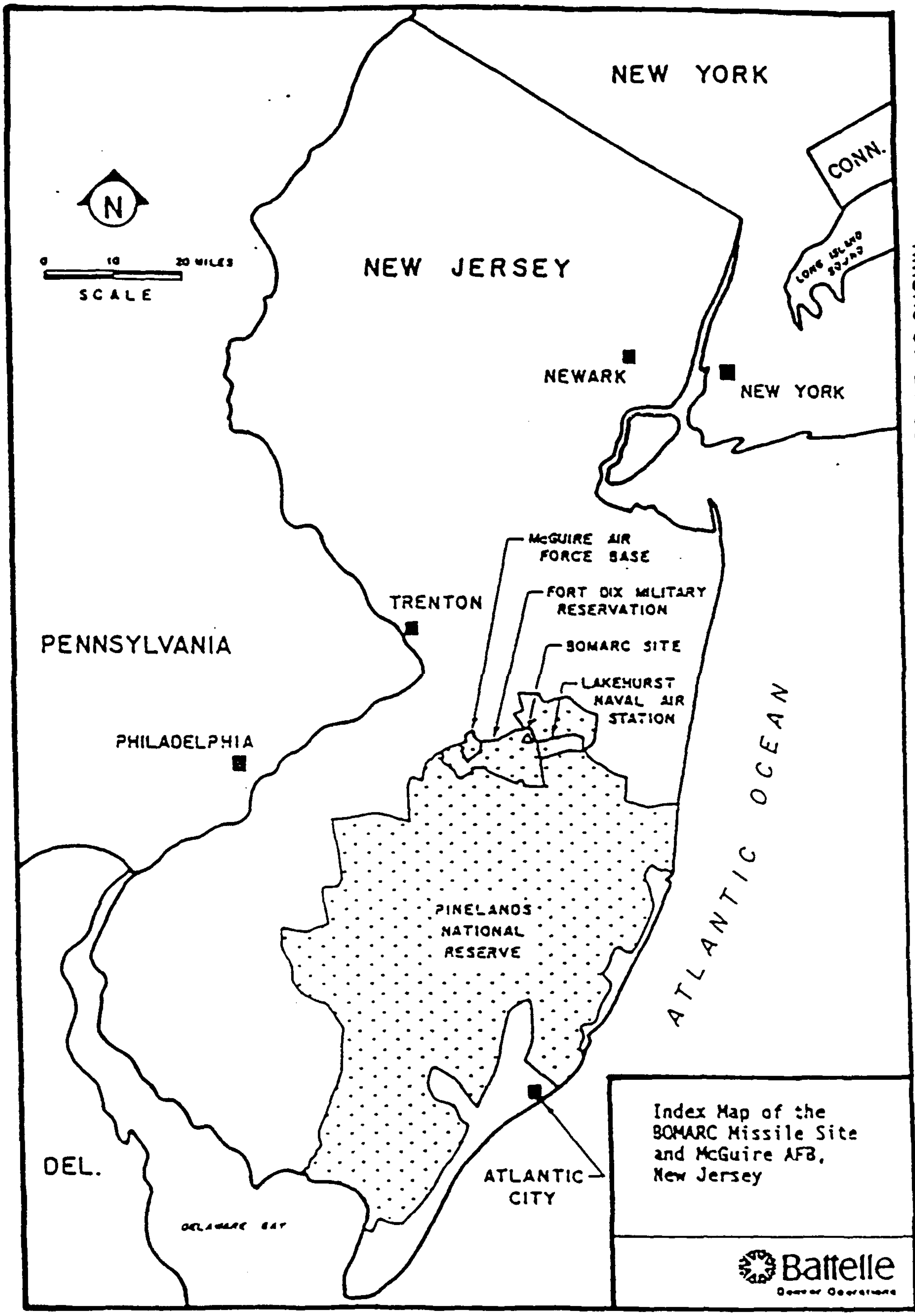
The BOMARC Missile Site, located in Ocean County, is in a heavily wooded, semirural part of east-central New Jersey, about 25 miles inland from the coast (Figure 1). It lies on the northern boundaries of the New Jersey Pinelands (Pine Barrens). The site is on Fort Dix Military Reservation property, leased to McGuire Air Force Base (AFB). Fort Dix extends to the west of the BOMARC facility, and to the southeast is the Lakehurst Naval Air Station (Figure 2). Part of the New Jersey Wildlife Game Refuge lies northeast of the BOMARC facility.

The topography of the area is gently rolling with elevations ranging between 60 and 180 feet above mean sea level (msl). It is generally low-lying, with poor drainage, many swamps, and slow-flowing streams. The maximum elevation at the BOMARC Missile Site is about 180 feet above msl near Shelter 204, and decreases to about 130 feet above msl at the southeastern perimeter of the facility.

The nearest and only na' ·ral drainageway in the vicinity of the site is to the south: the northeast-trending Elisha Branch which via Success Branch, Bordens Mill Branch, and Ridgeway Branch flows into the southeast-trending Toms River (Figures 2 and 3).

Drainage Ditch Topography

The total watershed area contributing to the drainage ditch is 15.5 acres and is shown on Figure 3. The drainage ditch runs southerly from Shelter 204, paralleling the site boundary fence for approximately 800 feet before entering into a twin 24-inch underground culvert of 230-foot length. Approximately 250 feet upstream of that point, an 18-inch pipe discharges surface runoff into the ditch. The twin 24-inch culvert discharges into the drainage ditch which runs another 320 feet before entering a single 30-inch culvert of 130-foot length crossing underneath Ocean County Highway 539. From this point, the culvert opens into a sandy ditch that eventually flattens into a wooded ponding area (Figures 3 and 4). There does not appear to be a natural surface



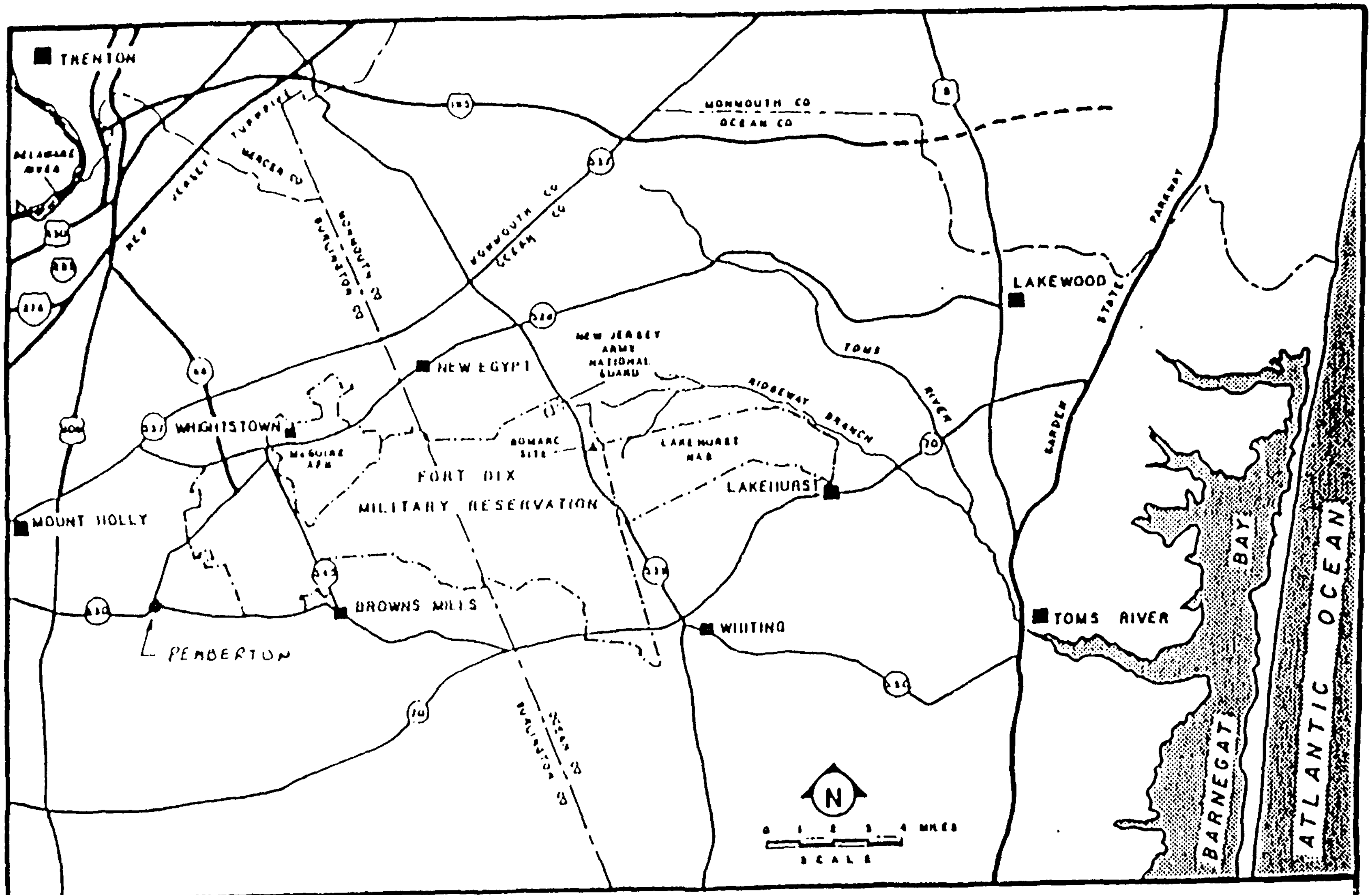
Index Map of the BOMARC Missile Site and McGuire AFB, New Jersey

BOMARC SITE, MCGUIRE AFB,
PLUTONIUM TRANSPORT MODEL

FIG. 1

BURGESS & NIPLE, LIMITED
ENGINEERS AND ARCHITECTS

SCALE: AS SHOWN
DATE: FEB. 1990



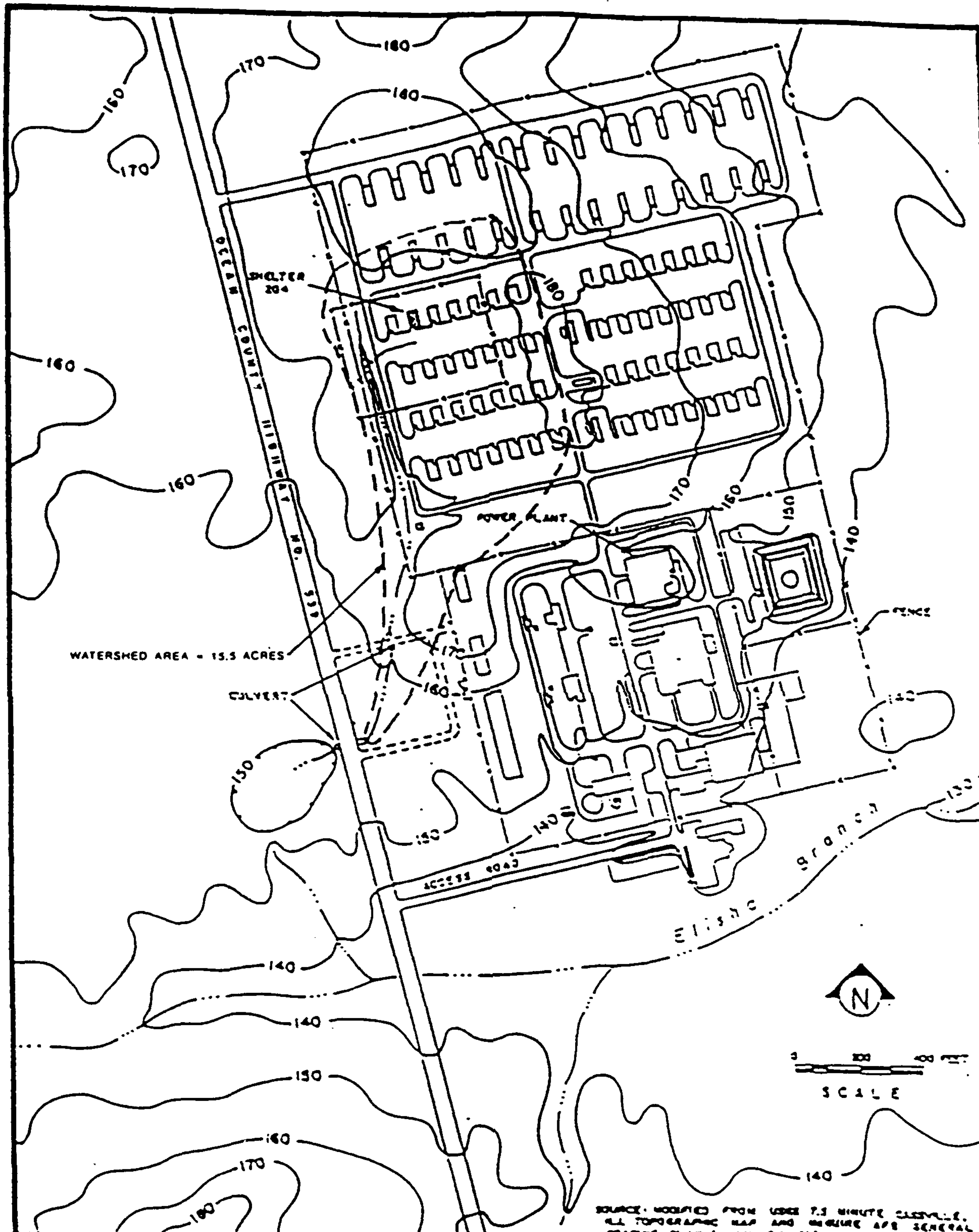
Map of Central New Jersey showing the location of the BOMARC Missle Site

BOMARC SITE, MCGUIRE AFB. PLUTONIUM TRANSPORT MODEL

FIG. 2

BURGESS & NIPLE, LIMITED
ENGINEERS AND ARCHITECTS

SCALE: AS SHOWN
DATE: FEB. 1990



Site Map of the BOMARC Missile Site

Battelle

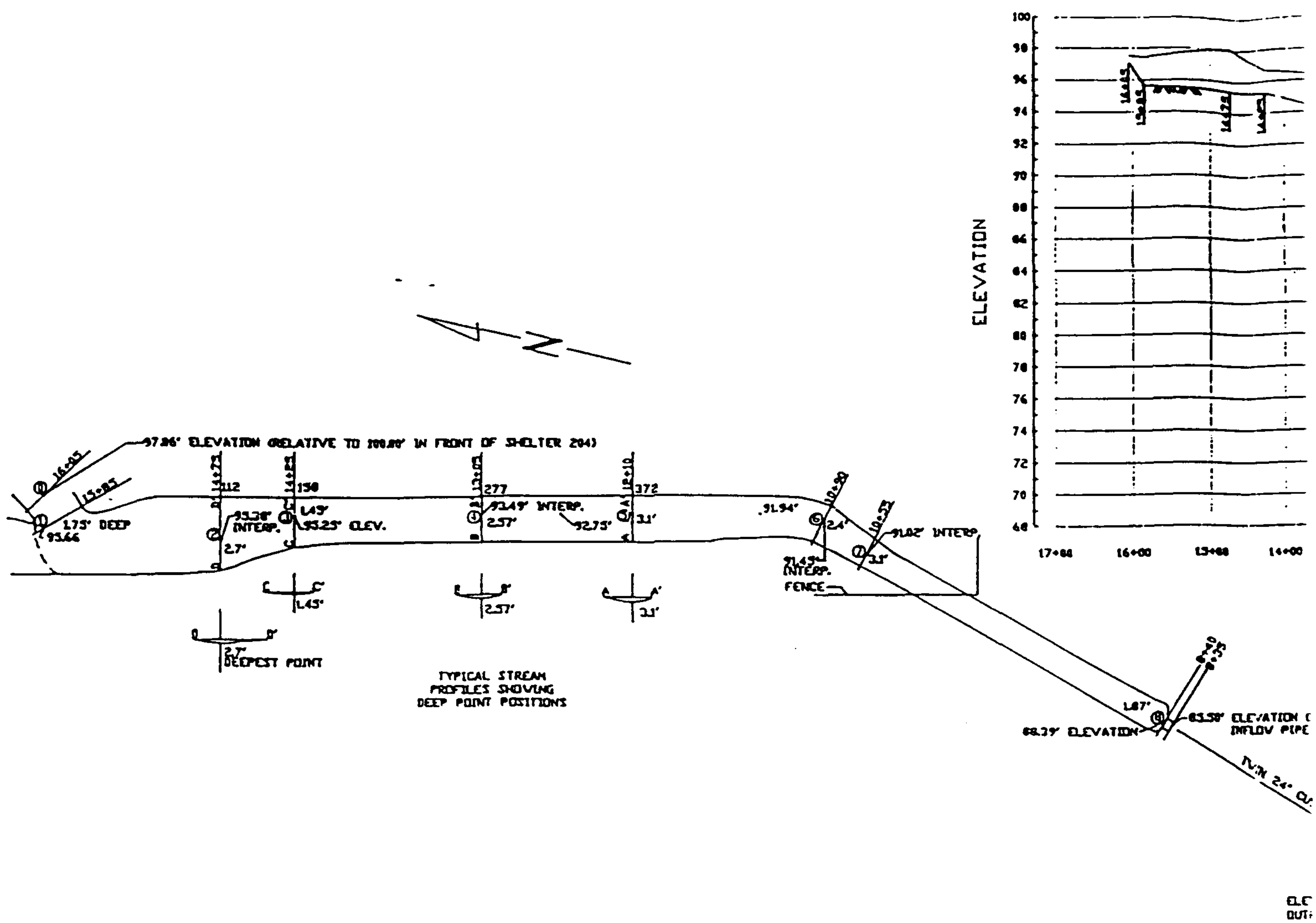
Figure 2-2

BURGESS & NIPLE, LIMITED
ENGINEERS AND ARCHITECTS

SCALE: AS SHOWN
DATE: FEB. 1990

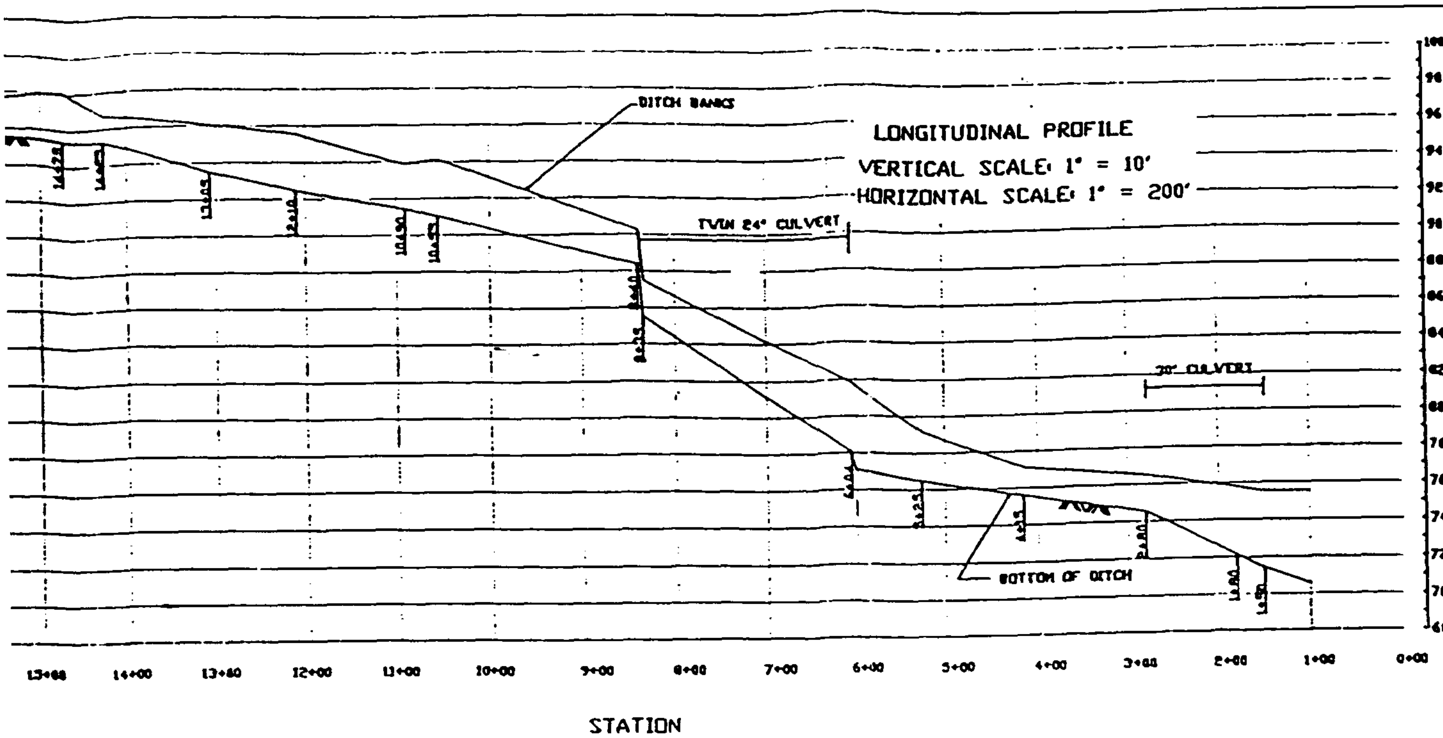
FIG. 3

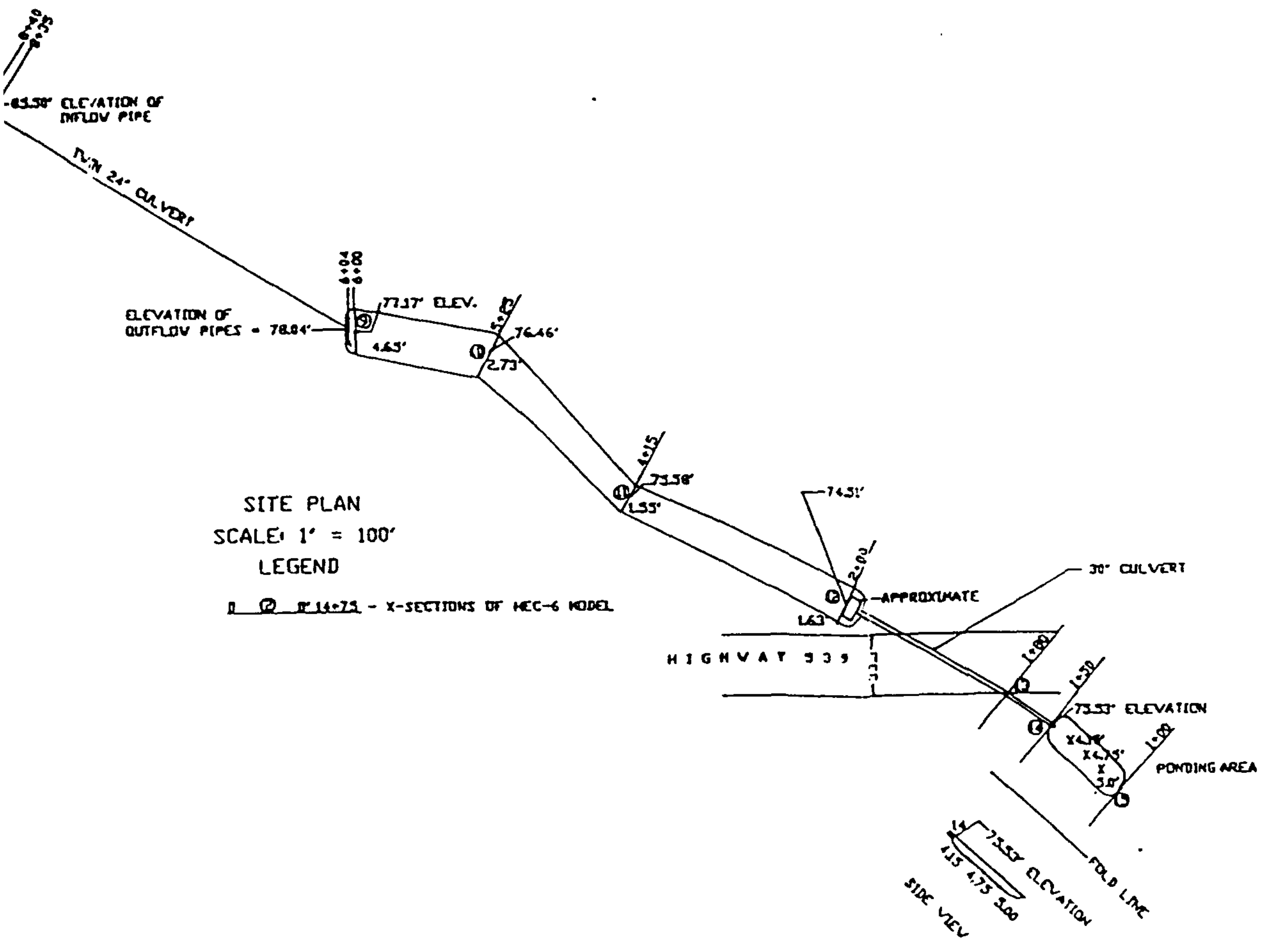
BOMARC SITE, MCGUIRE AFB.
PLUTONIUM TRANSPORT MODEL



NOTE: ELEVATIONS ARE RELATIVE TO THAT OF APRON IN FRONT OF SHELTER 204 WHICH IS 100 FEET.

BOMARC SITE, MCGUIRE AFB PLUTONIUM TRANSPORT MODEL	DITCH SITE PLAN & LONGITUDINAL PROFILE	BURGESS & ENGINEERS





URGESS & NIPLE, LIMITED NGINEERS AND ARCHITECTS	SCALE: AS SHOWN DATE: FEB. 90	FIGURE NO. 4

water outlet from the ponding area. Any surface water entering that ponding area would either evaporate, percolate downward to the water table, or possibly during periods of heavy rainfall flow until it reached the drainage of the Elisha Branch of the Toms River. The drainage ditch runs for a total of 1,505 feet and has a total vertical drop of 26.5 feet giving an average slope of 1.8 percent. The steepest portions of the drainage path are the culverts, the entrances to culverts, and a short upstream section. The depth of the ditch averages 2.5 feet except at the ponding area where it is 5 feet deep. The width at the top of the banks varies from 20 to 45 feet.

MODELING GOALS

The modeling goals were as follows:

1. Provide an "off-the-shelf," open-channel flow and sediment transport model.

2. Using this model and historical data provided by SAIC, define the worst-case scenarios for plutonium transport and dispersion from Shelter 204, along the drainage ditch and into the ponding area west of County Highway 539 during the 1960 firefighting efforts at the BOMARC Site. This model should incorporate scenarios both with and without the earthen dam erected to prevent or retard water flow down the ditch. It should also incorporate information on precipitation events at the site prior to covering the drainage ditch with asphalt in 1967. The information will be used to predict where "hot spots" may occur, based on all available information.

3. Under present conditions, determine what frequency storm would cause erosion of the drainage ditch and allow further distribution of plutonium into the environment. Include model analyses of predicted "hot spots" as additional sources.

During the course of the modeling, evaluation of preliminary results were made and upon conferencing with SAIC, additional modeling was performed to include scenarios for infiltration through the bottom of the drainage ditch and two other possible dam locations.

A total of eight scenarios were modeled, and the specific goals of each scenario are described in the Modeling Scenarios section of this report.

MODEL SELECTION

The model selected was the U.S. Army Corps of Engineers HEC-6 (Hydrologic Engineering Center) model. It is a one-dimensional steady-state open channel flow sediment transport model developed to analyze scour and deposition of sediments in natural or man-made water channels. Steady-state by definition means that conditions do not change with time. This does not allow HEC-6 to analyze continuous flow variation in a channel resulting from pulse flows or from infiltration losses through the channel bottom. HEC-6 can however, within some limitations, be used to analyze discrete steady-state flow rates over sequential time periods and over different stretches of a channel.

Since its development, the model has undergone several modifications as its application broadened, and today it is used to model a wide variety of hydraulic conditions.

HEC-6 analyzes scour and deposition by modeling the interaction between the water-sediment mixture, sediment material forming the channel's boundary, and the hydraulics of flow. It simulates the ability of the channel to transport sediment by performing a mass balance calculation on all particles present in both the incoming sediment load and the channel bed. A total of 15 sediment particle sizes ranging from very coarse gravel to clay can be defined by the HEC-6 model. These sediment groups are identified and subdivided based on the American Geophysical Union classification scale as shown in Table 1.

The modeling of plutonium transport and dispersion into the drainage ditch at the BOMARC Site is essentially a particle tracking study. HEC-6 is not a particle tracking model, per se, but has been adapted to address the issue. This was done by assuming that the hydraulic properties of a plutonium particle are the same as those of one of the silt particles of the HEC-6 model. Both particles are assumed to be hydraulically equivalent by equating their fall velocities and critical tractive forces (see Model Testing section). In this way, HEC-6 can be applied as a particle tracking model to predict the transport of plutonium released into the drainage ditch at the BOMARC Site.

Table 1

Grain Size Classification of Sediment Material
Burgess & Niple, Limited
Engineers and Architects

No.	Sediment Material	Classification	Grain Diameter (mm)
Clay			
1.	Clay	(Clay)	0.004
Silt			
1.	Very Fine Silt	(VFS1)	0.004 - 0.008
2.	Fine Silt	(FS1)	0.008 - 0.016
3.	Medium Silt	(MS1)	0.016 - 0.032
4.	Coarse Silt	(CS1)	0.032 - 0.0625
Sand and Gravel			
1.	Very Fine Sand	(VFS)	0.0625 - 0.125
2.	Fine Sand	(FS)	0.125 - 0.250
3.	Medium Sand	(MS)	0.250 - 0.500
4.	Coarse Sand	(CS)	0.500 - 1.000
5.	Very Coarse Sand	(VCS)	1.000 - 2.000
6.	Very Fine Gravel	(VFG)	2.000 - 4.000
7.	Fine Gravel	(FG)	4.000 - 8.000
8.	Medium Gravel	(MG)	8.000 - 16.000
9.	Coarse Gravel	(CG)	16.000 - 32.000
10.	Very Coarse Gravel	(VCG)	32.000 - 64.000

Other more esoteric models are available to perform particle tracking studies but require large amounts of input data that are not readily available. The HEC-6 model's input data requirements are flexible; the program generates much of its data subject to being overridden if such data is supplied. In this way, the model can be applied to the study rather than the study filling the requirements of the model.

Considering the unique and unknown nature of plutonium transport in a channel, it is questionable whether or not a more esoteric model could produce a better end result. In addition, the HEC-6 model has been widely used and recognized by consultants and regulatory agencies. In view of the above, the use of the HEC-6 model is appropriate.

MODELING ASSUMPTIONS

The following assumptions were made concerning the modeling. In cases where there was a choice of assumptions, the conservative (worst-case) choice was made.

1. The hydraulic conditions in the drainage ditch are steady state full flow. In reality, the hydraulic conditions were transient with an advancing water front over a dry ditch bed. Full flow assumes no infiltration and produces a worst-case analysis from the hydraulic portion of the model.

2. The frictional resistance to flow, Manning's n, is 0.06 for the ditch and 0.03 for the culverts. These were established from literature and a site visit.

3. The temperature of the flowing water is 65 degrees Fahrenheit (^{o} F.). No data are available on this parameter. The air temperature on June 7, 1960 at 1500 hours was 75^{o} F.

4. The plutonium load is in the form of plutonium dioxide (PuO_2) particles.

5. The PuO_2 particle is simulated in the model as a very fine silt, fine silt, medium silt, or coarse silt particle (see Model Testing Section).

6. From experiments conducted to measure the plutonium made airborne during oxidation (see Reference 2, page 4), the size of PuO_2 particle is between 4 um and 14 um in diameter.

7. The shape factor of a PuO_2 particle is 0.667. No data are available on this parameter so the HEC-6 model default value was used.

8. The internal friction angle of a PuO_2 particle is between 10 and 41 degrees. No data are available on this parameter. The selected range covers all noncohesive sediment particles.

9. The density of a PuO_2 particle is 11.46 g/cc (see Reference 2, page 4). The density of silt is 2.65 g/cc.

10. Critical tractive forces are calculated based on experiments by W. F. White (see reference 6, p. 94-96).

11. The dam erected to prevent or retard the flow of water was made of the same material as the existing ditch bed and its height extended to the top of the ditch banks.

12. Flow through the culverts is simulated by assuming a semi-circular open channel geometry, and scouring below the inverts of the culverts is not allowed.

MODEL INPUT AND OUTPUT

Input used for the HEC-6 Model consisted of the following sets of data:

- Geometric
- Hydraulic
- Hydrologic
- Plutonium load
- Ditch bed sediment

Geometric

Surveying of the drainage ditch was performed in July 1989 and outlined the space boundary of the model. This space boundary covers an area of approximately 50,000 square feet. The northern model boundary is at the upstream end of the drainage ditch next to the asphalt apron in front of Shelter 204. The southern model boundary is at the downstream end of the ponding area next to Ocean County Highway 539. The east and west boundaries of the model are the respective banks of the drainage ditch (see Figures 3 and 4). All surveyed elevations are relative to that of the apron in front of Shelter 204 which is set at 100 feet.

A total of 18 cross sections were produced spanning a distance of 1,505 feet, and these formed the geometric input data of the model.

Hydraulic

The total volume of water that flowed into the drainage ditch during the firefighting efforts on June 7, 1960 was 30,000 gallons during 8 hours (see Reference 1, p. 5-7). This corresponds to an average flow rate of 0.14 cfs. No additional data were available to define the flow rate. Subsequently during 1960-1967, the flow rate was a function of rainfall events and was calculated using the hydrological model HYDRAIN. HYDRAIN was developed by Burgess & Niple, Limited and is based on the SCS TR-55 method described in Reference 12.

Hydrologic

The hydrologic data used consisted of 24-hour precipitations from January 1, 1960 to December 31, 1967 and is shown graphically on Figure 5. The weather station used for the climatological data was Pemberton (see Figure 2) and the 24-hour, 10- to 100-year frequency storms were interpolated from charts in Reference 7. The HYDRAIN hydrological model calculated 24-hr storm hydrographs that were used by the HEC-6 model. Infiltration through the bottom of the ditch was between 0.2 and 6.3 inches/hr (see Reference 1, p. 3-15).

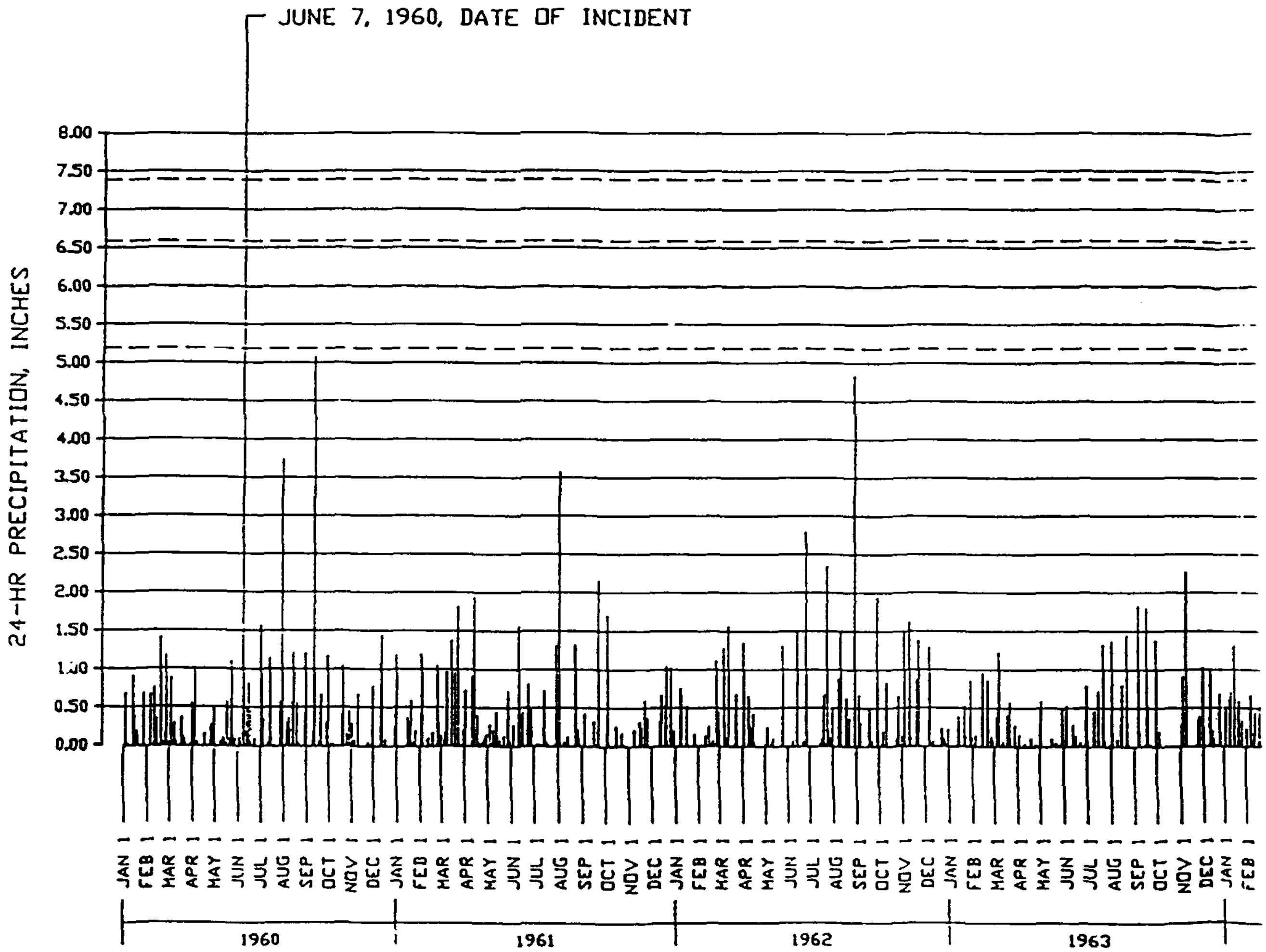
Plutonium Load

The plutonium load released into the drainage ditch during the firefighting efforts on June 7, 1960 was 1.5 kg as plutonium dioxide (PuO_2) (see Reference 1, p. 2-7, p. 5-6 and p. 5-7). This corresponds to an average loading rate of 0.19 kg/hr. No additional data were available to define the plutonium loading rate.

Ditch Bed Sediment

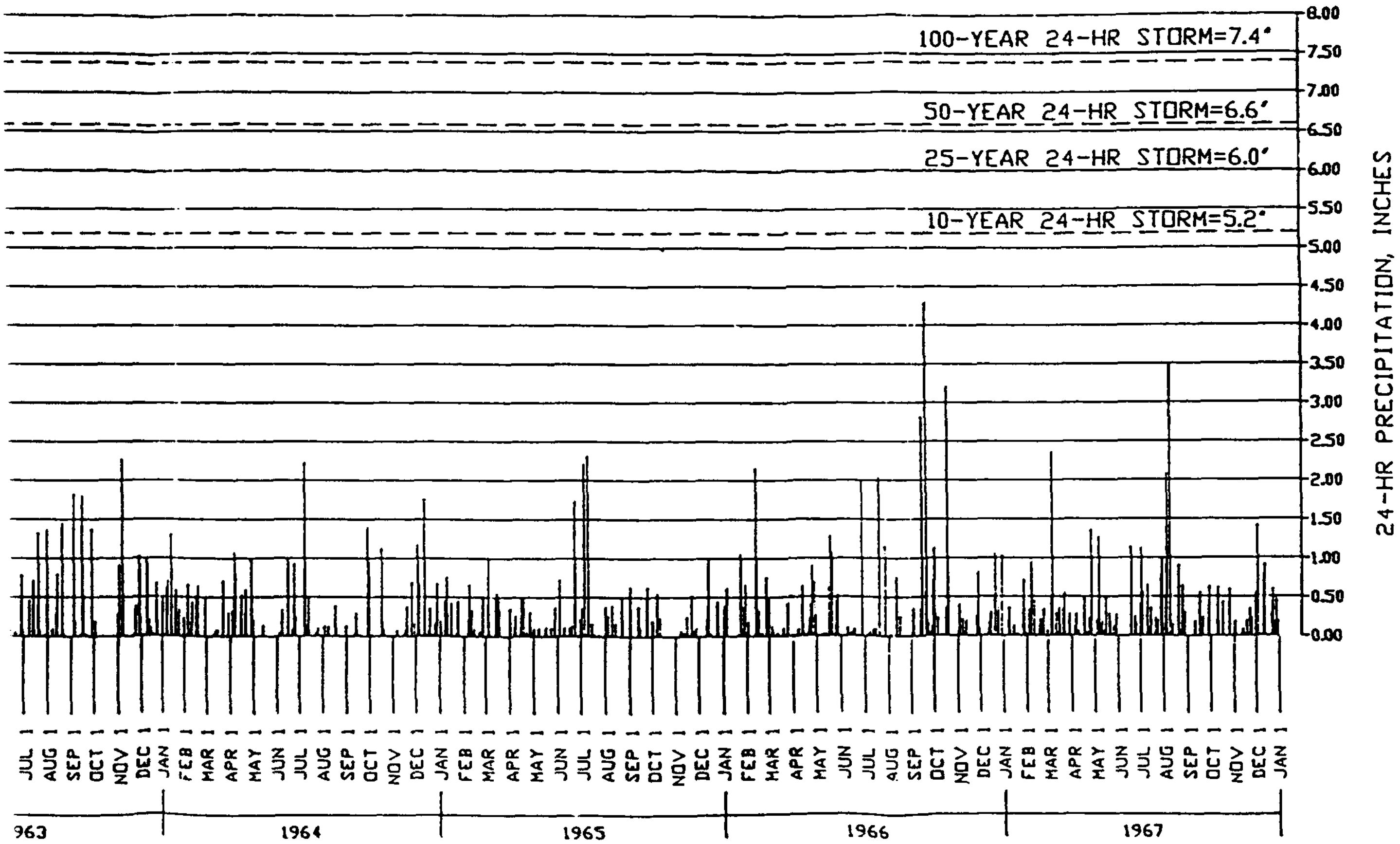
Test pits were dug around the site, and these are shown on Figure 6. Data from the test pits is included in Appendix A. Test pits E and F were used to determine the sediment profile of the drainage ditch bed. Figure 7 shows a gradation curve for test pits A through F. It indicates that the ditch bed is poorly graded and consists predominantly of coarse to fine sand. These sands are porous with moderately high permeabilities. This is concurrent with permeabilities of the BOMARC Site in general mentioned in Reference 1, p. 3-15 (from 0.2-6.3 in/hr).

(1)



JUNE 7, 1960, DATE OF INCIDENT
24-HR PRECIPITATION, INCHES
8.00
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
JAN 1
FEB 1
MAR 1
APR 1
MAY 1
JUN 1
JUL 1
AUG 1
SEP 1
OCT 1
NOV 1
DEC 1
1960
1961
1962
1963

②



BOMARC SITE, McGUIRE AFB
PLUTONIUM TRANSPORT MODEL
FIG. 5

HISTOGRAM OF 24-HR PRECIPITATION
FROM JAN. 1, 1960 - DEC. 31, 1967

BURGESS & NIPLE, LIMITED
ENGINEERS AND ARCHITECTS

SCALE: NONE
DATE: FEB. 1990

▲ LOCATION OF TEST PITS AND CHEMICAL ANALYSIS SOIL SAMPLES

NEW JERSEY

QUADRANGLE LOCATION

The Earth Technology Corporation

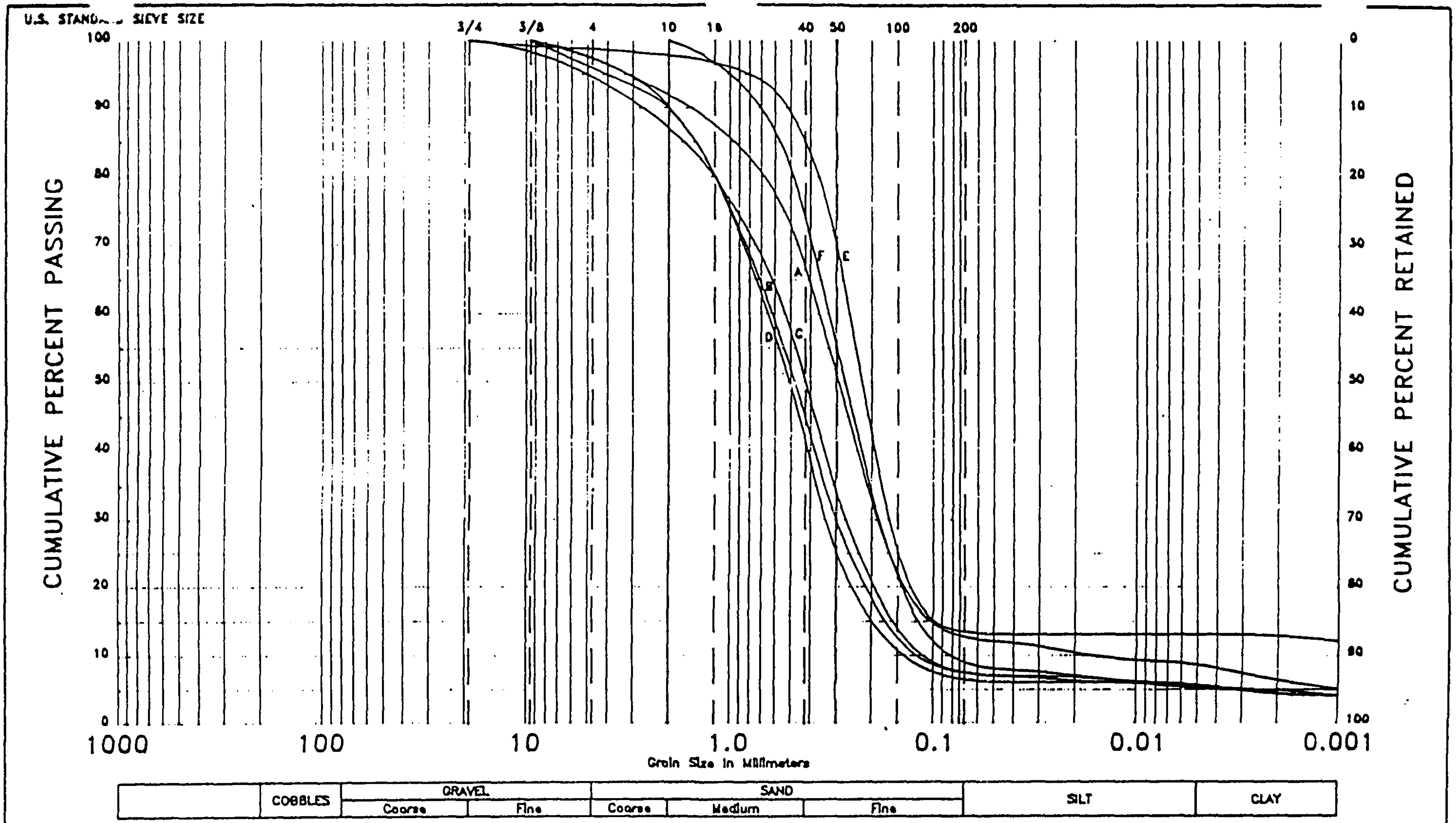
TEST PIT AND SOIL SAMPLE LOCATION MAP

BOMARC SITE, MCGUIRE AFB,
PLUTONIUM TRANSPORT MODEL

FIG. 6

BURGESS & NIPLE, LIMITED
ENGINEERS AND ARCHITECTS

SCALE: AS SHOWN
DATE: FEB. 1990



TOTAL PERCENT PASSING/RETAINED

SAMPLE DEPTH

U.S. STANDARD SIEVE ______ ______ ______ ______ ______

1"
3/4"
1/2"
3/8"
4
10
16
40
50
100
200

BOMARC, SITE, McGUIRE AFB
PLUTONIUM TRANSPORT MODEL

FIG. 7
DITCH BED
GRADATION CURVES

BURGESS & NIPLE, LIMITED
ENGINEERS AND ARCHITECTS

SCALE: NONE
DATE: FEB. 1990

MODEL TESTING

The HEC-6 model was applied to this study using hydraulic equivalency. From Stoke's law, the theoretical fall velocity in water of a PuO_2 particle was calculated and from there an equivalent diameter of a silt particle of equal theoretical fall velocity was obtained. The fall velocity of a particle is influenced by the hydraulic conditions within its surroundings. These conditions can be described by a dimensionless parameter known as Reynolds number (Re). The following assumptions were used:

- particles are spherical
- quiescent hydraulic conditions ($Re < 10^{-1}$)
- specific gravity of PuO_2 - 11.46
- specific gravity of silt - 2.65

This was done for several possible sizes of the PuO_2 particle and resulted in four HEC-6 sediment particles acting as PuO_2 particles. These were very fine silt, fine silt, medium silt and coarse silt. Model testing was done on each separately. For all four sediment particles sizes, maximum and minimum theoretical critical tractive forces were calculated for each cross section of the drainage path, and these were then compared to the actual computed tractive forces by the model at each cross section. In this way, a range of results was obtained for each modeled scenario, and this allowed worst-case and best-case possibilities to be evaluated.

A worst-case and a best-case model run was performed for each scenario. The worst-case run involved very fine silt and minimum critical tractive forces. This allowed for maximum possible transport of PuO_2 particles. The best-case run involved coarse silt and maximum critical tractive forces. This allowed for minimum possible transport of the PuO_2 particle. Table 2 shows the distinction between worst-case and best-case model runs as far as input data is concerned.

Preliminary runs were performed to determine overall model response and to check for input data errors prior to modeling different scenarios. The results of those runs are summarized in Table 3 and are included in Appendix B.

Table 2

Input Data for Worst-Case and Best-Case Model Runs
Burgess & Niple, Limited
Engineers and Architects

Model Run	Diameter of PuO_2 Particle (um)	Fall Velocity of PuO_2 Particle (S.G. = 11.46) (fps)	Equivalent Diameter of Silt Particle (S.G. = 2.65) (um)	Internal Friction Angle of PuO_2 Particle (deg.)	Input Data for HEC-6: HEC-6 Silt Type	Input Data for HEC-6: Critical Tractive Force (psf)
Worst-case (maximum transport of plutonium)	4	0.0003	10	10	Silt 1 (VFSI)	0.003 (min)
Best-case (minimum transport of plutonium)	14	0.0035	35	41	Silt 4 (CSI)	0.046 (max)

Table 3

Model Response to Input Data
Burgess & Niple, Limited
Engineers and Architects

Model Input Data	Input Data Reliability	Model Response
Ditch topography[1]	High	High
Ditch hydraulic properties[1]	Medium	High
Dam characteristics[2]	Low	High
Ditch flow rate[1]	Medium	High
Water temperature[1]	Low	Low
Ditch bed material gradation[1]	Medium	Medium
PuO_2 particle characterization[2]	Medium	Medium
Critical tractive forces[2]	Low	High

Note: Low, Medium, and High model responses are qualitative assessments based on experiences gained from diverse application of the HEC-6 model.

[1] From Reference 5.
[2] From this project.

Table 3 shows that the critical tractive forces and the dam characteristics are the two input data parameters most likely to introduce errors in the modeling. The critical tractive forces parameter can be improved by determining the internal friction angle of the PuO_2 particle. The dam characteristics parameter can be improved by determining the exact geometry and location of the dam.

Output produced by the HEC-6 model is included in Appendix C. The pertinent portions at each cross section are:

- Hydraulics of flow (subcritical, critical or supercritical)
- Actual tractive forces (greater than or less than critical tractive forces)
- PuO_2 load passing the cross section
- PuO_2 load deposited at the cross section.

In addition, a summary is given at the end of each run for the entire length of the drainage path. The summary includes:

- Total PuO_2 accumulated at all cross sections
- Total PuO_2 transported past downstream cross section
- Percent PuO_2 deposited (trapping efficiency).

MODELING SCENARIOS

A total of eight scenarios were modeled. Scenarios 1 to 6 are pertinent to the transport of plutonium during the firefighting efforts and cover different possibilities and conditions that could have occurred. Scenario 7 modeled the transport of plutonium from the date of the incident to the end of 1967 assuming a dam was in existence. Scenario 8 modeled the erosion possibility of today's asphalt-covered ditch based on a future rainstorm event.

Scenario 1

This scenario modeled plutonium transport during the firefighting under conditions of no infiltration and no dam. This scenario is the least likely and results are shown in Figure 8. For the worst-case run, the model predicted that all of the plutonium was transported beyond Station 1+00 (the model boundary) and into the ponding area. The computed tractive forces were greater than the critical tractive forces at every cross section resulting in no deposition of PuO_2 particles within the boundary of the model. For the best-case run, the model predicted that all of the plutonium was transported up to Station 14+75 and from there deposited in the stretch from Station 14+75 to Station 13+05. No plutonium was transported beyond Station 13+05.

Scenario 2

This scenario modeled plutonium transport during the firefighting under conditions of infiltration and no dam. Infiltration was simulated by reducing water flows over sequential stretches of the ditch as the model cannot directly simulate infiltration. Two quantities of infiltration were modeled, 10,000 gallons (inflow = 0.14 cfs, outflow = 0.09 cfs) and 25,000 gallons (inflow = 0.14 cfs, outflow = 0.02 cfs). Results are shown in Figure 9. For the worst-case run, the model predicted that all of the plutonium was transported beyond Station 1+00 (the model boundary) and into the ponding area for both infiltration quantities. For the best-case run and for an infiltration of 25,000 gallons, all of the plutonium was transported up to Station 14+75, and from there deposited along the drainage path up to

Station 2+80 except for the twin 24-inch culvert. For an infiltration of 10,000 gallons, deposition occurred in the stretch 14+75-13+05 and 5+25-4+15. No plutonium was transported beyond Station 4+15.

Scenario 3

This scenario modeled plutonium transport during the firefighting with an earthen dam located at Station 10+55. No infiltration was assumed and the dam height was set to the depth of the ditch. Results are shown in Figure 10. For both the worst-case and the best-case run, the model predicted that all of the plutonium was contained within the reservoir formed by the dam.

Scenario 4

This scenario was identical to Scenario 3 except that the dam was located at Station 8+40. Results are shown in Figure 11. For the worst-case run, the model predicted that 97 percent of the plutonium (1.455 kg) would be contained within the reservoir formed by the dam. The remaining plutonium (0.055 kg = 55 grams) was transported beyond Station 1+00 (the model boundary) and into the ponding area. For the best-case run, the model predicted that all of the plutonium was contained within the reservoir formed by the dam.

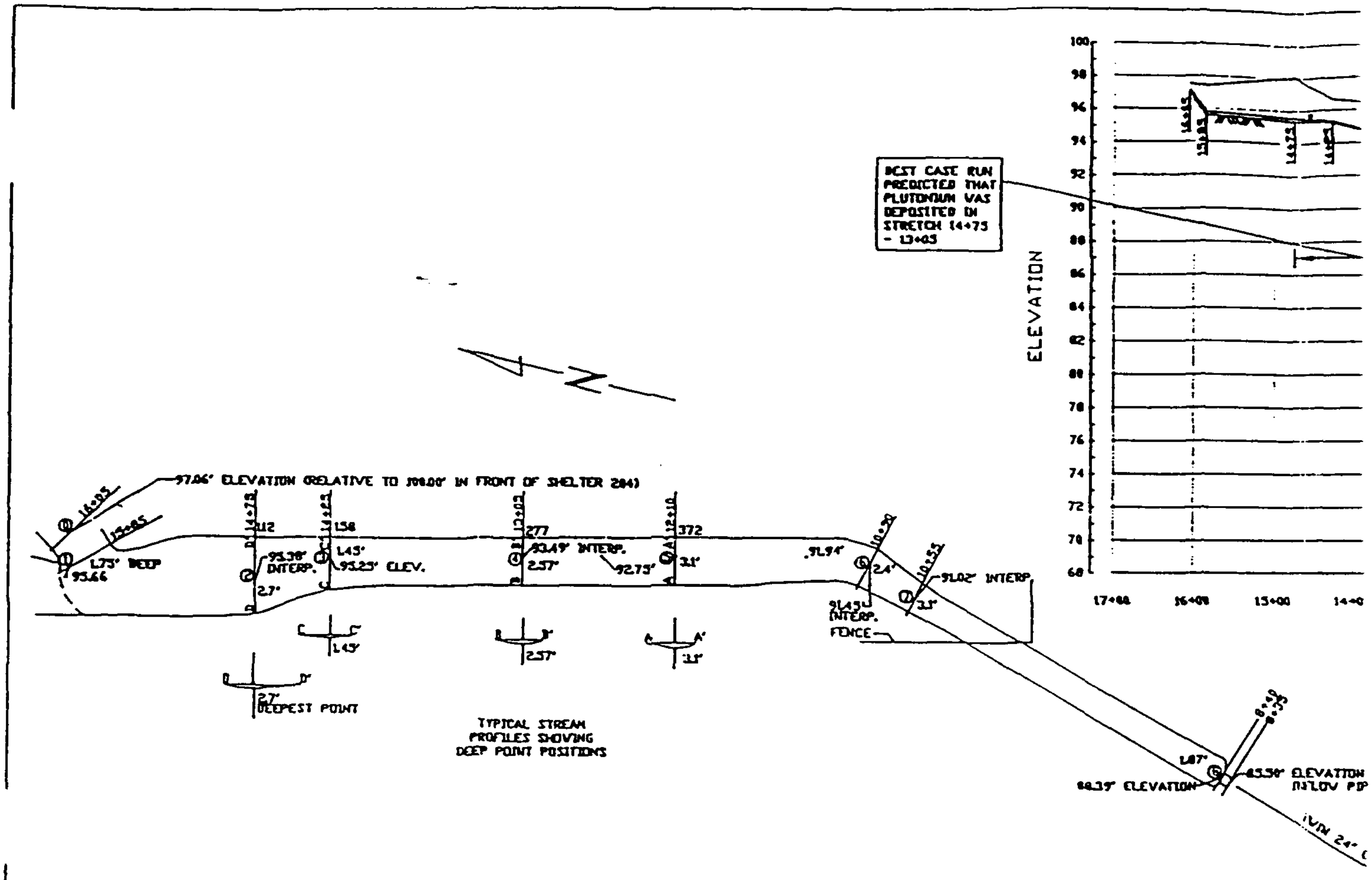
Scenario 5

This scenario was identical to Scenario 3 except that the dam was located at Station 6+00. Results are shown in Figure 12. For both the worst-case and the best-case run, the model predicted that all of the plutonium was contained within the reservoir formed by the dam.

Scenario 6

The purpose of this scenario was to look at a probabilistic approach to plutonium transport based on results of Scenario 1. A comparison between actual computed tractive forces and minimum critical tractive forces was made at each cross section of the model.

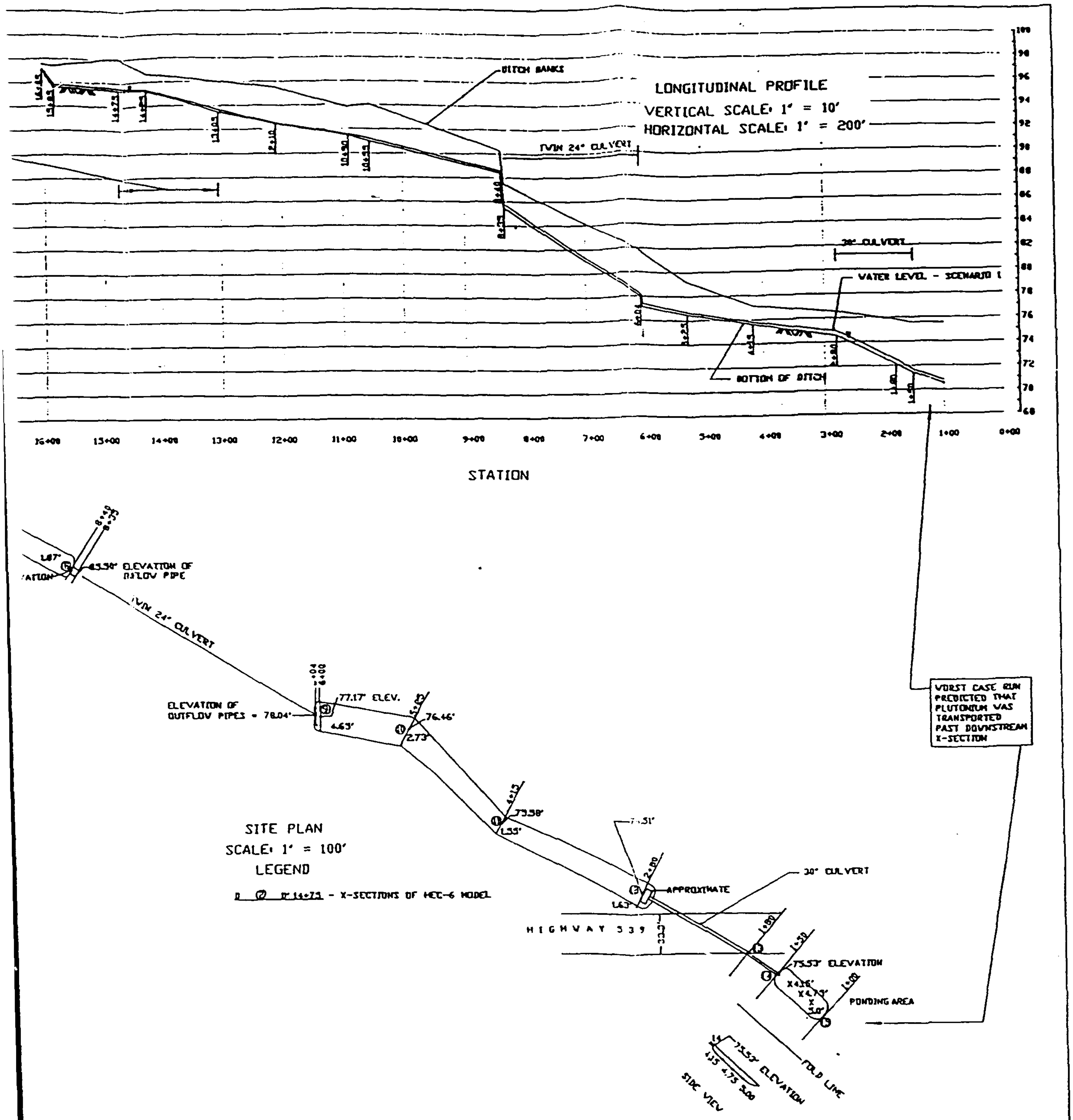
(1)



NOTE: ELEVATIONS ARE RELATIVE TO THAT OF APRON IN FRONT OF SHELTER 204 WHICH IS 100 FEET.

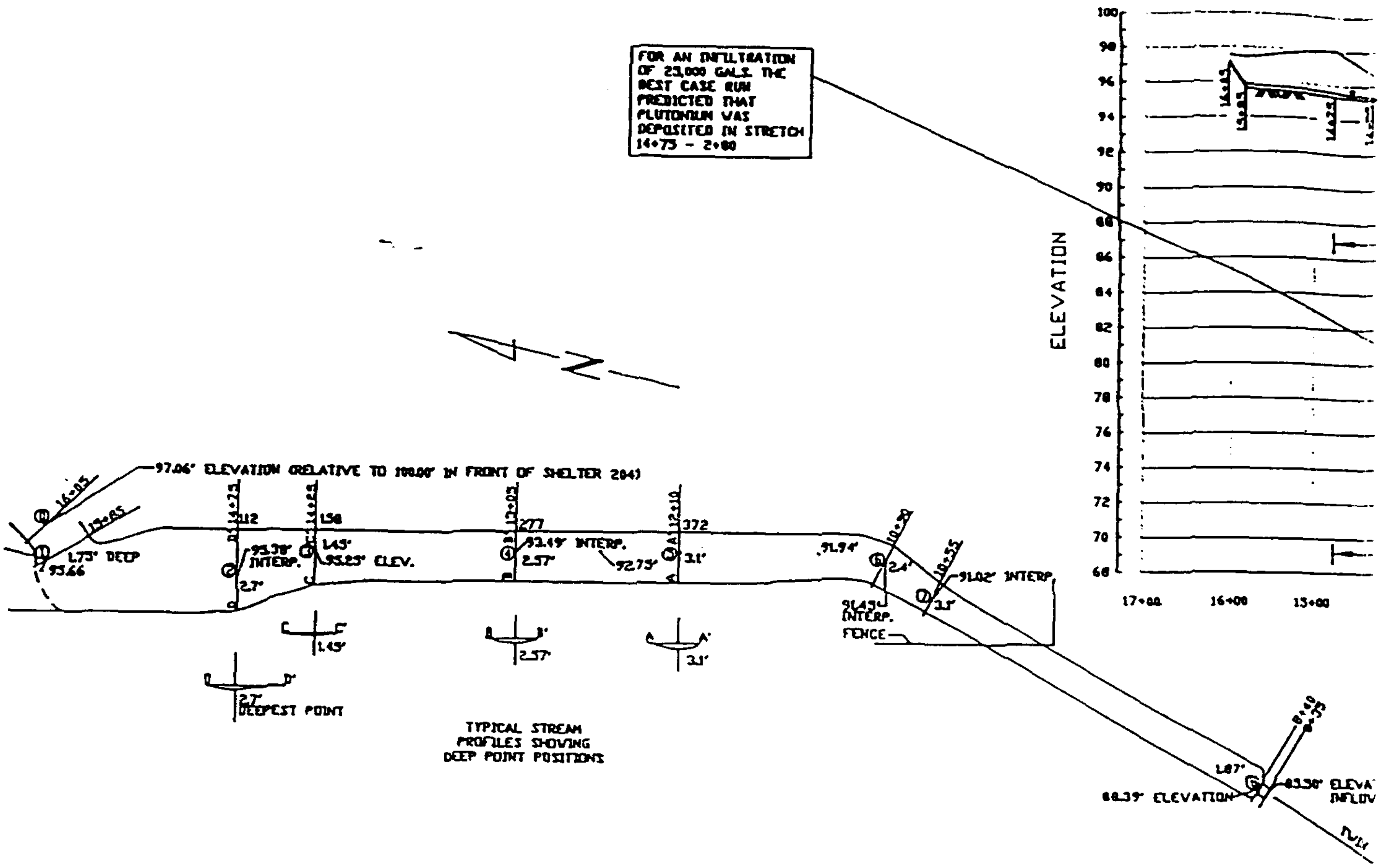
BOMARC SITE, MCGUIRE AFB PLUTONIUM TRANSPORT MODEL	SCENARIO 1	BURGESS & ENGINEERS

(2)



BURGESS & NIPLE, LIMITED ENGINEERS AND ARCHITECTS	SCALE: AS SHOWN DATE: FEB. 90	FIGURE NO. 8

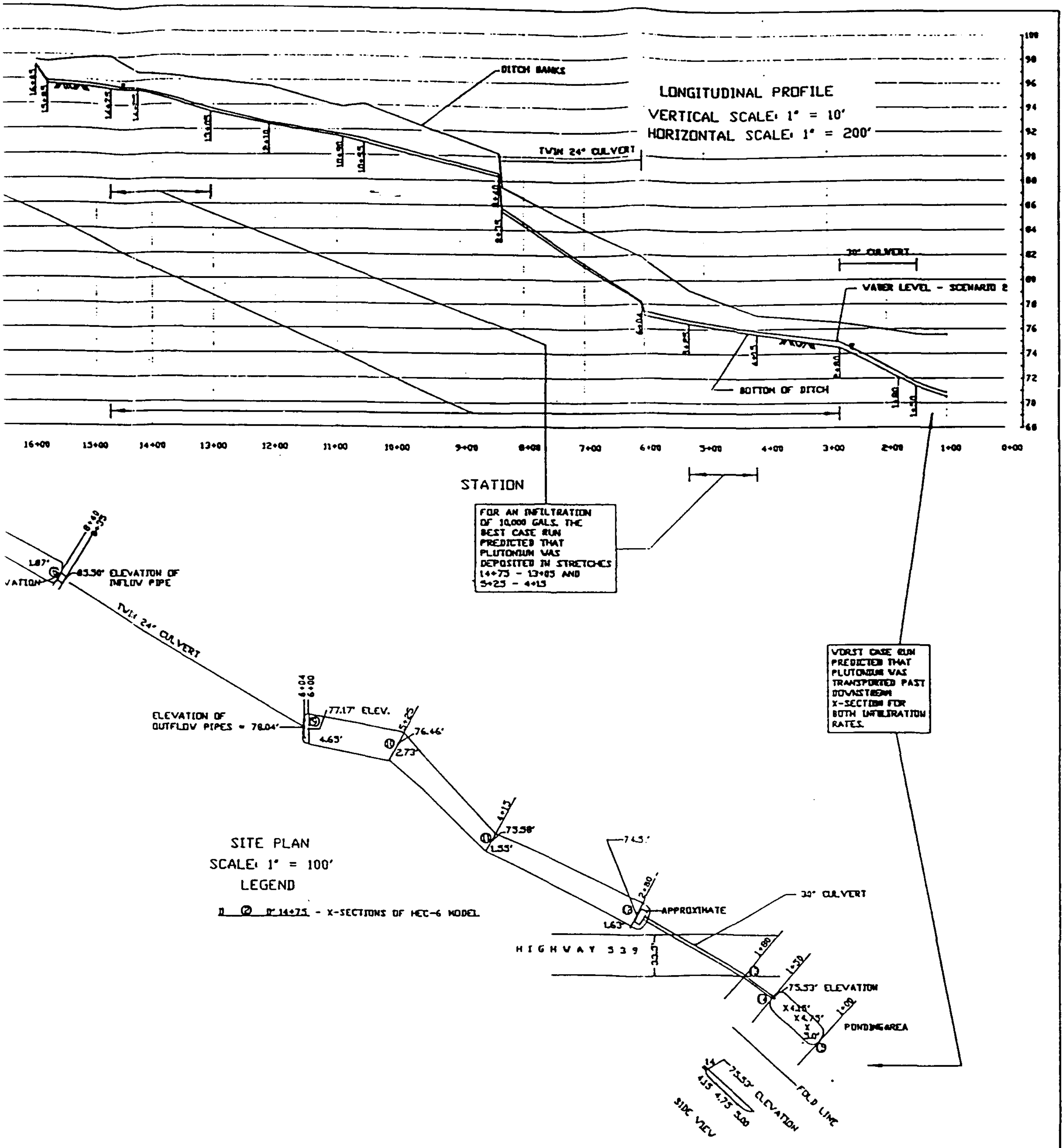
(1)



NOTE: ELEVATIONS ARE RELATIVE TO THAT OF APRON IN FRONT OF SHELTER 204 WHICH IS 100 FEET.

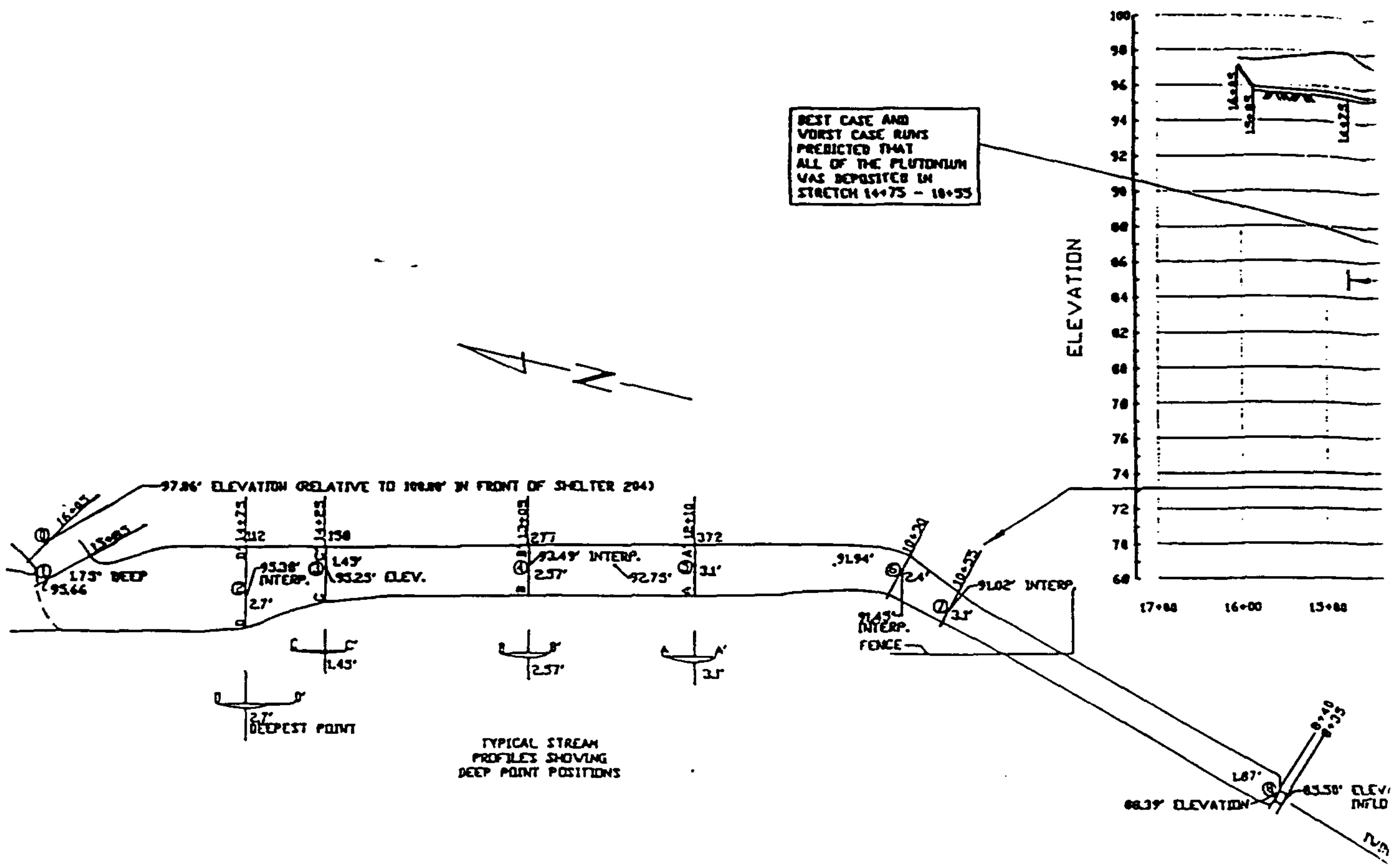
BOMARC SITE, MCGUIRE AFB PLUTONIUM TRANSPORT MODEL	SCENARIO 2	BURGESS ENGINEE

2



BURGESS & NIPLE, LIMITED ENGINEERS AND ARCHITECTS	SCALE: AS SHOWN DATE: FEB. 90	FIGURE NO. 9

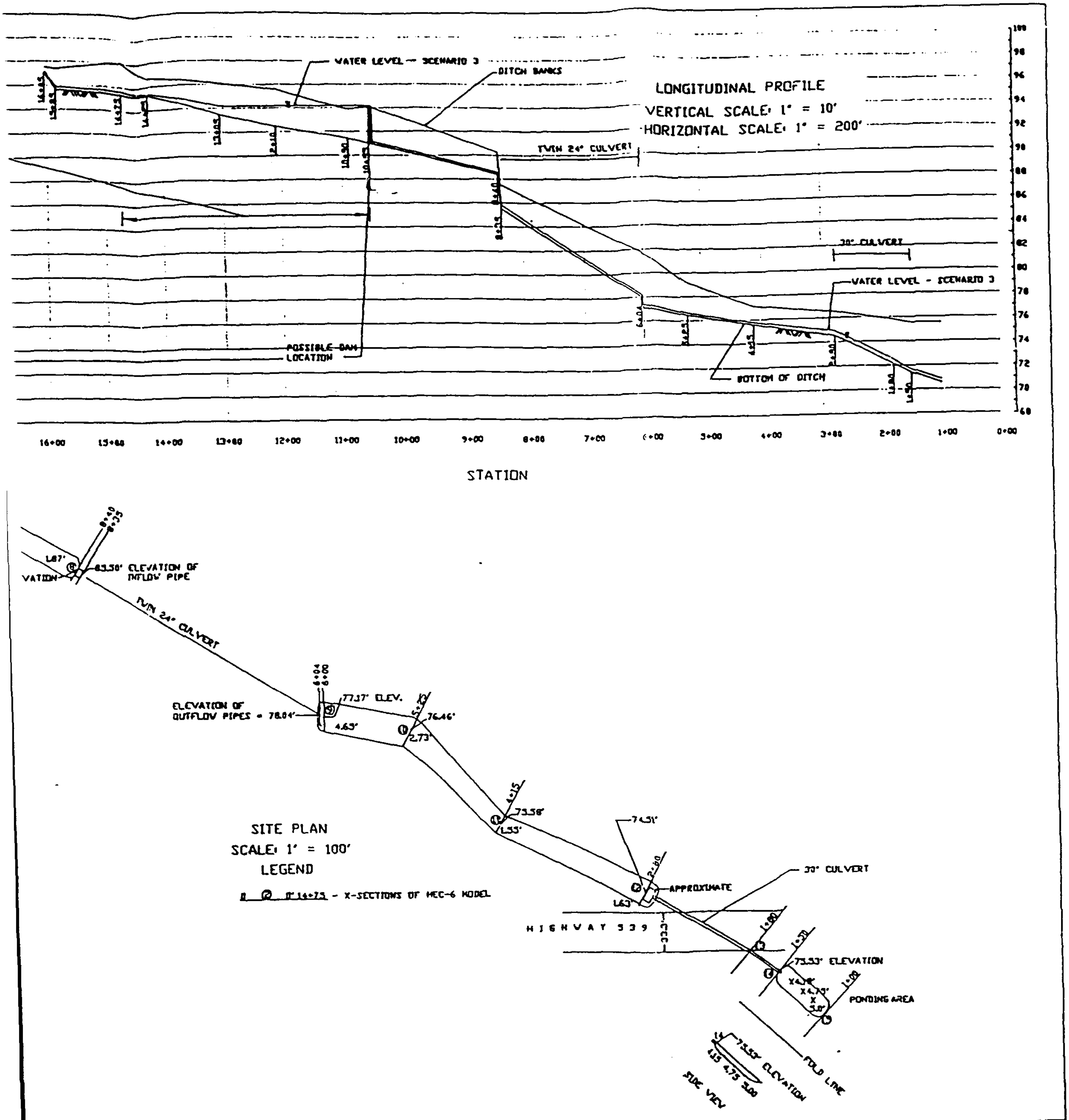
(1)



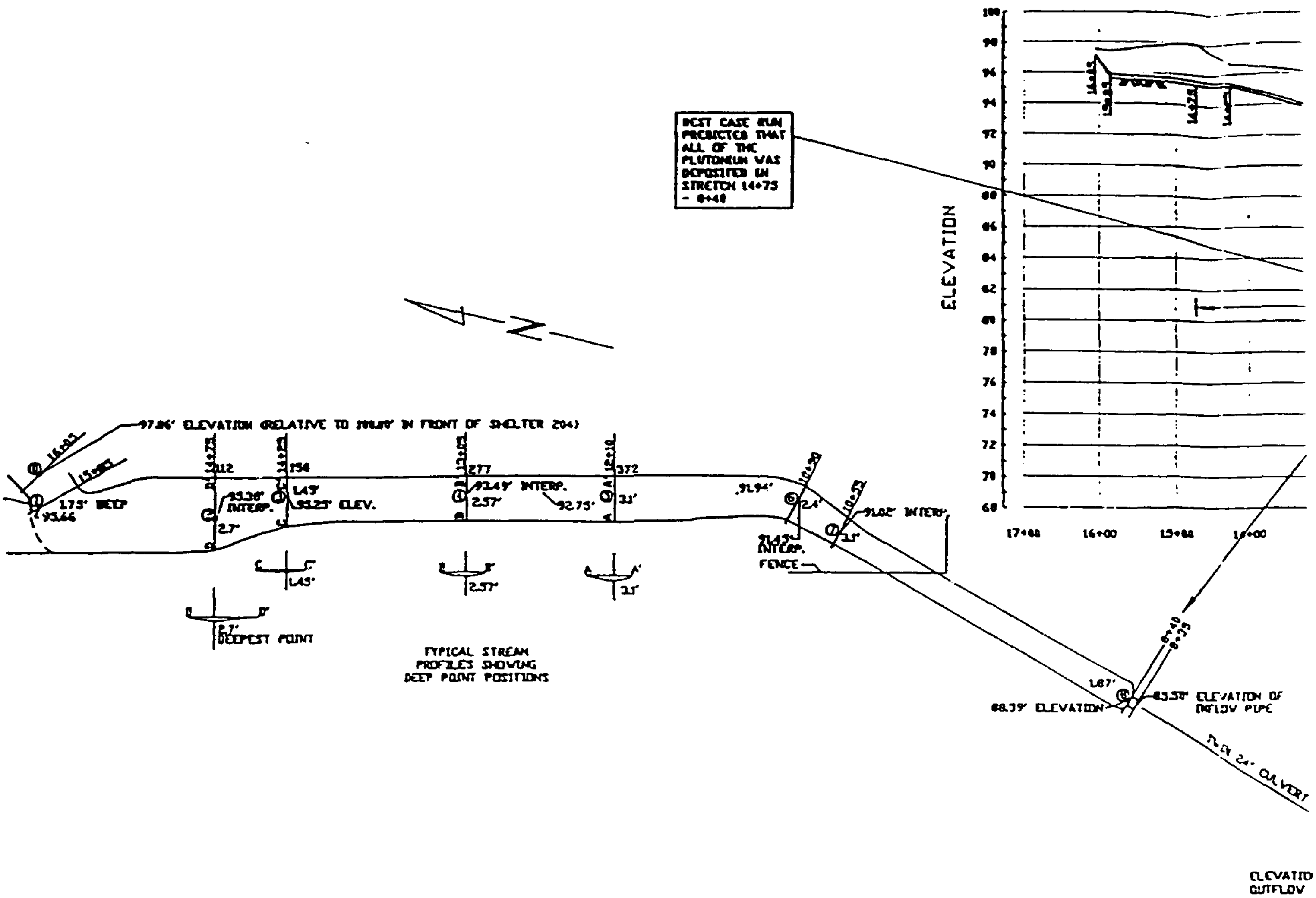
NOTE: ELEVATIONS ARE RELATIVE TO THAT OF APRON IN FRONT OF SHELTER 204 WHICH IS 100 FEET.

BOMARC SITE, MCGUIRE AFB PLUTONIUM TRANSPORT MODEL	SCENARIO 3	BURGESS ENGINEE

(2)

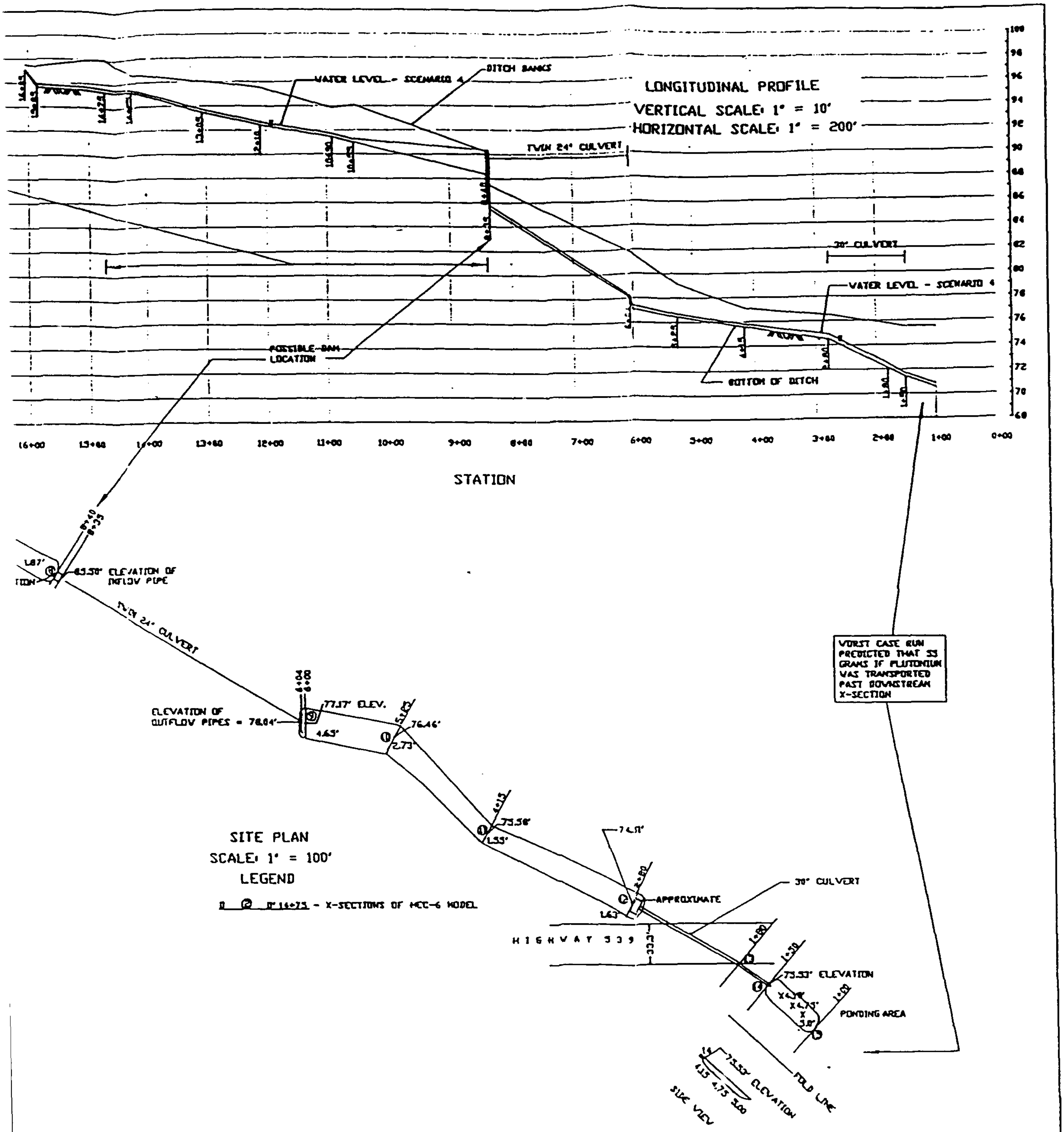


BURGESS & NIPLE, LIMITED ENGINEERS AND ARCHITECTS	SCALE: AS SHOWN DATE: FEB. 90	FIGURE NO. 10

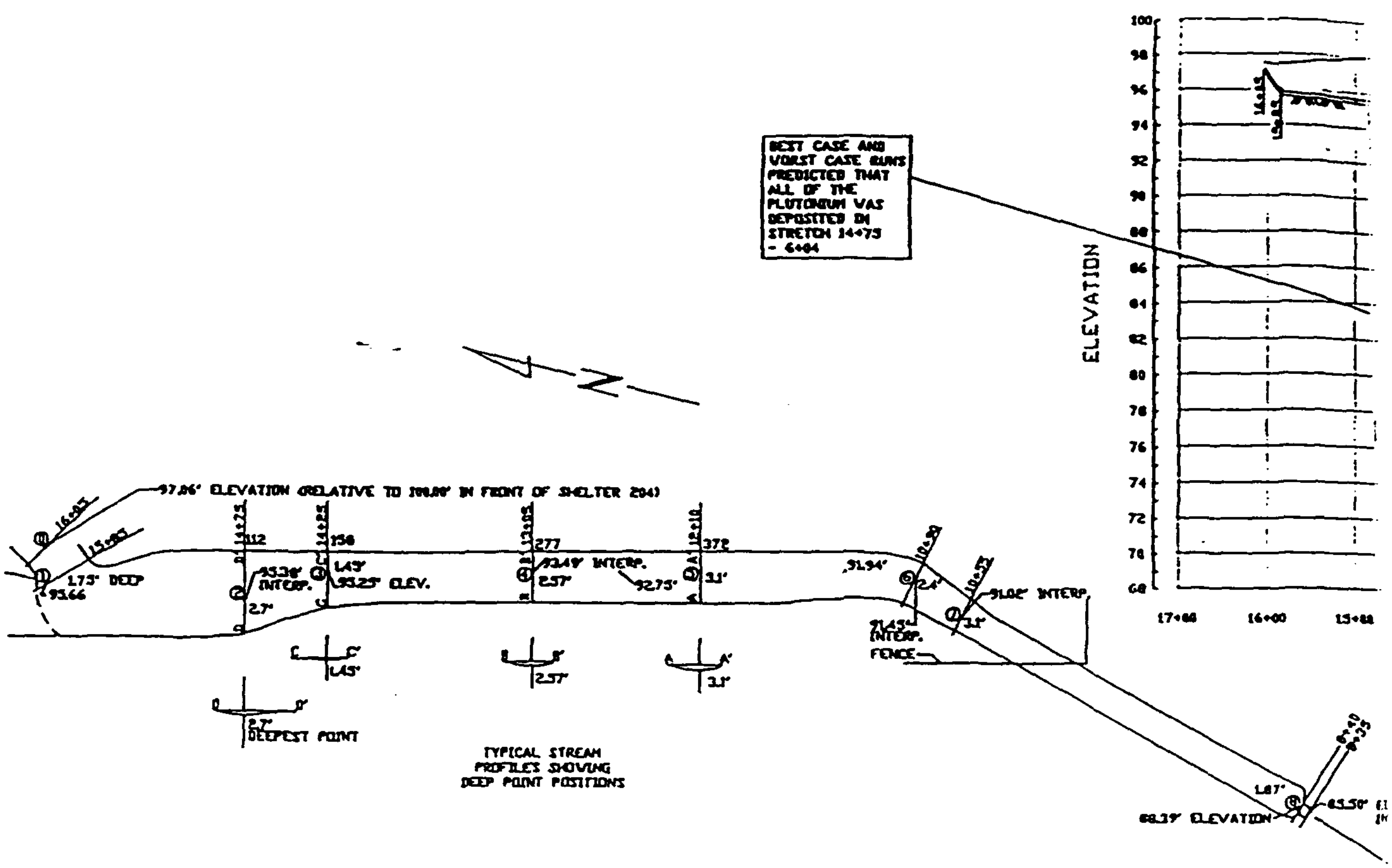


NOTE: ELEVATIONS ARE RELATIVE TO THAT OF APRON IN FRONT OF SHELTER 204 WHICH IS 100 FEET.

BOMARC SITE, MCGUIRE AFB PLUTONIUM TRANSPORT MODEL	SCENARIO 4	BURGESS & N ENGINEERS A



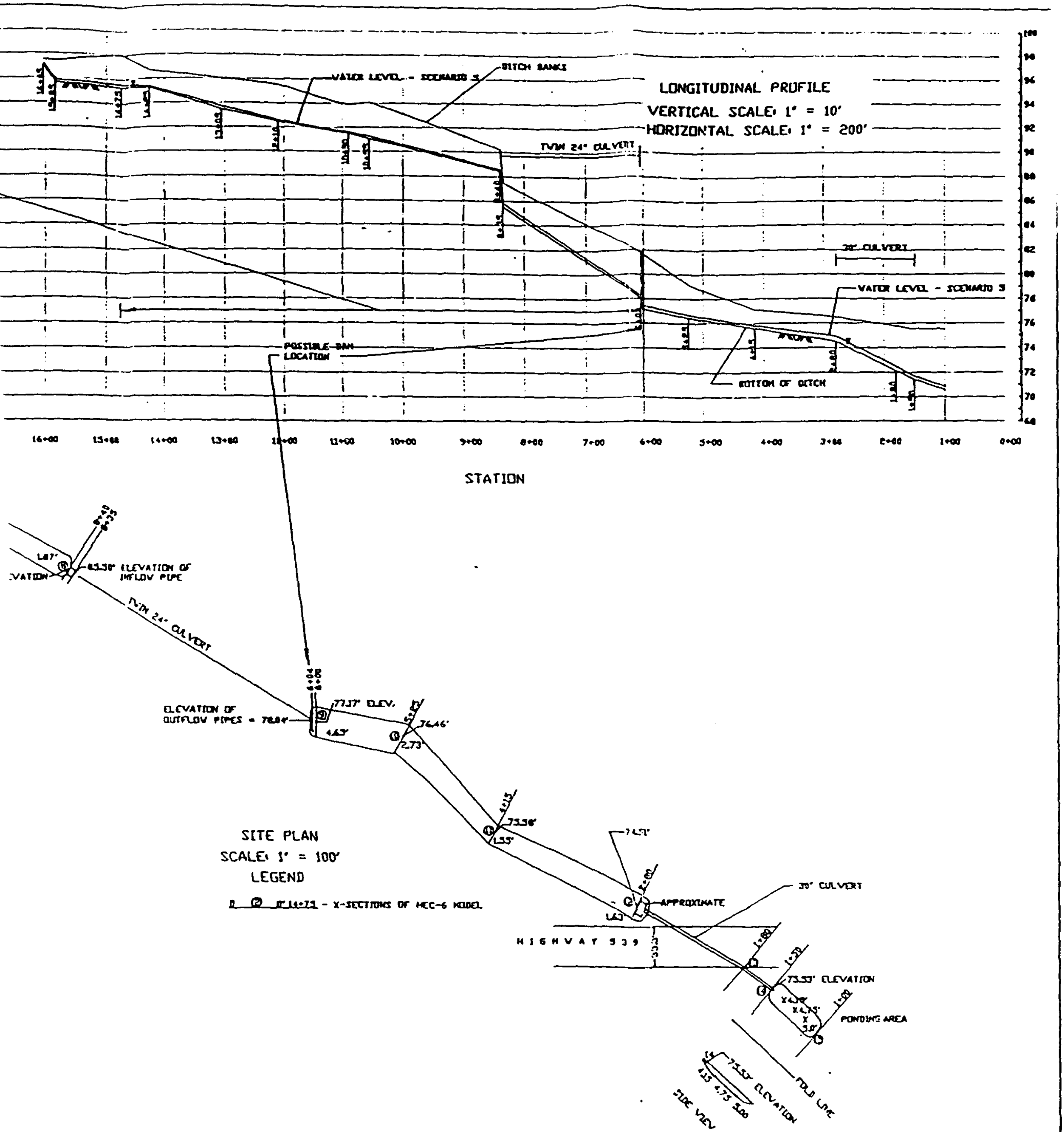
BURGESS & NIPLE, LIMITED ENGINEERS AND ARCHITECTS	SCALE: AS SHOWN DATE: FEB. 90	FIGURE NO. 11



NOTE: ELEVATIONS ARE RELATIVE TO THAT OF APRON IN FRONT OF SHELTER 204 WHICH IS 100 FEET.

BOMARC SITE, MCGUIRE AFB PLUTONIUM TRANSPORT MODEL	SCENARIO 5	BURGES ENGINE

(2)



BURGESS & NIPLE, LIMITED ENGINEERS AND ARCHITECTS	SCALE: AS SHOWN DATE: FEB. 90	FIGURE NO. 12

Based on the ratio of the two values, the probability of movement of a PuO_2 particle was calculated at each cross section (see Reference 3, Exhibit 3, page 20). From that, the cumulative probability of movement up to any cross section was calculated and results are shown on Figure 13. Based on this probabilistic approach, there is a maximum 55 percent chance that plutonium traveled beyond Section 1+00 (the model boundary) and into the ponding area during the firefighting. This scenario indicates that the problem can be modeled stochastically, which could be a contribution to any risk assessment analysis.

