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DOE/EIS-0064

Final Environmental Impact Statement
(Final Statement to ERDA 1545-D)

Rocky Flats Plant Site

Golden, Jefferson County, Colorado

U.S. DEPARTMENT OF ENERGY

APRIL 1980

Volume 1 of 3

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Rocky Flats Plant Site

Golden, Jefferson County, Colorado

Responsible Official

Lynda L. Brothers/for

Ruth C. Clusen
Assistant Secretary for Environment

U.S. DEPARTMENT OF ENERGY
Washington, D.C. 20585

APRIL 1980

Volume 1 of 3

FOREWORD

Shortly after the National Environmental Policy Act of 1969 (NEPA) was enacted, the Atomic Energy Commission (AEC) initiated a program of preparing environmental assessments and impact statements concerning ongoing activities at various AEC laboratories, major sites, and projects, including the Rocky Flats Plant site.

The Energy Reorganization Act of 1974 resulted in the AEC being dissolved and its functions being divided among two newly formed agencies. One of those agencies, the Energy Research and Development Administration (ERDA), assumed certain AEC responsibilities on January 19, 1975, that included operation of the Rocky Flats Plant site at Golden, Colorado. In 1977, these ERDA responsibilities were assigned to the Department of Energy (DOE), as a result of the Department of Energy Organization Act.

In May 1975, an environmental assessment of the Rocky Flats Plant was prepared to determine the significance of the environmental impacts for continued operation of the Rocky Flats Plant. Based on that assessment and other related documents, ERDA announced its intent to publish an environmental impact statement (40 FR 24234) assessing the environmental effects of continued operation of the Rocky Flats Plant and invited predraft comments and suggestions for consideration in preparation of the draft environmental impact statement (DEIS, ERDA 1545-D). Thirty-six responses from individuals, organizations, and Government agencies were received, and considered in the preparation of the DEIS, and are acknowledged in the document. The DEIS was issued in September 1977 and 29 formal comment letters were received as a result of public review. The draft EIS analyzed the cumulative environmental impact associated with current proposed activities and alternatives to such activities.

Notice of a public hearing on the DEIS was published in the Federal Register, in April 1978 (43 FR 17391). DOE conducted the public hearing in Denver on May 24 and 25, 1978. The purpose of this hearing was to afford further opportunity for public comment and to provide additional information to assist DOE in the review of the environmental effects of continued operation of the Plant. A DOE "Staff Statement in Response to Comments Received on the DEIS" was issued in April 1978 and made available to those who commented on the DEIS and others. It summarized and addressed the substantive points raised in the written comments. Specific issues raised at the hearing were recorded in the Hearing Transcript and Record. Copies of the Hearing Transcript and Record, which includes the presiding board's statement and the written responses to participants, were distributed to all hearing participants, and are available in appropriate DOE Public Document Rooms.

Two previous environmental statements have been issued for certain activities at the Plant site. One concerned a new plutonium recovery facility (WASH-1507, USAEC, January 1972*); a second concerned land acquisition (WASH-1518, USAEC, April 1972). Environmental assessments were also written for the Wind Systems Test Center at Rocky Flats and for soil removal of the "lip area."

This final EIS (FEIS) incorporates a number of changes as a result of the comments and suggestions received on the DEIS. The major additions and revisions are noted below.

Volume I, Chapter 2, includes updated information on seismic stability of the area and seismic design criteria are presented. A mechanism for dissemination of the data from seismic studies in progress is specified. The Plant's personnel protection program with respect to nonradioactive materials, Plant security systems, and the emergency plans of the Plant and the State of Colorado are discussed in greater detail. Material on the environmental monitoring program has been updated to reflect current monitoring and measuring conditions. Discussions of various soil sampling methods, plutonium background levels in soil, and plutonium soil standards, are presented. A new scientific report is included as Appendix A-2, which provides added information on the behavior of transuranics in soil. More detailed information on HEPA filter efficiency is also presented.

The dose calculations in Chapter 3 were extended to include comparisons of organ doses to natural background organ doses as well as the dose to the whole body. Doses to women and children are considered by exposure pathway as well as those for "Standard Man." A detailed presentation on the methodology for dose calculations is included as Appendix F. All source terms have been reviewed and revised as appropriate. The demography has been reevaluated and dose effects are calculated as a function of linear distance (not considering the effects of terrain) to a radius of 50 miles from the Plant.

All credible accident scenarios were reviewed and details updated. A comprehensive discussion of genetic and health effects is presented in Appendices G-2 through G-4. Also, nonradioactive toxic material spill data is discussed and a maximum credible accident for beryllium is postulated. The discussion of transportation shipping containers and applicable regulations was updated. A discussion of the nuclear materials inventory system was added.

*Throughout this document, references are noted within parentheses. The author or responsible organization is mentioned first and is followed by the publication date. All references are identified fully at the end of the section in which they are noted. The detailed references are listed alphabetically according to the originating organization or by the key author's last name. The publication date appears last.

Chapter 5 was revised to reflect the effort and cost involved in decontaminating soil, both on-site and offsite, relative to various decontamination criteria which might be employed.

Reports and documents included as Appendices to the DEIS, but which are now available to the public, are not reprinted as Appendices. Several new Appendices have been added.

To aid the reader in understanding the text, a glossary of terms not in common usage by the general public is included. An index has been included to aid the reader in identifying topics of special interest. As a further aid to understanding, English units of measure have been used, for the most part, throughout this document. Exceptions occur in technical discussions in which metric units are more commonly used. Volume II contains the detailed technical background on which the conclusions in the impact statement are based and Volume III contains the comments received to the DEIS with associated responses.

Numerous references are made herein to ERDA Manual Chapters (ERDAM) which continue to serve as appropriate DOE guidelines until superseded by final DOE Orders and Manuals.

REFERENCES

ERDA. Omnibus Environmental Assessment for the Rocky Flats Plant of the U.S. Energy Research and Development Administration. U.S. Energy Research and Development Administration, Rocky Flats Area Office, Golden, Colorado, 80401. May 1975.

ERDA. "Rocky Flats Site, Preparation of Environmental Statement." Federal Register, Vol. 40, Page 24234. June 5, 1975.

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USAEC. Environmental Statement, Land Acquisition, Rocky Flats Plant, Colorado. WASH-1518. U.S. Atomic Energy Commission. April 1972.

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ABBREVIATIONS, SYMBOLS, AND ACRONYMS

~	approximately
$\cong$	approximately equal to
°C	degree Celsius or Centigrade
°F	degree Fahrenheit
>	greater than
$\geq$	greater than or equal to
<	less than
μ	micro (a prefix meaning 10^{-6})
μCi	microcurie
χ/Q	chi-over-Q, dispersion factor
AEC	Atomic Energy Commission
Ag	silver
Al	aluminum
ALAP	As Low As Practicable
ALO	Albuquerque Operations Office (an organizational complex within the U.S. Department of Energy)
Am	americium
ARAC	Atmospheric Release Advisory Capability
ARMS	Aerial Radiological Measuring System
As	arsenic
ATMX	Atomic Munition Explosive Rail Transport Car
avg	average
B	boron
Ba	barium
Be	beryllium
BEIR	Biological Effects of Ionizing Radiation (a report)
BOD_5	Biochemical Oxygen Demand (five-day incubation period)
Br	bromine
Btu	British thermal unit
Ca	calcium
CCl_4	carbon tetrachloride
Cd	cadmium
CDH	Colorado Department of Health
Ce	cerium
CEQ	Council on Environmental Quality
cfm	cubic feet per minute
CFR	Code of Federal Regulations
Ci	curie

Cl	chlorine
Cl^-	chloride
cm	centimeter
cm^2	square centimeter
cm^3	cubic centimeter
CN^-	cyanide
CO	carbon monoxide
Co	cobalt
C.O.D.	chemical oxygen demand
Cr	chromium
Cs	cesium
CSU	Colorado State University
CU	University of Colorado
Cu	copper
CY	Calendar Year
dBA	decibel (on the "A" scale)
DCPA	Defense Civil Preparedness Agency
DEIS	Draft Environmental Impact Statement
d/m/g	disintegrations per minute per gram
D.O.	dissolved oxygen
DOD	Department of Defense
DOE	Department of Energy
DOS	Division of Operational Safety
DOT	Department of Transportation
DRCOG	Denver Regional Council of Governments
ECC	Emergency Control Center
EIS	Environmental Impact Statement
EML	Environmental Measurements Laboratory
EOC	Emergency Operating Center
EPA	Environmental Protection Agency
ERDA	Energy Research and Development Administration
ERDAM	Energy Research and Development Administration Manual
f	femto
F	fluorine
F^-	fluoride
Fe	iron
FR	Federal Register
FTS	Federal TeleCommunications System
FY	fiscal year

g	acceleration due to gravity
g	gram
GA	gross alpha
gal	gallon
Ge	germanium
gpm	gallons per minute
GI	gastrointestinal
^{3}H	tritium
HASL	Health and Safety Laboratory; renamed Environmental Measurements Laboratory, EML
HC	hydrocarbons
HCl	hydrochloric acid
HEPA	High Efficiency Particulate Air (filter)
Hg	mercury
hm	hectometer (100m; 0.1 Km)
hr	hour
HUD	Department of Housing and Urban Development
I	iodine
ICRP	International Commission on Radiological Protection
in.	inch
INEL	Idaho National Engineering Laboratory
IRAP	Interagency Radiological Assistance Plan
JCHD	Jefferson County Health Department
JNACC	Joint Nuclear Accident Coordinating Center
K	potassium
keV	kiloelectron volt
kg	kilogram
km	kilometer
Kr	krypton
kV	kilovolt
kVA	kilovolt ampere
kW	kilowatt
LAS	linear alkyl sulfonate
lb	pound
Li	lithium
LMFBR	Liquid Metal Fast Breeder Reactor
lpm	liters per minute
LSA	Low Specific Activity

m	meter
m^2	square meter
m^3	cubic meter
MDA	Minimum Detectable Amount
MDC	Minimum Detectable Concentration
METS	Metropolitan Emergency Telephone System
MeV	million electron volts
Mg	magnesium
mg/l	milligram per liter
mgd	million gallons per day
mi	mile
Mn	manganese
Mo	molybdenum
MPC	Marginal Propensity to Consume
MPC	Maximum Permissible Concentration
MPLB	Maximum Permissible Lung Burden
MPSB	Maximum Permissible Systemic Burden
mrem	millirem
MVA	megavolt ampere
MW-hr	megawatt hour
N	nitrogen
Na	sodium
NAWAS	National Warning System
Nb	niobium
NCAR	National Center for Atmospheric Research
nCi	nanocurie
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act
NH_3	ammonia
Ni	nickel
NO	nitrogen oxide
NO_2^-	nitrite
NO_2	nitrogen dioxide
NO_3^-	nitrate
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NRDC	National Resources Defense Council