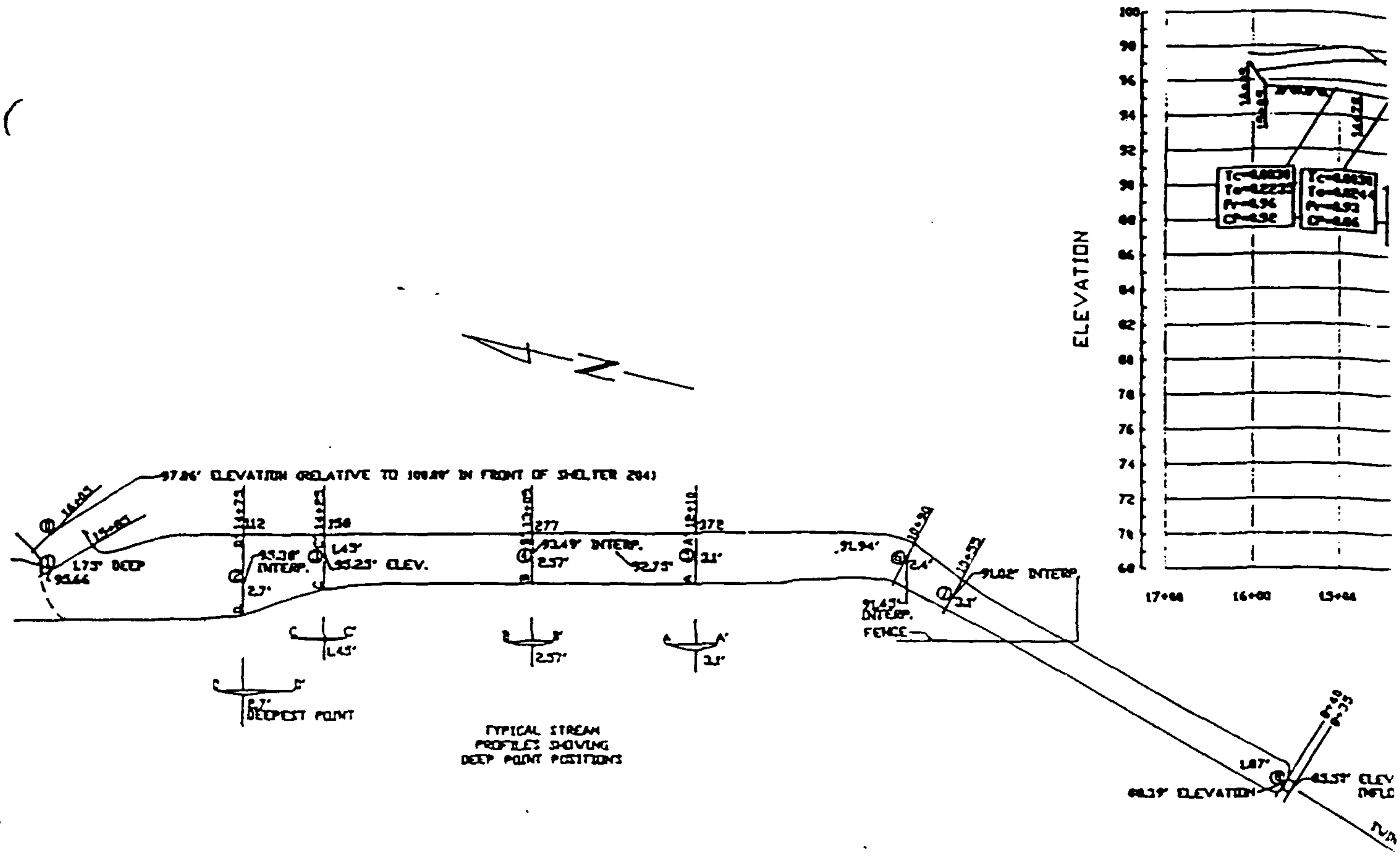
Scenario 7

The purpose of this scenario was to determine whether any rainstorm that occurred after the incident (June 7, 1960) and prior to covering the ditch with asphalt (sometime in 1967) caused plutonium transport over the earthen dam erected at Station 8+40 (see Scenario 4). This location of the dam was selected by SAIC as being a likely site of the three possible locations, and the one that would produce the worst-case results. The exact date of covering the ditch with asphalt is not available so the rainfall data used extended to December 31, 1967. No infiltration was assumed and no erosion of the dam itself was modeled.

Since the ditch flowed intermittently during the 7-year period of concern, an indirect method of modeling was applied for this scenario. The model was run for gradually increasing flow rates starting with a flow of 0.14 cfs (flow used for modeling transport during firefighting). Each flow rate was run separately and the model output checked for plutonium transport over the dam. The flow rates were increased until the flow rate necessary to transport plutonium over the top of the dam was obtained. From there, HYDRAIN was used to determine the minimum size 24-hour storm necessary to create such a flow rate.

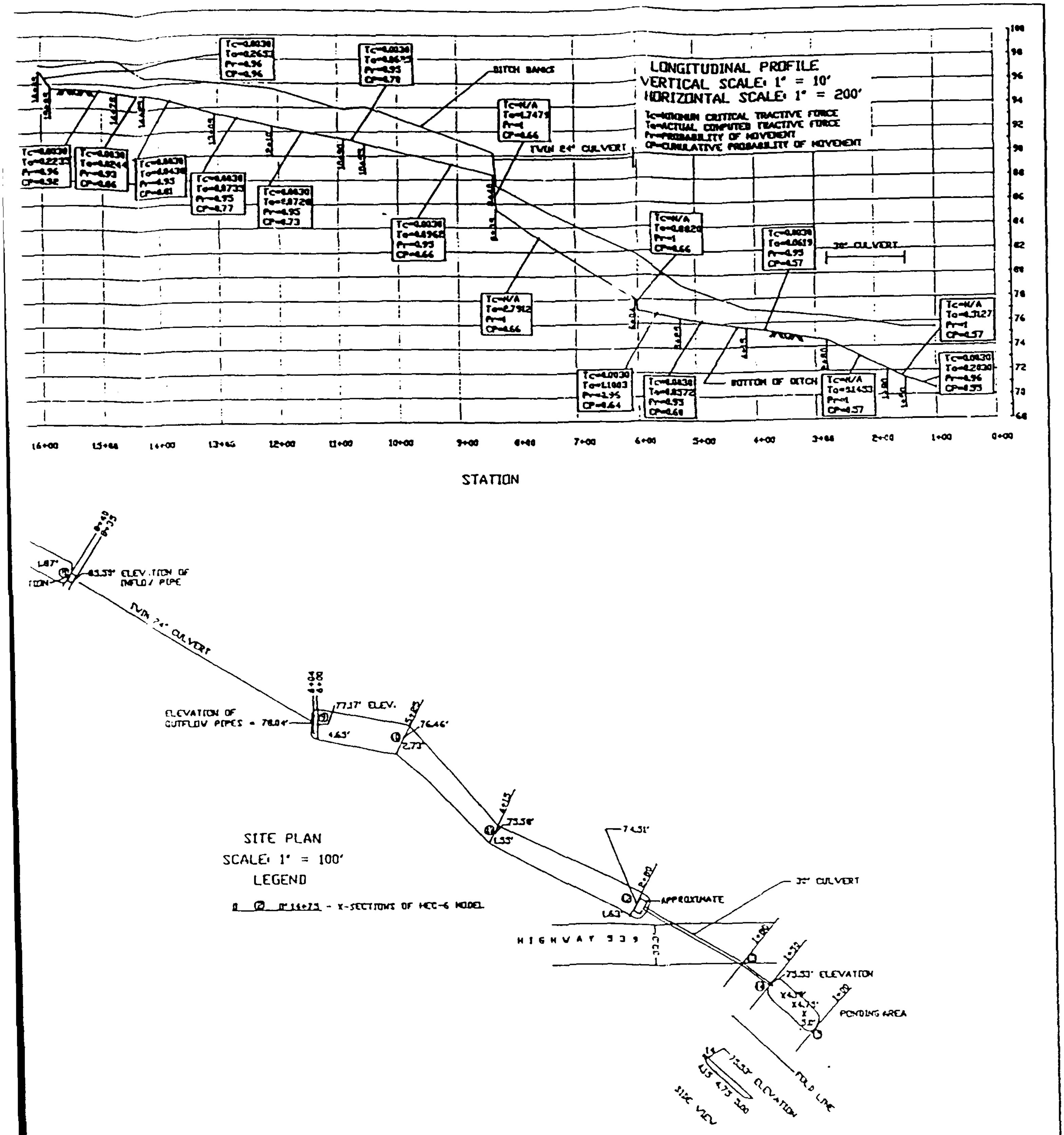
For the worst-case run, a flow of 0.65 cfs corresponding to a storm of at least 0.41 inches would transport the plutonium over the dam past Station 1+00 (the model boundary) and into the ponding area. For the best-case run, the

1



NOTE: ELEVATIONS ARE RELATIVE TO THAT OF APRON IN FRONT OF SHELTER 204 WHICH IS 100 FEET.

BOMARC SITE, MCGUIRE AFB PLUTONIUM TRANSPORT MODEL	SCENARIO 6	BURGES ENGINEE



BURGESS & NIPLE, LIMITED ENGINEERS AND ARCHITECTS	SCALE: AS SHOWN DATE: FEB. 90	FIGURE NO. 13

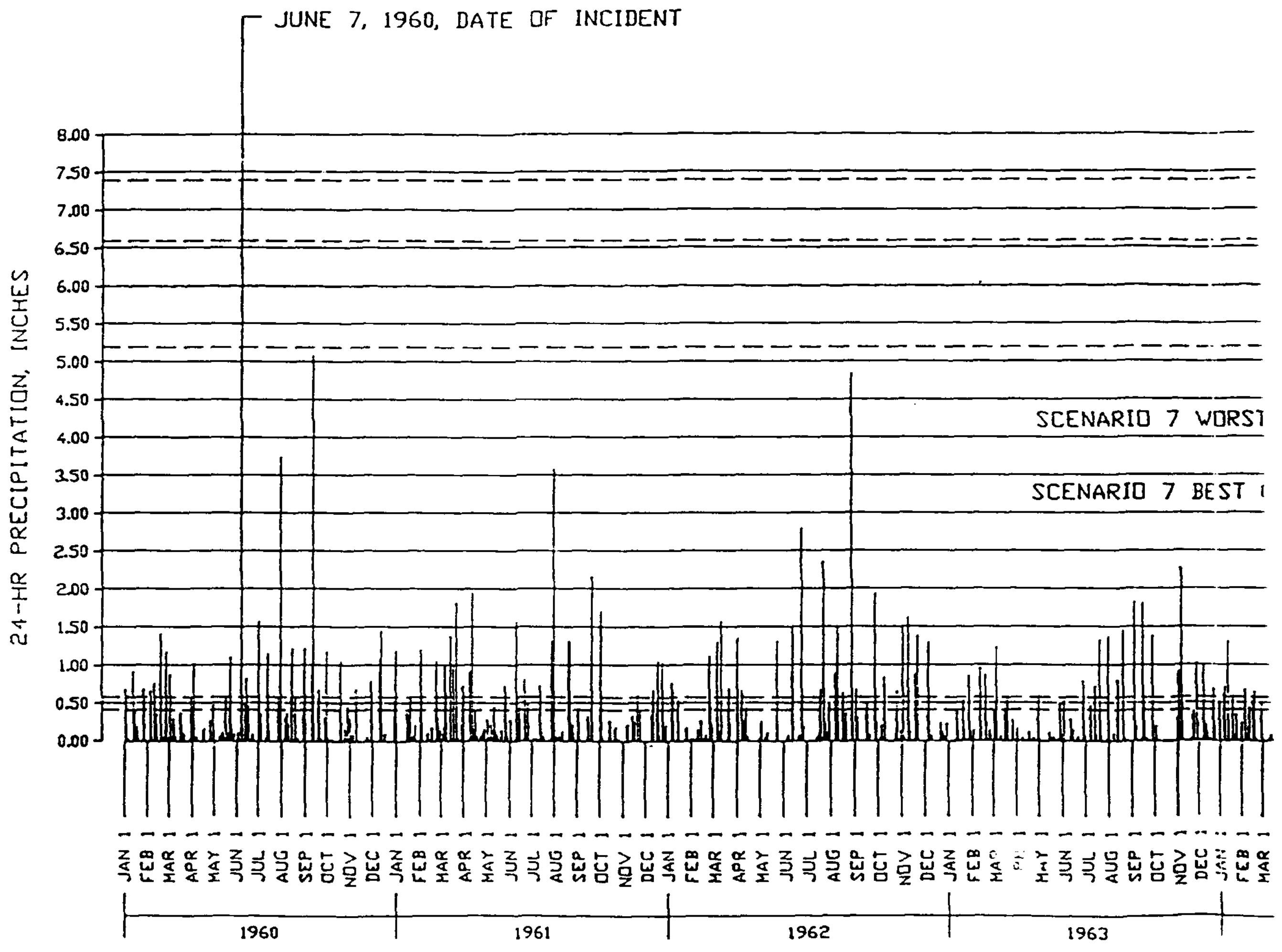
results are 1.70 cfs corresponding to a storm of at least 0.58 inches. These results are shown on Figure 14 and indicate that for the worst-case run any one of 260 storms could have caused transport of plutonium over the dam. The corresponding number for the best-case run is 184 storms. In addition, it should be noted that the dam itself was probably eroded or removed prior to 1967.

Scenario 8

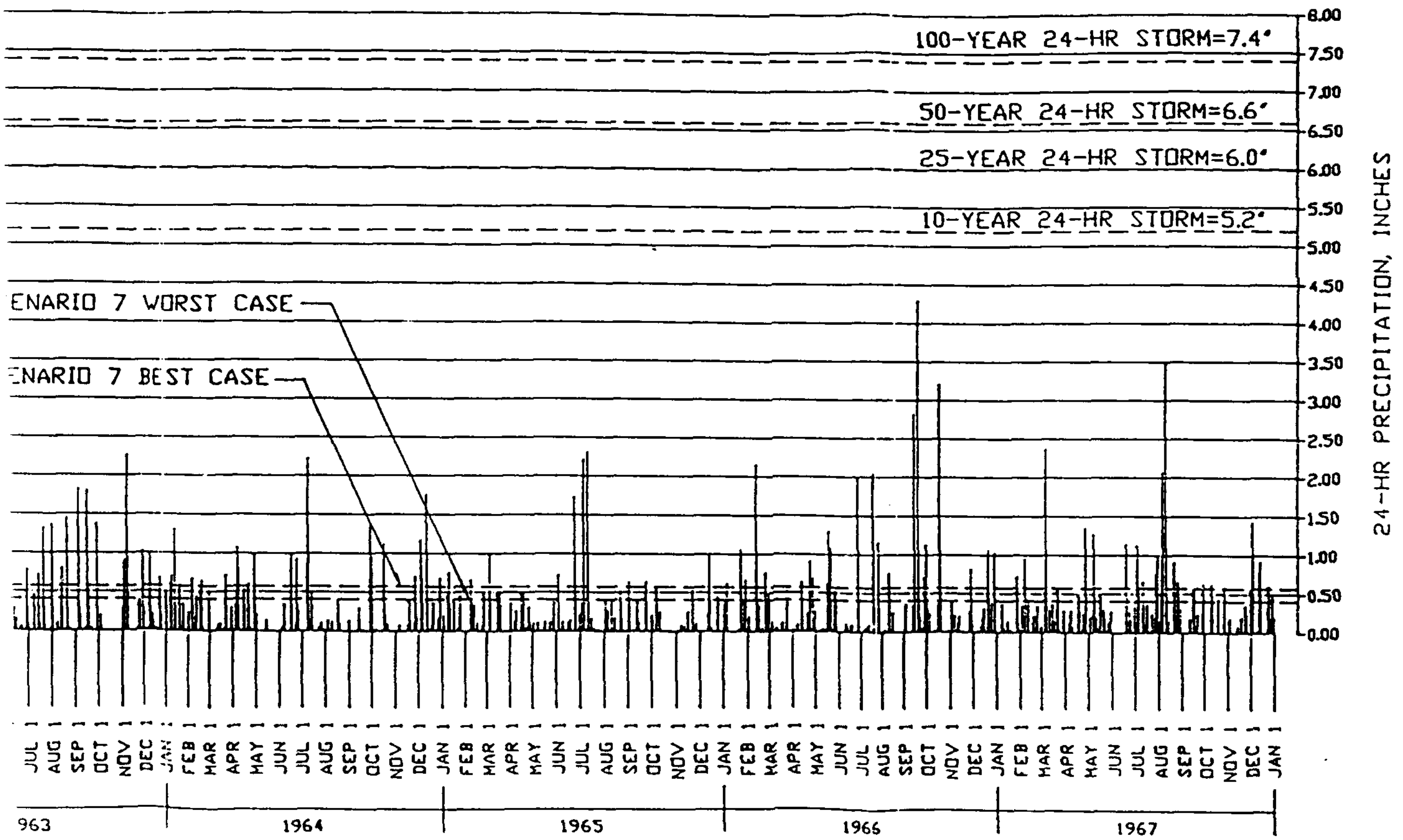
The purpose of this scenario was to determine what frequency storm would cause erosion of the present day asphalt cover of the drainage ditch and thereby allow further distribution of plutonium into the environment. A site visit was performed in January 1990 and revealed that the existing asphalt cover is generally in good condition. Portions of the cover were cracked but there was no dislodgement of asphalt pieces. Areas of the drainage ditch had sediment deposits which supported vegetation, and around a few of those areas breaking up of the asphalt by plant root was evident. Borings taken along the drainage ditch showed that the asphalt cover is 2 inches thick.

Based on the preceding data, it was assumed for the purpose of this scenario that the storm causing movement of a 2-inch-diameter asphalt particle is the storm that could potentially erode the asphalt cover. The tractive force necessary to move a 2-inch angular particle of crumbled asphalt is between 16 and 26 psf. The exact value depends on the slope of the drainage ditch at the point where the particle lies. Using HYDRAIN, the peak flow for a 100-year, 24-hour storm was obtained, and from HEC-6 the tractive force produced by that storm was calculated to be between 1 and 6 psf depending on the slope of the drainage ditch. Therefore, an excess of a 100-year, 24-hour storm is required to possibly erode the asphalt cover. In view of the conservative assumptions made, it is very unlikely that erosion of the existing asphalt cover would occur from storm runoff.

(1)


JUNE 7, 1960, DATE OF INCIDENT
24-HR PRECIPITATION, INCHES
8.00
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
SCENARIO 7 WORST
SCENARIO 7 BEST
JAN 1
FEB 1
MAR 1
APR 1
MAY 1
JUN 1
JUL 1
AUG 1
SEP 1
OCT 1
NOV 1
DEC 1
1960
1961
1962
1963

(2)



BOMARC SITE, McGUIRE AFB
PLUTONIUM TRANSPORT MODEL

FIG. 14

SCENARIO 7

BURGESS & NIPLE LIMITED
ENGINEERS AND ARCHITECTS

SCALE: NONE
DATE: FEB. 1990

SUMMARY AND CONCLUSIONS

A sediment transport model was used to predict plutonium transport in a drainage ditch at the BOMARC Site under different possible scenarios. Due to the unique and unknown nature of plutonium transport in a channel, worst-case and best-case model runs were performed for each scenario to define the range of possible outcomes. Based on the assumptions and modeling goals stated in this study, the following conclusions can be made concerning plutonium transport.

Transport During Firefighting on June 7, 1960

If there was no dam, the plutonium went as far as the water traveled. There is some evidence from Reference 1 that the water traveled approximately 500 feet along the drainage ditch. Due to infiltration it is unlikely that the water, and hence the plutonium, traveled to the ponding area.

If there was a dam with a minimum height of 3 feet, plutonium was contained within the reservoir formed by the dam due to small tractive forces upstream of the dam and due to infiltration.

Transport During 1960-1967

From the numerous precipitation events that occurred on the site in the 7-year time period, between 184 and 260 storms would have produced runoff and flow in the drainage ditch capable of transporting the plutonium over the dam. There is some evidence from Reference 1 that the dam was removed following the incident. If the dam was not removed, it was probably eroded prior to 1967. In view of the above, it is very likely that the plutonium traveled to the ponding area during this 7-year period before an asphalt cover was placed over the drainage ditch.

The model cannot determine plutonium transport in the ponding area as that is beyond model boundaries. Based on local topography and a site visit there does not appear to be a natural surface outlet from the ponding area (see drainage ditch topography, page 2).

During heavy rainfall, temporary drainage paths could possibly develop within the ponding area leading to the drainage of the Elisha Branch of the Toms River. However, their hydraulic gradient would be one or two orders of magnitude lower than the hydraulic gradient in the drainage ditch. Based on that, it is unlikely that the flowing water would have sufficient tractive force to transport the plutonium out of the ponding area.

Erosion of Existing Asphalt Cover

An excess of a 100-year, 24-hour storm is required to possibly erode the existing asphalt cover. In view of the conservative assumptions made, it is very unlikely that erosion of the cover would occur from storm runoff.

The worst-case and best-case model runs produced a range of possible outcomes. The following data is needed to narrow that range and increase confidence in the model predictions:

- The internal friction angle of the PuO_2 particle

- The dam characteristics (height, location, side slopes, and construction material)

This study was not typical of sediment transport modeling. The combination of uniqueness of the problem, conservative assumptions and unknown factors made this a challenging task. Models assist in making decisions based on the results. As long as this model is used as a management tool in the RI/FS, it can be useful in attempting to determine the extent of possible plutonium contamination.

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APPENDIX H

MODELED SURFACE DEPOSITION PATTERNS FROM THE 1960 BOMARC MISSILE ACCIDENT

FINAL DRAFT

MODELED SURFACE DEPOSITION PATTERNS FROM THE 1960 BOMARC MISSILE ACCIDENT

W. E. Davis
M. N. Schwartz

August 1990

Prepared for
Science Applications International Corporation
Environmental Remediation Division
Golden, CO 80401
under Contract 231126203A

Battelle
Pacific Northwest Laboratories
Richland, Washington 99352

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SUMMARY

An accidental explosion and fire occurred at the Fort Dix Military Reservation (New Jersey) BOMARC missile shelter 204 on 7 June 1960 at approximately 1500 hours LST (local standard time). The resulting fire engulfed a warhead containing plutonium (Pu). Preliminary undocumented measurements carried out by the Air Force shortly after the accident indicated considerable radioactive ground contamination near the shelter but no measurable ground contamination from potentially released Pu in the plume from the fire downwind of the shelter.

In 1989, the U.S. Air Force contracted with Earth Technology Corporation and its subcontractor Science Applications International Corporation (SAIC) to conduct a Remediation Investigation and Feasibility Study (RI/FS) of the existing contamination at the accident site. Battelle Northwest (BNW) was subcontracted by SAIC to perform a study of the Pu burn and to model possible airborne releases and surface deposition from the accident. The purpose of this study was to provide a sampling matrix for FIDLER radiation measurements in areas identified as potentially affected by the accident.

Results from this study are presented in the form of a comparison of predicted Pu deposition values over the entire region of interest with FIDLER samples taken over a limited area. The predicted values are derived from the MESOI 2.0 Code (to be described). Comparison of the two data sets is difficult as a result of model uncertainties and uncertainties in the radiation measurement (including measurement and calibration procedures, definition of the lower limit of detection, the protocol to determine the variation in backgrounds as a function of time or locations, and uncertainty estimates as a function of counting levels). The uncertainty was therefore felt to be too large to allow any meaningful correlation of the model results and physical measurements made.

Two conclusions are presented. First, the presence or absence of measurable levels of contamination cannot be confirmed from the FIDLER data. Therefore, a definable deposition pattern for radioactive ground contamination could not be established based on the measurements used to compare with model results. The fact that well defined patterns were predicted by MESOI 2.0, and none were found, argues that no measurable ground contamination occurred from the Pu plume released during the fire.

Second, by weighting the individual FIDLER data by their representative areas, a range of possible Pu deposition values could be calculated. These values can range from approximately 0 to 20 g depending on the lower level of detection limit of radioactivity used for the FIDLER instrument. The 20 g deposition was considerably larger than the 0.5 to 7.5 g calculated to be released to the atmosphere based on a burn analysis of the Pu warhead (Appendix A.)

INTRODUCTION

A non-nuclear explosion which resulted in a fire in the missile shelter 204 occurred at the Fort Dix Military Reservation (New Jersey) BOMARC missile site on 7 June 1960, at approximately 1500 hours LST (local standard time). At approximately 1515 LST, the warhead containing plutonium (Pu) was engulfed by the fire. The fire continued to burn for 30 to 60 minutes and was reported out between 1545 LST and 1615 LST. Preliminary undocumented measurements by the U.S. Air Force in 1960 showed considerable radioactive ground contamination near the shelter but no measurable ground contamination from airborne released Pu downwind of the shelter.

In 1989, the Air Force contracted with the Earth Technology Corporation and its subcontractor Science Applications International Corporation (SAIC) to conduct a Remedial Investigation and Feasibility Study (RI/FS) of existing contamination at the accident site. Battelle Northwest Laboratory was subcontracted by SAIC to perform a study of the Pu burn and its potential release of Pu to the atmosphere and to model possible airborne dispersion and resultant surface deposition of Pu from the accident. The results of the BNW study are contained in this report.

The purpose of this study was to provide guidance to SAIC for soil sampling by identifying areas downwind of the accident site where possible deposition occurred from the Pu released to the atmosphere in the fire plume. Identification was also to be made of any potential "hot spots" of deposited particulate from the fire plume. Both areas of ground deposition and potential hot spots were than to be investigated by a FIDLER survey conducted by SAIC. In addition, because of uncertainty in the model results, it was anticipated that there would be an iteration on the modeling process. In particular, the FIDLER survey results were to be compared with model results, with an adjustment in model variables to be made to bring the predicted and observed patterns into closer agreement. In this way it was hoped that the model could be used to identify any additional areas for FIDLER sampling.

The meteorological code to be used in this analysis was MESOI 2.0 (Ramsdell et al. 1983). This model provides a mathematical description of atmospheric transport and surface deposition on horizontal spatial scales similar to the accident. The code has demonstrated its usefulness in describing air concentration downwind from radioactive releases in similar terrain to the accident site at the Savannah River Plant in South Carolina (Ramsdell et al., 1984).

This report includes a description of the MESOI 2.0 code, the input used to run MESOI 2.0, modifications made to MESOI 2.0, the model-produced deposition patterns, recommended areas for sampling, and a comparison of the modeled Pu deposition with the FIDLER survey.

METHODOLOGY

DESCRIPTION OF MESOI 2.0

The MESOI 2.0 code is a single layer Lagrangian puff model that simulates the transport, diffusion, deposition, and decay of gases and small aerosols released to the atmosphere. The model uses near-surface winds and winds at the top of the planetary boundary layer for calculating transport. A wind speed and direction at the height of released material is found by interpolation. Material is deposited to the surface using a source depletion and a dry deposition model.

MESOI 2.0 code was selected because it can be used to compute transport and deposition over short distances, i.e., out to 10 km. The model's grid size and inputs can be adjusted to allow the user the level of detail necessary to represent an area of interest. For this study, the transport grid size was set at 1.0 km spacing and the deposition grid at 0.5 km spacing. A time step of 10 minutes was selected. There was only one modification of any significance to the documented code.

MODIFICATIONS TO MESOI 2.0

MESOI 2.0 has a built-in dry deposition velocity, but does not allow for particle settling within the puff. To simulate particle settling velocities, a modification was made to allow for a settling velocity to be input into the model and to change the height of the puff with time. By using several size ranges of particles, with their associated settling velocities, the behavior of a settling puff could be simulated.

INPUT FOR MESOI 2.0

Surface winds and winds above the top of the boundary layer are needed by the model to describe transport. Winds at these two heights are necessary to evaluate the wind speed and direction (by linear interpolation) at the height of the puff.

Two sites near the accident provided the wind data: McGuire Air Force Base, located 14.5 km to the west and Lakehurst Naval Air Station, located 10.0 km to the east (see Figure 1).

The top of the boundary layer at the time of the accident (and hence the presumed upper limit to vertical motions and mixing) was estimated using hourly surface temperatures at McGuire and Lakehurst along with the temperature soundings from Washington D. C. (about 250 km WSW) and New York International Airport (about 125 km NNE). The height of the mixing layer was made using the method described by Holzworth (1972). The resulting mixing layer height was estimated to be between 1800 and 2300 m above the surface; these heights were assumed to represent the height of the top of the boundary layer.

An estimate of the winds at the top of the boundary layer was made by using a National Weather Service 850 mb synoptic map (corresponding to approximately 1500 m over the accident site). The geostrophic analysis of this 850 mb surface yielded NNW winds at 3 kts over the accident site. This is the wind speed used to describe transport above the boundary layer.

The model represented the surface flow at the site of the accident by using nearby wind information from McGuire and Lakehurst. The surface wind observations at McGuire and Lakehurst are 5 min averages taken approximately 10 min before the hour on the date of the accident. Comments made by the weather observer (Table 1) indicate that wind speeds were light and/or variable during the time period of the accident. There does appear to be some consistency in the direction of the hourly reported winds at both stations. The wind directions at 1500 LST, near the time of the accident, are for the same direction (NNE) with similar wind speeds of 2 and 3 kts. The 1600 LST wind directions show a more westerly component with light W to NW winds at Lakehurst and McGuire, respectively.

A large potential source of error in predicted transport (and hence in predicting the deposition of Pu) may result as a result of using winds which are small in magnitude and variable in direction; typically there is a large degree of variability in these wind fields making transport estimates subject to a significant amount of uncertainty. In order to evaluate some of the error, the model was run in two different modes. The first mode allowed the winds to vary linearly in time between hourly observations. The second mode assumed the winds to be constant throughout the hour until the next observation. Both methods are felt to be defensible ways to treat these light and variable winds, although they will result in slight differences in wind speed and direction between the observing times. Our goal in performing this two-method approach was to evaluate the sensitivity of the model to the treatment of winds under these variable meteorological conditions.

After comparing the model deposition results with surface sampling for Pu, a reanalysis of the model was expected to be done using winds defined so as to bring the predicted results into closer agreement with the observed Pu deposition patterns. For reasons to be given later, this second analysis was not performed.

A variety of particle sizes were likely produced during the fire. To account for these various size particles, a number of settling velocities were used in the MESOI 2.0 simulations. Table 2 lists the geometric size ranges and the associated settling velocities (taken from Appendix A). The model was modified to incorporate the settling velocity by allowing the particles in the puff to settle towards the surface with time. The settling of the puff occurred at each 10 min time step with the height of the puff being decreased incrementally by the product of the settling velocity and the time step. The puff continued to diffuse vertically and horizontally while the center of the puff moved closer to the surface. When the center of the puff reached the surface, no more settling was allowed and a puff height of 0.0 m was used in the diffusion equations. For the the 12 micron and < 5 micron particles very little adjustment occurred, i.e., a decrease in height of only 144 m and 36 m per hour respectively.

Another variable that needs to be quantitatively described for simulations with MESOI 2.0 is the release height of the Pu. The actual height of the smoke plume was difficult to estimate during the fire. One unidentified observer indicated that the smoke rose to a height of 400 ft (123 m). The exact time of the observation is unknown, but was during the fire (1575 to 1615 LST). Clearly the height estimate will depend on the perspective of the observer and their experience at estimating heights. During the time of the fire, it might be expected that the heated plume of smoke would rise in the atmosphere until it reached a height where, because of adiabatic cooling and mixing with the surrounding air, it would attain a temperature equal to that of the surrounding atmosphere, at which point it would rise no farther. By examining the atmospheric soundings, a slightly heated plume with little or no entrainment could have risen to about 1800 m before reaching a stable layer. To account for both the observed (123 m) and the estimated (1800 m) plume height, the model was run with both release heights.

The last piece of information needed for a model run is a source term describing how much material was available for transport and removal via meteorological processes. A source term for the atmospheric release of Pu from the burning warhead was estimated to be between 0.5 g to 7.5 g depending upon the assumed mass of Pu in the warhead (see Appendix A). The model was run with a unit source term of (1.0 g); because MESOI 2.0 is linear (that is, there is a direct proportionality between Pu deposition and the source term), any increase in the source term would be reflected in a proportional increase in the associated deposition. Results may be scaled accordingly.

The model simulations may be summarized as follows. Simulation periods were for 3 hours, the source terms were fixed at 1.0 g, two release heights were examined (123 m and 1800 m), two methods were used to evaluate the wind fields and simulations were done using a series of settling velocities. For all of these cases, the 10-min positions of the puffs and the cumulative surface deposition values were noted. Both the trajectories and the deposition patterns were examined.

RESULTS

Figure 2 shows the puff trajectories of low level releases. These trajectories are for both time varying surface winds (Figure 2a) and constant winds (Figure 2b), a 123-m release height and no settling velocity. The settling velocity was removed from these calculations in order to visualize the trajectories for a simplified situation. They show that the plume moved initially from the NNE and then veering as a result of a shift in the winds from the NW. At approximately 1630-1700 LST (about 1-1/2 to 2 hours after the accident initiation), the trajectories shifted to the east, coming back on their path and moving to the W. This indicates that the winds used in the model for both modes, constant layer and time varying, will keep the released material in or near the accident site during the first two hours after the start of the accident.

Trajectories for the 1800 m release with no settling velocity are not shown since they will move to the SSE at a constant speed of 3 kts, i.e., the direction and speed at the top of the boundary layer. Material transported at this level will be continually moving away from the accident site.

The potential Pu deposition from the puffs released at 123 m height was examined first. Figure 3 shows the deposition results from the model for 20 micron particles. All of the simulations with the 123 m release height produced maximum predicted deposition of Pu very near the source. The locations of the maximum ground deposition from the model simulation are SW to SE of the release point. The location of the modeled highest deposition for 20 micron particles was located approximately 0.7 km SE of the BOMARC site (Figure 3a).

The model was rerun with a release height of the puffs at 1800 m. An additional complication was postulated for scenarios in which the puff was released at 1800 m; saturation of a parcel of air containing the puff should have occurred at about 1500 m. (that is, water condensation would have been expected to occur in a parcel of air lifted to this height, given the observed temperature and moisture conditions). This saturation estimate is based on an adiabatic puff rise using the surface temperatures and dewpoints from Lakehurst and McGuire. Associated with such condensation is the possible downward transport of Pu by raindrops, increasing the possible range of settling velocities to as much as 1 and 3 m/s. However, due to the dryness of the boundary layer air, any rain drops formed would evaporate before reaching the ground. To account for the possibility of raindrops reaching the surface, simulations were performed with 3 m/s and 1 m/s (Figures 4 and 5) fallspeeds.

The predicted Pu deposition isopleths for the 1800 m insertion are shown in Figures 4 through 9. In each case the "a" figure depicts results using the time varying winds and the "b" figure depicts results using constant winds. Figures 4 and 5 using the 3.0 and 1.0 m/s settling velocity show that with an 1800 m release height the maximum deposition occurs 2.5 km to the SE of the accident site for both modes of wind field analysis (constant winds and time varying winds). As the particle sizes being modeled become smaller the maximum deposition moves further away from the accident site. The predicted Pu deposition isopleths show that the maximum modeled deposition would occur for particles < 20 microns (Figures 8-9), just W of the intersection of Highways 539 and 70. The orientation of these patterns along a NNW to SSE line show the influence of the wind at the top of the boundary layer on the movement of diffusing puffs. As noted in the section discussing Table 2, there is little effect on the height of the puffs for settling velocities for particles < 20 microns.

The actual changes in the wind speed and direction that may have occurred during the time period of the accident may have altered the real patterns. Because of this, these patterns in Figures 3-9 were considered a first estimate for use in selecting a surface sampling area.

IDENTIFICATION OF SURFACE SAMPLING AREAS

Based on the above results, an area for FIDLER measurement of ground contamination was selected that covered all the maximum isopleths shown in Figures 3-9 (Figure 10). This figure was submitted to SAIC which in turn established a FIDLER sampling matrix. Measurements were subsequently made at the positions shown in Figure 11 and 12, and the results of the FIDLER survey presented to BNW (Appendix B).

COMPARISON WITH FIDLER SAMPLING RESULTS

To verify the presence of Pu deposition in the area predicted by the modified MESOI 2.0 code, radiation readings of selected ground surfaces using a FIDLER instrument were made. After the readings were taken, SAIC requested that a comparison be made between the model results and the observed FIDLER measurements in an attempt to adjust the model parameters to bring about better comparisons, and then to perform a reanalysis of areas of possible Pu deposition.

Comparison of the two data sets was difficult as a result of the uncertainty in the radiation measurements (including measurement and calibration procedures, definition of the lower limit of detection, the protocol to determine the variation in backgrounds as a function of time or locations, and uncertainty estimates as a function of counting level). Plotting 141 of the 146 uninterpreted surface samples (5 samples could not be located) given in Appendix B produced no cohesive patterns (Figures 11 and 12). Because no pattern was found, an iteration of the modified MESOI 2.0 was not performed.

Although no pattern was found, estimates of the total Pu deposited as a result of the fire, D, were estimated by using the FIDLER results in the following formula:

$$D = \sum dep_i * area_i * K$$

where dep_i is the estimated Pu deposition in curies/m^2 at sampling point i, $area_i$ is the weighted area assigned to sampling point i, and K is the conversion factor from curies/m^2 to g/m^2. A mix of 95% Pu^{239} and 5% Pu^{240} was assumed, yielding a value of K of approximately 15 g/ci.

Using 141 samples in the deposition equation, the deposition of Pu was calculated to be 20 g in the surveyed area between Highway 70 and the accident site (Figure 10.) This value was believed to be unrealistically high, based on the Pu burn analysis in Appendix A. By using a series of low-level discriminators ranging from background to 2.5 times background, deposition values for Pu could range from approximately 20 to 0 g (see Figure 13).

When examining the FIDLER results further, an area with twice the average of the radiation measured values were found to exist along Highway 70 (see D in Table 3 and Figure 12). These higher reading may have been due to deposition since this area was predicted by MESOI 2.0 to have high deposition for the 1800-m injection height for ≤ 20 micron particles (see Figures 7-9). However, other possibilities can be suggested.

One possibility is that the highway was constructed of material which would yield a higher background count. It is also possible that the instrument variations were higher in this area. Without soil measurements to confirm the presence of Pu and the uncertainty that exist in interpreting the FIDLER measurements, no conclusion can be drawn as to the cause of these higher readings.

CONCLUSIONS

Model simulations to describe the deposition of Pu all showed well defined patterns south of the BOMARC missile site. No pattern could be discerned when the SAIC FIDLER survey results were plotted. Since no pattern was discernable, a second iteration of the modified MESOI 2.0 code was not performed.

One area along Highway 70 was identified as having higher average values of radioactivity than the other surveyed areas. A comparison with model results did indicate the possibility of Pu deposition along the highway. However, because of the uncertainty associated with the FIDLER measurements and the fact that no soil samples were made available to BNW to confirm the presence of Pu, no definite conclusions can be stated to explain these higher readings.

Calculations of deposition indicate a possible range from 0 to approximately 20 g. The exact amount is strongly dependent on the specified lower limit of detection. The 20 g deposition value was considered larger than what would be expected by the burn analysis (Appendix A), where the release values were postulated to be between 0.5 to 7.5 g released to the atmosphere.

REFERENCE

Holzworth, G. C. 1972. "Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States", AP-101 EPA, Research Triangle Park, NC

Ramsdell, J. V., G. F. Athey, and C. S. Glantz. 1983. MESOI Version 2.0: An Interactive Mesoscale Lagrangian Puff Dispersion Model With Deposition and Decay. PNL–4753, Pacific Northwest Laboratory, Richland, Washington.

Ramsdell, J.V., C. S. Glantz and G. L. Andrews. 1984. "Comparison of MESOI Atmospheric Dispersion Estimates With Data and Estimates From Other Models." In Proceedings of the DOE/AMS Air Pollution Model Evaluation Workshop, Kiawah Island, South Carolina, October 23-26, 1984, DP-1701-1, Savannah River Laboratory, Aiken, South Carolina

TABLE 1.

Meteorological Observations, 7 June1960

Time LST	Wind Direction/ Speed (Kts)	Ceiling (ft)/ Sky Cover	Temperature (°F)/ Dew Point (°F)	Comments
McGuire Air Force Base				
1500	NNE/3	4500/Broken	74/50	Winds Variable
1600	NW/2	5000/Broken	75/47	Winds Light and Variable
1623	WNW/4			
1700	NW/2	5000/Scattered	75/48	Winds Light and Variable
1800	W/5	5000/Scattered	75/47	
Lakehurst Naval Air Station				
1500	NNE/2	4000/Broken	75/52	Wind Direction Variable N-E
1600	W/1	4000/Broken	75/50	Wind Direction Variable W-ENE
1700	ESE/7	4500/Broken	73/47	
1800	SE/4	4500/Scattered	72/51	Wind Direction Variable E-S

TABLE 2.

Settling Velocities For PuO_2

Size (microns)	Settling Velocity (m/s)
< 5	0.01
12	0.04
20	0.12
30	0.3
75	1.0
200	3.0

TABLE 3

Average Deposition From Radiation Reading

FIDLER Sample Set	Number of Samples	Average Value (microcuries/m^2)
A	52	0.013
B	43	0.016
C	26	0.013
D (near Highway 70)	20	0.033
Total	141*	0.017

* 5 sites could not be located

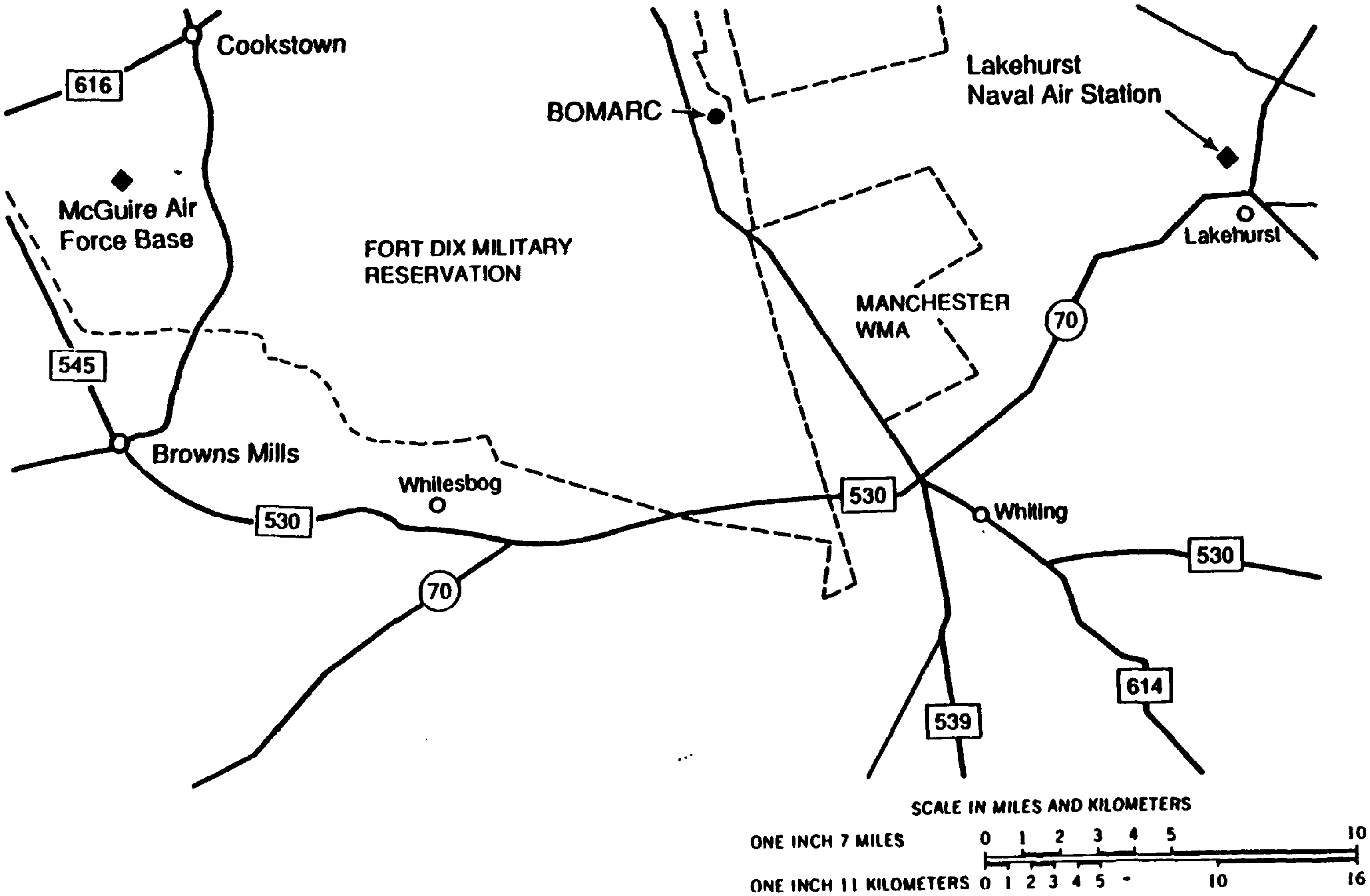

FIGURE 1. Local Map Near the BOMARC Site

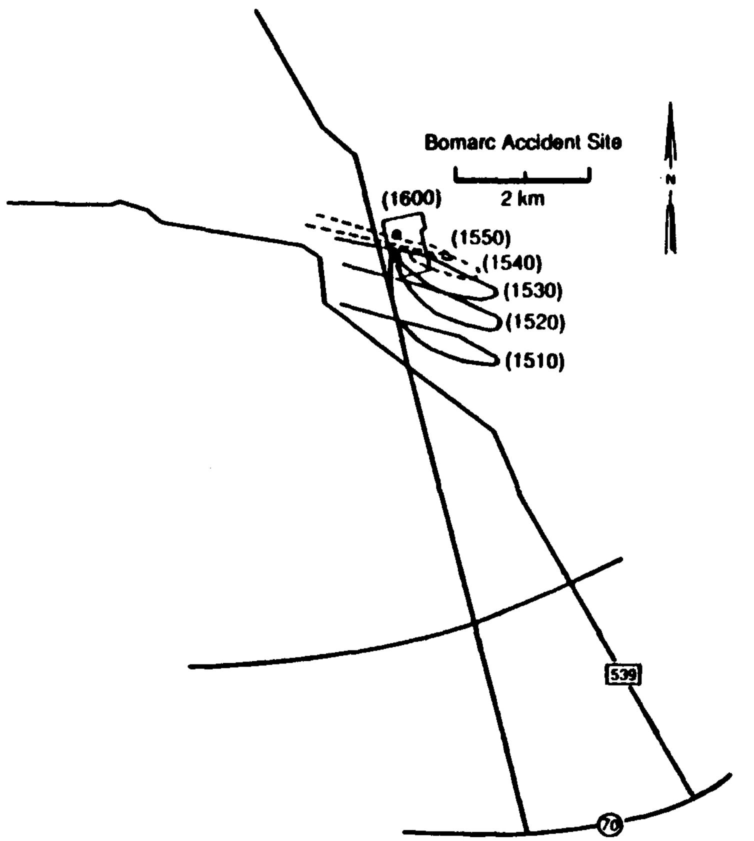

FIGURE 2a. Trajectories of Puffs Using Time Varying Winds and a Release Height of 123 m

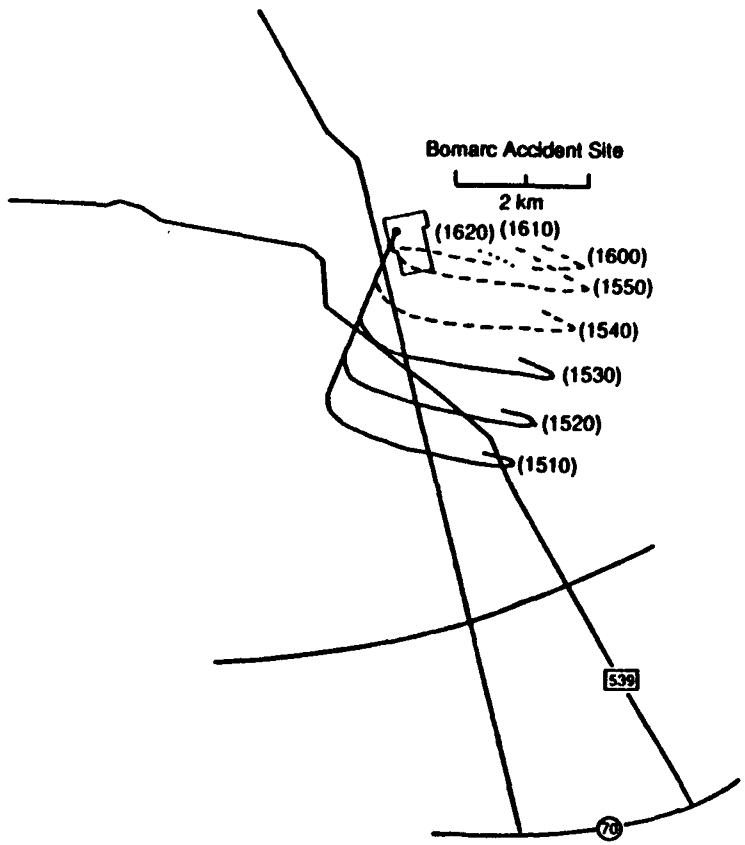

FIGURE 2b. Trajectories of Puffs Using Constant Winds and a Release Height of 123 m

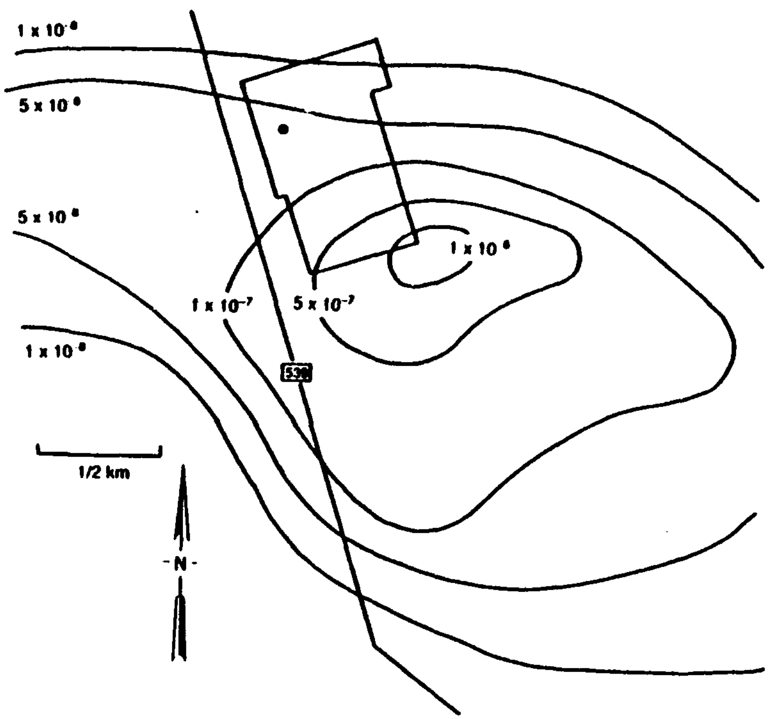

FIGURE 3a. Pu Deposition Pattern for a 1.0 Gram Release for 20 Micron Particles Using Time Varying Winds and a Release Height of 123 m (g/m²)

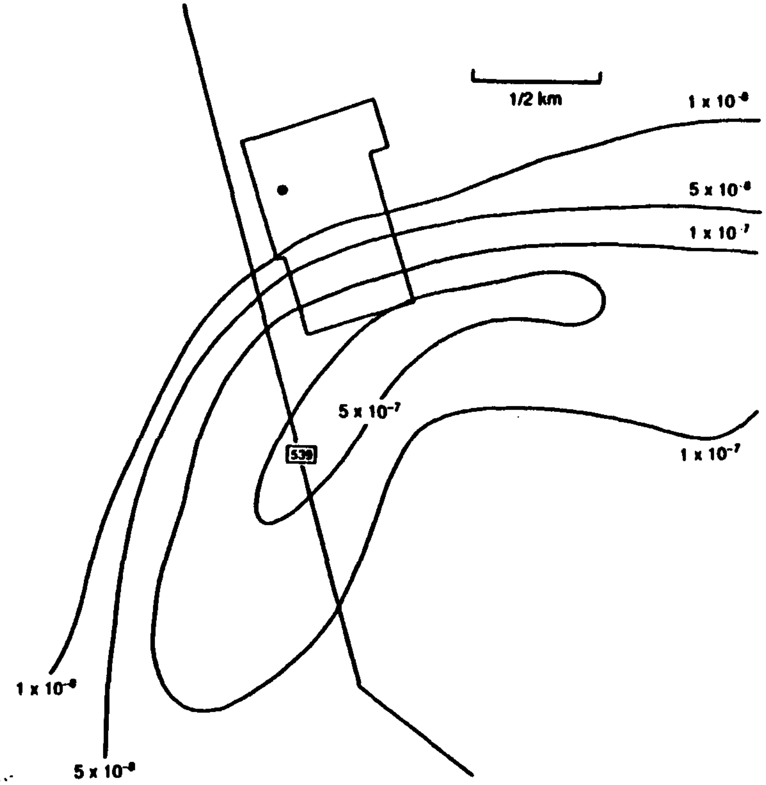

FIGURE 3b. Pu Deposition Pattern for a 1.0 Gram Release for 20 Micron Particles Using Constant Winds and a Release Height of 123 m (g/m²)

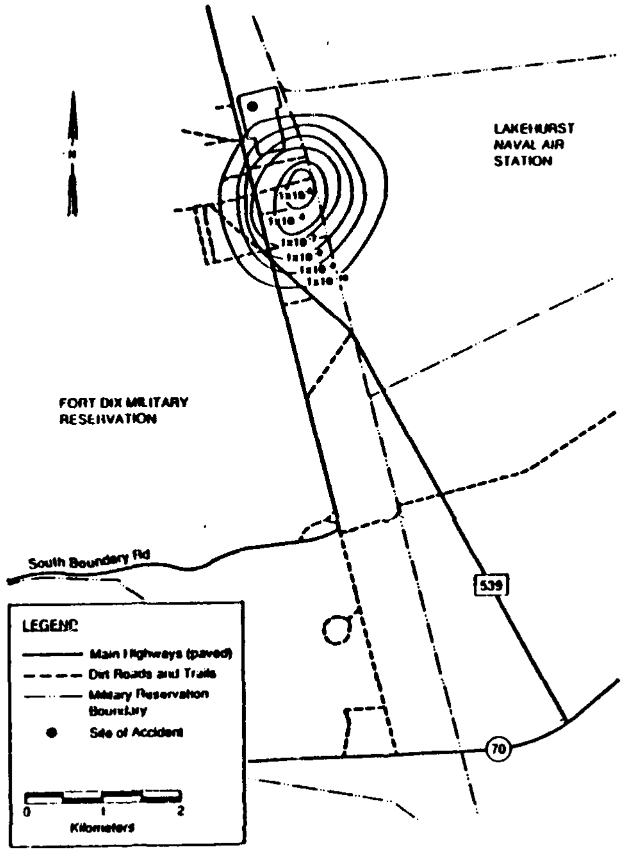

FIGURE 4a. Pu Deposition Pattern for a 1.0 Gram Release for 200 Micron Particles Using Time Varying Winds and a Release Height of 1800 m (g/m^2)

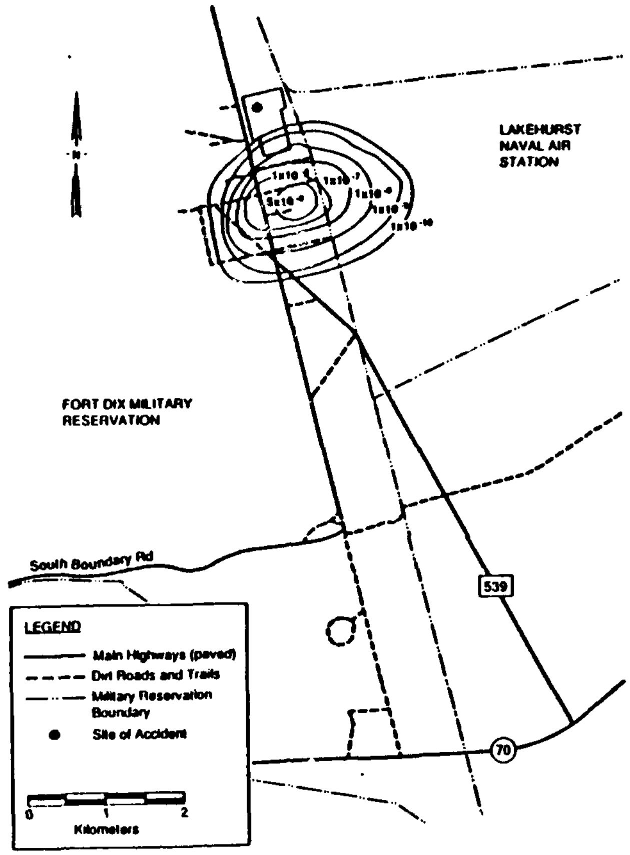

FIGURE 4b. Pu Deposition Pattern for a 1.0 Gram Release for 200 Micron Particles Using Constant Winds and a Release Height of 1800 m (g/m^2)

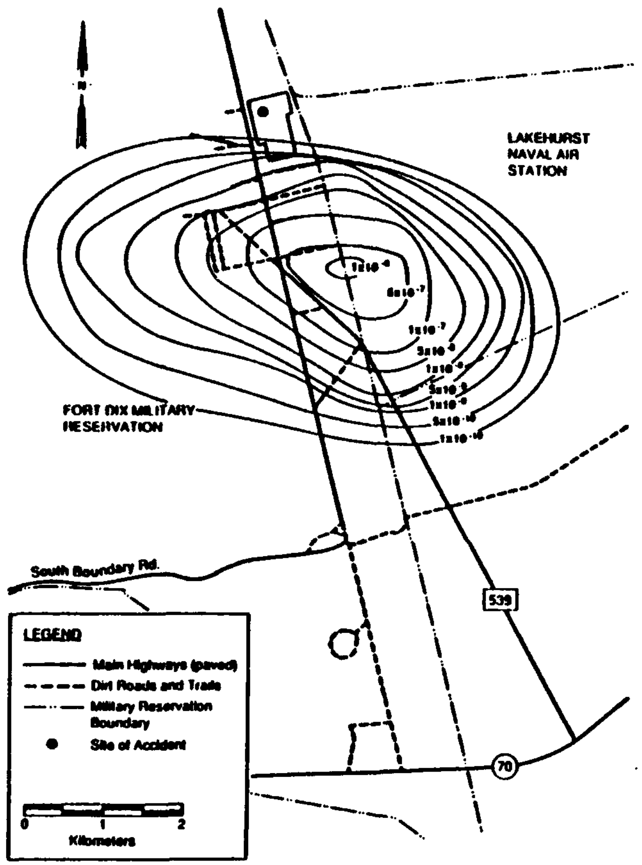

FIGURE 5a. Pu Deposition Pattern for a 1.0 Gram Release for 75 Micron Particles Using Time Varying Winds and a Release Height of 1800 m (g/m^2)

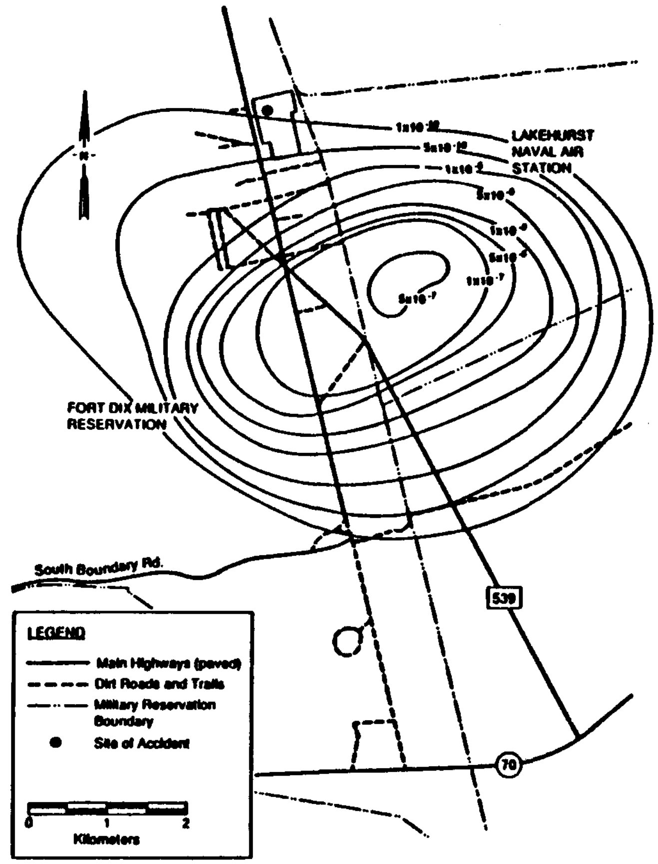

FIGURE 5b. Pu Deposition Pattern for a 1.0 Gram Release for 75 Micron Particles Using Constant Winds and a Release Height of 1800 m (g/m^2)

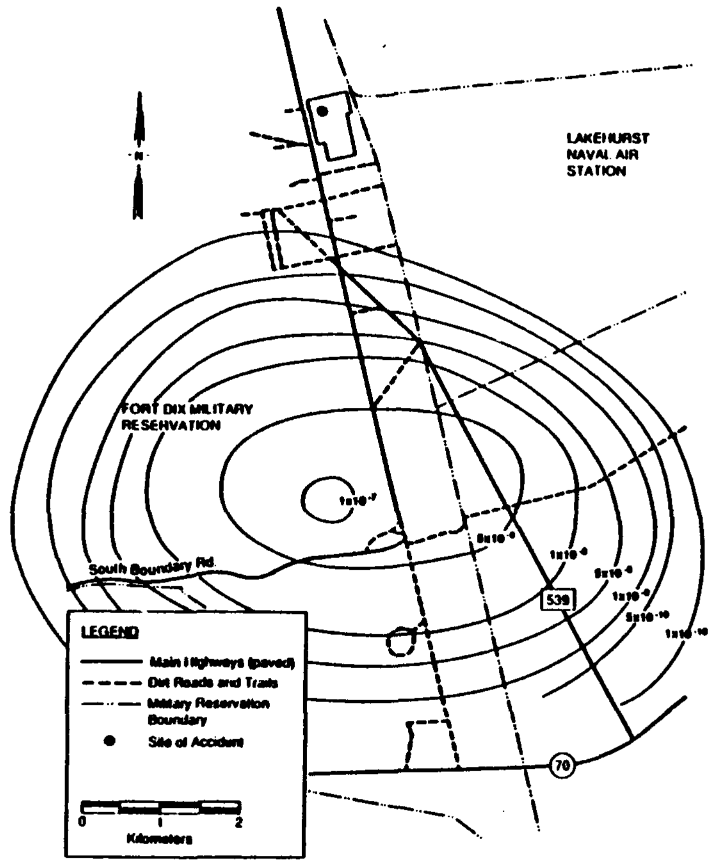

FIGURE 6a. Pu Deposition Pattern for a 1.0 Gram Release for 30 Micron Particles Using Time Varying Winds and a Release Height of 1800 m (g/m^2)

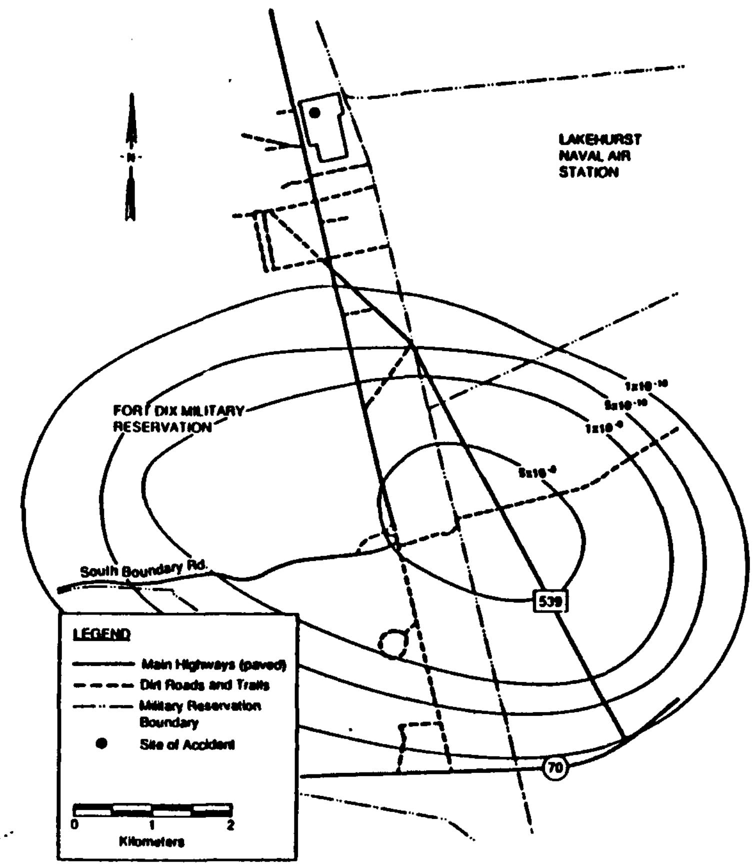

FIGURE 6b. Pu Deposition Pattern for a 1.0 Gram Release for 30 Micron Particles Using Constant Winds and a Release Height of 1800 m (g/m^2)

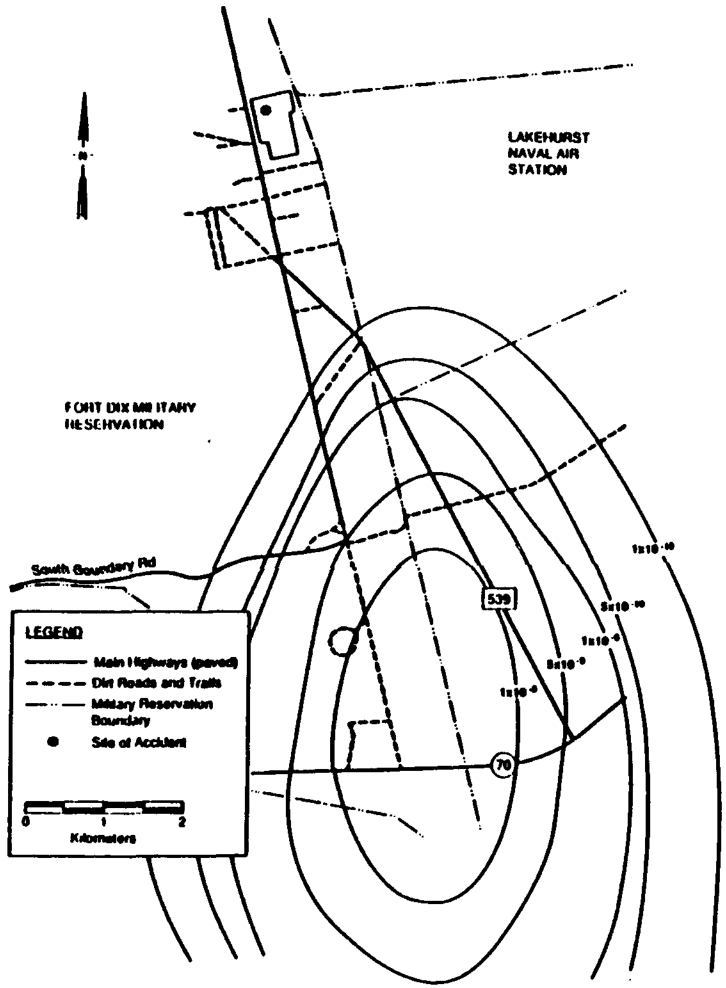

FIGURE 7a. Pu Deposition Pattern for a 1.0 Gram Release for 20 Micron Particles Using Time Varying Winds and a Release Height of 1800 m (g/m^2)

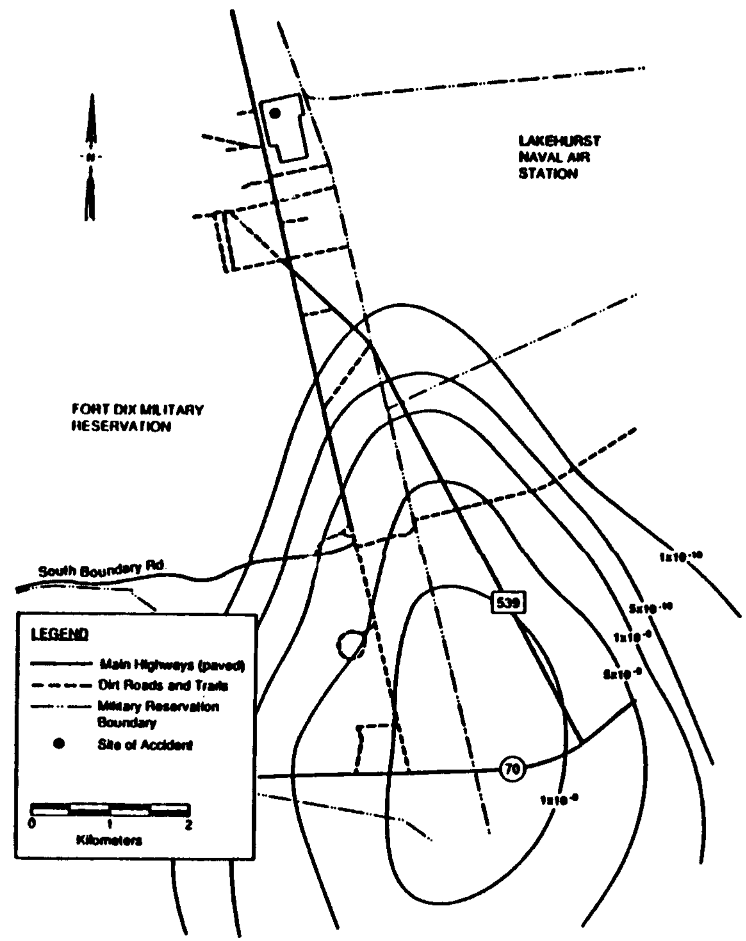

FIGURE 7b. Pu Deposition Pattern for a 1.0 Gram Release for 20 Micron Particles Using Constant Winds and a Release Height of 1800 m (g/m^2)

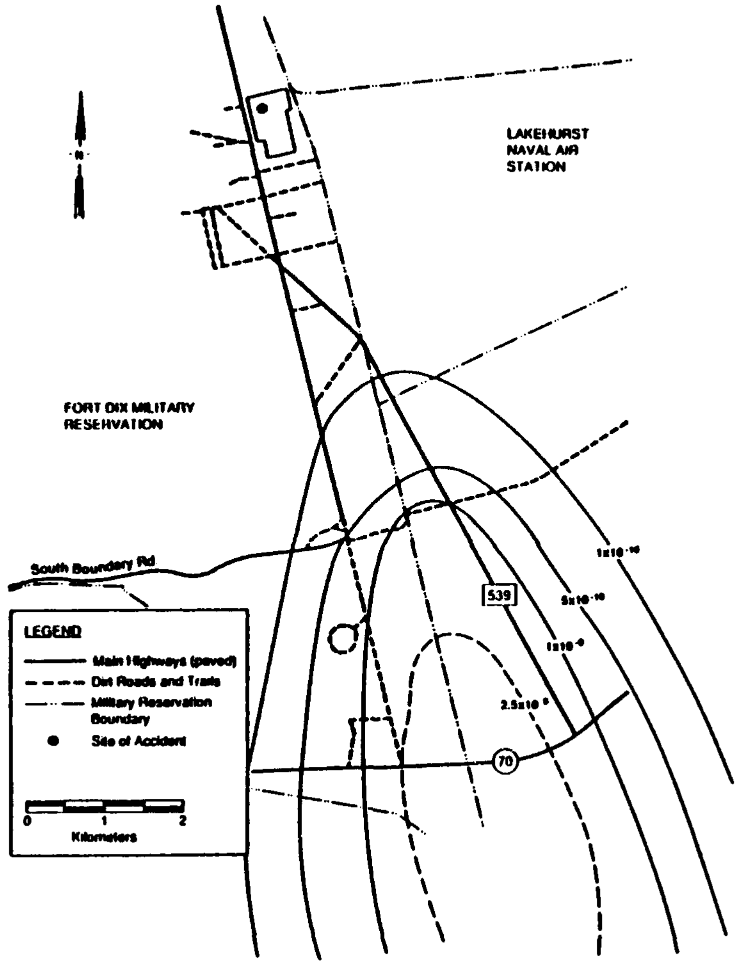

FIGURE 8a. Pu Deposition Pattern for a 1.0 Gram Release for 12 Micron Particles Using Time Varying Winds and a Release Height of 1800 m (g/m^2)

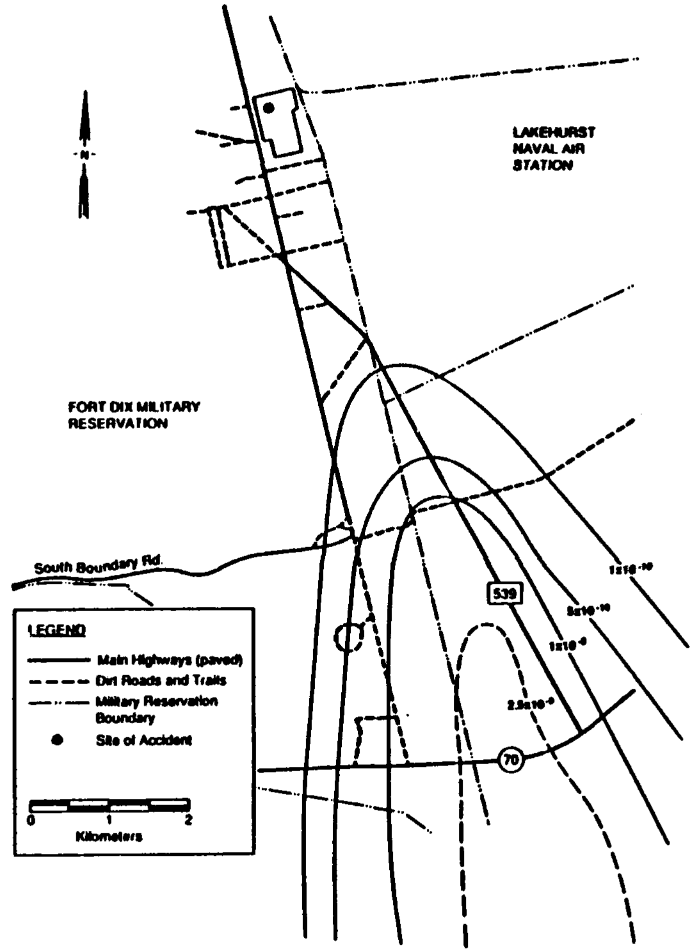

FIGURE 8b. Pu Deposition Pattern for a 1.0 Gram Release for 12 Micron Particles Using Constant Winds and a Release Height of 1800 m (g/m^2)

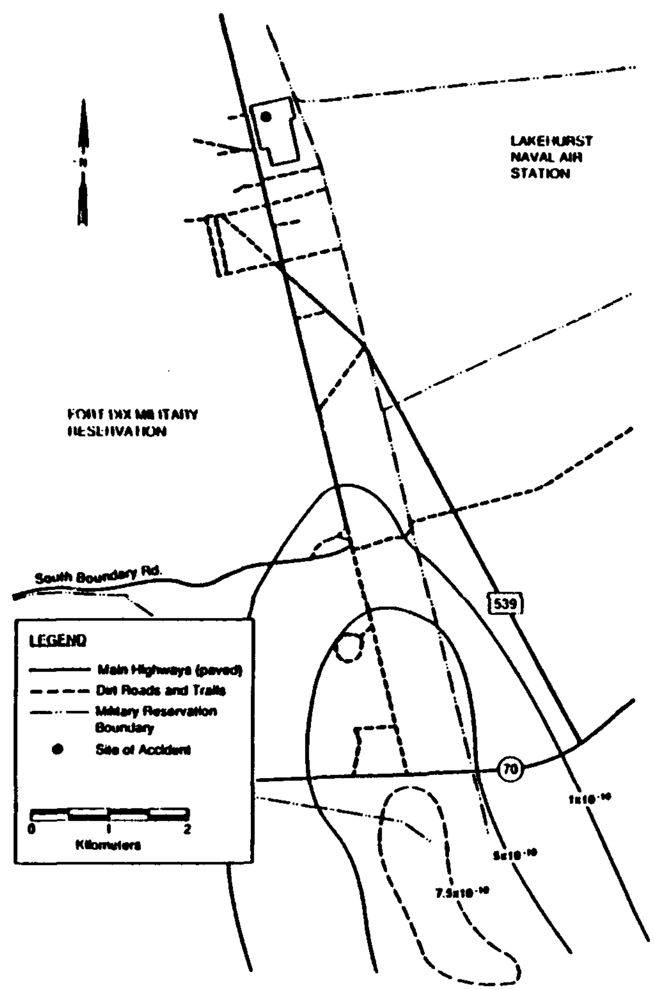

FIGURE 9a. Pu Deposition Pattern for a 1.0 Gram Release for <5 Micron Particles Using Time Varying Winds and a Release Height of 1800 m (g/m2)

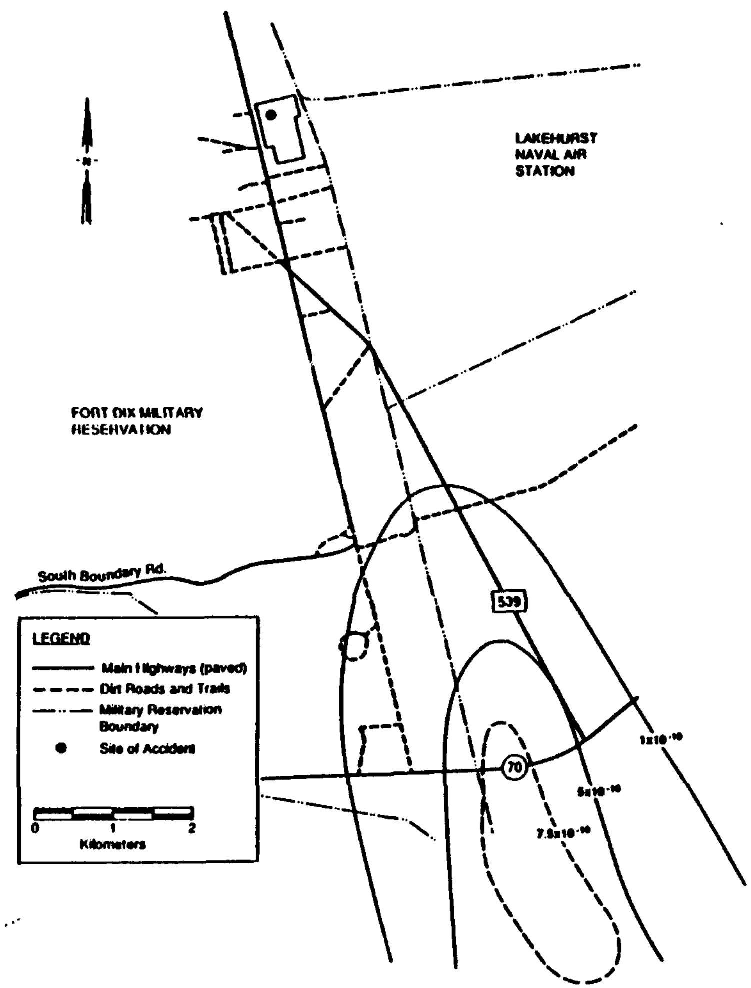

FIGURE 9b. Pu Deposition Pattern for a 1.0 Gram Release for <5 Micron Particles Using Constant Winds and a Release Height of 1800 m (g/m2)

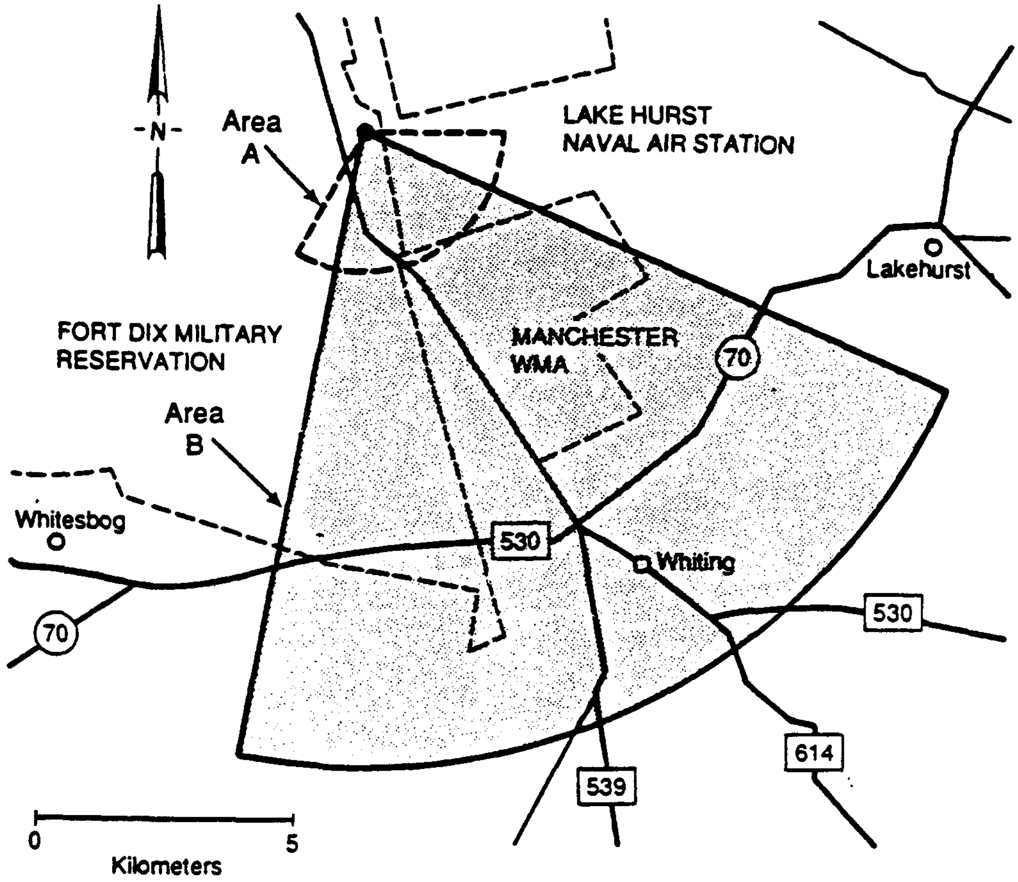

FIGURE 10. Proposed Sampling Area Based on Model Results

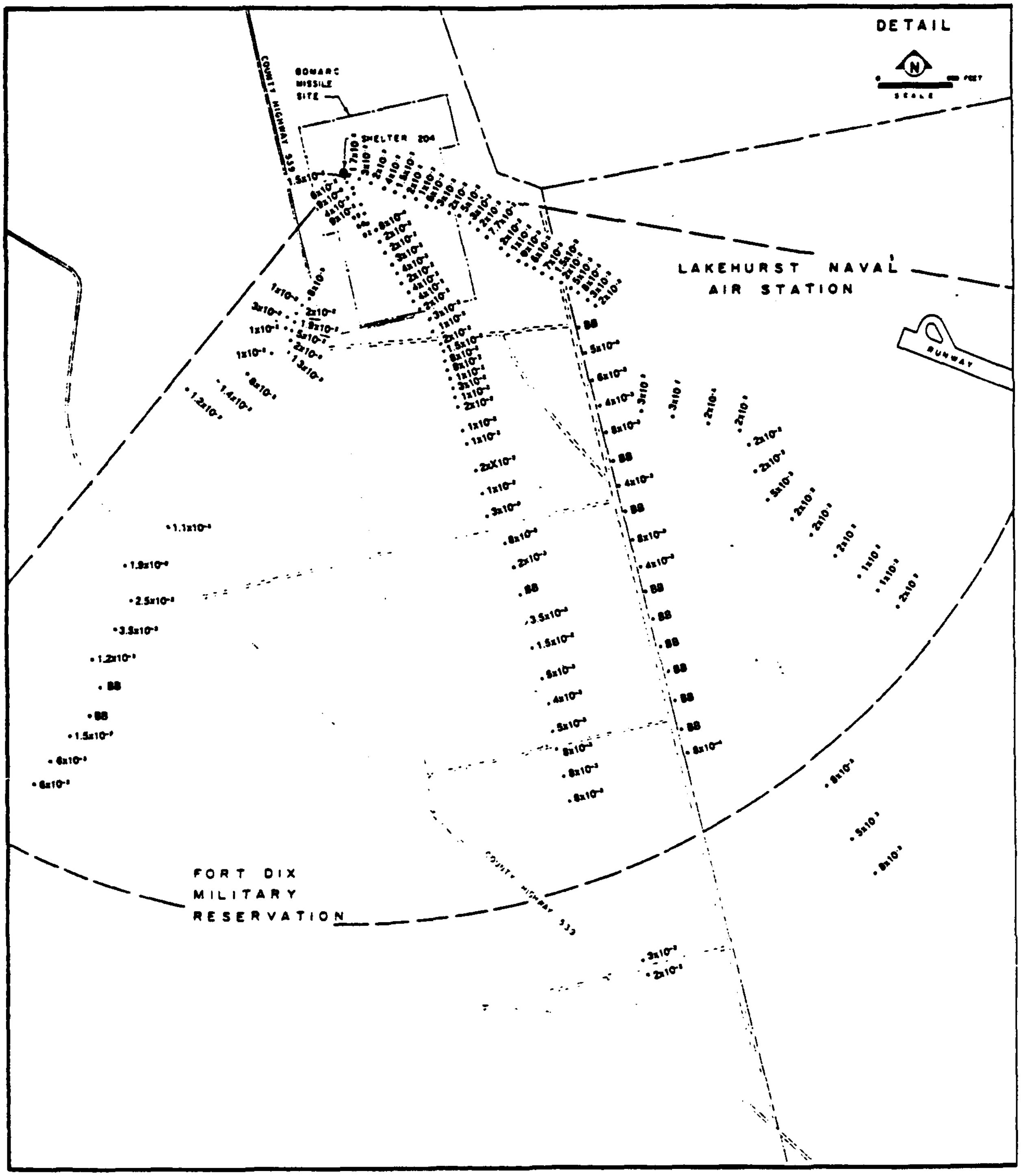

FIGURE 11. Sampling Results (µci/m2) (Area A; see Figure 10)

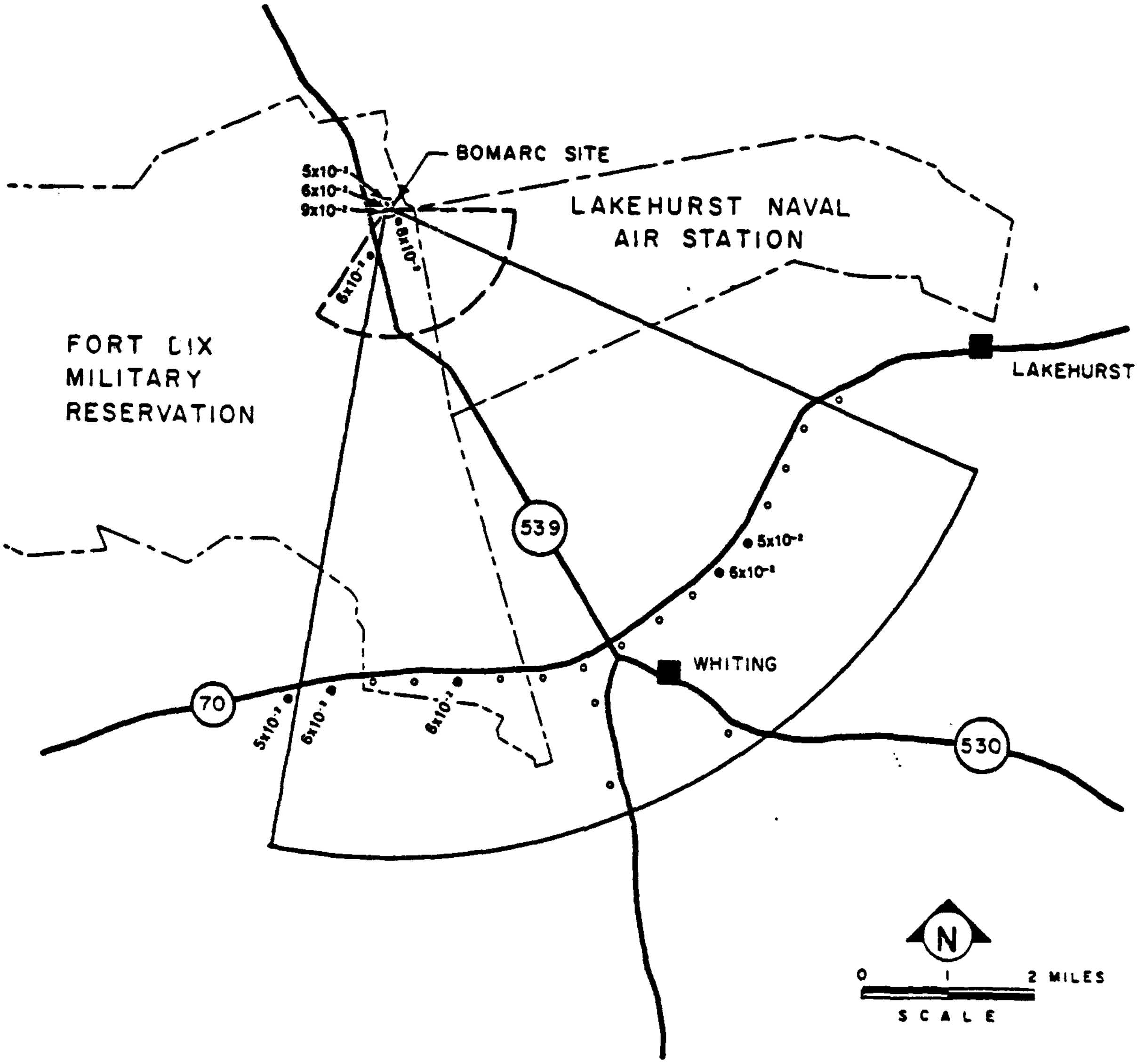

FIGURE 12. Samples with Values Approximately 1.6 Times Background (µci/m2)

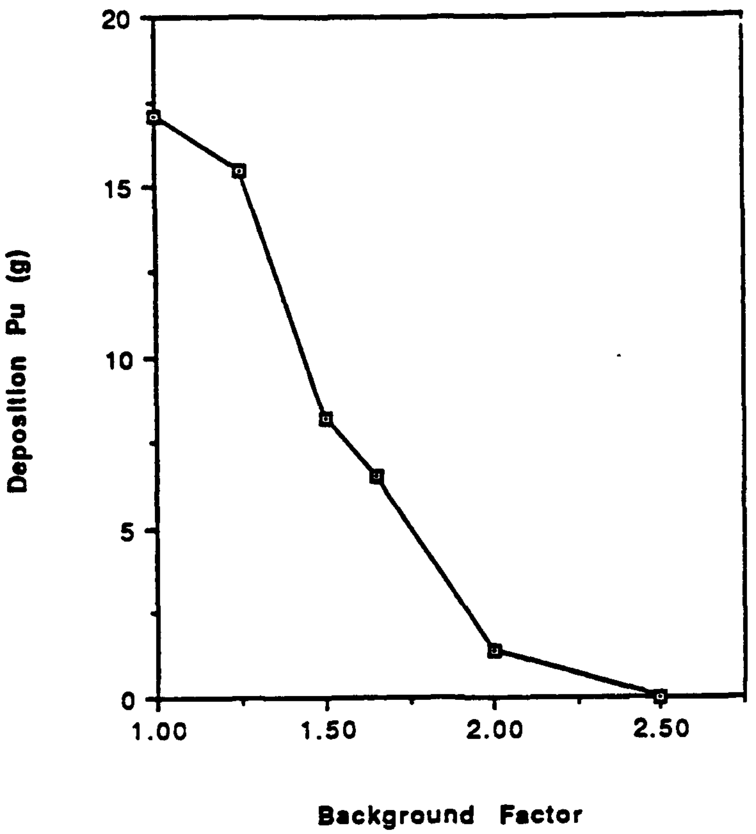

FIGURE 13. Pu Deposition Versus Background Factor

APPENDIX A

PROPOSED SCENARIO FOR BOMARC INCIDENT IN SHELTER 204, 6/7/60

FINAL DRAFT

Battelle
Pacific Northwest Laboratories

Project Number BOMARC

Internal Distribution

WE Davis K6-08
RR LaBarge K6-01
PJ Mellinger K5-11
EB Moore K6-55
File/LB

Date August 14, 1988

To Distribution

From Jofu Mishima, Source Term

Subject PROPOSED SCENARIO FOR BOMARC INCIDENT IN SHELTER 204, 6/7/60

INCIDENT

At approximately 1500 LST (3:00 P.M.), a fire was detected by sensors in shelter 204 at the BOMARC missile site adjacent to McGuire Air Force Base, New Jersey (Koshliek and Sherard 6/8/60). The shelter was unattended at the time (crew was not present) and the BOMARC (BOeing-Michigan Aeronautical Research Center) missile was in a "ready" state. Pumper 530B from the base (tanker with 30,000 gallons of water at 80 psi static and 40 psi residual pressure plus a crew of four) responded to the alarm within 3 to 5 minutes (Koshliek and Sherard 6/8/60). Approximately 100 lb of carbon dioxide in an extingui-sher was applied to control the fire by wedging the hose in the door prior to the order to evacuate due to the perceived hazards (Koshliek and Sherard 6/8/60). "The fire completely engulfed the warhead, causing it to melt and release Pu-239 to the floor of the shelter" (Young 11/22/72). (I do not know how this is inferred if no one was present. Furthermore, it is contrary to the normal physical behavior of plutonium metal to simply melt.) "After the fire died down, EOD (Explosive Ordinance Demolition)personnel went into the area to check it out. Firemen were cleared approx. 15 minutes later" (no exact times given)(Koshliek and Sherard 6/8/60). "Firemen proceeded to put water on the shelter trying to concentrate on warhead section. Time after time area was checked and each time firemen mover closer to shelter until a line could be brought into shelter (Koshliek and Sherard 6/8/60). The fire was brought under control by 1615 hr (Anon 6/27/60). " ... order to cease operations and leave lines charged and men returned to quarter (approx. 2000 hr). Approximately 30,000 gallons of water were used (Koshliek and Sherard 6/8/60).

The IM-99A missile 586950 (ADC 1060) and the high explosives were completely burned (Young 11/22/72. The 100 pounds of high explosives (HE) in the nuclear device did not explode but "cooked-off" (burned or, more descrip-tively, flared within a short period of time, seconds). Approximately 8,500 lb of fuel were onboard (IRFNA, ANPA, JPX, 80 octane gasoline)(Anon 6/27/60). 1.0 to 1.5 kg of plutonium were not recovered (Botts fax to Mishima 7/17/89).

BOMARC MISSILE
(Boeing Background Information sheet, March 1984)

The BOMARC (BOeing Michigan Aeronautical Research Center) supersonic IM-99 Interceptor Missile was a United States Air Force ground-to-air weapon designed to destroy attacking aircraft and missiles. The program was authorized in 1949. "The missiles were housed on a constant combat-ready basis in individual launcher-shelters. Upon receiving the alert signal the shelter roof slid back and the Bomarc was raised on its erector arm to its vertical launch position. The erector then descended and the missile was fired." The missile was initially launched by a rocket assist and propelled by two ramjet engines. Two versions were deployed - IM-99A (269 produced) and IM-99B (301 produced). "IM-99A was phased out of operations during 1964. The final IM-99B was produced in 1962. Bomarc B bases were located at ... McGuire AFB, New Jersey; ...".

The IM-99B specifications are:

Wing span	18 ft 2 in.
Overall length	45 ft
Height	10 ft 2 in.
Fuselage diameter	35 in.
Takeoff weight	~16,000 lb gross
Power	Solid rocket takeoff (Thiokol) 50,000 lb thrust; Two ramjet engines (Marquardt) 12,000 lb thrust each
Range	~400 miles

The IM-99A, involved in this incident, is similar to the IM-99B but used a liquid fueled (80 octane gasoline and fuming nitric acid) rocket assist. Use of a solid fuel rocket engine provide more space for the ramjet engine fuel extending the range of the IM-99B. (A photo of the missile ready to be launched is shown in Figure 1.)

ENCLOSURE

A sketch of the launcher-housing is shown in Figure 2. The area housing the missile is ~33 ft 2 in. wide by 60 ft 4 in. in long. Large sliding doors are found at both ends of the enclosure. The tail end of the missile projects over the "pit" area at the back end of the enclosure (see Figure 3) to allow the missile to be positioned for launch. Thus, most of the length of the missile containing the warhead would extend into the front portion of the enclosure that is slightly sloped towards the door. The forward portion of the enclosure in front of the pit is approximately 36 ft long and would normally be almost filled by the missile. The pit area is ~ 10 ft 5 in. wide by 23 ft 9 in. long and is 3 ft 7 in. deep. The surface area of the "pit" is 247 sq ft with a volume of 6600 gal. The roof is divided almost on the centerline of the missile and each half slides sideways towards the sides of the enclosure. The height of the missile is 10 ft 2 in and, at the "ready" condition, the missile would be elevated some distance above the floor of the enclosure. (An idea of the height the missile is above the floor can be obtained by reference to Figure 1 that shows the pivot point of the launcher is approximately at chest height to the personnel in the photo.)

POSTULATED SCENARIO

It is postulated that the failure of the high-pressure gas system ruptured the fuel line to the missile and released the liquid fuel (jet fuel and 80 octane gasoline plus fuming nitric acid)(Anon 8/27/60). The liquid fuel poured into the pit area where it ignited and burned, thereby displacing the rear portion of the roof over the "pit" area. It is postulated that the carbon dioxide and water used to combat the fire temporarily retarded the burning. During the initial fire-fighting efforts, some water is assumed to have entered the shelter and some may have collected in the "pit". The liquid fuel, which is immiscible although some water is adsorbed in the fluid, floated on the surface and continued to burn. This initial burning was confined to the tail portions of the missile. Other combustibles (e.g., papers, rags, wood, plastic) present in the enclosure were subsequently ignited.

It is postulated that the "muffled" explosions heard after approximately 15 min. (Young 11/22/72) were caused by the rapid burning of the high explosives in the warhead that was ignited by heat conducted through the metal portions of the missile and/or flames blown periodically in that direction. The rapid input of heat in a limited area resulted in the ignition of the plutonium and structural failure of members in the warhead section causing the nose of the missile to sag to the floor and releasing the ignited plutonium. (Plutonium is normally covered by a thin coating of non-radioactive metal to reduce the spread of contamination during handling. That coating is assumed to have melted or failed during the intense heat of the high explosive "cook-off".) Ignited plutonium looks like burning coal without the visible flames (Felt 1967, Figure 3, front piece). Owing to the high temperature from the heat of oxidation, the metal in the interior is molten. Periodically, the volume expansion of the oxide crust (which resembles slag) and internal pressure from the volume expansion of the molten metal caused cracks in the surface allowing molten plutonium to flow like lava down the mound of plutonium oxide. Water overflowing from the "pit" would flow down the slight incline to the front doors and may or may not have carried burning liquid fuel floating on its surface. The high temperature of the molten plutonium-oxide pile would cause the water near the surface to form steam providing a barrier separating the molten plutonium-oxide pile from liquid water and reducing heat loss from the mass. Based upon experimental observations with large plutonium billets (Mishima 1966, Table II, p. 13) and the large surface-to-volume ratio of the plutonium shape present, all the metal is assumed to have oxidized within 1 hour.

SOURCE TERMS

Two types of source terms are necessary to understand the atmospheric dispersion of plutonium oxide particles resulting from the fire: 1) radiological and 2) heat. The radiological source term covers the fraction of the plutonium that may be released to the air with time and the particle size distribution of the material released. The mass release rate of the oxide generated is required to define the material released to the fire plume with time. The mass of the plutonium dioxide particles in each size fraction must be known to determine the behavior of the material once it is released to the ambient atmosphere. The heat source term defines the heat energy released to the fire plume and it is used to determine the buoyancy of the plume. The buoyancy of the plume determines the height the plume may achieve before being affected by the local meteorological conditions. The height at which the particles are released to the ambient atmosphere determines, along with the local meteorological conditions, the distance and direction the released plutonium dioxide particles will travel and when they may be deposited on the ground or vegetation. The next two sections will discuss the two source terms separately since they will be used at separate points in the dispersion and transport calculations.

- Radiological Source Term

The fraction of plutonium made airborne as a consequence of a fire is dependent upon a variety of factors - oxidation rate, oxidation conditions, local airflow, etc. Several experiments have been conducted to measure the plutonium made airborne during oxidation and, in one case, the size distribution of the particles collected. Stewart (Mishima 1964, p 8) based upon laboratory and field experiments (200-g pieces of plutonium metal were suspended in a chimney over a burning pool of gasoline) determined that an airborne release fraction of 0.05 wt % bound most releases from ignited, oxidizing plutonium metal. Mishima (1965, 1966) measured the airborne release of plutonium from ignited metal in flowing air. Releases in the 0.001 to 0.0001 wt % range were measured for the small pieces at airflow velocities that ranged from 3.3 TO 50 cm/sec (Mishima 1965, Table III, p. 13). For pieces ranging from 455.5 g to 1770 g lying on a horizontal surface, airborne releases of 0.00039 to 0.049 wt % were measured at airflow velocities in the collection hood of 525 cm/sec. The Mass Median Diameter (using Projected Diameter) was measured at 4.2 micrometers (Mishima 1965, Figure 5, p. 11), a value that agrees with the size distribution suggested by Stewart based upon laboratory experiments on plutonium metal (1963, Figure 10, p. 564). The size distribution of the airborne particles from one experiment (using Scanning Electron Microscopy) is shown in Figure 4.

The Aerodynamic Equivalent Diameter of airborne particulate materials defines their transport characteristics and the fraction that can be deposited in the lungs. The density of plutonium dioxide is 11.46 g/cu cm and the Aerodynamic Equivalent Diameter of a 4.2 um Projected Diameter particle is approximately 14 um. Based upon laboratory measurements, Carter and Stewart (1970, Table IV, p. 835) reported a fractional airborne release of 0.01 wt % for particles 10 um and less from ignition and burning of plutonium, 1.0 wt % from melting and from partial disruption of liquid metal droplets. Additional data on the fractional airborne release of plutonium is given by Chatfield (1968).

The conditions found during the BOMARC fire are most similar to those described in Stewart's outdoor experiments with the exception of the presence of water and perhaps more turbulent local conditions. Mishima's measurements were performed on masses approaching those considered here. Both indicate that the fractional airborne release during the course of the event for plutonium dioxide particles that could be suspended is in the range of 0.05 wt. %. The local turbulence could result in higher local suspension from the suspension of large particles that would fall out in the enclosure or be lost rapidly.

Therefore, it is assumed that 0.05 wt. % of the plutonium involved is suspended and carried in the plume from the fire. The total mass of plutonium is not known. Assuming masses of 1, 5, 10 and 15 kg, the fractional airborne releases would be 0.5 g, 2.5 g, 5.0 g and 7.5 g of plutonium as dioxide over the course of the event, respectively.

Owing to the uncertainty of the oxidation rates during this event (the oxidation rate is a function of the type of metal, the surface area oxidizing, the air carried to the interface of the metal and oxide adhering to the metal, etc.), it is further assumed that the release rate is linear from 1515 LST to 1615 LST. Therefore, the release rates are 0.0083 g Pu/min, 0.042 g Pu/min, 0.083 g Pu/min, and 0.125 g Pu/min, respectively.

The size distribution reported by Mishima (1965, Figure 5, p. 11) shown in Figure 4 is also assumed.

- <u>Heat Source Term</u>

The heat generated from the fire is dependent upon the materials burned (e.g., liquid combustibles, solid combustibles), their heats of combustion, the burning efficiencies, etc. Many of these factors cannot be determined for the conditions during this incident. The convective heat generated during the portion of the fire during which plutonium particles are assumed to be released

(1515 to 1615 LST) will be estimated for this scenario based upon known information and engineering judgement.

The fuels present (e.g. jet fuel, 80 octane gasoline) are assumed to be only located in the fuel tanks toward the tail section of the missile. The initial release is assumed to vaporize some quantity of fuel resulting in a "fire ball" commonly observed in fires involving the rapid release of liquid combustible fuels. The remainder of the fuel is assumed to fall to the bottom of the "pit" and burn at that location. The surface area of the "pit" is approximately 247 sq ft. requiring 1851 gallons of fuel to fill the pit to a level of 1 ft. Burning fuel does not spread to the same distance as unignited fuel owing to the increased surface tension created by the evaporation of fuel from the surface. A portion of the heat from the flames radiates back to the surface of the liquid, evaporating fuel that entrains air along its edges as it rises. When the fuel-air mixture is combustible, the mixture is ignited by the flames anchored at that location. If the conditions are such that the fuel-air mixture cannot ignite owing to lack of oxygen, the flames could anchor at an opening where oxygen is available (e.g., the open portion of the roof of the enclosure). If wind velocity displaces or obstructions shield the flame from the liquid pool, lesser quantities of heat are radiated to the surface, reducing the burning rate. The attempt to extinguish the fire with carbon dioxide probably retarded the fire, diminishing the fuel consumption and heat generation rates. The presence of water in the pit also has a similar effect by cooling the fuel reducing evaporation, and by water absorbed in the liquids that increases the heat required to vaporize the fuel. The presence of a water vapor and mist in the shelter atmosphere reduces the radiant heat transfer to the surface. Only a portion of the heat generated by the burning goes into radiant heat, and the remainder can be transferred by conduction or convection (used to heat the air). Tewarson (1980) provides factors for the division of heat into various mechanisms and burning efficiencies. Other mechanisms (e.g., incomplete conversion, cracking of molecules, conversion of nitrogen in air into oxides of nitrogen) can also reduce the heat transferred. The convective heat transfer is an important parameter in defining plume buoyancy.

The amount of other combustible materials present (e.g., papers, rags, wood, oils/greases, plastics) is not known but combustion of other materials would also contribute to the heat generation after the first few minutes.

If we assume that 1000 gallons of jet fuel (similar in behavior to kerosene) and 1000 gallons of 80 octane gasoline were present, the heat generation from these materials during the period of interest could be estimated by assuming:

- 5% of the more volatile fuel (80 octane gasoline) were vaporized and burned during the initial "fire ball" portion of the fire.
- the vaporization rate from a standing pool for gasoline is approximately 6 to 12 inches per hour and 5 to 8 inches per hour for kerosine (NFPA 1976, p 3-25, **Burning Rates of Liquids**). Assume the more volatile fraction (gasoline) is evaporated first.
- the vaporization rate after 1515 LST is reduced to one half the normal rate by the fire-fighting efforts.

The volume of the "pit" is 6600 gallons. The total volume of fuel (2000 gallons) would fill the "pit" to 0.303 its' capacity [a depth of approximately 1 ft, half (6 in.) gasoline and half (6 in.) kerosene]. The fraction of the fuels consumed during the first 15 min of the fire are:

- 5% (50 gallons) of gasoline (during the "fire ball"); and,
- half of the remaining 95% (950/2 gallons = 475 gallons) of gasoline.

The remaining gasoline (approximately 475 gallons) are consumed in 30 min at the reduced rate indicated above. A quarter of the kerosine (jet fuel) is consumed in the remaining 30 min of the period of concern. A nominal heat of combustion of organic fuels is approximately 20,000 Btu/lb (5040 kg-cal). The density of liquid organic fuels is approximately 6 lb/gal. At a burning rate of (475 gal/30 min =) 15.83 gallons/min (X 6 pounds/gallon =) 95 lb of fuel per min are burned generating 1.9 X 10E+6 Btu/min over the first 30 minutes of the period.

Over the second 30 min of the period (1545 to 1615 LST), kerosene is burning at the rate of (250 gal/30 min =) 8.33 gal/min generating (8.33 gal/min X 6 pounds/gallon X 20,000 Btu/pound =) 10E+6 Btu/min.

Tewarson (1980, Table 2, p. 27) found the combustion efficiencies for solid, non-aromatic combustibles ranged from 0.35 to 0.99, the convective heat transfer coefficient ranged from 0.17 to 0.76, and the radiative heat coefficient ranged from 0.14 to 0.53. Although determined for solid materials, it is believed that the coefficients can also be applied to liquid pool fires. Given a convective heat transfer coefficient of 0.25, the convective heat energy generation rates would be 4.75 X 10E+5 Btu/min from 1515 to 1545 LST and 2.5 X 10 E+5 Btu/min from 1545 to 1615 LST. If a convective heat transfer coefficient of 0.75 is assumed, the convective heat generation rate would be 1.43 X 10E+6 Btu/min from 1515 to 1545 LST and 7.5 X 10E+5 Btu/min for the remainder of the period.

The quantity of other combustible fuels burned during the event cannot be estimated with the information currently available. It is presumed, owing to the higher burning rates of the liquid fuels, that any contribution from other fuels would not substantially increase the energy generation conservatively estimated here. The other fuels may have extended the total time of burning.

UNDEFINED PARAMETERS

1. Better definition of the sequence of events - How long did the fire burn uncontrolled? When was the liquid fuel all burned up? How long was water poured on the debris in the structure? Was the water directed into the enclosure sprayed on the debris or was the water directed upon certain objects?

2. What are the tank capacities for liquid fuel for the model present?

3. What amounts of other combustible materials were present?

4. The total amount of plutonium involved in the event?

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APPENDIX B

FIDLER SURVEY RESULTS

Appendix B contains the FIDLER survey results received from SAIC. The results include the raw counts per minute (cpm) along with the steps in subtracting out the background (81 cpm), the conversion to *disintegrations* per minute (dpm), the conversion to dpm/m^2, and finally the conversion to microcuries per m^2.

Background = 81 cpm

Sampler ID	Gross cpm	Net cpm	dpm	dpm/m2	µCi/m2
A1/A	102.00	21.00	4.81E2	3.80E4	1.71E-2
B2/B	92.00	11.00	2.52E2	1.99E4	8.96E-3
Soil(1)	96.67	15.67	3.59E2	2.83E4	1.28E-2
Soil(2)	106.00	25.00	5.73E2	4.52E4	2.04E-2
Soil(3)	115.33	34.33	7.87E2	6.21E4	2.80E-2
Soil(4)	125.33	44.33	6.02E3	8.02E4	3.61E-2
Soil(5)	128.67	47.67	1.09E3	8.62E4	3.88E-2
Soil(6)	115.33	34.33	7.87E2	6.21E4	2.80E-2
Soil(7)	112.00	31.00	7.10E2	5.61E4	2.52E-2
B-8	82.00	1.00	2.29E1	1.81E3	8.14E-4
B-9	112.67	31.67	7.25E2	5.73E4	2.58E-2
B-10	103.33	22.33	5.12E2	4.04E4	1.82E-2
B-11	115.33	34.33	7.87E2	6.21E4	2.80E-2
B-12	127.33	46.33	1.06E3	8.38E4	3.77E-2
B-13	108.67	27.67	6.34E2	5.00E4	2.25E-2
B-14	130.00	49.00	1.12E3	8.86E4	3.99E-2
B-15	124.67	43.67	1.00E3	7.90E4	3.56E-2
B-16	108.67	27.67	6.34E2	5.00E4	2.25E-2
B-17	112.67	31.67	7.25E2	5.73E4	2.58E-2
B-18	96.67	15.67	3.59E2	2.83E4	1.28E-2
B-19	106.67	25.67	5.88E2	4.64E4	2.09E-2
B-7	--	--	--	--	--
B-6	99.33	18.33	4.20E2	3.31E4	1.49E-2
B-5	186.00	105.00	2.41E3	1.90E5	8.55E-2
B-4	86.00	5.00	1.15E2	9.04E3	4.07E-3
A-2	122.00	41.00	9.39E2	7.41E4	3.34E-2
A-3	89.33	8.33	1.91E2	1.51E4	6.78E-3
A-4	106.00	25.00	5.73E2	4.52E4	2.05E-2
A-5	130.67	49.67	1.14E3	8.98E4	4.05E-2
A-6	99.33	18.33	4.10E2	3.31E4	1.49E-2
A-7	103.33	22.33	5.12E2	4.04E4	1.82E-2
A-8	117.33	36.33	8.32E2	6.57E4	2.96E-2
A-9	102.00	21.00	4.81E2	3.80E4	1.71E-2
A-10	95.33	14.33	3.28E2	2.59E4	1.17E-2

FINAL DRAFT

Sampler ID	Gross cpm	Net cpm	dpm	dpm/m2	µCi/m2
A-11	142.00	61.00	1.40E3	1.10E5	4.98E-2
A-12	123.33	42.33	9.70E2	7.65E4	3.45E-2
A-13	110.67	29.67	6.80E2	5.36E4	2.42E-2
A-14	175.33	94.33	2.16E3	1.71E5	7.68E-2
A-15	102.67	21.67	4.96E2	3.92E5	1.76E-2
A-16	92.67	11.67	2.67E2	2.11E4	9.50E-3
A-17	92.00	11.00	2.52E2	1.99E4	8.96E-3
A-18	88.67	7.67	1.76E2	1.39E4	6.24E-3
A-19	90.00	9.00	2.06E2	1.63E4	7.33E-3
A-20	99.33	18.33	4.20E2	3.31E4	1.49E-2
A-21	101.33	20.33	4.66E2	3.68E4	1.66E-2
A-22	87.33	6.33	1.45E2	1.15E4	5.16E-3
A-23	82.00	1.00	2.29E1	1.81E3	2.14E-4
A-24	114.67	33.66	7.71E2	6.09E4	2.74E-2
A-25	108.00	27.00	6.19E2	4.88E4	2.20E-2
A-26	112.00	31.00	7.10E2	5.61E4	2.52E-2
B-20	97.33	16.33	3.74E2	2.95E4	1.33E-2
B-21	91.33	10.33	2.37E2	1.87E4	8.42E-3
B-22	94.00	13.00	2.98E2	2.35E4	1.06E-2
B-23	90.67	9.67	2.21E2	1.75E4	7.87E-3
B-24	114.67	33.66	7.71E2	6.09E4	2.74E-2
B-25	100.67	19.67	4.51E2	3.56E4	1.60E-2
B-26	107.33	26.33	6.03E2	4.76E4	2.14E-2
B-27	97.33	16.33	3.74E2	2.95E4	1.33E-2
B-28	95.33	14.33	3.28E2	2.59E4	1.17E-2
B-29	107.33	26.33	6.03E2	4.76E4	2.14E-2
B-30	94.67	13.67	3.13E2	2.47E4	1.11E-2
B-31	85.33	4.33	9.93E1	7.84E3	3.53E-3
B-32	91.33	10.33	2.37E2	1.87E4	8.42E-3
B-33	90.00	9.00	2.06E2	1.63E4	7.33E-3
B-34	79.00	--	--	--	--
B-35	85.33	4.33	9.93E1	7.84E3	3.53E-3
B-36	101.33	20.33	4.66E2	3.68E4	1.66E-2
B-37	88.00	7.00	1.60E2	1.27E4	5.70E-3
B-38	86.67	5.67	1.30E2	1.02E4	9.62E-3
B-39	90.67	9.67	2.21E2	1.75E4	7.87E-3
B-40	91.33	10.33	2.37E2	1.87E4	8.42E-3
B-41	90.67	9.67	2.21E2	1.75E4	7.87E-3
B-42	114.00	33.00	7.56E2	5.97E4	2.69E-2
B-43	104.67	23.67	5.42E2	4.28E4	1.93E-2

Sampler ID	Gross cpm	Net cpm	dpm	dpm/m2	µCi/m2
C-1	91.33	10.33	2.37E2	1.87E4	8.42E-3
C-2	102.00	21.00	4.81E2	3.80E4	1.71E-2
C-3	98.00	17.00	3.89E2	3.07E4	1.38E-2
C-4	104.67	23.67	5.42E2	4.28E4	1.93E-2
C-5	117.33	36.33	8.32E2	6.57E4	2.96E-2
C-6	97.33	16.33	3.74E2	2.95E4	1.33E-2
C-7	148.67	67.67	1.55E3	1.22E5	5.51E-2
C-8	107.33	26.33	6.03E2	4.76E4	2.14E-2
C-9	95.33	14.33	3.28E2	2.59E4	1.17E-2
C10	96.00	15.00	3.44E2	2.71E4	1.22E-2
C-24	88.67	7.67	1.76E2	1.39E4	6.24E-3
C-23	88.67	7.67	1.76E2	1.39E4	6.24E-3
C-22	100.00	19.00	4.35E2	3.44E4	1.55E-2
C-21	74.00	--	--	--	--
C-26	73.00	--	--	--	--
C-19	95.33	14.33	3.28E2	2.59E4	1.17E-2
C-18	85.33	4.33	9.92E1	7.84E3	3.53E-3
C-17	113.33	32.33	7.41E2	5.85E4	2.63E-2
C-16	105.33	24.33	5.57E2	4.40E4	1.98E-2
C-15	94.00	13.00	2.98E2	2.35E4	1.06E-2
C-11	97.33	16.33	3.74E2	2.95E4	1.33E-2
C-12	92.00	11.00	2.52E2	1.99E4	8.96E-3
C-13	98.67	17.67	4.05E2	3.19E4	1.44E-2
C-14	95.33	14.33	3.28E2	2.59E4	1.17E-2
A-27	82.00	1.00	2.29E1	1.81E3	8.14E-4
A-28	87.33	6.33	1.45E2	1.15E4	5.16E-3
A-29	88.67	7.67	1.76E2	1.39E4	6.24E-3
A-30	86.67	5.67	1.30E2	1.02E4	4.62E-3
A-31	92.00	11.00	2.52E2	1.99E4	8.96E-3
A-32	79.00	--	--	--	--
A-33	85.33	4.33	9.92E1	7.84E3	3.53E-3
A-34	76.67	--	--	--	--
A-35	90.67	9.67	2.21E2	175E4	7.87E-3
A-36	86.00	5.00	1.15E2	9.04E3	4.07E-3
A-37	77.33	--	--	--	--
A-38	74.67	--	--	--	--
A-39	75.33	--	--	--	--
A-40	80.00	--	--	--	--
A-41	70.00	--	--	--	--
A-42	76.00	--	--	--	--
A-43	82.00	1.00	2.29E1	1.81E3	8.14E-4

 FINAL DRAFT

Sampler ID	Gross cpm	Net cpm	dpm	dpm/m^2	µCi/m^2
D-1	135.33	54.33	1.24E3	9.82E4	4.43E-2
D-2	120.00	39.00	8.93E2	7.05E4	3.18E-2
D-3	108.00	27.00	6.19E2	4.88E4	2.20E-2
D-4	140.00	59.00	1.35E3	1.07E5	4.81E-2
D-5	160.00	79.00	1.81E3	1.43E5	6.43E-2
D-6	115.33	34.33	7.86E2	6.21E4	2.80E-2
D-7	104.67	23.67	5.42E2	4.28E4	1.93E-2
D-8	107.33	26.33	6.03E2	4.76E4	2.14E-2
D-9	110.67	29.67	6.80E2	5.36E4	2.42E-2
D-10	104.00	23.00	5.27E2	4.16E4	1.87E-2
D-11	111.33	30.33	6.95E2	5.36E4	2.47E-2
D-12	103.33	22.33	5.12E2	4.04E4	1.82E-2
D-13	156.00	75.00	1.72E3	1.36E5	6.11E-2
D-14	125.33	44.33	1.02E3	8.02E4	3.61E-2
D-15	112.00	31.00	7.10E2	5.61E4	2.52E-2
D-16	157.33	76.33	1.75E3	1.38E5	6.22E-2
D-17	139.33	58.33	1.34E3	1.06E5	4.76E-2
D-18	114.00	33.00	7.56E2	5.97E4	2.69E-2
D-19	120.00	39.00	8.93E2	7.05E4	3.18E-2
D-20	112.67	31.67	7.25E2	5.73E4	2.58E-2
A-44	90.67	9.67	2.21E2	1.75E4	7.87E-3
A-45	88.00	7.00	1.60E2	1.27E4	5.70E-3
A-46	86.67	5.67	1.30E2	1.02E4	4.62E-3
A-47	104.67	23.67	5.42E2	4.28E4	1.93E-2
A-48	95.33	14.33	3.28E2	2.59E4	1.17E-2
A-49	97.33	16.33	3.74E2	2.95E4	1.33E-2
A-50	105.33	24.33	5.57E2	4.40E4	1.98E-2
A-51	100.00	19.00	4.35E2	3.44E4	1.55E-2
A-52	103.33	22.33	5.12E2	4.04E4	1.82E-2

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APPENDIX I

LINEAR REGRESSION ANALYSIS OF SITE SOIL SAMPLES

During the course of the BOMARC remedial investigation, EPA Region II exercised oversight of field activities, and obtained split samples of environmental media (soil, surface water, groundwater) to verify the results of the Air Force contractor laboratory radioanalysis. Due to the non-uniform distribution of plutonium in discrete particles within site soils, collection of split soil samples by the EPA field oversight contractor presented technical problems.

Both the Air Force and EPA believed that it would be impossible to obtain split samples in the field with approximately equal concentrations of plutonium, due to the non-uniform distribution of plutonium in site soils. Both parties agreed that if a soil sample was to be split in the field, it was likely that one half of the sample would contain the bulk of any plutonium present, and the other half would contain substantially less plutonium, due to the occurrence of plutonium in discreet particles. Since the purpose of split sample analysis by the EPA was to perform a quality control check on the Air Force contractor laboratory, the analysis of split samples containing unequal portions of analyte was considered essentially useless, because analytical results for split samples would not be comparable.

In an attempt to solve this problem, EPA proposed to use a customized sample preparation scheme to generate split samples with equivalent concentrations of plutonium. Under EPA's proposed sample preparation scheme, samples would not be split in the field, but would be shipped to an EPA laboratory for processing. There the samples would be mechanically pulverized so that soil particles were less than one micron in diameter, and homogenized so that pulverized plutonium particles would theoretically be equally distributed in the sample. The samples would then be split, with one-half of the sample returned to the Air Force contractor laboratory for analysis, and the remaining half being analyzed by the EPA laboratory. Using this scheme, EPA hoped to obtain split samples with equivalent concentrations of plutonium.

EPA took possession of nineteen soil samples generated by the Air Force RI/FS contractors. EPA intended to process the samples as described above, and return half of each sample to the Air Force contractor laboratory for analysis. However, subsequent to EPA taking possession of the soil samples, technical and institutional problems encountered by the EPA laboratory prevented processing and analysis of the samples, and the data points represented by the nineteen samples were lost.

All of the lost samples were screened in the field with a hyper-pure germanium detector prior to shipment offsite, and thirteen of the nineteen samples were also screened with a FIDLER instrument. While these field measurements are not considered as accurate as laboratory analysis by alpha spectroscopy, they do provide a close approximation of the actual level of radioactivity in the samples. Since some of the lost data points were considered critical to the RI/FS, EPA suggested that the best approach to including the lost samples in the RI/FS report would be to assign values for plutonium concentration to the lost samples based on linear regression analysis of existing data points. The Air Force agreed that short of obtaining actual analytical data, assigning values was a second best approach.

Using this approach, samples that were analyzed both in the field (FIDLER and hyper-pure germanium detector surveys) and in the laboratory were analyzed to determine the degree of correlation between field analytical values and laboratory analytical values generated using alpha spectroscopy. Preliminary analysis indicated that there was better correlation between the FIDLER measurements and laboratory data than between hyper-pure germanium detector surveys and laboratory data. Therefore, linear regression analysis was performed using FIDLER readings and corresponding alpha spectroscopy data generated for the same samples.

A population consisting of fourteen soil samples was selected for analysis. This population included all soil samples for which laboratory alpha spectroscopy analysis was performed and for which the FIDLER detector registered above-background readings in the field.

A relationship of the form:

Pu-239 activity = a (C/M)**b

was suspected to describe the relationship between C/M and Pu-239 activity, where:

1. Pu-239 activity is in picoCuries per gram (pCi/g), dry weight.

2. C/M is the FIDLER reading in counts per minute. This activity was corrected to background by deducting 90 counts per minute from readings.

3. a, b are constants to describe in the equation

The data were first plotted on log-log graph paper to observe qualitatively if a relationship existed. As a result, it was decided to use this equation to describe activities greater than 1 pCi/g. That is, the equation will not accurately describe activities less than 1 pCi/g and should not be used for that purpose.

A Hewlett-Packard statistical program was used to obtain curve fitting statistics for the BOMARC data. The fitted curve is a least-squares description of the best line which fits the data. The data are presented for 14 samples in Table 1. Three of the data points were not used since the associated activities were less than 1 pCi/g. The statistics were as follows:

a = .2299

b = .5970

r^2 = .8098 (coefficient of correlation)

Thus, the equation used to predict Pu-239 activity from the adjusted FIDLER counts is:

Pu-239 activity = .2299 (C/M)**.5970

The r^2 value of .8098 describes a fit that is reasonable, but not exact. The second column from the right on Table 1 presents predicted values from the equation for the C/M given. In some cases, the values are close; in others, they are quite different. For the values presented, the average percent difference is plus 27 percent. Thus, the equation, on the average, over-predicts values by a factor of 27 percent.

The equation above was used to predict plutonium activity for those samples in possession of EPA that had FIDLER readings above background. Of the nineteen samples in possession of EPA, eleven had FIDLER readings above background. As agreed by EPA and the Air Force, the remaining eight samples, which had either no FIDLER data or FIDLER readings close to background, were assigned values of zero for purposes of the RI/FS report.

Table 2 gives predicted plutonium activity for those samples in possession of EPA which did not undergo laboratory analysis. These assigned values are used in the RI/FS report as necessary, and wherever they appear, it is noted that the values were assigned rather than derived by laboratory analysis.

TABLE 2

LINEAR REGRESSION ANALYSIS

Data Generated:

Sample #	FIDLER Data Corrected c/m	Predicted Activity (pCi/g)
001-SL-B03-001	1750	19.8
001-SL-B04-001	2270	23.2
001-SL-B07-001	41,310	131
001-SL-B09-001	29,710	107.6
001-SL-B15-001	19,060	21.2
001-SL-IS1-055	88	3.3
001-SS-B25-002	110	3.8
001-SS-B10-002	40	2.0
001-SS-B14-002	20	1.4
001-SL-IS1-021	37	2.0
001-SL-IS1-056	29	1.7

Note: All other samples were either near background or had no FIDLER data, and were therefore assigned a value of zero.

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TABLE 1

LINEAR REGRESSION ANALYSIS

Data Used:

Sample #	FIDLER Data Corrected C/M	Activity (pCi/g)	Predicted Activity pCi/g)	Percent Difference
001-SL-B01-001	391	3.3	8.1	145
001-SL-B05-001	7130	17	45.9	170
001-SL-B06-001	2090	51	22	-57
001-SL-B08-001	43610	240	135	-44
001-SL-B11-001	110	1.8	3.8	111
001-SL-B12-001	13	1.0	1.1	10
001-SL-B13-001	662	18	11	-39
001-SL-B14-001	9410	63	54	-14
001-SL-B18-001	26	.08	--	--
001-SL-B19-001	113	2.3	3.9	70
001-SL-B21-001	21	.017	--	--
001-SL-B22-001	28	.34	--	--
001-SL-B23-001	20	5.1	1.4	-73
001-SL-B25-001	144	3.9	4.5	15
			Avg.	27

C/M = counts per minute
pCi/g = picoCuries per gram
r^2 = .8098
a = .2299
b = .5970
Pu 239 (pCi/gm) = $.2299(c/m)^{.5970}$

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APPENDIX J

BASELINE RADIOLOGICAL HAZARD ASSESSMENT:

METHODS USED TO ASSESS POTENTIAL RADIOLOGICAL IMPACTS

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1.0 INTRODUCTION

This appendix was prepared to support the analysis provided in the Baseline Risk Assessment of the Remedial Investigation/Feasibility Study (RI/FS). The objective of the appendix is to supplement the RI/FS by providing the reader with information to augment and support the analysis provided in the RI/FS.

Section 1 of this Appendix provides a brief background to information concerning radiological dose and risk associated with plutonium, as well as modeling uncertainties. Section 2 contains a discussion of the mechanisms by which radioactivity could potentially be released to the surrounding environment from the Boeing Missile Aeronautical Research Center (BOMARC) Missile Site, and the methods for assessing radiation dose from these releases are discussed in Section 3.

Assessment of potential radiological impacts requires the use of computerized models to describe the site conditions, the movement of radioactivity, the effect of human activities, and the resulting radiation doses. The models chosen for this assessment are designed specifically for situations such as those occurring at the BOMARC Missile Site. They include all site characteristics and exposure pathways relevant to sites with surface soils that are contaminated with radioactivity, including transuranic radionuclides. Potential off-site population doses have been evaluated using the GENII computer code as discussed in Section 3.1 of this Appendix. Doses to potential on-site intruders have been evaluated using the RESRAD code as discussed in Section 3.2.

These models require, as input, parameters that describe a variety of site characteristics. For this assessment, values specific to the BOMARC Missile Site have been used wherever possible. Where site-specific data are not available the default values have been used. These default values have been provided by the developers of the models after extensive review of the environmental literature. They represent generic conditions and are intended to be conservative, that is, they tend to over-estimate potential radiation dose.

In order to assess the potential impacts from the baseline conditions at the BOMARC Missile Site, many assumptions were made in order to model processes at the site. The assumptions are based on site-specific characteristics to the extent possible. However, some assumptions are generic, and, in order to bound potential impacts, most assumptions are conservative (i.e., tend to maximize any detriment). Some of the uncertainties in dose and risk assessments are discussed in this Appendix (Section 1.3). The modeling assumptions made in this assessment are intended only for the purposes of the Baseline radiological assessment of the BOMARC RI/FS.

1.1 Radiological Hazards Associated with Plutonium and Americium

In general, the calculation of radiation doses to an individual is based on the exposure pathways by which each radionuclide causes irradiation. Four pathways are considered in this analysis:

1. External exposure from immersion in a radioactive cloud.
2. External exposure from radioactive material on the ground.

3. Internal dose from inhalation of radioactive material.
4. Internal dose from ingestion of contaminated foods, soil, and water.

To present a significant hazard from external exposure, a radionuclide must emit penetrating radiation in the form of a photon or energetic beta particle. Among the radionuclides of concern at the BOMARC Missile Site, only Am-241 has a photon emission sufficient to pose a potential external exposure hazard.

Internal dose from ingestion of contaminated food depends on the uptake of each radionuclide into foods and subsequent uptake by the human body. All actinides are poorly taken up by plants, animals, and people. Consequently, while some potential exists for radiation dose from ingestion of contaminated food, this is not the dominant pathway for plutonium and americium. Intake of contaminated groundwater is another potential source of radiological dose from plutonium. However, plutonium and americium are relatively insoluble in groundwater, and are not readily transported via groundwater movement. Finally, direct ingestion of contaminated soil is a potential source of radiological dose from plutonium. Ingestion of soil occurs more frequently with infants and children than with adults, but it can be an important dose contributor.

The pathway of primary concern for plutonium and americium is inhalation of contaminated particles. This is a consequence of three factors. First, these radionuclides are alpha particle emitters. Alpha particles have very short ranges in tissue and deposit their energy in small volumes. Second, the chemically inert actinide oxides remain in the lung for long periods of time. Finally, radioactive contamination at the BOMARC Missile Site exists in a form that is likely to produce respirable particles during clean-up activities.

1.2 Radiation Dose and Risk

The measure of radiological hazard calculated in this assessment is in 50-year integrated dose commitments reported in units of rem, often referred to as "dose" for brevity. These are calculated for each of several organs of the body for each radionuclide. Because different radionuclides irradiate different organs and tissues, a method that expresses the total radiation risk to an individual is used. The International Commission on Radiological Protection (ICRP) has developed a model to equate the sum of the doses received by individual organs and body tissues to a single index of risk, the effective dose equivalent (EDE). The ICRP models for organ committed dose equivalents and effective dose commitments (ICRP, 1977; ICRP, 1979) have been used to develop a set of dose conversion factors that relate: (1) concentration (in the air and on the ground) to external dose rates; and (2) intake (by inhalation and ingestion) to internal dose. These dose conversion factors are presented in Table 1-1.

Health effects resulting from low doses of radiation are of a statistical nature. Knowledge of the delayed effects of low doses of radiation is necessarily indirect, because the incidence is too low to be observed against the much higher background incidence of similar effects from other causes. Hence, a relationship between health effect and radiation dose can only be estimated, based on observations made at much higher exposure levels, where effects have been observed in humans, and on animals through carefully conducted experiments. In the range of doses under consideration for the BOMARC Missile Site the incidence of resulting health effects is

Table 1-1
Dose Conversion Factors for Plutonium and Americium

Radionuclide	Effective Dose Equivalent	Bone Surface	Liver	Lung
External Dose Conversion Factors[a]:				
Air immersion (mrem/yr per μCi/m^3)				
Pu-239	4.1×10^{-1}	4.0×10^{-1}	2.0×10^{-1}	2.4×10^{-1}
Am-241	9.5×10^{1}	1.3×10^{2}	6.2×10^{1}	6.9×10^{1}
Ground surface (mrem/yr per μCi/m^2)				
Pu-239	3.8×10^{-2}	1.5×10^{-2}	4.8×10^{-3}	8.9×10^{-3}
Am-241	3.0×10^{0}	3.7×10^{2}	1.8×10^{0}	2.0×10^{0}
Internal Dose Conversion Factors[b]:				
Inhalation (mrem/μCi)				
Pu-239	5.1×10^{5}	9.3×10^{6}	2.0×10^{6}	1.2×10^{6}
Am-241	5.2×10^{5}	9.3×10^{6}	2.0×10^{6}	1.2×10^{6}
Ingestion (mrem/μCi)				
Pu-239	4.3×10^{3}	7.8×10^{4}	1.6×10^{4}	0
Am-241	4.5×10^{3}	8.1×10^{4}	1.7×10^{4}	0

a. Source: DOE (1988a).
b. Source: DOE (1988b). Aerosol class or gastrointestinal tract uptake fraction yielding the highest dose per unit were used.

very small. There have been no direct measurements of increased cancer incidence rates for low-level radiation exposures. Consequently, these estimates are relevant only to the average collective dose received by large populations of individuals and not to estimates of doses to individuals.

Because expected releases of radioactive material from the BOMARC Missile Site would be small and the projected radiation dose to any individual is small, the only effects considered are long-delayed somatic (cellular) effects. Acute radiation effects require exposures many orders of magnitude greater than those projected for BOMARC Missile Site remediation. The delayed effects considered in this assessment are potential excess fatal cancers of the lung, bone, and liver.

For the BOMARC Missile Site, the major concerns are associated with radiation dose to the lung, liver, and bone produced by plutonium isotopes taken into the body through inhalation or ingestion. The most comprehensive analysis of risks associated with this kind of radiation dose is presented in the report by the National Research Council (NRC), Committee on the Biological Effects of Ionizing Radiation (BEIR), entitled "Health Risks of Radon and Other Internally Deposited Alpha-Emitters" (the BEIR IV Report) (NRC, 1988). Although the BEIR committee has published a more recent report than their 1988 BEIR IV report (NRC, 1990), it is not appropriate to use the estimates contained in it for this assessment. The reason is that the 1990 report (BEIR V) does not contain risk estimates for alpha emitters like Pu-239. The BEIR IV report is the most recent BEIR committee report containing detailed risk information on the type of radionuclides found at the BOMARC Missile Site. The BEIR IV risk factor cited for lung cancer from internally deposited transuranic radionuclides is 700 lung cancer deaths per million person-rad. For liver the risk estimate is 300 cancer deaths per million person-rad. For bone the range of risk estimates is given as 80 to 1100 cancer deaths per million person-rad. In order to use these risk estimates, the doses obtained using the factors in Table 1-1 in units of mrem must be converted to units of rads. For external doses from gamma rays no conversion is required. For internal doses from alpha emissions the number of rads can be calculated by dividing the number of rems by 20.

1.3 Uncertainties and Sensitivities in Dose and Risk Assessments

Model Uncertainties. The dose and risk estimates in the baseline radiological hazard assessment are presented as discrete values. Each of these calculated values is an expression of impact on an individual or on a population as a whole. These values are intended to be upper-bounds estimates of risk. However, the models used to calculate risk are generalizations and simplifications of the processes which result in exposure and risk. The models that are used are more sensitive to some parameters than to others. In addition, the ability to model the processes is also limited by the availability of data characterizing each site and the understanding of the processes. As a result, the estimates of dose and risk have a considerable degree of uncertainty associated with them.

The sequence of analyses performed to generate the radiological impact estimates includes (1) estimation of releases, (2) estimation of environmental transport and uptake of radionuclides, (3) calculation of radiation doses to exposed individuals, and (4) estimation of health effects. There are uncertainties associated with each of these steps. For instance, the dose calculation models involve the use of simplified representations of complex processes. It is not feasible to obtain sufficient data to fully or accurately characterize transport and exposure processes. Similarly, it is not possible to predict future conditions with certainty. Hence, there will be uncertainties in the representation of the environmental processes as well as in the data required to use the models (due to measurement errors, sampling errors, or natural variability). Finally, there are uncertainties in the calculations themselves (e.g., roundoff errors by the computers).

In principle, one can estimate the uncertainty associated with each source and predict the remaining uncertainty in the results of each set of calculations. Thus, one can propagate the uncertainties from one set of calculations to the next and estimate the uncertainty in the final results. However, conducting such a full-scale quantitative uncertainty analysis is neither practical nor a standard practice for most assessments. Instead, the analysis is designed to ensure - through judicious selection of release scenarios, models, and parameter values - that the results are bounding. That is, the goal is to produce the maximum potential adverse impacts. This is accomplished by using assumptions in the calculations at each step that tend to maximize the potential adverse impacts (i.e., "conservative" assumptions). The models and parameters used in the calculations are selected in such a way that most intermediate results and, consequently, the final estimates of impacts are greater than what would actually be expected. As a result, even though the range of uncertainty in a calculated dose might be large, the dose is likely to be at the high end of the range of possible values. Therefore, the chance of the quantity being greater than the calculated value is low. Thus, a goal of the methodology for the baseline hazard assessment was to produce results that are *reasonably conservative.*

Finally, the uncertainties in risk associated with internally deposited alpha emitters like Pu-239 are often greater than for other types of radionuclides (EPA, 1989). One of the reasons is that there are limited human epidemiological data on the risks from alpha emitters. These data are largely confined to: (1) lung cancer induced by radon decay products; (2) bone cancer induced by radium; and (3) liver cancer induced by injected thorotrast (thorium). The epidemiological data for other types of radionuclides (e.g., gamma-emitting) are much more extensive.

Model Sensitivity. Any computational model will return different final results if input parameters are varied. The degree to which a change in a model parameter value impacts the model results is referred to as the sensitivity of the model to that parameter. If very little change occurs in the model output, the model is said to be insensitive to variations in that parameter. A formal sensitivity analysis involves a quantitative determination of the influence of several parameters on a specified model output. A sensitivity analysis can be very useful in limiting the scope of an uncertainty analysis by identifying those parameters that the model is sensitive to, and thus worthwhile investigating the uncertainties associated with. A formal sensitivity analysis can be very complex, especially on models that are coupled such as in the codes that are used in this assessment. For instance, a variation in a parameter value may greatly affect the output of a single model (e.g., unsaturated zone transport), but may not significantly impact the final output of the code (e.g., radiological dose). Also, there may be correlations between parameters that complicate the understanding of the sensitivity of the model to a parameter.

For the baseline hazard assessment, a simplified sensitivity analysis was conducted, using the capabilities of the RESRAD code used for calculation of intruder doses (see Sections 2 and 3). In RESRAD, a single parameter value can be varied plus and minus a preset range over its nominal value. The code then calculates final output values (i.e., radiological doses) using the nominal value and the extremes of the range specified for the nominal value. This gives an indication of the sensitivity of the code to a single parameter. Parameters in three categories were examined for their influence on the output of RESRAD. The categories are: (1) physical site characteristics, (2) radionuclide-specific parameters, and (3) exposure pathway-specific parameters. The results of the sensitivity analysis are discussed in Section 4.1.

2.0 RADIOLOGICAL RELEASES TO THE ENVIRONMENT

To assess potential radiological impacts to workers and the general public, estimates must first be made of the amounts of radioactivity released from the BOMARC Missile Site to the environment for each alternative. This section describes the assumptions, models, and data used for these estimates. Airborne and waterborne releases are the mechanisms by which radionuclides could be released from the BOMARC Missile Site to the uncontrolled environment. However, airborne releases present the only significant mechanism for exposing either on-site workers or off-site individuals. Methods for assessing potential radiation doses due to these releases are presented in Section 3.0.

In order to assess the radiological impacts from the non-uniform contaminated soil at the BOMARC site, the RESRAD guidance relating to inhomogeneous contamination was reviewed for the assessment. To implement this guidance, the area of the site was divided into four sub-areas based on measured soil contamination levels (see Figure 2-1). These areas are intended only for the purposes of the radiological assessment, and not for other purposes (e.g., areas of required remediation). The site characterization data supporting the BOMARC RI/FS were used to determine characteristics such as maximum concentrations of Pu-239 in soil, depth of contamination, and other physical characteristics. Essentially all locations on the BOMARC site that had elevated soil concentrations of Pu-239 (based on soil sampling data) as well as all locations that had measurable Am-241 HPG readings are contained within one of the four sub-areas ("elevated" means greater than twice the background level of Pu-239 for soil samples). The only exceptions are three sediment samples taken from Elisha Branch south of the developed portion of the BOMARC missile site. The highest of these samples contained 1.8 pCi/g Pu-239, and they averaged 1.08 pCi/g, approximately ten times the background level (0.1 pCi/g). These samples were not included in the analyses because there were only three isolated, elevated sample locations, the levels were not extremely high, there was not a general elevation of contamination levels in the area, and finally, the sample locations are beyond the developed area of the BOMARC missile site. The four sub-areas have a combined area of 76,500 m^2. Principal characteristics of the four sub-areas are given in Table 2-1.

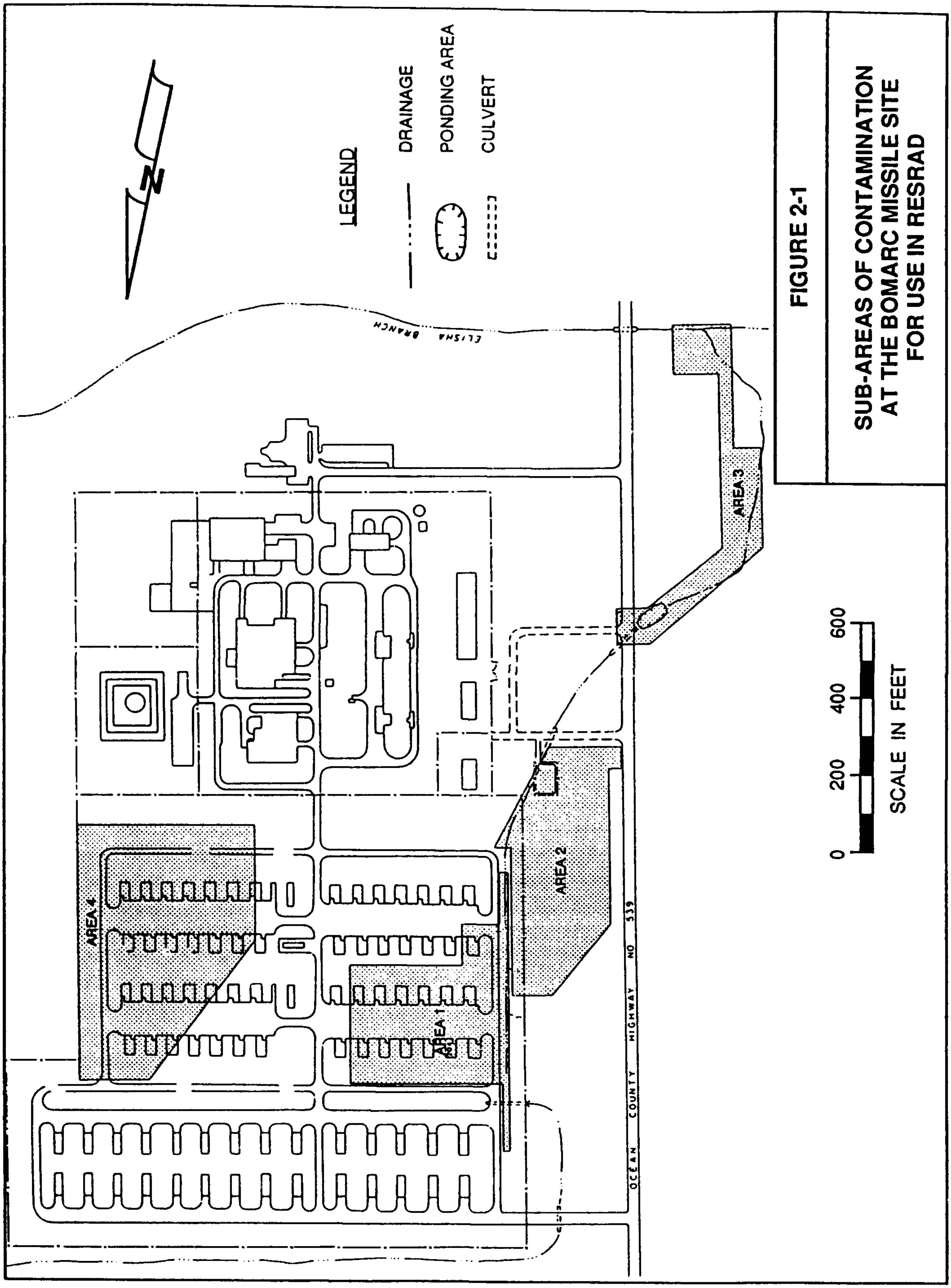


FIGURE 2-1

SUB-AREAS OF CONTAMINATION AT THE BOMARC MISSILE SITE FOR USE IN RESRAD

Table 2-1
Sub-Areas of Contamination on the BOMARC Missile Site Used for the Radiological Assessment

Sub-Area	Area (m^2)	Maximum Pu-239 Concentration (pCi/g)	Maximum Depth of Contamination (m)	Average Pu-239 Concentration to Maximum Depth (pCi/g)
1	16,000	240	3.05	22.6
2	18,800	180	1.83	20.6
3	10,800	3.9	1.22	3.9
4	30,900	3.3	0.15	3.3

Note: The maximum concentrations listed are for the 0 - 6 inch soil sampling depth.

The maximum concentration level in each sub-area was first estimated by combining the maximum concentration values at each depth from various soil sample locations within each sub-area. The average soil contamination level within each area was then assumed to be one third of the maximum composite values (Gilbert *et al.*, 1989). The depth profile samples were not used to determine contamination levels because there was not enough information consistently available to make the samples useful. In particular, the weights of each particle size fraction were not always available, and thus the activity concentrations could not be calculated.

Although high Pu-239 concentrations were obtained from some of these samples (e.g., 150,000 pCi/g), the high values are likely due to discrete particles rather than uniform contamination levels of an entire sample. This is supported by much lower concentrations in samples taken adjacent to the locations of high levels.

Preliminary results of the RESRAD code indicated that using the average soil concentration in the top soil sampling layer (generally 6 inches) produced higher doses than using a depth-weighted average concentration to the maximum depth. Therefore, the 0 - 6 inch depth concentrations were used in the final assessments.

2.1 Airborne Releases

Airborne particulates contaminated with plutonium and americium are the dominant hazard associated with the BOMARC Missile Site. Resuspension of contaminated soil is the primary mechanism by which airborne transport occur. Although no specific resuspension studies have been conducted at the BOMARC Missile Site, a conservative estimate of resuspension can be made (see Section 2.1.2). To address the radiological impacts of the baseline conditions, the following assumptions were made.

Baseline conditions consist of a continuation of current operational procedures designed to protect human health and the environment at the site. Contaminated areas would continue to be fenced and posted to preclude public access. The site would still be inspected on a regular basis to verify that conditions do not deteriorate to the point that public exposure is a concern. The concrete apron and building structures would be maintained and repaired as necessary, and radiological surveys would continue to be conducted annually to ensure that contaminants are not migrating from the site. However, there would be the potential for limited airborne release of plutonium and americium via resuspension. Under this alternative the missing missile launcher would not be located and removed. The radioactivity available for atmospheric release over the long term is assumed to include the existing average surface soil contamination (see Section 2.1.1).

2.1.1 BOMARC Missile Site Surface Contamination

Before estimating resuspension and off-site dispersion of Pu-239 and Am-241 from contaminated surface soils, an average level of contamination was needed for the baseline conditions. Existing baseline contamination characteristics were expressed in two ways, for each of the two types of assessments that were conducted (intruder and population). For the intruder assessment, it was assumed that an intruder could access only a single sub-area. This is reasonable because the sub-areas are large enough to support a resident intruder (see Table 2-1). One-third of the maximum Pu-239 sub-area contamination level (Gilbert, *et al.*, 1989) was used as the baseline contamination level for intruder scenario portion of the baseline assessment. Therefore a level of 80 pCi/g was used. For the population assessment, surface soil concentration levels in units of $\mu Ci/m^2$ were needed. Because the offsite population could potentially be exposed to contamination released from all contaminated areas of BOMARC Missile Site, the total of the four sub-areas listed in Table 2-1 was used for the population assessment (76,500 m^2). In order to be consistent with the bases for other calculations (e.g., intruder doses - Section 3.2), the mass concentrations of Pu-239 obtained from the soil samples taken as part of the RI/FS site characterization process were used to estimate average surface soil concentrations of Pu-239 (in units of $\mu Ci/m^2$). Using the values in Table 2-1, an average existing baseline concentration of 32 pCi/g was calculated for the 76,500 m^2 of contaminated surface area at the BOMARC Missile Site. This value was calculated by weighting and summing the contamination levels in each sub-area. An average contamination level of one-third of the maximum value was assumed (Gilbert *et al.*, 1989). Assuming a soil density of 1.6 g/cm^3, the areal concentration in the top 5 cm layer of the soil would be 2.6 $\mu Ci/m^2$. This calculated areal concentration was used only for resuspension leading to offsite dispersion.

2.1.2 Resuspension of Contaminated Particles

Resuspension from soils and subsequent inhalation of the resuspended material has long been considered the chief source of exposure to transuranium elements deposited in soils. The best method for determining quantities and rates of resuspension of contaminated surface soils is to directly measure air concentrations in the vicinity of contaminated soils. However, in order to obtain average concentrations, measurements must be done over a long period of time and under a variety of conditions. Therefore, direct measurements are not always practicable. Consequently, estimates of surface soil resuspension are most commonly obtained by modeling techniques. Although many resuspension modeling techniques are available, the following three basic techniques are most commonly used: (1) the resuspension factor model, (2) the resuspension rate approach, and (3) the mass-loading approach (Healy, 1980). Each method has its strengths and its weaknesses, particularly in view of the state of the technology at this time. The resuspension rate and mass-loading techniques are used directly in this assessment. The resuspension rate model is used in the off-site dispersion and dose calculations because it yields fractional resuspension per unit time, and because the area subjected to resuspension can be incorporated into calculations. The mass-loading approach is used in the on-site dose calculations because it relates surface soil concentration to the concentration in air in the immediate vicinity. The following discussion describes all three most common approaches, how they are related, and specific applications to the BOMARC site.

The assessments for the BOMARC Missile Site used two computer models. GENII was used for off-site population doses and RESRAD was used for on-site intruder doses. GENII does not treat resuspension directly but accepts a radionuclide release rate as input. RESRAD uses a mass loading approach. In order to insure consistency between these two models for the BOMARC Missile Site, the release rate for GENII input was derived from the RESRAD default mass loading value using the equations presented here.

In the **resuspension factor model**, the airborne dust concentration is given as a function of an empirically determined resuspension factor, the effective depth of the layer of soil from which resuspension occurs, and the bulk density of soil. The equation relating these parameters is

$$C_{dust} = R_f \times d_r \times \rho_b$$

where

C_{dust} = airborne dust concentration (g/m^3)
R_f = resuspension factor (m^{-1})
d_r = depth of soil (m)
ρ_b = density of surface soil (g/m^3).

In the **resuspension rate model**, the airborne dust concentration is given as a function of an empirically determined fractional resuspension rate, the areal density of soil, and the average deposition velocity of resuspended soil particles. The equation is

$$C_{dust} = (R_r \times \sigma_s) \div v_d$$

where

C_{dust} = airborne dust concentration (g/m^3)
R_r = fractional resuspension rate (s^{-1})
v_d = deposition velocity (m/s)
σ_s = areal density of soil (g/m^2)

and

σ_s = $d_r \times \rho_b$.

The third model is a **mass loading model** in which the value of airborne dust concentration is specified using empirical data or measured values of airborne dust under similar conditions.

$$C_{dust} = M$$

where

C_{dust} = airborne dust concentration (g/m^3)
M = mass loading factor (g/m^3).

The three models discussed above are not independent. They can be related by the following equalities:

$$R_f = M \div \sigma_s = M \div (d_r \times \rho_b) \quad \text{(ref: Gilbert } et\ al.\text{, 1989)}$$

and

$$R_r = R_f \times v_d. \quad \text{(ref: Napier } et\ al.\text{, 1988)}$$

Combining these two equations gives the following expression for the fractional resuspension rate in terms of the mass loading factor:

$$R_r = (M \times v_d) \div (d_r \times \rho_b).$$

For the Baseline radiological assessment, two separate computer codes were used. RESRAD was used for estimating doses to individuals, including intruders, located on the BOMARC site. GENII was used for estimating doses to the surrounding population located outside the site boundary out to a distance of 50 miles. RESRAD is specifically designed to estimate on-site doses for facilities with radioactively contaminated soils. In addition, it is intended to help set clean up criteria for those facilities. Therefore, it was considered to be the best available code for these BOMARC assessments. However, RESRAD does not allow the calculation of dose to the surrounding population. GENII was chosen to supplement RESRAD for the BOMARC assessments. GENII is a flexible, general purpose radiological assessment code capable of estimating doses to the surrounding population from ground level releases of airborne radioactivity (See Section 2.1.3).

A mass loading model is used in RESRAD to estimate air concentrations of resuspended particulates. GENII does not automatically estimate off-site releases from resuspension but must be supplied with an annual release rate. The equation above expressing the fractional resuspension rate in terms of the mass loading factor was used to estimate a release rate for the GENII calculation that is consistent with the RESRAD mass loading model.

$$R_r = (M \times v_d) \div (d_r \times \rho_b)$$

where

d_r = 5.1 cm = 0.051 m
ρ_b = 1.6 g/cm^3 = 1.6×10^6 g/m^3
M = 200 $\mu g/m^3$ = 2.0×10^{-4} g/m^3
v_d = 2 cm/s = 0.02 m/s

gives

R_r = 4.9×10^{-11} s^{-1} = 1.5×10^{-3} y^{-1}.

The value for d_r is a conservative value assumed for the BOMARC Baseline assessment. The values for ρ_b and M are those used in the RESRAD calculations. The value of 200 $\mu g/m^3$ for

M is not a site-specific value. It is the default value chosen by the authors of RESRAD (Gilbert *et al.*, 1989), and is two times the generic value suggested by the NCRP (NCRP, 1985). The value is therefore a conservative one, however, it is applicable to a broad range of circumstances, including the on-site residence scenario evaluated for the BOMARC Missile Site. The deposition velocity, v_d, is based on 10 μm resuspended soil particles and a friction velocity of 50 cm/s appropriate to the BOMARC site (Whicker and Shultz, 1982).

The fractional resuspension rate gives a total annual release according to the following equation

$$Q = R_r \times A \times C_{surf}$$

where

Q	=	total annual release rate (μCi/y)
R_r	=	fractional resuspension rate (y^{-1})
A	=	surface area (m^2)
C_{surf}	=	surface concentration ($\mu Ci/m^2$).

For the BOMARC site, the fractional resuspension rate of $1.5 \times 10^{-3}\ y^{-1}$ was used in conjunction with areas and surface concentration levels to estimate total annual atmospheric release rates in units of μCi/yr. This is the input required by GENII for calculating atmospheric dispersion and subsequent radiation dose from a ground level release. The average areal Pu-239 concentration of 2.6 $\mu Ci/m^2$ calculated in Section 2.1.1 was used to calculate an annual atmospheric release as follows:

$$Q = (1.5 \times 10^{-3}\ y^{-1}) \times (76{,}500\ m^2) \times (2.6\ \mu Ci/m^2)$$
$$= 298\ \mu Ci/y$$

An annual release of 50 μCi/y Am-241 was calculated by dividing the Pu-239 releases by 5.9 (298 μCi/y $\div$ 5.9 = 50 μCi/y).

2.1.3 Off-site Atmospheric Dispersion

Atmospheric dispersion of contaminated material to distances beyond the BOMARC Missile Site was evaluated using the appropriate modules of the GENII computer code (Napier *et al.*, 1988). GENII is a code developed by Battelle Pacific Northwest Laboratory (PNL) to assess the radiological consequences of releases to the environment. It allows several options for atmospheric dispersion calculations. Further, it is coupled directly to the dosimetry calculations necessary for assessing the potential impacts to the general public.

This assessment uses the straight-line Gaussian plume option of GENII for long-term, undisturbed conditions. The straight-line Gaussian plume model is the basis for a set of dispersion models that are widely accepted for routine dose assessment applications.

For this analysis, annual average air concentrations are estimated on a 16-sector grid out to a distance of 50 miles (80 km) as a basis for estimating potential impacts to the general public surrounding the site. The population surrounding the BOMARC Missile Site used to calculate the population dose is the estimated 1995 population. The assumed population is shown in Table 2-2.

Table 2-2
Population Forecast for BOMARC Missile Site Area - 1995[a]

	Outer Radius (miles)									
Direction	1	2	3	4	5	10	20	30	40	50
S	0	0	0	0	32	10,071	34,931	51,605	61,753	42,067
SSW	0	0	0	0	119	8,915	32,502	50,806	58,420	69,726
SW	0	0	0	0	0	8,453	32,502	76,204	185,880	85,913
WSW	0	0	0	0	0	8,298	32,502	59,175	314,380	328,145
W	0	0	78	198	240	8,453	32,502	158,134	868,405	630,755
WNW	0	52	208	297	375	10,143	42,144	94,159	148,676	204,130
NW	0	141	214	297	375	19,400	89,976	145,215	81,479	96,614
NNW	0	134	207	280	356	17,108	104,397	145,806	98,141	83,055
N	0	0	0	203	177	14,242	94,513	238,987	282,427	479,833
NNE	0	0	0	242	236	10,967	74,492	154,901	297,060	1,656,262
NE	0	0	0	0	310	10,148	71,680	121,506	41,612	595,909
ENE	0	0	0	0	310	10,148	59,794	52,431	0	0
E	0	0	0	0	90	10,148	39,325	5,074	0	0
ESE	0	0	0	314	909	10,148	39,748	10,148	0	0
SE	0	0	52	0	1,258	10,148	39,748	33,828	0	0
SSE	0	0	122	716	1,031	10,148	39,748	57,931	22,834	0

[a] Entries are in number of persons per sector. Total population: 9.24 million.

Other requirements for this calculation include the frequency of occurrence for winds, wind speeds, and stability class in each sector. These data are available for McGuire AFB and are summarized in STAR format, which presents the joint frequency of wind speed and stability (Table 2-3).

2.2 Waterborne Releases

In addition to airborne releases from the BOMARC Missile Site, waterborne releases were considered.

2.2.1 Groundwater Releases

Groundwater releases are evaluated in the construction/resident scenario (Section 3.2). This analysis provides a conservative estimate of groundwater release, as the intruder obtains water from a well located at the site. Results indicate that the groundwater pathway is insignificant relative to the airborne pathway.

2.2.2 Surface Water Releases

There are no permanent surface waters on the dry, upland soils of the BOMARC Missile Site. The principal surface water features associated with the site are the natural streams that drain the nearby low wetlands of the Pinelands. A majority of the surface runoff from both the missile launch area and support facilities, drains to the west, south, and east and eventually reaches the Elisha Branch. From Elisha Branch, surface water flows into larger tributaries leading to the Ridgeway Branch, the Tom's River, and ultimately reaches the Atlantic Ocean via Barnegat Bay.

The surface water pathway was not considered in the dose analyses for the following reasons. First, man-made control systems limit surface erosion and favor infiltration into the ground. The asphalt and concrete cover placed in the vicinity of Shelter 204 and in the drainage result in rapid runoff; however, the area covered is protected from surface erosion and transport of contaminated sediments. Some restriction to flow may occur on the upstream side of road culverts, which could result in ponding and augmented infiltration into the ground. Additional groundwater recharge over the long term is expected in the depression located at the downstream side of the culvert under Ocean County Highway No. 539. Second, surface waters in the near vicinity of the BOMARC Missile Site, i.e., the Elisha Branch and immediate downstream water courses, are not known to be presently in use as a water supply source. Third, the high recharge potential of the native sandy soils minimizes surface runoff. Finally, in light of the above discussion, the amount of contamination that could potentially reach surface waters used by humans is insignificant compared with that transported by air or groundwater.

3.0 METHODS FOR ASSESSING POTENTIAL RADIOLOGICAL IMPACTS

Because of the releases discussed previously (Section 2.0), members of the public may be exposed to radioactive material from the BOMARC Missile Site. These potential exposures (doses) may result in subsequent health effects in the exposed population as discussed in Section 1.2. This section explains how radiation doses for the general public are calculated.

Table 2-3
Meteorological Data* for the GENII Population Dose Calculations for the BOMARC Missile Site

	Wind from:	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WSW	NW	NNW
Average Windspeed (m/sec)																	
	0.8	0.08	0.03	0.03	0.04	0.04	0.01	0.02	0.03	0.09	0.06	0.07	0.06	0.11	0.06	0.07	0.06
	2.57	0.02	0.02	0.01	0.01	0.02	0.00	0.01	0.02	0.03	0.02	0.05	0.02	0.06	0.04	0.04	0.03
Class A	4.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	9.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.9	0.27	0.20	0.13	0.11	0.13	0.11	0.09	0.11	0.24	0.19	0.24	0.25	0.34	0.22	0.19	0.19
	2.57	0.21	0.17	0.14	0.08	0.13	0.09	0.08	0.09	0.15	0.16	0.28	0.25	0.40	0.24	0.19	0.17
Class B	4.37	0.10	0.05	0.04	0.03	0.04	0.03	0.03	0.01	0.05	0.07	.013	0.11	0.15	0.09	0.10	0.09
	6.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.8	0.23	0.12	0.10	0.10	0.13	0.10	0.09	0.16	0.28	0.25	0.18	0.15	0.21	0.12	0.11	0.14
	2.57	0.30	0.20	0.11	0.08	0.13	0.14	0.12	0.15	0.25	0.23	0.28	0.27	0.38	0.28	0.24	0.21
Class C	4.37	0.42	0.17	0.14	0.12	0.15	0.11	0.09	0.17	0.26	0.42	0.54	0.60	0.64	0.61	0.45	0.40
	6.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	9.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(Continued)

* Numbers in the main body of the text are fraction of time for persistence of conditions (Stability Classes A-G and windspeed category) for compass directions. The wind blows from the directions indicated.

Table 2-3
Meteorological Data* for the GENII Population Dose Calculations for the BOMARC Missile Site (Continued)

	Wind from:	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WSW	NW	NNW
	0.9	0.53	0.49	0.57	0.51	0.92	0.57	0.44	0.58	1.01	0.61	0.43	0.33	0.47	0.22	0.24	0.31
	2.57	0.68	0.51	0.61	0.61	1.07	0.56	0.44	0.54	1.09	0.82	0.61	0.50	0.68	0.39	0.43	0.38
	4.37	1.05	0.80	0.67	0.59	0.95	0.48	0.29	0.45	1.16	0.80	0.77	0.78	1.32	1.24	0.94	0.87
Class D	5.94	0.77	0.47	0.35	0.25	0.28	0.09	0.06	0.07	0.20	0.23	0.42	0.72	2.06	1.90	1.40	1.00
	9.64	0.12	0.05	0.04	0.04	0.03	0.00	0.01	0.01	0.02	0.01	0.05	0.07	0.45	0.45	0.31	0.14
	12.86	0.03	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.05	0.16	0.10	0.12	0.03
	0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2.57	0.23	0.16	0.14	0.08	0.14	0.11	0.13	0.34	0.94	0.60	0.32	0.27	0.31	0.30	0.22	0.23
	4.37	0.31	0.05	0.01	0.01	0.01	0.01	0.01	0.04	0.16	0.11	0.16	0.22	0.99	0.90	0.55	0.49
Class E	6.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	9.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.8	0.57	0.26	0.25	0.26	0.34	0.18	0.30	0.64	1.55	1.13	0.76	0.48	0.78	0.49	0.40	0.55
	2.57	0.51	0.09	0.04	0.03	0.04	0.05	0.07	0.20	0.80	0.60	0.61	0.49	1.07	0.75	0.57	0.67
Class F	4.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	9.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.8	0.85	0.25	0.19	0.14	0.29	0.25	0.27	0.62	2.35	1.63	1.04	0.85	1.38	0.86	0.66	0.86
	2.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Class G	4.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	9.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	12.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

* Numbers in the main body of the text are fraction of time for persistence of conditions (Stability Classes A-G and windspeed category) for compass directions. The wind blows from the directions indicated.

The methods used for assessing the radiological impacts on members of the general public are described in this section. Both long-term, undisturbed conditions and active remediation conditions are evaluated. Two types of calculations are done for this assessment: (1) potential dose to the population within 50 miles (80 km) of the site (Section 3.1) and (2) doses to inadvertent intruders (Section 3.2).

3.1 Potential Population Dose

Potential dose to the population was estimated using the GENII dose calculation program (Napier *et al.*, 1988). This program was used to model chronic releases to the atmosphere as described in Section 2.1.2. The basic input to GENII is a list of types and amounts of radionuclides released to the environment; Section 2.1.2 contains the calculated release for this assessment. Based on historical meteorological records for McGuire AFB, GENII then calculates the expected annual average air concentration in zones defined by radial intervals of 16 sectors out to a distance of 50 miles from the point of emission. Air concentrations are estimated using the straight-line Gaussian plume model of dispersion. The code takes into account the height of the emission point (ground-level releases were assumed for this assessment), radioactive decay of specific radionuclides, and other appropriate factors.

GENII then calculates the quantities of specific radionuclides that would be deposited in each of the 16 sectors and that could result in human exposure by various pathways. GENII then calculates the radiation doses to the entire population in all 16 sectors (population estimates for each sector are part of the input to GENII; see Section 2.1.3). The code is used only to calculate the population dose for this assessment, but it can also identify the dose for maximally exposed off-site individual. Potential pathways of exposure calculated by GENII include external radiation from contaminated air and ground surface as well as internal radiation dose from inhalation and ingestion of contaminated foods. Both EDE and organ dose commitments are reported in the baseline risk assessment section of the RI/FS. To convert doses, which are expressed in terms of person-rem, to health effects, the doses were multiplied by risk factors recommended by the BEIR IV committee (see Section 1.2).

Input parameters used and output table from GENII for the population dose scenario are provided in Annex 1 of this appendix.

3.2 Potential Doses to Inadvertent Intruders

The Baseline Assessment includes an assessment that evaluates the potential for radiation dose to individual members of the general public who may inadvertently expose themselves to soil or other contamination at the BOMARC Missile Site. All other alternatives assume either remediation of contaminated soil or long-term institutional control of the site, and therefore preclude significant exposure of intruders. The Inadvertent Intruder assessment is a hypothetical worst-case scenario, and includes a family farm assumption. To estimate the upper bound (worst-case) for doses to an intruder, it is assumed that long-term institutional control of the site would not exist and members of the public would have unrestricted access to the site at some time in the indefinite future. It was assumed that the intruder entered the sub-area resulting in the highest dose consequences (sub-area 1).

The farm family scenario consists of an agricultural/resident scenario. This scenario provides upper-bound estimates of potential doses for a hypothetical maximally exposed individual. Such a family-farm scenario, in which a family lives on the contaminated site and raises an appreciable fraction of its food on this site, is considered to be a credible bounding scenario by the NRC for assessments of waste disposal sites and by the DOE for decontaminated facilities. Even though such a scenario may be unlikely in the foreseeable future for the BOMARC Missile Site, it cannot be excluded as noncredible at some time several hundred years in the future.

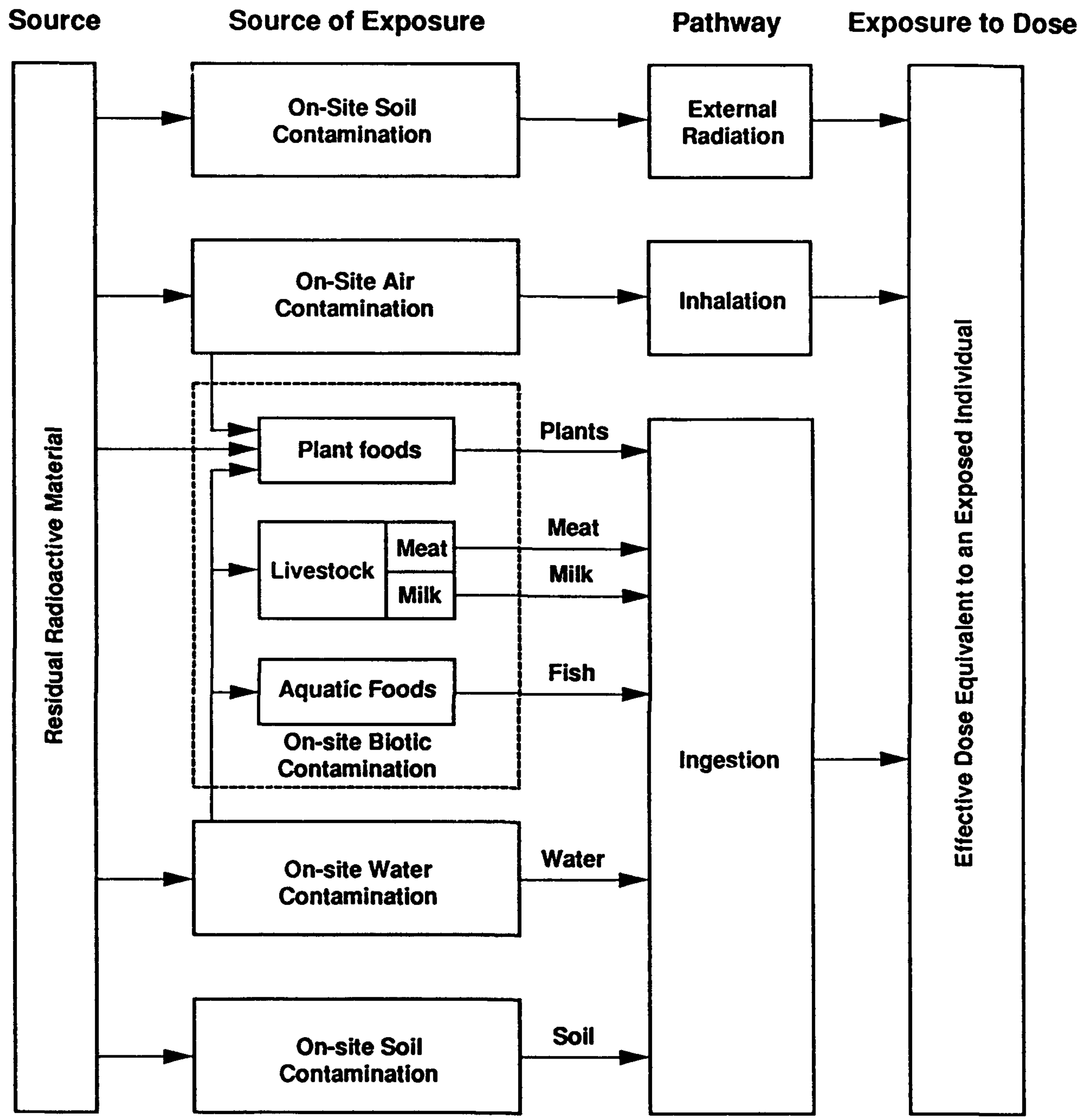
It is assumed that the agricultural resident lives continuously on the BOMARC Missile Site and consumes foods grown on the site. To provide an upper bound for potential doses, it has been assumed that all the contaminated soil on the site is available for transport through the environment. That is, the barriers presented by existing concrete and asphalt covers have been neglected. The intruder is assumed to be exposed to the existing surface soil contamination levels. The intruder is assumed to live in a house at this site and consume food products from a small garden located on the contaminated area.

This calculation was fully implemented in a computer code called RESRAD. This code has been developed for the specific purpose of determining cleanup criteria for radioactively contaminated soils (Gilbert *et al.*, 1989). It contains all the potential pathways of exposure discussed in Section 1.1 except external exposure from immersion in a radioactive cloud. Version 4.10 of the code was used for this assessment.

The dose calculations performed by RESRAD are based on a pathway analysis method known as the concentration factor method (NRC, 1977; Till and Meyer, 1983). With this method, the relation between radionuclide concentrations in soil and the dose to a member of a population is expressed as a pathway sum, which consists of a sum of products of "pathway factors." Pathway factors connect compartments in the environment between which radionuclides can be transported or radiation transmitted (see Figure 3-1). Most pathway factors are steady-state ratios of concentrations in adjoining compartments. Some are factors for conversion from a radionuclide concentration to a radiation level or radiation dose, and others are use and occupancy factors that affect exposure. Each term in the sum corresponds to a pathway. A pathway factor can be added, deleted, or replaced without affecting the other pathways or pathway factors. This structuring facilitates the use of alternative models for different conditions or transport processes and the incorporation of additional pathways. Thus, RESRAD was easily tailored to model the situation at the BOMARC Missile Site.

For this assessment, values specific to the BOMARC Missile Site have been used wherever possible. Where site-specific data are not available the default values have been used. A list of all required RESRAD input appears in Annex 2. This list indicates both the "user input" and the "default" values. Site-specific input values were used wherever there were enough data about the BOMARC Missile Site to justify deviations from the default values.

Site specific values were used to describe the physical dimensions of the contaminated region (surface area, thickness, distance to groundwater) and the characteristics of the contamination (radionuclide concentrations present). The water balance parameters were also site-specific (evapotranspiration, precipitation, and runoff) as were the hydrogeolgic parameters for the contaminated, unsaturated, and saturated strata (total and effective porosities, hydraulic



Source: Modified from Gilbert et al, 1983.

FIGURE 3-1

EXPOSURE PATHWAY DIAGRAM FOR CALCULATING THE DOSE TO AN ON-SITE RESIDENT FROM RESIDUAL RADIOACTIVE MATERIAL

conductivities). Site-specific distribution coefficients (K_ds) for Am-241 and Pu-239 were selected to better represent the sandy soils of the BOMARC Missile Site. Many of the remaining RESRAD parameters describe the human behavior associated with potential radiation doses. These include breathing rate and dietary intake for the assumed exposure scenario. Exposure factors conforming to EPA risk assessment guidance were used for all these parameters (EPA, 1991a).

Default values were used for the non-dietary agricultural parameters such as livestock feed rates. Of the remaining parameters for which default values were used, only one has a significant influence on dose estimates. This is the dust mass loading factor. No data were available on mass loading at the BOMARC Missile Site, so the RESRAD default value was used. Although this default value of 200 $\mu g/m^3$ is somewhat conservative, it is applicable to a broad range of circumstances. In the absence of specific data, no justification was found to support using a different value.

Potential pathways of exposure included in this analysis are external radiation from contaminated ground as well as internal radiation from inhalation, ingestion of food, drinking water, and soil (see Figure 3-1). Both EDE and organ dose commitments are reported. Consumption parameters were obtained from EPA (1991a). Values used for input parameters for this scenario are provided in the output tables from RESRAD in Annex 2 of this appendix.

RESRAD calculations were initially made to simulate a total time period of 10,000 years. Calculated doses do not change significantly after a period of approximately 5,000 years, however, so a time period of 6,000 years was eventually used. Values for the year of maximum dose rate were used for estimating potential impact to intruders on the BOMARC Missile Site. In all cases the maximum dose rate was given in the first year, represented by t = O in the tables in Annex 2. In subsequent years doses from surface contamination decreased because RESRAD treats the surface soil as eroding away with time.

Because plutonium is quite insoluble and immobile in the environment there are no significant contributions to estimated radiation doses via groundwater pathways until several hundred years have passed. The tables illustrating dose versus time in Annex 2 show the relative importance of groundwater pathways.

4.0 RESULTS OF BASELINE ASSESSMENT

4.1 Maximally Exposed Individual

As shown in Table 4-1, radiation doses to a hypothetical residential intruder in the maximum year of exposure are dominated by inhalation of Pu-239 contaminated resuspended dust. This exposure pathway accounts for approximately 65 per cent of the total dose of 47 mrem/yr. Inhalation of Am-241 contaminated dust contributes about 11 per cent. Ingestion of plutonium and americium account for an additional 24 per cent. Taken together, these routes of exposure resulting from internally deposited transuranic alpha emitters account for more than 99 percent of the total dose. External gamma radiation dose, primarily from Am-241, accounts for less than 1 per cent of the total. Waterborne radioactivity does not make a significant contribution even for calculations taken out to periods of greater than 100 years.

Table 4-1
Dose Contributions for Individual Radionuclides and Pathways: Maximally Exposed Individual

Radionuclide	Percent of Total EDE by Exposure Pathway						
	External	Inhalation	Ingestion				Total
	Ground	Dust	Plant	Meat	Milk	Soil	
Am-241	0.2	11.1	0.2	0.1	0.0	3.4	15.0
Pu-239	0.01	64.8	0.8	0.4	0.0	19.0	85.0
Total	0.2	75.9	1.0	0.5	0.0	22.4	100.0

Table 4-2 summarizes the potential radiation doses to the maximally exposed individual from each year of residence. This table also presents the rate of excess fatal cancers of the lung, liver, and bone for a hypothetical population of individuals exposed to these levels of radiation.

Table 4-2
Dose Rates and Health Risks: Maximally Exposed Individual

Radionuclide	Dose Rates (mrem/yr)			
	EDE	Bone Surface	Liver	Lung
Am-241	7	126	27	12
Pu-239	40	734	156	72
Total	47	860	183	84

Excess Fatal Cancers (Cancers/year per Million Persons)

Total	Bone Surface	Liver	Lung
19	13	3	3

Cancer risk estimates are intended to be applied to populations rather than to individuals. They are included in this table only for comparison to normal cancer incidence rates. The natural incidence rate for all fatal cancers exceeds 2500 cancers/year per million persons (NAS, 1990). In the United Sates, the natural incidence rate for liver cancers is about 50 cancers/year per million persons. The corresponding rate for lung cancers is about 600 cancers/year per million persons and the rate for bone cancers is about 10 cancers/year per million (NCI, 1982).

It is useful to compare these dose rates to those of natural background radiation in the United States (NCRP, 1987). The estimated total EDE dose rate of 47 mrem/year is small compared to the average annual background radiation dose of about 350 mrem/year. The lung dose rate of 84 mrem/year calculated for this assessment is less than half of the estimated 200 mrem/year average lung dose rate to the resulting from exposure to naturally occurring radon.

Sensitivity Analysis. The sensitivity of the RESRAD code to changes in parameter values was evaluated by using the sensitivity analysis capabilities of RESRAD. This consisted of varying a parameter over its nominal value by a preset amount and noting the change in code output. The code then graphically displays the output for the nominal value and the two extremes. For the purposes of this analysis, "code output" refers to the maximum calculated dose. This method does not yield a sophisticated quantification of sensitivity, but does give an indication of the impact that a single parameter has on the output of the code. Parameters in three categories were examined for their influence on the output of RESRAD. The categories are (1) physical site characteristics, (2) radionuclide-specific parameters, and (3) exposure pathway-specific parameters. The existing BOMARC site conditions were used as the base case; parameter values were varied around the values used for this scenario. Some subjective reasoning was used to limit the number of parameters examined. For instance, the water dependent pathway parameters were not examined except very grossly, because this pathway was not a significant factor in the BOMARC assessment. Also, the initial concentrations of radionuclides were not varied, because it is already known that the code output is linearly related to this input parameter.

Many of the RESRAD parameters affected specific pathway doses linearly - i.e., a two-fold increase in input value resulted in a two-fold increase in the pathway dose. Impact on the total dose then depended on the relative contribution of that pathway to the total dose. This is true of parameters such as inhalation rate and soil ingestion rate. Other parameters, such as erosion rate, significantly affected the total dose only when extreme values were used. Finally, the code appeared to be sensitive to changes in some parameters only over limited ranges of the parameter value; thickness of the contaminated zone is an example of this group of parameters. The three categories of parameters are discussed in more detail below.

Physical Site Characteristics. The parameters in this category are in RESRAD menus 011 and 013. The parameters (and their nominal values) that were examined include:

Cover thickness (0 m)
Cover erosion rate (not used)
Cover density (not used)
Contaminated zone thickness (15.24 cm)
Contaminated zone erosion rate (.001 m/yr)
Area of contaminated zone (16,000 m^2).
Irrigation rate (0.2 m/yr).

The parameters in this category having the greatest impacts on the final dose were erosion rate of a cover and contaminated zone thickness. Cover thickness did not significantly affect the calculated dose unless the erosion rate of the cover was set to an extremely small value. Doing this had the dual effect of reducing the magnitude of the dose as well as delaying the time the maximum dose was received. For instance, using a cover thickness of 15 cm and changing the erosion rate by an order of magnitude had a minimal effect, but when the rate was decreased by a factor of one hundred (to a value of 1 x 10^{-5} m/yr) the maximum dose was reduced by a factor of five, and occurred at a time beyond 5,000 years.

When the contaminated zone thickness was reduced to a value of 7.6 cm (one-half the nominal value), the calculated dose decreased by a factor of two. Increasing the thickness, even to two meters, had little effect. The cover density also had little effect on the calculated dose. This is presumably because the code treats the cover as if it were soil, and includes mixing of the cover and underlying contaminated zone regardless of cover density.

The contaminated zone erosion rate had an effect similar to that of the cover erosion rate. The contaminated zone area significantly affected the dose only when extremely low values were used (e.g., < 1 m^2). Finally, changes in the irrigation rate had an insignificant effect on the total dose.

Radionuclide-specific Parameters. A single parameter was examined in this category: the distribution coefficient (K_d). Changing the K_d for Pu-239 by an order of magnitude did not significantly change the calculated dose. Other radionuclide-specific parameters were judged to either have an authoritative source (e.g., dose conversion factors), or else they did not contribute significantly to the dose (e.g., bioaccumulation factors).

Pathway-specific Parameters. The parameters in this category are in menus 017 and 018 of RESRAD. Exposure pathways considered were inhalation and ingestion, which were the only significant exposure pathways. Within the ingestion pathway category, only ingestion of soil was significant, so other ingestion parameters were not examined. The parameters (and their nominal values) that were examined include:

Inhalation rate (7,000 m^3/yr)
Mass loading (0.0002 g/m^3)
Occupancy factor (0.55)
Soil ingestion (35 g/yr)
Mixing depth (15 cm)

As expected, calculated inhalation doses changed linearly with changes in values for the inhalation rate and mass loading. That is, a two-fold increase in either of these factors resulted in a two-fold increase in the code output. Occupancy factor, which relates time spent indoors to time spent outdoors, had a similar effect. Inhalation accounted for approximately 76% of the total dose, so the total dose increased (or decreased) slightly less than the increase (or decrease) in these factors.

The soil ingestion dose also changed linearly with soil ingestion rate. This pathway accounted for roughly 20% of the total dose, so doubling the value increased the total dose by approximately 20%.

Decreasing the depth of the topsoil mixing layer by a factor of two had no effect on the maximum total dose. However, increasing the value by a factor of two decreased both the inhalation and ingestion doses, resulting in a decrease of approximately a factor of two in the maximum total dose.

4.2 Potential Population Dose

The potential baseline dose rates to the population within 50 miles of the BOMARC site are summarized in Table 4-3. The total dose rate of 2.7 person-rem/year is distributed over a population of about 9 million persons within 50 miles. This gives an average of about 3×10^{-4} mrem/year to each individual in the population, a value that is several orders of magnitude less than that estimated for the hypothetical maximally exposed individual. The estimated total excess fatal cancer rate is very much less than one per year (9.1×10^{-4} cancers/year) over nine million persons and does not constitute a significant potential impact. This value should be compared to a natural incidence that exceeds 2500 cancers/year per million persons. This natural incidence rate corresponds to a lifetime incidence of approximately 20,000 cancer deaths per 100,000 individuals (NAS, 1990).

Table 4-3
Dose Rates and Health Risks: Population Within 50 Miles[a]

Dose Rates (mrem/yr)			
EDE	**Bone Surface**	**Liver**	**Lung**
2.7	51	9	0.4
Excess Fatal Cancers (Cancers/Year)			
Total	**Bone Surface**	**Liver**	**Lung**
9.1×10^{-4}	7.6×10^{-4}	1.3×10^{-4}	1.3×10^{-5}

[a]Estimated to be 9.3×10^6 people.

4.3 Soil Remediation Level

One of the intents of the Baseline risk assessment was to derive a risk-based remediation goal for contaminated soil at the BOMARC Missile Site. Such a remediation goal is a target to use during analysis and selection of remedial alternatives. There are no Applicable or Relevant and Appropriate Requirement (ARAR) values for the radionuclides found at the BOMARC Missile Site, so values for appropriate residual levels of these contaminants were calculated. Environmental Protection Agency (EPA) guidance (e.g., EPA, 1991b) was considered in the derivation of the remediation goal.

The RESRAD code was specifically designed to be used to calculate remediation levels for radionuclides in soil (Gilbert *et al.*, 1989). One of the output values of the code is the limiting soil concentration of all radionuclides in the scenario. The limiting soil concentration is directly related to the dose limit used in the code input. For derivation of a remediation goal for the BOMARC Missile Site, an EDE dose limit of 4 mrem/yr was used. This methodology does not follow all of the specific methodological guidance of the EPA, however it is felt to result in a remediation goal that is protective of human health.

For contaminated soils at the BOMARC site, the risk-based goal for remediation is 8 pCi/g Pu-239. This soil remediation level was derived by assuming unrestricted access, and a future farm-family scenario at the site as described in Section 3 of this Appendix. The scenario includes the assumption of a family living on the site and obtaining a majority of their food from a garden also on the site. Remediation of soils to a Pu-239 level of 8 pCi/g or less will result in a 4 mrem/yr annual effective dose equivalent to a maximally exposed individual (MEI). This MEI dose rate corresponds to a lifetime risk of less than 10^{-4} (EPA, 1990).

In order to estimate areas that may require soil remediation, it is useful to express the soil remediation goal of 8 pCi/g in terms of areal concentration (i.e., $\mu Ci/m^2$). This facilitates using the data generated by the HPG in situ survey (Section 3.6.2.4 of the RI/FS), which are the most comprehensive areal contamination survey data available for the site. The soil remediation goal can be converted to an areal concentration as follows:

$$C_{surf} = C_M \times \rho_b \times d_r \times .01$$

where

C_{surf}	=	Areal concentration of contamination in soil (μCi per m^2),
C_M	=	Mass concentration of contamination in soil (pCi/g),
ρ_b	=	bulk density of soil (g per cm^3),
d_r	=	contamination depth (cm)
.01	=	unit conversion factor.

Assuming a value of 1.6 g/cm^3 for bulk soil density and a value of 15.25 cm for contamination depth, the remediation goal of 8 pCi/g can be expressed as an areal concentration of 2 $\mu Ci/m^2$. The remediation goal was derived assuming a contamination depth of 15.24 cm (6 inches); therefore, the same depth is used in converting to areal concentration.

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APPENDIX J

ANNEX 1

GENII OUTPUT FOR THE

BASELINE RISK ASSESSMENT

```
------------------------------------------------------------------------------
                    GENII  Dose Calculation Program
                       (Version 1.485 3-Dec-90)

Case title:    BOMARC:  1995 POPULATION DOSE - BASELINE ASSESSMENT
Executed on:   04/23/92 at 15:26:22                            Page A.  1
------------------------------------------------------------------------------

         This is a far-field (wide-scale release, multiple site) scenario.
         Release is chronic
         Dose to exposed population of  9.236E+06

         THE FOLLOWING TRANSPORT MODES ARE CONSIDERED
              Air

         THE FOLLOWING EXPOSURE PATHS ARE CONSIDERED:
              Finite plume, external
              Ground, external
              Inhalation uptake
              Terrestrial foods ingestion
              Animal product ingestion
              Inadvertent soil ingestion

         THE FOLLOWING TIMES ARE USED:
              Intake ends after (yr):                  50.0
              Dose calculations ends after (yr):       50.0
              Release ends after (yr):                  1.0

========== FILENAMES AND TITLES OF FILES/LIBRARIES USED =====================

Input file name: \GENII\BASELINE.in                                  2-23-92
GENII DEFAULT PARAMETER VALUES                                       2-23-92
Radionuclide Master Library   (11/28/90 RAP)                        11-29-90
INEL GENII Food Transfer Factor Library - (ASR 15-May-90)            5-17-90
External Dose Factors for GENII in person Sv/yr per Bq/n (8-May-90 R 5-08-90
Internal Dose Increments, Worst Case Solubilities, 12/3/90 PDR      12-03-90
EXTGAM - Gamma Energies by Group for Finite Plume (13-May-90 RAP)    5-14-90
BOMARC POPULATION DISTRIBUTION - 1995 PROJECTION
McGuire Annual Star Data

==============================================================================

         -------- ----Release Terms------
         Release          Surface Buried
         Radio-   Air     Water   Source
         nuclide  uCi/yr  uCi/yr  uCi/m3
         -------- ------- ------- -------
         PU239    3.0E+02 0.0E+00 0.0E+00
         AM241    5.1E+01 0.0E+00 0.0E+00

========== AIR TRANSPORT =====================================================
         Joint frequency data input.
         Ground level release.

========== EXTERNAL EXPOSURE =================================================
 8.8E+03 Hours of exposure to plume
 2.9E+03 Hours of exposure to ground contamination

========== INHALATION ========================================================
 8.8E+03 Hours of inhalation exposure per year
       1 Resuspension model:  1-Mass Loading, 2-Anspaugh
 1.0E-04 Mass loading factor (g/m3)
```

========== INGESTION POPULATION ==========

1 Atmospheric production definition: 1 - Use population-weighted chi/Q

Food production in region assumed to equal consumption.