OP	Office of Preparedness
ORIGEN	The ORNL Isotope Generation and Depletion Code
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Administration
P	phosphorus
Pa	protactinium
Pb	lead
PCB	polychlorinated biphenyl
pCi	picocurie
pH	negative logarithm of the hydrogen ion concentration. Acids have a pH less than 7; bases are greater than 7.
ppm	parts per million
psi	pounds per square inch
psia	pounds per square inch absolute
Pu	plutonium
PVC	polyvinyl chloride
R&D	Research and Development
Ra	radium
Rb	rubidium
RCG	Radioactivity Concentration Guide (a subscript "a" after RCG represents air; a subscript "w" represents water).
rem	roentgen equivalent man
RFAO	Rocky Flats Area Office (an organizational component of DOE)
RFP	Rocky Flats Plant
SARP	Safety Analysis Report for Packaging
Sb	antimony
scfh	standard cubic feet per hour
scfm	standard cubic feet per minute
Se	selenium
sec	second
Si	silicon
Sn	tin
SNM	Special Nuclear Materials
$SO_4^{=}$	sulfate
Sr	strontium
SS	suspended solids
SST	Safe Secure Trailer
SWECS	Small Wind Energy Conversion System

t	metric ton (tonne); 1000 Kg
T	tritium; also ^{3}H
Ta	tantalum
T Coliform	total coliform
Te	tellurium
Th	thorium
Ti	titanium
Tl	thallium
TDS	Total Dissolved Solids
TRU	Transuranium
TSA	Transuranic Storage Area
U	uranium
USAEC	United States Atomic Energy Commission
USDA	United States Department of Agriculture
USDC	United States Department of Commerce
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USPHS	United States Public Health Service
V	vanadium
W	tungsten
wt %	weight percent
Xe	xenon
yr	year
Zn	zinc
Zr	zirconium

GLOSSARY

The following terms are defined in accordance with their use in this Environmental Impact Statement. Alternate definitions may exist that are not applicable to the intended usage in this document.

actinide series - A series of heavy radioactive metallic elements of increasing atomic number beginning with actinium (element number 89) and progressing to the end of the periodic table.

activity - A measure of the rate at which a material is emitting nuclear radiations, usually given in terms of the number of nuclear disintegrations occurring in a given quantity of material over a unit of time. The standard unit of activity is the curie (Ci).

acute - Occurring over a short period of time.

aerodynamic mean diameter - The aerodynamic mean diameter is the diameter of a unit density spherical particle which settles in a fluid at the same velocity as the particle being considered.

air sampling - The act of collecting samples of air to detect and measure airborne radioactive or nonradioactive substances.

aliquot - A fraction of a substance taken for sampling purposes.

alluvium - The materials eroded, transported, and deposited by streams.

alpha activity - The ejection of alpha particles from the nucleus of an atom.

alpha particle - A positively charged particle emitted by certain radioactive materials. It is made up of two neutrons and two protons bound together, hence is identical with the nucleus of a helium atom. It is the least penetrating of the three common types of radiation (alpha, beta, gamma).

ambient air - Surrounding air.

americium (Am) - A synthetic radioactive element of atomic number 95; a transuranic nuclide recovered as a by-product of the plutonium recovery process. Am-241 decays by alpha emission and has a 434-year half-life.

aquifer - A formation that contains sufficient permeable material to yield significant quantities of water to wells and springs.

asphalt pad - An expression used at the Rocky Flats Plant in reference to an on-site area of plutonium-contaminated soil that is covered with a layer of asphalt.

atomic number - The number of protons in the nucleus of an atom.

attack (chemical) - Corrosion caused by chemicals; chemical reaction.

background - Radiation in man's environment from naturally-occurring radioactive elements and from fallout.

beta decay - Radioactive decay in which a beta particle is emitted from the nucleus.

beta particle - An electron of either positive or negative charge which has been emitted by an atomic nucleus or neutron in a nuclear transformation.

biota - The flora and fauna of a region.

blowdown - The continuous or periodic discharge of a portion of cooling tower water to control the level of solids in the circulating water.

book inventory (BI) - The inventory reflected by accounting records, such as the general and subsidiary ledgers; the amount of nuclear materials shown by the records to be present at a given time.

briquette - A compacted, often brick-shaped mass of metal pieces and/or chips.

burden - The amount of a specified radioactive material or the combined total of various radioactive materials present in an animal or human body or organ.

button - A small ingot or casting or the metal residue from the chemical reduction process; usually a flat disk, having a diameter of a few inches or less; an ingot of this shape and size.

calcination - Heating to drive off moisture, which results in a change in the chemical state in addition to the physical state.

canyon - A large, enclosed, heavily shielded enclosure or room used for processing or storing radioactive materials.

capable fault - A fault which has exhibited one or more of the following characteristics: (1) movement at or near the ground surface at least once within the past 35,000 years, or movement of a recurring nature within the past 500,000 years; (2) macroseismicity, instrumentally determined with records of sufficient precision to demonstrate a direct relationship with the fault; (3) a structured relationship to a capable fault according to characteristics (1) and (2) listed above, such that movement on one could be reasonably expected to be accompanied by movement on the other.

carrier precipitation process - A process for removing an unwanted impurity from a solution by chemical coprecipitation with another isotope of the same element or with another element. By such means, small traces of materials can be decreased to lower concentrations than by normal direct chemical precipitation.

chinook winds - Warm, dry winds that descend the eastern slope of the Rocky Mountains.

chronic - Occurring over a long period of time.

clarifier - Equipment used to clear suspended material from a liquid.

coliform - A type of bacteria normally found in the intestinal tract of animals. Fecal coliform usually indicates sewage pollution.

conservative - In application to accident analysis or dose assessments, a conservative assumption is one that tends to overestimate damage, release of material, or other adverse effects.

contaminant - A substance present as an impurity in another substance.

continuous air monitor - An instrument that continuously monitors the air for contaminants or pollutants.

controlled area - Any specific area into which entry by personnel is regulated by a physical barrier or by administrative procedure.

criticality - A self-sustaining nuclear fission reaction. A chain reaction.

criticality accident - The unplanned or unexpected assembly of a critical mass.

curie (Ci) - The basic unit used to describe the amount of radioactivity in a sample of material. The curie is equal to 3.7×10^{10} disintegrations per second.

daughter products - The nuclides formed from the radioactive disintegrations or decay of another nuclide, which is called the parent. Same as decay product.

decay products - The product of radioactive decay of an element. Same as daughter product.

decommissioning - The process of removing a facility or area from operation and decontaminating and/or disposing of it.

decontamination - The removal of unwanted material from the surface or from within another material.

degraded - Reduced in complexity in relation to structure or function, such as a degraded material.

demister - Filter material in a ventilation system that prevents droplets of moisture from coming into contact with HEPA filters.

demographic - The dynamic balance of a population density; the capacity of the population to expand or decline.

depleted uranium - Uranium having a smaller percentage of uranium-235 than the 0.7% found in natural uranium.

design agencies - Organizations responsible for the design of nuclear weapons or weapon components.

design basis earthquake - The earthquake magnitude that a building or operation is designed to experience and survive without major damage.

diffusion categories - Processes whereby particles of liquids, gases, or solids intermingle as the result of their spontaneous movement from a region of higher to one of lower concentration. For example, the diffusion of particles from a stack into the air. (See Pasquill stability classes.)

dilatometry - The measurement of expansion properties.

disintegration - Any transformation of a nucleus, whether spontaneous or induced by irradiation, in which particles or photons are emitted.

disintegrations per minute (dpm) - The number of radioactive decay events occurring per unit time (minute).

dose - A general term indicating the amount of energy absorbed from incident radiation by a specified mass. For special purposes it must be appropriately qualified. In this Impact Statement it refers specifically to the term "dose equivalent."

dose commitment - The integrated dose that results from an intake of radioactive material when the dose is evaluated from the beginning of intake to a later time; also used for the long-term, integrated dose to which people are considered committed because radioactive material has been released to the environment.

dose equivalent - A quantity that 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 the dose equivalent is the rem.

ecology - A branch of science concerned with the interrelationships between biological systems and their environment.

economic discard limit - That point at which further recovery or recycling is no longer economically feasible.

ecosystem - The sum of physical features and biological systems occurring in a given area.

effluent - Used or waste gases, liquids, and solids discharged from a building, vehicle or facility.

eluate - The washings obtained when absorbed material is removed by means of a solvent.

empirical - Originated or based on observation or experience.

enriched uranium - Uranium in which the amount of one or more fissile isotopes has been increased above that occurring in nature.

evaporator overhead - Vapors discharged from an evaporator.

excursion - A brief, rapid, nuclear fission reaction; see criticality accident.

expected release - See probability-weighted release.

exposure - To be open to an action or influence such as weather, light, or radiation.

extrusion - A metal-working process whereby metal, usually at high temperatures, is forced through a hollow die, annular die, or into a die cavity, thereby changing the dimensions of the starting material.

fallout - Airborne particles containing radioactive material that descend through the atmosphere and are deposited on the earth's surface following the detonation of nuclear explosives.

fault - A tectonic structure along which differential slippage of the adjacent earth materials has occurred parallel to the fracture plane.

fault tree - An analytical, tree-like diagram used to analyze inconsistencies in a program or concept.