========== TERRESTRIAL FOOD INGESTION ==========

FOOD TYPE	GROW TIME d	--IRRIGATION-- S *	RATE in/yr	TIME mo/yr	YIELD kg/m2	PROD-UCTION kg/yr	--CONSUMPTION-- HOLDUP d	RATE kg/yr
Leaf Veg	90.0	0	0.0	0.0	1.5		14.0	1.5E+01
Oth. Veg	90.0	0	0.0	0.0	4.0		14.0	1.4E+02
Fruit	90.0	0	0.0	0.0	2.0		14.0	6.4E+01
Cereals	90.0	0	0.0	0.0	0.8		180.0	7.2E+01

========== ANIMAL FOOD INGESTION ==========

FOOD TYPE	---HUMAN---- CONSUMPTION RATE kg/yr	HOLDUP d	TOTAL PROD-UCTION kg/yr	DRINK WATER CONTAM FRACT.	DIET FRAC-TION	GROW TIME d	-IRRIGATION-- S *	RATE in/yr	TIME mo/yr	YIELD kg/m3	STOR-AGE d
					---STORED FEED---						
Meat	7.0E+01	34.0		0.00	0.3	90.00	0	0.0	0.0	0.80	180.0
Poultry	8.5E+00	34.0		0.00	1.0	90.00	0	0.0	0.0	0.80	180.0
Cow Milk	2.3E+02	4.0		0.00	0.3	45.00	0	0.0	0.0	2.00	100.0
Eggs	2.0E+01	18.0		0.00	1.0	90.00	0	0.0	0.0	0.80	180.0
					---FRESH FORAGE---						
Meat					0.75	45.0	0	0.0	0.0	2.00	100.0
Cow Milk					0.75	30.0	0	0.0	0.0	1.50	0.0

==========

Input prepared by: ______________________ Date: __________

Input checked by: ______________________ Date: __________

==========

6.4E-02 Population-weighted chi/Q

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: BOMARC: 1995 POPULATION DOSE - BASELINE ASSESSMENT
Executed on: 04/23/92 at 15:28:22 Page C. 1

Release period:	1.0
Uptake/exposure period:	50.0
Dose commitment period:	50.0
Dose units:	Person rem

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	7.0E-01	2.5E-01	1.8E-01
Breast	2.1E-05	1.5E-01	3.2E-06
R Marrow	3.9E+00	1.2E-01	4.7E-01
Lung	3.7E-01	1.2E-01	4.4E-02
Thyroid	2.1E-05	3.0E-02	6.4E-07
Bone Sur	5.1E+01	3.0E-02	1.5E+00
Liver	8.8E+00	6.0E-02	5.3E-01
LL Int.	6.1E-03	6.0E-02	3.7E-04
UL Int.	2.0E-03	6.0E-02	1.2E-04
S Int.	3.7E-04	6.0E-02	2.2E-05
Stomach	1.6E-04	6.0E-02	9.5E-06
Internal Effective Dose Equivalent			2.7E+00
External Dose			1.3E-07
Annual Effective Dose Equivalent			2.7E+00

Controlling Organ:	Bone Sur
Controlling Pathway:	Inh
Controlling Radionuclide:	PU239
Total Inhalation EDE:	2.6E+00
Total Ingestion EDE:	9.9E-02

```
Release period:                                          1.0
Uptake/exposure period:                                 50.0
Dose commitment period:                                 50.0
Dose units:                                          Person rem


              Dose Commitment Year
                    1          2          3        ...

Internal   :  |
Intake     :  |
Year:      3  |                       3.7E-04      ...
              |                          +
           2  |            3.7E-04    3.1E-04      ...              Internal
              |               +          +                          Effective
           1  | 1.2E-01 + 8.0E-02 + 7.9E-02 + ...  =  2.7E+00       Dose
                                                                     Equivalent
                 ||         ||         ||
Internal                                                            Cumulative
Annual        1.2E-01 + 8.0E-02 + 7.9E-02 + ...  =  3.0E+00         Internal
Dose                                                                Dose
                 +          +          +                 +
External
Annual        1.3E-07    1.2E-07    1.2E-07      ...    5.6E-06
Dose
                 ||         ||         ||                ||
Annual                                                              Cumulative
Dose          1.2E-01 + 8.0E-02 + 7.9E-02 + ...  =  3.0E+00         Dose

                                                                     Maximum
                                                    1.2E-01         Annual
                                                                     Dose Occurred
                                                                     In Year  1
```

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: BOMARC: 1995 POPULATION DOSE - BASELINE ASSESSMENT
Executed on: 04/23/92 at 15:28:22 Page C. 3

Release period:	1.0
Uptake/exposure period:	50.0
Dose commitment period:	50.0
Dose units:	Person rem

Committed Dose Equivalent by Exposure Pathway

Pathway	Lung	Stomach	S Int.	UL Int.	LL Int.	Bone Su	R Marro	Testes
Inhale	3.7E-01	3.4E-05	5.5E-05	2.2E-04	6.4E-04	4.9E+01	3.8E+00	6.8E-01
Leaf Veg	1.2E-07	1.8E-05	4.6E-05	2.6E-04	8.1E-04	2.7E-01	2.1E-02	3.8E-03
Oth. Veg	2.0E-07	3.2E-05	8.0E-05	4.5E-04	1.4E-03	4.7E-01	3.7E-02	6.6E-03
Fruit	6.4E-08	1.0E-05	2.5E-05	1.4E-04	4.4E-04	1.5E-01	1.2E-02	2.1E-03
Cereals	4.1E-07	6.4E-05	1.6E-04	9.1E-04	2.8E-03	9.4E-01	7.3E-02	1.3E-02
Meat	5.3E-11	7.8E-09	2.0E-08	1.1E-07	3.5E-07	1.1E-04	8.8E-06	1.6E-06
Poultry	2.5E-13	3.8E-11	9.6E-11	5.5E-10	1.7E-09	5.7E-07	4.4E-08	7.9E-09
Cow Milk	1.6E-11	2.4E-09	6.0E-09	3.4E-08	1.1E-07	3.5E-05	2.7E-06	4.8E-07
Eggs	2.9E-11	4.6E-09	1.1E-08	6.5E-08	2.0E-07	6.8E-05	5.3E-06	9.4E-07
Soil Ing	4.4E-10	6.8E-08	1.7E-07	9.7E-07	3.0E-06	1.0E-03	7.9E-05	1.4E-05
Total	3.7E-01	1.6E-04	3.7E-04	2.0E-03	6.1E-03	5.1E+01	3.9E+00	7.0E-01

Pathway	Ovaries	Muscle	Thyroid	Liver
Inhale	6.7E-01	2.1E-05	2.1E-05	8.5E+00
Leaf Veg	3.8E-03	1.3E-07	1.2E-07	4.8E-02
Oth. Veg	6.5E-03	2.2E-07	2.0E-07	8.3E-02
Fruit	2.1E-03	6.9E-08	6.3E-08	2.6E-02
Cereals	1.3E-02	4.6E-07	4.0E-07	1.7E-01
Meat	1.6E-06	6.6E-11	4.9E-11	2.0E-05
Poultry	7.8E-09	2.7E-13	2.4E-13	9.9E-08
Cow Milk	4.8E-07	1.9E-11	1.5E-11	6.1E-06
Eggs	9.4E-07	3.2E-11	2.9E-11	1.2E-05
Soil Ing	1.4E-05	4.7E-10	4.3E-10	1.8E-04
Total	7.0E-01	2.1E-05	2.1E-05	8.8E+00

Release period:	1.0
Uptake/exposure period:	50.0
Dose commitment period:	50.0
Dose units:	Person rem

External Dose by Exposure Pathway

Pathway	
Plume	1.0E-08
Sur Soil	1.2E-07
Total	1.3E-07

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: BOMARC: 1995 POPULATION DOSE - BASELINE ASSESSMENT
Executed on: 04/23/92 at 15:28:22 Page C. 5

Release period:	1.0
Uptake/exposure period:	50.0
Dose commitment period:	50.0
Dose units:	Person rem

Cumulative Internal Dose to Organs by Exposure Pathway

Pathway	Lung	Stomach	S Int.	UL Int.	LL Int.	Bone Su	R Marro	Testes
Inhale	3.7E-01	3.4E-05	5.5E-05	2.2E-04	6.4E-04	4.9E+01	3.8E+00	6.8E-01
Leaf Veg	1.2E-07	1.8E-05	4.6E-05	2.6E-04	8.2E-04	2.7E-01	2.1E-02	3.8E-03
Oth. Veg	2.0E-07	3.2E-05	8.0E-05	4.6E-04	1.4E-03	4.8E-01	3.7E-02	6.6E-03
Fruit	6.4E-08	1.0E-05	2.5E-05	1.4E-04	4.4E-04	1.5E-01	1.2E-02	2.1E-03
Cereals	4.4E-06	6.6E-04	1.7E-03	9.5E-03	2.9E-02	6.0E+00	4.7E-01	7.8E-02
Meat	5.3E-11	7.9E-09	2.0E-08	1.1E-07	3.5E-07	1.1E-04	8.9E-06	1.6E-06
Poultry	2.5E-13	3.8E-11	9.6E-11	5.5E-10	1.7E-09	5.7E-07	4.4E-08	7.9E-09
Cow Milk	1.6E-11	2.4E-09	6.1E-09	3.5E-08	1.1E-07	3.5E-05	2.7E-06	4.9E-07
Eggs	2.9E-11	4.6E-09	1.2E-08	6.6E-08	2.0E-07	6.8E-05	5.3E-06	9.5E-07
Soil Ing	2.1E-08	3.2E-06	8.1E-06	4.6E-05	1.4E-04	2.8E-02	2.1E-03	3.5E-04
Total	3.7E-01	7.6E-04	1.9E-03	1.1E-02	3.3E-02	5.6E+01	4.3E+00	7.7E-01

Pathway	Ovaries	Muscle	Thyroid	Liver
Inhale	6.7E-01	2.1E-05	2.1E-05	8.5E+00
Leaf Veg	3.8E-03	1.3E-07	1.2E-07	4.8E-02
Oth. Veg	6.5E-03	2.2E-07	2.0E-07	8.3E-02
Fruit	2.1E-03	7.0E-08	6.3E-08	2.6E-02
Cereals	7.7E-02	5.3E-06	4.2E-06	1.2E+00
Meat	1.6E-06	6.6E-11	5.0E-11	2.0E-05
Poultry	7.8E-09	2.7E-13	2.4E-13	1.0E-07
Cow Milk	4.8E-07	1.9E-11	1.5E-11	6.2E-06
Eggs	9.4E-07	3.2E-11	2.9E-11	1.2E-05
Soil Ing	3.5E-04	2.2E-08	2.0E-08	5.5E-03
Total	7.6E-01	2.6E-05	2.5E-05	9.9E+00

Release period:	1.0
Uptake/exposure period:	50.0
Dose commitment period:	50.0
Dose units:	Person rem

External Dose by Exposure Pathway

Pathway	
Plume	1.0E-08
Sur Soil	5.6E-06
Total	5.6E-06

Release period:	1.0
Uptake/exposure period:	50.0
Dose commitment period:	50.0
Dose units:	Person rem

Committed Dose Equivalent by Radionuclide

Radionuclide	Lung	Stomach	S Int.	UL Int.	LL Int.	Bone Su	R Marro	Testes
AM 241	5.9E-02	3.0E-05	7.0E-05	3.9E-04	1.2E-03	7.5E+00	5.8E-01	1.0E-01
PU 239	3.1E-01	1.3E-04	3.0E-04	1.6E-03	5.0E-03	4.3E+01	3.3E+00	6.0E-01
Total	3.7E-01	1.6E-04	3.7E-04	2.0E-03	6.1E-03	5.1E+01	3.9E+00	7.0E-01

Radionuclide	Ovaries	Muscle	Thyroid	Liver
AM 241	1.0E-01	3.5E-06	3.3E-06	1.3E+00
PU 239	5.9E-01	1.8E-05	1.8E-05	7.5E+00
Total	7.0E-01	2.1E-05	2.1E-05	8.8E+00

External Dose by Radionuclide

Radionuclide	
AM 241	1.2E-07
PU 239	7.7E-09
Total	1.3E-07

Release period:	1.0
Uptake/exposure period:	50.0
Dose commitment period:	50.0
Dose units:	Person rem

Cumulative Internal Dose to Organs by Radionuclide

Radionuclide	Lung	Stomach	S Int.	UL Int.	LL Int.	Bone Su	R Marro	Testes
AM 241	5.9E-02	3.1E-04	7.9E-04	4.5E-03	1.4E-02	9.8E+00	7.7E-01	1.4E-01
PU 239	3.1E-01	4.5E-04	1.1E-03	6.1E-03	1.9E-02	4.6E+01	3.6E+00	6.3E-01
Total	3.7E-01	7.6E-04	1.9E-03	1.1E-02	3.3E-02	5.6E+01	4.3E+00	7.7E-01

Radionuclide	Ovaries	Muscle	Thyroid	Liver
AM 241	1.3E-01	6.3E-06	5.1E-06	1.8E+00
PU 239	6.3E-01	2.0E-05	2.0E-05	8.1E+00
Total	7.6E-01	2.6E-05	2.5E-05	9.9E+00

External Dose by Radionuclide

Radionuclide	
AM 241	5.3E-06
PU 239	3.2E-07
Total	5.6E-06

APPENDIX J

ANNEX 2

RESRAD SUMMARY OUTPUT - INTRUDER DOSE

BASELINE RADIOLOGICAL HAZARD ASSESSMENT

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Summary : BOMARC BASELINE ASSESSMENT - 80 pCi/g (SUB-AREA 1)
File : C:\BOMARC\AREA1.INP

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Summary : BOMARC BASELINE ASSESSMENT - 80 pCi/g (SUB-AREA 1)
File : C:\BOMARC\AREA1.INP

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	1.600E+04	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	1.524E-01	1.000E+00	---	THICKO
R011	Length parallel to aquifer flow (m)	1.750E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	4.000E+00	1.000E+02	---	BRLD
R011	Time since placement of material (yr)	3.100E+01	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	5.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	5.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+02	1.000E+02	---	T(6)
R011	Times for calculations (yr)	5.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	5.000E+03	3.000E+03	---	T(9)
R011	Times for calculations (yr)	6.000E+03	1.000E+04	---	T(10)
R012	Initial principal radionuclide (pCi/g): Am-241	1.356E+01	0.000E+00	---	S(2)
R012	Initial principal radionuclide (pCi/g): Pu-239	8.000E+01	0.000E+00	---	S(5)
R012	Concentration in groundwater (pCi/L): Am-241	not used	0.000E+00	---	W(2)
R012	Concentration in groundwater (pCi/L): Pu-239	not used	0.000E+00	---	W(5)
R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVERO
R013	Density of cover material (g/cm**3)	not used	1.600E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.600E+00	1.600E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.100E-01	4.000E-01	---	TPCZ
R013	Contaminated zone effective porosity	3.200E-01	2.000E-01	---	EPCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	4.900E+02	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	4.380E+00	5.300E+00	---	BCZ
R013	Evapotranspiration coefficient	6.100E-01	6.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.100E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	0.000E+00	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	5.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06	---	WAREA
R014	Density of saturated zone (g/cm**3)	1.600E+00	1.600E+00	---	DENSAQ
R014	Saturated zone total porosity	4.100E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	3.200E-01	2.000E-01	---	EPSZ
R014	Saturated zone hydraulic conductivity (m/yr)	4.900E+03	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	1.670E-03	2.000E-02	---	HGWT
R014	Saturated zone b parameter	4.380E+00	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	3.600E+00	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Individual's use of groundwater (m**3/yr)	1.500E+02	1.500E+02	---	UW
R015	Number of unsaturated zone strata	1	1	---	NS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R015	Unsat. zone 1, thickness (m)	1.300E+01	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.600E+00	1.600E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	4.100E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	3.200E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	4.380E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	4.900E+03	1.000E+02	---	HCUZ(1)
R016	Distribution coefficients for Am-241				
R016	Contaminated zone (cm**3/g)	4.000E+02	2.000E+01	---	DCACTC(2)
R016	Unsaturated zone 1 (cm**3/g)	4.000E+02	2.000E+01	---	DCACTU(2,1)
R016	Saturated zone (cm**3/g)	4.000E+02	2.000E+01	---	DCACTS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.198E-03	RLEACH(2)
R016	Distribution coefficients for Pu-239				
R016	Contaminated zone (cm**3/g)	2.000E+04	2.000E+03	---	DCACTC(5)
R016	Unsaturated zone 1 (cm**3/g)	2.000E+04	2.000E+03	---	DCACTU(5,1)
R016	Saturated zone (cm**3/g)	2.000E+04	2.000E+03	---	DCACTS(5)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.398E-05	RLEACH(5)
R016	Distribution coefficients for daughter Ac-227				
R016	Contaminated zone (cm**3/g)	2.000E+01	2.000E+01	---	DCACTC(1)
R016	Unsaturated zone 1 (cm**3/g)	2.000E+01	2.000E+01	---	DCACTU(1,1)
R016	Saturated zone (cm**3/g)	2.000E+01	2.000E+01	---	DCACTS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.369E-02	RLEACH(1)
R016	Distribution coefficients for daughter Np-237				
R016	Contaminated zone (cm**3/g)	0.000E+00	0.000E+00	---	DCACTC(3)
R016	Unsaturated zone 1 (cm**3/g)	0.000E+00	0.000E+00	---	DCACTU(3,1)
R016	Saturated zone (cm**3/g)	0.000E+00	0.000E+00	---	DCACTS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	6.626E+00	RLEACH(3)
R016	Distribution coefficients for daughter Pa-231				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCACTC(4)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCACTU(4,1)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCACTS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.755E-02	RLEACH(4)
R016	Distribution coefficients for daughter Th-229				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCACTC(6)
R016	Unsaturated zone 1 (cm**3/g)	6.000E+04	6.000E+04	---	DCACTU(6,1)
R016	Saturated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCACTS(6)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.466E-05	RLEACH(6)
R016	Distribution coefficients for daughter U-233				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCACTC(7)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCACTU(7,1)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCACTS(7)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.755E-02	RLEACH(7)

Summary : BOMARC BASELINE ASSESSMENT - 80 pCi/g (SUB-AREA 1)
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Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for daughter U-235				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCACTC(8)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCACTU(8,1)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCACTS(8)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.755E-02	RLEACH(8)
R017	Inhalation rate (m**3/yr)	7.000E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	2.000E-04	2.000E-04	---	MLINH
R017	Dilution length for airborne dust, inhalation (m)	3.000E+00	3.000E+00	---	LM
R017	Occupancy factor, inhalation	5.500E-01	4.500E-01	---	FO3
R017	Occupancy and shielding factor, external gamma	6.000E-01	6.000E-01	---	FO1
R017	Shape factor, external gamma	-5.000E-01	1.000E+00	Negative shows SOILD used.	FS1
R017	Fractions of annular areas within AREA:				
R017	Outer annular radius (m) = $\sqrt{(1/\pi)}$	1.000E+00	1.000E+00	---	FRACA(1)
R017	Outer annular radius (m) = $\sqrt{(10/\pi)}$	1.000E+00	1.000E+00	---	FRACA(2)
R017	Outer annular radius (m) = $\sqrt{(20/\pi)}$	1.000E+00	1.000E+00	---	FRACA(3)
R017	Outer annular radius (m) = $\sqrt{(50/\pi)}$	9.500E-01	1.000E+00	---	FRACA(4)
R017	Outer annular radius (m) = $\sqrt{(100/\pi)}$	8.000E-01	1.000E+00	---	FRACA(5)
R017	Outer annular radius (m) = $\sqrt{(200/\pi)}$	7.500E-01	1.000E+00	---	FRACA(6)
R017	Outer annular radius (m) = $\sqrt{(500/\pi)}$	6.500E-01	1.000E+00	---	FRACA(7)
R017	Outer annular radius (m) = $\sqrt{(1000/\pi)}$	1.500E-01	1.000E+00	---	FRACA(8)
R017	Outer annular radius (m) = $\sqrt{(5000/\pi)}$	3.000E-02	1.000E+00	---	FRACA(9)
R017	Outer annular radius (m) = $\sqrt{(1.E+04/\pi)}$	2.000E-02	1.000E+00	---	FRACA(10)
R017	Outer annular radius (m) = $\sqrt{(1.E+05/\pi)}$	2.000E-02	0.000E+00	---	FRACA(11)
R017	Outer annular radius (m) = $\sqrt{(1.E+06/\pi)}$	1.000E-02	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	2.870E+01	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	1.400E+01	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	1.020E+02	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	2.630E+01	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	0.000E+00	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	0.000E+00	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	3.500E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	7.000E+02	4.100E+02	---	DWI
R018	Fraction of drinking water from site	1.000E+00	1.000E+00	---	FDW
R018	Fraction of aquatic food from site	0.000E+00	5.000E-01	---	FR9
R019	Livestock fodder intake for meat (kg/day)	6.800E+01	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	5.500E+01	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	5.000E+01	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	1.600E+02	1.600E+02	---	LWI6
R019	Mass loading for foliar deposition (g/m**3)	1.000E-04	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	9.000E-01	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	1.000E+00	1.000E+00	---	FGWDW
R019	Livestock water fraction from ground water	1.000E+00	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	1.000E+00	1.000E+00	---	FGWIR

Summary : BOMARC BASELINE ASSESSMENT - 80 pCi/g (SUB-AREA 1)
File : C:\BOMARC\AREA1.INP

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	1.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	2.000E-08	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average annual wind speed (m/sec)	not used	2.000E+00	---	WIND
R021	Average building air exchange rate (1/hr)	not used	1.000E+00	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	1.000E+00	---	FAI
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR
R021	Building depth below ground surface (m)	not used	1.000E+00	---	DMFL
R021	Fraction of time spent indoors	5.000E-01	5.000E-01	---	FIND
R021	Fraction of time spent outdoors (on site)	2.500E-01	2.500E-01	---	FOTD
R021	Emanating power of Rn-222 gas	not used	2.000E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.000E-01	---	EMANA(2)

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation	active
3 -- plant ingestion	active
4 -- meat ingestion	active
5 -- milk ingestion	active
6 -- aquatic foods	active
7 -- drinking water	active
8 -- radon	suppressed
9 -- soil ingestion	active

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Summary : BOMARC BASELINE ASSESSMENT - 80 pCi/g (SUB-AREA 1)
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Contaminated Zone Dimensions	
Area:	16000.00 square meters
Thickness:	0.15 meters
Cover Depth:	0.00 meters

Initial Soil Concentrations, pCi/g	
Am-241	1.356E+01
Pu-239	8.000E+01

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 4 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	5.000E+00	1.000E+01	5.000E+01	1.000E+02	5.000E+02	1.000E+03	5.000E+03	6.000E+03
TDOSE(t):	4.740E+01	4.736E+01	4.642E+01	4.471E+01	3.144E+01	1.571E+01	0.000E+00	0.000E+00	0.000E+00	8.227E-04
M(t):	1.185E+01	1.184E+01	1.161E+01	1.118E+01	7.860E+00	3.928E+00	0.000E+00	0.000E+00	0.000E+00	2.057E-04

Maximum TDOSE(t): 4.740E+01 mrem/yr at t = 0.000E+00 years

Summary : BOMARC BASELINE ASSESSMENT - 80 pCi/g (SUB-AREA 1)
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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways

Radio-	Ground		Dust		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	9.449E-02	0.0020	5.304E+00	0.1119	0.000E+00	0.0000	7.073E-02	0.0015	3.070E-02	0.0006	4.815E-05	0.0000	1.602E+00	0.0338
Pu-239	5.514E-03	0.0001	3.069E+01	0.6475	0.000E+00	0.0000	3.987E-01	0.0084	1.731E-01	0.0037	2.714E-06	0.0000	9.030E+00	0.1905
Total	1.000E-01	0.0021	3.599E+01	0.7594	0.000E+00	0.0000	4.695E-01	0.0099	2.038E-01	0.0043	5.086E-05	0.0000	1.063E+01	0.2243

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.101E+00	0.1498
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.030E+01	0.8502
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.740E+01	1.0000

*Sum of all water independent and dependent pathways.

Summary : BOMARC BASELINE ASSESSMENT - 80 pCi/g (SUB-AREA 1)
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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways

Radio-Nuclide	Ground mrem/yr	Ground fract.	Dust mrem/yr	Dust fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil fract.
Am-241	9.413E-02	0.0020	5.284E+00	0.1116	0.000E+00	0.0000	7.010E-02	0.0015	3.046E-02	0.0006	4.778E-05	0.0000	1.596E+00	0.0337
Pu-239	5.510E-03	0.0001	3.069E+01	0.6479	0.000E+00	0.0000	3.967E-01	0.0084	1.724E-01	0.0036	2.704E-06	0.0000	9.029E+00	0.1906
Total	9.964E-02	0.0021	3.597E+01	0.7594	0.000E+00	0.0000	4.668E-01	0.0099	2.028E-01	0.0043	5.048E-05	0.0000	1.063E+01	0.2243

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.074E+00	0.1494
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.029E+01	0.8506
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.736E+01	1.0000

*Sum of all water independent and dependent pathways.

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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+00 years

Water Independent Pathways

Radio-Nuclide	Ground		Dust		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	9.271E-02	0.0020	5.114E+00	0.1102	0.000E+00	0.0000	6.736E-02	0.0015	2.932E-02	0.0006	4.599E-05	0.0000	1.544E+00	0.0333
Pu-239	5.491E-03	0.0001	3.015E+01	0.6494	0.000E+00	0.0000	3.869E-01	0.0083	1.684E-01	0.0036	2.641E-06	0.0000	8.870E+00	0.1911
Total	9.820E-02	0.0021	3.526E+01	0.7595	0.000E+00	0.0000	4.542E-01	0.0098	1.977E-01	0.0043	4.863E-05	0.0000	1.041E+01	0.2243

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+00 years

Water Dependent Pathways

Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.847E+00	0.1475
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.958E+01	0.8525
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.642E+01	1.0000

*Sum of all water independent and dependent pathways.

Summary : BOMARC BASELINE ASSESSMENT - 80 pCi/g (SUB-AREA 1)
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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Independent Pathways

Radio-Nuclide	Ground mrem/yr	Ground fract.	Dust mrem/yr	Dust fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil fract.
Am-241	9.097E-02	0.0020	4.847E+00	0.1084	0.000E+00	0.0000	6.385E-02	0.0014	2.779E-02	0.0006	4.359E-05	0.0000	1.464E+00	0.0327
Pu-239	5.467E-03	0.0001	2.911E+01	0.6511	0.000E+00	0.0000	3.736E-01	0.0084	1.626E-01	0.0036	2.551E-06	0.0000	8.566E+00	0.1916
Total	9.643E-02	0.0022	3.396E+01	0.7595	0.000E+00	0.0000	4.375E-01	0.0098	1.904E-01	0.0043	4.614E-05	0.0000	1.003E+01	0.2243

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.494E+00	0.1452
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.822E+01	0.8548
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.471E+01	1.0000

*Sum of all water independent and dependent pathways.

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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+01 years

Water Independent Pathways

Radio-Nuclide	Ground mrem/yr	Ground fract.	Dust mrem/yr	Dust fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil fract.
Am-241	7.812E-02	0.0025	2.994E+00	0.0952	0.000E+00	0.0000	3.944E-02	0.0013	1.717E-02	0.0005	2.693E-05	0.0000	9.043E-01	0.0288
Pu-239	5.190E-03	0.0002	2.087E+01	0.6639	0.000E+00	0.0000	2.679E-01	0.0085	1.166E-01	0.0037	1.829E-06	0.0000	6.142E+00	0.1954
Total	8.331E-02	0.0026	2.387E+01	0.7592	0.000E+00	0.0000	3.073E-01	0.0098	1.338E-01	0.0043	2.876E-05	0.0000	7.046E+00	0.2241

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+01 years

Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.033E+00	0.1283
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.741E+01	0.8717
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.144E+01	1.0000

*Sum of all water independent and dependent pathways.

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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways

Radio-Nuclide	Ground		Dust		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	6.327E-02	0.0040	1.267E+00	0.0806	0.000E+00	0.0000	1.669E-02	0.0011	7.265E-03	0.0005	1.139E-05	0.0000	3.827E-01	0.0244
Pu-239	4.408E-03	0.0003	1.064E+01	0.6774	0.000E+00	0.0000	1.366E-01	0.0087	5.945E-02	0.0038	9.328E-07	0.0000	3.132E+00	0.1993
Total	6.767E-02	0.0043	1.191E+01	0.7580	0.000E+00	0.0000	1.533E-01	0.0098	6.672E-02	0.0042	1.233E-05	0.0000	3.514E+00	0.2237

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.737E+00	0.1106
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.397E+01	0.8894
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.571E+01	1.0000

*Sum of all water independent and dependent pathways.

Summary : BOMARC BASELINE ASSESSMENT - 80 pCi/g (SUB-AREA 1)
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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+02 years

Water Independent Pathways

Radio-	Ground		Dust		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

*Sum of all water independent and dependent pathways.

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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways

Radio-	Ground		Dust		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

*Sum of all water independent and dependent pathways.

Summary : BOMARC BASELINE ASSESSMENT - 80 pCi/g (SUB-AREA 1)
File : C:\BOMARC\AREA1.INP

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+03 years

Water Independent Pathways

Radio-	Ground		Dust		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

*Sum of all water independent and dependent pathways.

Summary : BOMARC BASELINE ASSESSMENT - 80 pCi/g (SUB-AREA 1)
File : C:\BOMARC\AREA1.INP

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 6.000E+03 years

Water Independent Pathways

Radio-	Ground		Dust		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 6.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Am-241	5.026E-04	0.6109	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.777E-06	0.0046	5.624E-06	0.0068	5.120E-04	0.6223
Pu-239	3.075E-04	0.3738	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.311E-06	0.0028	9.2[illegible]1E-07	0.0011	3.107E-04	0.3777
Total	8.101E-04	0.9846	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.087E-06	0.0074	6.552E-06	0.0080	8.227E-04	1.0000

*Sum of all water independent and dependent pathways.

Summary : BOMARC BASELINE ASSESSMENT - 80 pCi/g (SUB-AREA 1)
File : C:\BOMARC\AREA1.INP

Dose/Source Ratios Summed Over All Pathways, (mrem/yr)/(pCi/g)

Nuclide (i)	t= 0.000E+00	1.000E+00	5.000E+00	1.000E+01	5.000E+01	1.000E+02	5.000E+02	1.000E+03	5.000E+03	6.000E+03
Am-241	5.237E-01	5.217E-01	5.050E-01	4.789E-01	2.974E-01	1.281E-01	0.000E+00	0.000E+00	0.000E+00	3.776E-05
Pu-239	5.037E-01	5.036E-01	4.947E-01	4.778E-01	3.426E-01	1.747E-01	0.000E+00	0.000E+00	0.000E+00	3.884E-06

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 4 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+00	5.000E+00	1.000E+01	5.000E+01	1.000E+02	5.000E+02	1.000E+03	5.000E+03	6.000E+03
Am-241	7.638E+00	7.668E+00	7.921E+00	8.353E+00	1.345E+01	3.123E+01	*3.424E+12	*3.424E+12	*3.424E+12	1.059E+05
Pu-239	7.941E+00	7.942E+00	8.086E+00	8.373E+00	1.168E+01	2.290E+01	*6.203E+10	*6.203E+10	*6.203E+10	1.030E+06

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial pCi/g	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Am-241	1.356E+01	0.000E+00	5.237E-01	7.638E+00	5.237E-01	7.638E+00
Pu-239	8.000E+01	0.000E+00	5.037E-01	7.941E+00	5.037E-01	7.941E+00

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APPENDIX K

INSITU GAMMA RAY MEASUREMENTS AT THE BOMARC MISSILE SITE

SAIC-89/1621

In-Situ Gamma Ray Measurements At The BOMARC Missile Site

Science Applications International Corporation

October 26, 1989

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SECTION 1
INTRODUCTION

Gamma Spectroscopy Was Used To Determine The Location And Approximate Concentration Of Radioactivity At The BOMARC Missile Site

This report describes the equipment and methods used to perform the in-situ gamma ray measurements at the BOMARC missile site. Included is a discussion of the calibration and measurement techniques.

Section 1 is an introduction to the report. Section 2 describes the equipment used for the project. The detector efficiency calibrations are discussed in section 3, and section 4 reports on the experiments used to test the measurement technique and their results. Section 5 is concerned with the actual measurements, the location and results, as well as the measurements of the soil samples and core samples. Section 6 is a summary and conclusion for this report.

This report describes the in-situ gamma ray measurements, equipment calibration and measurement techniques, as well as listing the results of the survey.

SECTION 2
EQUIPMENT AND METHODOLOGY

Low Energy Photon Detectors Were Used To Acquire The Gamma Ray Spectra

The area on and around the BOMARC missile site was contaminated with Plutonium-239 and Americium-241. It was necessary to use a method that would detect the plutonium in concentrations less than 0.2 uCi per square meter.

We chose to look for the 60 kev gamma ray of the Am-241 because of the greater energy and penetrating power. We felt that after 30 years the plutonium would have migrated deeply enough into the soil that the low energies of radiation would be essentially completely absorbed by the soil.

The 60 kev gamma ray is low enough in energy that it undergoes significant absorption in the endcaps of conventional germanium detectors. This makes it difficult to achieve the desired sensitivity for field measurements. To increase counting efficiency, we acquired two low energy photon detectors with thin beryllium windows designed to measure x-ray and gamma radiation in the range in which we were interested.

The electricity for the detectors was supplied by a portable gas powered generator. The electrical power was run through a power conditioner to prevent variations in current and voltage from damaging the equipment. The high voltage power supply and amplifier for each detector were standard NIM modules mounted in NIM bins. The signal was processed using an analog to digital converter (ADC) and multichannel analyzer (MCA) on board an IBM compatible portable computer.

The spectra were analyzed using comercially available software prepared by Nuclear Data Corporation (now part of Canberra Industries Inc.).

There was a need to determine the area of ground surface at which the detector would actually be looking and to mount the detector so that it would be positioned the same for every measurement. We designed and built a lead shield to act as a collimator and to define the area from which the detector could receive activity. The area that was actually measured was approximately 12.57 square meters, or a circle 4 meters in diameter. Radiation at the energy of interest from outside this circle would be absorbed by the lead shield. The detector and shield were suspended 4 feet above the ground from a table designed for the purpose.

SECTION 3
EFFICIENCY CALIBRATION

The Detector Efficiencies Were Determined Using A Mathematical Model Of Calibration For Extended Sources

The absolute efficiency of a gamma ray detector is defined as the ratio of the number of counts a detector produces to the the number of gamma rays that the source emits (counts/gamma). The method of calibration for most applications is to prepare a source exactly like the samples to be measured containing a known amount of radioactivity, and then measure the prepared source and calculate the efficiency. This method proved impractical for the in-situ measurements.

The low energy photon detectors were calibrated using a NIST traceable mixed nuclide point source, and the efficiencies were calculated according to the method described in A Technique of Gamma-Ray Detector Absolute Efficiency Calibration for Extended Sources, J. E. Cline, Science Applications International Corporation (1978). The point source is measured at several locations around the detector to determine how the efficiency changes as the distance from the detector changes. These detector responses are represented by equations, which can then be used to calculate efficiencies for any regularly shaped object of known size and composition.

A problem with this method, or any other, is that the activity for these in-situ measurements was expected to be in discrete particles randomly distributed throughout the soil. We were forced to make an assumption that the activity was evenly distributed throughout the area that we were scanning, a circle of radius 2 meters and 5 centimeters deep. If the activity detected is from a single particle directly under the detector, the actual activity will be lower than the reported result. If the activity is from a single particle at the edge of the area being scanned or buried very deep in the ground (>5 cm), the actual activity will be greater than the reported result.

In addition, the assumed depth distribution influences the counting efficiency as well as the calculated contamination levels. If the activity were distributed evenly over the surface (i.e. zero depth distribution) the actual activity would be 0.66 of that reported for the assumed distribution. If the activity were evenly distributed throughout the top 15 centimeters, the actual activity would be 1.9 times that reported for the assumed distribution.

The benefits of using this method of calibration are that the efficiency can be calculated using any parameters for the size and composition of the sample. We were also able to measure the activity for the surface soils and cores of soil as well as concrete and asphalt to obtain preliminary results on these samples before they were shipped for analysis in a laboratory without any further calibration measurements.

SECTION 4
METHOD VERIFICATION

The Measurement Technique Was Successfully Tested At SAIC's Rockville Office

Using calculations we were able to show that we could theoretically detect Am-241 in the required concentrations using our equipment. We performed some experiments to show that the technique would work in the field.

A point source of Am-241 containing 8 uCi of activity was positioned at various locations around the detector and buried at various depths below the surface. Table 1 shows the location, depth below the surface, and the length of time the sample was counted to detect the activity with less than 50 per cent uncertainty at the 95 per cent confidence level.

Table 1
In-Situ Measurement Experiments

		Distance From Center Of Sample Area		
		0 meters	1 meter	2 meters
	0 cm	100 sec.	100 sec.	100 sec.
Depth	2.5 cm	100 sec.	100 sec.	1000 sec.
	5 cm	300 sec.	1000 sec.	3000 sec.

Count Times Required To Detect 8 uCi Of Am-241

Based on the results of these experiments and the calculations using theoretical backgrounds and efficiencies, we determined that a 3000 second count time would be sufficient for each of the in-situ measurements.

SECTION 5
DATA COLLECTION AND RESULTS

Over 400 Gamma Ray Analyses Were Performed To Complete The In-Situ Measurements

The first step in performing the measurements was to determine the locations to be measured. A grid was laid out with points to be gamma scanned every 60 feet. Map 1 shows the location of all of the points measured during the in-situ survey. The points on the map try to approximate the actual locations of the points that were measured, and in some cases are difficult to determine the identity of the point. To accurately identify a point locate the East-West line that the point is located in. For points inside the fence, start with the letter Z and move backwards through the alphabet as you move east on the map until you reach the desired point. For points outside the fence start with the letter A and move forwards through the alphabet as you move west on the map until you reach the desired point. The East-West lines should be easily identified by the numbers along the bottom of the page. All points that contained measureable quantities of Am-241 are circled on Map 1.

The measurements on-site, or inside the fence, showed that the activity was mostly inside the concertina wire or had been washed down the ditch following the water drainage. The only anomaly is point 99T. Some activity can be seen following the water drainage north as well as the main path to the south. Map 2 clearly shows the drainage ditch heading south and exiting the site where the drain goes under the fence. The largest concentration of activity is located at the edge of the pavement where the drainage from the road first enters the ditch. Another high activity area is directly east of the concrete apron, where the original decontamination may have taken place. Building 208 is shown as contaminated. This is where radioactive waste from previous surveys is presently being stored. The results of all of the on-site measurements are included in the second part of Table 2.

The off-site measurements, or outside the fence, show most of the activity collected in the ponding area across the road on the firing range. There is a small spot of high activity just north of the ditch after it crosses the road. The remainder of the activity across the road is in the low lying area between the road and a low ridge to the east of the ponding area. There was no activity in the dirt road leading west into the firing range (lines 36 and 37), but activity appears again south of the dirt road and follows the drainage towards the ditch going east under Route 539. There was no activity detected in the ditch on the east side of Route 539 south of the site.

There are patches of activity outside the fence on the east side of Route 539 directly west of the site. Some activity follows the water drainage from the site towards the transformer. The transformer size and location are not accurate on these maps, the measurement for point 19B is actually outside of the fenced in area. From the transformer the activity follows along the north edge of the paved driveway but stops before it reaches the road. There is also a small amount of activity at point 36F just south of where the ditch going west passes under Route 539. The remainder of the activity is located in the center of the woods. Line 11 shows a spot where activity is apparently coming across the fence. Line 13 shows a line of activity that stops before it reaches the road. Line 12 is along the top of a ridge through the woods and contains no measureable activity. There are two points in line 17 that showed some measureable activity also. The results of all of the off-site measurements are included in the first part of Table 2.

There were 23 points measured inside the fence that were not part of the grid. These points are identified on Map 1 as ES followed by a number. These were areas identified in previous surveys or by high background readings as potential areas of activity. ES9 and ES23 were the only two points that contained measureable Am-241 activity. ES9 was just outside the concertina wire behind building 212. ES23 was a drain behind building 202 that goes under West Von Braun Drive and leads to the drainage ditch heading north. The results for all of these extra points are listed at the end of Table 2.

The other measurements performed at the site were short counts (300-1000 seconds) on all of the samples that were to be shipped off site for additional analyses except the surface waters. The cement and asphalt cores were also scanned to determine the activity on the surface and between the layers of cement. Some of the cores were damaged or otherwise affected so that it was difficult to determine which end was the top and which end was the bottom, and some of the results may be reversed. All of the results on these samples are listed in tables 3 through 13.

SECTION 6
SUMMARY AND CONCLUSION

The results for all of the gamma scans for the in-situ survey were calculated using Nuclear Data software. The counting efficiencies and therefore absolute numerical results, were based on an assumption of uniform lateral distribution throughout the areas surveyed and uniform depth distribution to 5 cm.

The data in Figures 1 and 2 and Tables 1 and 2 show the distribution and relative quantities of contamination in the areas of interest. Absence of observed contamination in some areas (e.g., 12A, B and/or C) may not mean that contamination is not present but simply that it may have been covered with uncontaminated fill or cover material. Data reported in Tables 3 through 13 are for actual samples. These data were collected for screening purposes. The counting efficiencies used to obtain quantitative data assumed uniform distribution throughout the sample.

There were no background corrections performed. Backgrounds were collected at four points on the site behind buildings 111 and 113. Two spots are in a road and two spots are over soil. These points are marked on Map 1 with an X. No background activity was detected in the 60 kev region.

All of the spectra were visually checked to verify the presence or absence of peaks at 60 kev as well as at 14 kev. No activity was present in any of the spectra at 14 kev.

The work performed by personnel from the Rockville office of SAIC was completed using a quality assurance program based on USNRC Regulatory Guide 4.15.

Table 2
IN-SITU MEASUREMENTS
OUTSIDE THE FENCE

SAMPLE LOCATION	AM-241 ACTIVITY (uCi/sq. meter)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sq. meter)
1A	< 1.31E-02		< 7.86E-02
2A	< 7.29E-03		< 4.37E-02
3A	< 8.11E-03		< 4.87E-02
4A	< 1.23E-02		< 7.38E-02
5A	< 1.34E-02		< 8.04E-02
6A	< 8.73E-03		< 5.24E-02
7A	< 8.13E-03		< 4.88E-02
8A	< 1.11E-02		< 6.66E-02
9A	< 1.10E-02		< 6.60E-02
10A	< 7.89E-03		< 4.73E-02
11A	2.38E-02	57.4	1.43E-01
12A	< 1.05E-02		< 6.30E-02
13A	< 1.03E-02		< 6.18E-02
14A	< 8.73E-02		< 5.24E-01
15A	< 1.26E-02		< 7.56E-02
16A	< 8.31E-02		< 4.99E-01
17A	< 1.18E-02		< 7.08E-02
18A	8.89E-02	18.8	5.33E-01
19A	< 1.08E-02		< 6.48E-02
20A	< 7.89E-03		< 4.73E-02
21A	< 7.76E-03		< 4.66E-02
22A	< 1.05E-02		< 6.30E-02
3B	< 1.24E-02		< 7.44E-02
4B	< 1.26E-02		< 7.56E-02
5B	< 1.13E-02		< 6.78E-02
6B	< 1.08E-02		< 6.48E-02
7B	< 1.10E-02		< 6.60E-02
8B	< 8.73E-03		< 5.24E-02
9B	< 1.08E-02		< 6.48E-02
10B	5.55E-02	34.6	3.33E-01
11B	7.73E-02	21.4	4.64E-01
12B	< 8.45E-03		< 5.07E-02
13B	6.48E-02	27.6	3.89E-01
14B	< 8.47E-03		< 5.08E-02
15B	3.58E-02	40.4	2.15E-01
16B	< 9.16E-03		< 5.50E-02
17B	< 7.91E-03		< 4.75E-02
18B	< 6.54E-03		< 3.92E-02
19B	< 1.10E-02		< 6.60E-02
20B	6.42E-02	23.2	3.85E-01
21B	< 8.13E-03		< 4.88E-02
22B	< 6.54E-03		< 3.92E-02

Table 2 (Cont.)
IN-SITU MEASUREMENTS
OUTSIDE THE FENCE

SAMPLE LOCATION	AM-241 ACTIVITY (uCi/sq. meter)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sq. meter)
7C	< 7.60E-03		< 4.56E-02
8C	< 6.23E-03		< 3.74E-02
9C	< 8.28E-03		< 4.97E-02
10C	< 6.23E-03		< 3.74E-02
11C	< 9.12E-03		< 5.47E-02
12C	< 8.90E-03		< 5.34E-02
13C	8.21E-02	28.6	4.93E-01
14C	2.29E-02	80	1.37E-01
15C	5.66E-02	41.2	3.40E-01
16C	< 1.29E-02		< 7.74E-02
17C	< 1.14E-02		< 6.84E-02
18C	< 8.93E-03		< 5.36E-02
19C	2.57E-02	68.4	1.54E-01
20C	2.89E-01	10	1.73E+00
21C	< 9.83E-03		< 5.90E-02
22C	< 1.13E-02		< 6.75E-02
23C	< 8.06E-03		< 4.84E-02
10D	< 1.06E-02		< 6.36E-02
11D	< 9.56E-03		< 5.74E-02
12D	< 9.06E-03		< 5.44E-02
13D	5.93E-02	30.6	3.56E-01
14D	1.69E-02	78.6	1.01E-01
15D	< 8.23E-03		< 4.94E-02
16D	< 7.52E-03		< 4.51E-02
17D	4.14E-02	37.4	2.48E-01
18D	< 6.54E-03		< 3.92E-02
19D	< 1.22E-02		< 7.32E-02
20D	8.75E-02	29.2	5.25E-01
21D	< 6.54E-03		< 3.92E-02
22D	< 1.10E-02		< 6.60E-02
23D	< 8.32E-03		< 4.99E-02
24D	< 1.10E-02		< 6.60E-02

Table 2 (Cont.)
IN-SITU MEASUREMENTS
OUTSIDE THE FENCE

SAMPLE LOCATION	AM-241 ACTIVITY (uCi/sq. meter)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sq. meter)
10E	< 1.28E-02		< 7.68E-02
11E	< 2.32E-02		< 1.39E-01
12E	< 1.29E-02		< 7.74E-02
13E	3.48E-02	39.8	2.09E-01
14E	< 9.65E-03		< 5.79E-02
15E	< 1.20E-02		< 7.20E-02
16E	< 1.20E-02		< 7.20E-02
17E	2.76E-02	39.2	1.66E-01
18E	< 8.23E-03		< 4.94E-02
19E	< 1.20E-02		< 7.20E-02
20E	1.18E-01	19.8	7.08E-01
21E	< 1.13E-02		< 6.78E-02
22E	< 1.12E-02		< 6.72E-02
23E	< 8.04E-03		< 4.82E-02
24E	< 6.54E-03		< 3.92E-02
25E	< 8.30E-03		< 4.98E-02
26E	< 9.55E-03		< 5.73E-02
41E	< 9.95E-03		< 5.97E-02
10F	< 1.14E-02		< 6.84E-02
11F	< 9.28E-03		< 5.57E-02
12F	< 9.49E-03		< 5.69E-02
13F	< 8.34E-03		< 5.00E-02
14F	< 1.20E-02		< 7.20E-02
15F	< 8.58E-03		< 5.15E-02
16F	< 8.19E-03		< 4.91E-02
17F	< 7.83E-03		< 4.70E-02
18F	< 7.96E-03		< 4.78E-02
19F	< 7.76E-03		< 4.66E-02
20F	< 7.91E-03		< 4.75E-02
21F	< 7.47E-03		< 4.48E-02
22F	< 1.20E-02		< 7.20E-02
23F	< 6.54E-03		< 3.92E-02
24F	< 1.10E-02		< 6.60E-02
25F	< 1.02E-02		< 6.12E-02
26F	3.32E-02	61.8	1.99E-01
27F	< 7.81E-03		< 4.69E-02
28F	< 9.57E-03		< 5.74E-02
29F	< 8.87E-03		< 5.32E-02
30F	< 9.70E-03		< 5.82E-02
41F	< 9.23E-03		< 5.54E-02

Table 2 (Cont.)
IN-SITU MEASUREMENTS
OUTSIDE THE FENCE

SAMPLE LOCATION	AM-241 ACTIVITY (uCi/sq. meter)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sq. meter)
18G	< 1.07E-02		< 6.42E-02
19G	< 7.92E-03		< 4.75E-02
20G	< 8.73E-03		< 5.24E-02
21G	< 8.78E-03		< 5.27E-02
22G	< 7.87E-03		< 4.72E-02
23G	< 8.65E-03		< 5.19E-02
24G	< 1.16E-02		< 6.96E-02
25G	< 7.60E-03		< 4.56E-02
26G	< 6.54E-03		< 3.92E-02
27G	< 9.86E-03		< 5.92E-02
28G	< 7.98E-03		< 4.79E-02
29G	< 7.78E-03		< 4.67E-02
30G	< 9.20E-03		< 5.52E-02
40G	< 6.71E-03		< 4.03E-02
41G	< 1.86E-02		< 1.12E-01
42G	< 8.37E-03		< 5.02E-02
19H	< 7.88E-03		< 4.73E-02
20H	< 1.12E-02		< 6.72E-02
21H	< 1.16E-02		< 6.96E-02
22H	< 8.77E-03		< 5.26E-02
23H	< 6.54E-03		< 3.92E-02
24H	< 8.43E-03		< 5.06E-02
25H	1.14E-01	22.2	6.84E-01
26H	8.15E-01	10	4.89E+00
27H	< 1.33E-02		< 7.98E-02
28H	< 9.46E-03		< 5.68E-02
29H	< 8.02E-03		< 4.81E-02
30H	< 9.30E-03		< 5.58E-02
31H	< 9.71E-03		< 5.83E-02
32H	< 6.71E-03		< 4.03E-02
40H	< 9.81E-03		< 5.89E-02
41H	< 9.75E-03		< 5.85E-02
42H	< 9.49E-03		< 5.69E-02

Table 2 (Cont.)
IN-SITU MEASUREMENTS
OUTSIDE THE FENCE

SAMPLE LOCATION	AM-241 ACTIVITY (uCi/sq. meter)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sq. meter)
21I	< 1.18E-02		< 7.08E-02
22I	< 1.19E-02		< 7.14E-02
23I	< 1.14E-02		< 6.84E-02
24I	< 1.08E-02		< 6.48E-02
25I	< 8.59E-03		< 5.15E-02
26I	1.03E+00	10	6.18E+00
27I	< 8.54E-03		< 5.12E-02
28I	1.45E-01	11	8.70E-01
29I	< 7.37E-03		< 4.42E-02
30I	< 8.85E-03		< 5.31E-02
31I	< 8.06E-03		< 4.84E-02
32I	< 1.04E-02		< 6.24E-02
33I	< 8.06E-03		< 4.84E-02
34I	< 8.54E-03		< 5.12E-02
38I	< 8.06E-03		< 4.84E-02
39I	< 9.68E-03		< 5.81E-02
40I	< 1.03E-02		< 6.18E-02
41I	4.33E-02	50.2	2.60E-01
42I	< 1.06E-02		< 6.36E-02
25J	< 1.13E-02		< 6.78E-02
26J	< 9.25E-03		< 5.55E-02
27J	8.27E-02	18.6	4.96E-01
28J	< 9.53E-03		< 5.72E-02
29J	< 8.07E-03		< 4.84E-02
30J	< 8.27E-03		< 4.96E-02
31J	< 9.31E-03		< 5.59E-02
32J	< 1.02E-02		< 6.12E-02
33J	< 9.88E-03		< 5.93E-02
34J	< 8.68E-03		< 5.21E-02
35J	< 8.27E-03		< 4.96E-02
37J	< 9.28E-03		< 5.57E-02
38J	< 1.04E-02		< 6.24E-02
39J	2.50E-01	10	1.50E+00
40J	7.72E-02	21.6	4.63E-01
41J	< 8.24E-03		< 4.94E-02

Table 2 (Cont.)
IN-SITU MEASUREMENTS
OUTSIDE THE FENCE

SAMPLE LOCATION	AM-241 ACTIVITY (uCi/sq. meter)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sq. meter)
27K	< 7.99E-03		< 4.79E-02
28K	< 9.57E-03		< 5.74E-02
29K	1.20E-01	15.8	7.20E-01
30K	< 9.27E-03		< 5.56E-02
31K	< 8.34E-03		< 5.00E-02
32K	< 9.77E-03		< 5.86E-02
33K	< 9.50E-03		< 5.70E-02
34K	2.06E-01	10	1.24E+00
35K	2.45E-01	10	1.47E+00
36K	< 8.81E-03		< 5.29E-02
37K	< 7.65E-03		< 4.59E-02
38K	8.25E-02	26.4	4.95E-01
39K	5.51E-02	28.4	3.31E-01
40K	< 1.06E-02		< 6.36E-02
41K	< 7.82E-03		< 4.69E-02
28L	< 8.61E-03		< 5.17E-02
29L	4.25E-01	10	2.55E+00
30L	4.84E-01	10	2.90E+00
31L	< 8.17E-03		< 4.90E-02
32L	2.06E-01	10.6	1.24E+00
33L	3.73E-01	10	2.24E+00
34L	< 9.72E-03		< 5.83E-02
35L	< 9.26E-03		< 5.56E-02
36L	< 7.97E-03		< 4.78E-02
37L	< 1.01E-02		< 6.06E-02
38L	< 9.35E-03		< 5.61E-02
28M	< 9.23E-03		< 5.54E-02
29M	< 8.01E-03		< 4.81E-02
30M	< 9.10E-03		< 5.46E-02
31M	8.09E-02	26.6	4.85E-01
32M	< 9.92E-03		< 5.95E-02
33M	< 1.03E-02		< 6.18E-02
34M	< 9.65E-03		< 5.79E-02
35M	< 1.02E-02		< 6.12E-02
36M	< 6.77E-03		< 4.06E-02
37M	< 7.70E-03		< 4.62E-02
38M	< 9.92E-03		< 5.95E-02
30N	< 9.07E-03		< 5.44E-02
31N	< 9.95E-03		< 5.97E-02
32N	< 9.18E-03		< 5.51E-02

Table 2 (Cont.)
IN-SITU MEASUREMENTS
INSIDE THE FENCE

SAMPLE LOCATION	AM-241 ACTIVITY (uCi/sq. meter)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sq. meter)
8Q	< 1.05E-02		< 6.30E-02
9Q	< 1.12E-02		< 6.72E-02
10Q	< 7.90E-03		< 4.74E-02
11Q	< 7.27E-03		< 4.36E-02
12Q	< 8.01E-03		< 4.81E-02
13Q	< 9.57E-03		< 5.74E-02
3R	< 1.21E-02		< 7.26E-02
4R	< 9.88E-03		< 5.93E-02
5R	< 1.92E-02		< 1.15E-01
6R	< 1.74E-02		< 1.04E-01
7R	< 8.09E-03		< 4.85E-02
8R	5.83E-02	31.6	3.50E-01
9R	1.36E-01	16.6	8.16E-01
10R	< 9.94E-03		< 5.96E-02
11R	2.09E-02	90.4	1.25E-01
12R	< 1.00E-02		< 6.00E-02
13R	< 1.10E-02		< 6.60E-02
3S	< 1.21E-02		< 7.26E-02
4S	< 9.65E-03		< 5.79E-02
5S	< 8.16E-03		< 4.90E-02
6S	6.73E-01	10	4.04E+00
7S	< 5.30E-03		< 3.18E-02
8S	1.10E-01	15.8	6.60E-01
9S	< 8.24E-03		< 4.94E-02
10S	4.52E-02	35.8	2.71E-01
11S	< 6.81E-03		< 4.09E-02
12S	< 1.56E-02		< 9.36E-02
13S	< 9.17E-03		< 5.50E-02
97T	< 1.04E-02		< 6.24E-02
98T	< 1.03E-02		< 6.18E-02
99T	1.15E-01	20.4	6.90E-01
1T	< 9.15E-03		< 5.49E-02
3T	< 1.19E-02		< 7.14E-02
4T	< 9.17E-03		< 5.50E-02
5T	< 8.02E-03		< 4.81E-02
6T	< 1.21E-02		< 7.26E-02
7T	3.38E-01	12.6	2.03E+00
8T	1.85E+00	10	1.11E+01
9T	< 6.41E-03		< 3.85E-02
10T	5.79E-02	33.8	3.47E-01
11T	2.93E-02	39.6	1.76E-01
12T	< 1.62E-02		< 9.72E-02
13T	< 8.44E-03		< 5.06E-02

Table 2 (Cont.)
IN-SITU MEASUREMENTS
INSIDE THE FENCE

SAMPLE LOCATION	AM-241 ACTIVITY (uCi/sq. meter)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sq. meter)
97U	< 1.05E-02		< 6.30E-02
98U	< 1.26E-02		< 7.56E-02
99U	< 1.26E-02		< 7.56E-02
1U	< 1.14E-02		< 6.84E-02
2U	< 1.06E-02		< 6.36E-02
3U	< 1.20E-02		< 7.20E-02
4U	< 9.25E-03		< 5.55E-02
5U	< 1.89E-02		< 1.13E-01
6U	6.22E-02	38	3.73E-01
7U	< 9.38E-03		< 5.63E-02
8U	5.05E-02	41.2	3.03E-01
9U	< 7.00E-03		< 4.20E-02
10U	4.65E-02	26.8	2.79E-01
11U	1.85E-02	63.2	1.11E-01
12U	< 1.49E-02		< 8.94E-02
13U	< 8.91E-03		< 5.35E-02
97V	< 1.20E-02		< 7.20E-02
98V	< 1.07E-02		< 6.42E-02
1V	< 1.12E-02		< 6.72E-02
2V	< 6.54E-03		< 3.92E-02
3V	< 1.16E-02		< 6.96E-02
4V	< 9.17E-03		< 5.50E-02
5V	8.15E-02	24.2	4.89E-01
6V	6.34E-02	18	3.80E-01
7V	6.82E-01	10	4.09E+00
8V	4.09E-01	10	2.45E+00
9V	1.30E-01	21	7.80E-01
10V	4.36E-02	33.2	2.62E-01
11V	1.07E-02	105.4	6.42E-02
12V	< 1.62E-02		< 9.72E-02
13V	< 8.25E-03		< 4.95E-02
14V	< 7.06E-03		< 4.24E-02
15V	< 7.10E-03		< 4.26E-02
16V	< 1.12E-02		< 6.72E-02

Table 2 (Cont.)
IN-SITU MEASUREMENTS
INSIDE THE FENCE

SAMPLE LOCATION	AM-241 ACTIVITY (uCi/sq. meter)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sq. meter)
97W	< 1.09E-02		< 6.54E-02
98W	< 1.23E-02		< 7.38E-02
99W	< 1.01E-02		< 6.06E-02
1W	< 1.08E-02		< 6.48E-02
2W	< 1.04E-02		< 6.24E-02
3W	< 1.23E-02		< 7.38E-02
4W	< 1.07E-02		< 6.42E-02
5W	< 1.83E-02		< 1.10E-01
6W	1.25E-01	13.8	7.50E-01
7W	1.61E+00	10	9.66E+00
8W	8.33E-02	19	5.00E-01
9W	1.07E-01	17.4	6.42E-01
10W	5.42E-02	33.6	3.25E-01
11W	< 6.45E-03		< 3.87E-02
12W	< 1.52E-02		< 9.12E-02
13W	3.30E-02	40.8	1.98E-01
14W	< 8.40E-03		< 5.04E-02
15W	< 8.24E-03		< 4.94E-02
16W	< 8.43E-03		< 5.06E-02
97X	< 1.29E-02		< 7.74E-02
98X	< 1.19E-02		< 7.14E-02
99X	< 1.38E-02		< 8.28E-02
1X	< 1.10E-02		< 6.60E-02
2X	< 9.93E-03		< 5.96E-02
3X	< 1.23E-02		< 7.38E-02
4X	< 2.33E-02		< 1.40E-01
5X	4.79E-02	33.8	2.87E-01
6X	4.00E-02	61.6	2.40E-01
7X	< 9.31E-03		< 5.59E-02
8X	8.64E+00	10	5.18E+01
9X	9.13E-01	10	5.48E+00
10X	2.83E-02	71	1.70E-01
11X	6.97E-02	27.2	4.18E-01
12X	1.18E-01	22.5	7.08E-01
13X	1.11E-02	125.4	6.66E-02
14X	< 1.29E-02		< 7.74E-02
15X	< 1.24E-02		< 7.44E-02
16X	< 8.65E-03		< 5.19E-02
17X	< 1.03E-02		< 6.18E-02

Table 2 (Cont.)
IN-SITU MEASUREMENTS
INSIDE THE FENCE

SAMPLE LOCATION	AM-241 ACTIVITY (uCi/sq. meter)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sq. meter)
97Y	< 9.12E-03		< 5.47E-02
98Y	< 1.15E-02		< 6.90E-02
99Y	< 9.54E-03		< 5.72E-02
1Y	< 1.17E-02		< 7.02E-02
2Y	1.88E-02	57.8	1.13E-01
3Y	< 8.88E-03		< 5.33E-02
4Y	2.96E-02	64.6	1.78E-01
5Y	< 1.16E-02		< 6.96E-02
6Y	1.10E-01	19.6	6.60E-01
7Y	3.96E-02	40	2.38E-01
8Y	4.06E+00	10	2.44E+01
9Y	9.25E-02	24.6	5.55E-01
10Y	1.41E-01	14	8.46E-01
11Y	2.57E-02	56.8	1.54E-01
12Y	8.85E-02	27.6	5.31E-01
13Y	9.57E-02	18.4	5.74E-01
14Y	9.37E-02	17	5.62E-01
15Y	7.32E-02	22.8	4.39E-01
16Y	< 7.68E-03		< 4.61E-02
17Y	2.03E-02	63	1.22E-01
18Y	< 8.07E-02		< 4.84E-01
19Y	< 1.26E-02		< 7.56E-02
97Z	< 1.10E-02		< 6.60E-02
98Z	< 9.66E-03		< 5.80E-02
99Z	< 1.03E-02		< 6.18E-02
1Z	< 1.19E-02		< 7.14E-02
2Z	< 1.16E-02		< 6.96E-02
3Z	< 9.91E-03		< 5.95E-02
4Z	< 2.18E-02		< 1.31E-01
5Z	< 9.65E-03		< 5.79E-02
6Z	< 9.58E-03		< 5.75E-02
7Z	< 8.77E-03		< 5.26E-02
8Z	< 1.20E-02		< 7.20E-02
9Z	< 1.10E-02		< 6.60E-02
10Z	< 9.96E-03		< 5.98E-02
11Z	8.16E-02	32.2	4.90E-01
12Z	< 2.09E-02		< 1.25E-01
13Z	< 1.20E-02		< 7.20E-02
14Z	< 2.21E-02		< 1.33E-01
15Z	< 2.21E-02		< 1.33E-01
16Z	< 1.31E-02		< 7.86E-02
17Z	< 2.08E-02		< 1.25E-01
18Z	8.67E-02	33.6	5.20E-01
19Z	< 1.15E-02		< 6.90E-02

Table 2 (Cont.)
IN-SITU MEASUREMENTS
INSIDE THE FENCE

SAMPLE LOCATION	AM-241 ACTIVITY (uCi/sq. meter)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sq. meter)
ES1	< 1.32E-02		< 7.92E-02
ES2	< 1.07E-02		< 6.42E-02
ES3	< 1.12E-02		< 6.72E-02
ES4	< 1.40E-02		< 8.40E-02
ES5	< 9.98E-03		< 5.99E-02
ES6	< 9.49E-03		< 5.69E-02
ES7	< 1.31E-02		< 7.86E-02
ES8	< 1.01E-02		< 6.06E-02
ES9	1.80E-02	67.4	1.08E-01
ES10	< 2.48E-02		< 1.49E-01
ES11	< 8.57E-03		< 5.14E-02
ES12	< 9.70E-03		< 5.82E-02
ES13	< 1.00E-02		< 6.00E-02
ES14	< 1.04E-02		< 6.24E-02
ES15	< 1.07E-02		< 6.42E-02
ES16	< 1.03E-02		< 6.18E-02
ES17	< 2.52E-02		< 1.51E-01
ES18	< 1.06E-02		< 6.36E-02
ES19	< 1.04E-02		< 6.24E-02
ES20	< 2.27E-02		< 1.36E-01
ES21	< 2.62E-02		< 1.57E-01
ES22	< 1.08E-02		< 6.48E-02
ES23	6.40E-02	42.2	3.84E-01

TABLE 3
EPA WATER SAMPLES

SAMPLE NUMBER	AM-241 ACTIVITY (uCi/sample)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sample)
EPA 1	<8.95E-05		
EPA 2	<1.34E-04		
BO-SW-6-DUP #1	<1.23E-04		
BO-SW-6-DUP #2	<1.53E-04		

TABLE 4
001-SL-PS*-***

SAMPLE NUMBER	AM-241 ACTIVITY (uCi/sample)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sample)
001-SL-PS1-001	8.63E-04	11.0	5.18E-03
001-SL-PS2-001	2.02E+00	10.0	1.21E+01
001-SL-PS3-001	1.59E+00	10.0	9.54E+00

TABLE 5
001-SL-00*-***

SAMPLE NUMBER	AM-241 ACTIVITY (uCi/sample)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sample)
001-SL-001-001	<3.22E-04		
001-SL-001-002	1.91E-03	72.1	1.15E-02
001-SL-002-001	<5.82E-04		
001-SL-002-002	<3.45E-04		
001-SL-003-001	1.86E-03	57.4	1.12E-02
001-SL-003-002	<3.60E-04		
001-SL-004-001	<4.81E-04		
001-SL-004-002	<2.83E-04		

TABLE 6
001-SW-***-***

SAMPLE NUMBER	AM-241 ACTIVITY (uCi/sample)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sample)
001-SW-CB1-001	<5.69E-04		
001-SW-CB1-002	<2.54E-04		
001-SW-CB1-003	<5.55E-04		
001-SW-CB1-004	<3.01E-04		
001-SW-CB1-005	<6.33E-04		
001-SW-CB1-006	<5.82E-04		
001-SW-PB1-001	<2.92E-04		
001-SW-PB1-002	<2.88E-04		
001-SW-PB1-003	<6.20E-04		
001-SW-PB1-004	<5.95E-04		
001-SW-PB1-005	<6.45E-04		
001-SW-PB1-006	<2.92E-04		

TABLE 7
001-SL-AP*-***

SAMPLE NUMBER	AM-241 ACTIVITY (uCi/sample)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sample)
001-SL-AP1-001A	<9.37E-04		
001-SL-AP1-001B	5.98E-03	27.6	3.59E-02
001-SL-AP1-002A	4.74E-02	10.0	2.84E-01
001-SL-AP1-002B	1.71E-01	10.0	1.03E+00
001-SL-AP1-003A	2.33E-02	10.0	1.40E-01
001-SL-AP1-003B	1.21E-02	10.0	7.26E-02
001-SL-AP2-001A	<1.58E-03		
001-SL-AP2-001B	1.30E-03	75.0	7.80E-03
001-SL-AP2-002A	2.44E-03	38.8	1.46E-02
001-SL-AP2-002B	1.35E-03	59.8	8.10E-03
001-SL-AP2-003A	<2.02E-04		
001-SL-AP2-003B	<1.95E-04		
001-SL-AP3-001A	<1.17E-03		
001-SL-AP3-001B	<1.04E-03		
001-SL-AP3-002A	1.80E-03	52.8	1.08E-02
001-SL-AP3-002B	<6.26E-04		
001-SL-AP4-001A	<1.00E-03		
001-SL-AP4-001B	<9.69E-04		
001-SL-AP4-002A	<5.51E-04		
001-SL-AP4-002B	<5.46E-04		
001-SL-AP4-003A	<3.55E-04		
001-SL-AP4-003B	<3.24E-04		
001-SL-AP5-002A	<6.49E-04		
001-SL-AP5-002B	1.25E-03	65.6	7.50E-03
001-SL-AP5-003A	<2.44E-04		
001-SL-AP5-003B	<2.56E-04		
001-SL-AP5-003C	<2.43E-04		
001-SL-AP5-003D	<2.04E-04		

TABLE 8
MISCELLANEOUS

SAMPLE NUMBER	AM-241 ACTIVITY (uCi/sample)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sample)
001-SL-CC1-002	<2.42E-01		
001-SL-CC1-003	<5.83E-04		
001-SL-CC2-003A (VOA)	<3.33E-04		
001-SL-CC2-003A (METALS)	<1.03E-03		
001-SL-CC2-003B (VOA)	<3.19E-04		
001-SL-CC2-003B (METALS)	<1.02E-03		
FIELD MOUSE	<3.30E-04		

TABLE 9
CEMENT CORES

SAMPLE NUMBER	AM-241 ACTIVITY (uCi/sample)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sample)
001-CC-C01-001 TOP	<3.25E-04		
001-CC-C01-001 BOTTOM	5.62E-04	58.20	3.37E-03
001-CC-C01-002 TOP	<4.46E-04		
001-CC-C01-002 BOTTOM	<4.33E-04		
001-CC-C02-001 TOP	<3.19E-04		
001-CC-C02-001 BOTTOM	2.82E-03	20.40	1.69E-02
001-CC-C02-002 TOP	<2.40E-04		
001-CC-C02-002 BOTTOM	9.78E-04	31.70	5.87E-03
001-CC-C2A-001 TOP	<4.53E-04		
001-CC-C2A-001 BOTTOM	<4.89E-04		
001-CC-C03-001 TOP	3.48E-02	10.00	2.09E-01
001-CC-C03-001 BOTTOM	3.67E-02	10.00	2.20E-01
001-CC-C03-002 TOP	2.90E-02	10.00	1.74E-01
001-CC-C03-002 BOTTOM	5.13E-04	50.50	3.08E-03
001-CC-C04-001 TOP	<2.77E-04		
001-CC-C04-001 BOTTOM	8.15E-02	10.00	4.89E-01
001-CC-C04-002 TOP	7.04E-02	10.00	4.22E-01
001-CC-C04-002 BOTTOM	<2.04E-04		
001-CC-C05-001 TOP	<2.35E-04		
001-CC-C05-001 BOTTOM	1.23E-03	14.50	7.38E-03
001-CC-C05-002 PIECES*	3.58E-04	96.80	2.15E-03
001-CC-C06-001 TOP	<3.41E-04		
001-CC-C06-001 BOTTOM	<4.33E-04		
001-CC-C07-001 TOP	1.32E-03	68.80	7.92E-03
001-CC-C07-001 BOTTOM	3.91E-02	10.00	2.35E-01
001-CC-C07-002 TOP	7.50E-02	10.00	4.50E-01
001-CC-C07-002 BOTTOM	1.34E-03	15.40	8.04E-03
001-CC-C08-001 TOP	<2.30E-04		
001-CC-C08-001 BOTTOM	4.43E-03	11.60	2.66E-02
001-CC-C08-002 TOP	2.66E-03	21.40	1.60E-02
001-CC-C08-002 BOTTOM	<2.35E-04		
001-CC-C09-001 TOP	<2.51E-04		
001-CC-C09-001 BOTTOM	<2.68E-04		
001-CC-C09-002 TOP	7.93E-03	11.60	4.76E-02
001-CC-C09-002 BOTTOM	<3.46E-04		

TABLE 9 (Cont.)
CEMENT CORES

SAMPLE NUMBER	AM-241 ACTIVITY (uCi/sample)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sample)
001-CC-C10-001 TOP	3.00E-02	10.00	1.80E-01
001-CC-C10-001 BOTTOM	5.14E-01	10.00	3.08E+00
001-CC-C10-002 TOP	1.95E+00	10.00	1.17E+01
001-CC-C10-002 BOTTOM	5.02E-03	10.00	3.01E-02
001-CC-C11-001 TOP	2.23E-01	10.00	1.34E+00
001-CC-C11-001 BOTTOM	5.24E+00	10.00	3.14E+01
001-CC-C11-002 TOP	1.79E+02	10.00	1.07E+03
001-CC-C11-002 BOTTOM	1.60E+00	10.00	9.60E+00
001-CC-C12-001 TOP	8.83E-03	13.80	5.30E-02
001-CC-C12-001 BOTTOM	5.28E-03	21.40	3.17E-02
001-CC-C12-002 TOP	7.06E-04	38.80	4.24E-03
001-CC-C12-002 BOTTOM	2.51E-03	17.80	1.51E-02
001-CC-C13-001 TOP	<4.89E-04		
001-CC-C13-001 BOTTOM	2.58E-01	10.00	1.55E+00
001-CC-C13-002 PIECES*	2.67E-03	13.00	1.60E-02
001-CC-C13-003 TOP	<2.76E-04		
001-CC-C13-003 BOTTOM	<2.63E-04		
001-CC-C14-001 TOP	2.68E+00	10.00	1.61E+01
001-CC-C14-001 BOTTOM	2.58E-01	10.00	1.55E+00
001-CC-C14-002 TOP	1.21E+01	10.00	7.26E+01
001-CC-C14-002 BOTTOM	9.60E-01	10.00	5.76E+00
001-CC-C14-003 PIECES*	2.75E-03	10.00	1.65E-02
001-CC-C15-001 TOP	2.19E-02	10.00	1.31E-01
001-CC-C15-001 BOTTOM	2.78E+00	10.00	1.67E+01
001-CC-C15-002 TOP	9.04E+01	10.00	5.42E+02
001-CC-C15-002 BOTTOM	1.28E+00	10.00	7.68E+00
001-CC-C15-003 TOP	5.76E-02	10.00	3.46E-01
001-CC-C15-003 BOTTOM	4.45E-03	15.60	2.67E-02
001-CC-C16-001 TOP	9.25E-04	48.40	5.55E-03
001-CC-C16-001 BOTTOM	7.46E-02	10.00	4.48E-01
001-CC-C17-001 TOP	<9.86E-05		
001-CC-C17-001 BOTTOM	<1.08E-04		
001-CC-C17-002 TOP	6.90E-01	10.00	4.14E+00
001-CC-C17-002 BOTTOM	2.56E-03	31.00	1.54E-02
001-CC-C17-003 TOP	4.95E-01	10.00	2.97E+00
001-CC-C17-003 BOTTOM	2.78E-01	10.00	1.67E+00

TABLE 9 (Cont.)
CEMENT CORES

SAMPLE NUMBER	AM-241 ACTIVITY (uCi/sample)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sample)
001-CC-C18-001 TOP	7.09E-04	57.20	4.25E-03
001-CC-C18-001 BOTTOM	<2.41E-04		
001-CC-C18-002 TOP	2.54E-03	23.20	1.52E-02
001-CC-C18-002 BOTTOM	3.85E-03	15.40	2.31E-02
001-CC-C18-003 TOP	2.94E-02	10.00	1.76E-01
001-CC-C18-003 BOTTOM	<2.53E-04		
001-CC-C19-001 TOP	1.74E-03	22.40	1.04E-02
001-CC-C19-001 BOTTOM	2.90E-01	10.00	1.74E+00
001-CC-C19-002 TOP	2.48E-01	10.00	1.49E+00
001-CC-C19-002 BOTTOM	2.62E-01	10.00	1.57E+00
001-CC-C19-003 TOP	3.71E+00	10.00	2.23E+01
001-CC-C19-003 BOTTOM	1.42E-03	60.80	8.52E-03
001-CC-C20-001 TOP	<1.06E-04		
001-CC-C20-001 BOTTOM	<1.06E-04		
001-CC-C20-002 TOP	2.23E-03	12.00	1.34E-02
001-CC-C20-002 BOTTOM	6.21E-02	10.00	3.73E-01
001-CC-C20-003 TOP	3.26E+00	10.00	1.96E+01
001-CC-C20-003 BOTTOM	1.09E+01	10.00	6.53E+01
001-CC-C20-004 TOP	5.60E+00	10.00	3.36E+01
001-CC-C20-004 BOTTOM	2.65E-02	10.00	1.59E-01
001-CC-C21-001 TOP	<1.13E-04		
001-CC-C21-001 BOTTOM	<1.09E-04		
001-CC-C21-002 TOP	<1.53E-04		
001-CC-C21-002 BOTTOM	<1.55E-04		
001-CC-C21-003 TOP	2.23E-01	10.00	1.34E+00
001-CC-C21-003 BOTTOM	6.50E-02	10.00	3.90E-01
001-CC-C21-004 TOP	6.35E-02	10.00	3.81E-01
001-CC-C21-004 BOTTOM	8.09E-04	43.40	4.85E-03

* THE SAMPLE WAS BROKEN DURING DRILLING, AND THE PIECES WERE COUNTED

TABLE 10
001-SO-***-***

SAMPLE NUMBER	AM-241 ACTIVITY (uCi/sample)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sample)
001-SO-CB1-001	2.15E+00	10.0	1.29E+01
001-SO-PB1-001	2.93E+00	10.0	1.76E+01
001-SO-204-001	<3.14E-04		
001-SO-204-002	<7.23E-04		
001-SO-204-003	7.76E-04	47.8	4.65E-03
001-SO-204-004	1.46E-03	92.2	8.76E-03
001-SO-204-005	<2.28E-04		

TABLE 11
001-SD-***-***

SAMPLE NUMBER	AM-241 ACTIVITY (uCi/sample)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sample)
001-SD-CB1-001	3.63E-02	10.0	2.18E-01
001-SD-CB1-002	3.64E-02	10.0	2.18E-01
001-SD-CB1-003	2.07E-02	10.0	1.24E-01
001-SD-CB1-004	3.35E-03	22.4	2.01E-02
001-SD-CB1-005	2.36E-02	10.0	1.42E-01
001-SD-CB1-006	3.89E-03	39.0	2.33E-02

TABLE 12
001-SL-IS1-***

SAMPLE NUMBER	AM-241 ACTIVITY (uCi/sample)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sample)
001-SL-IS1-001	<4.04E-04		
001-SL-IS1-002	<2.92E-04		
001-SL-IS1-003	2.58E-03	36.8	1.55E-02
001-SL-IS1-004	<3.41E-04		
001-SL-IS1-005	<4.13E-04		
001-SL-IS1-006	<2.88E-04		
001-SL-IS1-007	<4.04E-04		
001-SL-IS1-008	<2.83E-04		
001-SL-IS1-009	<4.46E-04		
001-SL-IS1-010	<2.79E-04		
001-SL-IS1-011	<4.21E-04		
001-SL-IS1-012	<3.05E-04		
001-SL-IS1-013	<4.21E-04		
001-SL-IS1-014	<3.05E-04		
001-SL-IS1-015	<4.13E-04		
001-SL-IS1-016	<3.74E-04		
001-SL-IS1-017	<4.13E-04		
001-SL-IS1-018	<2.64E-04		
001-SL-IS1-019	<4.77E-04		
001-SL-IS1-020	<2.74E-04		
001-SL-IS1-021	<4.46E-04		
001-SL-IS1-022	<3.01E-04		
001-SL-IS1-023	<4.46E-04		
001-SL-IS1-024	<2.69E-04		
001-SL-IS1-025	<3.37E-04		
001-SL-IS1-026	<2.64E-04		
001-SL-IS1-027	<4.46E-04		
001-SL-IS1-028	<2.49E-04		
001-SL-IS1-029	<4.69E-04		
001-SL-IS1-030	<2.88E-04		
001-SL-IS1-031	<4.84E-04		
001-SL-IS1-032	<2.88E-04		
001-SL-IS1-033	<4.84E-04		
001-SL-IS1-034	<2.97E-04		
001-SL-IS1-035	<4.46E-04		
001-SL-IS1-036	<2.64E-04		
001-SL-IS1-037	<3.47E-04		
001-SL-IS1-038	<2.59E-04		
001-SL-IS1-039	1.31E-03	68.2	7.86E-03
001-SL-IS1-040	<2.83E-04		
001-SL-IS1-041	<4.69E-04		
001-SL-IS1-042	<2.59E-04		

TABLE 12 (Cont.)
001-SL-IS1-***

SAMPLE NUMBER	AM-241 ACTIVITY (uCi/sample)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sample)
001-SL-IS1-043	<3.67E-04		
001-SL-IS1-044	<2.59E-04		
001-SL-IS1-045	<4.04E-04		
001-SL-IS1-046	<2.39E-04		
001-SL-IS1-047	<4.38E-04		
001-SL-IS1-048	<2.49E-04		
001-SL-IS1-049	<3.77E-04		
001-SL-IS1-050	<2.79E-04		
001-SL-IS1-051	<3.15E-04		
001-SL-IS1-052	<3.05E-04		
001-SL-IS1-053	<3.95E-04		
001-SL-IS1-054	<2.69E-04		
001-SL-IS1-055	<4.62E-04		
001-SL-IS1-056	<2.74E-04		
001-SL-IS1-057	<3.77E-04		
001-SL-IS1-058	<2.49E-04		
001-SL-IS1-059	<3.47E-04		
001-SL-IS1-060	<2.59E-04		
001-SL-IS1-061	<4.62E-04		
001-SL-IS1-062	<3.05E-04		
001-SL-IS1-063	<4.77E-04		
001-SL-IS1-064	<2.97E-04		
001-SL-IS1-065	<4.91E-04		
001-SL-IS1-066	<2.28E-04		
001-SL-IS1-067	<3.95E-04		
001-SL-IS1-068	<2.10E-04		
001-SL-IS1-069	<3.95E-04		
001-SL-IS1-070	<2.39E-04		
001-SL-IS1-071	<3.86E-04		
001-SL-IS1-072	<2.92E-04		
001-SL-IS1-073	<4.54E-04		
001-SL-IS1-074	<2.69E-04		
001-SL-IS1-075	<3.86E-04		
001-SL-IS1-076	<2.88E-04		
001-SL-IS1-077	<4.77E-04		
001-SL-IS1-078	<3.14E-04		
001-SL-IS1-079	<4.13E-04		
001-SL-IS1-080	<2.69E-04		
001-SL-IS1-081	<4.21E-04		
001-SL-IS1-082	<3.05E-04		
001-SL-IS1-083	<4.84E-04		
001-SL-IS1-084	<2.79E-04		
001-SL-IS1-085	<4.21E-04		

TABLE 13
001-SL-IS*-***

SAMPLE NUMBER	AM-241 ACTIVITY (uCi/sample)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sample)
001-SL-IS2-001	1.00E-01	10.0	6.00E-01
001-SL-IS2-002	3.92E-02	10.0	2.35E-01
001-SL-IS2-003	2.79E+00	10.0	1.67E+01
001-SL-IS2-004	3.27E+00	10.0	1.96E+01
001-SL-IS2-005	5.24E-02	10.0	3.14E-01
001-SL-IS2-006	1.35E-01	10.0	8.10E-01
001-SL-IS2-007	3.02E-01	10.0	1.81E+00
001-SL-IS2-008	1.20E-02	10.0	7.20E-02
001-SL-IS2-009	2.26E-03	55.4	1.36E-02
001-SL-IS2-010	<3.81		
001-SL-IS3-001	<6.68E-04		
001-SL-IS3-002	1.58E-02	12.2	9.48E-02
001-SL-IS3-003	<3.81E-04		
001-SL-IS3-004	1.42E-01	10.0	8.52E-01
001-SL-IS3-005	1.21E-01	10.0	7.26E-01
001-SL-IS3-006	3.79E-01	10.0	2.27E+00
001-SL-IS3-007	4.35E-02	10.0	2.61E-01
001-SL-IS3-008	7.64E-02	10.0	4.58E-01
001-SL-IS3-009	6.72E-03	10.0	4.03E-02
001-SL-IS3-010	7.55E-03	10.0	4.53E-02
001-SL-IS3-011	3.82E-01	10.0	2.29E+00
001-SL-IS3-012	8.24E-01	10.0	4.94E+00
001-SL-IS4-001	1.93E-02	10.0	1.16E-01
001-SL-IS4-002	3.42E-01	10.0	2.05E+00
001-SL-IS4-003	8.87E-01	10.0	5.32E+00
001-SL-IS4-004	2.76E-01	10.0	1.66E+00
001-SL-IS4-005	6.93E-02	10.0	4.16E-01
001-SL-IS4-006	5.23E-02	10.0	3.14E-01
001-SL-IS4-007	2.54E-03	27.0	1.52E-02
001-SL-IS4-008	1.97E-03	27.2	1.18E-02
001-SL-IS4-009	<3.22E-04		
001-SL-IS4-010	<6.80E-04		
001-SL-IS5-001	5.09E-03	25.6	3.05E-02
001-SL-IS5-002	8.56E-03	18.0	5.14E-02
001-SL-IS5-003	8.84E-03	19.0	5.30E-02
001-SL-IS5-004	5.09E+00	10.0	3.05E+01
001-SL-IS5-005	1.47E-02	13.2	8.82E-02
001-SL-IS5-006	3.15E-03	24.0	1.89E-02
001-SL-IS5-007	2.15E-03	27.2	1.29E-02
001-SL-IS5-008	<5.82E-04		
001-SL-IS5-009	<5.82E-04		
001-SL-IS5-010	<5.82E-04		

TABLE 13
001-SL-IS*-***

SAMPLE NUMBER	AM-241 ACTIVITY (uCi/sample)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sample)
001-SL-IS6-001	5.22E-03	14.0	3.13E-02
001-SL-IS6-002	1.13E-02	15.0	6.78E-02
001-SL-IS6-003	8.25E-03	20.8	4.95E-02
001-SL-IS6-004	2.65E-03	26.2	1.59E-02
001-SL-IS6-005	9.13E-03	17.6	5.48E-02
001-SL-IS6-006	9.93E-04	57.8	5.96E-03
001-SL-IS6-007	<6.33E-04		
001-SL-IS6-008	<2.97E-04		
001-SL-IS6-009	<3.01E-04		
001-SL-IS6-010	<5.95E-04		
001-SL-IS7-001	2.36E-03	29.2	1.42E-02
001-SL-IS7-002	4.83E-01	10.0	2.90E+00
001-SL-IS7-003	5.80E-03	26.2	3.48E-02
001-SL-IS7-004	1.20E-02	16.4	7.20E-02
001-SL-IS7-005	2.13E-03	60.0	1.28E-02
001-SL-IS7-006	1.25E-03	73.6	7.50E-03
001-SL-IS7-007	<2.28E-04		
001-SL-IS7-008	<6.08E-04		
001-SL-IS7-009	<3.04E-04		
001-SL-IS7-010	<2.74E-04		

X

TABLE 14
001-SL-B**-***

SAMPLE NUMBER	AM-241 ACTIVITY (uCi/sample)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sample)
001-SL-B01-001	7.36E-03	24.8	4.42E-02
001-SL-B01-002	<2.28E-04		
001-SL-B01-003	<4.81E-04		
001-SL-B02-001	4.64E-03	30.4	2.78E-02
001-SL-B02-002	<2.39E-04		
001-SL-B02-003	<5.82E-04		
001-SL-B03-001	9.41E-01	10.0	5.65E+00
001-SL-B03-002	<2.64E-04		
001-SL-B03-003	<1.75E-04		
001-SL-B04-001	1.11E+00	10.0	6.66E+00
001-SL-B04-002	<5.82E-04		
001-SL-B04-003	<5.12E-04		
001-SL-B05-001	1.75E-01	10.0	1.05E+00
001-SL-B05-002	<5.55E-04		
001-SL-B05-003	<2.28E-04		
001-SL-B06-001	1.11E-01	10.0	6.66E-01
001-SL-B06-002	<2.59E-04		
001-SL-B06-003	<2.79E-04		
001-SL-B07-001	1.80E+01	10.0	1.08E+02
001-SL-B07-002	<5.55E-04		
001-SL-B07-003	<2.97E-04		
001-SL-B08-001	3.42E-01	10.0	2.05E+00
001-SL-B08-002	<2.33E-04		
001-SL-B08-003	<6.20E-04		
001-SL-B09-001	5.29E+00	10.0	3.17E+01
001-SL-B09-002	<5.55E-04		
001-SL-B09-003	<4.47E-04		
001-SL-B10-001	4.70E-03	16.4	2.82E-02
001-SL-B10-002	<8.22E-05		
001-SL-B10-003	<2.79E-04		

TABLE 14 (Cont.)
001-SL-B**-***

SAMPLE NUMBER	AM-241 ACTIVITY (uCi/sample)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sample)
001-SL-B11-001	<3.26E-04		
001-SL-B11-001	<5.95E-04		
001-SL-B11-003	<2.44E-04		
001-SL-B12-001	<2.92E-04		
001-SL-B12-002	<2.39E-04		
001-SL-B12-003	<5.69E-04		
001-SL-B13-001	5.12E-03	29.8	3.07E-02
001-SL-B13-002	<2.49E-04		
001-SL-B13-003	<2.49E-04		
001-SL-B14-001	6.46E-01	10.0	3.88E+00
001-SL-B14-002	<8.14E-05		
001-SL-B14-003	<2.79E-04		
001-SL-B15-001	1.97E-01	10.0	1.18E+00
001-SL-B15-002	<5.95E-04		
001-SL-B15-003	<2.92E-04		
001-SL-B16-001	<5.41E-04		
001-SL-B16-002	<5.55E-04		
001-SL-B16-003	<5.69E-04		
001-SL-B17-001	<6.91E-04		
001-SL-B17-002	<2.69E-04		
001-SL-B17-003	<5.69E-04		
001-SL-B18-001	<5.82E-04		
001-SL-B18-002	<3.14E-04		
001-SL-B18-003	<2.59E-04		
001-SL-B19-001	<4.96E-04		
001-SL-B19-002	<5.26E-04		
001-SL-B19-003	<5.12E-04		
001-SL-B20-001	<4.47E-04		
001-SL-B20-002	<4.81E-04		
001-SL-B20-003	<2.97E-04		

TABLE 14 (Cont.)
001-SL-B**-***

SAMPLE NUMBER	AM-241 ACTIVITY (uCi/sample)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sample)
001-SL-B21-001	<4.30E-04		
001-SL-B21-002	<4.64E-04		
001-SL-B21-003	<6.20E-04		
001-SL-B22-001	<2.74E-04		
001-SL-B22-002	<2.39E-04		
001-SL-B22-003	<2.28E-04		
001-SL-B23-001	<5.95E-04		
001-SL-B23-002	<4.64E-04		
001-SL-B23-003	<5.55E-04		
001-SL-B24-001	<2.92E-04		
001-SL-B24-002	<2.49E-04		
001-SL-B24-003	<3.01E-04		
001-SL-B25-001	1.86E-03	26.8	1.12E-02
001-SL-B25-002	<1.66E-04		
001-SL-B25-003	<2.69E-04		
001-SL-B26-001	<2.83E-04		
001-SL-B26-002	<2.34E-04		
001-SL-B26-003	<2.44E-04		

TABLE 15
001-SL-C**-***

SAMPLE NUMBER	AM-241 ACTIVITY (uCi/sample)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sample)
001-SL-C01-001	<3.10E-04		
001-SL-C01-002	<4.38E-04		
001-SL-C01-003	<3.05E-04		
001-SL-C02-001	<2.92E-04		
001-SL-C02-002	<2.69E-04		
001-SL-C02-003	<4.13E-04		
001-SL-C03-001	<2.97E-04		
001-SL-C03-002	<4.62E-04		
001-SL-C03-003	<2.22E-04		
001-SL-C04-001	<3.22E-04		
001-SL-C04-002	<3.58E-04		
001-SL-C04-003	<3.26E-04		
001-SL-C05-001	<3.10E-04		
001-SL-C05-002	<4.46E-04		
001-SL-C05-003	<2.04E-04		
001-SL-C06-001	<2.64E-04		
001-SL-C06-002	<5.55E-04		
001-SL-C06-003	<6.33E-04		
001-SL-C07-001	<2.79E-04		
001-SL-C07-002	<6.57E-04		
001-SL-C07-003	<2.83E-04		
001-SL-C08-001	<1.26E-03		
001-SL-C08-002	<3.10E-04		
001-SL-C08-003	<3.22E-04		
001-SL-C10-001	2.94E-02	10.0	1.76E-01
001-SL-C10-002	<2.54E-04		
001-SL-C10-003	<3.47E-04		
001-SL-C11-001	1.65E-03	52.4	9.90E-03
001-SL-C11-002	<3.01E-04		
001-SL-C11-003	<3.86E-04		
001-SL-C12-001	<2.88E-04		
001-SL-C12-002	<4.04E-04		
001-SL-C12-003	<2.54E-04		

TABLE 15
001-SL-C**-***

SAMPLE NUMBER	AM-241 ACTIVITY (uCi/sample)	2-SIGMA ERROR (%)	PU-239 ACTIVITY (uCi/sample)
001-SL-C13-001	<3.10E-04		
001-SL-C13-002	<4.04E-04		
001-SL-C13-003	<3.95E-04		
001-SL-C14-001	1.91E-02	11.0	1.15E-01
001-SL-C14-002	<2.44E-04		
001-SL-C14-003	<3.95E-04		
001-SL-C15-001	2.72E-03	37.6	1.63E-02
001-SL-C15-002	<3.01E-04		
001-SL-C15-003	<4.62E-04		
001-SL-C16-002	3.33E-03	33.6	2.00E-02
001-SL-C16-003	<2.64E-04		
001-SL-C17-001	<4.13E-04		
001-SL-C17-002	<3.05E-04		
001-SL-C17-003	<3.67E-04		
001-SL-C18-001	<3.86E-04		
001-SL-C18-002	<2.92E-04		
001-SL-C18-003	<4.54E-04		
001-SL-C19-001	3.16E-03	35.0	1.90E-02
001-SL-C19-002	<3.41E-04		
001-SL-C19-003	<2.74E-04		
001-SL-C20-001	4.04E-02	10.0	2.42E-01
001-SL-C20-002	1.43E-02	11.0	8.58E-02
001-SL-C20-003	1.21E-03	34.8	7.26E-03
001-SL-C21-002	<4.54E-04		
001-SL-C21-002A*	<6.36E-04		
001-SL-C21-002B*	3.50E-03	16.4	2.10E-02
001-SL-C21-002C*	1.42E-03	24.2	8.52E-03
001-SL-C21-003	<3.18E-04		
001-SL-C21-003A*	1.23E-03	69.2	7.38E-03

* THESE FRACTIONS WERE TAKEN BY EARTH TECH FOR ANALYSIS

APPENDIX M

CORRESPONDENCE WITH GOVERNMENTAL AGENCIES

U.S. Department of Labor

Occupational Safety and Health Administration
201 Varick Street
New York, New York 10014

Reply to the Attention of:

MAY 30 1989

Copies to:
Neil
Donna
Files

MEMORANDUM FOR: Neil E. Botts, Project Manager
Geologist for Battelle

THRU: James W. Stanley
Regional Administrator

FROM: Phyllis Kyner, Acting
Assistant Regional Administrator
for Technical Support

SUBJECT: Draft Health and Safety Plan
Bomare Missile Site

Technical Support reviewed the referenced draft Health and Safety Plan as requested. The following recommendations and comments are provided with the provison that OSHA's policy is to accept drafts for evaluation but does not have the authority to approve drafts.

OSHA has jurisdication over natural occurring isotopes, and N.R.C. (Nuclear Regulatory Commission) has jurisdiction over man-made materials. The New Jersey Radiation officer, at Trenton should be contacted for further assistance.

Page 10 3.1 - Plutonium, PU239 and Americium, AM241 of known concentration of b.g. to 7120 nCi/gm (i.e. Background to or greater than 120 nanocurier/gm.) are extremely intense sources of alpha particles. This concentration can also be expressed as 120,000 pCi/gm(120,000 pica Curier/gm) so that it can be compared or contrasted with normal radon concentration p 4pCi/liter.

Page 10 3.2. - Plutonium and Americium are examples of transuranium elements, that is, they are man-made isotopes and not natural occurring radioactive elements.

Page 11 3.2.1 - No Comment

Page 11 3.2.2 - No Comment

Page 13 3.2.3 - The last sentence in top paragraph should have "annual" inserted before average.

Page 13 3.2.3 - No Comment

Page 14 3.2.5 - No Comment. except that portable survey instrumentation should be specific such as, Eberline ESP-2, portable survey instrument with probes for alpha, and ESP-1 alpha probe for radon daughters, rather than state chiefly scintillation or air proportional prober in general.

1. GENERAL:

A- Plan lacks specifics for monitoring equipment as required by 1910.120 (i)(2)(i)(f).
B- Plan should include mechanisim(s) to ensure that deficiencies are corrected as required by 1910.120 (i)(2)(iii).

2. SPECIFICS:

A- Page 15 paragraph 3.2.5 - wound monitor type (sensitivity, etc) should be specified pursuant to 1910.120(i)(2)(i)(f).
B- Paragraph 4.4.4 - personnel monitoring is required under OSHA standard area monitoring only is not acceptable.
C- Paragraph 4.4.5 - procedures for oxygen (O2) monitoring as well as for radiation monitoring other table 4-1 instruments, should be described. Instruments capable of monitoring dose rates from Pu (alphas, X-rays, and neutrons) should be specified. Procedures and calibration techniques should be included for HNU and OVA.
D- Paragraph 4.5.2 - radiation monitor this paragraph appears to say that dosimetry will not be worn for more than 1 year. If dosimetry is necessary, it must be worn for the duration of the job. Bioassay(fical or lung counting) will be necessary to detect intake, then this should be included and described in the plan.
E- Paragraph 4.5.4 - cold stress monitoring given accuracy of thermometers and individual temperature variability, this criteria may be difficult to meet.
F- Paragraph 4.7 - personal protection final plan shall specify each job function for each task.
G- Paragraph 4.7.3 - surface contamination measurement procedure should be described pursuant to 1910.120(i)(2)(i)(f).
H- Paragraph 4.7.4 - does statement 1 (warning properties) exclude radioactive materials? Note: 30 CFR 11 prohibition on contaminants without warning properties may apply for protection against organic vapors.
I- Paragraph 4.7.4 - air purifying respirators may be used in situations requiring a PF 750, provided the 40 hour average results in an integrated exposure within the standard.

J- Paragraph 6.10 - Page (84) Rn ionizing radiation requirement in 1910.96 is 1.25 rem per quarter, (not 5 rem/year).
1.25 rem per quarter or 5 rme/year.
i.e. 1.25 x 4 quarter = 5 rem/year

K- Paragraph 3.4.3 - confined space entry. Step by step confined space entry procedure should be addressed (specific) in the site safety and health plan, which should include how the permit system is going to be implemented and enforced.

If you have any questions in this review, contact Nat Sanchez at FTS 660-2351.

Sincerely,

James W. Stanley
Regional Administrator

cc: Harry D. Allendorf
Marlton Area Office

For Review and Approval

No. G8851-2200 (844)

	Name	Initials	Date
Originator	D Collins	[initials]	3-6-89
Concurrence	N Botts	[initials]	3-6-89
	W Nelson	[initials]	030689
Approved			

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R Kennedy
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March 6, 1989

U.S. Environmental Protection Agency
Region 2
Federal Facility Coordinator
Hargrove/Hadden
Room 702
26 Federal Plaza
New York, New York 10278

Enclosed you will find one (1) copy of the Health and Safety Plan for the BOMARC Missile Site, McGuire AFB, New Jersey. This plan was submitted on February 23, 1989 to Joseph Nycz at the U. S. Occupational Safety and Health Administration in Marlton, New Jersey and to the USAF Occupational and Environmental Health Laboratory, Brooks AFB, Texas.

Sincerely,

Neil E. Botts
Project Manager

NEB:DC/dlMc

Enclosure

For Review and Approval

	Name	Initials	Date
Originator	D Collins	[illegible]	3-6-89
Concurrence	N Botts	[illegible]	3-6-89
	W Nelson	[illegible]	030689
Approved	R Kennedy	[illegible]	[illegible]

No. G8851-2200 (844)

Internal Distribution
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N Botts
W Nelson
R Kennedy
Files

March 6, 1989

Joseph Malazinsky
Bureau of Case Management
Department of Environmental Protection
5th Floor West
401 E. State Street
Trenton, New Jersey 08625

Dear Mr. Malazinsky:

Enclosed you will find one (1) copy of the Health and Safety Plan for the BOMARC Missile Site, McGuire AFB, New Jersey. This plan was submitted on February 23, 1989 to Joseph Nycz at the U. S. Occupational Safety and Health Administration in Marlton, New Jersey and to the USAF Occupational and Environmental Health Laboratory, Brooks AFB, Texas.

Sincerely,

Neil E. Botts
Project Manager

NEB:DC/dlMc

Enclosure

For Review and Approval

	Name	Initials	Date
Originator	NE Botts	NEB	5-18-89
Concurrence			
Approved	RK Kennedy	RKK	051889

No. G1576-0010 (844)

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May 18, 1989

Ms. Julia K. Hilburn
Chief, Contracts Acquisition Branch
Occupational and Environmental
Health Laboratory
Brooks Air Force Base, Texas 78235-5501

Attention Major John M. Clegg, Jr., Technical Program Manager

Dear Ms. Hilburn:

DELIVERABLE: SEQUENCE 4, WORK PLAN AND QUALITY ASSURANCE PROJECT PLAN,
CONTRACT NO. F33615-85-D-4507
TASK NO. 22, BOMARC MISSILE SITE, McGUIRE AFB, NEW JERSEY

Enclosed are three (3) copies of the final Work Plan, Quality Assurance Project Plan, and the Interim In-Situ Sampling Plan for the Stage 2 investigations at the BOMARC Missile Accident Site, McGuire AFB, New Jersey. In addition, four copies of each plan have been sent to the Region 2 Environmental Protection Agency and to the New Jersey Department of Environmental Protection at the request of Major Clegg.

Sincerely,

ORIGINAL SIGNED BY
ROBERT K. KENNEDY

Robert K. Kennedy
Program Manager

RKK:NEB/dlMc

Enclosure

cc: J. Richey, DCASMA (ltr only)

Major David Hunter (1 cy)
USAFOEHL/RZC
Building 140
Brooks AFB, TX 78235-5501

Mr. Wayne Caughman (4 cys)
HQ MAC/DEEV
Scott AFB, IL 62225

State of New Jersey (4 cys)
Attn Joseph Malazinsky
Department of Environmental Protection
CN 028-401 E. State Street
Trenton, NJ 08625

Mr. Marty Eisenhart (2 cys)
BCE/DEEV
McGuire AFB, NJ 08641-5300

U.S. Environmental Protection Agency (4 cys)
Attn Federal Facility Coordinator
26 Federal Plaza
New York, NY 10278

APPENDIX N

PREVIOUS INVESTIGATIONS

1. RESULTS OF THE 1987 RADIOLOGICAL SURVEY AT THE FORT DIX BOMARC SITE

2. INSTALLATION RESTORATION PROGRAM PHASE II - CONFIRMATION QUANTIFICATION STAGE 2, SITE 1: McGUIRE MISSILE SITE ACCIDENT AREA, NOVEMBER 1987

USAFOEHL REPORT

88-150RA0121MRD

FOR HEALTH & ENVIRONMENT

RESULTS OF THE 1987 RADIOLOGICAL SURVEY AT THE FORT DIX BOMARC SITE, NEW JERSEY

DAVID HUNTER, Maj, USAF, BSC

December 1988

Final Report

Distribution is authorized to U.S. Government agencies only for administrative or operational use, December 1988. Other requests for this document should be referred to USAFOEHL/RZA.

USAF Occupational and Environmental Health Laboratory
Human Systems Division (AFSC)
Brooks Air Force Base, Texas 78235-5501

Prepared By:

DAVID HUNTER, Major, USAF, BSC
Chief, Radioanalytical Branch

Reviewed By:

EDWARD F. MAHER, Lt Col, USAF, BSC
Chief, Radiation Services Division

Approved By:

JAMES C. ROCK, Colonel, USAF, BSC
Commander

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION
Unclassified

1b. RESTRICTIVE MARKINGS
N/A

2a. SECURITY CLASSIFICATION AUTHORITY
N/A

3. DISTRIBUTION / AVAILABILITY OF REPORT
Distribution statement B. See reverse.

2b. DECLASSIFICATION / DOWNGRADING SCHEDULE
N/A

4. PERFORMING ORGANIZATION REPORT NUMBER(S)
USAFOEHL Report 88-150RA0121MRD

5. MONITORING ORGANIZATION REPORT NUMBER(S)
N/A

6a. NAME OF PERFORMING ORGANIZATION
USAF Occupational and Environmental Health Laboratory

6b. OFFICE SYMBOL (If applicable)
RZA

7a. NAME OF MONITORING ORGANIZATION
N/A

6c. ADDRESS (City, State, and ZIP Code)
Brooks AFB TX 78235-5501

7b. ADDRESS (City, State, and ZIP Code)

8a. NAME OF FUNDING / SPONSORING ORGANIZATION
Same as 6a

8b. OFFICE SYMBOL (If applicable)
N/A

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c. ADDRESS (City, State, and ZIP Code)

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)

Results of the 1987 Radiological Survey at the Fort Dix BOMARC Site, NJ

12. PERSONAL AUTHOR(S) David Hunter, Maj, USAF, BSC

13a. TYPE OF REPORT
Final

13b. TIME COVERED
FROM ________ TO ________

14. DATE OF REPORT (Year, Month, Day)
December 1988

15. PAGE COUNT
51

16. SUPPLEMENTARY NOTATION

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
BOMARC Radiological Survey WATCH-DOG PLUTO
Plutonium Environmental Radioactivity Ft Dix

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This report documents the results of the radiological survey and environmental sampling conducted during the annual Radiological Survey at the BOMARC accident site, Ft Dix NJ. The survey was performed by personnel from the Radiation Services Division, USAFOEHL, during 14-18 September 1987. The report concludes that the plutonium ground contamination inside the site has not migrated outside the site boundaries. The plutonium contamination appears to be still fixed under the concrete apron in front of missile shelter 204. Significant plutonium contamination was not found outside the BOMARC site boundary. None of the offsite sampling locations exceeded the USEPA's proposed screening limits for transuranics in the uncontrolled environment.

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT
☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION
Unclassified

22a. NAME OF RESPONSIBLE INDIVIDUAL
Maj David Hunter

22b. TELEPHONE (Include Area Code)
(512) 536-3486

22c. OFFICE SYMBOL
RZA

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All other editions are obsolete.

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Item 3, Continued

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ACKNOWLEDGMENTS

USAFOEHL extends its gratitude and appreciation to the personnel from the USAF Clinic McGuire/SGPB for their superb support and assistance, in particular: Lt David Wannigman, SSgt Kevin Midder, Sgt Tonya Gibson, SrA Leticia Gonzolez-Falik, A1C Stephen Baffic and Mrs Clarine Sawyer. Their outstanding contributions greatly increased our capability to complete all of our survey objectives.

CONTENTS

ILLUSTRATIONS

I. INTRODUCTION

A. During 14-18 September 1987, personnel from the Radiation Services Division of the USAF Occupational and Environmental Health Laboratory (USAFOEHL/RZ) conducted the annual radiological survey of the Fort Dix BOMARC Site, New Jersey. Periodic environmental monitoring on and around the BOMARC site has been ongoing prior to 1976 as part of the Air Force's program to maintain the deactivated site and to monitor the residual plutonium (Pu-239) left as a result of the BOMARC missile fire in 1960.

B. The periodic environmental monitoring plan for this installation was implemented in 1975 at the request of the USAF Surgeon General under the operations plan entitled "WATCH-DOG PLUTO".(1) Since then, radiological site surveys have been completed in 1976, 1978, 1979, and 1981-87. This report contains the results of the 1987 site survey, observations, sample analyses, interpretations, and recommendations for future surveillance.

II. BACKGROUND

A. On 7 June 1960, an explosion and fire erupted in BOMARC missile launch shelter 204 of the now deactivated 46th Air Defense Missile Squadron, located on the Fort Dix Military Reservation in Jackson Township, New Jersey. The missile and its nuclear warhead were consumed in the intense fire. As part of the firefighting activities, copious amounts of water were used to control the fire and to prevent it from spreading to one of the other 84 missile shelters in the complex. As a result, a yet unknown portion of the warhead's fissile material (Pu-239) was flushed from inside the shelter and either contaminated the soil and asphalt in front of shelter 204, or was washed down the asphalt ramp into a drainage ditch (Figure 1).

B. The drainage ditch runs southerly from shelter 204, paralleling the site boundary fence for several hundred feet before entering an underground culvert, and crossing underneath County Highway 539. From this point the culvert opens into a sandy ditch that eventually flattens into a heavily wooded area across the highway.

C. On 10 June 1960 the interior of missile launch shelter 204 was spray painted in an attempt to fix the Pu-239 contamination. Also, the asphalt apron in front of launch shelter 204 to the drainage ditch was coated with a thick layer of paint. In addition to the paint, four inches of concrete were poured over the asphalt apron covering the entire width of the apron from shelter 206 to the drainage ditch in an effort to "fix" the plutonium contamination under a protective overburden. As a result of the 1966 radiological survey conducted by the USAFOEHL's predecessor, the USAF Radiological Health Laboratory (USAFRHL), an additional 2-inch layer of concrete was poured over a 55 x 43 foot area of the apron in front of launch shelter 204 and extended 15 feet into the shelter. Also, a 2-in layer of asphalt was laid in the drainage ditch over a 12 x 550 foot area extending from a line directly south of the launch shelter to the facility boundary fence (Figure 2). Early radiological surveys in 1970-1973, conducted by the USAFRHL, have shown most of the plutonium to be under the concrete pad in front of the launch shelter or in the uncovered grassy areas adjacent to launch shelters 202-208. These areas have been the sites of highest contamination, ranging from 10-120 microcuries per square meter (10-120 $\mu Ci/m^2$). Vertical Pu-239 soil profiles in the near bordering edges of the concrete, conducted in 1973, indicated that the plutonium contamination was contained within the top 6-8 inches of soil.(1) In addition to the above areas, lessor amounts are detectable along the entire length of the asphalt drainage ditch inside the boundary fence (< 0.5 $\mu Ci/m^2$).

D. Both "off-site" and "on-site" terms will be used throughout this report. "Off-site" refers to all locations outside the boundary fence, while "on-site" refers to all locations inside the boundary fence of the BOMARC site. Most of the off-site contamination sampling points, on both sides of highway 539, have been well below the U.S. Environmental Protection Agency's (USEPA) proposed "screening level" for limiting the public's exposure to transuranics of 0.2 $\mu Ci/m^2$.(2) At the few off-site locations that have in the past been found to exceed the proposed "screening level", there has not emerged an apparent trend of either decreasing or increasing plutonium soil contamination. A 10-year summary of the Pu-239 levels measured on and off the BOMARC site and trend analysis, as well as an interpretation of the results were published in a previous USAFOEHL Report.(3)

III. SURVEY METHODS AND PROCEDURES

A. Instrument Monitoring

1. Gamma Survey: Selected off-site locations were surveyed using both FIDLER (Field Instrument for the Detection of Low Energy Radiation) and PG-2 (Plutonium Gamma) scintillation detectors (Appendix A and B respectively). The FIDLER detector consists of a Bicron Corporation 5-inch-diameter x 0.063-inch-thick NaI(Tl) crystal, with 0.010-inch-thick beryllium window. The PG-2 detector is an Eberline Corporation scintillation probe and consists of 2-inch-diameter x 0.079-inch-thick NaI(Tl) crystal with 0.001 inch-thick aluminum window. A Ludlum Measurements Incorporated, Model 2220 survey meter was used to record the external radiation count rate at the grid survey locations. The gross count rate data were collected at high voltage settings (windows) optimized from Americium-241 (Am-241) for the 17 and 60 keV photons. The calibration method developed by Mr Steven G. Homann was used for both the FIDLER and PG-2 probes.(4) The gross count rate data were corrected for background radiation and used to assist the survey team in locating soil sampling sites. The soils were packaged and sent to USAFOEHL/RZA for sample preparation and a definitive counting analysis to determine plutonium soil concentrations.

2. Alpha Survey: Selected areas of the damaged missile launch shelter 204 were surveyed using a hand-held alpha detector (Figure 3).

The probe used for the survey was an Eberline Model AC-3-7 alpha scintillation detector and included the following specifications: active area 59 cm^2; window thickness 0.5 mg/cm^2; aluminized film ZnS(Ag), scintillation crystal. A Ludlum Model 18 survey meter was used to record the count rate. The radioactive standard used to calibrate the alpha instrument was an Eberline model S94-4 Pu-239 source. Instrument efficiencies were calculated at 30 percent for contact monitoring of the smooth dry surfaces of the missile launch shelter 204.

B. Swipe Survey: Swipe samples were collected from missile launch shelters and underground communications and electrical bunkers to determine levels of removable contamination from the various surface areas (Figure 4). A single swipe was collected by taking a 4.25-cm diameter Whatman number 1 filter paper and wiping about a 100-cm^2 area. Gross alpha activity was measured on each swipe with a windowless gas-flow proportional counter. The plutonium was determined by dissolving the swipe in nitric acid, white ashing the residue, dissolving it in hydrochloric acid, and passing it through an ion exchange column. A HCl-HI solution was used to elute the plutonium, which was then converted to the sulfate salt and electrodeposited onto a 10-mm stainless steel planchet for counting. A solid-state alpha spectrometer having a surface-barrier detector was used to measure the Pu-239 alpha activity present.

C. Soil Samples: Representative soil samples were collected from off-site and on-site areas. Some samples were collected by taking eight core samples (3 inch diameter by 8 inches deep) in a four point "cross" pattern at a distance of 15 and 30 feet from the center of each sampling site (Figure 5). A single site collection from this method resulted in approximately 6 Kg of soil before drying. Single core samples were collected at points on both sides of the concrete apron and along the asphalt drainage ditch leading off-site (Figure 6). A single core sample from this method resulted in approximately 1.8 Kg of soil before drying. Soil samples were collected from under and around the manhole covers leading to the underground communications and electrical bunkers located directly in front of the launch shelters (Figure 7). Also, sludge samples from the floor of the bunkers were collected to determine the presence of plutonium contamination. Upon arrival at the Laboratory, each soil sample was processed for counting. All soil samples were first analyzed for gamma-emitting radionuclides using high-resolution (GeLi) gamma spectroscopy. The counting configuration used consisted of sealing the sample in an aluminum can (8-cm diameter x 3-cm deep) centered inside a 600-ml Marinelli Beaker. Selected soil samples were radiochemical processed for plutonium isotopes and analyzed by high-resolution alpha spectrometry. The radiochemical procedures called for the complete dissolution of the 10 grams in a combination of strong acids (hydrochloric, sulfuric, hydrofluoric, and perchloric), extraction of the plutonium using a resin column, and electroplating the residual on a stainless steel planchet. Transfer efficiencies for the method were determined to be better than 40%.

D. Water Samples: The 1987 annual survey included the collection of nonpotable water samples from the on-site underground communications and electrical bunkers. Water samples were collected in 1-gallon collapsible plastic containers and stored without preservation until analyzed. Gross alpha concentrations were measured by evaporating a 200-ml volume of acidified water on a 2-inch stainless steel planchet and counting the residue in a windowless gas-flow proportional counter. Plutonium concentration was determined by coprecipitation with alkaline phosphate in a one liter sample. Plutonium was extracted using an ion exchange resin column, electrodeposited onto a 10-mm stainless steel planchet and counted using an alpha spectrometer having a solid-state surface-barrier detector.(5,6,7)

E. Soil sampling, FIDLER surveys, and water sampling at the BOMARC site have been extensive over the past 12 years. This year's monitoring efforts were expanded to include: (1) alpha surveys and swipe surveys of launch shelter 204; (2) swipe surveys of downwind launch shelters; and (3) surveys to determine the extent of contamination to underground bunkers located in front of launch shelters 202-210. With the focus of this year's survey on the above three tasks, the number of soil samples and FIDLER readings were reduced from previous years. Also, neither ground nor surface water monitoring from the 1985 or 1986 survey locations were repeated.

IV. RESULTS AND OBSERVATIONS

A. Instrument Monitoring

1. The FIDLER field survey measurements for Pu-239 at selected sites are given in Appendix A. The grid measurement identifiers, i.e., column letter and row number for a particular measurement site are also shown. The FIDLER survey was used to locate any gross Am-241 that would indicate plutonium contamination. Some data points were slightly above the ambient background radiation but did not demonstrate Pu-239 concentrations above the calculated minimal detectable area activity (MDAA) of 0.8-1.5 $\mu Ci/m^2$. The proper interpretation of the "less than MDAA" value is that there is a 95% probability that the true areal density is less than the stated MDAA. A comparison of the 1987 FIDLER data for the same locations with that of previous years indicates no substantial differences over what has been measured before.(3)

2. The PG-2 field survey measurements for Pu-239 contamination contours within the concertina wire area and along the asphalt ditch leading off-site are given in Appendix B. These survey data were used to identify increased Pu-239 soil activity for sampling sites and to better define the total area of contamination surrounding the concrete apron and asphalt drainage ditch (Figure 6).

3. Portable hand-held alpha meters were used to survey the walls, rear doors, and overhead metal roof structures of launch shelter 204. These surveys revealed low level alpha surface contamination

(Appendix C). Survey points 1, 2, and 3 from the south wall showed the highest alpha levels ranging from 4,200 to 37,520 dpm/100 cm^2 (Figure 3). The north wall and metal roof structures demonstrated values ranging from 420 to 560 dpm/100 cm^2. These values exceed the acceptable surface contamination levels for fixed contamination for both average levels (100 dpm/.00 cm^2) and maximum contamination levels (300 dpm/100 cm^2).(8) Several of the alpha survey points were also swipe tested to determine removable contamination levels.

B. Swipe Surveys

1. Missile Launch Shelter 204: The results of the gross alpha contamination levels are shown in Table 1. Swipe locations 1 and 10 showed the highest removable alpha activity ranging from 336.6 dpm/100 cm^2 (153 pCi/100 cm^2) and 72.6 dpm/100 cm^2 (33 pCi/100 cm^2) respectively (Figure 8). Both of these values exceed the removable activity of 20 dpm/100 cm^2.(8) The remainder of the eight swipes were all negative for contamination. Alpha particl spectroscopy results from swipe number 10 demonstrated the presence of removable Pu-239, thus confirming the gross alpha results for this sample.

2. Other Missile Launch Shelters: The gross alpha swipe analyses of the other missile launch shelters are summarized in Table 2. The location of these launch shelters to damaged shelter 204 is shown in Figure 4. None of the swipe samples showed any measurable or removable contamination.

3. Underground Communications and Electrical Bunkers: A summary of the swipe results are shown in Table 3. All of the swipes were negative for any removable contamination.

C. Soil Samples

1. Eighty-six soil samples were collected and first analyzed by high resolution gamma spectroscopy to determine the radioactive concentrations of Am-241, uranium (U-238 and U-235), and cesium (Cs-137). Sixteen of the 86 samples were then analyzed by alpha particle spectroscopy to directly measure the Pu-239 soil concentration. Thirteen of these samples in which Pu-239 and Am-241 were measurable, yielded an average Pu-239/Am-241 ratio of 5.9. This ratio was used to estimate the Pu-239 concentration in soil samples in which no alpha particle spectroscopy was performed. A Pu-239/Am-241 ratio of 5.8 was calculated by the New Jersey Department of Environmental Protection to estimate the Pu-239 concentrations in which Am-241 was detectable but the Pu-239 was less than the MDAA.(9)

2. On-Site and Off-Site Soil Concentration Levels

a. The radioanalytical results for both on-site and off-site soil samples are summarized in Table 4. The on-site sample points that had elevated Pu-239 concentrations included several near the damaged launch shelter as well as sites next to the asphalt drainage ditch (sites 167, 172, 173, and 177)(Figure 5). These sites have shown elevated levels in past surveys and represent contamination carried by the runoff water from firefighting activities during the accident. One sample point (site 179) showed a slightly elevated Pu-239 value. This site has not shown elevated values in past surveys (1976-1986). The reason for this result is unclear; however, with the absence of elevated Pu-239 in adjacent locations it is unlikely that the contamination is due to the missile accident and most likely represents a laboratory artifact.

b. The off-site sample points (54, 116, and 213) that had elevated Pu-239 values were all downwind from the missile accident site (Figure 5). Sample point 54, located about 25 meters north of sample point 116, would have been in the general area of the firefighting water runoff. Both sample points (sites 116 and 213), have shown elevated Pu-239 concentrations in past years. These results, despite some variability, are consistent with past years findings and show no new trends in Pu-239 concentrations.

3. Soil Levels Near Concrete Apron and Asphalt Ditch Area

a. Results of the single core soil samples surrounding the concrete apron and along the asphalt drainage ditch are shown in Table 9. The range of plutonium soil concentrations varied from a low of 0.27 to 3,221 pCi/g. The wide range of values suggests that a nonuniform deposition of plutonium exists.

b. Soil sample locations (sites 1-30) bordering both sides of the concrete apron and the relationship to the eight launch shelters (201-210) are shown in Figure 6. Soil sampling points surrounding launch shelter 204 showed the highest cluster of plutonium concentrations. One sample point (site 6), located about 20 feet from the northwest corner of launch shelter 204 had the highest plutonium concentration in this sampling group. These results were not surprising since elevated levels were present in previous surveys. The 12 sampling points surrounding launch shelter 204 spanned a wide range of plutonium concentrations values (1.9 to 2,478 pCi/g). This wide range of variability in plutonium soil concentrations will make site characterization more difficult than previously thought.

c. Nineteen single core soil samples were collected along both sides of the asphalt drainage ditch area (Figure 6). Plutonium soil concentration values (0.24 to 3,221 pCi/g), despite their variability, are consistent with previous years survey results. These sites were downwind from the smoke plume and firefighting water runoff flowed in this direction which would explain the measured plutonium soil concentrations.

4. Soil Scrapings from the Bunker Manhole Covers

a. Radiological data for the bunker sampling points are shown in Table 6. The locations of the bunker manhole covers in relation to the surrounding launch shelters are shown in Figure 4.

b. Significant plutonium soil contamination was found between the manhole cover and the metal rim support structure from all the bunkers. The bunkers in front of launch shelters 206, 208, and 210 were upwind from the plume at the time of the accident. We believe that this area may have been used as the upwind decontamination point for personnel, property, and vehicles. The loose contamination from the decontamination procedures could quite easily have been lodged in the space between the manhole cover and the metal rim support structure. The bunkers in front of launch shelter 204 were covered over with concrete in 1960, shortly after the accident, and for this reason we were unable to survey it. Both bunkers in front of launch shelter 202 were found to have plutonium contamination on the upper metal rim, lower metal rim, and the inner lid covering. Plutonium contamination would be expected since the bunkers were in direct line of the firefighting water runoff.

5. Soil Samples from Underground Bunkers

Soil sample results collected from the floor of the underground bunkers are listed in Table 7. All the soil samples showed the presence of plutonium contamination, bunkers 1A and 5A respectively. Again, this is probably due to the water runoff from decontamination and firefighting efforts.

6. Water Sampling

Results of the plutonium measurements in the nonpotable water samples taken from the underground bunkers are shown in Table 12. The samples were collected from 18-24 inches of standing water from each of the bunkers. The water color was a light brown in appearance and contained some suspended solids.

V. CONCLUSIONS AND RECOMMENDATIONS

A. Instrument monitoring with the FIDLER detector showed similar results for the same locations with that of previous surveys. The FIDLER surveys should continue as part of the survey, but should be limited to within the concertina wire area where the sensitivity of the FIDLER is adequate. The sensitivity of the FIDLER instrument is optimal when the plutonium is freshly deposited on the surface. Previous soil surveys have shown that the plutonium is predominantly at 6-8 inches below the soil surface which limits the area sensitivity of the FIDLER instrument to approximately 0.8-1.5 $\mu Ci/m^2$. Both FIDLER and PG-2 instrument surveys supported the soil sample results in the higher contaminated tract within the concertina wire area.

B. Portable alpha monitoring of missile launch shelter 204 demonstrated fixed alpha contamination in excess of acceptable levels. Also, swipe survey results of the same launch shelter showed removable contamination in excess of the acceptable removable surface contamination of 20 dpm/100 cm^2. We recommend painting missile launch shelter 204 with a protective strippable skin coating to prevent spreading of contamination. The strippable paint will not only contain radioactive contamination, but when "peeled-off" will remove contamination adhering to it. Two vendors manufacture and market strippable paint for this purpose and are referenced for your information.(10,11)

C. Results of the off-site soil samples are not substantially different from previous years surveys. Despite the annual variations that typify some sampling locations, there is no evidence to suggest that large scale plutonium migration is occurring. Three areas (sites 54, 110, and 213) located off-site suggest that additional soil sampling needs to be done as part of the remedial investigation/ feasibility study (RI/FS) process to fully characterize the plutonium soil concentration. This task will require a program to do both surface and vertical soil sampling.

D. Plutonium soil concentrations vary considerably in and around missile launch shelter 204. The plutonium contamination is not distributed uniformly over this area, but occurs in discrete "hot spots", which most likely represents a single particle of Pu-239. Thus, Pu-239 soil concentrations within a small area can and do vary somewhat. Generally, however, the Pu-239 concentrations indicate that the levels of Pu-239 have remained stable over the intervening years. The wide range of plutonium soil concentration values will present challenges in performing site characterization of the BOMARC installation during the RI/FS process.

E. The plutonium soil contamination located between the manhole cover and the metal support rim was removed for analyses. While most, if not all, of the contaminated soil was removed from this location, a resurvey of this same area is recommended. Also, the contaminated soil collected from the floors of the underground bunkers indicated that the entire floor is probably contaminated. The bunkers should be considered for decontamination as part of a remedial action plan.

F. The nonpotable water samples collected from the seven underground bunker sites showed slight traces of plutonium. Particles were suspended in the water samples, possibly minute plutonium particles, which could easily account for the small tracer concentrations of plutonium in the water. The soil from the floor of the bunker showed a plutonium concentration of 1,180 pCi/dry g. The water sample from the same bunker had a Pu-239 concentration of 0.83 pCi/liter which supports the idea that the chemical form of the plutonium is primarily insoluble.

G. The quarterly visual inspections of the BOMARC installation should be continued by the McGuire AFB Radiation Protection and Environmental Coordinator. This inspection would be valuable to ascertain the condition of the site and to identify any potential loss of site integrity in the concertina fence area or site boundaries.

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6. Sheehan, W.E., et al: Urinalysis for Metabolized Plutonium, published in Proceedings of the Ninth Annual Conference on Bioassay and Analytical Chemistry, San Diego, California, Oct 10-11, 1963.

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10. Atomic Products Corporation, P.O. Drawer R, Shirley, New York (516) 924-9000. Product Name, "Atompeel," stock number, 111-105.

11. Imperial Protective Coatings, Houston, Texas (713) 688-4430. Product Name, "ALARA-1146 DECON."

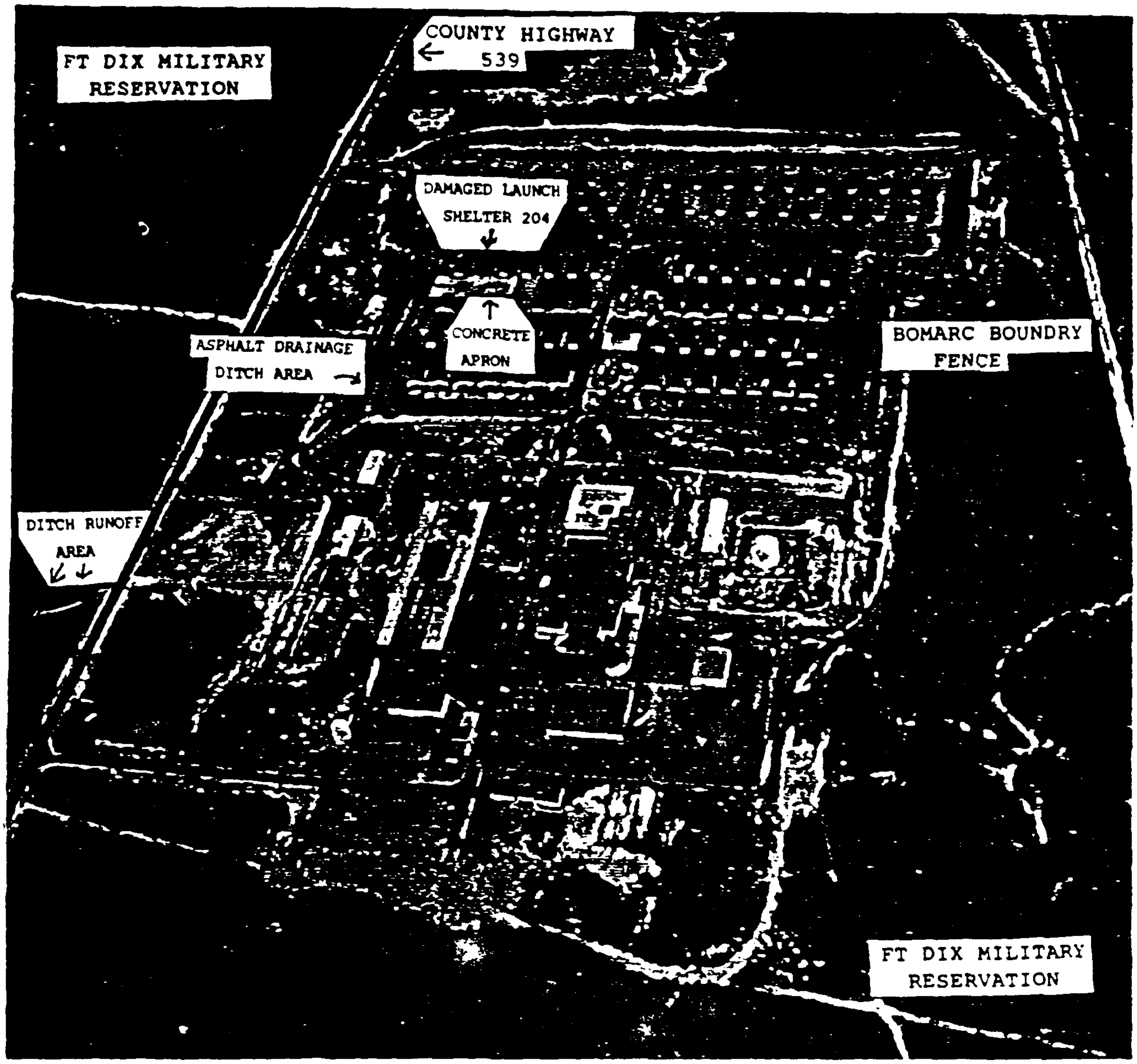


Figure 1: Aerial Photo of BOMARC Site

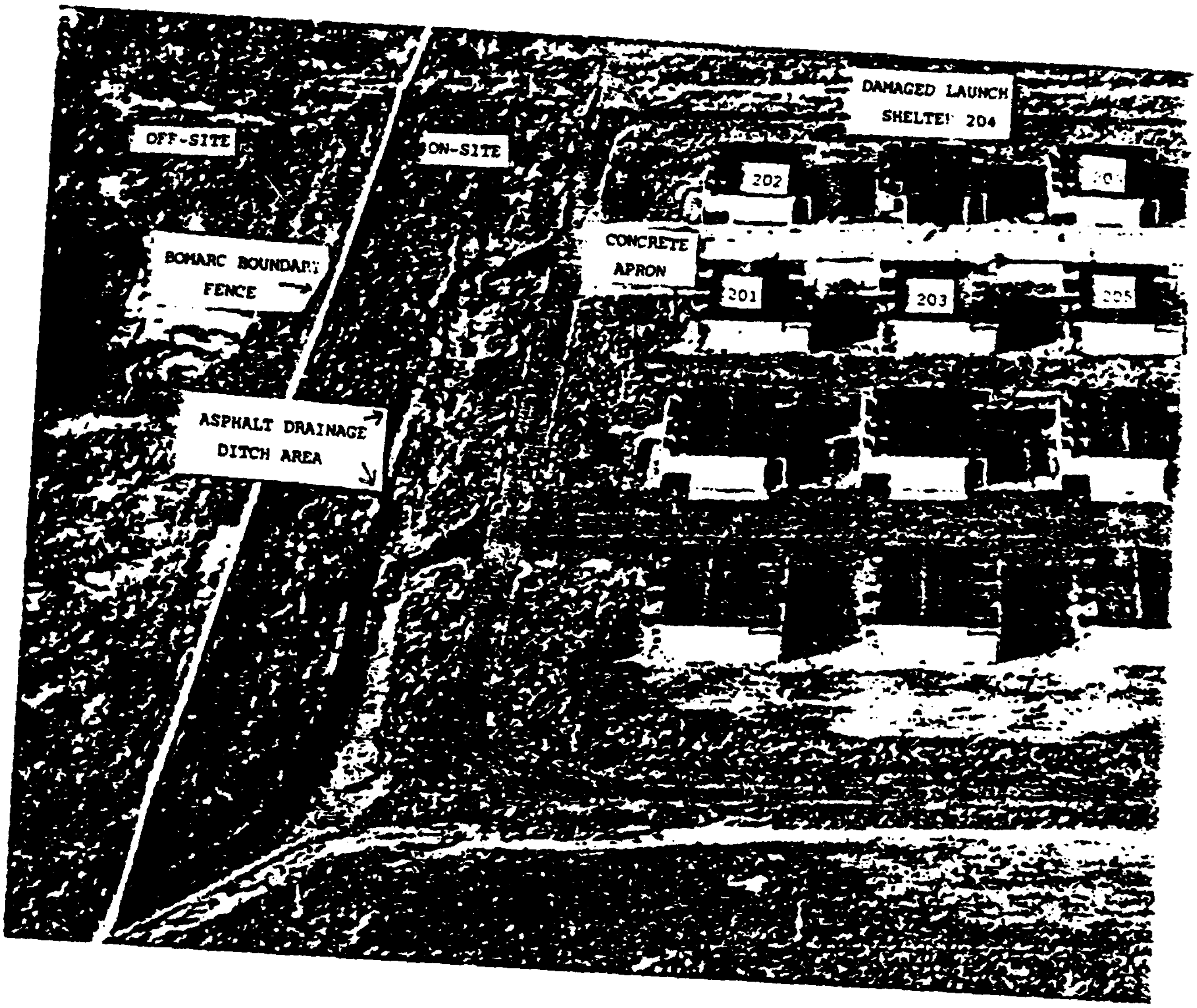
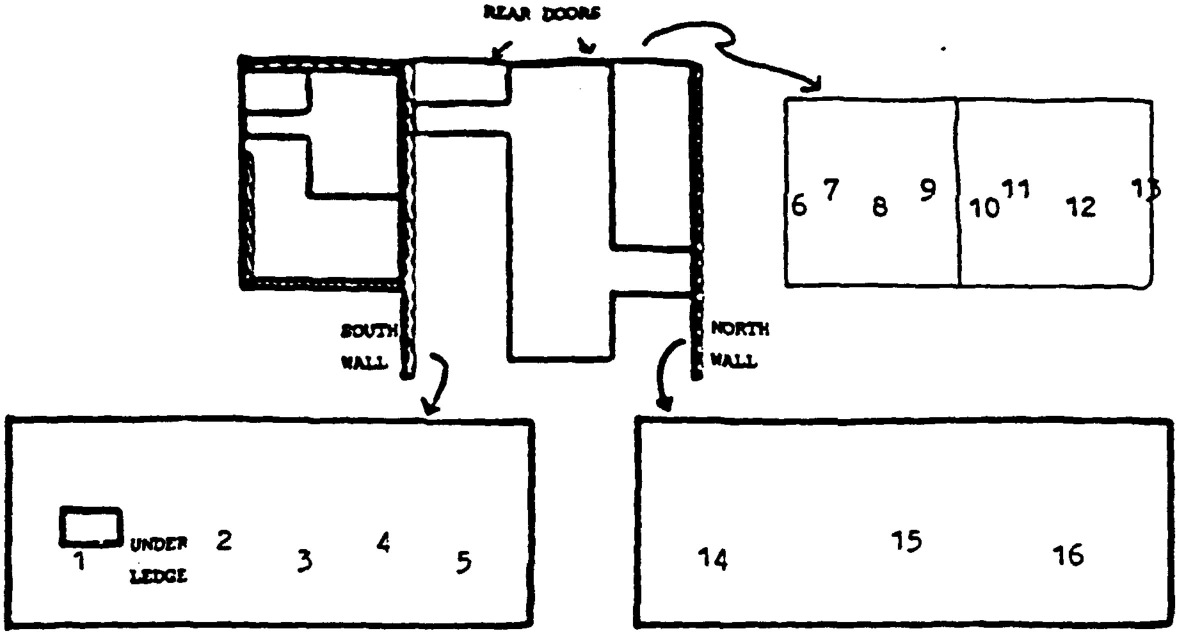


Figure 2: Aerial Photo of Asphalt Drainage Ditch



Survey Location	Readings (dpm/100 cm^2)	Survey Location	Readings (dpm/100 cm^2)
1	6,300	11	420
2	4,200	12	560
3	37,520	13	420
4	840	14	560
5	420	15	420
6	560	16	560
7	420	17*	420
8	560	18*	420
9	420	19*	420
10	420	20*	420

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*Measurements taken from the metal roof support structures.

Figure 3: Alpha Survey of Launch Shelter 204.

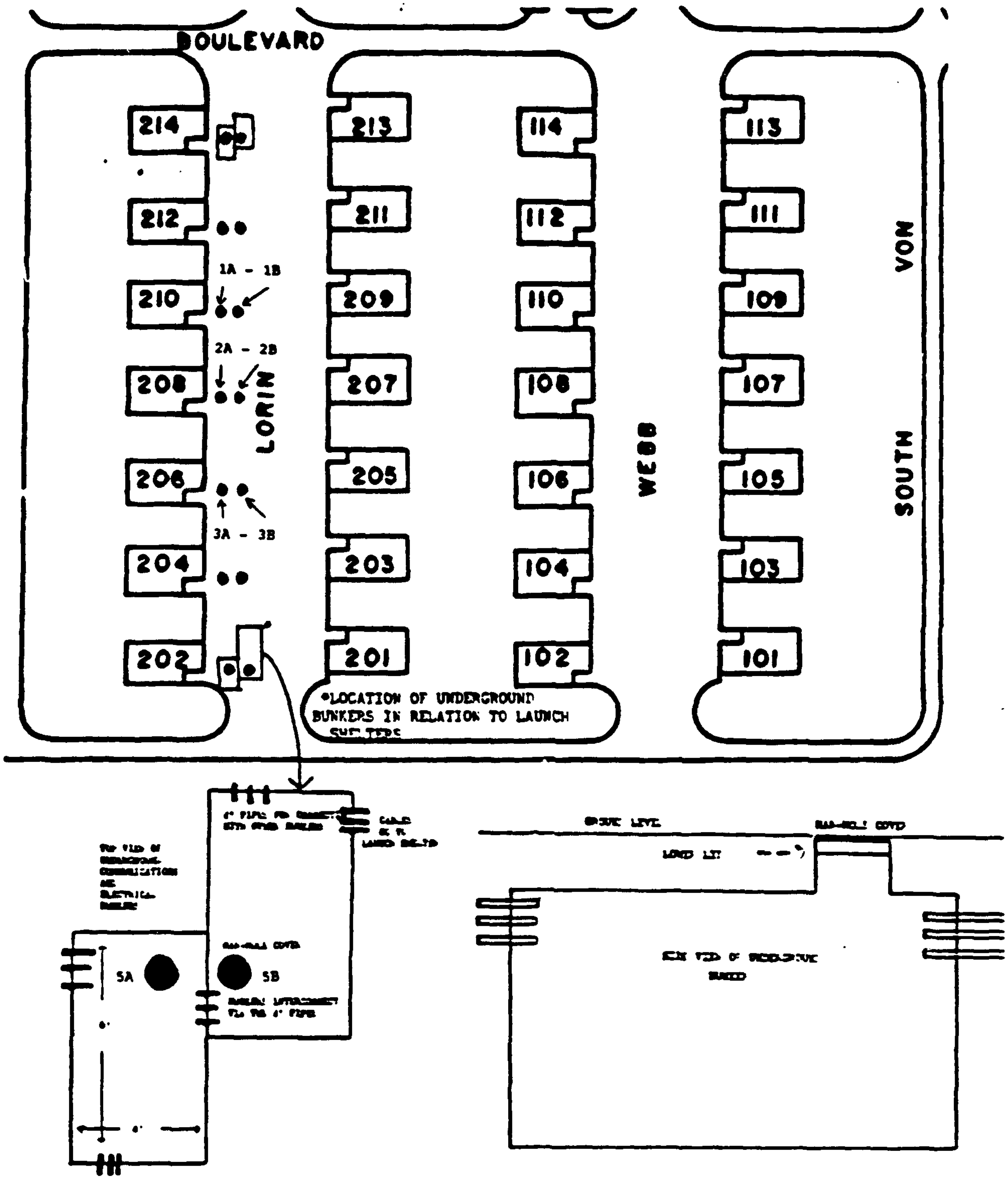


Figure 4: Missile Launch Shelters and Underground Communications/Electrical Bunkers

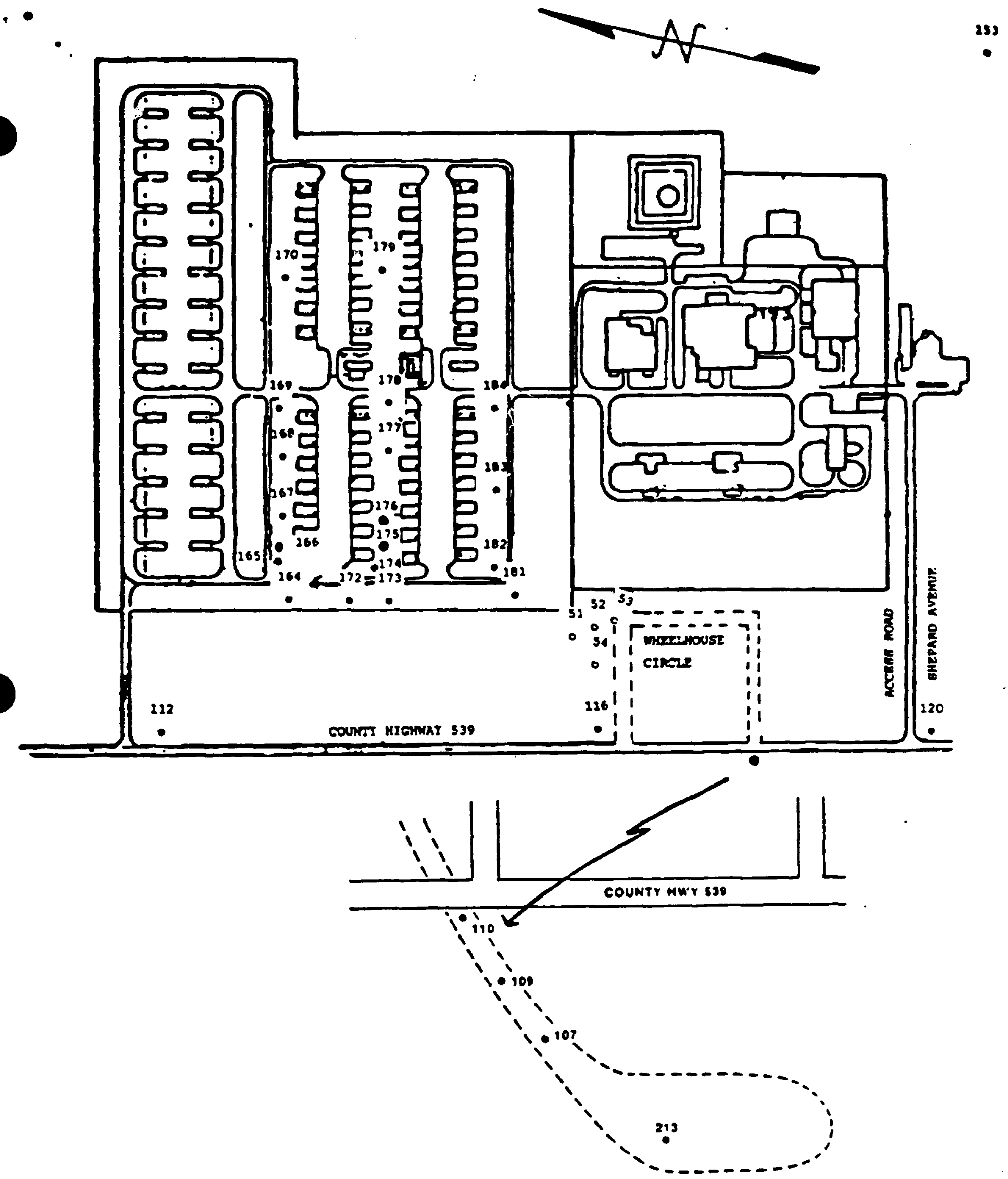


Figure 5: On-Site/Off-Site Soil Sampling Locations

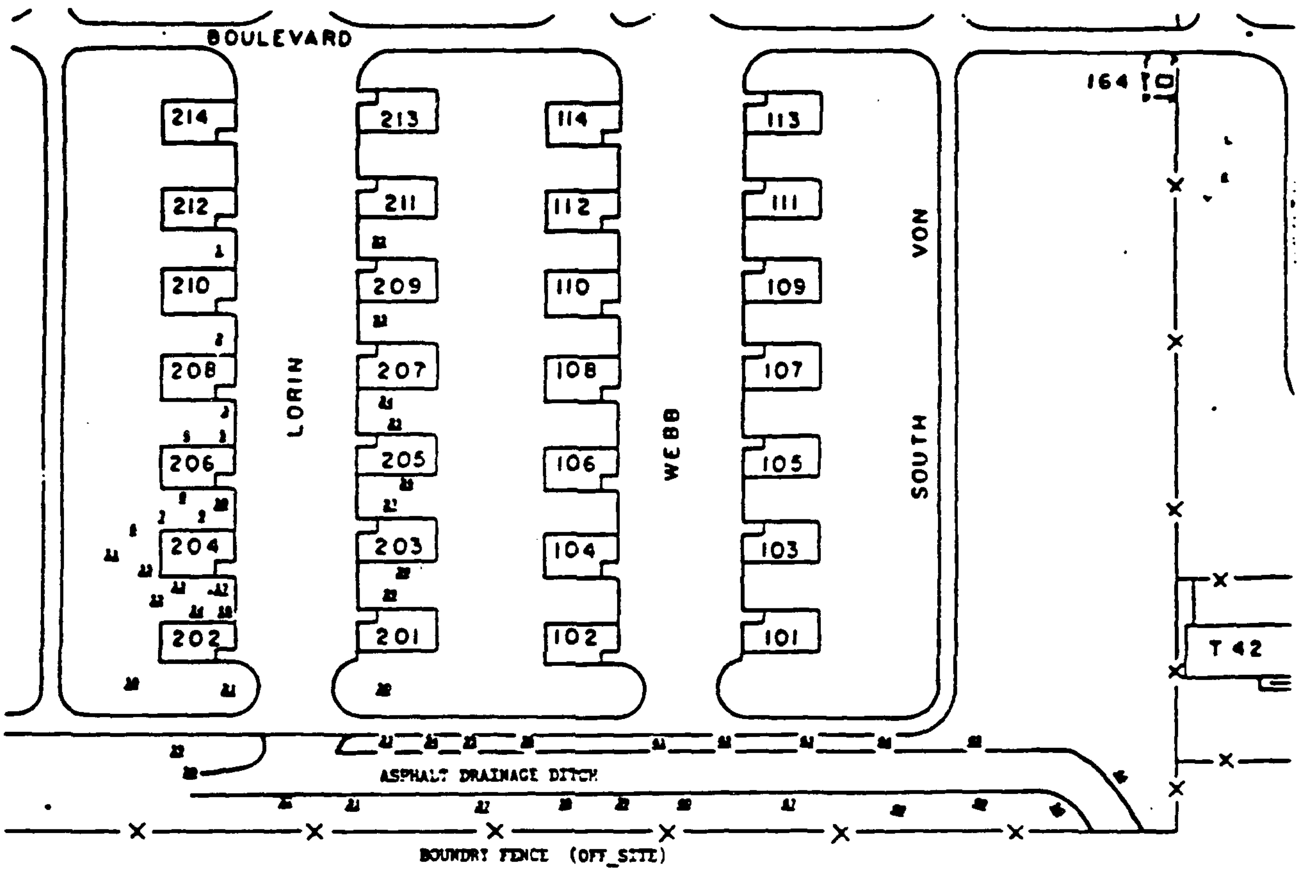


Figure 6: Soil Sites for Concrete Apron and Asphalt Drainage Ditch

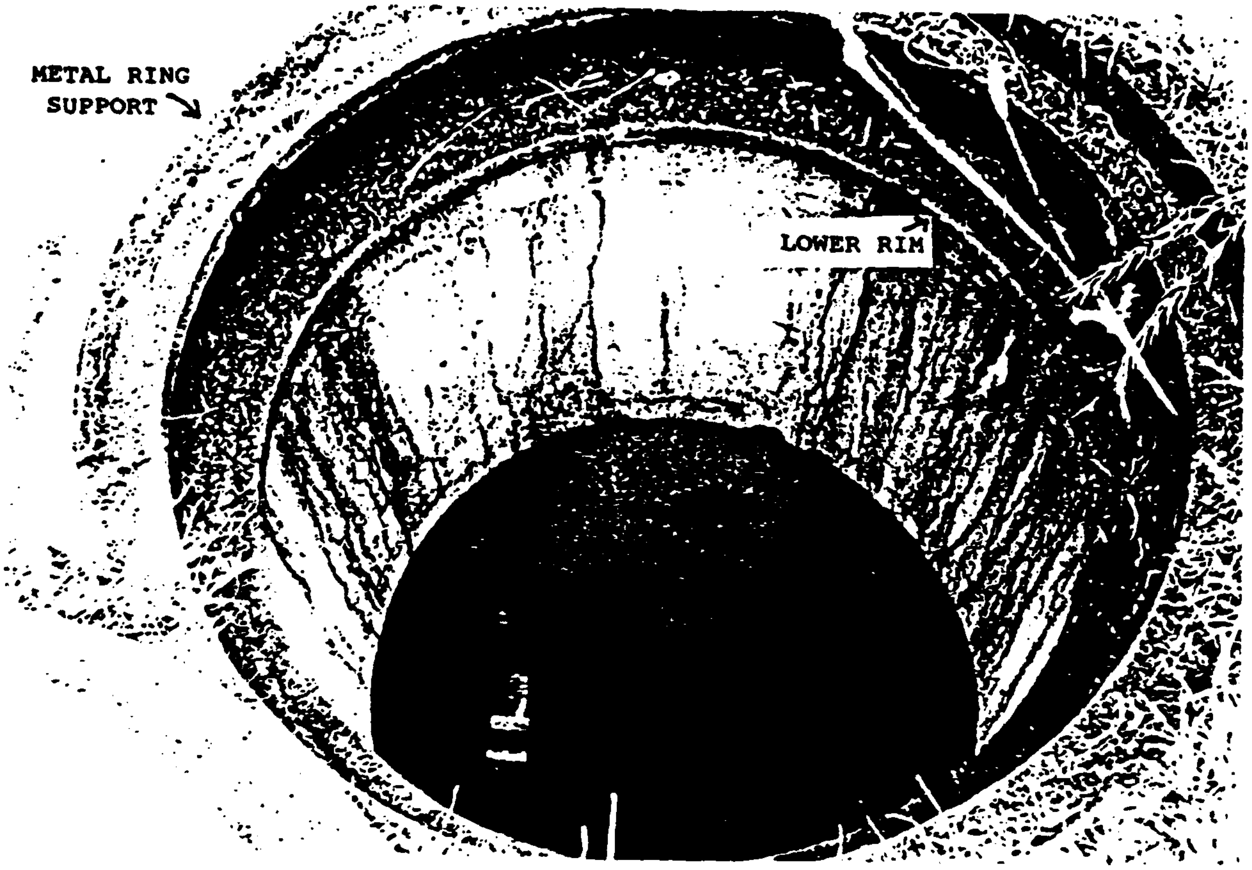
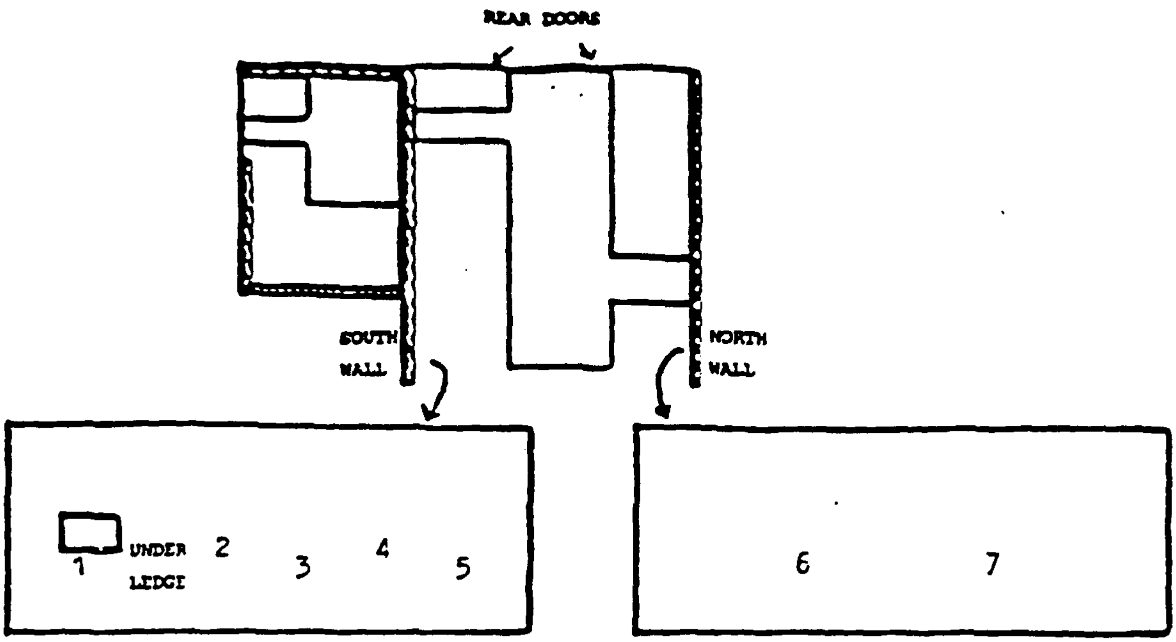


Figure 7: Underground Communications and Electrical Bunkers



Swipe Location	Gross Alpha (pCi/100 cm^2)	Swipe Location		Gross Alpha (pCi/100 cm^2)
1	153. +/- 8	6		< 1
2	< 1	7		2. +/- 1
3	< 1	8		< 1
4	< 1	9		< 1
5	< 1	10		33. +/- 4
		11*	Pu-239	3.2 +/- 0.6

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*Swipes 8-10 are from the metal roof support structure. Swipe number 10 was from the roller assembly on the north wall. Alpha spectroscopy was used to analyze swipe number 10..

Figure 8: Swipe Survey of Launch Shelter 204.

TABLE 1: Launch Shelter 204 Swipe Data

Swipe* Identification	USAFOEHL Number	Gross Alpha pCi/100 cm^2	Gross Beta pCi/100 cm^2 **
No. 1	48704383	153. +/- 8	< 3
No. 2	48704382	< 1	< 2
No. 3	48704381	< 1	< 2
No. 4	48704380	< 1	< 2
No. 5	48704379	< 1	< 2
No. 6	48704378	< 1	< 2
No. 7	48704405	2. +/- 1	< 2
No. 8	48704406	< 1	< 2
No. 9	48704407	< 1	< 2
No. 10	48704408	33. +/- 4	< 2
No. 11***	18701211	Pu-239 Pu-238	3.2 +/- 0.6 < 0.1

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*Reference Figure 3 for swipe locations.
**Results accurate to 2 significant figures. Error term at 95% confidence level.
***Alpha spectroscopy results from swipe number 10 in pCi/swipe.

TABLE 2: Gross Alpha Swipe Results From Surrounding Launch Shelters

Site* Identification	USAFOEHL Number	Gross Alpha pCi/100 cm^2	Gross Beta pCi/100 cm^2 **
Shelter 210 "I" Beam	48704391	< 1	< 2
Shelter 210 Roof, Rear	48704392	< 1	< 2
Shelter 210 Roof, Middle	48704393	< 1	2 +/- 1
Shelter 210 Roof, Front	48704394	< 1	< 2
Shelter 208 Roof, Rear	48704388	< 1	< 1
Shelter 208 Roof, Middle	48704389	< 1	< 2
Shelter 208 Roof, Front	48704390	< 1	< 2
Shelter 206 "I" Beam	48704384	< 1	< 2
Shelter 206 Roof, Rear	48704385	< 1	< 2
Shelter 206 Roof, Middle	48704386	< 1	< 2
Shelter 206 Roof, Front	48704387	< 1	< 2
Shelter 202 Roof, Front	48704409	< 1	< 2
Shelter 202 Roof, Middle	48704410	< 1	< 2
Shelter 202 "I" Beam	48704403	< 1	< 2
Shelter 202 Roof, Rear	48704404	< 1	< 2

Site* Identification	USAFOEHL Number	Gross Alpha pCi/100 cm^2	Gross Beta pCi/100 cm^2 **
Shelter 203 Roof, Middle	48704395	< 1	< 2
Shelter 203 Roof, Front	48704396	< 1	< 2
Shelter 203 Roof, Rear	48704397	< 1	< 2
Shelter 203 "I" Beam	48704398	< 1	< 2
Shelter 201 "I" Beam	48704399	6 +/- 2	< 2
Shelter 201 Roof, Front	48704400	< 1	< 2
Shelter 201 Roof, Middle	48704401	< 1	< 2
Shelter 201 Roof, Rear	48704402	< 1	< 2
Shelter 104 Roof, Rear	48704426	< 1	< 2
Shelter 104 Roof, Middle	48704427	< 1	< 2
Shelter 104 Roof, Front	48704428	< 1	< 2
Shelter 102 Roof, Front	48704423	< 1	< 2
Shelter 102 Roof, Middle	48704424	< 1	< 2
Shelter 102 Roof, Rear	48704425	< 1	< 2

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*Reference Figure 4 for launch shelter locations.
**Results accurate to 2 significant figures. Error term at 95% confidence level.

TABLE 3: Gross Alpha Swipe Results From Underground Communications and Electrical Bunkers

Swipe* Identification	USAFOEHL Number	Gross Alpha pCi/100 cm^2	Gross Beta pCi/100 cm^2	Gross Gamma pCi/100 cm^2**
Shelter 210 Bunker 1A North Wall	48704414	< 1	< 2	< 50
Shelter 210 Bunker 1A South Wall	48704412	< 1	< 2	< 50
Shelter 210 Bunker 1A East Wall	48704413	< 1	< 2	< 50
Shelter 210 Bunker 1A West Wall	48704411	< 1	< 2	< 50
Shelter 208 Bunker 2A North Wall	48704422	< 1	< 2	< 50
Shelter 208 Bunker 2A South Wall	48704421	< 1	< 2	< 50
Shelter 208 Bunker 2A East Wall	48704420	< 1	< 2	< 50
Shelter 208 Bunker 2A West Wall	48704419	< 1	< 2	< 50
Shelter 206 Bunker 3A North Wall	48704415	< 1	< 2	< 50
Shelter 206 Bunker 3A South Wall	48704417	< 1	< 2	< 50
Shelter 206 Bunker 3A East Wall	48704418	< 1	< 2	< 50
Shelter 206 Bunker 3A West Wall	48704416	< 1	< 2	< 50

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*Reference Figure 4 for bunker locations.
**Results accurate to 2 significant figures. Error at 95% confidence level.

TABLE 4: On-Site and Off-Site Radionuclide Soil Concentration Data

Site* Number	USAFOEHL Number	Sample WT. Dry Gram	Radio-Nuclide	Concentration (pCi/dry gram)**	Surface Area (μCi/m^2)***
51	18701246	1960.8	Pu-239	≤ 0.24	0.1
			Am-241	< 0.04	
			U-238	< 0.5	
			U-235	< 0.06	
			Cs-137	0.17 +/- 0.02	
52	18701247	1779.3	Pu-239	≤ 0.18	0.07
			Am-241	< 0.03	
			U-238	< 0.3	
			U-235	< 0.04	
			Cs-137	0.23 +/- 0.1	
53	18701235	2532.6	Pu-239	≤ 0.24	0.13
			Am-241	< 0.04	
			U-238	< 0.4	
			U-235	< 0.07	
			Cs-137	0.14 +/- 0.02	
54	18701237	2656.2	Pu-239	≤ 0.94	0.5
			Am-241	0.16 +/- 0.07	
			U-238	< 0.6	
			U-235	< 0.07	
			Cs-137	0.13 +/- 0.01	
107	18701283	3767.1	Pu-239	≤ 0.23	0.05
			Am-241	< 0.039	
			U-238	< 0.35	
			U-235	< 0.051	
			Cs-137	< 0.015	
109	18701284	5328.0	Pu-239	≤ 0.24	0.07
			Am-241	< 0.042	
			U-238	< 0.34	
			U-235	< 0.054	
			Cs-137	< 0.015	
110	18701285	3923.7	Pu-239	≤ 0.29	0.06
			Am-241	< 0.049	
			U-238	0.39 +/- 0.36	
			U-235	< 0.06	
			Cs-137	< 0.02	

Site* Number	USAFOEHL Number	Sample WT. Dry Gram	Radio-Nuclide	Concentration (pCi/dry gram)**	Surface Area (μCi/m²)***
112	18701287	7618.6	Pu-239	≤ 0.40	0.08
			Am-241	< 0.068	
			U-238	< 0.55	
			U-235	0.069 +/- 0.065	
			Cs-137	0.32 +/- 0.02	
116	18701288	8560.0	Pu-239	≤ 0.54	0.13
			Am-241	< 0.092	
			U-238	< 0.74	
			U-235	< 0.068	
			Cs-137	0.26 +/- 0.02	
120	18701265	9239.2	Pu-239	≤ 0.30	0.08
			Am-241	< 0.05	
			U-238	< 0.35	
			U-235	< 0.06	
			Cs-137	0.29 +/- 0.02	
144	18701271	9066.2	Pu-239	≤ 0.30	0.07
			Am-241	< 0.05	
			U-238	< 0.43	
			U-235	< 0.1	
			Cs-137	0.21 +/- 0.02	
153	18701272	10061.9	Pu-239	≤ 0.24	0.07
			Am-241	< 0.04	
			U-238	< 0.36	
			U-235	< 0.06	
			Cs-137	0.11 +/- 0.01	
164	18701279	8920.5	Pu-239	≤ 0.30	0.07
			Am-241	< 0.05	
			U-238	< 0.37	
			U-235	< 0.07	
			Cs-137	< 0.02	
165	18701280	8333.0	Pu-239	≤ 0.35	0.08
			Am-241	< 0.06	
			U-238	< 0.46	
			U-235	< 0.07	
			Cs-137	< 0.03	
166	18701289	8385.9	Pu-239	≤ 0.24	0.12
			Am-241	< 0.04	
			U-238	< 0.4	
			U-235	< 0.06	
			Cs-137	0.12 +/- 0.01	

Site* Number	USAFOEHL Number	Sample WT. Dry Gram	Radio-Nuclide	Concentration (pCi/dry gram)**	Surface Area ($\mu Ci/m^2$)***
167	18701290	9037.6	Pu-239	0.38	0.09
			Am-241	0.65 ± 0.094	
			U-238	< 0.81	
			U-235	< 0.059	
			Cs-137	1.8 ± 0.016	
168	18701264	9394.1	Pu-239	0.12	0.03
			Am-241	< 0.02	
			U-238	< 0.25	
			U-235	< 0.05	
			Cs-137	0.21 +/- 0.02	
169	18701263	8550.1	Pu-239	0.24	0.05
			Am-241	< 0.04	
			U-238	< 0.34	
			U-235	< 0.07	
			Cs-137	0.24 +/- 0.02	
170	18701273	8323.4	Pu-239	0.47	0.01
			Am-241	< 0.08	
			U-238	< 0.62	
			U-235	< 0.06	
			Cs-137	0.26 +/- 0.02	
172	18701261	6503.8	Pu-239	30.68	5.4
			Am-241	5.2 +/- 0.16	
			U-238	< 1.6	
			U-235	< 0.084	
			Cs-137	0.29 +/- 0.02	
173	18701262	7950.7	Pu-239	1.9	0.4
			Am-241	0.32 +/- 0.08	
			U-238	< 0.67	
			U-235	< 0.064	
			Cs-137	0.16 +/- 0.02	
174	18701281	7461.2	Pu-239	0.24	0.05
			Am-241	0.04 +/- 0.03	
			U-238	< 0.6	
			U-235	< 0.06	
			Cs-137	0.029 +/- 0.02	
175	18701282	6641.2	Pu-239	0.2	0.04
			Am-241	< 0.034	
			U-238	< 0.27	
			U-235	< 0.033	
			Cs-137	< 0.022	

Site* Number	USAFOEHL Number	Sample WT. Dry Gram	Radio-Nuclide	Concentration (pCi/dry gram)**	Surface Area ($\mu Ci/m^2$)***
176	18701306	8403.4	Pu-239	≤ 0.47	0.1
			Am-241	< 0.08	
			U-238	< 0.58	
			U-235	< 0.05	
			Cs-137	0.23 +/- 0.02	
177	18701307	8544.6	Pu-239	≤ 0.65	0.15
			Am-241	0.11 +/ 0.06	
			U-238	< 0.3	
			U-235	< 0.06	
			Cs-137	< 0.02	
178	18701260	9378.3	Pu-239	≤ 0.24	0.06
			Am-241	< 0.04	
			U-238	< 0.36	
			U-235	< 0.06	
			Cs-137	0.21 +/- 0.016	
179	18701274	8979.7	Pu-239	≤ 0.71	0.17
			Am-241	< 0.12	
			U-238	0.97 +/- 0.97	
			U-235	< 0.12	
			Cs-137	0.66 +/- 0.04	
181	18701259	3472.3	Pu-239	≤ 0.35	0.07
			Am-241	< 0.06	
			U-238	< 0.71	
			U-235	< 0.12	
			Cs-137	0.26 +/- 0.02	
182	18701299	6279.5	Pu-239	≤ 0.30	0.05
			Am-241	< 0.05	
			U-238	< 0.4	
			U-235	< 0.064	
			Cs-137	0.29 +/- 0.02	
183	18701300	6048.2	Pu-239	≤ 0.24	0.04
			Am-241	< 0.04	
			U-238	0.36 +/- 0.3	
			U-235	< 0.06	
			Cs-137	0.29 +/- 0.02	
184	18701266	9260.0	Pu-239	≤ 0.41	0.1
			Am-241	< 0.07	
			U-238	0.63 +/- 0.59	
			U-235	< 0.07	
			Cs-137	0.21 +/- 0.02	

Site* Number	USAFOEHL Number	Sample WT. Dry Gram	Radio-Nuclide	Concentration (pCi/dry gram)**	Surface Area ($\mu Ci/m^2$)***
213	18701286	3628.2	Pu-239	≃ 0.3	0.06
			Am-241	0.53 +/- 0.07	
			U-238	< 0.66	
			U-235	< 0.06	
			Cs-137	0.23 +/- 0.02	

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*Reference Figure 5 for soil sample locations.
**All Pu-239 values are calculated based on the Pu-239/Am-241 ratio of 5.9. All other radionuclide concentrations were measured using high-resolution gamma spectroscopy.
***Surface area calculated using assumptions from USAFOEHL Report 86-034 R121ERD.

TABLE 5: Radionuclide Soil Concentrations for Concrete Apron and Asphalt Ditch Area

Site* Number	USAFOEHL Number	Sample WT. Dry Gram	Radio-Nuclide	Concentration (pCi/dry gram)**	Surface Area ($\mu Ci/m^2$)***
1	18701239	2152.1	Pu-239	0.68 +/- 0.08	0.31
			Am-241	<0.06	
			U-238	<0.5	
			U-235	<0.06	
			Cs-137	0.18 +/- 0.01	
2	18701241	2021.5	Pu-239	≥ 1.23	0.54
			Am-241	0.21 +/- 0.07	
			U-238	<0.6	
			U-235	<0.03	
			Cs-137	0.13 +/- 0.01	
3	18701238	1786.6	Pu-239	439. +/- 36.	17.3
			Am-241	7.5 +/- 0.2	
			U-238	<1.8	
			U-235	0.21 +/- 0.07	
			Cs-137	0.31 +/- 0.02	
4	18701240	1888.2	Pu-239	11. +/- 1.4	4.5
			Am-241	1.7 +/- 0.1	
			U-238	<1.	
			U-235	<0.1	
			Cs-137	0.3 +/- 0.02	
5	18701295	310.3	Pu-239	≥ 3.89	0.26
			Am-241	0.66 +/- 0.046	
			U-238	<0.97	
			U-235	<0.5	
			Cs-137	0.52 +/- 0.12	
6	18701296	1932.	Pu-239	≥ 2,478.	1,033
			Am-241	420. +/- 1.2	
			U-238	<12.	
			U-235	0.12 +/- 0.091	
			Cs-137	0.079 +/- 0.013	
7	1870297	1882.5	Pu-239	7.8 +/- 0.71	3.3
			Am-241	<0.12	
			U-238	<0.43	
			U-235	0.08 +/- 0.06	
			Cs-137	<0.43	

Site* Number	USAFOEHL Number	Sample WT. Dry Gram	Radio-Nuclide	Concentration (pCi/dry gram)**	Surface Area (μCi/m^2)***
8	18701298	1970.4	Pu-239	18. +/- 1.6	7.5
			Am-241	6.5 +/- 0.13	
			U-238	<1.4	
			U-235	<0.06	
			Cs-137	0.19 +/- 0.13	
9	18701253	1845.0	Pu-239	≃ 23.6	9.3
			Am-241	4. +/- 0.2	
			U-238	0.94 +/- 0.63	
			U-235	<0.07	
			Cs-137	0.15 +/- 0.016	
10	18701256	1911.9	Pu-239	≃ 595.6	248
			Am-241	101. +/-0.85	
			U-238	<0.75	
			U-235	0.12 +/- 0.083	
			Cs-137	0.14 +/-0.017	
11	18701256	2017.0	Pu-239	≃ 23.5	10.3
			Am-241	3.9 +/- 0.2	
			U-238	<0.64	
			U-235	<0.066	
			Cs-137	0.11 +/- 0.013	
12	18701257	2413.7	Pu-239	≃ 46.	24.2
			Am-241	7.8 +/- 0.25	
			U-238	<0.38	
			U-235	<0.07	
			Cs-137	0.22 +/- 0.018	
13	18701301	2031.8	Pu-239	34. +/- 3.1	14.9
			Am-241	4.5 +/- 0.1	
			U-238	<1.2	
			U-235	<0.08	
			Cs-137	0.21 +/- 0.02	
14	18701302	2716.3	Pu-239	95. +/- 7.8	56.3
			Am-241	41. +/- 0.35	
			U-238	<3.6	
			U-235	0.16 +/- 0.09	
			Cs-137	0.03 +/- 0.01	
15	18701303	1599.0	Pu-239	191. +/- 20.	67.0
			Am-241	23. +/- 0.24	
			U-238	<2.7	
			U-235	0.14 +/- 0.1	
			Cs-137	0.12 +/- 0.01	

Site* Number	USAFOEHL Number	Sample WT. Dry Gram	Radio-Nuclide	Concentration (pCi/dry gram)**	Surface Area ($\mu Ci/m^2$)***
16	18701304	2498.8	Pu-239	1.9 +/- 0.18	1.04
			Am-241	0.17 +/- 0.057	
			U-238	<0.54	
			U-235	<0.079	
			Cs-137	0.036 +/- 0.009	
17	18701252	2256.1	Pu-239	± 218.	
			Am-241	37. +/- 0.4	110
			U-238	<3.9	
			U-235	<0.07	
			Cs-137	0.15 +/- 0.02	
18	18701267	2106.5	Pu-239	2.8 +/- 0.98	1.3
			Am-241	0.37 +/- 0.13	
			U-238	1.1 +/- 1.	
			U-235	<0.13	
			Cs-137	0.24 +/- 0.02	
19	18701268	1944.3	Pu-239	± 0.47	0.19
			Am-241	0.08 +/- 0.08	
			U-238	<0.61	
			U-235	<0.07	
			Cs-137	0.3 +/- 0.02	
20	18701269	1271.0	Pu-239	± 0.70	0.18
			Am-241	0.12 +/- 0.06	
			U-238	<0.52	
			U-235	<0.06	
			Cs-137	0.7 +/- 0.03	
21	18701270	1113.0	Pu-239	7.2 +/- 0.96	1.73
			Am-241	3.9 +/- 0.17	
			U-238	<1.6	
			U-235	<0.14	
			Cs-137	0.54 +/- 0.03	
22	18701249	2035.6	Pu-239	± 1.4	0.6
			Am-241	0.23 +/- 0.06	
			U-238	<0.5	
			U-235	<0.05	
			Cs-137	0.14 +/- 0.01	
23	18701251	2296.0	Pu-239	± 53.7	27.1
			Am-241	9.1 +/- 0.2	
			U-238	<2.	
			U-235	<0.07	
			Cs-137	0.23 +/- 0.02	

Site* Number	USAPOEHL Number	Sample WT. Dry Gram	Radio-Nuclide	Concentration (pCi/dry gram)**	Surface Area ($\mu Ci/m^2$)***
25	18701250	1864.6	Pu-239	≥ 153.	60.4
			Am-241	26. +/- 0.3	
			U-238	<3.2	
			U-235	<0.06	
			Cs-137	0.35 +/- 0.02	
26	18701231	2167.0	Pu-239	≥ 34.8	16.7
			Am-241	5.9 +/- 0.2	
			U-238	<1.6	
			U-235	<0.04	
			Cs-137	0.25 +/- 0.02	
27	18701233	1718.0	Pu-239	≥ 88.5	33
			Am-241	15. +/- 0.3	
			U-238	<2.6	
			U-235	<0.1	
			Cs-137	0.36 +/- 0.02	
28	18701230	2057.2	Pu-239	0.27 +/- 0.038	0.12
			Am-241	0.09 +/- 0.06	
			U-238	<0.5	
			U-235	<0.05	
			Cs-137	0.15 +/- 0.01	
29	18701232	2534.4	Pu-239	4.5 +/- 0.53	2.5
			Am-241	1.8 +/- 0.1	
			U-238	<1.	
			U-235	<0.07	
			Cs-137	0.19 +/- 0.02	
30	18701275	1900.0	Pu-239	0.49 +/- 0.037	0.20
			Am-241	<0.08	
			U-238	<0.59	
			U-235	<0.09	
			Cs-137	<0.03	
31	18701276	1158.0	Pu-239	≥ 0.94	0.24
			Am-241	<0.16	
			U-238	<0.5	
			U-235	<0.09	
			Cs-137	<0.04	
32	18701277	2335.8	Pu-239	≥ 3221.	1625
			Am-241	546. +/- 1.3	
			U-238	<14.	
			U-235	1.2 +/- 0.11	
			Cs-137	0.19 +/- 0.02	

Site* Number	USAFOEHL Number	Sample WT. Dry Gram	Radio-Nuclide	Concentration (pCi/dry gram)**	Surface Area ($\mu Ci/m^2$)***
33	18701278	1234.3	Pu-239	212.	55.8
			Am-241	36. +/- 0.38	
			U-238	<3.9	
			U-235	0.21 +/- 0.12	
			Cs-137	0.34 +/- 0.023	
34	18701305	2131.7	Pu-239	106.	48.8
			Am-241	18. +/- 0.2	
			U-238	<2.3	
			U-235	0.16 +/- 0.1	
			Cs-137	0.13 +/- 0.014	
35	18701243	2474.4	Pu-239	0.53	0.29
			Am-241	0.09 +/- 0.07	
			U-238	0.7 +/- 0.6	
			U-235	<0.07	
			Cs-137	0.15 +/- 0.02	
36	18701227	2117.0	Pu-239	3.48	1.6
			Am-241	0.59 +/- 0.09	
			U-238	<0.77	
			U-235	<0.07	
			Cs-137	0.43 +/- 0.02	
37	18701229	2004.2	Pu-239	0.53	0.23
			Am-241	<0.09	
			U-238	<0.8	
			U-235	<0.09	
			Cs-137	0.19 +/- 0.02	
38	18701228	2219.5	Pu-239	0.29	0.14
			Am-241	<0.05	
			U-238	<0.6	
			U-235	<0.1	
			Cs-137	0.21 +/- 0.02	
39	18701291	2180.5	Pu-239	4.2	2.0
			Am-241	0.71 +/- 0.07	
			U-238	0.68 +/- 0.52	
			U-235	<0.07	
			Cs-137	0.3 +/- 0.02	
40	18701292	1847.7	Pu-239	0.49 +/- 0.09	0.20
			Am-241	<0.083	
			U-238	0.65 +/- 0.59	
			U-235	<0.073	
			Cs-137	0.19 +/- 0.02	

Site* Number	USAFOEHL Number	Sample WT. Dry Gram	Radio-Nuclide	Concentration (pCi/dry gram)**	Surface Area ($\mu Ci/m^2$)***
41	18701293	1612.3	Pu-239	≃ 3.1	1.1
			Am-241	0.52 +/- 0.09	
			U-238	<0.53	
			U-235	<0.14	
			Cs-137	0.35 +/- 0.02	
42	18701294	1977.8	Pu-239	≃ 12.98	5.7
			Am-241	2.2 +/- 0.1	
			U-238	<0.53	
			U-235	<0.065	
			Cs-137	0.22 +/- 0.02	
43	18701234	1945.0	Pu-239	≃ 17.7	7.4
			Am-241	3. +/- 0.2	
			U-238	<1.5	
			U-235	<0.1	
			Cs-137	0.28 +/- 0.02	
44	18701245	1456.2	Pu-239	≃ 7.1	2.3
			Am-241	1.2 +/- 0.1	
			U-238	<1.	
			U-235	<0.08	
			Cs-137	0.31 +/- 0.02	
45	18701248	2119.8	Pu-239	0.43 +/- 0.052	0.2
			Am-241	<0.06	
			U-238	<0.5	
			U-235	<0.06	
			Cs-137	0.09 +/- 0.01	
46	18701242	2125.0	Pu-239	≃ 0.29	0.13
			Am-241	<0.05	
			U-238	<0.4	
			U-235	<0.07	
			Cs-137	0.32 +/- 0.02	
47	18701236	1482.0	Pu-239	≃ 1.8	0.59
			Am-241	0.3 +/- 0.1	
			U-238	<0.8	
			U-235	<0.08	
			Cs-137	0.18 +/- 0.02	
48	18701244	2092.9	Pu-239	≃ 0.24	0.11
			Am-241	<0.04	
			U-238	<0.4	
			U-235	0.09 +/- 0.08	
			Cs-137	0.17 +/- 0.02	

Site* Number	USAFOEHL Number	Sample WT. Dry Gram	Radio-Nuclide	Concentration (pCi/dry gram)**	Surface Area (µCi/m²)***
49	18701255	2153.9	Pu-239	~ 0.41	0.2
			Am-241	<0.07	
			U-238	<0.6	
			U-235	<0.07	
			Cs-137	0.15 +/- 0.02	
50	18701258	1773.5	Pu-239	~ 5.84	2.3
			Am-241	0.99 +/- 0.17	
			U-238	<0.78	
			U-235	<0.072	
			Cs-137	0.21 +/- 0.019	

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*Reference Figure 6 for site map locations.
**Pu-239 results preceded with the approximation sign (~) are calculated based on the Pu-239/Am-241 ratio of 5.9. Pu-239 values without the approximation sign were measured by alpha spectroscopy and are in concentrations of picocuries (pCi) per gram ashed. All other radionuclide concentrations are in pCi per dry gram and were measured by high-resolution gamma spectroscopy.
***Surface area calculated using assumptions from USAFOEHL Report 86-034 R121ERD.

TABLE 6: Radionuclide Soil Concentration Data from Manhole Covers

Site* Number	USAFOEHL Number	Sample WT. Dry Gram	Radio-Nuclides	Concnetration pCi/gm**
Shelter 210 Bunker 1A	18701324	49.3	Pu-239	≃ 6,324.
			Am-241	1,072. +/- 0.004
			U-238	< 43
			U-235	< 0.22
			Cs-137	0.62 +/- 0.07
Shelter 208 Bunker 2A	18701322	42.4	Pu-239	≃ 7.1
			Am-241	1.2 +/- 0.2
			U-238	< 1.9
			U-235	< 0.07
			Cs-137	0.30 +/- 0.05
Shelter 206 Bunker 3A	18701323	208.6	Pu-239	≃ 926.
			Am-241	157. +/- 0.8
			U-238	< 7.9
			U-235	0.14 +/- 0.3
			Cs-137	0.69 +/- 0.03
Shelter 202 Bunker 5A, Upper Rim	18701321	25.2	Pu-239	≃ 273.
			Am-241	46.3 +/- 1.1
			U-238	< 12.
			U-235	< 0.3
			Cs-137	1.2 +/- 0.1
Shelter 202 Bunker 5A, Lower Rim	18701320	35.5	Pu-239	≃ 63.
			Am-241	10.6 +/- 0.5
			U-238	< 5.3
			U-235	< 0.3
			Cs-137	0.61 +/- 0.08
Shelter 202 Bunker 5A, Lower Rim	18701319	13.1	Pu-239	≃ 2,271.
			Am-241	384.9 +/- 4.5
			U-238	< 48
			U-235	2.5 +/- 1.0
			Cs-137	0.7 +/- 0.2
Shelter 202 Bunker 5A, Inner Lid	18701318	9.2	Pu-239	≃ 2,024.
			Am-241	343. +/- 5.
			U-238	< 53
			U-235	1.0 +/- 1.0
			Cs-137	< 0.1

*Reference Figure 4 for bunker locations.
**Results for Pu-239 are calculated based on the Pu-239/Am-241 ratio of 5.9. All other radionuclide concentrations are measured values using high resolution gamma spectroscopy.

TABLE 7: Radionuclide Soil Concentrations From the Floor of Underground Bunkers

Site* Number	USAFOEHL Number	Sample WT. Grams Dry	Radio-Nuclide	Concentration pCi/dry g
1A	18701314	597.0	Pu-239	≃ 65.
			Am-241	11. +/- 0.53
			U-238	< 5.5
			U-235	< 0.21
			Cs-137	1.4 +/- 0.1
2A	18701316	748.4	Pu-239	≃ 212.
			Am-241	36. +/- 1.1
			U-238	< 11.
			U-235	< 0.33
			Cs-137	2.8 +/-0.15
3A	18701312	592.4	Pu-239	≃1,050.
			Am-241	178. +/- 2.5
			U-238	< 26
			U-235	< 0.05
			Cs-137	2.2 +/- 0.17
5A	18701317	623.0	Pu-239	≃1,180.
			Am-241	200. +/- 2.5
			U-238	< 26
			U-235	< 0.46
			Cs-137	1.4 +/- 0.13
5A-2	18701315	1552.6	Pu-239	≃ 77.
			Am-241	13. +/- 0.25
			U-238	< 2.5
			U-235	< 0.1
			Cs-137	0.27 +/- 0.02
5A-5B	18701313	170.3	Pu-239	≃ 2.53.
			Am-241	0.43 +/- 0.07
			U-238	< 0.7
			U-235	< 0.05
			Cs-137	0.03 +/- 0.01

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*Reference Figure 4 for bunker locations.
**Results for Pu-239 are calculated based on the Pu-239/Am-241 ratio of 5.9. All other radionuclide concentrations are measured values using high resolution gamma spectroscopy.

TABLE 8: Pu-239 Concentration in Nonpotable Water Samples from Underground Bunkers

Site* Number	USAFOEHL Number	Site Description	Concentration (pCi/liter)** Pu-239
1A	18701325	Underground Bunker in Front of Shelter No. 210	0.071 +/- 0.027
1B	18701326	Underground Bunker in Front of Shelter No. 210	< 0.017
2A	18701327	Underground Bunker in Front of Shelter No. 208	0.028 +/- 0.022
2B	18701328	Underground Bunker in Front of Shelter No. 208	0.025 +/- 0.02
3A	18701329	Underground Bunker in Front of Shelter No. 206	0.74 +/- 0.11
3B	18701330	Underground Bunker in Front of Shelter No. 206	< 0.018
5A	18701331	Underground Bunker in Front of Shelter No. 202	0.83 +/- 0.12

*Refernece Figure 4 for bunker locations.
**Results accurate to 2 significant figures. Error term at 95% confidence level.

APPENDIX A

ALPHA SURVEY DATA

1987 FIDLER Grid Survey Data

COL	ROW	DATE	GROSS CPM	BACKGROUND CPM	CALIBRATION FACTOR CPM-µCi/m²	Pu-239 LEVEL µCi/m²
C	10	15 SEP 87	500	500	3,500	< MDAA*
C	14	15 SEP 87	500	500	3,500	< MDAA
C	18	15 SEP 87	500	500	3,500	< MDAA
C	22	15 SEP 87	500	500	3,500	< MDAA
C	25	15 SEP 87	750	500	3,500	< MDAA
C	30	15 SEP 87	750	500	3,500	< MDAA
C	34	15 SEP 87	600	500	3,500	< MDAA
D	30	15 SEP 87	1,000	500	3,500	< MDAA
D	34	15 SEP 87	900	500	3,500	< MDAA
E	34	15 SEP 87	1,500	500	3,500	< MDAA
E	35	15 SEP 87	1,000	500	3,500	< MDAA
E	36	15 SEP 87	750	500	3,500	< MDAA
E	37	15 SEP 87	750	500	3,500	< MDAA
G	34	15 SEP 87	1,500	500	3,500	< MDAA
G	37	15 SEP 87	750	500	3,500	< MDAA
H	34	15 SEP 87	750	500	3,500	< MDAA
H	37	15 SEP 87	1,000	500	3,500	< MDAA
I	34	15 SEP 87	600	500	3,500	< MDAA
I	37	15 SEP 87	800	500	3,500	< MDAA
J	34	15 SEP 87	800	500	3,500	< MDAA
J	35	15 SEP 87	1,250	500	3,500	< MDAA
J	36	15 SEP 87	1,100	500	3,500	< MDAA
J	37	15 SEP 87	900	500	3,500	< MDAA
L	34	15 SEP 87	1,250	500	3,500	< MDAA
L	35	15 SEP 87	1,250	500	3,500	< MDAA
L	36	15 SEP 87	750	500	3,500	< MDAA
L	37	15 SEP 87	1,000	500	3,500	< MDAA
M	34	15 SEP 87	1,000	500	3,500	< MDAA
M	35	15 SEP 87	1,250	500	3,500	< MDAA
M	36	15 SEP 87	700	500	3,500	< MDAA
M	37	15 SEP 87	850	500	3,500	< MDAA
N	13	15 SEP 87	600	500	3,500	< MDAA
N	17	15 SEP 87	500	500	3,500	< MDAA
N	9	15 SEP 87	500	500	3,500	< MDAA

COL	ROW	DATE	GROSS CPM	BACKGROUND CPM	CALIBRATION FACTOR CPM-μCi/m^2	Pu-239 LEVEL μCi/m^2
N	21	15 SEP 87	450	500	3,500	< MDAA
N	25	15 SEP 87	550	500	3,500	< MDAA
N	29	15 SEP 87	500	500	3,500	< MDAA
N	33	15 SEP 87	600	500	3,500	< MDAA
N	34	15 SEP 87	500	500	3,500	< MDAA
N	35	15 SEP 87	575	500	3,500	< MDAA
N	36	15 SEP 87	525	500	3,500	< MDAA
N	37	15 SEP 87	500	500	3,500	< MDAA
O	35	15 SEP 87	600	500	3,500	< MDAA
O	37	15 SEP 87	500	500	3,500	< MDAA
Q	35	15 SEP 87	600	500	3,500	< MDAA
Q	37	15 SEP 87	500	500	3,500	< MDAA
S	35	15 SEP 87	600	500	3,500	< MDAA
S	37	15 SEP 87	700	500	3,500	< MDAA
U	35	15 SEP 87	700	500	3,500	< MDAA
U	37	15 SEP 87	600	500	3,500	< MDAA
W	35	15 SEP 87	500	500	3,500	< MDAA
W	37	15 SEP 87	600	500	3,500	< MDAA
Y	35	15 SEP 87	550	500	3,500	< MDAA
Y	37	15 SEP 87	600	500	3,500	< MDAA
AA	35	15 SEP 87	725	500	3,500	< MDAA
AA	37	15 SEP 87	600	500	3,500	< MDAA
CC	35	15 SEP 87	700	500	3,500	< MDAA
CC	37	15 SEP 87	600	500	3,500	< MDAA
EE	35	15 SEP 87	600	500	3,500	< MDAA
EE	37	15 SEP 87	600	500	3,500	< MDAA

*MDAA for Pu-239 was determined to be 0.8 - 1.5 μC/m^2.