Federal impact funds - Government funds distributed to local governments to offset the impact of Federal facilities in the local area.

fertile nuclide - A nuclide capable of being converted to a fissile nuclide by neutron capture.

filter bank - An arrangement of filters.

fiscal year (FY) - A 12-month period for handling financial matters. Since the Plant's beginning until 1976, each new fiscal year began on July 1; e.g., FY 1975 covered the period from July 1, 1974 through June 30, 1975. A change in 1976 resulted in fiscal years beginning on October 1; thus, FY 1977 extends from October 1, 1976 through September 30, 1977.

fissile material - Material capable of undergoing nuclear fission by interaction with neutrons of any energy.

fission - The splitting of a heavy nucleus into approximately equal parts (that are nuclei of lighter elements), accompanied by the release of a large amount of energy and generally one or more neutrons.

fissionable material - Material capable of undergoing nuclear fission by interaction with fast neutrons.

flocculation - The formation of aggregated or compound masses of particles.

food chain - The sequence of organisms, including producers, consumers, and decomposers, through which energy and materials may move.

forb - Any herb that is not grass or grass-like.

forming, as a metal - Any metal-working technique whereby metal sheet is shaped by pressing against a die with minimal change in the thickness of the sheet.

friable - Easily crumbled or reduced to powder.

gamma rays - Electromagnetic radiation originating from the nucleus of an atom following a nuclear transformation.

gamma scan - Estimating the radioactive material in a sample by means of a survey with a detection instrument sensitive to gamma rays.

Gaussian - Relating to the Gaussian Law of Error. A deviation of measured values about a true value.

generic release - A release to the environment of hazardous material from a particular class of sources (e.g. from a filter failure).

geophysical refraction survey - A survey of the geological strata underlying an area, performed by observing the refraction and reflection of surface sound waves.

glove box - A sealed box in which workers, using gloves attached to and passing through openings in the box, can handle radioactive materials safely from the outside.

gradient - The change in quantity per unit distance in a particular direction.

gram (g) - A metric unit of mass (nearly equal to the mass of one cubic centimeter of water at its maximum density).

gross alpha - The total rate of alpha particle emission from a sample.

gross beta - The total rate of beta particle emission from a sample.

half-life - The time required for the activity of a radionuclide to decay to half its value. Half-life is used as a measure of the persistence of radioactive materials.

health physics - The science concerned with recognition, evaluation, and control of health hazards from ionizing and non-ionizing radiation.

heating degree-day - A unit representing one degree of declination from a given temperature (usually 65 °F) in the mean daily outdoor temperature. Used to estimate heating requirements.

high gradient magnetic field separations - A technique developed to separate paramagnetic material from diamagnetic matter by passing the mixture, in slurry form, through a high gradient magnetic field.

hot particle theory - The theory which holds that the controlling factor in radiation dose received by a body organ (usually the lung) is the presence of localized radioactive ("hot") particles.

hydrogenous - Containing or referring to hydrogen.

hydrostatic stability - pertaining to the conditions under which an object in contact with a fluid will maintain equilibrium.

induced employment - Supporting employment induced in the surrounding communities that is not directly related to Rocky Flats but is required because of the presence of Rocky Flats employees in those communities. Primarily service-related employment.

inert atmosphere - A chemically unreactive atmosphere; one incapable of supporting combustion.

ingot - A mass of metal cast into a bar or other convenient shape.

inhibitors - Agents that slow or interfere with a chemical action.

inventory difference (ID) - The algebraic difference between the nuclear material book inventory (BI) and a physical inventory (PI). Inventory difference (ID) was formerly referred to as Book Physical Inventory Difference (BPID) and Material Unaccounted For (MUF).

ion - An electrically charged atom or group of atoms, the electrical charge of which results when a neutral atom or group of atoms gains or loses one or more electrons.

ion exchange - Phenomenon by which cations or anions in one phase exchange with species of like charge (positive or negative) in a second phase.

ionizing - Conversion to the ionized state; causing ions to be formed.

irradiated fuel material - Reactor fuel that has been used in a reactor so that a significant fission product inventory is present.

irradiation - Exposure to any form of radiation.

isopleths - A line on a map connecting points at which a given variable has a specified constant value.

Julian days - The consecutive days in a 365-day year (366-day leap year) as measured from January 1st.

Kjeldahl N - Nitrogen as determined by the Kjeldahl technique of analysis.

leaching - The process of extracting a soluble component from a mixture by percolation of a solvent (usually water) through the mixture.

license - An authorization issued by the Nuclear Regulatory Commission (NRC) to a person or organization to perform specified activities pursuant to Title 10, Code of Federal Regulations, Parts 30, 40, 50, and 55 of the NRC.

licensee - A person or organization authorized to conduct activities under a license or construction permit issued by the Nuclear Regulatory Commission (NRC).

liter (l) - A metric unit of capacity; equivalent to about 1.1 quarts in the English system.

loadings (earthquake induced) - Additional pressure or stress on a structure due to an earthquake.

long lived - Isotopes with half-lives greater than one week.

low level - Containing small amounts of radioactivity.

low-level activity - Amount of radioactivity that is in the range established for background.

low-level wastes - Wastes that can be discharged to the environment with assurance that persons will not be exposed to concentrations in excess of those prescribed in Chapter 0524 of the ERDA Manual.

low specific activity (LSA) waste - Having a low rate of radioactive decay. When applied to radioactive waste management, it refers to that waste having less than 0.1 microcurie of plutonium per gram of waste material or less than 300 microcuries of uranium per gram of waste material.

macroearthquake - Earthquake large enough to be felt, i.e., detected without instruments.

macroinvertebrates - Refers to the species of larger animals that lack a backbone and internal skeleton.

man-rem - A unit of population dose; often the average dose per individual, expressed in rem, times the population affected.

maximum credible accident - A hypothetical accident, the result of one or more improbable events, which leads to the most severe consequences. Accidents with probabilities less than 1×10^{-7} per year are excluded from consideration in this EIS.

maximum permissible concentration (MPC) - The greatest concentration of a radionuclide in air or water to which a worker or member of the general population may be continuously exposed without exceeding an established standard of radiation dose.

maximum permissible dose (maximum permissible exposure) - That dose of ionizing radiation below which there is no reasonable expectation of risk to human health, and which is below the lowest level at which a definite hazard is believed to exist.

maximum probable accident - The accident with the highest probability of occurrence.

meter (m) - The basic metric unit of length.

microearthquake - Earthquake that can be detected only by an instrument.

mist eliminator - A device that removes liquid mist or droplets from a gas stream.

moderation (of neutrons) - Slowing down of neutron speed.

modules - Self-contained laboratory or process areas, environmentally isolated from one another.

multiple exhaust filtration - Filtration process in which the exhaust air passes through several filters in series.

neutralized (chemical) - A chemical solution that is neutral (neither acidic or basic, i.e., a pH = 7). Accomplished by adding acid to a basic solution or a base to an acidic solution.

neutron - An uncharged elementary particle existing in or emitted from the atomic nucleus.

neutron absorber - A nuclide that interacts with a neutron primarily by absorption, without the production of additional neutrons.

neutron poison - A strong neutron absorber, such as boron or cadmium.

normal operations - Planned, routine activities, as contrasted to accidents.

nuclear radiation - Particles and electromagnetic energy given off from the nucleus of an atom.

nuclide - A general term referring to the nucleus of the elements. Nuclides are distinguished by their atomic number, atomic mass, and energy state.

occupational exposure guide - Radiation exposure limits established for persons working in a radiation-related occupation.

one-hundred-year storm - A storm of such severity that with a probability of more than .01 per year it is unlikely to occur.

oolite - A rock consisting of small round grains, usually calcium carbonate, cemented together.

operating basis earthquake - The earthquake magnitude that an operation can experience and safely shut down.

order of magnitude - An estimate of size or magnitude expressed as a power of ten.

organic - Relating to chemical compounds containing carbon rings or chains.

orogeny - The process of mountain building especially by folding of the earth's crust.

Pasquill stability classes - Relates atmosphere stability to plume dispersion according to weather conditions; especially surface wind speed, local insolation, and vertical temperature profile. Specifically the following:

A-Extremely unstable conditions
B-Moderately unstable conditions
C-Slightly unstable conditions
D-Neutral conditions (applicable to heavy overcast day or night)
E-Slightly stable conditions
F-Moderately stable conditions

physical inventory (PI) - The quantity of nuclear material which is determined to be on hand by physically ascertaining its presence using techniques which include sampling, weighing and analysis; a process by which the quantity is determined.

plenum - A location in which air pressure within an enclosed space is greater than in outside atmosphere. Usually applied to the enclosure containing the air filters, as filter plenum.

plume shine - Radiation exposure received directly from a plume or cloud of radioactive material.

plutonium (Pu) - A heavy, radioactive, man-made, metallic element with atomic number 94. Its most important isotope is fissile plutonium-239, produced by neutron irradiation of uranium-238. It is used for reactor fuel and in nuclear weapons. Plutonium-239 decays by alpha emission with a 2.4×10^4 year half-life and has a spontaneous fission half-life of 5.5×10^{15} years.

pollutant - A contaminant which, when present in sufficient quantity for a sufficient time, has been determined to be harmful to the environment or to people.

population dose (population exposure) - The summation of individual radiation doses received by all those exposed to the source or event being considered.

precipitation process - The process of separating one or more components from a solution by solidification.

probability-weighted release - The magnitude of a release multiplied by the probability of its occurrence. Also referred to as "expected release."

process air - Air that has been exposed to radioactive or other contaminants, such as in a glove box.

process hood - An enclosure having an open front and used to prevent the spread of hazardous contamination.

puck - A solid mass of metal similar in size and shape to a hockey puck.

radiation - The electromagnetic energy or particles emitted as a result of a nuclear transformation. The term includes alpha and beta particles, gamma radiation, X rays, neutrons, and cosmic radiation. Nuclear radiation is that emitted from atomic nuclei in various nuclear reactions.

radiation protection guide (RPG) - The officially determined radiation doses that should not be exceeded without careful consideration. These standards, established by the Federal Radiation Council, are equivalent to what was formerly called the maximum permissible exposure.

radioactivity - The property possessed by some elements of spontaneously emitting alpha or beta particles and sometimes also gamma rays by the disintegration of the nuclei of atoms.

radioactivity concentration guide (RCG) - The concentration of radioactive material in an environment that would result in doses equal, over a period of time, to those in the Radiation Protection Guide.

radiological - That which involves radioactive or nuclear materials.

radiometric analysis - Quantitative chemical analysis that is based on measurement of the absolute disintegration rate of a radioactive component.

radionuclide - A radioactive nuclide.

Raschig ring - A small, annular, borosilicate-glass cylinder used as a neutron poison.

reactor - A device capable of bringing about controlled nuclear fission.

reference man - The adult male having anatomical and physiological characteristics defined in the ICRP Publication 23, "Report of the Task Group on Reference Man," 1975.

reflection - The change of direction of light, heat, or sound after striking a surface; the change of direction of a neutron after a collision with a nucleus.

release - The act of allowing contaminants to leave direct human control; may be scheduled or accidental.

rem - The unit of dose equivalent which is numerically equal to the absorbed dose in rads multiplied by the quality factor, the distribution factor and any other necessary modifying factors.

resuspension factor - The ratio of the concentration in air, measured at some specified distance above the ground, to that in the soil:

$$K(m^{-1}) = \frac{\text{concentration in air (activity/m}^3\text{)}}{\text{concentration in soil (activity/m}^2\text{)}}$$

reverse osmosis - A technique used in wastewater treatment. Pressure is applied to the surface of a waste solution, forcing pure water to pass from the solution through a membrane.

risk - Possibility of radiation exposure to individuals as a result of normal Plant operations or potential Plant accidents.

risk dose - A hypothetical dose obtained by assuming that each of the postulated accidents occurs yearly but at a magnitude equal to the probability of occurrence per year multiplied by a maximized estimate of the magnitude of the release; sometimes called the expected or probability-weighted dose from accidents.

roentgen (R) - A unit of exposure to ionizing radiation. One roentgen corresponds to the release of ionization of 83.8 ergs of energy per gram of air.

rolling, as a metal - A metal-working process whereby metal is compressed between rotating cylinders to form a sheet or foil.

safe geometry - A configuration used to ensure that fissile material is restricted to a critically safe shape and/or limited to a critically safe quantity.

safe secure trailer (SST) - A special trailer for transporting nuclear materials.

safeguards - Precautionary measures to prevent the unauthorized diversion of nuclear materials.

saltation - An abrupt movement or transition, such as the movement of soil particles along the ground by the action of wind.

scrap - Material which can be recycled for productive use, and plutonium/oraloy contaminated material which exceeds the economic discard level.

scrubber - An apparatus for removing impurities from a gas stream.

security fence - The high, chain-link fence that encompasses the Plant's operational area and prevents uncontrolled access.

seismicity - The relative magnitude, frequency, and distribution of earthquakes.

seismology - The science of earthquakes and attendant phenomena.

shear forming, shear spinning - A metal-working process whereby a preform on a rotating mandrel is forced by the action of a rotating die to elongate against the mandrel with an accompanying decrease in the thickness of the preform.

shielding - A barrier designed to protect persons from radiation exposure.

shutdown - The cessation or suspension of an activity.

sintering - A heating action resulting in a substance becoming a coherent mass.

site boundary - The perimeter of the Government-owned land on which the Rocky Flats Plant is located.

solid wastes (radioactive) - Either solid radioactive waste material or solid objects that contain radioactive material or bear radioactive surface contamination.

somatic - Relating to or affecting the body.

sorption - The binding of one substance to another by any mechanism, such as absorption or adsorption.

source term - The quantity of radioactive material, released in an accident or during normal operations, that can subsequently cause exposure of personnel.

special nuclear material (SNM) - In atomic energy law, this term refers to plutonium-239, uranium-233, uranium containing more than the natural abundance of uranium-235, or any material artificially enriched in any of these substances.

specific activity - The radioactivity per unit mass of radioactive material.

spill - The accidental release of radioactive material.

stability (atmospheric) - A description of the effect of atmospheric forces on a parcel of air following vertical displacement in an atmosphere otherwise in hydrostatic equilibrium. If the forces tend to return the parcel to its original level, the atmosphere is stable; if the forces tend to move the parcel further in the direction of displacement, the atmosphere is unstable. If the air parcel tends to remain at its new level, the atmosphere has neutral stability. See Pasquill stability classes.

stack - A chimney, vent, or pipe-like opening that exhausts filtered air to the outside atmosphere.

standards - Acceptable limits established by recognized authorities.

standby - The status of a facility that is placed in a non-operating condition but is maintained in readiness for operation.

surfactant - A compound that affects (usually reduces) surface tension when dissolved in water.

surficial - Of or relating to a surface.

swaging - A metal-working process whereby a rod or tube is elongated with decreasing diameter or tapered by the action of hammer-like dies.

systemic burden - Amount of accumulated radioactive material within the body.

taxonomy - Laws and principles covering classification of organisms.

tectonic - Pertaining to structures resulting from deformation of the earth's crust.

telemetry - Transmitting the readings of instruments to a remote location by means of wires or radio waves.

tertiary age - Designating the earlier principal division of the Cenozoic geological era, of 3,000,000 to 65,000,000 years ago, marked by widespread geographic changes, as in the Alps; it includes the Paleocene, Eocene, Oligocene, Miocene, and Pliocene periods.

tertiary treatment - Sewage treatment beyond secondary treatment, involving additional clarification and filtration steps; a third treatment.

thorium (Th) - A naturally occurring radioactive element with atomic number 90 and, an atomic weight of approximately 232.

topography - General configuration of natural surface features of a region.

total alpha - Total number of alpha particles emitted by a radioactive substance.

total long-lived alpha (TLLα) activity - Total number of alpha particles emitted by a radioactive substance, but where the radioactive substance has a long half-life.

tracers - A foreign substance, usually radioactive, mixed with or attached to a given substance so the distribution or location of the substance may be determined.

transuranic element - An element with an atomic number greater than that of uranium in the periodic table; i.e., with an atomic number greater than 92. All 11 transuranic elements are produced artifically and are radioactive.

transuranium registry - Register of people exposed to transuranic elements.

tritium (^3H) - A radioactive isotope of hydrogen with two neutrons and one proton in the nucleus. Tritium decays by beta particle emission with a 12.3 year half-life.

turbidity - A measure of the degree to which sediments and other foreign matter are suspended in water cloudiness.

uptake - The ability of a biosystem, such as a plant, to absorb radioactive materials.

uranium (U) - A radioactive element with the atomic number 92 found in natural ores. It has an average atomic weight of approximately 238. The two principal natural isotopes are uranium-235 (0.7% by weight of natural uranium), which is fissile, and uranium-238 (99.3% by weight of natural uranium), which is fertile. Natural uranium also includes a minute amount of uranium-234.

valence - A positive or negative number that characterizes the chemical combining power of an element; measured by the number of atomic bonds formed upon chemical combinations.

vibroseis reflection survey - A means of acquiring data for seismic studies. "Vibroseis" is a trademark of Continental Oil Company.

waste - Material deemed to have no recoverable value, and plutonium/uranium contaminated material which is determined to be below the economic discard level.

watershed - The area drained by a river system.

weight percent - Percentage of a material in a mixture of materials determined by weight.

wind rose - A diagram showing the distribution of prevailing wind directions at a given location; some variations include wind speed groupings by direction.

worst case condition - The situation or parameter value of a particular factor which leads to the most severe accident consequences; for example, in the analysis of a release of radioactivity, the worst case condition for wind direction is to be toward the largest nearby population center.

X rays - An electromagnetic radiation produced by electron transitions within the atom and by electron bombardment.