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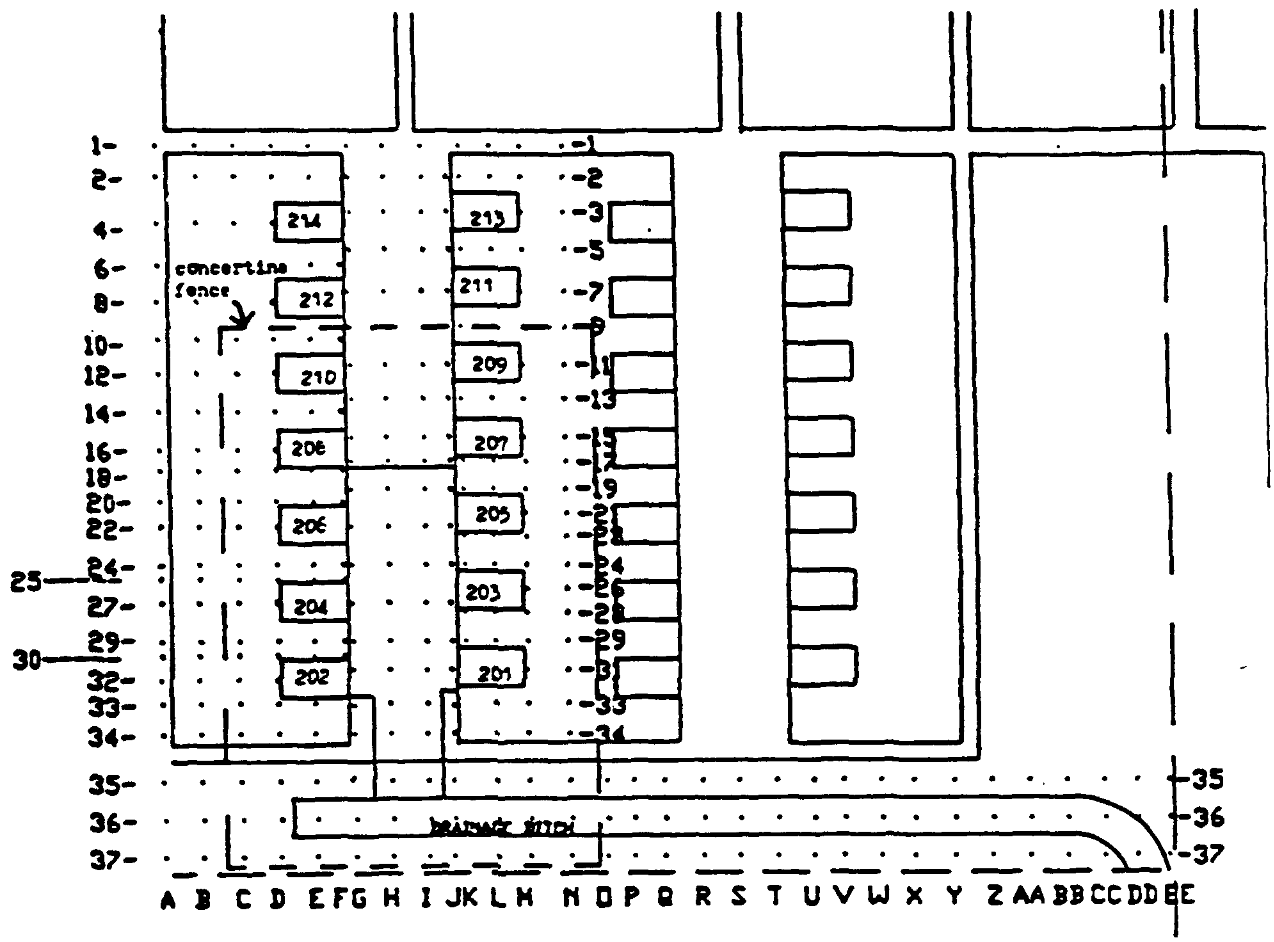

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APPENDIX B

PG-2 SURVEY DATA

PG-2 READINGS

DATE -- 16 Sep 87

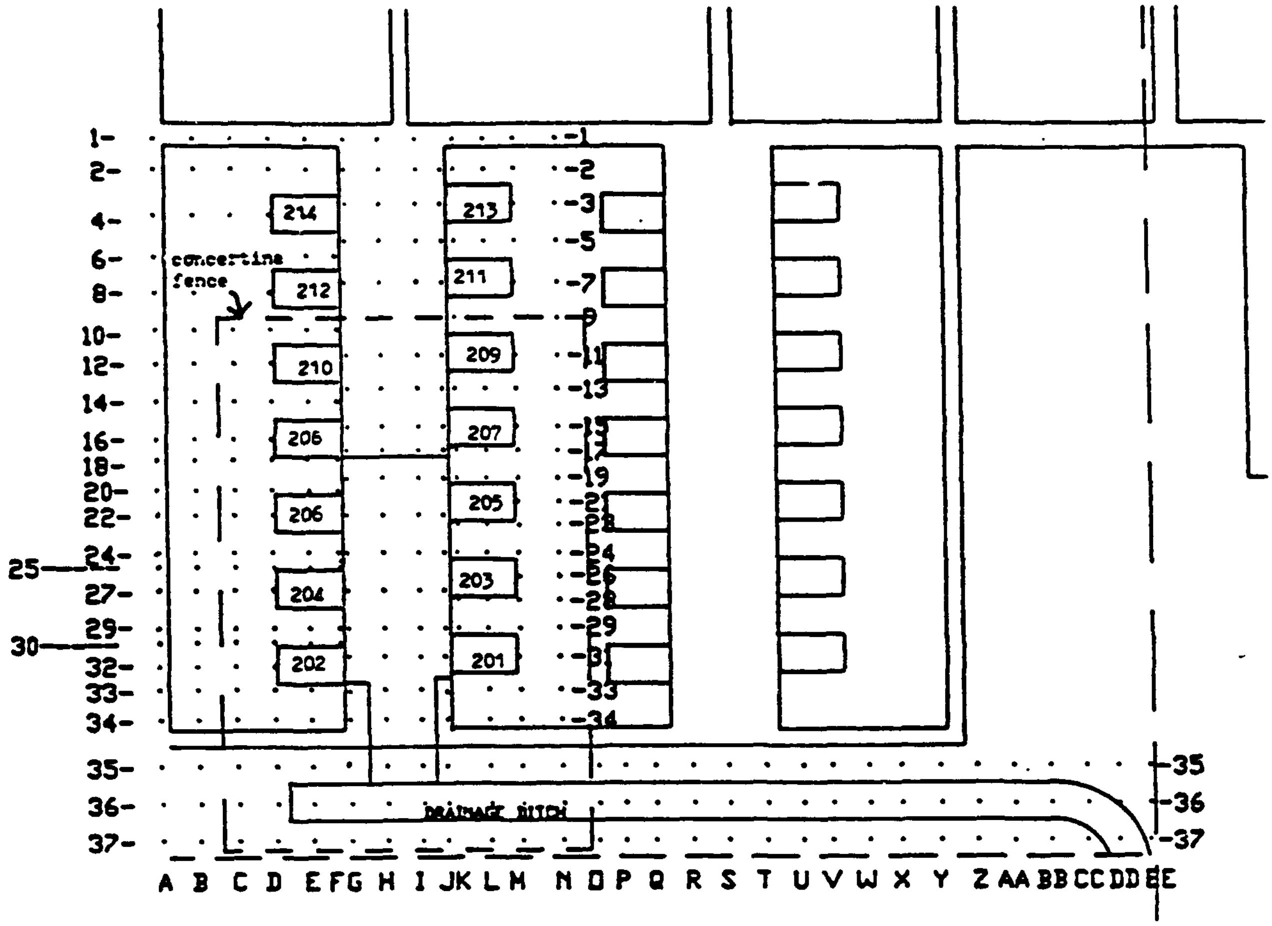
PLACE- BOMARC Site, Ft Dix NJ

PEOPLE- SMS Eichin , TSgt Dugger, SrA Anthony

NOTES -Use red ink, pencil, or type.
-Rows are numbers.
-Columns are letters.
-Do the whole left column first, then finish the right.

COL	ROW	KIT #	HV1	HV2	HV3
C	25	301	1000	1500	
C	27	301	1000	1500	
C	33	301	1000	1500	
XXXXXX	XXXXXX	XXXXXXXXX	XXXXXX	XXXXXX	XXXXXX
D	27	301	1200	1700	
D	35	301	1000	1500	
XXXXXX	XXXXXX	XXXXXXXXX	XXXXXX	XXXXXXX	XXXXXX
E	20	301	1100	1600	
E	24	301	1500	1900	
E	29	301	1700	3000	
E	35	301	1000	1500	
XXXXXX	XXXXXX	XXXXXXXXX	XXXXXX	XXXXXXX	XXXXXX
G	10	301	1000	1500	
G	14	301	1000	1500	
G	18	301	1100	1700	
G	20	301	1300	1800	
G	24	301	2000	3100	
G	25	301	2000	3100	
G	29	301	2100	3100	
G	30	301	2100	3100	
G	34	301	1000	1500	
XXXXXX	XXXXXX	XXXXXXXXX	XXXXXX	XXXXXXX	XXXXXX
H	37	301	1000	1500	
XXXXXX	XXXXXX	XXXXXXXXX	XXXXXX	XXXXXXX	XXXXXX
K	10	301	1000	1500	
K	14	301	1000	1500	
K	18	301	1000	1500	
K	20	301	1200	1700	
K	24	301	1200	1700	
K	28	301	1100	1500	
K	29	301	1100	1300	
K	33	301	1000	1500	
XXXXXX	XXXXXX	XXXXXXXXX	XXXXXX	XXXXXX	XXXXXX
L	33	301	1000	1600	
XXXXXX	XXXXXX	XXXXXXXXX	XXXXXX	XXXXXX	XXXXXX
N	34	301	1100	1600	
XXXXXX	XXXXXX	XXXXXXXXX	XXXXXX	XXXXXXX	XXXXXX
P	34	301	1000	1500	
P	35	301	1000	1500	
XXXXXX	XXXXXX	XXXXXXXXX	XXXXXX	XXXXXXX	XXXXXX
R	37	301	1000	1500	
XXXXXX	XXXXXX	XXXXXXXXX	XXXXXX	XXXXXXX	XXXXXX
S	35	301	1000	1500	

COL	ROW	KIT #	HV1	HV2	HV3
S	37	301	1000	1500	
XXXX	XXXXXXX	XXXXXXXX	XXXXX	XXXXXX	XXXXXX
U	41	301	1000	1500	
XXXXXX	XXXXXXX	XXXXXXXX	XXXXXX	XXXXXX	XXXXXX
V	35	301	1000	1500	
V	37	301	1000	1500	
XXXXXX	XXXXXX	XXXXXXXX	XXXXXX	XXXXXX	XXXXXX
X	35	301	1000	1500	
X	37	301	1000	1500	
XXXXXX	XXXXX	XXXXXXXX	XXXXXX	XXXXXX	XXXXXX
Z	35	301	1000	1500	
Z	37	301	1000	1500	
XXXXXXX	XXXXXX	XXXXXXXXX	XXXXXX	XXXXXX	XXXXXX
BB	35	301	1000	1500	
BB	37	301	1000	1500	
XXXXXX	XXXXXXX	XXXXXXXX	XXXXXXX	XXXXXX	XXXXXX
CC	37	301	1000	1500	
XXXXXXX	XXXXXX	XXXXXXXXX	XXXXXX	XXXXXX	XXXXXX
DD	36	301	1000	1500	



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APPENDIX C

ALPHA SURVEY DATA

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ALPHA INSTRUMENT READINGS

Survey Location	Instrument Reading* CPM/60 cm^2	X	Instrument Correction Factor	Corrected Reading DPM/100 cm^2
1	1,125		5.6	6,300
2	750		5.6	4,200
3	6,750		5.6	37,520
4	150		5.6	840
5	75		5.6	420
6	100		5.6	560
7	75		5.6	420
8	100		5.6	560
9	75		5.6	420
10	75		5.6	420
11	75		5.6	420
12	100		5.6	560
13	75		5.6	420
14	100		5.6	560
15	75		5.6	420
16	100		5.6	560
17	75		5.6	420
18	75		5.6	420
19	75		5.6	420
20	75		5.6	420

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*Represents net cpm after subtracting background of about 25 CPM.

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HQ AFSC/SGPB Andrews AFB MD 20334-5000	1
HQ MAC/SGPB Scott AFB IL 62225-5001	1
USAF Clinic McGuire/SG/SGPB McGuire AFB NJ 08641-5300	1 ea
438 MAW/DE McGuire AFB NJ 08641-5000	1
438 MAW/CC/PA/JA McGuire AFB NJ 08641-5000	1 ea
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INSTALLATION RESTORATION PROGRAM
PHASE II - CONFIRMATION/QUANTIFICATION
STAGE 2

SITE 1: McGUIRE MISSILE SITE
ACCIDENT AREA

McGUIRE AIR FORCE BASE, NEW JERSEY

PREPARED BY:

Roy F. Weston, Inc.
West Chester, Pennsylvania 19380

NOVEMBER 1987

DRAFT REPORT

PREPARED FOR:

HEADQUARTERS MILITARY AIR LIFT COMMAND/SGPB
SCOTT AIR FORCE BASE, ILLINOIS 62225-5000

UNITED STATES AIR FORCE
OCCUPATIONAL & ENVIRONMENTAL HEALTH LABORATORY (USAFOEHL)
TECHNICAL SERVICES DIVISION (TS)
BROOKS AIR FORCE BASE, TEXAS 78235-5501

WESTON

INSTALLATION RESTORATION PROGRAM
PHASE II- CONFIRMATION/QUANTIFICATION
STAGE 2

SITE 1: McGUIRE MISSILE SITE
ACCIDENT AREA

DRAFT REPORT

McGuire Air Force Base, New Jersey

November 1987

Roy F. Weston, Inc. (WESTON),
Weston Way
West Chester, Pennsylvania 19380

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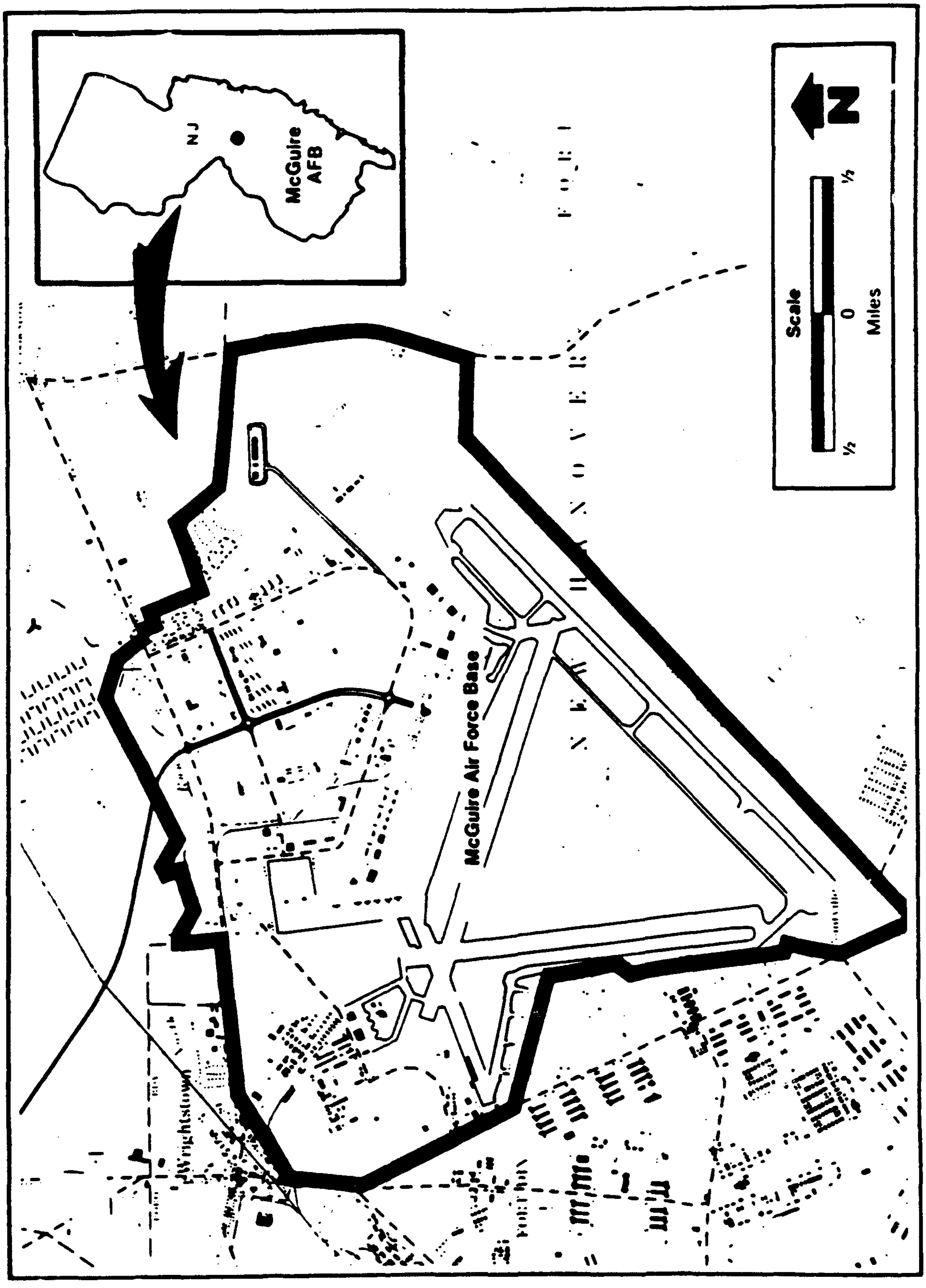


FIGURE 1-1 INDEX MAP OF McGUIRE AFB

In July 1954, McGuire AFB was officially assigned to the Military Air Transport Service with the Air Defense Command (ADC) and the New Jersey Air National Guard (NJ ANG) as major tenant organizations. NJ ANG consolidated its activities on the west side of the base supported by a Major Construction Program (MCP). Subsequently, SAC and CAC tenant units were assigned to McGuire AFB. In January 1966, the Military Air Transport Service became the Military Airlift Command (MAC) with headquarters at Scott AFB, Illinois. Eastern Transport Air Force became the 21st Air Force with headquarters at McGuire AFB, and the 1611th Air Transport Wing became the 438th Military Airlift Wing (MAW). The SAC Tanker Squadron left McGuire AFB in 1965, and its facilities were occupied by the 170th Air Transport Group of NJ ANG.

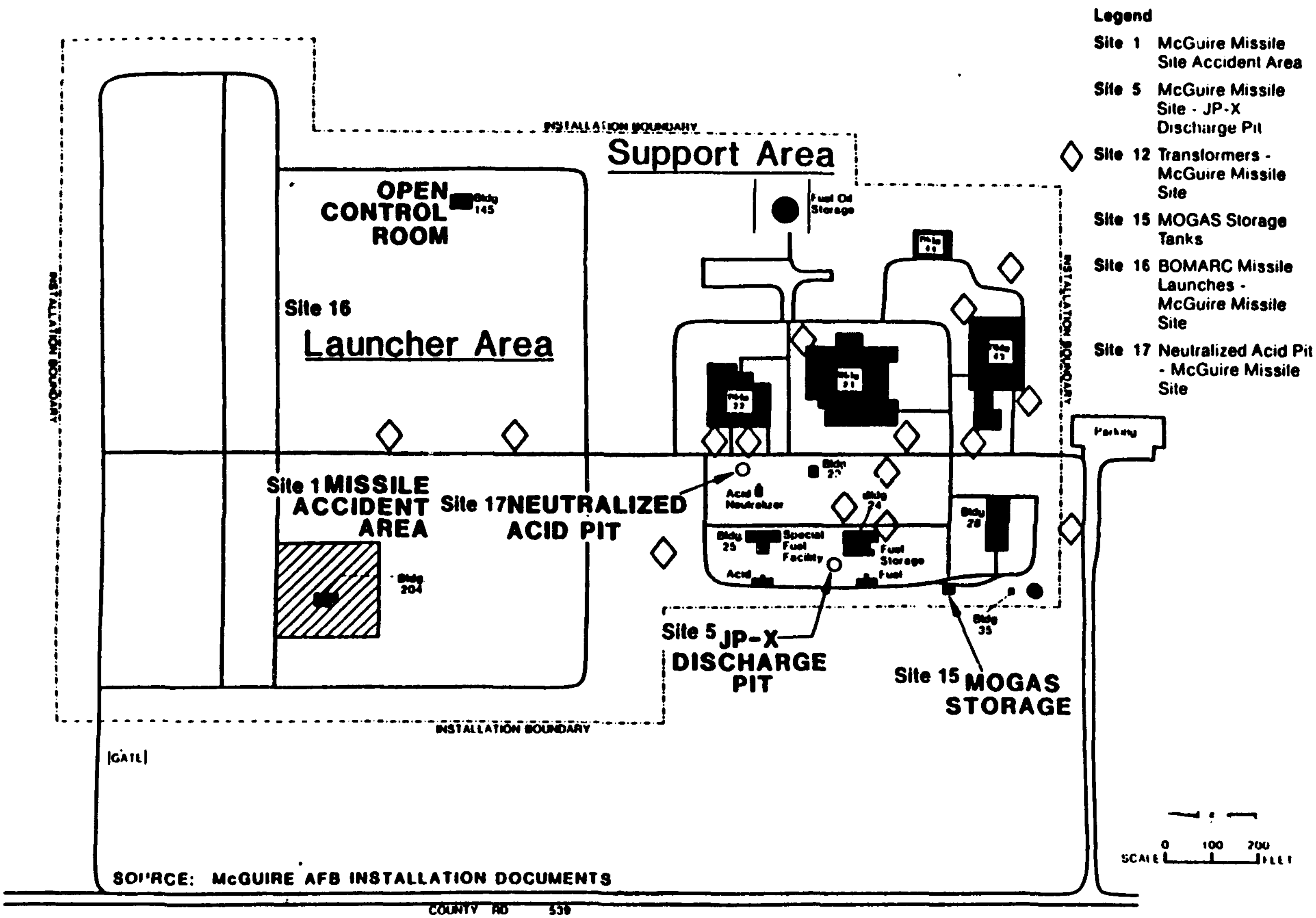
The present host organization at McGuire AFB is the 438th MAW whose primary mission is to provide quick-reacting, concentrated, massive airlift capabilities for emplacement of DOD forces into combat situations in a fighting posture and to then furnish materials support to those forces. The Wing also is responsible for operating McGuire AFB and for providing adequate support to a large number of tenant units.

Past Air Force activities in support of operational missions at McGuire AFB have resulted in several waste disposal sites of potential concern at the base. Task Order 0016 requires evaluation of these sites to determine their impact on public health and the environment. Figure 1-3 represents the locations of sites to be investigated at the BOMARC Missile Site under this Task Order. A brief description of each site is presented as follows.

1.4 DESCRIPTION AND HISTORY OF SITES TO BE INVESTIGATED

1.4.1 Site 1: McGuire Missile Site Accident Area (New Site)

The McGuire Missile Site (BOMARC) shown in Figure 1-3 is located on the Fort Dix Military Reservation, approximately 11 miles to the east of McGuire AFB and on the eastern side of New Jersey Route 539. The site is divided into two separate areas which together constitute 219 acres. A launcher area on the northern side of the site houses the launch shelters, and a support area exists on the southern end of the site. The missile site, constructed in the mid-1950's, is the site of the 46th Air Defense Missile Squadron (ADMS) and initially housed 56 liquid-fueled BOMARC missiles. The site was deactivated in 1972, and the missiles and warheads were removed.



Source: Phase I Report
From LSI Report

FIGURE 1-3 LOCATION OF SITES INVESTIGATED AT THE BOMARC MISSILE SITE

In 1960, an accident occurred in the launcher area involving a fire in one of the missile launcher shelters (Building 204). During the fire, the burning missile released plutonium residue from the launcher building. Consequently, the area around the launcher building was contaminated with plutonium. The contaminated area has been covered with a concrete pad since 1961 to contain the released radioactive material. Since the missile accident, periodic radiation surveys have been conducted in the vicinity of the launcher area and downwind of the site. The results of the survey indicate that the majority of the plutonium residue was contained in the covered areas. No field program was implemented at Site 1 during the Phase II Stage 1 field investigation.

SECTION 2

BACKGROUND

2.3 REGIONAL GEOLOGY

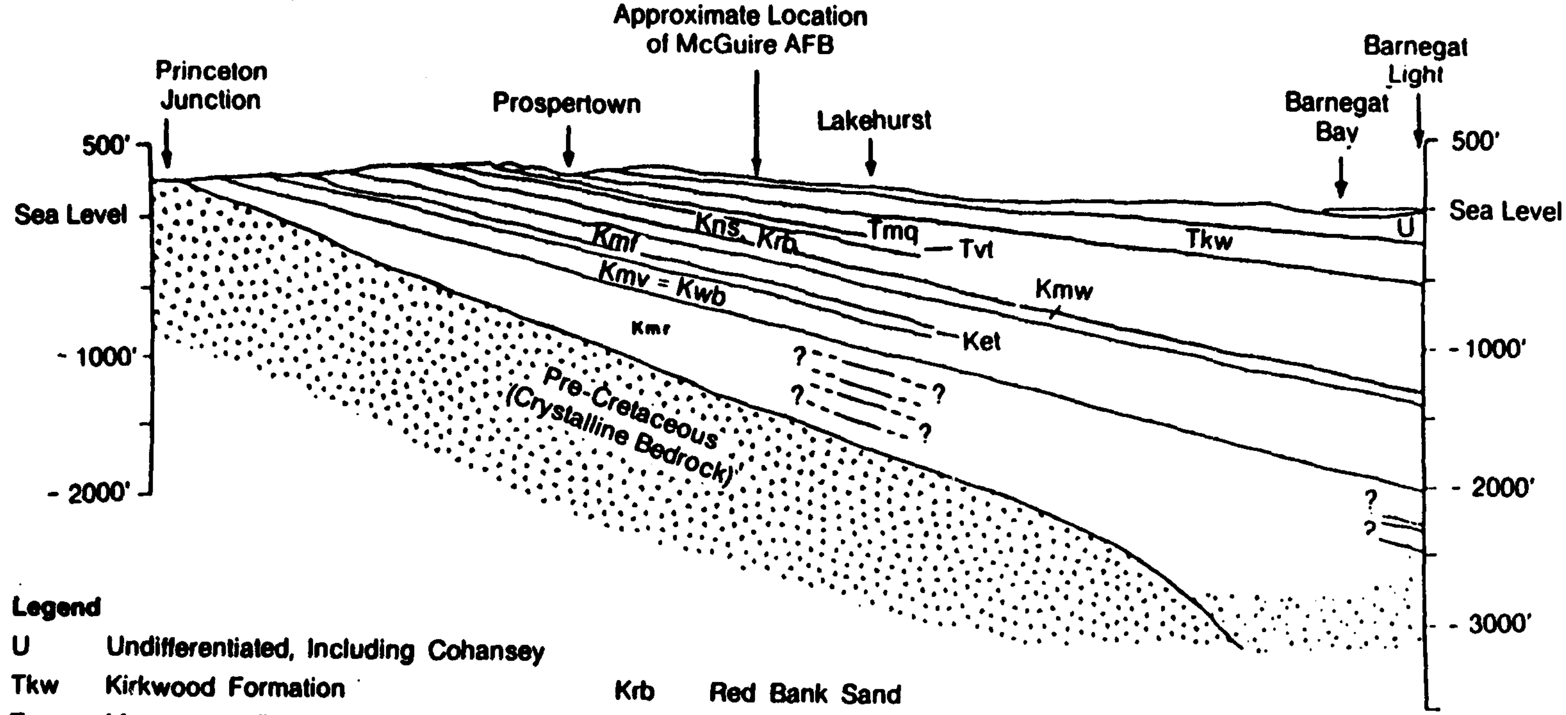
Geologic units ranging in age from Cretaceous to Quaternary have been identified in the New Jersey Coastal Plain (see Figure 2-2). These units are typically unconsolidated materials consisting of gravel, sand, silt, clay, glauconite, marl, and organic materials reposing on a Precambrian/Lower Paleozoic crystalline basement complex. Coastal plain sediments form a southeasterly dipping wedge thickening to the southeast. Individual geologic units tend to thicken down dip and possess an average unit dip ranging from 10 to 45 feet per mile.

The geology of McGuire AFB is dominated by interbedded continental and seashore marine sands and clays of the Cohansey, Kirkwood, and Vincentown Formations all of which outcrop at the Main Base (see Figure 2-3). The BOMARC Missile Site is underlain by the Cohansey Formation which consists of fine- to coarse-grained quartzose sand with lenses of gravel that are usually 1 foot or less thick. The quartzose sand is predominantly yellow because of limonite staining, but also occurs in shades of white, red, brown, and gray. The Cohansey forms a thin veneer over much of the base and is in hydraulic connection with the underlying Kirkwood Formation.

The Kirkwood Formation is reported to be a variable lithologic unit divided into an upper component of silt and clay and a lower component consisting of a very fine, dark micaceous sand.

Underlying the Kirkwood Formation is the Vincentown Formation which consists of fine- to coarse-grained quartzose and glauconitic sand with local clay. The Vincentown outcrops in localized zones primarily in the northern portion of the base.

The Cohansey and Kirkwood Formations are of hydrogeologic interest because they act as a single aquifer at or near ground surface in the vicinity of McGuire AFB. Other lower-yielding aquifers which underly the Cohansey-Kirkwood include the Vincentown, Mount Laurel, Wenona, and Englishtown Formations. Regionally, there is some degree of hydraulic interconnection between all these aquifers. The Raritan-Magothy regional aquifer system occurs at depth and is isolated from the upper aquifers by the confining clays of the Merchantville and Woodbury Formations (New Jersey Pinelands Commission, 1980).



Legend

U	Undifferentiated, Including Cohansey
Tkw	Kirkwood Formation
Tmq	Manasquan Formation
Tvt	Vincentown Foundation
Kmw	Mount Laurel Sand and Wenonah Formation
Ket	Englishtown Formation
Kmr	Raritan and Magothy Formation
Krb	Red Bank Sand
Kmt	Marshalltown Formation
Kwb	Woodbury Clay
Kmv	Merchantville Formation
Kns	Navesink Formation

Source: Means (1981)

NOTE: Vertical Scale Greatly Exaggerated

FIGURE 2-2 NEW JERSEY COASTAL PLAIN

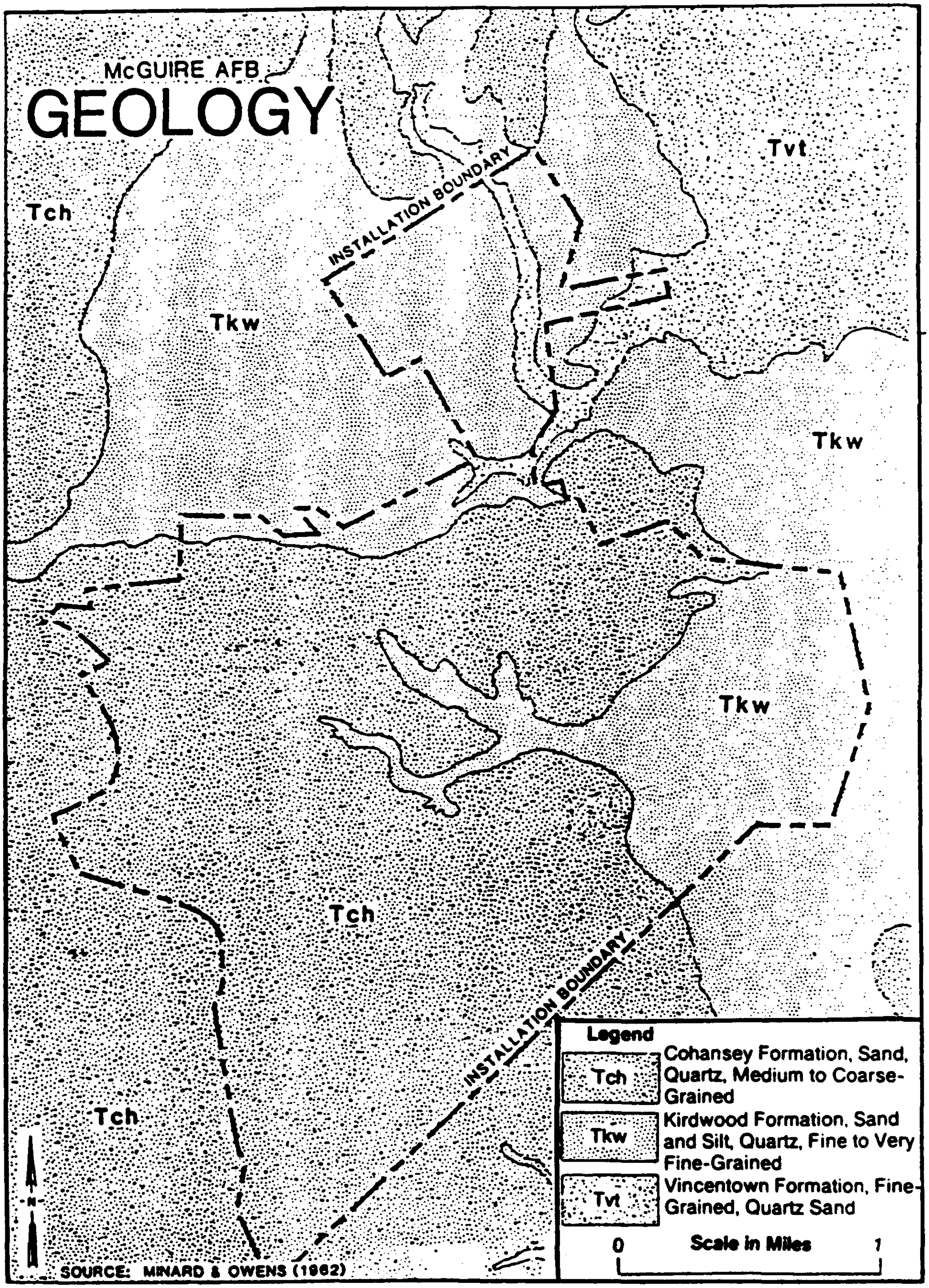


FIGURE 2-3 McGUIRE AFB GEOLOGY

Approximately 23 soil types have been identified within the installation boundaries of McGuire AFB. The units described impose moderate to severe constraints on the development of waste disposal facilities since these soil units are typically sandy and well-drained (E&S Phase I Report, 1982).

SECTION 3

FIELD PROGRAM

3.1 PROGRAM OBJECTIVES

The scope of work for Task Order 0016, which is presented in Appendix B, was developed in part from recommendations presented in the Phase II Stage 1 Report. The objective of this Task Order is to collect additional data from all sites investigated previously in Stage 1 and from nine additional sites to completely characterize groundwater and soil contamination at those sites. Data from this investigation will be used to define the extent of contamination in soils and groundwater, if any, and the potential for migration within the environment. The data also will be used to determine if there are any hazards to public health and the environment based on applicable State and Federal regulations.

3.1.1 Scope of Work

The scope of work includes the installation of 35 monitor wells; groundwater sampling of 52 existing or newly installed monitor wells; completion of 51 soil borings; soil, sediment, and surface water sampling; and geophysical surveys.

Data from this investigation have been incorporated with data obtained during the Phase II Stage 1 effort to characterize soil and groundwater contamination at each site. All individual sites are listed under one of three IRP Categories. Category I sites are sites where no further action (including remedial action) is required. Category II sites are sites which require additional data to further assess the extent of current or future contamination. Category III sites are sites that have been completely characterized and require remedial action. Cost estimates for Categories II and III sites are provided in a separate report.

3.1.2 Analytical Requirements

The analytical protocol was developed based on the Phase I and Phase II Stage 1 investigations. Contaminants of concern detected at significant concentrations at McGuire AFB are listed in Table 3-1. Analytical procedures developed for this investigation are presented in Appendix J. A complete list of U.S. EPA priority pollutant VOCs, BNAs, and pesticides is provided in Table 3-2.

Table 3-1

Water Quality Guidelines for Compounds Detected in Significant Concentration (mg/L)

Contaminants of Concern Detected at McGuire AFB	MCL	SMCL	MCLG	Taste and Odor Thres-hold	NJ DEP Correct-ive Actions Criteria	SNARL	Ambient Water Quality Criteria[c]
Oil and Grease	---	---	---	0.010	---	---	---
Nitrate	10	---	---	---	---	---	---
Nitrite	---	---	1.0	---	---	---	---
Arsenic	0.05	---	0.05	---	---	---	---
Cadmium	0.010	---	0.005	---	---	150[a]	0.010
Chromium	0.05	---	0.12	---	---	---	0.05
Copper	---	1.0	1.3	---	---	---	1.00
Lead	0.05	---	0.02	---	---	---	0.05
Mercury	0.002	---	0.003	---	---	---	0.000144
Nickel	---	---	---	---	---	---	0.0134
Iron	---	0.3	---	---	---	---	---
1,2-Dichlorobenzene	0.75	---	0.75	---	---	---	---
1-4-Dichlorobenzene	---	---	0.62	---	---	---	---
1,2-Dichloropropene	---	---	0.006	---	---	---	---
1,1-Dichloroethane	0.005	---	---	---	---	---	---
trans-1,2-Dichloro-ethene	---	---	0.006	---	---	0.270	---
Trichloroethene	0.005	---	---	---	0.005	---	0.0027
Tetrachloroethylene	---	---	0.20	---	0.005	0.020[a]	---
Phenol	---	---	---	0.300	---	---	3.5
2,4-Dimethylphenol	---	---	---	---	---	---	0.400
Naphthalene	---	---	---	---	---	---	0.143
Benzene	---	---	---	---	0.005	0.070[a]	0.00066
Chloride	---	250	---	---	---	---	---
Cyanide	---	---	---	---	---	---	0.20
Chlordane	---	---	---	---	---	---	0
4,4'-DDD	---	---	---	---	---	---	0
4,4'-DDE	---	---	---	---	---	---	0
4,4'-DDT	---	---	---	---	---	---	0
Dieldrin	---	---	---	---	---	---	0

[a]Chronic
[b]Toxic
[c]For ingestion of aquatic organisms.
MCL = Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
MCLG = Maximum Contaminant Level Goal
SNARL = Suggested No Adverse Reaction Level

Table 3-1
(continued)

Contaminants of Concern Detected at McGuire AFB	MCL	SMCL	MCLG	Taste and Odor Thres-hold	NJ DEP Correct-ive Actions Criteria	SNARL	Ambient Water Quality Criteria[c]
Chlorobenzene	---	---	---	---	---	---	0.02
Ethylbenzene	---	---	---	---	---	---	1.4
Sulfate	---	250	---	---	---	---	---
Toluene	---	---	2.0	---	---	0.340	14.300[b]
Xylenes	---	---	---	---	---	1.400	---
Vinyl chloride	0.001	---	---	---	0.005	---	.002
Diethyl phthalate	---	---	---	---	---	---	313.0
1,2-Dichloroethane	0.005	---	---	---	0.005	---	---
Methylene chloride	---	---	---	---	.0.005	1.300	---

[a]Chronic
[b]Toxic
[c]For ingestion of aquatic organisms.
MCL = Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
MCLG = Maximum Contaminant Level Goal
SNARL = Suggested No Adverse Reaction Level

Table 3-2

Compounds Analyzed at McGuire AFB

Metals

Arsenic
Boron
Cadmium
Chromium
Copper
Iron
Lead
Mercury
Nickel
Selenium
Silver
Zinc

Pesticides

Aldrin
Alpha-BHC
Beta-BHC
Gamma-BHC
Delta-BHC
Chlordane
4,4'-DDD
4,4'-DDE
4,4'-DDT
Dieldrin
Alpha endosulfan
Beta endosulfan
Endosulfan sulfate
Endrin
Endrin aldehyde
Heptachlor
Heptachlor epoxide
PCB 1016
PCB 1221
PCB 1232
PCB 1242
PCB 1248

Base-Neutral Extractibles

Acenaphthene
Acenaphthylene
Anthracene
Benzidine
Benzo(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(g,h,i,)perylene
Benzo(k)fluoranthene
Bis(2-chloroethoxy)methane
Bis(2-chloroethyl)ether
Bis(2-chloroisopropyl)ether
Bis(2-ethylhexyl)phthalate
4-Bromophenyl phenyl ether
2-Chloronaphthalene
Chrysene
4-Chlorophenyl phenyl ether
1,2,5,6-Dibenzanthracene
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
3,3-Dichlorobenzidine
Diethyl phthalate
Dimethyl phthalate
Di-n-butyl phthalate
2,4-Dinitrotoluene
2,6-Dinitrotoluene
Di-n-octyl phthalate
1,2-Diphenylhydrazine
Fluoranthene
Fluorene
Hexachlorobenzene
Hexachlorobutadiene
Hexachlorocyclopentadiene
Hexachloroethane
Indeno(1,2,3-c,d,)pyrene
Isophorone

Acid Extractibles

2-Chlorophenol
2,4-Dichlorophenol
2,4 Dimethylphenol
4,6-Dinitro-o-cresol
2,4-Dinitrophenol
2-Nitrophenol
4-Nitrophenol
p-Chloro-m-cresol
Pentachlorophenol
Phenol
2,4,6-Trichlorophenol

Volatiles

Acrolein
Acrylonitrile
Benzene
Bromodichloromethane
Bromoform
Carbon tetrachloride
Chlorobenzene
Chloroethane
2-Chloroethyl vinyl ether
Chloroform
cis-1,3-Dichloropropene
Dibromochloromethane
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethylene
1,2-Dichloropropane
Ethylbenzene
Methyl bromide
Methyl chloride
1,1,2,2-Tetrachloroethane
Tetrachloroethylene
trans-1,2-Dichloroethylene
trans-1,3-Dichloropropene

WESTON

Table 3-2
(continued)

Metals	Base-Neutral Extractibles	Volatiles
PCB 1254	Naphthalene	1,1,2-Trichloroethane
PCB 1260	n-Butyl benzyl phthalate	Trichloroethylene
Toxaphene	Nitrobenzene	1,1,1-Trichloroethane
	N-nitrosodimethylamine	Toluene
Miscellaneous	N-nitrosodi-n-propylamine	Vinyl chloride
	N-nitrosodiphenylamine	Total xylenes
Ammonia	Phenanthrene	Methylene chloride
Chloride	Pyrene	
Petroleum hydrocarbons		
	Radionuclides	
Hydrazine		
Nitrate	Plutonium-238	
Sulfate	Plutonium-239	

At the BOMARC Missile Site, where a radioactive spill occurred in the 1960's, soil and water samples were collected and analyzed for plutonium.

3.2 FIELD INVESTIGATION

The Phase II Stage 2 field investigation was conducted to:

- Determine the presence or absence of contamination within specified areas.
- Determine the magnitude and extent of contamination and the potential for these contaminants to migrate in various environmental media.
- Identify significant public health and environmental hazards based on applicable State and Federal regulations.

Data presented in this report were obtained from 52 monitor wells, 1 production well, 36 deep soil borings, 22 near-surface borings, 5 test pits, 9 sediment and 9 surface water sampling locations, and 2 geophysical investigations.

During drilling of the monitor wells, split-spoon samples were collected at regular intervals for visual inspection of the unconsolidated sediments in the unsaturated and saturated zone. During installation of the monitor wells at Site 1, samples were collected at discrete intervals for chemical analysis to determine the extent of possible vertical migration of contaminants. Installation of monitor wells also provided water level data for determining groundwater flow gradients and directions in the unconfined, shallow water table aquifer at the sites. A stream elevation survey provided additional information on the interrelationship between surface and groundwaters. The field work is summarized on a site-by-site basis in Table 3-3.

3.2.1 Schedule of Activity

The field investigation at McGuire AFB commenced on 15 October 1986 and was completed on 15 August 1987. Table 3-4 is a summary of WESTON's field activities schedule at McGuire AFB.

Table 3-3

McGuire AFB
Field Work Summary On a Site-by-Site Basis

Site	Stage 2 Activity
Site 1: McGuire Missile Site Accident Area (new site)	Install six groundwater monitor wells for plutonium analyses. Collect three soil samples from each boring for soil plutonium analyses. Perform well and groundwater elevation surveys. Collect groundwater samples from the six wells. Analyze soil and water samples for Pu-238 and Pu-239. In addition, one well (PU-7), otherwise associated with Site 5, was also sampled for Pu-238 and Pu-239.
Site 2: Zone 1 - Landfills 4, 5, and 6 and Sludge Disposal Area	Collect groundwater samples from five existing wells for petroleum hydrocarbons, phenols, ammonia, boron, iron, chloride, nitrate, sulfate, VOCs, Base/Neutrals and Acid Extractables (BNAs) pesticides, PCBs analyses. Collect three surface water samples for these parameters except BNAs, pesticides, and PCBs. Drill 10 deep borings and conduct a geophysical survey. Perform well and groundwater elevation surveys.
Site 3: Landfill 2	Install three groundwater monitor wells and collect samples of groundwater for petroleum hydrocarbons, phenols, ammonia, boron, iron, chloride, nitrate, sulfate, VOCs, BNAs, pesticides, and PCB analyses. Collect groundwater samples from three existing monitor wells. Collect three surface water samples for petroleum hydrocarbons, phenols, ammonia, boron, iron, chloride, nitrate, sulfate, and VOCs analyses. Drill six deep borings and conduct a geophysical survey. Perform well and groundwater elevation surveys.

Table 3-3
(continued)

Site	Stage 2 Activity
Site 4: Landfill 3	Install three groundwater monitor wells and collect groundwater samples for petroleum hydrocarbons, phenols, ammonia, boron, iron, chloride, nitrate, sulfate, VOCs, BNAs, pesticides, and PCBs analyses. Collect groundwater samples from three existing wells. Collect three surface water samples for petroleum hydrocarbons, phenols, ammonia, boron, iron, chloride, nitrate, sulfate, and VOCs analyses. Perform well and groundwater elevation surveys.
Site 5: McGuire Missile Site JP-X Discharge Pit	Install five groundwater monitor wells and collect groundwater samples for petroleum hydrocarbons, phenols, ammonia, boron, iron, chloride, nitrate, sulfate, VOCs, hydrazine, and xylenes analyses. Collect groundwater samples from two existing wells. Perform well and groundwater elevation surveys. One well (PU-7) will be sampled for Pu-238 and Pu-239 to supply additional data for the Site 1 investigation.
Site 6: Pesticide Wash Area	Collect three sediment samples and three 2-foot core samples from the wash area drainage path. Analyze for organochlorine pesticides.
Site 7: DPDO Storage Area	Collect 12 near-surface soil samples around perimeter of drum storage and buried tank areas. Analyze six samples for PCBs and archive the remaining samples.

Table 3-3
(continued)

Site	Stage 2 Activity
Site 8: Fire Training Area 1	Collect groundwater samples from two existing wells for petroleum hydrocarbons, VOCs, and xylenes analyses. Perform well and groundwater elevation surveys.
Site 9: Bulk Fuel Storage Tank Farm	Collect groundwater samples from two existing monitor wells for petroleum hydrocarbons, VOCs, and xylenes analyses. Perform well and groundwater elevation surveys.
Site 10: Civil Engineering Compound	Perform five backhoe excavations to confirm the presence or absence of buried barrels. Collect five soil samples and test for priority pollutant purgeable organics.
Site 11: Fire Training Area 2	Install three monitor wells and analyze groundwater for petroleum hydrocarbons, lead, and VOCs. Perform well and groundwater elevation surveys.
Site 12: McGuire Missile Site Transformers (new site)	Perform 10 test borings and collect soil samples for petroleum hydrocarbons and PCBs analyses.
Site 13: Fire Training Area 3 (new site)	Install three monitor wells and collect groundwater samples for petroleum hydrocarbons, lead, and VOCs analyses. Perform well and groundwater elevation surveys.

Table 3-3
(continued)

Site	Stage 2 Activity
Site 14: NDI Shop - Drain Field (new site)	Install three monitor wells and collect groundwater samples for petroleum hydrocarbons, cadmium, total chromium, copper, nickel, lead, zinc, mercury, silver, selenium, and arsenic analyses. Collect 10 near-surface soil samples and analyze for the same parameters. Perform well and groundwater elevation surveys.
Site 15: McGuire Missile Site - MOGAS Storage Tanks (new site)	Install three monitor wells and collect groundwater samples for petroleum hydrocarbons and lead analyses. Collect three soil samples from each boring and analyze for petroleum hydrocarbons and lead. Perform well and groundwater elevation surveys.
Site 16: McGuire Missile Site - BOMARC Missile Launchers (new site)	Install three monitor wells and collect groundwater samples for petroleum hydroocarbons analyses. Perform well and groundwater elevation surveys.
Site 17: McGuire Missile Site Neutralized Acid Pit (new site)	Install three monitor wells and collect groundwater samples for nitrate analyses. Perform well and groundwater elevation surveys.
Site 18: PCB Spill Site (new site)	Perform 10 test borings around the perimeter of the site and collect soil samples for PCBs and petroleum hydrocarbons analyses.

Table 3-4

McGuire AFB
Field Activities Schedule - 1986-1987

Stage 2 Activity	Date
Geophysical Surveys	20 October - 15 November 1986
Soil Borings (includes deep and shallow soil and sediment sampling, test pit excavations, and surface water samples)	15 October - 24 November 1986
Monitor Well Installations (35, including well development)	23 October 1986 - 5 February 1987
Monitor Well Elevation Surveys	5 February - 23 February 1987
Groundwater Sampling	
Round 1	9 February - 2 March 1987
Round 2	9 March - 25 March 1987
Monitor Wells PU-1 through PU-7	
Round 1	6 July - 8 July 1987
Round 2	12 August 1987

3.2.3 Site-Specific Investigations

The following subsection describes the detailed soil, groundwater, and surface water investigations conducted Site 1.

3.2.3.1 Site 1: McGuire Missile Site Accident Area

During drilling, the water level was encountered at 50 to 67 feet. The Scope of Work originally planned six shallow (30-foot) wells at Site 1. A typical well construction diagram is presented in Figure 3-1. Six deep monitor wells were installed at Site 1 at locations shown in Figure 3-9. Each was screened in the upper portion of the water table aquifer, and all were positioned around the site to gain complete coverage of the accident area. The wells, numbered PU-1 through PU-6, were screened 12 feet into the water table. Monitor well PU-1 was intended to represent the upgradient well, and monitor well PU-2 was intended to be downgradient of the site. Wells PU-3 through PU-6 were installed at locations determined to be in the surface drainage path flow direction away from the Missile Launcher Site. The wells were screened in saturated, well-sorted fine sand of the Cohansey Formation.

In addition to the six shallow monitor wells installed, a second, deep well was initially specified for installation at the monitor well PU-4 location. Because groundwater was deeper than estimated, it was determined that a well cluster would not intercept any water at the shallower well point. Therefore, only one well was installed at PU-4. Monitor well construction and elevation summary is shown in Table 3-5.

During drilling operations for the wells at Site 1, WESTON's Health Physicist used an Alpha Scintillator, an air pump, and LDS dosimeters to monitor air quality and personnel radiation dosage.

Groundwater samples were collected from wells PU-1 through PU-6 and from PU-7 (otherwise considered a monitoring point for Site 5); the samples were analyzed for Pu-238 and Pu-239.

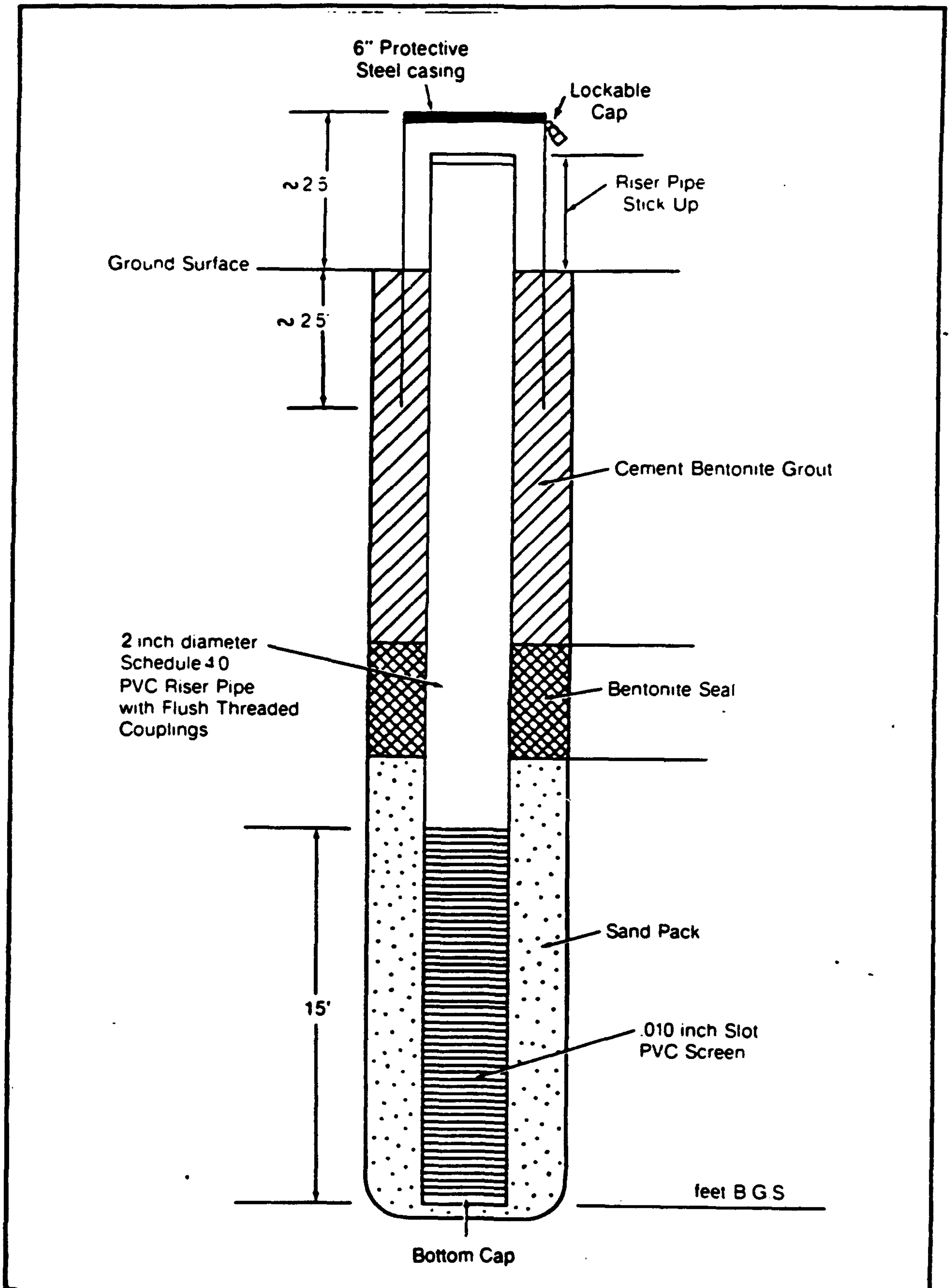


FIGURE 3-1 TYPICAL MONITOR WELL CONSTRUCTION

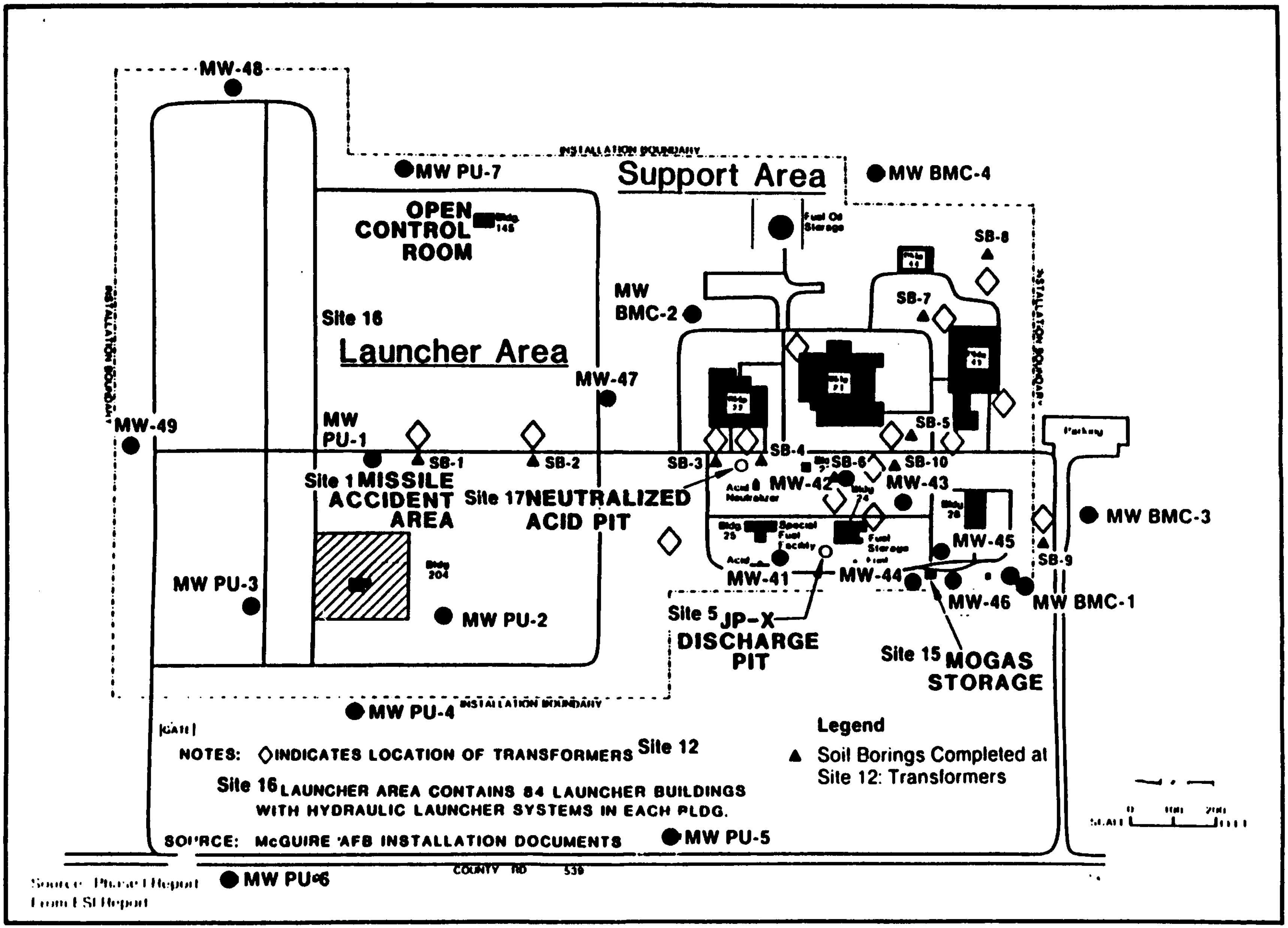


FIGURE 3-9 LOCATION OF MONITOR WELLS AND SOIL BORINGS AT THE BOMARC MISSILE SITE

Table 3-5

Monitor Well Construction and Elevation Summary

Well Number	Site Number	Top of Casing Elevation Above MSL	Screen Length (ft)	Casing Length (ft)
MW-1	2	100.71	20	10
MW-2	2	87.35	20	9
MW-3	2	93.16	15	10
MW-4	2	97.67	10	21
MW-5	2	---		
MW-6	3	131.12	15	22
MW-7	3	129.59	10	27
MW-8	3	126.39	10	26
MW-9	4	116.84	10	21.5
MW-10	4	114.63	20	12
MW-11	4	119.69	20	21
MW-12	9	114.75	20	19
MW-13	9	113.21	20	9
MW-14	8	117.43	20	7
MW-15	8	116.78	20	7
MW-16	5	155.92	15	23
MW-17	5	153.66	15	16
MW-26	3	125.72	15	12
MW-27	3	130.01	15	15
MW-28	3	125.79	15	15
MW-29	4	122.56	15	15
MW-30	4	123.30	15	15
MW-31	4	122.20	15	15
MW-32	14	116.13	15	7
MW-33	14	115.53	15	7
MW-34	14	115.52	15	7

Table 3-5
(continued)

Well Number	Site Number	Top of Casing Elevation Above MSL	Screen Length (ft)	Casing Length (ft)
MW-35	13	118.71	15	7
MW-36	13	118.72	15	7
MW-37	13	119.43	15	7
MW-38	11	109.60	15	7
MW-39	11	109.35	15	7
MW-40	11	110.65	15	7
MW-41	17	159.87	15	29
MW-42	17	156.69	15	25
MW-43	17	155.47	15	29
MW-44	15	152.01	15	25
MW-45	15	150.54	15	25
MW-46	15	149.93	15	25
MW-47	16	169.62	15	40
MW-48	16	145.73	15	19
MW-49	16	167.10	15	40
BMC-1	5	144.73	15	15
BMC-2	5	153.74	15	25
BMC-3	5	143.14	15	15
BMC-4	5	140.08	15	15
PU-7	5	152.30	15	25
PU-1	1	182.89	15	52
PU-2	1	174.31	15	42
PU-3	1	177.06	15	45
PU-4	1	177.67	15	45
PU-5	1	169.01	15	37
PU-6	1	168.27	15	45

SECTION 4

RESULTS

4.1 SITE INTERPRETIVE GEOLOGY

The interpretations presented in this section are based on geologic records reviewed during the records search and on the logs of existing and newly installed monitor wells and borings.

4.1.2 BOMARC Site (Site 1)

The BOMARC Missile Site, located approximately 11 miles east of the base, is directly underlain by the Cohansey Formation which, in turn, overlies the Kirkwood and Vincentown Formations. Generalized descriptions of the formations are given in Subsection 2.3. Figure 4-2 presents a fence diagram for the BOMARC Site.

Sediments penetrated by wells drilled at the BOMARC Site consist of four general units presented in order of decreasing abundance:

- Medium-to-fine quartz sand.
- Coarse-to-medium quartz sand.
- Coarse-to-fine quartz gravel.
- Clay, silt, and peat.

Medium-to-Fine Sand - This unit consists of well-sorted medium-to-fine quartz sand containing minor amounts of gravel, coarse sand, silt, and clay. Color ranges from light gray to brownish-yellow, and color laminations and mottling are common. Rusty-orange layers of iron oxide enrichment were noted often occurring just above clay- and silt-rich layers. Hard, brittle, indurated iron-rich layers were occasionally encountered, and thin horizons rich in heavy mineral grains also were noted. Medium-to-fine sand units appear to be laterally extensive throughout the BOMARC Site and range from less than 5 to more than 40 feet in thickness.

WESTON

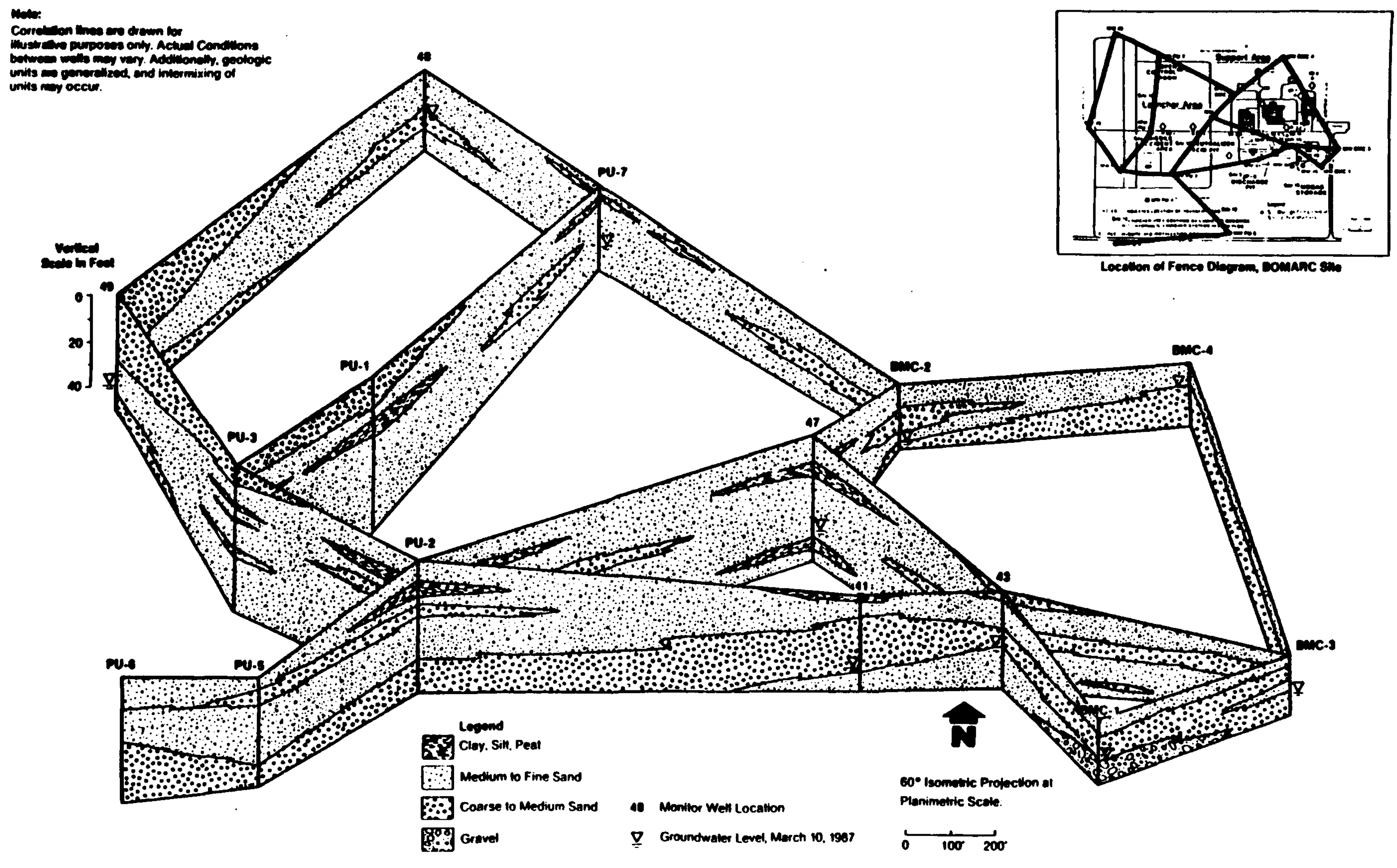


FIGURE 4-2 FENCE DIAGRAM BOMARC MISSILE SITE McGUIRE AIR FORCE BASE

APPENDIX O

BIOGRAPHIES OF KEY PERSONNEL

RICHARD G. BIZUB
Project Geologist

THE EARTH TECHNOLOGY CORPORATION

Education:
Graduate Studies, Geology, Rutgers University, 1983-1986
B.A., Geology, Rutgers University, 1981
A.A.S., Chemistry, Morris County Community College, 1977

Registration:
Certified Professional Geologist, Arkansas, No.709
Registered Professional Geologist, Tennessee, No. TN 1224
American Institute of Professional Geologists, CPG No. 8013

Professional Experience:

Richard Bizub has nearly 10 years experience in designing and implementing field investigations related to hydrogeologic site assessments, hazardous waste investigations, environmental compliance and permitting, geologic studies, and geophysical mapping. He has over 7 years experience in site inspections, soil and groundwater sampling, supervision of monitoring well construction, aquifer testing, site mapping, and geologic research. Mr. Bizub is familiar with the environmental regulations governing discharge, and water quality protection.

Prior to joining Earth Technology, Mr. Bizub was involved in a variety of geological investigations related to geotechnical engineering. His duties included supervising field projects, interpretating test boring logs, and preparing geological maps and cross sections. In addition, he served as an inspector in charge of construction seismology on EPA construction sites in New York. Mr. Bizub also assisted in preparing Geology of elected Areas of New Jersey, a guidebook of the geology of New Jersey. Mr. Bizub's environmental experience encompasses:

GEOPHYSICAL SURVEY ON NEW JERSEY'S ROUTE 78
PHILLIPSBURG, NEW JERSEY
NEW JERSEY DEPARTMENT OF TRANSPORTATION (through Louis Berger and Associates)

Assisted with a geophysical investigation using Ground Penetrating Radar (GPR) to map the presence or absence of sinkholes beneath Route 78 in northern New Jersey. This project was conducted in the Jacksonburg and Kittatanny Formations, both prominent karst topography. Confirmation drilling was conducted by the client to evaluate the validity of the geophysical data. A 75% success ratio resulted. Mr. Bizub assisted with the field work and final report. He also acted and the primary liaison between the Earth Technology geophysical team and the New Jersey DOT.

LANDFILL DISRUPTION AND CLOSURE
NEW JERSEY
TRAP ROCK INDUSTRIES

Assisted in the technical development of a sanitary landfill disruption permitting program located in the wetlands of New Jersey. The program required a detailed soil erosion and sediment control plan, and an extensive disruption engineering work plan.

GROUNDWATER QUALITY MONITORING AT AN INACTIVE LANDFILL
MAYS LANDING, NEW JERSEY
AMERICAN CYANIMID COMPANY

Managed and supervised a groundwater quality monitoring program for an inactive landfill to obtain a groundwater discharge permit. The project required the installation of four monitoring wells and the development of a comprehensive sampling program to characterize contaminant transport from the site. As part of the permit requirements, quarterly sampling is performed and summary reports are prepared.

HAZARDOUS WASTE INCINERATOR SITING
MONROE TOWNSHIP, NEW JERSEY
R-H DEVELOPMENT CORPORATION

Performed an in-depth hydrogeologic analysis of existing data relative to the siting of a hazardous waste incinerator. The project involved reviewing well locations and construction details, aquifer test data, aquifer properties, groundwater flow conditions, geophysical logs and performing a regional flownet analysis.

NJPDES PERMITTING
NEW HANOVER TOWNSHIP, NEW JERSEY
KUPPER ASSOCIATES

Supervised field activities for a groundwater investigation leading to a subsurface wastewater disposal permit for a proposed hotel. The project required installation of monitoring wells, aquifer tests to characterize the saturated zone, a computer simulation of groundwater mounding as a result of wastewater disposal, and laboratory testing to identify hydraulic properties of the unsaturated zone.

REDMEDIAL INVESTIGATION\FEASIBILITY AT BOMARC MISSILE SITE
McGUIRE AIR FORCE BASE, NEW JERSEY
U.S. AIR FORCE

Assisting with the field investigation for a two-million-dollar Phase II Installation Restoration Program studies at the BOMARC Missile Site at McGuire AFB, New Jersey. These studies include an RI\FS and an Environmental Impact Study. Contaminants of concern are radionuclides. Contamination migration through air, soil, groundwater, surface water, and sediment is under evaluation. Mr. Bizub is collecting soil samples, overseeing groundwater monitoring well installation, and ensuring subcontractor performance in the field.

RCRA CLOSURE ACTIVITIES
NIAGARA COUNTY, NEW YORK
U.S. AIR FORCE OCCUPATIONAL AND ENVIRONMENTAL HEALTH LABORATORY

Assisting with the RCRA closure activities at Air Force Plant 38 in Niagara County, New York. The activities included removal of four underground storage tanks, sampling for contaminants, and backfilling the excavation; sampling and incinerator for asbestos and dismantling the incineratory; preparing a health and safety plan, nd a QA\QC plan; and coordinating activities with state and federal agencies. Mr. Bizub assisted with the soil sampling collection and subcontractor oversight in the field.

AQUIFER TESTING
WARMINISTER, PENNSYLVANIA
U.S. NAVY

Performed water supply well test tests, and Packer tests to evaluate specific capacity reductions and to assess the usefulness of several water supply wells tapping a fractured, Triassic aquifer at the U.S. Naval Air Development Center. The well drawdown and recovery data were analyzed to evaluate aquifer properties and well efficiencies. Based on this data, strategies were planned to optimize pumping cycles and pumping rates to meet water demands.

ENVIRONMENTAL SITE ASSESSMENT
PHILADELPHIA, PENNSYLVANIA
PANOCEAN, U.S.A.

Conducted an environmental assessment of the C. Brewer Terminal site located in the Port of Richmond section of Philadelphia, Pennsylvania. The objective of this assessment was to compile and analyze data concerning the environmental condition of the site that might have potential to negatively affect ownership. Mr. Bizub conducted a review of existing literature, plans and records, an on-site visual inspection and preliminary soil sampling. The results and data compiled during this assessment was analyzed to determine the environmental status of the property.

SITE EVALUATION AT THE HUNTINGTON TERMINAL
HUNTINGTON, WEST VIRGINIA
CHEVRON, U.S.A.

Assisted with an environmental assessment of the Huntington oil distribution-transfer facility in Huntington, West Virginia. Determined the geology of the site and assessed with the removal and inspection of three underground oil storage tanks. Responsible for collecting soil samples from within each of the tanks' excavated pits to evaluate if the tanks had leaked. Shallow soil sampling was performed throughout the facility to test for petroleum compounds. Mr. Bizub also assisted with groundwater sampling of eight existing monitoring wells to analyze for petroleum hydrocarbons and evaluate aquifer characteristics.

PRELIMINARY SITE EVALUATION AT THE CHARLESTON TERMINAL
CHARLESTON, WEST VIRGINIA
CHEVRON, U.S.A.

Assisted with a preliminary environmental site evaluation for the Charleston oil distribution-transfer terminal to evaluate existing site conditions concerning possible soil and groundwater contamination. Mr. Bizub was responsible for determining the geologic and hydrogeologic settings of the site and collecting soil and groundwater samples for laboratory analyses for the presence of petroleum hydrocarbons and volatile organic compounds.

CONTAMINATION DELINEATION OF IN THE GROUNDWATER
SUSSEX, NEW JERSEY
CONFIDENTIAL CLIENT

Overseeing the installation of monitoring wells to sample groundwater and determine the extent and degree of soil and contamination. Once completed with this phase, Mr. Bizub will determine remedial measures for cleanup. There are six areas of environmental concern that had previously been identified at the site: an oil stain of unknown origin in the gravelled parking area; empty and crushed drums; stained soil; an abandoned septic tank; a 10,000-gallon aboveground fuel oil tank; and a 1,000-gallon abandoned fuel oil tank. Mr. Bizub implemented a soil gas analysis program to determine the extent of soil contamination.

GEOLOGIC STUDY OF AN 1870 ORE OCCURRENCE
MOUNT OLIVE, NEW JERSEY

Conducted a geologic study of a pre-1870 iron ore occurrence to assess possible radon hazards associated with magnetite cores. The investigation consisted of a literature review, scintillation counter traverses to determine areas of anomalous radioactivity, diamond drill cores logging and a sampling program to analyze for uranium, iron and cerium.

Professional Organizations

American Institute of Professional Geologists
Association of Engineering Geologists
Association of Groundwater Scientists and Engineers (NWWA)
Geological Society of America

Publications

"Shortening of Cover and Basement in the Greenpond Outlier of Northern New Jersey", Geological Society of America, 21st Annual Meeting, Northeastern Section, 1986, with Joseph Hull

"Deformation Zones in the New Jersey Highlands", Geological Association of New Jersey, in Geology of the New Jersey Highlands and Radon in New Jersey, October 1986, with Joseph Hull and Robert Koto

"The Design and Implementation of Groundwater Monitoring Systems", American Society of Civil Engineers,, Water Resources Planning and Management Division, 16th Annual Specialty Conference, May 1989, with Leonard Cilli

ROBERT A. COLONNA
SENIOR VICE PRESIDENT
THE EARTH TECHNOLOGY CORPORATION

Education

M.B.A., Operations Research, 1965, American University
B.S., Management Engineering, 1961, Rensselaer Polytechnic Institute

Professional Experience

Robert Colonna has more than 26 years of experience in engi-neering, most of which is related to solid and hazardous waste management. He has worked for both industry and EPA, and understands the concerns of both industry and government in meeting regulatory requirements. He has managed nationwide waste management programs involving as many as 65 professionals. For the past ten years he has been responsible for land disposal site evaluations throughout the U.S. He is the past Chairman of the Professional Services Council (PSC) of the National Solid Waste Management Association. As a senior executive at The Earth Technology Corporation and assigned to Washington, D.C., he is responsible for corporate-wide hazardous waste management pro-grams and can call upon corporate resources as needed on any pro-ject.

Mr. Colonna has proven managerial skills directing diverse and complex hazardous waste projects. He has successfully and cost-effectively managed numerous tasks and subcontractors on multi-disciplinary projects for the EPA and is experienced in producing rapid results with EPA quality control and quality assurance pro-cedures.

His experience in managing and successfully controlling large and technically complex projects has been demonstrated throughout his career on numerous government projects. Additionally, he has many years of experience with the U.S. Navy, drilling and ana-lyzing wells at several sites for groundwater contamination, and making recommendations for remedial actions.

With his management experience, he is well versed in the need for preventative management, so potential problems are recognized and diffused early.

o HAZARDOUS WASTE
RI/FS AND RCRA REMOVAL (3 SITES)
USAF/OEHL

Mr. Colonna is the overall program manager on three major Air Force waste management projects. The first is a RCRA removal at Air Force Plant 38 in Buffalo, NY involving removal of four underground storage tanks, soil excavation and testing, and the dismantling of an incinerator. The second is an RI/FS at Air Force Plant 3 in Tulsa, Oklahoma involving a major well installation, groundwater monitoring program followed by site remediation. The third site is March AFB in San Bernardino, California, and involves well installation, soil and groundwater sampling, and site remediation.

- HAZARDOUS WASTE
  WASTE MINIMIZATION AT AFSC BASES
  USAF/AFSC ANDREWS AIR FORCE BASE

  Responsible corporate officer for analysis of waste manage-ment practices at six Air Force bases and three Air Force stations seeking waste minimization.

- LAND DISPOSAL REGULATORY PROGRAM
  NUS (SUBCONTRACT ON AN EPA/OSW PROGRAM)
  WASHINGTON, D.C.

  Managed $700K worth of Work Assignments for the Development of the Leak Detection and Double Liner Rules, their Preambles, and Background Documents. Responsible Corporate Office for six other work assignments including the no migration petition and chemical waste repository guidance documents. Project Manager for an additional $250K work assignment with EPA's Municipal Solid Waste Task Force involving the development of a strategy report to the Administrator and Congress.

- ENVIRONMENTAL AUDITS AT AF GOCO FACILITIES AND AFSC BASES
  USAF/AFSC/ASD
  WRIGHT PATTERSON AFB, OHIO

  Responsible corporate office conducting environmental audits of eleven Air Force Production Plants. Project Manage on a project involving comprehensive environmental audits of seven AFSC bases.

- RCRA FACILITY ASSESSMENTS (RFA'S)
  AND PART BE PERMIT REVIEW
  KEARNEY (SUBCONTRACTOR ON EPA/OSW PROGRAM)
  WASHINGTON, D.C.

  Responsible corporate officer for site inspection and facility assessments at fourteen industrial facilities (hazardous waste generators, storers, disposers).

- MISSION SUPPORT CONTRACT
  TECHNICAL AND MANAGEMENT SERVICES (TMS-III)
  USEPA/ORD
  CINCINNATI AND EDISON, NJ

  As national program manager for a ten million dollar, four year research and development contract involving hazardous waste site cleanup and containment, he ensured that an inte-grated team, comprised of professional staff from several companies, produced technical work that was completed accurately, on time, and with appropriate cost control.

- o INDUSTRY STUDIES AND DELISTING PROGRAM
  USEPA/OSW
  WASHINGTON, D.C.

  As corporate officer on this multi-million dollar, three year contract, Mr. Colonna managed the development of a nationwide database for the chemical industries' waste generator, storage and disposal practices. Experience from this project provided Mr. Colonna with a thorough under-standing of past and present industrial practices that are invaluable for technology transfer for the REM IV contract.

- o RCRA PANELS PROGRAM
  USEPA REGION V
  CHICAGO, IL

  Managed and directed numerous RCRA projects for state and local governments on waste-to-energy, municipal land dis-posal, collection and storage, and data system support.

- o REMEDIAL ACTION MANUAL DEVELOPMENT
  USEPA/HEADQUARTERS
  WASHINGTON, D.C.

  Developed Remedial Action Manual of R.A. Technologies for site encapsulation groundwater control and soil treatment.

- o HAZARDOUS WASTE SITE RANKING METHODOLOGY
  USEPA/HEADQUARTERS
  WASHINGTON, D.C.

  Developed a methodology for prioritizing sites based on a composite index of danger to health and environment which was developed for national use.

- o RCRA PANELS PROGRAM
  USEPA REGION III
  PHILADELPHIA

  Managed numerous RCRA projects for state and local govern-ments on waste-to-energy, hazardous waste disposal, muni-cipal waste disposal, waste collection and transfer.
- o RCRA 4004 CRITERIA EIA
  USEPA/OSW
  WASHINGTON, D.C.

  Managed development for EIA for non-hazardous disposal site regulations.

Registrations

Professional Engineer, Maryland, 1967, No. 5712

Previous Employers

JRB Associates - Sr. Vice President
Decision Systems Inc. - President
USEPA - Division Director/OSW
Applied Management Sciences - Sr. Vice President
Booz, Allen & Hamilton - Consultant

International Experience

Mr. Colonna presented a paper entitled "Domestic Waste Management -- Alternatives to Landfilling" at an AFSC workshop at Andrews AFB in August 1988.

Mr. Colonna presented a paper entitled "Waste Minimization Techniques for Waste Oils and Solvents" at the Sixth International Conference on Chemistry for Protection of the Environment, September 15-18, Torino, Italy.

Mr. Colonna presented a paper entitled "Materials and Energy Recovery Potential from the Leather Products Industry" at the IRC Conference in Berlin in 1982. In addition, he presented a paper entitled "Upgrading Techniques for Land Disposal Sites" at the ISWA Conference in Munich in June 1981. Prior to that, he pre-sented a paper on methane gas recovery from landfills at a con-ference sponsored by UNITAR and IIASA in Vienna, Austria in June 1976. In addition, he served as the head of EPA's delegation to the Soviet Union to exchange land disposal and incineration tech-nology in July 1975.

References

Mr. Donald Sanning, USEPA/HWERL
Manager of Superfund Research
26 West St. Clair
Cincinnati, Ohio

Col. Frank Gallagher
USAFSC
Andrews AFB
Washington, D.C.

Mr. Robert Tonetti, USEPA/OSW
Manager, Land Disposal Branch
401 M Street, S.W.
Washington, D.C.

Foreign Languages: None

Citizenship: USA

Security Clearance: Secret

Professional Organizations

ADPA
NSWMA Professional Services Council

LISA E. GOLDBERG **The Earth Technology Corporation**
Staff Environmental Scientist

B.S., Natural Resources, Cornell University, 1985

Lisa Goldberg has over 4 years of experience in environmental policy assessment, RCRA compliance inspection, RI/FS reviews, remediation oversight, hazardous waste site assessment and monitoring, and **comprehensive environmental audits** for the Air Force, USEPA and commercial clients for environmental consultants. Relevant experience includes:

- Member of a team responsible for performing **comprehensive environmental audits** for Air Force contractors (GOCOs). Identified current and potential environmental compliance problems and identified opportunities for waste minimization, and opportunities for conserving, reusing and recycling materials in industrial plant operations. **Recommended alternative waste disposal methods and generation practices.** Project also involved hazard identification and a **follow-up to previous compliance assessments.**

- Performed RCRA **compliance inspections** which involved site inspections at industrial facilities with RCRA interim status as hazardous waste generators and/or treatment storage and disposal facilities (TSD). Prepared **inspection evaluation reports** regarding the **compliance status** of each facility with applicable state and federal RCRA regulations.

- Performed **environmental compliance assessments** of four properties involved in **real estate transactions.** This work was done on behalf of a confidential client and involved: a document review of the property and adjoining properties for ownership and regulatory history; examining historical aerial photographs; and reviewing geologic, hydrogeologic and soils maps and bulletins. Each site was visually inspected for evidence of past and present environmental contamination. **Recommendations were made to the client regarding environmental liability likely to be associated with property based on the investigations.**

DAVID S. NALEID
SENIOR STAFF CHEMICAL ENGINEER
THE EARTH TECHNOLOGY CORPORATION

Education

Bachelor of Chemical Engineering, Georgia Institute of Technology (1977)

Experience Summary

Six years of professional experience as a Chemical Engineer with two of those in the environmental engineering industry. Extensive experience in engineering cost estimating. Examples of relevant project experience include:

- **Developed Feasibility Studies of remedial alternatives for hazardous waste sites at the Air National Guard Base in Burlington, Vermont, the Air Force Plant 3 in Tulsa, Oklahoma and the BOMARC Missile Site near McGuire Air Force Base, New Jersey. Developed and screened remedial alternatives and calculated capital, operating and maintenance costs.**

- **Performed a Waste Minimization Study of several DoD facilities in Hawaii. The study is based on an integrated approach using unit operations and a mass balance around them. Surveyed four facilities and prepared recommendations for waste minimization. Developed life-cycle cost estimates in support of the recommendations.**

- **Participated in the Remedial Investigation/Feasibility Study of Air Force Plant 3 in Tulsa, Oklahoma. Tasks included a geophysical survey to locate underground obstacles at borehole sites, a soil-gas survey along a 5,000 foot abandoned fuel line to delineate any leakage, and subsurface sampling of soil and groundwater to define boundaries and concentration levels. Assisted in the installation of boreholes and groundwater monitoring wells for plume delineation, both laterally and vertically, contaminant definition and concentration.**

- **Managed a crew and well logging computer truck for a wireline service company in the Permian Basin of west Texas. Performed geophysical wireline services for national and independent petroleum companies using sophisticated logging equipment in conjunction with computers to obtain exploratory well logs. Responsible for interpreting the logs for the client.**

- **Supervised high speed manufacturing lines for a manufacturing company. Oversaw five production lines and maintained immediate quality control. Promoted to Staff Engineer whose responsibilities included budgeting, project engineering, and long-term quality control.**

Professional Memberships

Member, American Institute of Chemical Engineers

JANET ROBINSON **The Earth Technology Corporation**
Project Environmental Scientist

M.S., Environmental Science and Engineering, 1986
M.S., Biological Sciences, 1983
B.S., Biology, 1980

Janet E. Robinson has a strong background in **environmental regulatory analysis** and waste management. Her experience includes **environmental compliance assessments,** remedial investigations, RCRA facility assessments, and regulatory policy support on land disposal and a variety of other issues for federal, state, and local governments. Relevant experience is summarized below:

- Participated in **comprehensive environmental compliance audits** of eight Air Force bases nationwide. Compliance with federal, state, local and Air Force environmental regulations was evaluated. Each audit consisted of an extensive literature review, a 1-2 week site visit, and **reports that listed and discussed observed environmental problems, recommended solutions,** and **evaluated the short- and long-term cost of those solutions.** In addition, a ranking system was devised to **prioritize resource allocations for corrective actions.** A final summary report discussed potential solutions to environmental compliance problems across the Command.

- Participated in RCRA Facility Assessments of a large zinc smelting operation, a munitions manufacturing plant, and a pipe foundry to identify and evaluate solid waste management units (SWMUs). Each RFA included a literature review of plant operations and environmental records to identify past waste management practices; a site visit to identify current waste management practices and to confirm information collected during the records search; and a **final report describing and evaluating observed solid waste management units.** Each report also contained **recommendations for further actions** to determine if releases of hazardous constituents to the environment had occurred at specific facilities.

- Produced a series of policy support documents for state and local policy makers on topics such as **underground storage tank management and disposal,** small quantity hazardous waste generator regulations, incineration techniques, and environmental regulations.

- Investigated and **costed several remedial alternatives** for radioactively contaminated soils and buildings as part of feasibility study for an abandoned facility in New Jersey. The isotopes consisted of plutonium and americium, and remedial alternatives included building decontamination, soil volume reduction, and material disposal.

A. EDWARD SCIULLI
SENIOR STAFF GEOPHYSICIST

THE EARTH TECHNOLOGY CORPORATION

Education

B.S., Geoscience-Geophysics option, Pennsylvania State University, 1986

Professional Experience

Ed Sciulli has more than 4 years of experience in all phases of geophysical applications. He has successfully applied the following techniques to investigate subsurface problems on waste-related, geotechnical and hydrological projects: seismic refraction and downhole velocity surveys (P and S wave), spectral analysis of surface wave (SASW) sounding, electromagnetic induction, ground magnetics, and ground penetrating radar profiling.

Mr. Sciulli's major projects have included mapping contaminant groundwater plumes, mapping landfill and trench boundaries, and locating abandoned wells. Other projects have included road bed foundation studies, groundwater depth estimation and bedrock mapping.

As a senior staff geophysicist, Mr. Sciulli provides support in all geophysical activities, including data collection, processing, and interpretation.

o IRON ORE EXPLORATION
NATIONAL CEMENT COMPANY
LEBEC, CALIFORNIA

Served as Field Supervisor of a three-man crew conducting a magnetic survey at 5 sites within an active quarry. The sites ranged in size from 600 x 600 feet to 3000 x 7000 feet. Responsibilities included grid and site map construction, data collection, and evaluation of data integrity. Assisted in all phases of data processing and interpretation, including first-order trend surface analysis. A total of six magnetic anomalies were interpreted as being economical iron ore deposits. Assisted in three-dimensional block modeling of the six anomalies providing estimates of ore body depth and volume. To date, mining has begun at one site and exploratory drilling is planned for a second in the near future.

o SUBSURFACE CLEARANCE
VARIOUS
WESTERN UNITED STATES

Successfully applied technique that uses 3 complimentary geophysical methods (electromagnetic induction, ground penetrating radar, and magnetics) to locate subsurface man-made objects which may be hazards to drilling and trenching operations. Surveyed hundreds of sites, locating utility lines and storage tanks.

Clients include: Brown and Caldwell, Leighton and Associates, ERC WESTEC, Hydro-Geo-Chem, Precision Tank Testing, BCL, and RTD. Responsibilities include all data collection, processing, interpretation, and anomaly mapping.

- ABANDONED WELL SEARCH
  BROWN AND CALDWELL
  SHELL OIL REFINERY
  WILMINGTON, CA

  Conducted magnetic and ground penetrating radar survey at an active refinery to locate an abandoned well. Coincident anomalies were found with both techniques and are thought to represent the abandoned well. Responsibilities included all phases of data collection, processing, and interpretation.

- MOFFETT NAVAL AIR STATION
  SUNNYVALE, CALIFORNIA

  Provided field and office support for geophysical program using three complementary geophysical methods at 16 sites to find the most probable location of buried, steel-cased irrigation wells that were abandoned before the base was built. Ground penetrating radar, electromagnetic profiling, and ground magnetics located geophysical anomalies thought to represent steel casing about 650 feet long.

  Data were automatically transferred to portable computers in the field and processed at night. Results were posted on base maps showing nearby cultural features, and the effects of these features were removed from the data. The three data sets were then correlated to determine the most probable locations for the wells at each site. One well and a buried access cover have been uncovered to date.

- AQUA DULCE GROUNDWATER ASSESSMENT

  Assisted in a deep refraction study to estimate hydrological resources in an alluvial valley. Bedrock depth and configuration, and overburden lithology were determined. A bedrock fault was located and is thought to be a major source of groundwater recharge to the surrounding area. Results were used to design a well field.

- MELOLAND BRIDGE
  EL CENTRO, CALIFORNIA

  Used spectral analysis of surface waves technique to map the detailed shear wave velocity profile at the bridge pile. Results were used to model bridge/soil interaction during earthquake loading.

- o BURLINGTON ANGB
  BURLINGTON, VERMONT

  Conducted geophysical survey using electromagnetic induction and ground magnetics to map the boundaries of an exiting landfill and old fire-training area. Responsible for all data collection. Assisted in all phases of data reduction and interpretation. Results outlined the landfill and detected a possible contaminant plume in the shallow groundwater.

- o HAZARDOUS WASTE CONTAMINATION CONFIRMATION STUDY
  PORT HUENEME NAVAL CONSTRUCTION BATTALION CENTER
  U.S. NAVY

  Assisted with magnetic and ground penetrating radar survey over an earth-moving area and a hazardous waste storage area to support a Confirmation Study (the Navy's equivalent to an RI/FS) within the Base. Results located five possible burial trenches in the earth-moving area and possible buried drums at the storage area.

- o MX MISSILE SITING STUDIES
  ARIZONA, NEW MEXICO, MONTANA
  U.S. AIR FORCE

  Assisted in soil stiffness studies in support of engineering investigations for the MX missile program. Methods included shallow refraction and spectral analysis of surface waves (SASW) for P- and S-wave velocity data. Completed all phases of field data collection, processing, modeling and interpretation. Results used to compute engineering properties of sites to 8 feet in depth.

- o HYDROLOGIC STUDY, DEEP SEISMIC REFRACTION
  FORT BLISS, NEW MEXICO
  U.S. AIR FORCE

  Provided field support to a hydrologic study in an effort to locate possible well sites using the seismic refraction method. Participated in all phases of field data collection and interpretation.

- o 3-D COMPUTER MODELING, DEEP BASING PROJECT
  WESTERN UNITED STATES
  U.S. AIR FORCE

  Provided support to 3-D computer modeling project using MINPAK data base to characterize possible sites. Responsible for digitizing, plotting, and correlating geologic cross sections for input into MINPAK to delineate subsurface structure and lithology of 25 sites.

- HIGH LEVEL WASTE REPOSITORY SITING
  SOUTHEASTERN UNITED STATES
  OFFICE OF NUCLEAR WASTE ISOLATION

  Collected and organized data from various geotechnical activities. Responsible for the transfer of computer data to magnetic tape in effort to keep record of all activity conducted in the field and office.

- HIGH LEVEL WASTE REPOSITORY SITING
  SOUTHEASTERN UNITED STATES
  OFFICE OF CRYSTALLINE REPOSITORY DEVELOPMENT

  Collected and organized data from various geotechnical activities. Responsible for transfer of computer data to magnetic tape, and management of the project data base.

Registrations

None

Foreign Languages

None

International Experience

None

Professional Organizations

None

Previous Employers

None

Citizenship

U.S.

Publications

None

Professional References

To be submitted.

MELVIN L. TYREE

	Years of Experience
Senior Staff Geologist The Earth Technology Corporation	Professional: 6 Environmental/Hazardous Waste: 2.5

QUALIFICATIONS SUMMARY

Mr. Tyree has experience in several areas of environmental science and hazardous waste management including environmental impact analysis, biological assessment, wetland delineation, monitoring well installation and development, soil sampling and classification, groundwater and surface water sampling, and land transfer assessments. In addition, he has assisted in the development of the Quality Assurance Plans and Sampling and Analysis Plans of 2 NPL EPA sites (Aladdin Plating and Brown's Battery sites).

EDUCATION

B. A. Biology and Education, Marshall University, 1984
B. A. Geology and Anthropology, Marshall University, 1980

SELECTED TECHNICAL EXPERIENCE

- Principal Investigator, Earth Technology for Environmental Impact Statement (EIS) of the BOMARC Missile Site, Wrightstown, NJ.
  - Developed sampling methodology, supervised data collection and currently writing the geological and biological sections.
- Earth Technology, project staff for Air Nation Guard Base, Burlington, VT Remedial Investigation and Feasability Study (RI/FS)
  - Participated in monitoring well slug testing and groundwater sampling
- Earth Technology, project staff for Aladdin Plating Superfund Site, Scranton, PA (RI/FS)
  - Assisted in the compilation of the remedial Sampling and Analysis Plan (SAP) and the Quality Assurance Project Plan (QAPjP). Participated in on-site soil and groundwater sampling
- Earth Technology project staff for Browns Battery Superfund site, Reading PA (RI/FS)
  - Assisted in the development of the remedial (SAP) and participated in on-site monitoring well sampling.
- Earth Technology, project staff for Tulsa Oklahoma Air Force Plant 3 (RI/FS)
  - Participated in soil gas survey of abondoned fuel line, classified soil boring samples assisted in monitoring well development.

OTHER ENVIRONMENTAL AND HAZARDOUS WASTE MANAGEMENT/ TECHNICAL EXPERIENCE

- Environmental Scientist, STS Consultants, Chantilly, Virginia
  - Researched and wrote more than 15 land transfer assessments and performed additional Phase II sampling and testing for commercial clients.
  - Performed wetland delineations and investigations (as per the Clean Water Act section 404) for residential and commercial develoment clients.
  - Performed geotechnical testing and investigations includign testing of: slope stability, soil infiltration, soil dry density and moisture content.
- Biology Teacher, King George County Schools, King George, Virginia
  - Developed and evaluated tests, exams and lab exercises. Lectured and planned lessons and units. Calcualted semester and final grades.
- Field Archaeologist, University of Kentucky, Achaeology Institute, Lexington, Kentucky
  - Member of numerous archaeological field survey and excavation teams in the investigation of precolumbian sites in Kentucky and Tennessee.

CERTIFICATIONS

- OSHA/EPA 40 hour level B Health and Safety Certification
- OSHA 8 hour Hazardous Waste Supervisor's Certification
- Provisional Certificate for Secondary Level Teaching in Biology and General Science
- Washington Area Council of Engineering Laboratories Soils Level II Certification
- First Aid and CPR, Certified, American Red Cross

C. Phillip Watts
Senior Geologist
The Earth Technology Corporation

Education

B.S., Geology, James Madison University, 1982

Registration

Certified Professional Geologist, Virginia, Arizona

Phil Watts has 8 years of experience as a hydrogeologist in environmental consulting. His responsibilities include: work plan development, subcontracting, field supervision of subcontractors and multidisciplinary technical teams, development and onsite management of the health and safety plans, data reduction, and report preparation. He has expertise in hazardous waste site investigation, groundwater contamination studies, groundwater monitoring programs, environmental auditing and environmental risk assessments.

His relevant project experience includes:

- Currently Project Manager of the Phase II IRP studies at the BOMARC Missile Site, McGuire AFB, New Jersey. This $2.8 million project includes an RI/FS and an EIS. Contaminants of concern are radionuclides. Contaminant migration through air, soil, groundwater, surface water, and sediment is under evaluation.

- Currently Project Manager of an RI/FS at an inactive battery reclamation facility in Pennsylvania. The project is being conducted under the U.S. EPA Region III ARCs contract.

- Managed and participated in seven RI/FS studies under contract to the U.S. Army Corps of Engineers and the U.S. EPA. Duties included supervision of design and installation of groundwater monitoring systems, design of integrated hydrogeological investigations including geological and logging of boreholes, test pitting, surface geophysical surveys, aquifer testing, soil gas analysis, groundwater sampling and analysis, and data reduction/interpretation. Supervised subcontractors and sampling teams in the field.