METRIC TO ENGLISH CONVERSIONS

Efforts have been made to use English units of measure throughout this Environmental Impact Statement. In some cases, however, Metric units have been used because they are more common to the topic being discussed. Meteorological data and calculations are examples of subject areas commonly reported in the Metric system. To assist the reader in converting from Metric values to the more familiar English values, the following conversion table is provided.

To Convert from	To	Multiply by
Calories (cal)	Btu	0.00397
Centimeters (cm)	Inches (in.)	0.394
Centimeters (cm)	Feet (ft)	0.0328
Cubic centimeters (cm^3)	Cubic feet (ft^3)	0.0000353
Cubic meters (m^3)	Cubic feet (ft^3)	35.314
Degrees Centigrade (°C)	Degrees Fahrenheit (°F)	*
Grams (g)	Ounces (oz)	0.0353
Grams (g)	Pounds (lb)	0.00220
Kilograms (kg)	Pounds (lb)	2.204
Kilometers (km)	Miles (mi)	0.621
Liter (l)	Cubic feet (ft^3)	0.0353
Liter (l)	Gallons (gal)	0.264
Liter (l)	Quarts (qt)	1.0567
Meter (m)	Feet (ft)	3.281
Meters per second (m/sec)	Miles per hour (mi/hr)	2.237
Microns (micrometer or mm)	Inches (in.)	0.000039
Milligrams (mg)	Ounces (oz)	0.000035
Milliliters (ml)	Quarts (qt)	0.00106
Milliliters (ml)	Ounces (oz)	0.0338
Millimeter (mm)	Inches (in.)	0.0394
Square meter (m^2)	Square feet (ft^2)	10.764

* °F = (°C x 9/5) + 32

SCIENTIFIC NOTATION

The conventional notation, when dealing with very large or very small numbers is awkward and cumbersome. Writing 0.000000000000001, for example, is undesirable as is calling this number "a millionth of a billionth." To overcome this problem, a notation system in general use throughout the scientific community has been employed in this Environmental Impact Statement. This system would indicate the above number as 1×10^{-15}. This notation then can be converted back to the original number by moving the decimal point according to the power of ten. If the power of ten is positive, for example, the decimal is moved right the number of places indicated by the power. If the power of ten is negative, the decimal is moved left the number of places indicated by the power. An example of a positive and negative power of ten follows:

$$1.25 \times 10^{5} = 125000$$
$$1.25 \times 10^{-4} = 0.000125$$

Prefixes are often added to units (such as curies or grams) to indicate the magnitude of the value. Prefixes used in this Statement, their values, and their abbreviations are as follows:

Prefix	Power	Value	Symbol
mega	10^{6}	1,000,000	M
kilo	10^{3}	1,000	k
centi	10^{-2}	0.01	c
milli	10^{-3}	0.001	m
micro	10^{-6}	0.000001	μ
nano	10^{-9}	0.000000001	n
pico	10^{-12}	0.000000000001	p
femto	10^{-15}	0.000000000000001	f

Thus, 1 kilogram (kg) = 10^{3} grams = 1,000 grams
and 1 microcurie (μCi) = 10^{-6} curie = 0.000001 curie

An abbreviation used in some tables for large or small numbers utilizes a value followed by the letter E. After the E is another number, which represents a power of 10. The number 1.055E+3 (or 1.055E3), for example, is 1.055×10^{3}. The number 1.08E-8 is identical to 1.08×10^{-8}.

1. SUMMARY

1.1 INTRODUCTION

This Environmental Impact Statement presents an overview of the Rocky Flats Plant at Golden, Colorado, and its operations, a description of the area in the general vicinity of the Plant, and an assessment of the actual and potential environmental impacts associated with current Plant operations and with alternatives to current Plant operations. This EIS is designed to serve as input for DOE decisions on the continued operation of the Rocky Flats Plant site. The arrangement of this information in Chapter 1 corresponds to the order in which the information appears in the body of the Environmental Impact Statement.

The Rocky Flats Plant site is used primarily for producing components for nuclear weapons to assist in fulfilling U.S. nuclear weapons production requirements which are imposed on DOE by the Congress and the President. The United States defense policy, and nuclear weapons requirements in support of that policy, which are established by the President and the Congress, restrict alternatives as to DOE's weapons production activities. However, the converse is not true. DOE's production of nuclear weapons does not foreclose options with respect to the overall U.S. national defense program. Consequently, decisions on the continued operation of the Rocky Flats Plant site does not foreclose U.S. options associated with maintenance of a nuclear weapons stockpile or a possible nuclear war. Therefore, this Environmental Impact Statement focuses on the site specific environmental impacts of conducting nuclear weapons production activities at the Rocky Flats Plant and alternatives for the conduct of such activities which assess the environmental impacts of the U.S. policy to produce nuclear weapons. Meaningful decisionmaking on the continued operation of the Rocky Flats Plant site does not require a consideration of issues related to maintenance of nuclear weapons stockpile or the possible effects of a nuclear war. Environmental assessments or impact statements have been prepared for all major facilities in the DOE weapons complex.

1.2 BACKGROUND

To fully evaluate the Plant impact, Chapter 2 presents a detailed description of the Plant and its activities. Information concerning the Plant's physical characteristics, demography, geology, seismology, hydrology, ecology, and meteorology is presented.

Activities at the Plant are divided into those considered major and those that are supportive. Major operations involve fabrication and assembly (of plutonium, beryllium, uranium, and other metals), plutonium recovery, americium separation, and research and development. Operations that support the major activities are those that have to do with the control of quality, safety, and maintenance; utilities as electricity, fuel, inert gas, water, and steam; and the transfer or shipping of materials and products to and from the Plant.

1.2.1 History - Summary of Section 2.1

The Rocky Flats Plant is a Government-owned and contractor-operated facility, which is part of a nationwide nuclear weapons production complex. This facility was located at Rocky Flats after the U.S. Government decided to expand its weapons capability in 1950. Thirty-five possible sites were investigated before the present site was selected. Construction of the facility began in 1951, and start-up of operations occurred the following year. The need for new facilities, plus the expansion and upgrading of existing facilities, has resulted in virtually continual construction on the Plant site since 1951.

The Plant was operated for the U.S. Atomic Energy Commission from the Plant's inception until the AEC was dissolved in January 1975, as a result of the Energy Reorganization Act of 1974. The responsibility was assigned at that time to the Energy Research and Development Administration, which was subsequently succeeded by the Department of Energy (DOE) in 1977. The Plant is operated under the direction of the DOE Albuquerque Operations Office (ALO). The prime operating contractor of the facility from 1951 until June 30, 1975, was Dow Chemical U.S.A., an operating unit of The Dow Chemical Company. Rockwell International was selected to succeed Dow Chemical U.S.A., beginning July 1, 1975, as the prime contractor responsible for operating the Rocky Flats Plant.

1.2.2 Plant Description - Summary of Section 2.2

The Plant is a key Federal facility, with unique processing capabilities, for the production of materials for the nuclear weapons program and other work directly related to national defense. Some work at Rocky Flats, such as Wind Energy Systems evaluation, is in support of other programs for the DOE and other government agencies. The Plant is involved primarily with metal fabrication, assembly, and chemical processing. There also is heavy emphasis on production-related research. Production activities include numerous metalworking, fabrication, and assembly shops; chemical recovery and purification processes; and associated quality control functions. Research includes such disciplines as chemistry, physics, materials technology, ecology, nuclear safety, mechanical engineering, health physics, environmental sciences, and wind energy.

The Rocky Flats Plant is located in northern Jefferson County about 16 miles northwest of downtown Denver. The Plant site encompasses about 6,550 acres of

Federally-owned land with the major structures of the Plant located within a security-fenced area of 384 acres. The remainder of the land serves as a buffer zone between the central facility and the general public.

The original Plant consisted of some 20 structures with about 700,000 square feet of building floor space. Subsequent construction and additions have increased the capacity to more than 1.7 million square feet of building floor space in over 100 structures. With the addition of new plutonium recovery and waste treatment facility, the total floor space will exceed 2.1 million square feet.

1.2.3 Site Environment - Summary of Section 2.3

The area in the immediate vicinity of the Rocky Flats site is primarily agricultural or undeveloped. No public facilities or institutions, such as schools, prisons, or hospitals are located within 5 miles of the Plant. There are four commercial/industrial facilities, including Jeffco Airport, within 5 miles of the Plant. Several population centers are located within 10 miles with the closest being the small community of Leyden, 3.3 miles south of the Plant.

The 1977 population living within 50 miles of the Rocky Flats Plant was about 1.8 million, projected to increase to 3.5 million by the year 2000. The 1977 Denver metropolitan area population was about 1.5 million persons living within 50 miles of the Rocky Flats Plant. Based upon growth projections used by the Denver Regional Council of Governments, the Denver-area population by the year 2000 is projected to be 2.4 million. The area within 5 miles of the Plant had an estimated 1977 population of approximately 4,100, i.e., an average density of about 52 persons per square mile. This area population is projected to increase to about 9,200 in the year 2000 or roughly 188 persons per square mile. The most populated sector is to the southeast, which is in the direction of the center of Denver. The 1977 estimated population between 10 and 50 miles in this sector was 524,900. This number is expected to increase to 1,212,600 by the year 2000.

The natural environment of the Plant site and vicinity is influenced primarily by its proximity to the Front Range of the Rocky Mountains, which is immediately west of the site, and the elevation of the site, which is approximately 6,000 feet above sea level. The surficial geology is described by the title given the area, i.e., Rocky Flats. The area consists of a thin gravelly topsoil layer underlain by 20 to 50 feet of thick, coarser, clayey gravel. This in turn is underlain by an impermeable bedrock structure upon which most of the buildings' foundations are supported. Detailed seismologic investigations have been undertaken for the more recently built structures. Studies are still underway to investigate the seismologic integrity of the older buildings. The results of these studies will be incorporated in the Safety Analysis Reports.

Area hydrology is controlled by a thin gravelly alluvium, which is highly permeable. The result is little water retention in the soil, as is evidenced by sparse vegetation in the area. Surface and groundwater flow is from west to east, originating in the Front Range mountains. Most groundwater eventually surfaces to join the natural streams traversing the site and flowing to Great Western Reservoir or Standley Lake (see Figure 2.1-1).

The meteorology of the site is characterized as mild; however, occasional hurricane-force winds occur as a result of the site's proximity to the Front Range mountains. Tornadoes are rare in this region, and the damage resulting from individual tornadoes tends to be less than from tornadoes in the Great Plains. Precipitation is generally light, with the yearly average being slightly over 15.8 inches.

The natural background radiation level in the Denver area is somewhat higher than the national average. The sources of natural background radiation include cosmic radiation and naturally occurring radioactive elements, such as uranium and thorium.

Man-made releases of long-lived radionuclides, chiefly plutonium, from atmospheric weapons testing have deposited plutonium in the soil. In addition, Plant operations have increased the plutonium concentrations in the immediate vicinity of the Plant, the main source being from drums that leaked plutonium-contaminated oil between 1959 and 1968. This resulted in the dispersal of about 2.4 curies of plutonium to areas outside the present site boundaries.

Plant and animal life is typical of that found in nearby areas. Several species of small mammals and larger animals inhabit the site. The small intermittent streams flowing through the site do not support large aquatic communities, but a variety of species are present because of the high, natural water quality.

1.2.4 Wind Energy Test Facility - Summary of Section 2.4

A wind-energy test facility has been constructed in the northwest corner of the Plant's buffer zone. The purpose of the facility is to test small wind-energy generating systems. Approximately 450 acres of land are used and contain meteorological and test towers, some roads, and some instrument trailers. No radioactive materials are used with this project. A small potential hazard exists because of the possibility of a blade falling off a windmill during periods of high winds. However, because of the remote location of the site and the controlled access to the area, the possibilities of injury to personnel from a major incident are slight.

1.2.5 Major Activities and Facilities - Summary of Section 2.5

The chief function at Rocky Flats is the fabrication of nuclear weapons components utilizing both radioactive and nonradioactive materials. In support of the fabrication, the Plant provides facilities for the recovery of plutonium and americium from waste residues, treatment and disposal of these wastes, chemical laboratories, research and development, and special support operations for other DOE facilities. The facilities for fabrication and recovery of plutonium comprise the majority of the buildings. The plutonium and other radioactive or toxic materials processed are handled in enclosures within the buildings. Both the enclosures and buildings are designed and operated to minimize any exposure of personnel and the environment to these materials and the radiation they produce. Elaborate controls, such as sprinkler systems for fire suppression, controlled pressure ventilation, and air sampling for radioactivity are used to ensure personnel safety and protection of equipment and the environment.

1.2.6 Support Activities and Facilities - Summary of Section 2.6

In support of the principal Plant activities are many functions and systems such as Quality Engineering and Control (QE&C); the Health, Safety and Environment (HS&E) Program; Utility and Maintenance Services; and Material Shipments.

The QE&C Department is divided into various subgroups which provide inspections and chemical analyses of materials. Under the HS&E department the divisions include the Medical Program, Nuclear and Facility Safety, Environmental Sciences, Health Sciences and Industrial Safety, Radiation Monitoring, and Fire Protection Engineering.

The Utility and Maintenance Services provide such functions and services as water treatment systems, steam production, and laundry facilities. The Plant meets almost all of its heating requirements with in-plant steam boilers that are normally fueled with natural gas. The Public Service Company of Colorado, who supplies the natural gas, also supplies electricity to the Plant from two separate facilities: the Boulder Hydro and the Valmont Steam Generating Plants. Water is obtained from the Denver Water Board and is drawn from Ralston Reservoir and the South Boulder Diversion Canal. All incoming water is treated in an on-site water treatment plant. The water is used for process and sanitary purposes. After treatment, the process wastewater is evaporated. Sanitary wastewater, treated by an on-site tertiary treatment facility, is subject to limits of a NPDES (National Pollutant Discharge Elimination System) permit.

A variety of materials is shipped to and from the Plant by truck, rail, and air. Shipment by truck, the mode used most frequently, includes both commercial truck lines and Government-owned Safe-Secure Trailers. Rail shipments are made in government-owned ATMX-600 Series rail cars that have been modified to carry radioactive waste materials. Shipments of radioactive material by air are restricted to non-passenger aircraft. The air shipment mode is chosen when the need for rapid delivery of the package justifies the premium cost of air freight. Air shipments of nuclear materials meet the safety standards of The Department of Transportation and The Nuclear Regulatory Commission. No shipments of plutonium by air have been made since April, 1977. However, shipments by designated air carriers can be made in special cases for national security purposes, under the provisions of Public Law 94-187 (see Section 2.10) and of DOE regulations in 10 CFR 871.1.

The primary reliance for safety in the shipping of radioactive material is placed on stringent packaging criteria as specified in the Plant's quality assurance program. This program calls for adherence to the Department of Transportation (DOT) packaging requirements in 49 CFR 171-178 and to ERDA Manual Chapter 0529. Since the start-up of Plant operations in 1952, shipments of radioactive materials from Rocky Flats have covered more than 4 million miles; yet there has never been a transportation accident which released radioactive materials.

1.2.7 Radioactive Waste Systems - Summary of Section 2.7

Operations at the Rocky Flats Plant result in addition of radioactive materials to various liquids, solids, and gases used in research, production, and manufacturing. Radioactive materials are handled in accordance with stringent procedures and within multiple containments designed to minimize their release to the environment. The radioactive waste systems include local collection, filtration, and temporary storage facilities for those process wastes known or suspected to contain radioactivity. The systems also involve centralized processing facilities for maximum recovery of plutonium-bearing liquid and solid wastes. Solid wastes receive treatment to concentrate and package nonrecoverable radioactive materials for shipment to DOE-approved storage sites.

1.2.8 Chemical and Biocidal Waste - Summary of Section 2.8

The Rocky Flats Plant has over 1,800 different chemicals on the site, of which the majority are present only in laboratory quantities. Wastes from the use of these chemicals are transferred to the waste treatment plant. Before disposal, some of the chemicals may require specialized treatment to make them innocuous.

Biocides are used in cooling-tower water treatement to prevent biological fouling. Biocides and herbicides are used in weed and pest control on the Plant site. Plans for application of pesticides and herbicides are prepared in accordance with the Federal Working Group on Pest Management.

1.2.9 Sanitary Waste - Summary of Section 2.9

Sanitary waste lines collect human wastes and convey them to the sanitary waste (sewage) treatment plant. Effluents from the sewage plant flow into holding ponds which are monitored on a regular basis. Sanitary wastewater is kept separate from all process wastewaters, and is routinely monitored for radiation levels.

Rocky Flats has ditches, culverts, and underground pipes for collecting and controlling surface water runoff. Surface water runoff from inside the security fence leaves the Plant through the North and South Walnut Creek drainage. These waters are monitored daily.

1.2.10 Environmental Monitoring Program - Summary of Section 2.10

The operating contractor conducts a comprehensive environmental monitoring program to determine whether operation of the Plant is causing an adverse effect on the surroundings. The program is designed to provide confirmation that the many pollution control systems and procedures are working properly, that concentrations of effluents are within applicable guides and limits, and that the quantity of waste in effluents is at the lowest practical level. Air, water, biota, and soil are sampled not only on the Plant site but also in the surrounding region for radioactivity and for chemical and biological pollutants.

Numerous agencies conduct additional independent environmental surveys, both on and off the Plant site. The Colorado Department of Health, for example, conducts air, water, and soil sampling programs around the Rocky Flats site. The DOE Environmental Measurements Laboratory (EML) of New York maintains particulate air sampling stations in the vicinity of the Rocky Flats Plant and periodically performs soil sampling and analysis.

The Jefferson County Health Department has a continuous particulate air sampler on the site. These samples are analyzed by the Colorado Department of Health. The County also samples and analyzes sewage plant effluent monthly. The U.S. Environmental Protection Agency provides additional routine liquid effluent monitoring to determine compliance with the NPDES (National Pollutant Discharge Elimination System) permit. EPA conducts special studies of the Plant environment.

1.2.11 Emergency Plans - Summary of Section 2.11

Emergency plans are maintained in a state of readiness to meet any emergency situation that may occur. The basic Rocky Flats Emergency Plan defines responsibilities and provides guidance to all supervision regarding immediate notifications and actions. Supplemental plans describe procedures which are to be implemented by specialized response groups and building personnel in the event of an emergency situation. Communication is maintained with off-site agencies as part of the State emergency response plan for the Rocky Flats area, and to keep State and local officials informed of emergency matters which may raise public concern.

If an emergency should occur that could present an actual or potential hazard to the general populace, the Colorado Emergency Radiological Response Plan would be implemented. This plan interfaces with the overall Rocky Flats Emergency Plan.

Training exercises are performed to ensure personnel familiarity with emergency procedures. Off-site exercises are coordinated with cognizant civil emergency agencies.