- Provided key support to EPA OERR in developing the Field Analytical Screening Project (FASP), including participation in design of mobile analytical laboratories and drafting of Data Quality Objectives for field chemical analysis.

- Conducted environmental audits and prepared risk assessments for commercial hazardous waste treatment, storage, and disposal facilities.

- Performed site evaluations, provided strategic advice, and designed and managed the installation of a groundwater monitoring system for a multiple property acquisition by a major agribusiness.

- Prepared draft "Data Quality Objectives for Preremedial Site Investigations" for EPA's Hazardous Site Evaluation Division.

- Directed excavation/removal and field analysis of soil samples for a major PCB remediation project in Alaska.

- Designed and installed a groundwater monitoring system for a gasoline pipeline terminal storage facility belonging to a major oil company.

D. Jay Wilburn

THE EARTH TECHNOLOGY CORPORATION

Fields of Competence

Hydrogeologic and geotechnical investigations of hazardous waste sites; Remedial Investigations and Feasibility Studies of Hazardous waste sites; Environmental site assessments of potential hazardous waste sites.

Experience Summary

Prepared for a remedial investigation of an Air Force manufacturing plant in Tucson, AZ. Activities included the development of a workplan, a quality assurance project plan, and a health and safety plan.

Participated in two RCRA Facility Assessments of pipe foundries in Alabama. Activities included researching and writing the facility description sections of the report.

Collected contaminated soil and surface water samples at an Air Force Plant in NY in addition to giving geologic support throughout the project.

Collected contaminated soil, sediment, surface water, and groundwater samples at an Air National Guard Base in VT as part of an Installation Restoration Program (RI/FS). Responsibilities included soil logging and overseeing the installation of boreholes, and shallow and deep groundwater wells.

Completed geophysical surveys at an Air Force Facility as part of an Installation Restoration Program (RI/FS).

Credentials

B.A., Geology - Albion College (1987)
M. En., Environmental Geology - Miami University (1989)

Employment History

January, 1989-Present

Key Projects

Staff geologist on a remedial investigation/feasibility study on a plutonium contaminated Air Force Facility in New Jersey.

Staff geologist on an environmental site assessment of two private facilities in Alabama.

Staff geologist on a remedial investigation/feasibility study at an United States Air Force facility in Vermont.

NEIL E. BOTTS

University of California at Santa Barbara: B.A., Geology (1982)

PROFESSIONAL SUMMARY

Mr. Botts is an experienced project manager, with expertise in quality management, hydrogeology, and geology, particularly in environmental applications. He has been responsible for project management of several U.S. Air Force Installation Restoration Projects (IRP) as well as for quality assurance and quality control management and compliance for U.S. EPA Superfund Projects. These projects have included remedial investigations, feasibility studies, and environmental impact statements. Mr. Botts has extensive training in uncontrolled hazardous-waste-site entry and auditing activities.

PROFESSIONAL EXPERIENCE

Science Applications International Corporation, Golden, Colorado
(1989 - present)

Mr. Botts is the Principal Investigator for installation restoration activities (IRP) at Air Force installations in the states of New Jersey and Washington, where the pollutants of concern include plutonium, PCBs, POLs, and chlorinated solvents.

As Principal Investigator, Mr. Botts has been responsible for management of these two projects, planning, budgeting, technical direction, field operations, data analysis, and preparation of project reports, including both an Environmental Impact Statement (EIS) and Remedial Investigation/Feasibility Study on the New Jersey mixed waste site. Mr. Botts' current assignment is integrating on the Fairchild AFB IRP effort into compliance with CERCLA guidance at a Superfund Site in the State of Washington.

Battelle Memorial Institute, Golden, Colorado
(1987 - 1989)

Mr. Botts was the Project Manager for four IRP tasks issued by the U.S. Air Force Occupational and Environmental Health Laboratory. These installations were in the states of Washington and New Jersey. Major objectives comprised planning and conducting remedial investigations and feasibility studies at these installations and preparing an environmental impact statement for a plutonium-contaminated facility. Additionally, Mr. Botts prepared Quality Assurance plans for five Air Force installations under the IRP contract. This required extensive contact with laboratory and technical personnel to ensure compliance with site specific ARARs.

Camp, Dresser, & McKee, Inc., San Francisco, California
(1986 - 1987)

As Quality Assurance Coordinator, Mr. Botts wrote, reviewed, and approved Quality Assurance Project Plans for the Region 9 USEPA REM II Project (California, Arizona, and Nevada). He was also responsible for monitoring project activities to verify compliance with project operation plans and performing routine system and procedure audits for each work assignment.

Accord Consultants, Lakewood, Colorado
(1982 - 1986)

Mr. Botts was involved in several environmental and energy development-related projects. His responsibilities as staff scientist included permit compliance and supervision of well drilling, construction, and sampling.

ADDITIONAL EDUCATION

OSHA Hazardous Waste Site Health and Safety Refresher Course, 1989 (8 hours)
OSHA Hazardous Waste Site Health and Safety Course, 1986 (40 hours)

PROFESSIONAL AFFILIATIONS AND CERTIFICATIONS

Registered Professional Geologist, Delaware #467
Registered Professional Geologist, California (pending)
Association of Groundwater Scientists and Engineers
National Water Well Association

MARK E. BYRNES

Portland State University, Oregon: M.S. Geology (1985)
University of Colorado, Boulder: B.A., Geology (1981)

PROFESSIONAL SUMMARY

Mr. Byrnes has experience in assessing soil, sediment, surface-water, groundwater, air, and building foundation contamination problems throughout many parts of the United States and Guam. He is knowledgeable in vapor-, production-, and monitoring-well installation using auger and rotary-type drilling techniques. He has experience in overseeing the installation of landfill gas-migration probes and in performing landfill gas-stream characterization and ambient air monitoring tests. Mr. Byrnes has experience working in both chemical (including mustard gas and its breakdown products) and radioactive environments.

PROFESSIONAL EXPERIENCE

Science Applications International Corporation, Golden, Colorado
(1989 - present)

Mr. Byrnes is the Principal Investigator of a soil, sediment, surface water, and groundwater quality assessment study performed at Vandenberg AFB, California. This study was performed around abandoned missile silos, landfills, service stations, an entomology wash rack, fuel tank farm and fuel decontamination facility. In this investigation, he was responsible for overseeing: the installation, development, purging, and sampling of 71 groundwater monitoring wells; the drilling of four 200-foot coreholes and five 300-foot rotary boreholes; the magnetic and electromagnetic geophysical surveying of a number of Base landfills; the running of pump tests in two deep aquifer monitoring wells; the soil-gas surveying of 35 sites with the OVA and two sites using the Petrex method; and the collection of 478 deep soil, 227 shallow soil/sediment, and 18 surface water samples. Mr. Byrnes is the principal author of the Vandenberg AFB, Stage 1, Main Report.

Mr. Byrnes is responsible for overseeing the preparation and execution of an air monitoring test plan for the Sanitary Landfill at Vandenberg AFB, California. The purpose of this study is to test the quality of the air moving across and through the landfill. This was achieved by running a gas stream characterization, gas migration, and ambient air monitoring study. The gas stream air immediately above the landfill was tested using an integrated surface sampling device. The gas migration study tested the quality of the air moving through the landfill and required the installation of four gas-migration probes. Finally, the ambient air quality was tested seven feet above ground surface both upwind and downwind of the landfill. Mr. Byrnes is also responsible for overseeing the preparation of the Final Report for this study.

Mr. Byrnes is presently the Field Manager for an environmental investigation at Hill AFB, Utah. This investigation requires the sampling of soil-gas, and lake sediment as well as the installation of nine groundwater monitoring wells around two sites on the National Priority List.

Mr. Byrnes is presently the Field Manager for an environmental investigation at the Utah Test and Training Range. This investigation requires the collection of surface soil samples from an unexploded ordnance burn pit, and the soil-gas surveying and deep soil sampling around an abandoned chemical pit.

Battelle Memorial Institute, Denver, Colorado
(1986 - 1989)

Mr. Byrnes was a Field Manager for a recent environmental investigation performed at the BOMARC missile site at McGuire AFB, New Jersey and was responsible for overseeing the collection of ambient air, concrete, shallow soil, sediment, and dust samples in a low-level radioactive environment. The objective of this investigation was to determine the extent of radioactive plutonium and americium contamination in and around a missile shelter which caught fire in 1960. Mr. Byrnes is the co-author of the BOMARC environmental report.

Mr. Byrnes was a member of the field team that investigated the soil, sediment, and surface water quality around a number of facilities at Malmstrom AFB, Montana. An auger drill rig was used in this investigation along with a split-spoon sampler and California Barrel sampler for the collection of deep soil samples. Soil samples were screened with an Organic Vapor Analyzer (OVA) immediately after removal from the borehole. Samples revealing high concentrations of organic vapors were selected and prepared for chemical analysis. Shallow soil cores and sediment and surface water samples also were collected from drainages leaving suspect sites.

Mr. Byrnes was a Field Manager of the soil and groundwater quality assessment study performed at Anderson AFB, Guam. In this investigation, he was responsible for overseeing the installation of three 500-foot groundwater monitoring wells, as well as the collection of a number of shallow soil-core samples. In addition, Mr. Byrnes oversaw the collection of deep soil samples from 20 landfill test pits. Other responsibilities on this job included planning work schedules, setting up sample logbooks and instrument calibration logbooks, and ordering equipment.

Mr. Byrnes was a member of the Battelle field team that collected concrete foundation core samples, below-foundation soil core samples, paint scraping samples, and storage tank wipe samples from a building at the Rocky Mountain Arsenal known to be contaminated by mustard gas and its breakdown products. This work was all performed in Army Level A protective clothing. Mr. Byrnes was a co-author of the Main Report for this study.

Riedel Environmental Services, El Segundo, California
(1986 - 1986)

As an Environmental Geologist, Mr. Byrnes was responsible for installing vapor, production, and groundwater monitoring wells; water and hydrocarbon sampling; adjusting single and duel pump product recovery systems; running step drawdown well tests; and drafting and minor report writing.

AWARDS AND HONORS

Thesis Funded by Union 76, Shell Western, and Marathon Oil Companies

PUBLICATIONS

Yoong, Matt; Byrnes, Mark E.; Nelson, R. Wayne; McNeill, William. 1990. Vandenberg Air Force Base, California, Installation Restoration Program, Solid Waste Air Quality Assessment Test Report, Contract No. F33615-85-D-4507, Task Order 16 (awaiting Air Force approval for release).

Collins, Donna; Byrnes, Mark E.; DiGregorio, Greg; Olsen, Catherine. (First Draft soon to be released). McGuire Air Force Base, New Jersey, Installation Restoration Program, Stage 2 (RI/FS), Contract No, F33615-85-D-4507, Task Order 21.

Byrnes, Mark E.; Moore, James H.; Nelson, R. Wayne; Dwyer, John R.; McNeill, William; Charles, Robert J.; Jones, Sandra L.; Huggins, Eve M.; Shafer, Matthew M.G.; and Randall, Rotha A. 1990. Vandenberg Air Force Base, California, Installation Restoration Program, Stage 1 (Remedial Investigation), Contract No. F33615-85-D-4507, Task Order 16, (awaiting Air Force approval for release).

Marks, Janet E.; Deignan, Timothy M.; Byrnes, Mark E.; Nelson, R. Wayne. 1988. Vandenberg Air Force Base, California, Installation Restoration Program, Geophysical Survey of Underground Fuel Storage Tanks, Contract NO. F33615-85-D-4507, Task Order 19, December.

Byrnes, Mark E.; Nelson, R. Wayne; La Poe, Robert G.; Lundquist, Dennis E.; McNeill, William, (Pending Air Force Approval). Complementary Investigative Techniques For Accurate Site Assessment with Low-Level Contaminants. Groundwater Monitoring Review.

Byrnes, Mark E., 1985. Provenance Study of Eocene Sedimentary Rocks in Southwest and Central Washington. GSA Cordilleran Section Meeting, May 8-11, Vancouver, B.C.

Byrnes, Mark E., 1985. Petrographic and Geochemical Analysis of Late Eocene Arkosic Sandstone Deposits in Southwest and Central Washington with Emphasis on Determining Provenance. Proceeding of the Oregon Academy of Science, V.21, Ashland, OR.

Byrnes, Mark E., 1984. Petrographic and Geochemical Analysis of Late Eocene Arkosic Sandstone Deposits in Southwest and Central Washington. Northwest Mining Association Convention, Dec. 6-8, Spokane, WA.

DONNA BISHOP COLLINS

Colorado State University: B.S., Geology (1974)

PROFESSIONAL SUMMARY

Ms. Collins has multidisciplinary experience in geology, specializing in hazardous-waste investigations and mineral-resource assessments. Her background includes project procurement and leadership on government contracts; environmental assessment of hazardous waste sites, including plutonium and depleted uranium-contaminated sites; field and research studies on mineral deposits, with emphasis on uranium deposits; studies on ground-water quality; studies on geochemistry of ground water and surface water; and facility siting studies. Clients have included private sector firms and State and Federal agencies. Ms. Collins has written and edited numerous reports for the U.S. Air Force, U.S. Army, U.S. Department of Energy, U.S. Geological Survey, U.S. Bureau of Land Management, U.S. Forest Service, Colorado Department of Natural Resources, and Colorado Geological Survey.

PROFESSIONAL EXPERIENCE

Science Applications International Corporation, Golden, Colorado
(1989 - present)

Ms. Collins is managing a combined RI/FS and Environmental Impact Statement (EIS) program at the BOMARC Missile Site at McGuire AFB, NJ, where site assessments with extensive sampling and monitoring are being conducted to determine environmental releases of plutonium and americium from this site. Ms. Collins participated in a study for the U.S. Army to investigate the environmental and health effects associated with the use of kinetic energy penetrators composed of depleted uranium and/or tungsten by the Army. She serves as a field team member for site assessments, monitor well installation, and environmental sampling programs, as needed.

Ms. Collins serves as the Health and Safety Manager for the Environmental Remediation Division, providing emphasis on recognizing, evaluating, and preventing or controlling occupational health hazards. She prepares and reviews project Health and Safety Plans in accordance with OSHA requirements and guidance. She institutes use of, and ensures field compliance with, the health and safety plans. She coordinates health and safety issues, training, reports, and medical monitoring programs. Ms. Collins is an American Red Cross instructor, and provides training in First Aid, Cardiopulmonary Resuscitation, and Basic Life Support for the Professional Rescuer.

Ms. Collins is a staff leader, supervising technical staff within the Division. She monitors work performance of those staff members to provide guidance and assure work quality. She conducts performance reviews; plans, recommends, and ensures timeliness of staff training and medical surveillance; coordinates with other supervisors and project managers to ensure project work commitments; and functions as liaison to upper-level management.

Battelle Memorial Institute, Denver, Colorado
(1987 - 1989)

Ms. Collins conducted environmental and hydrogeological assessments of hazardous waste sites under the Installation Restoration Program for USAF installations in Guam, New Jersey, California, Washington, and Montana, incorporating CERCLA, SARA, and NEPA guidance. She participated in site assessments, monitor well installation, and environment sampling programs. She is experienced in report and document preparation and editing, including RI/FS Final Reports, Work Plans, Quality Assurance Project Plans, Health and Safety Plans, and Technical Documents to Support No Further Action (Records of Decision).

Consulting Geologist, Arvada, Colorado

As a consulting geologist, Ms. Collins provided contract services in diverse capacities. She conducted environmental and hydrogeological assessments for Battelle Memorial Institute (see separate listing); conducted educational programs for clients such as Jefferson County (Colorado) Schools and the Denver Museum of Natural History; performed research and preparation of technical manuscripts for Renaissance House Publishers; and performed meeting and field trip planning and field guide preparation for the American Institute of Professional Geologists.

Colorado Geological Survey, Denver, Colorado
(1977 - 1985)

As a Project Geologist, Ms. Collins managed projects dealing primarily with the mineral resources of Colorado. She evaluated the uranium potential of extensive parts of Colorado for the U.S. Department of Energy. In addition, she participated in geological engineering site selection and groundwater studies. She managed, coordinated, and implemented office and field activities, wrote proposals, hired and supervised personnel, managed field crews and support staff, conducted field studies, handled budgeting and accounting, maintained equipment, compiled progress reports, and prepared final reports. She provided technical evaluation and reviews of proposed Federal Wilderness withdrawals, and performed peer review on other State and Federal publications. She handled inquiries from the public and various local, State, and Federal agencies. Ms.

Collins represented the Agency as mineral resource director at investigations and conferences.

U.S. Geological Survey, Lakewood, Colorado
(1975 - 1977)

Ms. Collins researched geochemical prospecting for uranium using surface water, stream sediments, and organic sediments. She conducted extensive water and sediment sampling programs in the field, and prepared samples for analysis. She performed radiometric analyses using gamma spectrometry. She also identified anomalous analyses, performed statistical calculations, and prepared technical reports.

ADDITIONAL EDUCATION

American Red Cross Certification, 1990:
- Advanced First Aid, Instructor Level
- Standard First Aid, Instructor Level
- Cardiovascular Pulmonary Resuscitation (CPR), Instructor Level
- CPR-Basic Life Support for the Professional Rescuer, Instructor Level

OSHA Hazardous Waste Site Supervisor Course, 1988 (8 hours)
OSHA Hazardous Waste Site Health and Safety Course, 1988 (40 hours)
University of Colorado, Denver: Graduate Studies, Business, 1983-1985
Colorado School of Mines: Graduate Studies, Geology, 1975-1980

AWARDS AND HONORS

AIPG Distinguished Service Award, 1988
Listed in Who's Who in the West, 20th Edition ,1985-86
Listed in Who's Who of American Women, 13th Edition, 1983-84

PROFESSIONAL AFFILIATIONS AND CERTIFICATIONS

Certified Professional Geologist (CPG 4813), 1980, American Institute of Professional Geologists
Registered Geologist, Delaware 1990, Delaware State Board of Registration of Geologists, (pending)
Member, American Institute of Professional Geologists
Member, Geological Society of America
Member, Rocky Mountain Association of Geologists.

PUBLICATIONS

Ms. Collins is the author or co-author of over twenty technical publications.

Collins, D. B. and Botts, N. E., 1990. Installation Restoration Program, Stage 2, Health and Safety Plan for Fairchild Air Force Base, Washington. U.S. Air Force Human Systems Division (USAF HSD), 86 p., appendices.

Botts, N. E., Collins, D. B. and others, 1990. Installation Restoration Program, Stage 2, Work Plan for Fairchild Air Force Base, Washington. USAFHSD, 199 p.

McNeill, N. W., Collins, D. B. and others, 1989. Kinetic energy penetrators - environmental considerations. U.S. Army Production Base Modernization Activity, 102, p., appendices.

Botts, N.E., Collins D. B., and others. 1989. Installation Restoration Program, Stage 2, Work Plan for the BOMARC Missile Site, McGuire Air Force Base, New Jersey: U.S. Air Force Occupational and Environmental Health Laboratory, Technical Services Division (USAFOEHL/TS), 120 p., appendices.

Collins, D.B., N.E. Botts, and others. 1989. Installation Restoration Program, Stage 2, Health and Safety Plan for the BOMARC Missile Site, McGuire AFB, New Jersey: USAFOEHL/TS, 116 p., appendices.

Collins, D. B. and Botts, N. E., 1988. Installation Restoration Program, Technical Documents to Support No Further Action, Fairchild Air Force Base, Washington. USAFOEHL/TS.

Collins, D. B., 1988. Colorado Day Trips. Colorado Traveler Series, Renaissance House, Frederick, Colorado, 48 p.

Botts, N. E., Collins, D. B., Dwyer, J. R. McNeill, W. Woods, C. A., 1988. Installation Restoration Program, Stage 2, Work Plan, Work Plan for Andersen Air Force Base, Guam. USAFOEHL/TS, 196 p.

Botts, N. E. Collins, D. B., McNeill, W., 1988. Installation Restoration Program, Quality Assurance Project Plan, Andersen Air Force Base, Guam. USAFOEHL/TS, 153 p.

Botts, N.E., D.B. Collins, and W. McNeill. 1988. Quality Assurance Project Plan, Vandenberg AFB, California: USAFOEHL/TS, 170 p.

McNeill, W., M. Bergstrom, D.B. Collins, and others. 1988. Installation Restoration Program, Phase II, Stage 1 Final Report for Andersen Air Force Base, Guam: USAFOEHL/TS, 272 p., appendices.

Collins, D. B., 1987. Natural Sites, A Guide to Colorado's Natural Wonders. Colorado Traveler Series, Renaissance House, Frederick, Colorado, 48p.

Collins, D. B. Collins, D. S. 1986. Scenic Trips into Colorado Geology: Lake Country--Keystone, Dillon, Silverthorne, Frisco, Copper Mountain, Leadville, Red Cliff, Minturn, Vail. 41 p., map, road log (published for the American Institute of Professional Geologists, 1986 Annual National Meeting, post-meeting Field Trip).

Collins, D. B. and Hornbaker, A. L., 1985. Mineralized areas of Colorado. Colorado Geological Survey Report, tables, map.

Collins, D. B., 1985. Scenic Trips into Colorado Geology: Uncompahgre Plateau--Montrose, Ridgway, Norwood, Naturita, Uravan, Gateway, Delta. Colorado Geological Survey Special Publication 27, map, road log.

Rogers, W.P., R.M. Kirkham, D.B. Collins, and K. Crouch. 1985. Suitability of the Pierre Shale in Eastern Colorado as a Tunneled Bedrock Site for the SSC Research Facility: Colorado Geological Survey (CGS) Open-File Report 85-2, 24 p., plates.

Collins, D. B. and Collins, D. S., 1984. A Colorado-Wyoming border diatreme and a potential kimberlite indicator plant. Mountain Geologist, v. 21, no. P. 68-71.

Collins, D.B., D.C. Graham, and A.L. Hornbaker. 1982. National Uranium Resource Evaluation, Leadville Quadrangle, Colorado: U.S. Department of Energy Open-File Report PGJ/F-027(82), 81 p.

Repplier, F.N., F.C. Healy, D.B. Collins, and P.A. Longmire. 1981. Atlas of Ground Water Quality in Colorado: CGS Map Series 16.

Schwochow, S. D., Boreck, D. L., and Collins, D. B., 1979. The Colorado Geological Survey and the mineral industry--energy resourcce development. Mines Magazine, v. 69, no. 5, p. 5-9.

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WILLIAM E. DAVIS, Research Scientist
Atmospheric Dynamics and Transport Section
Atmospheric Sciences Department

Education

B.A.	Mathematics, College of Great Falls, Montana	1963
M.S.	Atmospheric Physics, Colorado State University	1965
M.S.	Chemical Engineering, University of Washington	1986
	Graduate Study, Atmospheric Sciences, University of Washington	1966-70

Experience

Mr. Davis has been a member of the Battelle Staff since 1965. During this period he has worked as an individual technical contributor, a member of an interdisciplinary research team, a project director for field experiments, and a project manager. Mr. Davis' areas of expertise include research planning and organization, applied studies of three-dimensional air motions in the vicinity of synoptic scale storms, acid rain, and numerical studies of mesoscale and long-range transport. He has also performed studies in wind energy and solar energy. He has made significant contributions to the following projects:

- Long-Range Transport. Since 1982, Mr. Davis has led in developing techniques for examining long-range transport. He is developing techniques for evaluating source/receptor relationships. He led the team for computing the intercontinental transport of the debris from the Chernobyl accident.

- Mesoscale Transport. Since 1986, Mr. Davis has led work in producing mesoscale transport, diffusion, and deposition. Techniques developed are being applied to emergency response for nuclear accidents.

- Acid Rain. Present modeling work includes examining the effects of vertical motion on $SO_4^=$ wet deposition. During 1985, Mr. Davis was field director for an acid rain field study that included aircraft and surface measurements for the PRECP program. His work on evaluation of PRECP results during 1987 has been directed toward the calculation of scavenging ratios. In earlier projects, Mr. Davis tested errors in use of single-layer winds in long-range transport models. In 1980 and 1981, he applied a multilayer model to the problem of acid rain in the vicinity of frontal storms. The model was developed in a modular form to test parameterization of in-cloud conversion and below-cloud scavenging. The transport portion of the model was developed during his earlier work investigating transport errors that occur in using single-layer models to describe flow in frontal storm situations.

<u>WILLIAM E. DAVIS</u> (continued)

- <u>Solar Energy</u>. Mr. Davis developed a data base for the graphical display of solar energy in the United States.

- <u>Wind Energy</u>. In 1983 Mr. Davis took part in a study of eigenvector extrapolation of short-term wind measurement to the long term. This was for use in wind energy prospecting.

- <u>Ballistics</u>. Mr. Davis worked on and developed a technique for improving meteorological information usage to minimize ballistic errors in the upper stratosphere.

- <u>Oil Shale</u>. In 1981 Mr. Davis was involved in determining new techniques for describing regional transport in complex terrain.

- <u>Regional Studies</u>. During 1980, Mr. Davis led a team developing new techniques for regional assessment work. These new techniques have been demonstrated to reduce the cost of assessments by a factor of six. The same project developed a data bank of assessments that can be used in future assessment studies.

- <u>Light Water Reactor Studies</u>. Mr. Davis provided technical assistance to the study of macroscale transport and deposition with respect to a proposed fuel rod recycling plant. From 1977 to 1979, Mr. Davis had the responsibility of providing air concentrations and surface deposition patterns for four proposed sites. He also prepared a document for users of a computer program used for macroscale transport and diffusion of radioactive pollutants.

- <u>Precipitation Scavenging</u>. From 1969 to 1975, Mr. Davis assisted in developing a model to describe in-cloud scavenging. This model was applied to the results of Battelle field studies designed to evaluate in-cloud scavenging. Mr. Davis was field director for one of the 1973 studies.

- <u>Fallout Studies</u>. During the period 1965 to 1970, Mr. Davis studied mesoscale and macroscale three-dimensional flows affecting the transport and deposition of radioactive fallout. During this period, he developed a computer program to calculate stream functions from surface data in order to estimate low-level flow and studied diabatic effects that could alter surface mixing patterns. He provided the post-trajectory analysis of the path of the debris from the nuclear test shot Cabriolet in 1968.

- <u>Stratospheric Transport</u>. During the period of 1963 to 1965, Mr. Davis studied adiabatic transport processes in the stratosphere, in particular, the intercontinental transport of radioactive material from Russian nuclear tests.

WILLIAM E. DAVIS (continued)

Professional Affiliation

American Meteorological Society
Link Foundation Fellow

WILLIAM E. DAVIS

Publications

Goldman, M, R. J. Catlin, L. Anspaugh, R. G. Cuddihy, W. E. Davis, et al. 1987. Health and Environmental Consequences of the Chernobyl Nuclear Power Plant Accident. DOE/ER-0332, National Technical Information Service, Springfield, Virginia.

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Davis, W. E., A. R. Olsen, B. T. Didier, P. E. Tucker and D. W. Damschen. 1986. Surface Footprint from Initial Chernobyl Release as Indicated by the Meso-Alpha MLAM Model. PNL-X-767, Pacific Northwest Laboratory, Richland, Washington.

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Davis, W. E. 1983. "A Comparison of the Regional Scale Effects on In-Cloud Conversion of SO^2 to $SO_4^=$ in an Eight Layer Diabatic Model With a Single Layer Model." In Air Pollution Modeling and Its Application, II, ed. G. DeWispelaere, pp. 159-174. Plenum Press, New York.

Davis, W. E. 1983. "An Intercomparison of the Washout of $SO_4^=$ From a Single-Layer Regional Transport Model With a Multilayer Vertical-Motion Regional Transport Model." In Proceedings of Precipitation Scavenging, Dry Deposition, and Resuspension, pp. 663-673. Elsevier Pub., New York, New York.

Bander, T. J., and W. E. Davis. 1982. The Use of the Fallout Meteorological Message for High Altitude Ballistic Trajectories. ASL-CR-82-0100-2, U.S. Army Electronics Research and Development Command Atmospheric Sciences Laboratory, White Sands, New Mexico.

Barchet, W. R., and W. E. Davis. 1982. Assessment of Electric Power Conservation and Supply Resources in the Pacific Northwest. Vol. 10 WIND. Report to the Pacific Northwest Electric Power and Conservation Planning Council, by Battelle, Pacific Northwest Laboratories, Richland, Washington.

Berkowitz, C. M., and W. E. Davis. 1982. Uncertainties Associated With Layering Winds for Use in Trajectory Calculations. Technical Memorandum, Pacific Northwest Laboratory, Richland, Washington.

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Drake, R. L., C. H. Huang and W. E. Davis. 1982. The Green River Ambient Model Assessment Program, August 1981 Progress Report for the Regional and Mesoscale Flow Modeling Components. PNL-3988, Pacific Northwest Laboratory, Richland, Washington.

Droppo, J. G., J. Allwine and W. E. Davis. 1982. "A Computer Model for Estimating Long-Term Wet and Dry Deposition of Particulates from Power Plant Stacks." In Proceedings of the APCA PNWIS 1982 Annual General Meeting, pp. 183-187. American Pollution Control Association.

Knudsen, D., M. Davis, J. Shannon, D. Sisterson, S. Viessman, M. W. Wesely, R. Whitfield, L. Kleinman, C. Berkowitz and W. Davis. 1982. Preliminary Evaluation of Acidic Deposition Assessment Uncertainties. Prepared for U.S. Department of Energy by Argonne National Laboratory, Brookhaven National Laboratory, and Pacific Northwest Laboratory.

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Davis, W. E. 1972. "A Model for In-Cloud Scavenging of Cosmogonic Radionuclides." J. Geophys. Res. 77(12).

GREGORY D. DiGREGORIO

University of Colorado: B.A., Geology (1984)

PROFESSIONAL SUMMARY

Mr. DiGregorio has experience in conducting geological and environmental monitoring programs at hazardous waste sites. He is proficient in many aspects of field work including well-site analysis, monitoring of drilling operations, lithologic description and evaluation of drilled formations, preparation of well and pressure logs, ground-water and surface-water sampling, and soil-gas surveys. He has experience in computer applications, including well log and map digitizing techniques.

PROFESSIONAL EXPERIENCE

Science Applications International Corporation, Golden, Colorado
(1989 - present)

Mr. DiGregorio is currently participating in the Stage B, Phase 2 studies, as part of the Air Force Installation Restoration Program at Arnold AFB. He was the Field Team Leader for all of the geological and environmental monitoring conducted at the site. The field efforts included groundwater and surface-water sampling, sediment and soil sampling, soil-gas surveys and aquifer pump and slug tests. He was also the Field Team Leader for Stage A, Phase 2 studies at Arnold, AFB. The field efforts included soil-gas surveys and the installation of ground-water monitoring wells.

Mr. DiGregorio participated as the Field Team Leader in the Air Force Installation Restoration Program at the Bomarc Missile Site, McGuire AFB. The field efforts used in characterizing the site for Pu239 included concrete/asphalt coring, wipe sampling, surface water sampling, sediment and soil sampling and FIDLER surveys. Mr. DiGregorio used several alpha and gamma-ray detectors to characterize the site and assure the health and safety of the field team.

Battelle Memorial Institute, Denver, Colorado
(1988 - 1989)

Mr. DiGregorio has participated in the Installation Restoration Program at Arnold AFB, Tennessee. He researched the geologic characteristics of the site, emphasizing groundwater flow. He also developed SOPs and protocols for the onsite drilling effort and prepared the Quality Assurance Program Plan for site investigation efforts.

EI Corporation, Boulder, Colorado
(1986 - 1987)

Mr. DiGregorio interpreted and digitized oil and gas logs using Smartscan I. He trained personnel on both Smartscan I (well log digitizing system) and Smartscan II (map digitizing system), while assisting in quality assurance and production performance.

EG&G Continental Laboratories, Houston, Texas
(1985 - 1986)

As a Well Site Analyst, Mr. DiGregorio monitored drilling operations to detect and analyze hydrocarbons. He also provided lithologic description and evaluation of drilled formations, prepared well and pressure logs, and supervised logging units on the drilling platform.

IBM Corporation, Boulder, Colorado
(1984)

Mr. DiGregorio initiated and converted connections for remote computer systems with the use of telephone lines and fiber optics. He programmed microcode for various computer applications.

ADDITIONAL EDUCATION

CPR Training, 1989
OSHA Hazardous Waste Site Health and Safety Refresher Course, 1989 (8 hours)
OSHA Hazardous Waste Site Health and Safety Course, 1988 (40 hours)

PROFESSIONAL AFFILIATIONS AND CERTIFICATIONS

Registered Geologist in the State of Tennessee

REGINALD L. GOTCHY, Ph.D.

EDUCATION

Ph.D.: Radiation Biology, Colorado State University (1968)
M.S.: Radiation Health, Colorado State University (1966)
B.S.: Zoology, minor in Chemistry, University of Washington (1958)
AEC Radiological Physics Fellow, University of Washington (1958-59)

WORK SUMMARY

Dr. Gotchy is a Senior Scientist of the Technology Assessment Division within SAIC's Energy Systems Group. His responsibilities include technical, regulatory and policy guidance to the Department of Energy and it's contractors in safety, environmental matters and emergency planning. Dr. Gotchy also provides technical support to the Nuclear Regulatory Commission in health physics matters, SAIC efforts involving the Radiation Exposure Information Reporting System (REIRS), and a study of the feasibility of reducing current uncertainties in human risk estimates from low dose, low dose-rate through the use of state-of-the-art cellular and molecular radiobiology techniques. Other areas of support include evaluation of ALARA programs, radiological and non-radiological impact assessments for normal operations and accidents in LWRs and fuel cycle facilities, emergency response planning, and health physics training and development programs. His expertise in radiological and non-radiological health risk assessment is nationally recognized, and he is certified by the American Board of Health Physics (1969-1993). His experience as an NRC Administrative Judge (Technical) brings not only working knowledge of the NRC adjudicatory process, but a broad technical knowledge of numerous NRC regulatory activities.

PROFESSIONAL EXPERIENCE

SAIC, 1986 - Present

Dr. Gotchy is the Principal Investigator for the NRC Radiation Exposure Information Reporting System (REIRS) program which is responsible for collation and reporting of occupational radiation exposure among NRC licensees (NUREG-0713 series), and an ongoing feasibility study to determine if state-of-the-art cellular and molecular radiobiology techniques can reduce the current uncertainty in estimating human risk from low dose, low dose-rate exposures. In 1989, he completed an EA for the NRC addressing the potential environmental impacts of the proposed license renewal of the Babcock and Wilcox Apollo Nuclear Services Operation. He is currently the Principal Investigator responsible for developing the radiological impact sections of an EIS for an inactive USAF BOMARC missile

Verified for accuracy by:

R. L. Gotchy

Date: Sept 13, 1989

PROFESSIONAL EXPERIENCE (CONTINUED)

accident site which is being considered for decontamination of weapons grade plutonium, and provided short-term health physics support at the site for RI/FS efforts. Dr. Gotchy is also now providing technical and policy support for the DOE New Production Reactor, the Superconducting Super Collider, the Advanced Photon Source, and the ERAB review of a conceptual tritium production accelerator. In 1988, he was a member of a select team to review the key safety issues identified in the NRC's Systematic Evaluation Program and recent safety appraisals of DOE reactors which could be relevant the DOE Advanced Test Reactor. In 1988, he also worked as a radiological and licensing consultant on a potential radiation source leakage problem at a medical supplies irradiator, providing guidance on solutions to the problem to enable the company to continue operation without having to shut down their entire facility. During the 1987 to 1989 period, Dr. Gotchy provided radiological sciences support regarding potential risks from failure of plutonium-powered thermoelectric generators from accidents during launch or reentry and responded to comments from reviewers of the final draft of the NASA Galileo Mission EIS. He also established a technical and management support contract with Commonwealth Electric for ongoing litigation before the Federal Energy Regulatory Commission, providing technical personnel to support CommElec's Washington attorneys as necessary. That successful effort has now lead to an ongoing out-of-court settlement of the dispute. In 1988, he also headed the development of a new employee orientation course for the Nuclear Regulatory Commission through the USDA Graduate School.

He was Principal Investigator for technical review and coordination of comments from major DOE operations offices on the new DOE Order 6430.1A (General Design Criteria for Nonreactor Nuclear Facilities), and has provided technical and policy reviews of several other DOE projects (e.g., Savannah River Plant waste sites draft EIS, Special Isotope Separation Project draft EIS, and the Feed Material Production Center); reviewed documents for DOE policy implications in several areas (BNL and LANL guidance for sitting and design of DOE non-reactor nuclear facilities, numerous draft CIRRP fact sheets regarding federal regulation of radiation protection of workers and the general public by NRC, EPA, and DOE, etc.).

Dr. Gotchy has served as a peer reviewer of the SAIC methodology developed for the Defense Nuclear Agency (DNA) for assessment of radiation doses to U.S. military personnel participating in various exercises during numerous above ground weapons tests in the U.S. and South Pacific, and will provide future health physics support in the future under the continuing DNA contract.

Verified for accuracy by:

R L Gotchy

Date: September 13, 1989

PROFESSIONAL EXPERIENCE (CONTINUED)

From 1986 to 1987 he was responsible for licensing and NRC hearing training for several hundred NNWSI Project participants, and served as a technical reviewer for other NNWSI Project documents, such as the Regulatory Compliance Plan and the Regulatory Document Manual.

Nuclear Regulatory Commission, 1981 - 1986

Prior to joining SAIC, Dr. Gotchy was employed as an Administrative Judge (Technical), Atomic Safety and Licensing Appeal Panel for the U.S. Nuclear Regulatory Commission (NRC). He performed technical evaluations on over fifty Atomic Safety and Licensing Board decisions concerning seismic design, safety-related systems, quality assurance and quality control in reactor design, construction and operation, radiological and non-radiological risk, emergency planning, as low as reasonably achievable (ALARA) programs, steam generator repairs, environmental qualifications, safety margins in as-built reactor structures, systems and components, design basis accidents, probabilistic risk assessment, ocean dumping of low level waste, environmental impacts of reactor construction and operation, and other topics.

AEC/NRC, 1972-1981

As a Senior Radiobiologist, Dr. Gotchy was instrumental in the development of NRC regulatory guides dealing with environmental monitoring (Reg. Guide 4.2), interim ALARA guidance for radioiodine releases from LWRs (Reg. Guide 1.42), and preparation of environmental reports (Reg. Guide 4.1). He was a principal expert witness at numerous NRC hearings involving the entire uranium fuel cycle including the GESMO and Table S-3 (Part 51) rule makings, and individual LWR licensing hearings dealing with the potential public health impacts of radon released from uranium mining and milling, the comparative long-term health risks of the coal and nuclear fuel cycles, Appendix I (Part 50) ALARA assessments, and radiological and nonradiological risk assessments. He established and directed the NRc's public whole body counting program following the TMI-2 accident, and provided briefings to the news media, general public and local physicians on the potential health risk associated with the radioactive releases during and after the accident.

Plowshare Office, USAEC (Nevada Operations Office), 1969 - 1972

As a Physical Scientist, Dr. Gotchy prepared and presented technical risk assessments and briefings to the AEC Plowshare Advisory Committee, Governor of Colorado's Advisory Committee, and Director, AEC Plowshare Office. He also directed rad-safe contractors at the Nevada Test Site, and at a Colorado natural

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R. L. Gotchy

Date: September 13, 1989

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PROFESSIONAL EXPERIENCE (CONTINUED)

gas experiment (Project Rulison) during demonstration tests and site decontamination and decommissioning. He developed emergency evacuation plans and portable computer techniques for radiological dose projections (Project Rio Blanco). In addition, he coordinated final reviews and publication of the Presidential Report on the Interoceanic Canal Study.

Reynolds Electrical & Engineering Company (Nevada Test Site), 1968 - 1969

While employed as a Senior Health Physicist with Reynolds Electrical & Engineering Company, Dr. Gotchy reviewed the Nevada Test Site (NTS) respiratory protection program, and demonstrated the cost/effective re-use of activated charcoal respirator canisters (cost savings of several hundred thousand dollars over a period of a few years). He was also responsible for coordinating REECo's technical activities in support of the AEC Plowshare program at NTS and elsewhere. While with REECo, he prepared several radiological assessments of potential Plowshare projects in oil shale, natural gas reservoirs, and in situ mineral recovery.

Colorado State University, 1965-1968

While completing doctoral requirements, Dr. Gotchy conducted AEC funded research on relationships between radon (and short-lived progeny) exposures of uranium miners and levels of long-lived progeny in bioassay samples. He worked as part of a multi-disciplinary team of scientists to develop methods of monitoring exposures to radon and its short-lived progeny.

Lawrence Radiation Laboratory (Nevada Test Site (NTS)), 1962 - 1965

Dr. Gotchy was a health and safety engineer in support of the AEC weapons testing and development program. In addition to post-shot radiological safety support for LRL tests, he was responsible for systems designs for remote radiation monitoring systems and for developing the systems and methods for estimating releases of radioactivity in accordance with the limited nuclear weapons test ban treaty. He designed and developed the LRL- N laboratory for alpha and gamma spectrometry, a mobile radiological measurements laboratory, an instrument calibration facility, and a support radiochemistry laboratory and hot cell facility at NTS.

Verified for accuracy by:

R. L. Gotchy

Date: September 13, 1989

Prior to 1962, Dr. Gotchy worked as a health physicist for the Off-Site Radiological Safety Group of the U.S. Public Health Service at the Nevada Test Site and in Las Vegas, and as a quality control chemist at Ohio Ferro Alloys Corporation in Tacoma, Washington.

SELECTED PUBLICATIONS

Over 125 radiological reports and papers dealing with nuclear weapons tests (1962 - 1965), biological assays for uranium miners (1967 - 1968), and radiological and bioenvironmental reports and papers dealing with peaceful uses of nuclear explosives (Plowshare), regulatory guides, and papers and publications dealing with assessments of health effects from radiological and non-radiological agents. Some of the most recent include:

Health Effects Attributable to Coal and Nuclear Fuel Cycle Alternatives, U.S. NRC Final Report, NUREG-0332 (June 1987).

Health Risks from the Nuclear Fuel Cycle in: Health Risks Associated with Energy Technologies, American Association for the Advancement of Science Symposium Series, Westview Press, Inc., Boulder, Colorado (1983).

Results of the Public Whole Body Counting Program Following the Three Mile Island Accident, NUREG-0636 (December 1980).

Health Effects of Uranium Mining and Milling for Commercial Nuclear Power (co-author), in Health Implications of New Technologies, Ann Arbor Science Publishers, Inc. (1980).

NRC Estimates of Health Risks Associated with Low Level Radiation Exposure, Proceedings of the Tenth Annual Conference on Radiation Control, Harrisburg, Pennsylvania, April 30-May 4, 1978, HEW (FDA) 79-8054 (June 1979).

Estimation of Life-Shortening Resulting from Radiogenic Cancer per Rem of Absorbed Dose, Health Physics Journal, Vol. 35, pp.563-656 (October 1978).

Verified for accuracy by: R. L. Gotchy

Date: September 13, 1989

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SCOTT S. HAY

EXPERIENCE

As the Radiometrics Supervisor at SAIC's Laboratory Services Division in Rockville, Maryland, Mr. Hay is responsible for the operation and maintenance of a variety of radiation detectors. He performs nuclide measurements using alpha and gamma spectrometers, NaI(Tl) detectors, low-level beta systems and liquid scintillation systems; and constructs calibration curves and other quality control tools as required. Mr. Hay has served as field supervisor on projects requiring analysis of radiation measurements and collection of samples outside of the laboratory.

Before working with the radiation measurements, Mr. Hay worked as the Senior Chemist in the radioanalytical laboratory. He performed radiochemical dissolutions, separations and purifications of matrices including filter paper, soil, biological specimens, resin, evaporator residue, oil and reactor coolant. Mr. Hay has performed research and development on difficult-to-analyze elements such as technetium and niobium and has improved laboratory procedures for elements such as strontium and iodine. His research has led to a reduction in the laboratory's lower limit of detection for isotopes such as ^{55}Fe, $^{89,90}Sr$, ^{94}Nb, ^{99}Tc, and the transuranics $^{238,239,240,241,242}Pu$, ^{241}Am and $^{242,243,244}Cm$. Mr. Hay's other responsibilities included carrier and tracer control, initial and continuing radiochemistry training, and lab chemistry procedures. The SAIC laboratory is frequently audited by utility auditors, and they always comment favorably on these areas.

Prior to joining SAIC, Mr. Hay was employed for four years as a radiochemist by the U. S. Air Force at the Atomic Energy Detection Laboratory. He received extensive training and hands-on experience in the dissolution, separation, and purification of samples for radionuclide analyses, and in the proper methods and techniques for analyzing environmental, low level, and high level samples. Mr. Hay developed and implemented several environmental monitoring programs. These programs involved large numbers of samples taken over large areas and long time durations, establishment of sample logging and tracking procedures, extensive data quality control measures, strict attention to sample radiological purity during chemical analysis, and collation and interpretation of nuclide data. Matrices analyzed by Mr. Hay included filter papers used to collect atmospheric samples, aquatic and terrestrial flora and fauna, fresh and seawater samples, organs from grazing animals, and various soils. He gained extensive experience in the techniques required for ensuring that nuclides such as $^{238,239,240,241,242}Pu$ do not form complexes and thereby become fractionated during the dissolution process. Mr. Hay also gained extensive experience in the preparation and standardization of carriers and tracers used in radionuclide analysis and in the preparation and documentation of laboratory procedures.

ROBERT K. KENNEDY
DIVISION DIRECTOR

EDUCATION

University of Oklahoma: Ph.D., Plant Ecology/Geography (1973)
Iowa State University: M.S., Ecology/Soils (1969)
South Dakota State University: B.S., Botany/Biology (1967)
Washington State University: Additional study in Environmental Biophysics

SUMMARY OF EXPERIENCE

Dr. Kennedy has had over 23 years experience in planning and managing compliance-centered technical operations, including field and laboratory components requiring auditable documentation. Recent responsibilities included managing compliance activities for Battelle's Office of Nuclear Waste Isolation, Salt Repository Project with the Department of Energy (licensing, environmental, and regulatory compliance; systems engineering; systems analysis; configuration management; and institutional affairs). He previously established and managed regional offices for two environmental consulting firms, and has directed a diverse array of multidisciplinary EIAP projects (EAs and EISs); mineral development and permitting projects; reclamation and remediation feasibility studies; regulatory analyses; and facility siting programs. He has participated on Government task force efforts and has had extensive participation in briefings, presentations, and decision meetings involving Government and public sector participants. He is currently the program manager for two large, multiproject USAF hazardous waste Installation Restoration Program contracts.

EMPLOYMENT HISTORY

June 1989 to present: Science Applications International Corporation (SAIC)

Dr. Kennedy is the Division Director at SAIC Golden, CO, where he is responsible for a group of 25 multidisciplinary professionals. The Division has as its primary business focus the conduct of remedial investigation/feasibility studies and interim remediation at hazardous waste sites. The Division also prepares Environmental Impact Statements for a variety of efforts. In addition to division management, Dr. Kennedy is responsible for Program Management of two large contracts for the Air Force and for EIS preparation on the New Jersey BOMARC Missile Site mixed waste remediation project.

March 1983 to June 1989: Battelle Memorial Institute (Denver)

Dr. Kennedy was the General Manager for Battelle Denver Operations. In this capacity he was responsible for the effective execution of environmental and hazardous waste program investigations, analyses, and reporting; implementation of a responsive quality assurance program; staff training and development; maintenance of business, project, and data management systems; administration of the health and safety program and records; and maintenance of responsive client relationships.

Previously at Battelle Project Management Division, Dr. Kennedy held the positions of Assistant Program Manager-Compliance, Regulatory Project Office Manager, Environment/Socioeconomics Department Manager, and Chief Environmental Scientist. The number of staff members under his direction varied from 20 to 125 with budget authority of $3 million to $55 million annually. Dr. Kennedy was responsible for the planning and preparation of major compliance documents, including regulatory and statutory plans and reports, the development and validation of total and subsystem models, the tracking of compliance actions, the implementation of environmental, air quality and socioeconomic site-specific field and laboratory studies and the project institutional program.

February 1981 to December 1982: Normandeau Associates, Inc.

Dr. Kennedy directed regional office operations and project management for this multiregion engineering and environmental consulting services company. He was responsible for comprehensive planning and direction of coal and metals mining development, reclamation, and permitting projects. His project management experience included preparation of technical response to regulatory questions covering revegetation success criteria and protection of riparian habitat for underground coal mines in Mesa and Delta Counties, Colorado; conduct of vegetation and soils field surveys, reclamation planning, mine reclamation plan preparation, and technical response to regulatory review of the plans for an underground coal mine in Delta County, Colorado; direction of a Routt County, Colorado project designed to evaluate various vegetation sampling methods for cost efficiency, statistical validity, and appropriateness for use on revegetated land areas; evaluation of erosion and sedimentation control methods for use in stabilization of active and revegetated cuts and slopes in four lignite surface mines in North Dakota; direction and preparation of final reclamation plans, including drainage restoration, for three underground coal mines in Carbon County, Utah; and direction of the field surveys and preparation of the revegetation and reclamation management plan for a proposed surface coal mine in Campbell County, Wyoming.

May 1976 to February 1981: Texas Instruments, Inc.

Dr. Kennedy held the positions of Western Regional Manager, Utility Services Manager, Biological and Land Resources Manager, and Senior Ecologist. He was responsible for project management and operations in the Western Regional Office. Earlier, he was responsible for operations of four regional and two field operations centers in the midwestern and eastern United States. These operations supported site characterization studies, monitoring, and licensing/permitting field studies to establish compliance with NRC, EPA, and State regulations. His project management experience included design and direction of a multi-year environmental assessment of the impact of cooling tower salts on vegetation and soils in a 12,000-acre area of Indiana and Kentucky adjacent to a nuclear generating station; direction of preparation of the draft and final documents for the proposed Colstrip, Montana Units 3 & 4, mining, generating plant and cross-state transmission system EIS for Bonneville Power Authority; direction of assessment of the impact of urbanization and agricultural practices on loss of wetlands over the period 1949 through 1977 in southern Wisconsin for the Corps of Engineers; and management of a baseline vegetation study and report preparation for a large power park siting study in central Florida.

May 1973 to May 1976: Sargent & Lundy Engineers

As an Environmental Project Manager, Dr. Kennedy directed and monitored environmental contract work in support of utility client licensing and permitting documentation. He prepared applicant environmental reports (ER) and preliminary safety analysis reports (PSAR) for six midwestern nuclear generating plants. He also prepared technical responses to NRC interrogatories and contentions in support of applicant's licensing process.

AWARDS AND HONORS

Management performance awards, Texas Instruments, Inc. (1979, 1981)
Who's Who in the West
American Men and Women of Science

SELECTED PUBLICATIONS

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"Plans for Characterization of Salt Sites." Coauthor in Proceedings of the 1983 Civilian Radioactive Waste Management Information Meeting, December, 1984. U.S. Department of Energy, Washington, D.C.

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KEYWORDS

Program management, EIS, RI/FS, Remediation, Plant Ecology, DoD, DOE, CoE, Mining, Reclamation, Systems Analysis, Hazardous Waste, Facility Siting, Habitat Restoration, Licensing, Environmental Compliance, Permitting, Regulation, CoaL, Vegetation, Revegetation, Nuclear, Environmental Assessment, Resource management.

RESUME

PETER J. MELLINGER

Program Manager
Environmental Management Operations

EDUCATION

B.A.	Biological Sciences, University of the Pacific	1964
M.S.	Oceanography/Radiation Biology, Oregon State University	1966
Ph.D.	Radioecology/Radiation Biology, Oregon State University	1972

EXPERIENCE

Dr. Mellinger has spent the major part of his career as project manager or individual contributor to environmental and risk assessments of DOD defense projects including rocket boosters, SDI, submarine acoustic measuring facilities, and DOE projects related to energy production, reclamation, and isotope separation facilities. These assessments involve defining routine and fugitive emissions from facilities, modeling the environmental transport and fate of the released material, predicting exposure to man and other biota, and estimating the health risks to the exposed human populations. Specific areas and projects include:

- Human Risk Assessments. Dr. Mellinger is currently involved in an EPA project assessing potential human exposure to airborne asbestos from unpaved roads and other disturbed soils in California. - Project Manager

  Dr. Mellinger completed an assessment involving potential cancer incidence from formaldehyde and B(a)P exposure in the indoor environment. In addition, the potential incidence of lung cancer mortality from the operation of a proposed coal liquefaction industry have been quantified. Lung cancer mortality estimates of an occupationally exposed work force were compared to estimated health effects of the U.S. population. A very important part of this work involves selection of surrogate models, potency matrices, and tracking the estimates of uncertainty through the assessment. - Project Manager

  Dr. Mellinger completed an evaluation of alternative systems for the management of airborne radioactive noble gas wastes emphasizing public health and safety. Using the assessment of krypton-85 management schemes, tradeoffs involving the contrasting concepts of dilute/disperse and capture/contain were evaluated as to their impacts upon the world population dose. Health effects were predicted for both the occupational work force and the U.S. population. - Project Manager

Dr. Mellinger presented voluntary risk perspective to a residential weatherization risk assessment. Tightening residences may cause an increase in the concentration of natural radon gas, cigarette smoke, and formaldehyde within the residence. These risks are being compared quantitatively with other voluntary risks such as driving, air travel, and becoming involved with fires, firearms, falling objects, and electrocution. - Individual Contributor

- CERCLA. Dr. Mellinger is currently Project Manager for a plutonium burning analysis, historical air dispersion patterns, ARARs preparation and a baseline risk assessment in support of a BOMARC missile fire.

  Dr. Mellinger is managing a project to prepare a PA/SI for 54,000 acres the Air Force is interested in obtaining at Vandenberg AFB in support of future space launches.

- NEPA Documentation and Related Assessments. Two projects that Dr. Mellinger is currently managing include estimating potential environmental impacts from acquiring additional buffer land at Vandenberg AFB to support future space launches and a project to estimate potential impacts of Air Force laser systems and their support equipment at AMOS, Maui, Hawaii.

  Potential environmental impacts from routine assembly, transport, and airborne launch of a three stage rocket booster and from accident scenarios were recently estimated by Dr. Mellinger and his assessment team. - Project Manager

  Dr. Mellinger and his team completed an environmental impact statement concerning potential impacts from the construction and operation of a submarine acoustic measurement facility proposed for Behm Canal, Alaska.

  Dr. Mellinger was the project manager for a document to describe the potential environmental impacts of the construction and operation of an Atomic Vapor Laser Isotope Separation facility if it were to be sited at Hanford. The purpose of the facility is to convert fuel-grade plutonium to weapon-grade material. - Project Manager

  He was project manager for two multiyear Advanced Isotopic Separation (AIS) Environmental Assessments involving laser, plasma, and advanced gas centrifuge technologies for the enrichment of uranium. These projects are aimed at systematically examining effects on the environment and upon society that may occur when this technology is introduced, extended, or modified. These studies concentrate on anticipation, identification, and evaluation of potential direct, indirect, and delayed impacts. A wide range of impacts are environmental health (occupational and public) and safety, socioeconomic, and legal and institutional. - Project Manager

  He was also responsible for site- and region-related research and data acquisition and for the preparation of the environmental licensing documents to satisfy the National Environmental Policy Act (NEPA) for a major southeastern nuclear facility. - Project Manager

- Outer Continental Shelf Oil. Current fossil fuel studies involve state-of-the-art descriptions and future alternative methods utilized in the exploration, retrieval, and transportation of outer continental shelf oil and the environmental impact of released hydrocarbons and other contaminants from these activities.

- Fossil Fuel Transportation. A one-year research and analysis program for the U.S. Maritime Administration resulted in an environmental assessment of the transportation of crude oil from the Persian Gulf to the United States via a 400,000 DWT nuclear-powered Very Large Crude Carrier (VLCC).

- Consulting Services. Dr. Mellinger has provided consulting services to a number of electrical power utilities related to such activities as:

  1. Prediction of environmental consequences of the release of nonradioactive and radioactive materials from utility plant operations.

  2. Estimation of the biological consequences to plants and animals from chemicals and heat discharged to the environment from electrical generating stations.

  3. Evaluation of potential heavy metal cycling in fresh water, marine, and estuarine ecosystems.

  4. Prediction of probable pathways by which released chemicals could lead to the intoxication of the biota themselves or to man.

  5. Preparation and delivery of technical testimony to the Atomic Safety and Licensing Board (ASLB) and the Advisory Committee on Reactor Safeguards (ACRS).

- Oceanographic Instrumentation. Dr. Mellinger managed a research and development effort to develop radioisotopic uses in oceanographic instrumentation for applied and basic research and pollution detection and control.

Dr. Mellinger is a member of the Hazardous Materials Control Research Institute, Society for Risk Analysis and ASTM Subcommittee on Aquatic Toxicology. He is a member of the Research Committee of the Washington Association of Wine Grape Growers and a member of the Washington Wine Advisory Board. His honors include a U.S. Atomic Energy Commission Summer Research Fellowship, 1970, and a U.S. Public Health Service Grant for Environ-mental Toxicology, 1970-1972.

Publications

Journal Articles:

Mellinger, P. J., and V. Schultz. 1975. "Ionizing Radiation and Wild Birds: A Review." Critical Reviews in Environmental Control. CRC Press, 5(3):397-421.

Technical Reports:

Mellinger, P. J., et al. 1988. Final Environmental Impact Statement, Southeast Alaska Acoustic Measurement Facility (SEAFAC), Behm Canal, Ketchikan Gateway Borough, Alaska. Prepared for David Taylor Naval Ship Research and Development Center, Detachment Puget Sound, U.S. Department of the Navy.

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JOFU MISHIMA, Staff Scientist
Earth Sciences Department

Education

B.S. Chemistry, Wayne University 1951

Experience

Mr. Mishima has been associated with the Hanford Project since 1955. From 1955 to 1962, he performed professional functions in the Process Control Laboratory for the PUREX process. Since 1962, Mr. Mishima has worked as an individual technical contributor and as a member or leader of intra- and interdisciplinary research teams. Mr. Mishima's areas of expertise include the fractional airborne release of radionuclides as a consequence of nonnuclear-initiated accidents, energy output and products of fire and explosions, nuclear air cleaning systems, particulate sampling of gaseous effluents from nuclear facilities and research planning and organization. He has made significant contributions in the following areas:

Assessment of Consequences of Occurrences in Nuclear Fuel Cycle Facilities. Mr. Mishima has been involved in experimental studies to generate data on the airborne release of radionuclides under various types and levels of stress and the application of such data for the estimation of the radiological consequences of accidents involving facilities holding radioactive materials. The range of events covered are nonnuclear, process-related (i.e., fires, explosions, spills, etc.) to external (i.e., earthquakes, tornado, impact of aircraft, etc.). The studies also require a sound knowledge of energy generation rates, hazardous conditions, and the products of fires and explosions. Some of the experimental data developed are:

The fractional airborne release of plutonium metal and various solid and liquid forms under thermal stress.

The fractional airborne release of uranium dioxide powder and nitrate solution under aerodynamic and thermal stress.

The washout of methyl iodide from post-accident LWR containment atmospheres by hydrazine solutions.

The airborne release of fission products from contaminated soils and vegetation during range fires.

The transport of fine particles through small orifices, capillaries and other leaks.

The retention and release of inert gases in water.

The fractional airborne release of powders and liquids during free fall spills.

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Exxon Nuclear's Mixed Oxide Fabrication Plant at Richland, Washington.

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(As a Contributor)

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Owczarski, P.C., S.L. Sutter, J. Mishima, L.C. Schwendiman and T.J. Bander. 1979. Measured and Predicted Gas Flow Rates Through Rough Capillaries. NUREG/CR-0745 (PNL-2623), Pacific Northwest Laboratory, Richland, Washington.

Glissmeyer, J.A., J. Mishima and R.L. Gilchrist. 1978. Characterization of Airborne Uranium from Test Firings of XM-774 Ammunition. PNL-2944, Pacific Northwest Laboratory, Richland, Washington.

Parker, G.B., J. Mishima and R.L. Gilchrist. 1978. Radiological and Technology Assessment of an External Heat (Burn) Test of the 105 mm Cartridge. APFSDS-T, XM-774, Pacific Northwest Laboratory, Richland, Washington.

Sutter, S.L., T.J. Bander, J. Mishima and L.C. Schwendiman. 1978. Measured Air Flow Rates Through Microorifices and Flow Prediction Capability. NUREG/CR-0066 (PNL-2611), Pacific Northwest Laboratory, Richland, Washington.

Oscarson, E.E., J. Mishima and D.A. Waite. 1977. Detailed Accident Analysis for the High Level Waste Preparation Phase of the Commercial Nuclear Waste Vitrification Project. BNWL-2207, Pacific Northwest Laboratory, Richland, Washington.

Schneider, K.J. and C.E. Jenkins (coordinators). 1977. Technology, Safety, and Cost of Decommissioning a Reference Nuclear Fuel Reprocessing Plant. NUREG-0278, Pacific Northwest Laboratory, Richland, Washington.

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Sutter, S.L. and J. Mishima. 1975. ^{99}Sr in Surface Constituents in the B-C Control Area and ^{90}Sr:^{137}Cs Ratios. BNWL-B-433, Pacific Northwest Laboratory, Richland, Washington.

Sutter, S.L. and J. Mishima. 1975. Potential Airborne Release of ^{137}Cs Upon Heating B-C Control Area Surface Materials from 200 C to 600 C. Pacific Northwest Laboratory, Richland, Washington.

Sutter, S.L. and J. Mishima. 1975. A Survey of the Distribution of Surface Contamination of Terrain Adjacent to U-Pond. Pacific Northwest Laboratory, Richland, Washington.

Sutter, S.L., J. Mishima and L.C. Schwendiman. 1974. Fractional Airborne Release of Strontium During the Combustion of 30 Percent Tri-n-butyl Phosphate in a Kerosene-Type Diluent. BNWL-B-358, Pacific Northwest Laboratory, Richland, Washington.

Selby, J.M., et al. 1973. Technical Considerations in Emergency Instrumental Preparedness, Phase IIB. Emergency Radiological and Meteorological Instrumentation for Mixed Oxide Fuel Fabrication Facilities. BNWL-1742, Pacific Northwest Laboratory, Richland, Washington.

Mishima, J. and L.C. Schwendiman. 1973. Fractional Airborne Release of Uranium (Representing Plutonium) during the Burning of Contaminated Waste. BNWL-1730, Pacific Northwest Laboratory, Richland, Washington.

Selby, J.M., et al. 1973. Considerations in the Assessment of the Consequences of Effluents from Mixed Oxide Fuel Fabrication Plants. Pacific Northwest Laboratory, Richland, Washington.

Schwendiman, L.C., J. Mishima, A.K. Postma, L.L. Burger and R.A. Hasty. 1967. The Washout of Methyl Iodide by Hydrazine Sprays. BNWL-530, Pacific Northwest Laboratory, Richland, Washington.

Presentations

Kenoyer, J.L., D.B. Higby, K.L. Swinth and J. Mishima. Presented at the 1st DOE Workplace Aerosol Monitoring Workshop at Napa, CA, 10/28-30/85. "Performance Testing of Workplace Air Monitors Using Procedure Based on Draft ANSI-N42.17B", PNL-SA- .

Mishima, J., P.C. Owczarski, S.L. Sutter and L.C. Schwendiman. 1980. "Pressurized Powder Release Through Micro Openings in Faulted Corners." PNL-SA-8510. Presented at the 6th International Symposium Packaging and Transportation of Radioactive Material in Berlin, Germany, November 10-14, 1980.

Mishima, J. and L.C. Schwendiman. 1970. "The Amount and Characteristics of Plutonium Made Airborne Under Thermal Stress." BNWL-SA-3379. Presented at the 5th Midyear Topical Symposium of the Health Physics Society in Idaho Falls, Idaho, November 3-6, 1970.

Mishima, J. and L.C. Schwendiman. 1968. "Some Observations on the Nobel Gas Partitioning in Dynamic Air-Water Systems." BNWL-SA-3360. Presented at the 11th AEC Air Cleaning Conference at Richland, Washington, August 31-September 3, 1970.

Mishima, J. and L.C. Schwendiman. 1966. "The Fractional Airborne Release of Plutonium During Overheating Incident." BNWL-SA-2695. Presented at 1969 Winter Meeting of the American Nuclear Society, San Francisco, California, November 30-December 4, 1969.

Mishima, J., L.C. Schwendiman, L.L. Burger and R.A. Hasty. 1966. "Removal of Methyl Iodide From Simulated Reactor Containment Atmospheres." BNWL-SA-821. Presented at the 9th AEC Air Cleaning Conference, Boston, Massachusetts, September 13-16, 1966.

PUBLICATIONS

J MISHIMA

Scientific Articles

Mishima, J. 1982. "Long-Term Stabilization of Uranium Mill Tailings Piles, Project Overview." In Fifth Annual Symposium on Uranium Mill Tailings Management. Colorado State University, Fort Collins, Colorado.

Mishima, J., S.L. Sutter, P.C. Owczarski and L.C. Schwendiman. 1980. "Pressurized Powder Release Through Micro-Openings in Faulted Corners." In Proceedings of the 6th International Symposium Packing and Transportation of Radioactive Materials (PATRAM-80). (H.W. Huber, ed), Bundesanstatl fur Materialprufung/COC Kongressorganisation GmbH.

Mishima, J. 1974. "Fractional Airborne Release of Plutonium Under Shipping Accident Conditions." In 4th International Symposium on Packaging and Transportation of Radioactive Materials, CONF-740901-P3, U.S. Atomic Energy Commission.

Mishima, J. and L.C. Schwendiman. 1970. "Some Observations on Noble Gas Partitioning in Dynamic Air-Water Systems." In Proceedings of the Eleventh AEC Air Cleaning Conference. CONF-700816, Vol. 2, U.S. Atomic Energy Commission.

Mishima, J. and L.C. Schwendiman. 1966. "The Airborne Release of Plutonium During Overheating Incidents." Transactions of the American Nuclear Society, 12(2). (Proceedings 1969 Winter Meeting).

Mishima, J. 1966. "Review of Methyl Iodide Behavior in Systems Containing Airborne Radioiodine." Nuclear Safety, 9(2):35-43.

Mishima, J., L.C. Schwendiman, L.L. Burger and R.A. Hasty. 1966. "Removal of Methyl Iodide from Simulated Reactor Containment Atmospheres with Hydrazine." In Proceedings of the Ninth AEC Air Cleaning Conference, CONF-660904, Vol. 1, U.S. Atomic Energy Commission.

(As a Contributor)

Sutter, S.L., M.Y. Ballinger, M.A. Halverson and J. Mishima. 1984. "Accident-Generated Radioactive Particles Source Term Development for Consequence Assessment of Fuel Cycle Facilities." Submitted to Particulate Science and Technology, an International Journal.

CATHERINE M. OLSEN

Weber State College: B.S., Geology (1987)
Weber State College: A.A.S., Chemistry (1987)

PROFESSIONAL SUMMARY

Ms. Olsen has experience in various geological field methods, including mapping and interpretation. She has participated in hydrogeologic and geologic hazard studies and has performed geotechnical laboratory testing, surveying, and stream gauging. She is experienced in the use of analytical chemistry instrumentation including gas chromatograph and gas chromatograph mass spectrometer, X-Ray diffractometer, and spectrometric analysis. She has experience in aquifer characterization and has performed field tests on RCRA-compliance wells.

PROFESSIONAL EXPERIENCE

Science Applications International Corporation, Golden, Colorado
(1989 - present)

Currently, Ms. Olsen supports the Air Force installation restoration program, performing geologic and hydrologic analyses associated with remedial investigations. She is working at the Fairchild AFB in Spokane, Washington on the evaluation of contamination from base activities.

Ms. Olsen was involved in detemining the Waste Acceptance Criteria (WAC) for low level and low level mixed waste at Rocky Flats. Her responsibilities involved investigating various waste streams and determining waste acceptable for transportation to the Nevada Test Site.

Ms. Olsen was a team member for the Installation Restoration Program at the BOMARC Missle Site at McGuire AFB, New Jersey. Her responsibilities were to evaluate the extent of Plutonium 239 contamination by conducting radiological surveys, wipe sampling water sampling. She is experienced with various radiological equipment including the Eberline ESP2, FIDLER, PAC-42 Alpha Detector, Radeco Alpha Cam, and Rap-1 and Alpha-3 Cam. and has worked in level C personal protection. She was involved in the RI/FS and ITIR reports for that site.

As field team member under NOAA'S Quick reaction Task Order Contract, Ms. Olsen was responsible for the screening analysis for petroleum hydrocarbons in sediment and sediment pore waters using ultra-violet fluorescence spectrophotometry for the Exxon Valdez Damage Assessment. Her responsibilities included collection and analysis of water, sediment, and biota samples from sites throughout the Prince William Sound and coastal Gulf of Alaska, daily reports to the NOAA Chief Scientist and assisting NOAA scientists with sampling operations.

Battelle Memorial Institute, Denver, Colorado
(1988 - 1989)

Ms. Olsen was field team member for the installation of a ground water monitoring well, surface water sampling and surface and subsurface soil sampling in the Malmstrom AFB installation restoration program. Her responsibilities included the documentation of field activities during the installation of monitoring well, water and soil sampling. Ms. Olsen also ensured compliance with all quality assurance project plan procedures regarding the collection, preservation, packaging, and shipping of environmental samples.

Ms. Olsen was a field team member during the magnetometer survey and initial site reconnaissance and preparation for IRP Stage 2 at the Andersen AFB installation. Her responsibilities included the documentation of field activities during the geophysical survey, mapping landfill features, locating sites for monitor well installation and soil sampling and obtaining clearance to drill at these locations from Air Force personnel.

Ms. Olsen supervised the drilling and construction of wells in the design and implementation remedial action for the Tanguisson Power Plant oil spill in Guam. Her responsibilities included onsite geological assessments and design and construction of oil recovery wells, water injection wells, and monitoring wells. She also was responsible for field report completion, contractor liaison, and maintaining contact with Guam Power Authority (GPA) personnel on the project.

Sirrine Environmental Consultants, Aiken, South Carolina
(1987 - 1988)

As Assistant Hydrogeologist, Ms. Olsen was responsible for determining aquifer characterization by performing slug tests on RCRA compliance wells at a tritium seepage basin facility in South Carolina. She was responsible for the completion of field testing of groundwater monitoring wells and data reduction using the Hvorslev (1961), Bouwer & Rice (1976), and Nguyen & Pinder (1984) methods to determine hydraulic conductivity.

Saint Benedicts Hospital, Ogden, Utah
(1983 - 1987)

Ms. Olsen served as a Lab Technician/Systems Operator. Her responsibilities involved a variety of technical skills in a pathology laboratory, including computer pathology and medical laboratory testing.

ADDITIONAL EDUCATION

OSHA 40-Hour Hazardous Waste Site Training, 1988
OSHA 8-Hour hazardous Waste Site Health and Safety Supervisor Course, 1990
OSHA 8-Hour Annual Health and Safety Refresher Course, 1990
American Red Cross Community CPR, 1990.
American Red Cross CPR: Basic Life Support For The Professional Rescuer, 1990.

AWARDS AND HONORS

Women Geoscientists Award (1987)

PROFESSIONAL AFFILIATIONS AND CERTIFICATIONS

Colorado Groundwater Association
Association of Engineering Geologist

MARK D. OTIS

Position with Company:
Division Manager,
Environmental Analysis &
Performance Assessment

EDUCATION

Ph.D, Radioecology, Colorado State University (1983)
M.S., Radiation Health, Colorado State University (1973)
B.S., Physics, University of Colorado (1972)

PROFESSIONAL CERTIFICATION

Comprehensive Certification by the American Board of Health Physics, 1981. Recertified in 1985 and 1989.

EXPERIENCE

Dr. Otis is an ecologist and a certified health physicist with a wide range of experience in modeling the movement of radioactive pollutants through the environment and assessing their potential impacts. He also managed and supervised multidisciplinary teams of scientists and engineers conducting research and assessments of environmental impacts from both radioactive and hazardous, nonradioactive pollutants.

Dr. Otis has provided support to the Department of Energy (DOE) and to the commercial nuclear power industry in performance assessments of low-level radioactive waste (LLW) disposal facilities. He has worked through both the DOE National Low level Waste Management Program and the host state's Technical Coordinating Committee. He has participated in the development and review of conceptual designs, prototype license applications, and environmental monitoring plans for LLW facilities. He is co-author of "Guidelines for Radiological Performance Assessment of DOE low-Level Radioactive Waste Disposal_Sites," DOE/LLW-62T, 1988.

As a principal investigator for a series of Nuclear Regulatory Commission studies, Dr. Otis has evaluated the long term performance of alternative LLW disposal facility designs incorporating engineered barriers such as concrete vaults and overpacks.

Dr. Otis has applied his understanding of the environmental behavior of pollutants to the design of environmental monitoring programs for nuclear facilities and waste disposal operations. Examples of these monitoring programs include operational activities at the Radioactive Waste Management Complex and decontamination activities at the site of the SL-1 reactor accident at the Idaho National Engineering Laboratory (INEL). He is presently developing a comprehensive environmental monitoring plan for a broad spectrum of nuclear and non-nuclear facilities at the INEL. He is also serving on the Health Physics Society Standards Committee N13.9, Environmental Surveillance Around Nuclear Facilities.

He has been a contributor to a variety of safety analyses and environmental assessment documents for DOE nuclear facilities. These include performance assessments for the Radioactive Waste Management Complex and the Environmental Assessment for the Fuel Processing Restoration Project at the INEL. Work on proposed new DOE facilities has included participation in draft Environmental Impact Statement for the Special Isotope Separation project, the New Production Reactor, and the Compact Ignition Tokamak fusion reactor.

Dr. Otis has participated in several major studies designed to provide best estimates of radiation doses received by individuals from past releases of radioactivity. He has developed the uncertainty analysis techniques used for estimates of internal doses to residents of southern Utah from atmospheric weapons testing at the Nevada Test Site. He applied similar techniques to the uncertainty of house shielding nd organ dose calculations for the DS86 reevaluation of doses to the Japanese atomic bomb survivors. Dr. Otis is currently involved in a retrospective assessment of offsite doses in the vicinity of the INEL.

Dr. Otis has participated in a series of training and classroom teaching activities in health physics and environmental modeling. These include the 12th Annual Health Physics Society Summer School on Pathway Analysis and Risk Assessment (June 18 -23, 1989); two DOE National Low-Level Waste Management Program workshops on LLW Facility Performance Assessment (September, 1989 and January, 1990); and graduate level courses in environmental modeling and advanced health physics for the University of Idaho (1986 to the present).

In addition to scientific and technical experience, Dr. Otis has over five years of administrative and project management experience. He has managed an interdisciplinary team of six to ten modelers, health physicists, ecologists, and environmental engineers assessing the transport, fate, and effect of radioactive and nonradioactive pollutants.

SECURITY CLEARANCE - Department of Energy "L", 1985 to present.

PUBLICATIONS AND REPORTS

Concrete Barrier Performance for Radioactive Waste Disposal in the Unsaturated Zone, J. C. Walton and M. D. Otis, XIIIth Symposium on the Scientific Basis for Nuclear Waste Management, Materials Research Society, January 1990.

Uncertainty in Predictions of Fallout Radionuclides in Foods and of Subsequent Ingestion, D. D. Breshears, T. B. Kirchner, M. D. Otis, F. W. Whicker, J. Health Physics, Vol. 57, No. 6, December 1989.

A Review and Selection of Computer Codes for Establishment of the Low-Level Waste Performance Assessment Center, M. J. Case, S. J. Maheras, M. D. Otis, R. G. Baca, DOE/LLW-83, National Low-Level Waste Management Program, U.S. Department of Energy, Idaho Falls, ID, July 1989.

Characterization Survey of a Site Contaminated with Discrete Radioactive Particles, M. D. Otis and G. J. White, presented at the Health Physics Society 34th Annual Meeting, Albuquerque, NM, June 25-29, 1989.

Guidelines for Radiological Performance Assessment of DOE Low-Level Radioactive Waste Disposal Sites, M. J. Case and M. D. Otis, DOE/LLW-62T, National Low-Level Radioactive Waste Management Program, U.S. Department of Energy, Idaho Falls, ID, July 1988.

Safety Assessment of Alternatives to Shallow Land Burial of Low-Level Radioactive Waste, Vol. 2, Environmental Conditions Affecting Reliability of Engineered Barriers, F. Cerven and M. D. Otis, NUREG/CR 4701, Vol. 1, U.S. Nuclear Regulatory Commission, Washington, September 1987.

Organ Dosimetry, Kaul, D. C., S. D. Egbert, M. D. Otis, T. Kuhn, G. D. Kerr, K. F. Eckerman, M. Cristy, T. Maruyama, J. C. Ryman, J. S. Tank, in US-Japan Joint Reassessment of Atomic Bomb Radiation Dosimetry, W. C. Roesch, Ed., National Research Council, Washington, DC, 1987.

House and Terrain Shielding, W. A. Woolson, M. L. Gritzner, S. D. Egbert, J. R. Roberts, M. D. Otis, S, Fujita, in US-Japan Joint Reassessment of Atomic Bomb Radiation Dosimetry, W. C. Roesch, Ed., National Research Council, Washington, DC, 1987.

Safety Assessment of Alternatives to Shallow Land Burial of Low-Level Radioactive Waste, Vol. 1, Failure Analysis of Engineered Barriers, M. D. Otis, NUREG/CR-4701, U.S. Nuclear Regulatory Commission, Washington, DC, August 1986.

Multi-media Design Principles Applied to the Development of the Global Baseline Integrated Monitoring Network, G. B. Wiersma, M. D. Otis, in Pollutants in a Multi-media Environment, Y. Cohen, ed., Plenum Press, New York, June 1986.

"Uncertainty and Sensitivity Analyses of the PATHWAY Radionuclide Transport Model," Ph.D. Thesis, Colorado State University, 1983.

"PATHWAY": A Simulation Model of Radionuclide Transport Through Agricultural Foodchains," Proc. Third Int. Conf. on State-of-the-Art in Ecological Modeling, Colorado State University, 1982.

"Evaluation of AIRDOS-EPA and MILDOS Food Chain Models," Proc. Third Symposium on Uranium Mill Tailings Management, Colorado State University, 1980.

"A Preliminary Investigation of the Absorbent Properties of Materials Used in the Packaging of Low-Level Radioactive Liquids," Operational Health Physics, Proc. Ninth Midyear Topical Symposium, Health Physics Society, 1976.

"The Utilization of Mo-99 from Spent Mo-99/Tc-99m Generators," Int. J. Appl. Rad. Isotopes, Vol. 27, No. 3, 1976.

"Important Considerations in Determining Biologically Essential Nutrients by Depletion Studies," J. Colorado-Wyoming Academy of Sciences, Vol. 8, 1976.

MICHAEL A. MCKENZIE-CARTER

Position with Company:
Staff Scientist,
Environmental Analysis &
Performance Assessment

EDUCATION

M.S., Radiation Health, Oregon State University (1985)
B.A., Zoology, Humboldt State University (1981)

EXPERIENCE

Mr. McKenzie-Carter has a Master's Degree in Radiation Health and over 6 years of experience in operational health physics and environmental radiation dose assessment. He has conducted radiological dose assessments for a variety of facilities, performance assessments for low-level radioactive waste (LLW) disposal facilities, and impact assessments for non-radioactive pollutants. He is familiar with both mainframe and personal computer codes for atmospheric dispersion, shielding, and radiological dose assessment.

Mr. McKenzie-Carter's environmental assessment experience includes numerous analyses of potential radiation doses from airborne releases at DOE facilities on the Idaho National Engineering Laboratory (INEL) site in support of NESHAP applications. He has conducted performance assessments for LLW disposal facilities at the INEL and the Nevada Test Site. He participated in the preparation of the license application for the proposed California LLW disposal facility. He conducted the offsite radiological dose calculations for the draft Environmental Assessment (EA) for the Compact Ignition Tokamak fusion reactor at the Princeton Plasma Physics Laboratory while managing the preparation of the entire EA. His experience with assessments for non-radioactive pollutants includes evaluation of potential hazardous materials releases from facilities at the Rocky Flats Plant, and estimates of potential impacts from airborne organic toxins associated with the remediation of groundwater contamination at McClellan Air Force Base, CA.

Mr. McKenzie-Carter's operational health physics experience includes radiological engineering support of the LOFT test reactor and a large Hot Shop complex at the INEL. This support required performance of shielding analyses of reactor components, fuel shipments, and other sources; occupational dose assessments for radiation workers; off-site dose assessment for accident and normal operating conditions; and evaluation of other miscellaneous radiological engineering problems. Responsibilities also included review of project work packages, designs, and procedures, and recommendation of methods to keep radiation doses ALARA.

July 1990

PUBLICATIONS AND PRESENTATIONS

McKenzie-Carter, M. A. and D. A Bruns, "Environmental Risk Assessment of Volatile Organics Released From the Ground Water Treatment Plant at McClellan AFB", Informal Report EGG-ESE-8180, EG&G Idaho, Inc., August, 1988.

McKenzie-Carter, M.A. and J. R. Stencel, "Environmental Assessment for the Compact Ignition Tokamak", Proceedings of the IEEE 12th Symposium on Fusion Engineering, October 12-16, 1987.

McKenzie-Carter, M. A., and R. E. Lyon, "Methodology for Assessing the Radiological Consequences of Radiological Releases from the CIT Facility at PPPL", Internal Report EGG-ESE-8600, EG&G Idaho, Inc., August 1989.

McKenzie-Carter, M. A., and M. D. Otis, "An Example of a Methodology for Comparison of Radiological Assessment Codes Using AIRDOS-EPA and RSAC-3", Presented at the 32nd Annual Meeting of the Health Physics Society, July 5-9, 1987.

Stencel, J. R., R. B. Fleming, J. C. Commander, and M. A. McKenzie-Carter, "Health Physics Considerations for the Compact Ignition Tokamak", Proceedings of the 20th Midyear Topical Symposium of the Health Physics Society, Reno, Nevada, February 8-12, 1987.

Willis, D. L. and M. A. McKenzie-Carter, "Radiotechnetium Metabolism in Two Freshwater Species, the Crayfish Pacifastacus leniusculus, and the Snail Juga silicula", (Thesis), presented at the 29th Annual Meeting of the Health Physics Society, June 3-8, 1984, New Orleans, LA.

Numerous internal reports documenting facility radiological hazards assessments.

Curriculum Vitae
Mark C. Roberts, CHP

Education

Duquesne University -- BS, Physics, 1973
University of Pittsburgh -- MS, Radiation Health, 1974

Experience

June 1988 to Present	**Porter Consultants, Inc., Ardmore, PA** - *Health Physics Consultant.* Responsible for providing complete radiation safety services for field personnel involved in sampling and surveying a plutonium and americium contaminated site. Duties included personnel monitoring, site hazards training, air sampling and radiation surveys and proper handling and shipment of radioactive samples and wastes. Performed radiation safety checks on radiation-producing machines for a large university and two affiliated hospitals. Prepared a decontamination plan for a thorium contaminated industrial facility, including performing a site assessment and data analysis, as well as, serving as technical interface for client to state and federal regulatory agencies. Co-Coordinator for radon testing specialists course. Responsibilities include developing lesson plans and exams and presenting course lectures. Prepared health physics lectures and wrote procedures for laboratory and utility clients. Developed radiological emergency medical response plans for a nuclear utility and served as radiation emergency response team member.
February 1988 to June 1988	**Salem and Hope Creek Generating Stations, Public Service Electric & Gas Company, (Porter Consultants, Inc.)** - *Health Physics Consultant.* Responsible for whole body counting program during initial refueling outage at Hope Creek. Duties included review of all personnel whole body counts, determinations of internal versus external contamination of individuals, assessments of MPC-hour intakes, review of Quality Control data, and procedure revisions. Supervised technicians performing whole body counting and respirator fit-testing and reviewed fit-testing results. Assisted Radiation Health Department in budgetary reviews and the implementation of cost-savings measures.
March 1987 to October 1987	**Limerick Generating Station, Philadelphia Electric Company, (Porter Consultants, Inc.)** *Health Physics Consultant.* Responsible for the whole body contamination monitoring program during the initial refueling outage. Duties included directing the placement of whole body contamination monitors for optimum job coverage, shielding determinations and placement and directing troubleshooting activities. Assisted in evaluations involving effluent calculations and unplanned releases. Member of committee responsible for updating skin contamination determinations and skin dose calculation procedures.
March 1986 to February 1987	**Salem and Hope Creek Generating Stations, PSE&G, (Porter Consultants, Inc.)** - *Health Physics Consultant.* Responsible for assisting the corporate health physics section in the areas of whole-body counting, dosimetry, instrument calibration and respirator fit-testing. Prepared data for performance testing of personnel dosimeters, with primary emphasis on beta response evaluation. Worked with computer dose/record-keeping system for access control, dose records and training documentation. Evaluated data and performance of NaI and Germanium whole body counters to identify system capabilities and to aid in determination of internal vs. external contamination. Also responsible for developing

responses to NRC licensing and inspection findings in health physics areas, including generation of empirical data to support conclusions. Participated as a controller/evaluator for numerous Emergency Planning Drills and NRC Graded Exercises.

October 1987 to February 1988 & January 1986 to March 1986	**Porter Consultants, Inc.** - *Emergency Planning and Health Physics Consultant.* Responsible for writing documents to provide background for attorneys involved in radiation litigation cases, including personnel radiation dosimetry, whole body counting and radiation environmental monitoring.
March 1984 to December 1985	**Salem and Hope Creek Generating Stations, PSE&G, (Porter Consultants, Inc.)** - *Emergency Planning and Health Physics Consultant.* Responsible for writing health physics sections of the Emergency Plan and Emergency Plan Procedures. Developed lesson plans and conducted classroom and practical instruction for radiation protection and chemistry staffs. Involved in conducting, observing and critiquing the inplant health physics actions during numerous Emergency Planning Drills and developing corrective actions. Participated as a controller/evaluator in three annual Emergency Plan Graded Exercises in the area of health physics. Assisted in the evaluation and selection of the offsite dose calculation computer model.
January 1982 to February 1984	**Radiation Management Corporation (RMC), Philadelphia, PA.** - *Senior Health Physicist/ Corporate Radiation Safety Officer.* Responsible for managing health physics and environmental monitoring program for a depleted uranium test firing project at a U.S. government installation. This work required holding a Department of Defense "Secret" industrial clearance. Directly involved in numerous other health physics projects including evaluating data and assessing hazards at an industrial park contaminated with uranium and radium. Experienced in using large Curie sources for dosimeter and instrumentation irradiation. Responsible for all radiation safety and licensing activities as corporate Radiation Safety Officer, including dosimetry, source inventories, radioactive waste disposal and laboratory surveys.
October 1980 to January 1982	**Radiation Management Corporation** - *Manager, Radiological Laboratories.* Responsible for managing radiochemistry, environmental chemistry and counting laboratories and data review activities. Supervised more than 25 health physicists, chemists and technicians.
August 1974 to September 1980	**Radiation Management Corporation** - *Health Physicist/Environmental Scientist.* Responsible for instructing and developing course material for two 5-month training programs in health physics for new BWR health physics technicians. Prepared and presented General Employment Training and other basic and advanced health physics courses to various clients. Performed calibration of effluent and process monitors and determined set-points for radiation monitoring systems. Responsible for radiological environmental monitoring programs for nuclear power plants, including data review for trends and anomalies and preparation of annual and other technical reports.

Curriculum Vitae
Mark C. Roberts, CHP

May 1974 to August 1974 — **University of Pittsburgh, Pittsburgh, PA** - *Health Physics Associate.* Responsible for writing health physics procedures and nuclear instructions for Duquesne Light Company at its Beaver Valley Power Station. Work was performed part-time while in graduate school under an arrangement with the University of Pittsburgh.

Certifications

Comprehensive Certification in Health Physics (CHP) by the American Board of Health Physics (ABHP) - 1980. Recertified through 1992.

Professional Affiliations

Health Physics Society - Plenary Member, 1975 to present.

Delaware Valley Society for Radiation Safety (DVSRS) - Member, 1974 to present; Secretary 1980 - 1982, President-Elect 1987-1988, President 1988-1989, Member of By-laws and Local Meeting Arrangements Committees.

Susquehanna Valley Chapter - HPS, 1988 to present.

Additional Training

American Association of Radon Scientists and Technologists (AARST) - Certification Review for Radon Testing Specialists (16 hours) - 1988.

Public Service Electric & Gas Company - Boiling Water Reactor Technology Course (60 hours) - 1984.

DVSRS - Health Physics Training/Refresher Courses (54 hours each) - 1983, 1977, 1975.

DVSRS - Internal Dosimetry Symposium (12 hours) - 1982.

Experienced in the use of IBM-compatible micro-computers and database, spreadsheet, and word-processing software.

References

Furnished upon request.

STANLEY J. WALIGORA JR., CHP
Environmental Dimensions Inc.

QUALIFICATIONS SUMMARY

Mr. Waligora has over 30 years of diversified experience as a health physicist. His experience has included emergency training, applied health physics and industrial hygiene in the field and in research laboratories, environmental monitoring and assessment, radiochemical analysis, and a broad scope of related consulting projects. Services have been provided to nuclear utilities, nuclear fuel plants, uranium mills, and to a variety of government and industrial facilities. He has over 20 years experience in remedial action. He has prepared over 100 environmental surveillence reports at Nevada Test Site and for nuclear utilities, nuclear fuel plants, uranium resources companies, government facilities and for extractive industries dealing with naturally occuring radioactive materials. Mr. Waligora has been selected for a number of government and standards committees including ANSI Standards for internal and external dosimetry.

More recent project experience includes:

Evaluation and environmental risk assessment of naturally occuring radioactive materials in oil and gas production facilities.

Technical and Health & Safety support for Phase 2 of a RI/FS at a plutonium contaminated DOD site.

Environmental and health physics audits for a DOE prime contractor.

Internal dosimetry program for transuranic radionuclide.

CERTIFICATIONS

American Board of Health Physics-General Practice (Since 1968)
U.S. Public Health Service-Laboratory Director for Radiobioassay (Since 1973)
NM Environmental Improvement Division-Registered Qualified Expert (Since 1980)

EDUCATION

1959 **Siena College, B.S. Physics**
(N.Y. State Regents Scholarship and Siena College Tuition Scholarship)

1959-62 **U.S. Army**
Short Courses in health physics, instruction techniques, and management.

1964-67 **Environmental Protection Agency and Reynolds Electric**
Short courses in management, computer programming, and scheduling/critical path analysis.

1967-71 **University of New Mexico**
Part time graduate student in Physics (advanced calculus, quantum mechanics, radiological physics) and in Business Administration (law and psychology of motivation).

EMPLOYMENT HISTORY

1959-62 **Nuclear Weapons Officer-Instructor**
U.S. Army Defense Nuclear Agency (DASA)
Kirtland (Sandia) Base
Albuquerque, NM

Taught nuclear weapons and health physics to nuclear emergency teams. Major work at Nevada Test Site. Co-authored basic texts. Produced technical manuals, training films, and other training aids. Performed tritium bioassay analyses. Specialized in radiation detection instruments and biological effects of radiation. Rose to Course Supervisor for several programs and was Radiation Safety Officer for AEC By-product License.

1962-64 **Training Supervisor**
Radiological Sciences Dept.
Reynolds Electrical & Engineering Co., Inc.
Nevada Test Site
Mercury, NV

Technical and professional training in health physics and industrial hygiene. Developed and implemented a two-year training program for site technicians which became part of their Union Contract. Significant external training in Radiological Emergency Operations and other contracted AEC training for non/NTS personnel. Filled in as Radiological Safety Shift Supervisor. Special projects. Whole body counting liaison with EPA for routine and accident dosimetry.

1964-66 **Health Physicist (then) Chief, Data Processing**
U.S. Environmental Protection Agency (PHS)
Las Vegas, NV

Field Monitoring and environmental report writing for first 10 months. Data Processing supported data reduction for radiochemical analysis, environmental monitoring, whole body counting, and for radiobiological research. Supervised reorganization of this section and rapid hardware improvements (IBM 1620, SDS-925, CDC-1604). Helped prepare and teach the first Associate Degree program in X-Ray Technology (medical) at the University of Nevada-Las Vegas.

1966-67 **Health Physicist**
Reynolds Electrical & Engineering Co., Inc.
Nevada Test Site
Mercury, NV

Responsible for all applied health physics and industrial hygiene support for Lawrence Livermore Laboratory tests. Special projects in training, radioiodine monitoring, permissible levels of short half-lived radionuclides, and abatement of gaseous Ru-Rh-106. Design of new radiological facilities.

EMPLOYMENT HISTORY(cont'd)

1967-72 **Chief, Health Physics and Industrial Hygiene**
Inhalation Toxicology Research Institute
Lovelace Foundation
Albuquerque, NM

Responsible for occupational and environmental controls for research with radiological and non-radiological intoxicants along with laboratory safety. Radiation dosimetry assistance to principal investigators. Close work with Aerosol Physics Dept. Developed an effective cascade centripeter (virtual impactor) for airborne particle size distributions. Operated whole body counter (fission and activation products) and worked with Los Alamos for transuranic isotopes. Active in other DOE-ALOO work at Rocky Flats and G.E.-Pinellis (FL). Assisted in the first bronchopulmonary lavage for accidentally inhaled radioactive material. Clinical duties in Radiology at Lovelace Medical Center including therapy planning, calibration, and treatment. Taught math and physics to Radiology residents for Board Exams.

1972-89 **Facility Manager (then) Technical Director**
Eberline Analytical Corporation
Albuquerque, NM(Columbia, SC)

Joined the, then, Services Division of Eberline Instrument Corp. to build, staff, and manage the Southeastern Facility in Columbia, SC. Primarily a radiochemistry laboratory with radiation dosimetry, instrument calibration and maintenance, and instrument sales for southeastern U.S. Also responsible for business development. Reputation for quality work with rapid turnaround. Consulting in environmental programs, internal dosimetry, and medical physics. Prepared over 60 environmental reports for nuclear utilities and nuclear fuel plants including pre-operational summaries and annual assessments. Original work in radiochemical procedures. Major shielding integrity study (to 14 ft. thick concrete) for a reprocessing plant under construction. Designed and established an environmental analytical laboratory in Spain. Member of the SC Technical Education Committee for five Centers providing Assoc. Degrees in Nuclear Engineering Technology.

Promoted and transferred back to NM in 1977 to become Technical Director for the Nuclear Services Division.

Provided technical direction and business development for health physics services, radiochemical analyses, and external radiation dosimetry. Significant consulting and field work for governments and industry in radiological assessments and remedial actions. Early work for uranium mills and solution mining operations permitted effective solutions to problems associated with naturally occuring radioactive materials. Services for the latter were provided to oil and gas, phosphate, rare earths, geothermal, and other extractive industries. The diverse consulting practice included work for manufacturers of radium bearing building materials, users of a large pulsed x-ray machine, and attorneys and physicians for radiation dose assessments. Through applied research, he developed a six element radiation dosimetry badge capable of distinguishing shallow and deep doses in mixed radiation fields.

PUBLICATIONS AND PRESENTATIONS

"A Six Element Dosimetry Badge for Beta and Photon Spectrometry", Second Conference on Radiation Protection and Dosimetry, Orlando, FL, 1988.

"External Radiation Dosimetry at Nuclear Power Plants", 21st Midyear Topical Symposium, Health Physics Society, Miami, FL, 1987.

"Fundamentals and Current Directions of Solid State Dosimetry", Professional Enrichment Program. Health Physics Society Annual Meeting, Salt Lake City, UT, 1987.

"Pre-Operational Radiological Environmental Monitoring - Answers and Questions", Health Physics Society 19th Midyear Symposium, Colorado Springs, CO, 1985.