1.2.12 Safeguards and Security - Summary of Section 2.12

The Rocky Flats Safeguards and Security Program is designed to protect nuclear material, classified information, and other government and contractor assets from loss, theft, diversion, sabotage, espionage, or other harm by internal or external hostile forces. The Safeguards and Security Department consists of Plant Protection, Technical Security, Nuclear Materials Control, Plant Utilities, Fire Department, Emergency Planning, Document Control and Access Control functions. The program is administered within Department of Energy requirements.

1.3 ENVIRONMENTAL IMPACT

Chapter 3 contains an in-depth description of the physical, economic, and social impact that results from Plant operations.

Normal operations at the Plant use such resources as water, natural gas, fuels, and electricity. In addition, operations at the Plant may alter the topography, geology, hydrology, and ecology of the immediate area. The impact of emissions from operations as they affect the water, air, and soil in and around the Plant are addressed. Radioactive and nonradioactive releases from normal operations, though small, are taken up in the soil, water, vegetation, and air. On the basis of past and current releases, estimates of future releases are made.

The impacts caused by accidents, both actual and postulated, man-made and natural, are studied.

1.3.1 Environmental Effects of Normal Plant Operation - Summary of Section 3.1

Efforts to restrict routine releases of radioactive and nonradioactive material to the lowest practical level have resulted in normal Plant operation which has no significant impact on the environment. For example during the entire year of 1977, 4.9 grams of beryllium (a non-radioactive, but toxic element) were released from Rocky Flats during normal operations. The EPA standard accepts the release of up to 10 grams of beryllium per day or 3,650 grams per year from a single stationary source.

Off site, concentrations of radioactivity in liquid effluent from the Plant are also well below applicable limits. This is confirmed by the weekly samples taken from Great Western Reservoir. Water is recycled and returned to the environment as water vapor. During CY 1977, these samples showed average plutonium concentrations of less than 0.10 pCi/l and tritium concentrations of about 750 pCi/l. These quantities are a very small fraction of the Radioactivity Concentration Guide (RCG) adopted by the DOE, as well as EPA and State limits and are near background levels. The RCG values are 1,667 pCi/l for plutonium and 1,000,000 pCi/l for tritium in drinking water. The EPA and Colorado drinking water limits relating to plutonium are 15 pCi/l for alpha activity (excluding natural uranium) and 20,000 pCi/l of tritium.

The radiological impact on persons living within 50 miles of the center of the Plant is assessed in terms of the 70-year dose which would result from 70 years of continuous Plant operation. Of primary interest for the types of radioactive materials routinely released are doses to the total body, liver, bone, and lungs. The organ doses received by a person residing continuously for 70 years at a distance of two miles from the center of the Plant in the east-southeast direction (the location of the maximum annual air concentration) is expected to be 0.0012 rem to the total body, 0.11 rem to the liver, 0.25 rem to the bone, and 0.079 rem to the lungs. Perspective for these values is obtained by comparison with organ doses received by a Denver-area resident from natural background radiation. This comparison shows that the maximum organ doses received from normal operation of the Rocky Flats Plant are the following fractions of the organ doses from natural background radiation: 0.00011 for the total body, 0.010 for the liver, 0.020 for the bone, and 0.0043 for the lungs. The values for persons residing at greater distances or in other directions from the Plant are smaller. The radiological impact on persons living within 50 miles of the Rocky Flats Plant, from routine operation, is therefore imperceptible, as an addition to that received from natural background sources.

The radiological impact of routine operations is also assessed in terms of the health effect on the population within 50 miles of the Plant, based on demographics both for the year 1977 and projected to the year 2000. Of concern is the possible number of cancer mortalities plus genetic defects resulting from organ doses summed for the population for 70 years of exposure to routine emissions from the Plant. This impact is a total of less than one (0.59) effect over 70 years for the year 1977 population group and less than one (1.00) effect over 70 years for the year 2000 population group. Thus the health effects from routine Plant operations on the population surrounding the Plant are imperceptible in a population which experiences health effects from other sources.

The population demography, as determined from area planning departments for the year 2000, projects a relatively low density to the east of the Rocky Flats Plant. If one postulates a very high population density of 7296 persons per square mile for the east through south-southeast sectors for distances of two to five miles from the Plant, the increase in the population bone dose is 19.8% (from 5.00×10^4 to 5.99×10^4 man-rems). The increase does not change the conclusion that the radiological impact is imperceptible. Of course, the dose and impact assessments for individuals are not affected by consideration of population densities.

1.3.2 Environmental Effects of Postulated Plant Accidents - Summary of Section 3.2

Postulated Plant accidents that could release either or both radioactive and nonradioactive materials include the following: spills, mechanical or administrative failure, impoundment failure, fire, criticality, aircraft impact, tornadoes, high winds, and earthquakes. Each of these accidents is described and the probability of occurrence and the maximum probable and maximum credible releases are assessed.

This impact statement gives the impacts on man primary consideration. The assessment of this impact on man is made in two ways. First a risk dose to organs of persons living within 50 miles of the Plant is determined for a period of 70 years. The risk dose is a hypothetical dose obtained by assuming that each of the postulated accidents occurs yearly but at a magnitude equal to the probability of occurrence per year multiplied by a maximized estimate of the magnitude of the release. The results of this assessment are that the organ risk doses (over 70 years) are from two to four times smaller than the 70-year organ doses from natural background radiation. This indicates that the organ risk doses for the person residing for 70 years at a distance of 2 miles from the Plant in the ESE direction are the following fractions of the background organ doses: 0.000070 for the total body, 0.0023 for the liver, 0.0045 for the bone, and 0.0013 for the lungs. For persons living in other directions or at other distances, these values are even smaller.

The second approach to the assessment of the impact is to determine the consequences if each of the postulated maximum credible accidents were to occur. For this assessment the doses (70-year dose commitments) to organs of persons downwind for the postulated accidents are calculated. The greatest dose commitment to an individual results from the maximum credible aircraft impact, for which the 70-year dose to a person 1.2 miles downwind from the release point is 2.2 rem to the total body, 270 rem to the liver, 690 rem to the bone, and 160 rem to the lungs. These values decrease by a factor of greater than 100 for a person 40 miles downwind. The risk of cancer mortality plus genetic defects over 70 years for any person from any of the postulated maximum credible accidents is less than the risk of death to an individual in the general population from common accidents over the 70 years, which is about 0.03 per person for 70 years. Comparison with organ doses for background radiation indicates that the 70-year background doses are greater than the 70-year dose commitments to the organs for a person at any off-site location for all types of maximum credible accidents except the aircraft impact (expected to occur once per 7.7 million years) and high winds of 158 to 206 mph (expected to occur once per ten thousand years).

The effect of the worst case maximum credible accident (the aircraft impact) is also assessed. For this assessment, the wind is assumed to blow toward the sector of maximum population, the southeast. The maximum impact is 60 cancer mortalities plus 3.5 genetic defects over 70 years in a downwind population of over one-half million, from an accident which has a possibility of occuring once every 7.7 million years. Analysis of the impact on a hypothetical population density (which is not expected to occur before the year 2000) of 7296 persons per square mile between two and five miles on the east to south-southeast sectors indicates a 16.9% increase (from 6.97×10^6 to 8.15×10^6 man-rems) in the population bone dose.

The risk of cancer mortalities and genetic defects over 70 years is assessed for the maximum individual for exposure at the Plant boundary and a subsequent 70-year dose from each of the maximum credible accidents. For any type of maximum credible release, the total resulting mortality risk to this maximum individual is less than the risk of the average person in the total population being killed by a common accident over 70 years.

Except for releases from criticality accidents, where food usage would be controlled, all other doses have been calculated assuming no mitigating actions are taken to reduce exposure to or intake of radionuclides. If an accident were to occur, people could be advised to stay inside, and to avoid consumption of contaminated food or water.

A fire in a filter containing 10 kg of beryllium is <u>postulated</u> as the maximum credible accident involving nonradioactive materials. A short-term concentration of 7.7 $\mu g/m^3$ <u>might occur</u> at the Plant boundary. This is in excess of 0.01 $\mu g/m^3$, which is the permitted average monthly concentration at the breathing zone level in the neighborhood of any facility handling beryllium, but less than 25 $\mu g/m^3$, which is the maximum permitted 30-minute peak concentration for occupational exposures.

1.3.3 <u>Environmental Effects of Transportation</u> - Summary of Section 3.3

Several different effects of air, rail, transport truck, and delivery truck transportation associated with Rocky Flats are analyzed. They are associated with normal operations of the system and with accidents that could occur.

The environmental effects of (1) increased traffic on the various transportation links, (2) fuel consumption by Rocky Flats-related transportation vehicles, (3) exhaust emissions of these vehicles, and (4) thermal effects of these vehicles are all determined to be imperceptible.

The consequence of a beryllium release in the case of a major transportation accident and fire is analyzed. The maximum air concentration to which an individual downwind could be exposed is 0.07 $\mu g/m^3$. This concentration falls between the previously mentioned 0.01 $\mu g/m^3$ ambient air quality standard for continuous public exposure and the permitted in-Plant 8-hour average atmospheric concentration of 2 $\mu g/m^3$.

The radiological effect of normal operation of the transportation vehicles associated with Rocky Flats results from external penetrating radiation to the entire United States population. By assuming that all shipments are made by commercial carrier and the maximum external dose rate allowed for these vehicles, the population dose is 4900 man-rem to the total body. Much of this dose would be received by these transportation workers. The effect of 70 years of Rocky Flats transportation at maximum levels is a possible increase of 1.2 cancer fatalities and 1.5 genetic defects for the population of the United States. The possibility of higher than average exposure to selected individuals was assessed. Transport truck drivers could receive up to 1.4 rem per year.