"Applied Neutron Spectrometry and Dosimetry", Health Physics Society, Rio Grande Chapter, Los Alamos, NM, 1985.

"Remedial Action Experience", EPA Region VII Conference, Lincoln, NE, 1982 (Invited).

"Instrumental and Radiochemical Assessment of Decontamination Operations", Health Physics Society Annual Meeting, Las Vegas, NM, 1982. Co-authors: Leon Leventhal, Robert Wessman, and Richard Powell.

"New Concepts in Radon and Radon Daughter Measurements", International Conference on Radiation Hazards in Mining, Golden, CO, 1981. Co-authors: Richard G. Terry and Rex Beard.

"Eberline's New Microcomputer Based Radon Daughter Instrument", International Symposium on Indoor Air Pollution, Health and Energy Conservation, Boston, MA, 1981. Co-authors: Eric L. Geiger and Rex Beard.

"Uranium Monitoring", "Operational Experience on Uranium Monitoring", and "Operational Experience on Radon Monitoring" (Invited), Summer School on Uranium Health Physics, South African Association of Physicists in Medicine and Biology, Johannesburg and Pretoria, South Africa, 1980.

"Neutron Monitoring and Dosimetry at Nuclear Power Plants", Health Physics Society Annual Meeting, Seattle, WA, 1980.

"Neutron Dosimeter Calibration at Nuclear Power Plants Through Instrument Surveys", American Industrial Hygiene Conference, Chicago, IL, 1979.

"Radiochemistry" Chapter in <u>Quality Assurance for Health Laboratories</u>, American Public Health Association, 1978.

PUBLICATIONS(cont'd)

"Pre-Operational Baseline Data - Methodology Used in Environmental Surveillance", Southeastern Seminar on Environmental Radiation Surveillance, Montgomery, AL, 1974.

"Pulmonary Retention of Zirconium Oxide (Nb-95) in Man and Beagle Dogs", Health Physics, 1971. Co-author: Chester R. Richmond.

"Safety Aspects of Research with Respirable Radioactive Aerosols", Radiation in High Level Facilities (IAEA), Saclay, France, 1970. Co-author: J.A. Mewhinney.

"Incineration of Solid Wastes", Solid Waste Disposal Symposium, Defense Nuclear Agency, Albuquerque, NM, 1970.

"Off-Site Survey Operation Roller Coaster, U.S. Public Health Service, 1969. Co-authors: J.S. Coogan and D.L. Waite.

"Incineration of Low Level Radioactive Wastes", 4th ALO Health Protection Conference, St. Petersburg, FL, 1969.

"Health Physics Aspects of the Fission Product Inhalation Program", Western Industrial Health Conference, Las Vegas, NV, 1968. Co-authors: C. R. Richmond, R. G. Cuddihy, and R. O. McClellan.

Radiological Emergency Operations (editor and contributor) for AEC by Reynolds Electrical and Engineering Co., Mercury, NV, 1967. (Many co-authors for this combined student text and instructors manual.)

Basic Nuclear and Radiation Physics, Defense Nuclear Agency, Albuquerque, NM, 1961. Co-authors: Otto G. Raabe and M. Edward Wrenn.

Principles of Radiation Detection Instruments, Defense Nuclear Agency, Albuquerque, NM, 1960. Co-author: William Lynch.

Many reports have been written for customers through consulting work. These include:

60 Annual Reports of environmental surveillance results for nuclear power plants. Four reports were a detailed summary of multi-year baseline or pre-operational data.

12 Environmental reports for uranium mills, heap leaching and solution mining operations. Most for License Applications with source term determination and dose modeling.

2 Pre-operational monitoring summary reports for special Nuclear fuel plants.

PUBLICATIONS(cont'd)

1 Extensive, multi-volume, health physics procedures manual for the U.S. Navy.

6 Reports to oil and mining companies characterizing naturally occuring radioactive materials at various sites.

COMMITTEES, OFFICES AND HONORARIA

1987 (Continues) American National Standard Institute and Health Physics Society Committee to review/revise ANSI N 13.11 Standard for Dosimetry - Personnel Dosimetry Performance - Criteria for Testing.

1988 (Continues) Continuing and General Education Committee of the Health Physics Society.

1983-86 American Board of Health Physics Preparation Course. Rio Grande Chapter of the Health Physics Society. Organized and helped instruct three five-month courses for members preparing for Certification by ABHP.

1982-83 U.S. Environmental Protective Agency. "Radiological Sampling and Analytical Methods for National Primary Drinking Water Regulations". Two years culminating in a Work Shop. Final report part of Analytical Methods for National Drinking Water Regulations.

1981-83 Chapter Council. Rio Grande Chapter, Health Physics Society (elected).

1980 South African Association of Physicists in Medicine. Presented three of ten lectures for Uranium Health Physics Summer School in Pretoria.

1977-78 American National Standards Institute and Health Physics Society Committee to prepare ANSI-N-1978 Internal Dosimetry for Fission and Activation Products.

1974-77 Environmental Radiation Committee. Charter member of ad hoc committee led by Dr. James Watson, Univ. of North Carolina. Now the Environmental Radiation Section of the Health Physics Society.

1973-77 South Carolina Technical Education Committee. Committee directing programs at five Centers offering Associate Degrees in Nuclear Engineering Technology.

1976-77 American Public Health Association. Co-authored chapter on Radiochemistry for Quality Assurance Practices for Health Laboratories (published 1978).

COMMITTEES, OFFICES AND HONORARIA(cont'd)

1969 and 1971 American Industrial Hygiene Association Chairman, Technical Committee on Ionizing Radiation.

1966 Secretary-treasurer, Lake Mead Chapter, Health Physics Society (elected).

REMEDIAL ACTION EXPERIENCE

1961 KIWI-A-PRIME - Nevada Test Site
Retrieved fuel rod fragments and graphite core components which were ejected from this bare reactor prototype of a nuclear rocket engine.

1970 Nuclear Fuel Plant - Maryland
Consultant for Eberline and client in the decontamination and restoration of a special nuclear fuel plant and associated radiochemistry laboratory totalling approximately 100,000 square feet. Tasks included assessment, planning and management, decontamination procedures, packaging and shipment of major waste quantities, and final certification. Occupational and environmental health physics.

1979 Canonsburg - Pennsylvania
Decontamination of vicinity properties for NLO before the UMTRA program. Characterization, assessment, clean-up and final certification. Occupational and environmental health physics.

1981 Present Formerly Utilized Sites Remedial Action Program (FUSRAP) Technical and field tasks for various sites in this 30+ site program with Bechtel National for DOE. On-site work for periods up to one month.

1986 Town of Tonawanda, NY
Decontamination of sewer line and sewage treatment plant and remediation of land fill contaminated with Americium-241. Five to ten curies of effluent from smoke detector manufacturing plant. Started as consultant, then bid successfully on remedial action.

1988 Los Alamos National Laboratory Environmental Restoration Program. Assist in planning remedial investigations with Roy F. Weston for DOE.

1989 U.S. Air Force Installation Restoration.
RI/FS Phase 2 for plutonium contaminated BOMARC site of McGuire AFB with Science Applications International Corp.

RADIATION DETECTION SYSTEMS EXPERIENCE

U.S. ARMY - Responsible for unit instruction on radiation detection for several courses; included theory and instrument application. Helped evaluate Eberline PAC-3G and PAC-1S to permit military standard; became AN/PDR-54 and AN/PDR-60. Taught and demonstrated portable and fixed instruments for field use and for analytical measurements.

Reynolds Electric - Helped design and develop a new low background proportional counter.

Helped design and implemented gate monitoring systems for security gates. Utilized a set of four arrays of long G-M tubes below grade, vertical sides, and overhead.

Worked with EPA in whole body counter calibration and data interpretation for accidental over-exposure to I-131.

Environmental Protection Agency - Gamma scintillation counters with 5x8 NaI(Tl) detectors in shields fabricated from pre WWII 16 in. naval gun barrels. Rapid screening of vegetation samples with quick isopleths for airborne effluent.

Assisted in the first use of EG&G thermoluminescent dosimeters in environmental monitoring. Identified and helped remove self-dosing dosimeter components containing natural radioactive material.

Developed and maintained algorithims for analytical data reduction with input of raw data from instruments including laboratory and whole body counting equipment. Took gamma spectrometry from an eight isotope array to a library of 28 isotopes.

Lovelace Inhalation Toxicology Research Institute - Operated whole body counter for routine gamma ray energies and worked with Los Alamos on analysis of very low energied photons for transuranics.

In-house systems for continuous air monitors and surface (personnel) contamination monitors. Work with Rocky Flats on similar design and applications.

Supported research dosimetry with Harshaw TLD system.

Designed and fabricated an effective cascade centripeter to determine airborne particle size distributions for effective inhalation dose modelling.

RADIATION DETECTION SYSTEMS EXPERIENCE(cont'd)

<u>Eberline</u> - Build and implemented a radiochemistry laboratory and instrument calibration facility.

Designed and implemented an environmental radiochemistry laboratory. Two year effort for a Spanish architect-engineering firm.

Input to design of various new Eberline instruments. Radon daughter monitor modified to prevent plate out of polonium-218 and added automatic post sampling counts for thoron daughter determination.

Assisted in assessing a special detection system to monitor transuranics in Johnston Atoll on a conveyor belt system.

INTERNAL RADIATION DOSIMETRY

1959-62 Taught internal dosimetry for plutonium, enriched uranium, tritium, and fission and activation products to nuclear emergency team personnel. Analyzed routine urine samples for tritium from military personnel throughout the world.

1962-64 Training for Nevada Test Site personnel and for DOE (AEC) and contractor personnel from other facilities. Detailed dosimetry for several personnel through accidental over-exposure to iodine-131. Detailed and extensive whole body counts with EPA (PHS) to determine effective half-life and dose commitment.

1965-66 Computer programs and algorithms for the Bioenvironmental Research Program and for the thyroid counting of residents in the vicinity of the Nevada Test Site. Project Roller Coaster report of off-site surveillance included estimated dose commitments from plutonium inhalations.

1967 Dose Commitment calculations for short, half-lived fission and activation products, primarily with gaseous precursors, at Nevada Test Site.

1967-72 Lovelace Inhalation Toxicology Research Institute. Chief of Health Physics and Industrial Hygiene for major research project with emphasis on inhalation studies with fission and activation products, and transuranic radionuclides. In-house whole body counting of research staff, supplemented with routine phoswich counting at Los Alamos. Able to determine clearance with very low but measurable burdens of specific radionuclides and matrices. Assisted in bronchopulmonary lavage for an individual following accidental inhalation; including relationships of chest counts at various DOE facilities to extensive bioassay (urine, feces, blood, nose blows, etc.) along with combined effects of the lavage and chelate therapy.

INTERNAL RADIATION DOSIMETRY (cont'd)

1972-89 Internal dosimetry for many clients and projects utilizing Eberline health physics and radiochemistry services. The scope ranged from contractor and vicinity residents during remedial action projects to discrete and unrelated incidents. Examples include uptake of C-14 and H-3 labelled glucose in a hospital laboratory by children who were in-patients. Relation of post mortem tissues analyses to potential occupational uptake. Work with both physicians and attorneys. Internal dosimetry for personnel in the extractive industries who have encountered naturally occuring radioactive material.

1977-78 ANSI-N-1978 Internal Dosimetry for Fission and Activation Products.

SUMMARY OF CONSULTING EXPERIENCE

Environmental monitoring program design, implementation, and assessment for uranium mills and solution mines, nuclear fuel plants, nuclear utilities, waste disposal sites, and government and industrial facilities. Modelling of predicted and actual source terms. Special studies and problems.

Internal radiation dosimetry including correlation of inhaled/ingested material to bioassay data for the above client base plus physicians and attorneys. Routine and accident dose commitment determinations.

Remedial investigations and actions for local, state and federal facilities. Also for extractive industries and other corporations. Routine and emergency conditions.

Radiochemistry including new procedures, bench-top tests prior to major processing, quality assurance audits, identity of physical-chemical matrices containing contaminants, and establishment of analytical laboratories.

Shielding integrity studies for fuel reproccessing tanks, shipping casks, neutron poison panels, and large burst x-ray machines.

Neutron spectrometry including measurements and use of LOUHI and BON codes for data reduction. Nuclear power plants and a DOE facility.

SUMMARY OF CONSULTING EXPERIENCE(cont'd)

Licensing assistance to uranium mills and a broad scope of medical and industrial applications. Source materials licensing including unusual concentrations of naturally occuring radioactive materials in the extractive industries.

Naturally occuring radioactive materials in the latter case above including occupational and environmental controls, locations of specific source terms within processes, and disposal and stabilization of mixed (radioactive and toxic) wastes.

Development of radiation detection systems ranging from field laboratories to special equipment to monitor unique problems.

Program reviews and audits for occupational and environmental health physics; exposure monitoring and control programs, radiochemistry laboratories, and procedure assessments. Follow-up after Technical Safety Appraisals and Tiger Team audits.

Special projects for a broad scope of operations. Examples include radon emanation from radium bearing construction materials, tracer radionuclides for process monitoring and enhanced oil recovery, alpha emitting contaminants in microchip manufacturing, and as an intermediary between industry and regulatory agencies.

Training ranging from basic health physics and radiation detection to specialized programs encompassing virtually all topics above. Regulatory compliance training has included elements of the new NRC 10 CFR 20 and DOE orders including 5480.11.

APPENDIX P

RADIOACTIVE MATERIALS LICENSES, CERTIFICATES FOR EXEMPT QUANTITIES SHIPPING MANIFESTS

NRC Form 374
(5-84)

U.S. NUCLEAR REGULATORY COMMISSION

MATERIALS LICENSE

Amendment No. 02

Pursuant to the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974 (Public Law 93-438), and Title 10, Code of Federal Regulations, Chapter I, Parts 30, 31, 32, 33, 34, 35, 40 and 70, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, acquire, possess, and transfer byproduct, source, and special nuclear material designated below; to use such material for the purpose(s) and at the place(s) designated below; to deliver or transfer such material to persons authorized to receive it in accordance with the regulations of the applicable Part(s). This license shall be deemed to contain the conditions specified in Section 183 of the Atomic Energy Act of 1954, as amended, and is subject to all applicable rules, regulations and orders of the Nuclear Regulatory Commission now or hereafter in effect and to any conditions specified below.

Licensee

1. Teledyne Isotopes, Inc.

2. 50 Van Buren Avenue
Westwood, New Jersey 07675

In accordance with letter dated August 27, 1986,

3. License number SNM-107 is amended in its entirety to read as follows:

4. Expiration date July 31, 1992

5. Docket or Reference No. 070-00124

6. Byproduct, source, and/or special nuclear material	7. Chemical and/or physical form	8. Maximum amount that licensee may possess at any one time under this license
A. Uranium 232	A. Any	A. 2.0 micrograms
B. Uranium 233	B. Any	B. 1.5 grams
C. Uranium 235	C. Any	C. 240[illegible] grams
D. Plutonium 236	D. Any	D. 2.0[illegible] micrograms
E. Plutonium 238	E. Any	E. 5.[illegible] milligrams
F. Plutonium 239	F. Any	F. 10.[illegible]16 grams
G. Plutonium 240	G. Any	G. 10[illegible]4 milligrams
H. Plutonium 241	H. Any	H. 8[illegible]00089 milligrams
I. Plutonium 242	I. Any	I. [illegible]0 milligrams
J. Plutonium 244	J. Any	J. [illegible]00 milligrams
K. Any Special Nuclear Material.	K. Any	K. 2.0 grams

9. Authorized use

For use in research and development as defined in Section 70.4(j), 10 CFR Part 70, sample analysis, calibration of instruments and dosimeters for clients and as reference samples in tracer studies. For possession as recovered from decontamination processes on precious metals.

CONDITIONS

10. Licensed material shall be used only at 50 Van Buren Avenue, Westwood, New Jersey.

11. Licensed material shall be used by, or under the supervision of, individuals designated by the licensee's Radiation Safety Committee, Donald F. Schultz, Chairman.

12 A(1) Any sealed sources specified in Items 7.A. through 7.K. shall be tested for leakage and/or contamination at intervals not to exceed three months. Any source received from another person which is not accompanied by a certificate indicating that a test was performed within three months before the transfer shall not be put into use until tested.

NRC Form 374A (4-82)

U.S. NUCLEAR REGULATORY COMMISSION

MATERIALS LICENSE
SUPPLEMENTARY SHEET

License number: SNM-107

Docket or Reference number: 070-00124

Amendment No. 02

(12. continued)

CONDITIONS

(2) Notwithstanding the periodic leak test required by this condition, any licensed sealed source is exempt from such leak tests when the source contains 100 microcuries or less of beta and/or gamma emitting material or 10 microcuries or less of alpha emitting material.

B. Any sealed source or detector cell in storage and not being used need not be tested. When the source or detector cell is removed from storage for use or transfer to another person, it shall be tested before use or transfer.

C. The test shall be capable of detecting the presence of 0.005 microcurie of radioactive material on the test sample. If the test reveals the presence of 0.005 microcurie or more of removable contamination, the source or detector cell shall be removed from service and decontaminated, repaired, or disposed of in accordance with Commission regulations. A report shall be filed within 5 days of the date the leak test result is known with the U.S. Nuclear Regulatory Commission, Region I, ATTN: Chief, Nuclear Materials Safety and Safeguards Branch, 631 Park Avenue, King of Prussia, Pennsylvania 19406. The report shall specify the source involved, the test results, and corrective action taken. Records of leak test results shall be kept in units of microcuries and shall be maintained for inspection by the Commission. Records may be disposed of following Commission inspection.

D. Tests for leakage and/or contamination shall be performed by the licensee or by other persons specifically licensed by the Commission or an Agreement State to perform such services.

13. The licensee shall conduct a physical inventory every 6 months to account for all sources and/or devices received and possessed under the license. Records of inventories shall be maintained for 2 years from the date of each inventory.

14. The licensee may transport licensed material in accordance with the provisions of 10 CFR Part 71, "Packaging and Transportation of Radioactive Material".

15. The licensee is exempted from the requirement of Section 70.24 of 10 CFR Part 70, insofar as the Section applies to the material covered by this license. The total quantities of Special Nuclear Material in the laboratory facility shall contain less than 450 grams.

NRC Form 374A
(8-82)

U.S. NUCLEAR REGULATORY COMMISSION

MATERIALS LICENSE
SUPPLEMENTARY SHEET

License number: SNM-107

Docket or Reference number: 070-00124

Amendment No. 02

(Continued)

CONDITIONS

16. Except as specifically provided otherwise in this license, the licensee shall conduct its program in accordance with the statements, representations, and procedures contained in the documents including any enclosures, listed below. The Nuclear Regulatory Commission's regulations shall govern unless the statements, representations and procedures in the licensee's application and correspondence are more restrictive than the regulations.

    A. Letter dated August 27, 1986
    B. Radiation Safety Code and Quality Control Manual dated August, 1986
    C. Letter dated May 14, 1987

For the U.S. Nuclear Regulatory Commission

Date JUL 27 1987

By [signature]
Nuclear Materials Safety and
Safeguards Branch, Region I
King of Prussia, Pennsylvania 19406

NEW MEXICO
HEALTH AND ENVIRONMENT
DEPARTMENT

ENVIRONMENTAL IMPROVEMENT DIVISION

RADIOACTIVE MATERIAL LICENSE

JUN 18

Pursuant to the New Mexico Radiation Protection Act of 1971, and the Radiation Protection Regulations Part 3, and in reliance on statements and representations heretofore made by the licensee designated below, a license is hereby issued authorizing such licensee to transfer, receive, possess and use the radioactive material(s) designated below; and to use such radioactive materials for the purpose(s) and at the place(s) designated below. This license is subject to all applicable rules, regulations, and orders now or hereafter in effect, of the New Mexico HED Environmental Improvement Division and to any conditions specified below.

1. LICENSEE NAME TMA/Eberline	3. LICENSE NUMBER NM-TMA-GL-00
2a. ADDRESS 5635 Kircher Blvd., NE Albuquerque, New Mexico 87109	4. EXPIRATION DATE October 31, 1992 5. PREVIOUS/OTHER LICENSE NUMBER NM-EBE-BL
2b. TELEPHONE NO. (505)345-9931 (505)345-3461	2c. ACTUAL LOCATION OF OPERATION 5635 Kircher Blvd., NE, Albuq., NM 87109 (Admin., Dosimetry, Health Phys.), 7201 Pan American HWY., Albuq. (Lab. Facilities)

6. RADIOACTIVE MATERIALS (element and mass number)	7. CHEMICAL or PHYSICAL FORM	8. MAXIMUM QUANTITY Licensee may possess at any one time
A. Any radioactive materials between atomic numbers 1 and 83, inclusive.	A. Any.	A. Not to exceed 20 millicuries per radionuclide, except: Hydrogen 3. 5 curies Cobalt 60. 10 curies Krypton 85. 2 curies Strontium 90. 1 curie Xenon 133. 1 curie Promethium 147. 1 curie
B. Neptunium 237. and 239.	B. Any.	B. 20 millicuries.
C. Americium 241.	C. Any.	C. Ten curies.
D. Americium 243.	D. Any.	D. 20 millicuries.
E. Radium (any isotope)	E. Any.	E. One millicurie.
F. Actinium (any isotope)	F. Any.	F. One millicurie.
G. Protactinium (any isotope)	G. Any.	G. One millicurie.

NEW MEXICO HEALTH AND ENVIRONMENT DEPARTMENT

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H. Any radioactive material with atomic number greater than 95.	H. Any.	H. One millicurie total.
I. Uranium 235.	I. Any.	I. Two grams (4.4 microcuries).
J. Uranium 233.	J. Any.	J. 0.01 grams (94 microcuries).
K. Plutonium 239.	K. Any.	K. 30 grams (1.8 curies).
L. Plutonium 238.	L. Any.	L. 0.1 gram (1.7 curies).
M. Plutonium (all isotopes other than 238. and 239.).	M. Any.	M. Two grams (maximum of eight millicuries).
N. Polonium 210.	N. Any.	N. Five microcuries.
O. Depleted uranium.	O. Metallic (99.8 percent U-238).	O. Not to exceed 12 kilograms.
P. Californium 252.	P. Sealed source (Isotope Products Model No. N-252-3).	P. One source not to exceed 50 microcuries.
Q. Cesium 137.	Q. Sealed sources (Eberline Instrument Corp. Model No. 1000B	Eight sources totaling 180.362 curies contained in a single shield. Individual sources are: 100 microcuries. 28 millicuries. 7.9 millicuries. 158 millicuries. 292 millicuries. 3.1 curies. 7.8 curies. 169 curies.

NEW MEXICO
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R. Cesium 137.	R. Sealed source (Troxler Encapsulation Dwg. No. A-102112).	R. Not to exceed eight millicuries.
S. Americium 241./Beryllium.	S. Sealed source (Troxler Encapsulation Dwg. No. A-102451.	S. Not to exceed 40 millicuries.
T. Thorium 230.	T. Any.	T. Not to exceed 30 microcuries.
U. Americium 241.	U. Calibration and reference source DNS-5.	U. As stated in sub-item C.
V. Barium 133.	V. Calibration and reference sources S-2, S-3 and CS-18.	V. As stated in sub-item A.
W. Carbon 14.	W. Calibration and reference source CS-4A.	W. As stated in sub-item A.
X. Cesium 137.	X. Calibration and reference sources CS-7A, CS.7B, CS-21 and CS-23.	X. As stated in sub-item A.
Y. Cobalt 60.	Y. Calibration and reference source DNS-6.	Y. As stated in sub-item A.
Z. Depleted uranium.	Z. Calibration and reference source DNS-26.	Z. As stated in sub-item O.
AA. Hydrogen 3.	AA. Calibration and reference source CS-14.	AA. As stated in sub-item A.

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BB. Plutonium 239.	BB. Calibration and reference sources CS-1, CS-3, DNS-1, DNS-7, DNS-16, DNS-16S, DNS-21S, S-S94-1 and S-94-4.	BB. As stated in sub-item K.
CC. Strontium 90/Yttrium 90.	CC. Calibration and reference sources CS-19, CS-20, CS-22, CS-24, DNS-2 and DNS-14.	CC. As stated in sub-item A.
DD. Technitium 99.	DD. Calibration and reference sources CS-13, DNS-3, DNS-12, DNS-13, DNS-18, DNS-19, S-4, S-5 and CS-13.	DD. As stated in sub-item A.
EE. Technitium 99/Thorium 230.	EE. Calibration and reference sources DNS-8 and DNS-9.	EE. As stated in sub-item A for technitium and as stated in sub-item T. for thorium.
FF. Thorium 230.	FF. Calibration and reference sources CS-10, CS-11, CS-12, CS-15, CS-16, CS-17, DNS-4, DNS-11 and S-1.	FF. As stated in sub-item T.

9. AUTHORIZED USE (Unless otherwise specified, the authorized place of use is the location stated in Item 2c. above)

Licensed material shall be used only at:

7201 Pan American Hwy., N.E., Albuquerque, New Mexico 87110;
5635 Kircher Blvd., N.E., Albuquerque, New Mexico 87109, and

NEW MEXICO HEALTH AND ENVIRONMENT DEPARTMENT

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temporary job sites as specified in Condition 16. of this license.

A. through M. For use in research and development, calibration, demonstration and training, manufacture of calibrations and reference sources for distribution to authorized recipients, leak testing and radiochemistry applications.

N. For use as a tracer in chemical analysis.

O. For the manufacture of calibration or reference sources for distribution to authorized recipients.

P. For use as a training aid during instruction in the operation and interpretation of neutron measuring instruments.

Q. For use in calibration of instruments and lithium fluoride chips used in thermo-luminescent dosimeters.

R. and S. For use in Troxler 3400 Series Density/Moisture gauge used for neutron spectrometry calibration studies.

T. For the manufacture of calibration or reference sources to authorized recipients.

U. through FF. Manufacture and distribution of calibration and reference sources to persons generally licensed to receive such sources in accordance with New Mexico Radiation Protection Regulations 3-220 D or equivalent provision of regulations of the U.S. Nuclear Regulatory Commission or any Agreement State.

10. The licensee shall comply with the provisions of Parts 3., 4., and 10., New Mexico Radiation Protection Regulations.

11. Radioactive materials shall be used by or under the direct supervision of individuals deemed qualified by the Corporation's Isotope Committee. Names and evidence of training of these individuals shall be kept on file for inspection by this Division.

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ENVIRONMENTAL IMPROVEMENT DIVISION

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License Number NM-TMA-GL-00

12. The Director of the Division or his authorized representatives shall be allowed to enter the premises and inspect the radiation related activities at all times. Failure of the licensee to admit the Director or his authorized representatives shall constitute grounds for issuance of an immediate cease and desist order.

13. A. (1) Each sealed source acquired from another person and containing licensed material, other than Hydrogen 3, with a half-life greater than thirty days and in any form other than gas shall be tested for contamination and leakage prior to use. In the absence of a certificate from a transferor indicating that a test has been made within six months prior to the transfer, a sealed source received from another person shall not be put into use until tested.

(2) Notwithstanding the periodic leak test required by this condition, any licensed sealed source is exempt from such leak tests when the source contains 100 microcuries or less of beta and gamma emitting material or 10 microcuries or less of alpha emitting material.

(3) Except for alpha sources, the periodic leak test required by this condition does not apply to sealed sources that are stored and not being used. The sources excepted from this test shall be tested for leakage prior to any use or transfer to another person unless they have been leak tested within six months prior to the date of use or transfer.

B. Each sealed source fabricated by the licensee shall be inspected and tested for construction defects, leakage, and contamination prior to use or transfer as a sealed source. If the inspection or test reveals any construction defects or 0.005 microcurie or greater of contamination, the source shall not be used or transferred as a sealed source until it has been repaired, decontaminated and retested.

C. Each sealed source containing licensed material, other than Hydrogen 3, with a half-life greater than thirty days and in any form other than gas, shall be tested for leakage and contamination at intervals not to exceed six months except that each source designed for the purpose of emitting alpha particles shall be tested at intervals not to exceed three months.

D. The test shall be capable of detecting the presence of 0 005 microcurie of radioactive material on the test sample. The test sample shall be taken from the sealed source or from the surfaces of the device in which the

NEW MEXICO HEALTH AND ENVIRONMENT DEPARTMENT

ENVIRONMENTAL IMPROVEMENT DIVISION

RADIOACTIVE MATERIAL LICENSE

License Number NM-TMA-GL-00

sealed source is permanently or semi-permanently mounted or stored on which one might expect contamination to accumulate. Records of leak test results shall be kept in units of microcuries and maintained for inspection by the Division.

E. If the test required by paragraph A. or C. of this condition reveals the presence of 0.005 microcurie or more of removable contamination, the license shall immediately withdraw the sealed source from use and shall cause it to be decontaminated and repaired or to be disposed of in accordance with Division regulations. A report shall be filed within five days of the test with the Radiation Protection Bureau, Environmental Improvement Division, P.O. Box 968, Santa Fe, New Mexico 87504-0968.

14. The licensee shall furnish each general licensee to whom such sources are transferred a copy of Part 3-220.D., New Mexico Radiation Protection Regulations. The licensee may substitute for Part 3-220.D., the equivalent provisions of U.S. Nuclear Regulatory Commission or other Agreement State regulations for recipients under U.S. Nuclear Regulatory Commission or other Agreement State regulations for recipients under U.S. Nuclear Regulatory Commission or other Agreement State jurisdiction.

15. The storage container for each sealed source distributed under this license shall be provided with a durable label containing the radiation symbol in conventional colors (magenta or purple on yellow background), the words "CAUTION - RADIOACTIVE MATERIAL", the name of the manufacturer and the following statements or substantially similar statement:

A. The receipt, possession, use and transfer of this source, Model ________, Serial ______________, are subject to a general license and the regulations of the U.S. Nuclear Regulatory Commission or of a State with which the Commission has entered into an agreement for the exercise of regulatory authority.

B. Do not remove this label.

16. Calibration and reference sources listed in sub-items U. through FF. may be used at temporary job or training sites by the licensee, provided the licensee maintains an inventory and date and place of use, on record, for inspections by the Division.

NEW MEXICO HEALTH AND ENVIRONMENT DEPARTMENT

ENVIRONMENTAL IMPROVEMENT DIVISION

RADIOACTIVE MATERIAL LICENSE

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17. No source distributed under this license shall contain more than five microcuries of Americium-241 or Plutonium.

18. Except for plutonium contained in a medical device designed for individual human application, no plutonium, regardless of form, shall be delivered to a carrier for shipment by air transport or transported in an aircraft by the licensee except in packages the design of which the U.S. Nuclear Regulatory Commission has specifically approved for transport of plutonium by air.

19. Except as specifically provided otherwise by this license, the licensee shall possess and use licensed material described in Items 6., 7. and 8. of this license in accordance with statements, representations and procedures contained in the following:

    A. Application for New Mexico Radioactive Material License Number NM-EBE-GL-00, dated December 16, 1976, signed by Eric L. Geiger.

    B. Additional documentation supplied by Eric L. Geiger on April 7 and June 23, 1977.

    C. Application dated October 29, 1985, signed by Roger Herd and Dara L. Greiger.

    D. Application dated June 25, 1986, signed by Nels Johnson and Dara L. Greiger.

For the New Mexico HED Environmental Improvement Division

DATE November 6, 1987

BY [signature]

Benito J. Garcia, Program Manager
Licensing and Registration Section

Science Applications International Corporation
An Employee-Owned Company

March 16, 1990

Ms. Donna Collins
SAIC
14062 Denver West Parkway
Building 52, Suite 250
Golden, Colorado 80401

Dear Ms. Collins

This letter is to confirm my position, as outlined by our phone conversation, regarding the use of our Rockville Maryland Radioactive Material License Number MD-31-076-01 at the Air Force site in New Jersey during 1989. The license is very specific as to the use of various sources and the location where such sources can be used. Three such sources may be used in locations other than the Rockville laboratory and they are Cesium-137, Thorium-228 and Nickel-63. On page 5 (of 9) of the license under "Authorized Use" is the Thorium-228 source, used for calibration of radiation measurement instrumentation. This Thorium-228 sealed source is the only source supplied by the Rockville lab to the Air Force site in New Jersey. As you can see, we can not assume responsibility for any other sources that may have been used there. Please, as requested by phone, notify the Air Force and any others concerned of our position and responsibilities regarding this matter.

If you have any questions, please feel free to call me at 301-977-4480.

Sincerely,

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

Edgar D. Barefoot

Edgar D. Barefoot
Radiation Safety Officer
Utility Service Operation

RECEIVED
MAR 19 1990

3 Choke Cherry Road, Rockville, Maryland 20850 (301) 977-4480
Other SAIC Offices: Albuquerque, Boston, Colorado Springs, Dayton, Huntsville, Las Vegas, Los Angeles, McLean, Oak Ridge, Orlando, Palo Alto, San Diego, Seattle, Tucson

State of Maryland

(CORRECTED COPY OF PAGES 1 AND 7 ONLY)

DEPARTMENT OF THE ENVIRONMENT

ASSISTANT SECRETARIAT FOR

TOXICS, ENVIRONMENTAL SCIENCE AND HEALTH

CENTER FOR RADIOLOGICAL HEALTH

RADIOACTIVE MATERIAL LICENSE

In accordance with application dated February 28, 1986, Radioactive Material License MD-31-076-01 is amended in its entirety.

Pursuant to the Maryland Radiation Act, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, acquire, possess and transfer radioactive material listed below; and to use such radioactive material for the purpose(s) and at the place(s) designated below. This license is subject to all applicable rules, regulations and orders of the Maryland State Department of the Environment, now or hereinafter in effect and to any conditions specified below.

LICENSEE	
1. Name: Science Applications International Corporation 2. Address: 3 Choke Cherry Road, Rockville, Maryland 20850	3. License No.: MD-31-076-01 4. Amendment No.: 24 5. Expiration Date: March 31, 1993

6. Radioactive material (element and mass number)	7. Chemical and/or physical form	8. Maximum amount of radioactivity which licensee may possess at any one time
A. Beryllium-7	A. Any	A. One millicurie
B. Sodium-22	B. Any	B. One millicurie
C. Radium-228	C. Any	C. One millicurie
D. Hydrogen-3	D. Any	D. One curie
E. Carbon-14	E. Any	E. One curie
F. Phosphorus-32	F. Any	F. One millicurie
G. Sulphur-35	G. Any	G. 100 millicuries
H. Chlorine-36	H. Any	H. 100 millicuries
I. Chromium-51	I. Any	I. One curie
J. Manganese-54	J. Any	J. 100 millicuries
K. Iron-55	K. Any	K. One curie

9. Authorized Use

A thru KKKK Contained in samples received for analysis; tracer in radiochemical separations; except standard or reference material; calibration of instruments and analytical methods DDD&PPP) development.

State of Maryland

201 WEST PRESTON STREET
BALTIMORE 21201

DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIAL LICENSE

Supplementary Sheet

License No. MD-31-076-01 | Amendment No. 24

CONT'D

6. Radioactive material (element and mass number)	7. Chemical and/or physical form	8. Maximum amount of radioactivity which licensee may possess at any one time
L. Cobalt-57	L. Any	L. 100 millicuries
M. Cobalt-58	M. Any	M. 100 millicuries
N. Nickel-59	N. Any	N. 100 millicuries
O. Iron-59	O. Any	O. 100 millicuries
P. Cobalt-60	P. Any	P. One curie
Q. Nickel-63	Q. Any	Q. One curie
R. Nickel-63	R. Sealed source (Valco Model No. 140 BN)	R. No source to exceed 5 millicuries; Total possession 100 millicuries
S. Zinc-65	S. Any	S. 100 millicuries
T. Krypton-85	T. Any	T. One curie
U. Strontium-89	U. Any	U. 10 millicuries
V. Strontium-90	V. Any	V. 10 millicuries
W. Yttrium-90	W. Any	W. 10 millicuries
X. Niobium-94	X. Any	X. 10 millicuries
Y. Niobium-95	Y. Any	Y. 100 millicuries
Z. Zirconium-95	Z. Any	Z. 100 millicuries

9. Authorized use

T. In addition to above, also for testing the efficiency of various absorbers for noble gas retention.

Date

State of Maryland

201 WEST PRESTON STREET
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DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIAL LICENSE

Supplementary Sheet

License No. MD-31-076-01	Amendment No. 24

CONT'D

6.	Radioactive material (element and mass number)	7.	Chemical and/or physical form	8.	Maximum amount of radioactivity which licensee may possess at any one time
AA.	Calcium-45	AA.	Any	AA.	100 millicuries
BB.	Scandium-46	BB.	Any	BB.	100 millicuries
CC.	Selenium-75	CC.	Any	CC.	100 millicuries
DD.	Cobalt-56	DD.	Any	DD.	10 millicuries
EE.	Yttrium-88	EE.	Any	EE.	100 millicuries
FF.	Strontium-85	FF.	Any	FF.	100 millicuries
GG.	Cerium-139	GG.	Any	GG.	10 millicuries
HH.	Bismuth-207	HH.	Any	HH.	10 millicuries
II.	Barium-133	II.	Any	II.	10 millicuries
JJ.	Barium-133	JJ.	Sealed source (Amersham Model BDC.800 series)	JJ.	10 millicuries
KK.	Lead-210	KK.	Any	KK.	10 millicuries
LL.	Molybdenum-99	LL.	Any	LL.	100 millicuries
MM.	Technetium-99	MM.	Any	MM.	100 millicuries
NN.	Ruthenium-103	NN.	Any	NN.	10 millicuries
OO.	Ruthenium-106	OO.	Any	OO.	10 millicuries
PP.	Silver-110m	PP.	Any	PP.	100 millicuries
QQ.	Tin-113	QQ.	Any	QQ.	10 millicuries
RR.	Antimony-124	RR.	Any	RR.	10 millicuries
SS.	Antimony-125	SS.	Any	SS.	100 millicuries

Date____________________

State of Maryland

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DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIAL LICENSE

Supplementary Sheet

License No. MD-31-076-01	Amendment No. 24

CONT'D

6. Radioactive material (element and mass number)	7. Chemical and/or physical form	8. Maximum amount of radioactivity which licensee may possess at any one time
TT. Iodine-125	TT. Any	TT. 10 millicuries
UU. Xenon-127	UU. Any	UU. 10 millicuries
VV. Iodine-129	VV. Any	VV. 10 millicuries
WW. Iodine-131	WW. Any	WW. 100 millicuries
XX. Iodine-133	XX. Any	XX. 100 millicuries
YY. Xenon-133	YY. Any	YY. One curie
ZZ. Cesium-134	ZZ. Any	ZZ. One curie
AAA. Iodine-135	AAA. Any	AAA. 100 millicuries
BBB. Cesium-136	BBB. Any	BBB. One curie
CCC. Cesium-137	CCC. Any	CCC. One curie
DDD. Cesium-137	DDD. Sealed source (Amersham Model CDC.800 series)	DDD. 2.6 curies
EEE. Barium/Lanthanum-140	EEE. Any	EEE. 10 millicuries

9. Authorized use

TT.&WW. Also used for testing the efficiency of radioiodine absorbers and studying the behavior of radioiodine.

UU.&YY. Used for testing the efficiency of various absorbers for noble gas retention.

DDD. For use in Amdel Model AM 624/20 on-pipe density gauge.

Date____________________

State of Maryland

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201 WEST PRESTON STREET
BALTIMORE 21201

DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIAL LICENSE

Supplementary Sheet

License No. MD-31-076-01	Amendment No. 24

CONT'D

6.	Radioactive material (element and mass number)	7.	Chemical and/or physical form	8.	Maximum amount of radioactivity which licensee may possess at any one time
FFF.	Cerium-141	FFF.	Any	FFF.	100 millicuries
GGG.	Cerium-144	GGG.	Any	GGG.	100 millicuries
HHH.	Polonium-209	HHH.	Any	HHH.	One millicurie
III.	Polonium-210	III.	Any	III.	One millicurie
JJJ.	Radium-226	JJJ.	Any	JJJ.	10 millicuries
KKK.	Cadmium-109	KKK.	Any	KKK.	100 millicuries
LLL.	Promethium-147	LLL.	Any	LLL.	100 millicuries
MMM.	Europium-152	MMM.	Any	MMM.	10 millicuries
NNN.	Mercury-203	NNN.	Any	NNN.	100 millicuries
OOO.	Lead-203	OOO.	Any	OOO.	10 millicuries
PPP.	Thorium-228	PPP.	Sealed source (Isotope Product Lab Model 246D)	PPP.	No source to exceed 15 microcuries; 10 millicuries total
QQQ.	Thorium-228	QQQ.	Any	QQQ.	One millicurie
RRR.	Thorium-230	RRR.	Any	RRR.	One millicurie
SSS.	Thorium-232	SSS.	Any	SSS.	One millicurie
TTT.	Uranium-233	TTT.	Any	TTT.	One millicurie

9. Authorized use

PPP. Used only for calibration of radiation measurement instrumentation.

Date

State of Maryland

201 WEST PRESTON STREET
BALTIMORE 21201

DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIAL LICENSE

Supplementary Sheet

License No. MD-31-076-01	Amendment No. 24

CONT'D

6. Radioactive material (element and mass number)	7. Chemical and/or physical form	8. Maximum amount of radioactivity which licensee may possess at any one time
UUU. Uranium-235	UUU. Any	UUU. One millicurie
VVV. Plutonium-236/ Uranium-232	VVV. Any	VVV. One millicurie
WWW. Neptunium-237	WWW. Any	WWW. One millicurie
XXX. Uranium-232	XXX. Any	XXX. One millicurie
YYY. Uranium-234	YYY. Any	YYY. One millicurie
ZZZ. Plutonium-238	ZZZ. Any	ZZZ. One millicurie
AAAA. Uranium-238	AAAA. Any	AAAA. One millicurie
BBBB. Neptunium-239	BBBB. Any	BBBB. One millicurie
CCCC. Plutonium-239, 240	CCCC. Any	CCCC. One millicurie
DDDD. Plutonium-241	DDDD. Any	DDDD. One millicurie
EEEE. Americium-241	EEEE. Any	EEEE. 10 millicuries
FFFF. Americium-241	FFFF. Sealed source (Amersham Model AMC.26)	FFFF. 10 millicuries
GGGG. Curium-242	GGGG. Any	GGGG. One millicurie
HHHH. Plutonium-242	HHHH. Any	HHHH. One millicurie
IIII. Americium-243	IIII. Any	IIII. One millicurie
JJJJ. Curium-243, 244	JJJJ. Any	JJJJ. One millicurie

Date__________

State of Maryland

(CORRECTED PAGE)

DEPARTMENT OF THE ENVIRONMENT
ASSISTANT SECRETARIAT FOR
TOXICS, ENVIRONMENTAL SCIENCE AND HEALTH

CENTER FOR RADIOLOGICAL HEALTH

RADIOACTIVE MATERIAL LICENSE

Supplementary Sheet

License No. MD-31-076-01	Amendment No. 24

CONT'D

6. Radioactive material (element and mass number)	7. Chemical and/or physical form	8. Maximum amount of radioactivity which licensee may possess at any one time
KKKK. Any radioactive material other than source material, or alpha emitting material not listed above, except special nuclear materials in quantities as defined in Section A of COMAR 10.14.02.01	KKKK. Any	KKKK. 10 millicuries

CONDITIONS

10. The authorized place of use is the licensee's address stated in Item 2

    (a) item R, JJ, and FFFF may also be used at 16835 Oakmont Avenue, Gaithersburg, Maryland 20877;

    (b) items DDD and PPP may also be used at temporary job sites throughout Maryland.

11. The radiation protection program shall be under the supervision of Edgar D. Barefoot.

    B. Radioactive material shall be used by, or under the supervision of Edgar D. Barefoot, Linnea Coffey, Kelvin L. Wright, Mark Bierman, James E. Cline, Scott S. Hay, Sun G. Lee, David M. Tondi, Robert Lubaszewski, Charles J. Marcinkiewicz, and/or Kathy Strauss.

FOR THE MARYLAND DEPARTMENT OF THE ENVIRONMENT

Date ____________________

ADMINISTRATOR, CENTER FOR RADIOLOGICAL HEALTH

State of Maryland

201 WEST PRESTON STREET
BALTIMORE 21201

DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIAL LICENSE

Supplementary Sheet

License No. MD-31-076-01	Amendment No. 24

CONDITIONS CONT'D

12. The licensee shall comply with provisions of Part D. "Standards for Protection Against Radiation" and Part J, "Notices, Instructions and Reports to Workers; Inspections" of the Maryland Regulations 10.14.02.01 "Regulations for Control of Ionizing Radiation".

13. A. Each sealed source containing radioactive material, other than Hydrogen-3 with a half-life greater than thirty days and in any form other than gas shall be tested for leakage and/or contamination at intervals not to exceed 6 months. In the absence of a certificate from a transferor indicating that a test has been made within six (6) months prior to the transfer, the sealed source shall not be put into use until tested. If there is reason to suspect that a sealed source might have been damaged, or might be leaking, it shall be tested for leakage before further use.

    B. The test shall be capable of detecting the presence of 0.005 microcurie of radioactive material on the test sample. The test sample shall be taken from the sealed source or from the surfaces of a device in which the sealed source is permanently mounted or stored on which one might expect contamination to accumulate.

    C. Records of leak tests shall be kept in units of microcuries and maintained for inspection by the Department.

    D. If the test reveals the presence of 0.005 microcurie or more of removable contamination, the licensee shall immediately withdraw the sealed source from use and shall cause it to be decontaminated and repaired or to be disposed of in accordance with Department regulations. A report shall be filed within five (5) days of the test with the Administrator, Center for Radiological Health, 201 West Preston Street, Baltimore, Maryland 21201 describing the equipment involved, the test results, and the corrective action taken.

    E. Test for leakage and/or contamination shall be performed by Edgar O. Barefoot and/or Scott Hay or by other persons specifically authorized by the Department, the U.S. Nuclear Regulatory Commission or another Agreement State to perform such services.

14. Sealed sources containing radioactive material shall not be opened.

Date_______________ _______________

State of Maryland

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
201 WEST PRESTON STREET
BALTIMORE 21201

DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIAL LICENSE

Supplementary Sheet

License No. MD-31-076-01	Amendment No. 24

CONDITIONS CONT'D

15. Radioactive material shall not be used in or on human beings or in products distributed to the public.

16. Except as specifically provided otherwise by this license, the licensee shall possess and use radioactive material authorized by this license in accordance with statements representations, and procedures contained in application dated February 28, 1986, letters with attachments dated June 18, 1987 and December 29, 1987, and SAIC procedures received June 22, 1987, July 8, 1987, October 30, 1987, November 4, 1987, November 16, 1987, February 8, 1988 and February 16, 1988. COMAR 10.14.02.01 "Regulations for Control of Ionizing Radiation" shall govern the licensee's statements in applications or letters, unless the statements are more restrictive than the regulations.

FOR THE MARYLAND DEPARTMENT OF THE ENVIRONMENT

Roland G. Fletcher

ADMINISTRATOR, CENTER FOR RADIOLOGICAL HEALTH

Date February 26, 1988

CRF/amc

DHMH-300-6 (Supp.) (10/86)

State of Maryland

DEPARTMENT OF THE ENVIRONMENT
ASSISTANT SECRETARIAT FOR
TOXICS, ENVIRONMENTAL SCIENCE AND HEALTH

CENTER FOR RADIOLOGICAL HEALTH

RADIOACTIVE MATERIAL LICENSE

Supplementary Sheet

License No. MD-31-076-01	Amendment No. 28

Science Applications International Corp.
3 Choke Cherry Road
Rockville, Maryland 20850

In accordance with letter dated November 16, 1989 Radioactive Material License Number MD-31-076-01 is amended as follows:

To Add:

6. Radioactive material (element and mass number)	7. Chemical and/or physical form	8. Maximum amount of radioactivity which licensee may possess at any one time
OOOO. Californium-249	OOOO. Any	OOOO. One millicurie
PPPP. Californium-250	PPPP. Any	PPPP. One millicurie
QQQQ. Californium-252	QQQQ. Any	QQQQ. One millicurie

9. Authorized use

OOOO. Contained in sample received for analysis.

PPPP. Contained in sample received for analysis.

QQQQ. Contained in sample received for analysis and as a tracer to quantify californium analyses.

Condition 11B is amended to read:

11. B. Radioactive material shall be used by, or under the supervision of Edgar D. Barefoot, Kelvin L. Wright, Mark R. Bierman, James E. Cline, Scott S. Hay, David M. Tondi, Richard L. Hollis, Edward J. Dunn, Farideh Moghadam, and/or Charles J. Marcinkiewicz.

FOR THE MARYLAND DEPARTMENT OF THE ENVIRONMENT

Roland G. Fletcher
ADMINISTRATOR, CENTER FOR RADIOLOGICAL HEALTH

Date November 28, 1989

CRF/amc

MDEP-L1 (supp.) (3/88)

State of Maryland

DEPARTMENT OF THE ENVIRONMENT
201 WEST PRESTON STREET
BALTIMORE 21201

DIVISION OF RADIATION CONTROL
RADIOACTIVE MATERIAL LICENSE

Supplementary Sheet

License No.	Amendment No.
MD-31-076-01	25

Science Applications International
Corporation
3 Choke Cherry Road
Rockville, Maryland 20850

In order to correct errors on Amendment 24 Radioactive Material License Number MD-31-076-01 is amended to read:

Item 8JJ: No source to exceed 10 millicuries

Item 8FFFF: No source to exceed 250 millicuries

Condition 16 is amended to add:

16. Procedure SAIC 139-4-002 Revision Number 1, issued February 22, 1988 delivered to the Center for Radiological Health March 10, 1988.

FOR THE MARYLAND DEPARTMENT OF THE ENVIRONMENT

Roland G. Fletcher

ADMINISTRATOR, CENTER FOR RADIOLOGICAL

Date March 11, 1988

CRF/amc

State of Maryland

DEPARTMENT OF THE ENVIRONMENT
ASSISTANT SECRETARIAT FOR
TOXICS, ENVIRONMENTAL SCIENCE AND HEALTH

CENTER FOR RADIOLOGICAL HEALTH

RADIOACTIVE MATERIAL LICENSE

Supplementary Sheet

License No. MD-31-076-01	Amendment No. 26

Science Applications International
Corporation (SAIC)
3 Choke Cherry Road
Rockville, Maryland 20850

In accordance with letter dated May 13, 1988 Radioactive Material License Number MD-31-076-01 is amended to read:

Condition 10A:

10. A. SAIC authorization for operations at 16835 Oakmont Avenue, Gaithersburg, Maryland 20877 are hereby removed from this license.

Condition 11B:

11. B. Radioactive material shall be used by or under the supervision of Edgar D. Barefoot, Linnea Coffey, Kevin L. Wright, Mark Bierman, James E. Cline, Scott S. Hay, David M. Tondi, and/or Charles J. Marcinkiewicz.

FOR THE MARYLAND DEPARTMENT OF THE ENVIRONMENT

Roland G. Fletcher
ADMINISTRATOR, CENTER FOR RADIOLOGICAL HEALTH

Date August 4, 1988

CRF/amc 6847

MDEPH-L1 (supp.) (3/86)

State of Maryland

DEPARTMENT OF THE ENVIRONMENT
ASSISTANT SECRETARIAT FOR
TOXICS, ENVIRONMENTAL SCIENCE AND HEALTH

CENTER FOR RADIOLOGICAL HEALTH

RADIOACTIVE MATERIAL LICENSE

Supplementary Sheet

License No. MD-31-076-01	Amendment No. 27

Science Applications International Corp.
3 Choke Cherry Road
Rockville, Maryland 20850

In accordance with letter dated October 7, 1988 Radioactive Material License Number MD-31-076-01 is amended as follows:

To Add Item 9R:

To be used in the manufacture and distribution of SAIC model 101A Fluorotracer Analyzer under COMAR Section C.28(d) to general licensees in accordance with Section C.22(d) or equivalent regulations of NRC or an Agreement State.

Delete the following special nuclear materials:

6. Radioactive material (element and mass number)	7. Chemical and/or physical form	8. Maximum amount of radioactivity which licensee may possess at any one time
TTT. Uranium-233	TTT. Any	TTT. One millicurie
UUU. Uranium-235	UUU. Any	UUU. One millicurie
VVV. Plutonium-236/ Uranium-232	VVV. Any	VVV. One millicurie
ZZZ. Plutonium-238	ZZZ. Any	ZZZ. One millicurie
CCCC. Plutonium-239, 240	CCCC. Any	CCCC. One millicurie
DDDD. Plutonium-241	DDDD. Any	DDDD. One millicurie
HHHH. Plutonium-242	HHHH. Any	HHHH. One millicurie

FOR THE MARYLAND DEPARTMENT OF THE ENVIRONMENT

Date ______________________

ADMINISTRATOR, CENTER FOR RADIOLOGICAL HEALTH

State of Maryland

DEPARTMENT OF THE ENVIRONMENT
ASSISTANT SECRETARIAT FOR
TOXICS, ENVIRONMENTAL SCIENCE AND HEALTH

CENTER FOR RADIOLOGICAL HEALTH

RADIOACTIVE MATERIAL LICENSE

Supplementary Sheet

License No. MD-31-076-01	Amendment No. 27

CONT'D

To Add:

6. Radioactive material (element and mass number)	7. Chemical and/or physical form	8. Maximum amount of radioactivity which licensee may possess at any one time
LLLL. Uranium-235	LLLL. Any	LLLL. Not to exceed 350 grams
MMMM. Uranium-233	MMMM. Any	MMMM. Not to exceed 200 grams
NNNN. Plutonium	NNNN. Any	NNNN. Not to exceed 200 grams

9. Authorized use

LLLL - NNNN Contained in samples received for analysis; tracer in radiochemical separations.

To Add Condition 17:

17. The sum of ratios for all kinds of special nuclear material in combination shall not exceed one.

FOR THE MARYLAND DEPARTMENT OF THE ENVIRONMENT

Roland G. Fletcher

ADMINISTRATOR, CENTER FOR RADIOLOGICAL HEALTH

Date October 19, 1988

CRF/amc

NRC Form 374
(5-84)

U.S. NUCLEAR REGULATORY COMMISSION

MATERIALS LICENSE

Pursuant to the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974 (Public Law 93-438), and Title 10 Code of Federal Regulations, Chapter I, Parts 30, 31, 32, 33, 34, 35, 40 and 70, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, acquire, possess, and transfer byproduct, source, and special nuclear material designated below; to use such material for the purpose(s) and at the place(s) designated below; to deliver or transfer such material to persons authorized to receive it in accordance with the regulations of the applicable Part(s). This license shall be deemed to contain the conditions specified in Section 183 of the Atomic Energy Act of 1954, as amended, and is subject to all applicable rules, regulations and orders of the Nuclear Regulatory Commission now or hereafter in effect and to any conditions specified below.

Licensee	JAN 13 1989
1. Battelle Columbus Division	3. License number SNM-7, Amendment No. 3
2. 505 King Avenue Columbus, Ohio 43201-2693	4. Expiration date April 30, 1988 (on timely renewal)
	5. Docket or Reference No. 70-8

6. Byproduct, source, and/or special nuclear material	7. Chemical and/or physical form	8. Maximum amount that licensee may possess at any one time under this license
Special Nuclear Material		
West Jefferson Site		
A. Uranium enriched in the U-235 isotope --irradiated	A. Any	A. 125 kilograms of contained U-235 plus the associated and unseparated plutonium
B. Uranium enriched in the U-235 isotope --unirradiated	B. Any	B. 1900 grams of contained U-235
C. Plutonium (Pu-238 principal isotope)	C. Sealed source	C. 13 grams
D. Plutonium (Pu-239 principal isotope)	D. Oxide	D. 17 grams
King Avenue Laboratories		
E. Uranium enriched in the U-235 isotope --unirradiated	E. Any	E. 500 grams of contained U-235
Source Material		
West Jefferson and King Avenue Sites		
F. Uranium (natural and depleted) and thorium	F. Any	F. 500 kilograms

(Note: Licensee is also authorized to possess any source material that may be contained in the irradiated uranium of Item A above.)

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Byproduct Material

West Jefferson Site

G. Any byproduct material	G. Irradiated fuel material, activated reactor materials and components	G. 22,000,000 Ci total, not more than 100,000 Ci of any one radioisotope (excluding Items H through Q below)
H. Hydrogen-3	H. Any	H. 500 Ci
I. Polonium-210	I. Any	I. 500 Ci
J. Californium-252	J. Any	J. 500 Ci
K. Sulfur-35	K. Gas	K. 15,000 Ci
L. Chlorine-36	L. Gas	L. 15,000 Ci
M. Iodine-131	M. Any	M. 1000 Ci
N. Iodine-129	N. Any	N. 60 Ci
O. Cobalt-60	O. Any	O. 315,000 Ci
P. Cesium-137	P. Any	P. 250,000 Ci
Q. Strontium-90	Q. Any	Q. 250,000 Ci
R. Any byproduct material	R. Low-level radioactive waste	R. 50 Ci total
S. Carbon-14	S. Any	S. 3 Ci

King Avenue Laboratories

T. Any byproduct material	T. Any	T. 500 Ci total, not more than 35 Ci of any one radioisotope
U. Iridium-192	U. Sealed Source	U. 150 Ci

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9. Authorized Use:

a. For use in accordance with statements, representations and conditions contained in the following portions of the licensee's application for renewal (BCL Document 1081) submitted by letter dated October 23, 1981, except as may be modified by the conditions of this license:

1. Pages vi through xi, Introduction
2. Part I, License Conditions
3. Appendix A, Radiological Safety Committee Charter

The effective pages of these portions of the application shall be those identified in Annex A that is attached to this license.

b. Operation of the Volume Reduction Demonstration Facility in accordance with Condition 26 of this license.

c. Conduct controlled field studies using up to a maximum of 3 curies of carbon-14 labelled compounds at the licensee's West Jefferson, Ohio, site.

10. Authorized Places of Use:

The licensee's West Jefferson Site and King Avenue Laboratories located as described in pages vii through xi and pages 2.1 through 2.5, Part II, of the licensee's application for renewal submitted by letter dated October 23, 1981.

11. The licensee shall comply with the provisions of Annex B (attached), "License Condition for Leak Testing Sealed Byproduct Material Sources," for byproduct sealed sources in its possession. These leak test procedures shall also be used for the Pu-238 sealed source (Item 6.C above) at such time as it is removed from its storage package in the JN-2 Vault for use or transfer.

12. Notwithstanding Table III and Table IV presented in Part I, Sections 3.4 and 3.5, for the release of materials, equipment and facilities for unrestricted use the licensee shall adhere to the provisions of Annex C attached to this license, "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use" dated July 1982.

13. Item 9 above incorporates Appendix A (Radiological Safety Committee Charter) of the licensee's renewal application (BCL-1081) as a condition of the license to clarify and define more fully administrative procedures for review, approval and audit of activities covered by the license, as described in Section 1.3 and Section 2.0 of Part I. The licensee may make revisions to the provisions of Appendix A, based upon written evaluation of the changes, without NRC approval if it is determined that

13. continued

such changes will not decrease the effectiveness of the Committee in carrying out its functions. Revisions to the Charter and supporting evaluations shall be submitted to the Director, Division of Industrial and Medical Nuclear Safety, NRC, with a copy to the Administrator, Region III Office, NRC, within 60 days following such changes.

14. In addition to the subjects identified in Section 5.1.1, Appendix A, the annual review and appraisal of facilities shall include an assessment of occupational radiation exposures and releases of radioactive material over the past year with regard to maintaining such exposures and releases as low as is reasonably achievable, as stated in Section 20.1(c), 10 CFR Part 20.

15. Part I, Section 2.1 of the licensee's application specifies when mandatory criticality reviews for new operations are required by the Nuclear Safety Subcommittee. The reviews by the Nuclear Safety Subcommittee shall include (1) an initial analysis by an individual qualified in accordance with provisions of Section 1.2.2 and Section 2.2, Part I; (2) an independent review by a second qualified individual to determine that the methods used in the analysis are appropriate and that the results are correct; and (3) as appropriate, physical inspection by the individual performing the original analysis to assure that the physical environment and parameters assumed in the analysis are valid.

16. Part I, Section 2.4 of the application for renewal provides for use of KENO as an acceptable criticality analysis method. Prior to use of this analytical method for nuclear safety evaluations under this renewed license, the licensee shall submit a demonstration (as an addition to Part II or a new Appendix) of its use to NRC for approval.

17. Notwithstanding the formula in Section 4.3.1(4)(c) of the Radiation Safety Committee Charter (Appendix A of the application for renewal), the licensee shall use the formula:

$$\frac{\text{Grams U-235}}{L_{235}} + \frac{\text{Grams Pu}}{\text{220 grams}} \leq 1$$

where L_{235} is the mass limit from Table 1, Appendix A of the application, for the approriate U-235 enrichment.

18. The licensee is hereby exempted from the provisions of Section 70.24, 10 CFR Part 70, insofar as this section applies to special nuclear material authorized under this license for possession and use at the licensee's King Avenue Laboratories.

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19. The licensee shall provide three copies each year of its annual environmental report to the Director, Division of Industrial and Medical Nuclear Safety, NRC, and a copy to the Administrator, Region III Office, NRC.

20. Sections 2.1 and 3.10, Part I refer to provisions for training and periodic retraining of employees, as appropriate and related to employee work assignments with radioactive and fissionable materials. Such training shall be conducted, as appropriate, for new employees and prior to initiating new operations approved by the Radiological Safety Committee and retraining shall be conducted on topics appropriate to employee work assignments at least annually. Documentation of such training and retraining shall be maintained.

21. Section 4.0, Part I of the licensee's renewal application incorporates the text of previous amendments issued by the NRC to Special Nuclear Material License No. SNM-7 and Byproduct Material License No. 34-6854-5. For clarification, the licensee's authority to permit increases in the radioactivity in the Hot Cell Laboratory pool water to levels above the limits for routine operations, as specified in Section 4.0 is hereby affirmed, subject to the following provisions:

   a. The period that non-routine levels of radioactivity exist in the pool shall not exceed 45 days before they are reduced to routine levels or below;

   b. Work requests, as approved by the Laboratory Operations Manager and the resident Health-Physicist, shall be utilized during the non-routine operations to assure that personnel are aware of the specific radiological safety considerations for the operations;

   c. The pool lid cover shall be in place during down time and after hours;

   d. Radiation monitoring will be performed at least twice weekly around the perimeter of the pool and radiation levels with the cover in place and the cover removed will be posted;

   e. Pool water samples will be collected and analyzed at least weekly; and

   f. The resin bags of ion columns will be replaced when readings of 300mR/hour at one foot are reached.

The above provisions, extracted from the licensee's letter to the NRC of October 31, 1980 eliminate the need for reference in this license to this letter, which requested the non-routine operational levels to accommodate such activities as pool cleaning and maintenance, examination and maintenance of storage racks, and the handling of additional fuel assemblies.

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22. The licensee shall implement, maintain, and execute the response measures of his Radiological Contingency Plan submitted to the Commission on March 5, 1982. The licensee shall also maintain implementing procedures for his Radiological Contingency Plan as necessary to implement Plan. This Radiological Contingency Plan and associated implementing procedures incorporate the emergency planning requirements of 10 CFR 70.22(i) as they refer to onsite planning and notification procedures. The licensee shall make no change in his Radiological Contingency Plan that would decrease the response effectiveness of the Plan without prior Commission approval as evidenced by a license amendment. The licensee may make changes to his Radiological Contingency Plan without prior Commission approval if the changes do not decrease the response effectiveness of the Plan. The license shall maintain records of changes that are made to the Plan without prior approval for a period of two years from the date of the change and shall furnish the Chief, Fuel Cycle Safety Branch, Division of Industrial and Medical Nuclear Safety, NMSS, U.S. Nuclear Regulatory Commission, Washington, DC 20555, and the Region III NRC Regional Office at the address specified in Appendix D of 10 CFR Part 20, a report containing a description of each change within six months after the change is made.

23. Section 5.0, Part I, of the licensee's renewal application incorporates the text of previous amendments issued by NRC to Special Nuclear Material License No. SNM-7 and Byproduct Material License No. 34-68845 covering decontamination and decommissioning plans applicable to the Battelle Hot Cell Laboratory. It is hereby affirmed that the provisions of these decontamination and decommissioning plans, including financial arrangements, continue in effect under this renewed license, and also apply to the retired Battelle Research Reactor.

24. At such time that facilities covered by this license are decontaminated for proposed unrestricted release (in accordance with Annex C), the licensee shall submit a report that identifies the facilities where radioactive materials were used and stored, or disposed on the site. The report shall briefly describe operations conducted and radioactive materials used in the facilities and shall assess the results of the decontamination activities. The report shall provide the basis for unrestricted release of the facilities and the site, including a description of sampling and survey methods and instrumentation used, and shall include final contamination survey data for the facilities and grounds. The licensee may segment the report to obtain release of certain areas of facilities or individual structures if it is demonstrated that ongoing activities in other areas will not lead to recontamination of the area or structure proposed for release.

25. The licensee is authorized to backfill the retired filter bed area on the West Jefferson site where contaminated soil was removed as described in the licensee's letter of May 13, 1981. The homogenized bed containing low levels of residual contamination shall be covered with approximately three feet of soil as stated in the letter of May 13, 1981.

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25. In addition to other applicable conditions of this license, operation of the Volume Reduction Demonstration Facility (VRDF) shall be in accordance with the following conditions:

a. Operation of the VRDF shall not commence without a valid permit or permits issued therefor by the State of Ohio Environmental Protection Agency and other permits or authorizations required by federal statutes.

b. Operation of the VRDF shall be conducted by the licensee in accordance with the conditions, statements and representations contained in the application for license amendment dated August 15, 1983, and revisions dated September 28, 1984, January 4, 1985, January 3, 1986, and March 10, 1986, except as modified by conditions of this license. The licensee may make changes in the VRDF, its equipment and procedures described in the application without license amendment provided that any proposed change does not involve (i) a modification to the provisions of Conditions 8, 9, or 10 of this license (ii) a significant increase in radiation exposure of employees; (iii) an unreviewed safety question; or (iv) a decrease in effectiveness of VRDF effluent treatment systems. An evaluation shall be required to validate a change to the VRDF not requiring amendment to the license. Such evaluation shall be reviewed and approved by the Health Physics Supervisor and the Radiological Safety Committee, and shall provide the basis for determining that the change will not involve a modification to the provisions of Conditions 8, 9, or 10 of this license, a significant increase in radiation exposure of employees, an unreviewed safety question, or a decrease in effectiveness of VRDF effluent treatment systems. A change shall be deemed to involve an unreviewed safety question if an accident analysis for the change, (i) results in consequence values exceeding the values of the accident analyses described in Section 6 of the licensee's Appendix 6, or the probability of occurrence for the types of events there evaluated is judged to increase; or (ii) reveals a possibility for an accident of a different type than previously evaluated. Records of evaluations and approvals of changes shall be maintained by the licensee.

c. The licensee shall not retain low-level radioactive waste in physical inventory in the VRDF, either in the form of incoming waste or end-product, on behalf of customers, freight forwarders, carriers, brokers or the licensee, for a period of time in excess of one year from the time of receipt.

d. The licensee shall limit release of iodine-125 in effluents from the VRDF to not more than 0.010 curies per year. The licensee shall maintain administrative control procedures and records to achieve and demonstrate that such limits have not been exceeded.

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e. The licensee shall use appropriate methods for the continuous collection of gaseous hydrogen-3, carbon-14 and iodine-125 samples in VRDF airborne effluents and shall analyze such samples on a daily basis when industrial and institutional waste containing these radionuclides is being processed, and on a weekly basis when other waste, including waste from nuclear utilities, is being processed. If only nuclear reactor waste is being processed, no sampling or analysis for I-125 is required.

f. The licensee shall install and operate a real-time continuous monitor for particulate radionuclides in the VRDF incinerator off-gas discharge stack whenever the incinerator is operating. The monitor shall annunciate in the control room and shall alarm if concentrations of expected mixtures of particulate radionuclides should exceed 24 MPC-hours, or equivalent, using Appendix B, Table II values of 10 CFR Part 20. The control room shall be continuously manned during periods when the incinerator is operating.

g. The licensee shall prepare and submit to the NRC Regional Administrator semiannually a report that provides an evaluation of VRDF operations performance, including the licensee's experience with correlating and managing the receipt, processing, shipment and release of radioactive material as the result of VRDF operations. The first report shall be submitted 6 months after initial operation and at 6-month intervals thereafter.

h. The licensee shall have available onsite a technical representative from the incinerator vendor for the first six months of VRDF incinerator operation to assist with operations, training and trouble-shooting.

i. The licensee shall install a fence or other means of access control around the VRDF or portions thereof for radiation protection of individuals in unrestricted areas.

j. The licensee shall test installed HEPA filters used in the VRDF after initial installation, at intervals not to exceed six months, and after filter change. Testing shall comply with ANSI N101.1, "Efficiency Testing of Air-Cleaning Systems Containing Devices for Removal of Particles," using a "cold DOP" test with acceptance based on an efficiency of 99.95 percent or better.

k. The licensee shall monitor the environment surrounding the VRDF for radionuclides processed therein, including hydrogen-3, carbon-14, and iodine-125 in air, water, soil and vegetation.

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27. The licensee shall perform quarterly surveys, not to exceed 4 months, for radiation, contamination and integrity of physical barriers at the retired Battelle Research Reactor. Records of such surveys shall be maintained by the licensee.

28. The licensee shall conduct controlled field studies using carbon-14 labelled compounds in accordance with the statements and representations contained in the licensee's application for amendment submitted by letter dated August 5, 1988.

UNITED STATES NUCLEAR REGULATORY COMMISSION

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Date: JAN 18 1989

By: [signature]
Leland C. Rouse, Chief
Fuel Cycle Safety Branch
Division of Industrial and
Medical Nuclear Safety, NMSS
Washington, DC 20555

PO# R5417331 DATE 7-25-89 METHOD SHIPPED UPS Red.

ITEM	QTY SF	QTY OR	QTYBOR	DESCRIPTION
1	1	1	0	Thorium 230 47mm Standard ~0.0128 uCi
2	1	1	0	Americium 241 47mm Standard ~0.0340 uCi

NOTICE: This package conforms to conditions and limitations specified in 49CFR 173.4 through 173.424 for excepted radioactive materials, limited quantity, n.o.s., UN 2910.

THE CONTENTS ARE EXEMPT FROM NRC OR AGREEMENT STATE LICENSING REQUIREMENTS;RADIOACTIVE MATERIAL-NOT FOR HUMAN USE-INTRODUCTION INTO FOODS,BEVERAGES,COMSMETICS,DRUGS OR MEDICINALS, OR INTO PRODUCTS MANUFACURED FOR COMMERCIAL DISTRIBUTION IS PROHIBITED-EXEMPT QUANTITIES SHOULD NOT BE COMBINED.

THE SOURCE,Inc.
2989 INDUSTRIAL RD.
SANTA FE, NM 87501 (505)473-9538

PACKING LIST

Thorium 230   S-Th-47

<20dpm/source

07-25-89

<20dpm/source

<20dpm/source

Michael A. Ortiz

89TH4704168

Source

Leak Test Certificate

Americium 241   S-Am-47

<20dpm/source

07-25-89

<20dpm/source

<20dpm/source

Michael A. Ortiz

88AM4701865

THE SOURCE INC.

Radiation standards and check sources
2889 Industrial RD. Santa Fe, NM 87501
(505)473-9538

REF.PO# R5417331

Certificate of Calibration

(Alpha Sources)

The Americium 241 alpha source was measured in a hemispherical 2pi windowless proportional counter using P-10 as counting gas. The alpha emissions from the surface of the source were measured at its plateau voltage to determine its 2pi cpm rate. Corrections were applied for background, coincidence loss and backscatter factors when applicable. The source is referenced to NIST(formerly NBS) 4904N-G-64.

Active Diameter(or area) 44mm Mounting Material SS

Total Diameter(or area) 47mm

38,400 cpm +/- 1,920 cpm 2pi

75,600 dpm +/- 3,780 dpm 4pi

0.0340 microcurie

07-25-89 date of measurement

Michael A. Ortiz calibrated by [signature]

Charles L. Gonzales approved by [signature]

88AM4701865 source number

The uncertainty of the measurement at the 99% confidence interval is 5.0 percent.

THE SOURCE INC.
Radiation standards and check sources
2889 Industrial RD. Santa Fe, NM 87501
(505)473-9538

REF.PO# R5417331

Certificate of Calibration
(Alpha Sources)

The Thorium 230 alpha source was measured in a hemispherical 2pi windowless proportional counter using P-10 as counting gas. The alpha emissions from the surface of the source were measured at its plateau voltage to determine its 2pi cpm rate. Corrections were applied for background, coincidence loss and backscatter factors when applicable. The source is referenced to NIST(formerly NBS) 4904N-G-64.
Active Diameter(or area) 44mm Mounting Material SS
Total Diameter(or area) 47mm

12,700 cpm +/- 640 cpm 2pi

25,000 dpm +/- 1,250 dpm 4pi

0.0128 microcurie

07 - 25 - 89 date of measurement

Michael A. Ortiz calibrated by [signature]

Charles L. Gonzales approved by [signature]

89TH4704168 source number

The uncertainty of the measurement at the 99% confidence interval is 5.0 percent.

RADIOACTIVE MATERIALS SHIPPING RECORD

Trip Number: BOMARC-1

FROM: (Consignor)
SAIC
c/o BOMARC Missile Site
Route 539
McGuire AFB, N.J.

TO: (Consignee)
Teledyne Isotopes
50 Van Buren Avenue
Westwood, N.J. 07675
Attn: David Martin, Laboratory Manager
(201) 632-3030

EMERGENCY CONTACT POINT:

SAIC
14062 Denver West Parkway
Golden, Colorado 80401
Attn: Donna Collins/Neil Botts
(303) 278-8460

RADIOACTIVE MATERIALS SHIPPING RECORD

Trip Number: ECYARC-1

Hazardous material: Radioactive material, low specific activity, NOS

Number of Packages: 6

Proper shipping name: Radioactive material, LSA, NOS

Identification Number: UN2912

Total weight: 340 POUNDS

Description: Soil samples contaminated with Pu-239 and Am-241

Physical Form: Solid

Chemical Form: Metal oxides in soil

Specification Labeling: Non-specification container,
Radioactive LSA markings

Fissile class: Not applicable, Fissile exempt iaw 49CFR173.453

Transport Index: Not applicable

Container: Strong, tight package

Other: Transportation to be as exclusive use iaw 49CFR173.425(b)

Exclusive Use Instructions:

1. Shipment to be shored/braced so as to prevent shifting or lading under conditions normally incident to transportation.

2. Driver to make no intermediate stops to pick up or discharge freight.

3. Delivery to be made directly to consignee.

4. In the event of an incident during transportation, notify consignee/consignor as soon as reasonably possible.

5. Vehicle to display Radioactive placards on 4 sides.

Driver Acknowledgment: I hereby acknowledge the maintenance instructions for exclusive use.

Catherine M. Olsen

RADIOACTIVE MATERIALS SHIPPING RECORD

Trip Number: 20MARC-1

Quantity:	Package #1	Pu-239	99.5	microcuries
		Am-241	16.6	microcuries
	Package #2	Pu-239	5.54	microcuries
		Am-241	0.92	microcuries
	Package #3	Pu-239	0.23	microcuries
		Am-241	0.04	microcuries
	Package #4	Pu-239	0.12	microcuries
		Am-241	0.02	microcuries
	Package #5	Pu-239	0.39	microcuries
		Am-241	0.26	microcuries
	Package #6	Pu-239	0.12	microcuries
		Am-241	0.02	microcuries
	Package #7	Pu-239	0.07	microcuries
		Am-241	0.01	microcuries
	Package #8	Pu-239	0.22	microcuries
		Am-241	0.04	microcuries
	Total	Pu-239	106	microcuries
		Am-241	17.7	microcuries

Shipper's Certification:

"This is to certify that the above named materials are properly classified, described, packaged, marked and labeled, and are in proper condition for transportation according to applicable regulations of the Department of Transportation."

Mark Roberts

Mark Roberts, CHP
for SAIC

Departure Date: 12/20/89
Departure Time: 13[illegible]

APPENDIX Q

SUMMARY REPORT ON PLUTONIUM INVENTORY, BOMARC MISSILE SITE

During the initial incident, Explosive Ordnance Disposal personnel filled seven metal containers with residues from the nuclear warhead. This followed established procedures for recovering materials and components and for ensuring the proper protection of vital information. According to a report prepared by the Los Alamos National Laboratory, the containers were stored at the Medina facility in San Antonio, Texas until 1965 and then transferred to the Pantex facility at Amarillo, Texas. The containers were apparently transferred to the Nevada Test Site in the early 1980s.

Scientists from the Los Alamos National Laboratory studied the containers during 1979 to 1982 using a variety of nuclear measurements techniques to assess the amounts of radioactive materials present in each. The results of these analyses show that most of the weapons grade plutonium (WGP) was recovered. The amount of unrecovered WGP remaining on the site was estimated at about 60 grams. This residual quantity is subject to analytical uncertainties from the measurement process and other factors. The most probable error for the estimated residual amount is much larger than the quantity itself. Considering all of these factors leads to a conservative estimate for an upper limit to the residual amount of 300 grams. This analysis supports conclusion about the fate of the WGP from the accident. First, the major portion of the WGP was recovered and returned to the Atomic Energy Commission, now the Department of Energy (DoE). The remainder of the WGP was distributed on the site from the initial incident and response actions take at the time. The residual WGP essentially remains in the environment of Building 204 and the remainder of the site.

Reference: LA9696-MS, Measurement of Nuclear Weapons Accident Residues Stored in Containers, Phase I, J.T. Caldwell, J.M. Bieri, and H.H. Hsu, Los Alamos National Laboratory, May 1983.

APPENDIX R

RESULTS OF BOMARC MONITORING WELL SAMPLES

RESULTS OF BOMARC MONITORING WELL SAMPLES
(Sampling Conducted by Armstrong Laboratory--22 Jan 92)

Sample #	Lab #	Description	Gross Alpha	Gross Beta	Pu-239	Th-232	U-234	U-235	U-238	Ra-226
BK920001	19200131	Blank-unfltrd	1.1 ± 0.5	< 0.09	DNT	DNT	DNT	DNT	DNT	DNT
BK920002	19200132	Blank-fltrd	< 0.06	3.1 ± 1.8	DNT	DNT	DNT	DNT	DNT	DNT
ON920003	19200133	Filter-Blank	.07 ± .05	< 0.56	DNT	DNT	DNT	DNT	DNT	DNT
GN920004	19200134	PU-3, Fltrd	1.3 ± 0.6	< 3.3	DNT	DNT	DNT	DNT	DNT	DNT
GN920005	19200135	PU-3, Unfltrd	13.2 ± 2.9	2.2 ± 1.7	<1.7	1.8±1.1	32±15	23±11	26±12	.43±.45
ON920006	19200136	PU-3, Filters	2.6 ± 0.5	2.7 ± 0.5	DNT	DNT	DNT	DNT	DNT	DNT
GN920007	19200137	PU-3, Unfltrd (dup)	22.2 ± 4.1	2.7 ± 1.8	<8.7	1.6±1.1	18±8	4.5±3.1	12±6	.96±.69
GN920008	19200138	PU-3, Filtrd (dup	2.9 ± 0.8	1.8 ± 1.7	DNT	DNT	DNT	DNT	DNT	DNT
GN920009	19200139	PU-6, Unfltrd	57.5 ± 8.3	8.3 ± 2.1	<0.9	3.0±1.5	44±37	22±33	22±22	.31±.48
GN920010	19200140	PU-6, Fltrd	2.5 ± 1.1	2.6 ± 1.7	<0.66	<4.4	.9 ± .4	< 0.17	< 0.16	< 0.13
ON920011	19200141	PU-6, Filters	3.1 ± 0.5	2.3 ± 0.4	DNT	DNT	DNT	DNT	DNT	DNT
ON920012	19200142	PU-3, Filters (dup)	3.2 ± 0.5	2.4 ± 0.4	DNT	DNT	DNT	DNT	DNT	DNT

Notes:
1. All results are in units of pCi/l
2. DNT = DID NOT TEST
3. IP = IN PROGRESS
4. The instrument used for the gross alpha determinations is normally used for determining gross alpha in drinking water. These samples had a much higher suspended solids content; therefore, the apparent discrepancy between gross alpha and the uraniums is due to the alpha self-absorption on the gross alpha planchettes.

SAMPLE ANALYSIS RESULTS REPORTED ON 22-APR-1992
ARMSTRONG LABORATORY
OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
RADIOANALYTICAL FUNCTION (OEBSA)
BROOKS AIR FORCE BASE, TEXAS 78235-5000

OE ID

19200131

AL/OEBSC
CONSULTANT SERVICES
BROOKS AFB, TX 78235-5501

BASE ADDRESS CODE: Q00253C

IDENTIFICATION:
Base Sample #: GN920013 BOMARC SITE WELL PU-3
OEHL ID: 19200131
Type of Sample: WATER, NONPOTABLE, NOT SDWA
Workplace or Site ID: 0253 ____ ____ BROOKS AFB, TX
Date Collected: 22-JAN-92
Date Received: 24-JAN-92
Date Completed: 06-FEB-92

BLANK-UNFILTERED

GROSS ALPHA		1.1	+/-	0.5	PICOCURIES PER LITER
GROSS BETA	<	0.09			PICOCURIES PER LITER

RESULTS ACCURATE TO 2 SIGNIFICANT FIGURES.
ERROR TERM AT 95% CONFIDENCE LEVEL.

MICHAEL D. McKINNON, Maj, USAF, BSC
Health Physicist
AUTOVON 240-2061

SAMPLE ANALYSIS RESULTS REPORTED ON 22-APR-1992
ARMSTRONG LABORATORY
OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
RADIOANALYTICAL FUNCTION (OEBSA)
BROOKS AIR FORCE BASE, TEXAS 78235-5000

OE ID

19200132

AL/OEBSC
CONSULTANT SERVICES
BROOKS AFB, TX 78235-5501

BASE ADDRESS CODE: Q00253C

IDENTIFICATION:
Base Sample #: GN920002 BOMARC SITE WELL PU-3
OEHL ID: 19200132
Type of Sample: WATER, NONPOTABLE, NOT SDWA
Workplace or Site ID: 0253 ____ ____ BROOKS AFB, TX
Date Collected: 22-JAN-92
Date Received: 24-JAN-92
Date Completed: 06-FEB-92

BLANK-FILTERED

GROSS ALPHA	<	0.6			PICOCURIES PER LITER
GROSS BETA		3.1	+/-	1.8	PICOCURIES PER LITER

RESULTS ACCURATE TO 2 SIGNIFICANT FIGURES.
ERROR TERM AT 95% CONFIDENCE LEVEL.

MICHAEL D. McKINNON, Maj, USAF, BSC
Health Physicist
AUTOVON 240-2061

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ARMSTRONG LABORATORY
OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
RADIOANALYTICAL FUNCTION (OEBSA)
BROOKS AIR FORCE BASE, TEXAS 78235-5000

OE ID
19200133

AL/OEBSC
CONSULTANT SERVICES
BROOKS AFB, TX 78235-5501

BASE ADDRESS CODE: Q00253C

IDENTIFICATION:
Base Sample #: ON920003 BOMARC SITE WELL PU-3
OEHL ID: 19200133
Type of Sample: WATER, NONPOTABLE, NOT SDWA
Workplace or Site ID: 0253 ____ ____ BROOKS AFB, TX
Date Collected: 22-JAN-92
Date Received: 24-JAN-92
Date Completed: 11-FEB-92

GROSS ALPHA		0.07	+/-	0.05	PICOCURIES PER LITER
GROSS BETA	<	0.56			PICOCURIES PER LITER

RESULTS ACCURATE TO 2 SIGNIFICANT FIGURES.
ERROR TERM AT 95% CONFIDENCE LEVEL.

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AUTOVON 240-2061

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ARMSTRONG LABORATORY
OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
RADIOANALYTICAL FUNCTION (OEBSA)
BROOKS AIR FORCE BASE, TEXAS 78235-5000

OE ID

19200134

AL/OEBSC
CONSULTANT SERVICES
BROOKS AFB, TX 78235-5501

BASE ADDRESS CODE: Q00253C

IDENTIFICATION:
Base Sample #: GN920004 BOMARC SITE WELL PU-3
OEHL ID: 19200134
Type of Sample: WATER, NONPOTABLE, NOT SDWA
Workplace or Site ID: 0253 ____ ____ BROOKS AFB, TX
Date Collected: 22-JAN-92
Date Received: 24-JAN-92
Date Completed: 06-FEB-92

WELL PU-3 FILTERED

GROSS ALPHA		1.3	+/-	0.6	PICOCURIES PER LITER
GROSS BETA	<	3.3			PICOCURIES PER LITER

RESULTS ACCURATE TO 2 SIGNIFICANT FIGURES.
ERROR TERM AT 95% CONFIDENCE LEVEL.

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AUTOVON 240-2061

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ARMSTRONG LABORATORY
OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
RADIOANALYTICAL FUNCTION (OEBSA)
BROOKS AIR FORCE BASE, TEXAS 78235-5000

OE ID

19200135

AL/OEBSC
CONSULTANT SERVICES
BROOKS AFB, TX 78235-5501

BASE ADDRESS CODE: Q00253C

IDENTIFICATION:
Base Sample #: GN920005 BOMARC SITE PU-3
OEHL ID: 19200135
Type of Sample: WATER, NONPOTABLE, NOT SDWA
Workplace or Site ID: 0253 ____ ____ BROOKS AFB, TX
Date Collected: 22-JAN-92
Date Received: 24-JAN-92
Date Completed: 27-FEB-92

RA 226 MDA 0.11 PCI/L
ALPHA UNFLAMED 13.2 +/- 2.9 PCI/L
ALPHA FLAMED 10.3 +/- 2.5 PCI/L
PU-3 UNFILTERED

GROSS ALPHA		13.2	+/-	2.9	PICOCURIES PER LITER
GROSS BETA		2.2	+/-	1.7	PICOCURIES PER LITER
PLUTONIUM 239		1.	+/-	0.3	PICOCURIES PER LITER
RADIUM 226		0.43	+/-	0.45	PICOCURIES PER LITER
THORIUM 228	<	3.2			PICOCURIES PER LITER
THORIUM 232		1.8	+/-	1.1	PICOCURIES PER LITER
URANIUM 234		33.1	+/-	15.1	PICOCURIES PER LITER
URANIUM 235		22.5	+/-	10.9	PICOCURIES PER LITER
URANIUM 238		26.2	+/-	11.9	PICOCURIES PER LITER

RESULTS ACCURATE TO 2 SIGNIFICANT FIGURES.
ERROR TERM AT 95% CONFIDENCE LEVEL.

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OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
RADIOANALYTICAL FUNCTION (OEBSA)
BROOKS AIR FORCE BASE, TEXAS 78235-5000

OE ID

19200136

AL/OEBSC
CONSULTANT SERVICES
BROOKS AFB, TX 78235-5501

BASE ADDRESS CODE: Q00253C

IDENTIFICATION:
Base Sample #: ON920006 BOMARC SITE PU-3
OEHL ID: 19200136
Type of Sample: WATER, NONPOTABLE, NOT SDWA
Workplace or Site ID: 0253 ____ ____ BROOKS AFB, TX
Date Collected: 22-JAN-92
Date Received: 24-JAN-92
Date Completed: 11-FEB-92

FILTERS FOR PU-3 FILTERED SAMPLE

GROSS ALPHA	2.58	+/-	0.5	PICOCURIES PER LITER
GROSS BETA	2.7	+/-	0.5	PICOCURIES PER LITER

RESULTS ACCURATE TO 2 SIGNIFICANT FIGURES.
ERROR TERM AT 95% CONFIDENCE LEVEL.

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BROOKS AIR FORCE BASE, TEXAS 78235-5000

OE ID

19200137

AL/OEBSC
CONSULTANT SERVICES
BROOKS AFB, TX 78235-5501

BASE ADDRESS CODE: Q00253C

IDENTIFICATION:
Base Sample #: GN920007 BOMARC SITE PU-3
OEHL ID: 19200137
Type of Sample: WATER, NONPOTABLE, NOT SDWA
Workplace or Site ID: 0253 ____ ____ BROOKS AFB, TX
Date Collected: 22-JAN-92
Date Received: 24-JAN-92
Date Completed: 27-FEB-92

ALPHA UNFLAMED 22.2 +/- 4.1 PCI/L
ALPHA FLAMED 18.9 +/- 3.7 PCI/L
PU-3 UNFILTERED DUPLICATE

GROSS ALPHA		22.2	+/-	4.1	PICOCURIES PER LITER
GROSS BETA		2.7	+/-	1.8	PICOCURIES PER LITER
PLUTONIUM 239		2.4	+/-	0.7	PICOCURIES PER LITER
RADIUM 226		0.96	+/-	0.69	PICOCURIES PER LITER
THORIUM 228	<	2.1			PICOCURIES PER LITER
THORIUM 232		1.65	+/-	1.05	PICOCURIES PER LITER
URANIUM 234		18.5	+/-	7.8	PICOCURIES PER LITER
URANIUM 235		4.5	+/-	3.1	PICOCURIES PER LITER
URANIUM 238		11.9	+/-	5.9	PICOCURIES PER LITER

RESULTS ACCURATE TO 2 SIGNIFICANT FIGURES.
ERROR TERM AT 95% CONFIDENCE LEVEL.

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AUTOVON 240-2061

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RADIOANALYTICAL FUNCTION (OEBSA)
BROOKS AIR FORCE BASE, TEXAS 78235-5000

OE ID

19200138

AL/OEBSC
CONSULTANT SERVICES
BROOKS AFB, TX 78235-5501

BASE ADDRESS CODE: Q00253C

IDENTIFICATION:
Base Sample #: GN920008 BOMARC SITE PU-3
OEHL ID: 19200138
Type of Sample: WATER, NONPOTABLE, NOT SDWA
Workplace or Site ID: 0253 ____ ____ BROOKS AFB, TX
Date Collected: 22-JAN-92
Date Received: 24-JAN-92
Date Completed: 06-FEB-92

WELL PU-3 FILTERED DUPLICATE

GROSS ALPHA	2.9	+/-	0.8	PICOCURIES PER LITER
GROSS BETA	1.8	+/-	1.7	PICOCURIES PER LITER

RESULTS ACCURATE TO 2 SIGNIFICANT FIGURES.
ERROR TERM AT 95% CONFIDENCE LEVEL.

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SAMPLE ANALYSIS RESULTS REPORTED ON 22-APR-1992
ARMSTRONG LABORATORY
OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
RADIOANALYTICAL FUNCTION (OEBSA)
BROOKS AIR FORCE BASE, TEXAS 78235-5000

OE ID

19200139

AL/OEBSC
CONSULTANT SERVICES
BROOKS AFB, TX 78235-5501

BASE ADDRESS CODE: Q00253C

IDENTIFICATION:
Base Sample #: GN920009 BOMARC SITE PU-6
OEHL ID: 19200139
Type of Sample: WATER, NONPOTABLE, NOT SDWA
Workplace or Site ID: 0253 ____ ____ BROOKS AFB, TX
Date Collected: 22-JAN-92
Date Received: 24-JAN-92
Date Completed: 26-FEB-92

RA 226 MDA 0.13 PCI/L

GROSS ALPHA		57.5	+/-	8.3	PICOCURIES PER LITER
GROSS BETA		8.3	+/-	2.1	PICOCURIES PER LITER
PLUTONIUM 239	<	0.9			PICOCURIES PER LITER
RADIUM 226		0.31	+/-	0.48	PICOCURIES PER LITER
THORIUM 228	<	3.7			PICOCURIES PER LITER
THORIUM 232		3.	+/-	1.5	PICOCURIES PER LITER
URANIUM 234		44.2	+/-	36.8	PICOCURIES PER LITER
URANIUM 235		22.3	+/-	32.6	PICOCURIES PER LITER
URANIUM 238		22.2	+/-	22.	PICOCURIES PER LITER

RESULTS ACCURATE TO 2 SIGNIFICANT FIGURES.
ERROR TERM AT 95% CONFIDENCE LEVEL.

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AUTOVON 240-2061

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OE ID

19200140

AL/OEBSC
CONSULTANT SERVICES
BROOKS AFB, TX 78235-5501

BASE ADDRESS CODE: Q00253C

IDENTIFICATION:
Base Sample #: GN920010 BOMARC SITE PU-6
OEHL ID: 19200140
Type of Sample: WATER, NONPOTABLE, NOT SDWA
Workplace or Site ID: 0253 ____ ____ BROOKS AFB, TX
Date Collected: 22-JAN-92
Date Received: 24-JAN-92
Date Completed: 26-FEB-92

RA 226 MDA 0.12 PCI/L

GROSS ALPHA		2.5	+/-	1.1	PICOCURIES PER LITER
GROSS BETA		2.6	+/-	1.7	PICOCURIES PER LITER
PLUTONIUM 239	<	0.66			PICOCURIES PER LITER
RADIUM 226		0.13	+/-	0.25	PICOCURIES PER LITER
THORIUM 228	<	1.15			PICOCURIES PER LITER
THORIUM 232	<	4.4			PICOCURIES PER LITER
URANIUM 234		0.92	+/-	0.45	PICOCURIES PER LITER
URANIUM 235	<	0.17			PICOCURIES PER LITER
URANIUM 238	<	0.16			PICOCURIES PER LITER

RESULTS ACCURATE TO 2 SIGNIFICANT FIGURES.
ERROR TERM AT 95% CONFIDENCE LEVEL.

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AUTOVON 240-2061

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RADIOANALYTICAL FUNCTION (OEBSA)
BROOKS AIR FORCE BASE, TEXAS 78235-5000

OE ID

19200141

AL/OEBSC
CONSULTANT SERVICES
BROOKS AFB, TX 78235-5501

BASE ADDRESS CODE: Q00253C

IDENTIFICATION:
Base Sample #: ON920011 BOMARC SITE PU-3
OEHL ID: 19200141
Type of Sample: WATER, NONPOTABLE, NOT SDWA
Workplace or Site ID: 0253 ____ ____ BROOKS AFB, TX
Date Collected: 22-JAN-92
Date Received: 24-JAN-92
Date Completed: 11-FEB-92

FILTERS FOR PU-6 FILTERED SAMPLE

GROSS ALPHA	3.1	+/-	0.5	PICOCURIES PER LITER
GROSS BETA	2.3	+/-	0.4	PICOCURIES PER LITER

RESULTS ACCURATE TO 2 SIGNIFICANT FIGURES.
ERROR TERM AT 95% CONFIDENCE LEVEL.

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ARMSTRONG LABORATORY
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OE ID

19200142

AL/OEBSC
CONSULTANT SERVICES
BROOKS AFB, TX 78235-5501

BASE ADDRESS CODE: Q00253C

IDENTIFICATION:
Base Sample #: ON920012 BOMARC SITE PU-3
OEHL ID: 19200142
Type of Sample: WATER, NONPOTABLE, NOT SDWA
Workplace or Site ID: 0253 ____ ____ BROOKS AFB, TX
Date Collected: 22-JAN-92
Date Received: 24-JAN-92
Date Completed: 11-FEB-92

FILTERS FOR PU-3 DUPLICATE FILTERED SAMPLE

GROSS ALPHA	3.2	+/-	0.5	PICOCURIES PER LITER
GROSS BETA	2.4	+/-	0.4	PICOCURIES PER LITER

RESULTS ACCURATE TO 2 SIGNIFICANT FIGURES.
ERROR TERM AT 95% CONFIDENCE LEVEL.

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AUTOVON 240-2061