The risk to the U.S. population from transportation accidents is quantified in terms of the "risk dose", as was done for Plant accidents. The risk dose for 70 years of Rocky Flats transportation of radioactive materials is 1.8×10^4 man-rem to the bone, 1.2×10^4 man-rem to the lung, 7.6×10^3 man-rem to the liver, and 6.1×10^1 man-rem to the total body. These exposures are small in comparison to the 70 year background dose to the U.S. population of 2.7×10^9 man-rem to the lung, 1.8×10^9 man-rem to the bone, and 1.2×10^9 man-rem to the liver and total body. This risk dose can result in a possible increase of 0.63 cancer deaths and 0.02 genetic defects. Man-rem is the dose in rem times the number of personnel potentially exposed.

The risk dose is not actually received by any individual in the population, or by the population as a whole. Rather, most individuals would receive zero dose, and if an accident occurred, individuals downwind would receive more. The maximum credible transportation accident might result in a 70-year exposure of 18 rem to the bone, 7.2 rem to the liver, 4.9 rem to the lung, and 0.06 rem to the total body over a 70-year period to the individual at the point of maximum air concentration. These doses do not take into account any protective actions to effect a decrease in the dose.

An analysis is done for the hypothetical maximum consequence accident, although the probability of this accident is very low. A severe accident involving a truck carrying a large amount of Rocky Flats plutonium is assumed to occur in a highly populated metropolitan area such as that modeled for New York City. Different diffusion modeling techniques are used in this analysis to model an urban landscape as compared to the rural characteristics of land near the Rocky Flats Plant. The resulting population dose is 4.1×10^6 man-rem bone dose, 1.7×10^6 man-rem liver dose, 1.0×10^6 man-rem lung dose, and 1.4×10^4 man-rem total body dose. The resulting health effects would be an increase of 71 cancer fatalities and an increase of four genetic defects for a 70-year exposure period. A similar accident involving enriched uranium would have health effects of two and three orders of magnitude less, respectively. This accident, however, is predicted to occur only once in 3.3 million years.

1.3.4 Economic and Social Impacts - Summary of Section 3.4

The principal benefit from the Rocky Flats Plant is its contribution to national defense. Portions of the Plant's operation and facilities, particularly those portions involved in fabricating plutonium parts for nuclear weapons, are highly specialized. Socioeconomic effects include primary and secondary impacts. The operation of the Rocky Flats Plant creates direct employment for approximately 2,800 people and induces employment for an additional 6,500 individuals. Although this employment contributes to the population in surrounding communities, it does not place a new burden on the schools, municipal services, or general community facilities in the region. The Plant has been in operation for well over two decades, and community services have already adjusted to meet these requirements. The Rocky Flats Plant has an annual payroll of nearly $40 million and is responsible for about $90 million of income from induced employment. Of this $130 million total, about $100 million is disposable income. Also, $30 million is spent by the Plant for materials, services, and utilities. Of this total, $8.3 million is spent locally for materials and services and $5 million for utilities. The $100 million plus the Plant's local expenditures of $13.3 million each year add a significant amount to the overall regional income. This increased income helps further the economic viability of the Denver area.

Because of its location and the nature of its operation, the Rocky Flats Plant does not create any significant adverse impacts with respect to noise.

Technological benefits stem from Plant operations and from personnel who offer technical knowledge, expertise, and advice in chemistry, metallurgy, machining, nondestructive testing, safety, fire prevention, health physics, environmental science, and numerous other scientific and industrial subjects. This information is disseminated throughout the local communities, the United States, and the world. One resulting benefit is the contribution this information makes to the overall economic, social, and cultural growth of the region and the United States.

1.4 UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

Chapter 4 considers the unavoidable, adverse environmental impacts of continued operation of the Rocky Flats Plant. Those effects caused by alterations to the physical environment, the use of natural resources, and the biological impact from the release of nonradioactive materials are mentioned. Other effects outlined are those attributable to the release of radioactive effluents, the social and economic consequences of the increase in population and decrease in land use, and the ways the Plant has reduced adverse effects.

1.4.1 Nonradiological Effects - Summary of Section 4.1

Normal operation of the Plant results in the consumption of fossil fuels (oil and natural gas), chemicals, metals, and electricity. Water is used by the Plant and returned to the region as a resource through water vapor from the liquid process wastewater treatment plant and through evaporation from cooling towers, solar evaporation ponds, and holding ponds.

Plant operations resulting in small discharges of nonradioactive effluent in air and water are described in Chapter 2. With a few exceptions, discharges have been within the applicable State and Federal limits.

1.4.2 Radiological Effects - Summary of Section 4.2

Normal Plant operation also results in unavoidable release of small amounts of radioactivity to the general environment. In addition, there will be continuing dispersal of radioactivity to the general environment from past releases. The amounts of material that may be released during future operation of Rocky Flats from both routine and accident conditions are considered in Chapter 3.

1.4.3 Socioeconomic Effects - Summary of Section 4.3

The socioeconomic impacts of the Rocky Flats Plant are attributable primarily to Plant-related employment and to the associated increase in population in the general vicinity of the Plant. These impacts include an increased demand for housing, school facilities, and municipal services. Because of the proximity of Rocky Flats to several population centers, the Plant's socioeconomic impacts, although unavoidable, have little adverse impact on the surrounding region. Most of the communities in which Rocky Flats Plant employees and their families reside have grown substantially in recent years. These communities have developed adequate housing, schools, and municipal services to meet the needs of this growing populace.

Other impacts include (1) the loss of agricultural productivity and income from the land comprising the Rocky Flats Plant site, and (2) a change in the tax base because of the land being withdrawn from the public tax rolls and tax revenue being generated instead by income, property, and sales taxes collected from Plant employees.

1.4.4 Mitigation of Adverse Environmental Effects - Summary of Section 4.4

Several areas of endeavor serve to lessen environmental effects from Plant operation. These include an enlarged buffer zone, total water recycle, and actions such as improvements in accident prevention to reduce potentially adverse radioactive and nonradioactive effects on the environment.

Recent energy conservation efforts have reduced the Plant's energy consumption by about 26% for FY 1977 as compared to FY 1973. As almost one-third of the Plant's water usage is for cooling tower operation, and is directly related to energy use. A net reduction of approximately 33% in water consumption was also realized during the same period. A tertiary project improved the existing sewage treatment plant by adding a clarifier, filter system, pumphouse, pumps, and instrumentation. The effluent now has less suspended solid material and it meets present effluent standards for off-site release. Another mitigating action, expected to be operational in the early 1980's is a total water-recycle project which will eliminate all routine wastewater discharges. No Plant wastewater will leave the site except by evaporation. A part of the zero water discharge program under construction will eliminate the routine discharge of Plant sanitary wastewater into Great Western Reservoir. A surface water control project designed to contain contaminants which might leave the Plant site in storm water runoff is also underway.

Included among other mitigating actions are modifications and upgrading of filtration systems, double containment of process liquid waste lines, removal of on-site soil containing plutonium, and laundry wastewater impoundment until a new process waste-treatment facility is completed. The new process waste-treatment facility, a part of the new plutonium-recovery facility project, will recover water from Plant liquid process wastes for subsequent reuse in Plant cooling towers. Upon completion, the plutonium-recovery and waste-treatment facilities will help reduce the discharge of radioactive materials to the environment (see Section 2.7.3.2).

1.5 ALTERNATIVES

A variety of alternatives to the continuing operation of the Plant as it is presently being administered are considered in Chapter 5. The monetary costs and radiation dose reduction from the alternatives are projected. One alternative that can be considered is to continue current operations without any change. The environmental impact of this alternative also can serve as a basis on which to compare other alternatives. The other alternatives involve changes in Plant operations at the present site in addition to consideration of more encompassing actions such as relocating portions or all of the Plant's current activities. Various alternatives have been postulated and analyzed in terms of five primary categories. The five are (1) no change in current activities, (2) completion of changes currently underway, (3) relocation, (4) termination of operations, and (5) other potential alternatives.

1.5.1 No Change in Current Activities - Summary of Section 5.1

If Plant operations were to continue for 70 years, with no changes, the radiological impact on persons living within 50 miles of the Plant for that period would be imperceptible, both compared to doses received from natural background radiation and based on risk of cancer mortality and genetic defects. From an economic standpoint, the region would continue realizing an overall input roughly comparable to $113.7 million per year (in 1976 dollars) because of the Rocky Flats Plant.

1.5.2 Completion of Changes Currently Underway - Summary of Section 5.2

Several actions already have been initiated and, upon completion, will alter the environmental impact of Plant operations. The principal changes that make up this alternative are (1) the construction of a new facility for plutonium recovery, (2) construction of a facility for treating process waste, (3) total recycle of the Plant's water, and (4) partial removal of on-site, plutonium-contaminated soil.

The new plutonium recovery facility will result in plutonium recovery operations being performed in greater safety than the presently used facility, with greater operating economy, and with a reduced amount of plutonium generated as waste. The possibility of spreading contaminants by fire or other accidents will be lessened, and an overall decrease will be achieved in the levels and amounts of plutonium leaving the Plant in effluents. This new facility is being built to more stringent earthquake, tornado, fire, and other specifications as required by the DOE criteria for new plutonium facilities. The facility will recover as much plutonium as practicable for return to the manufacturing system; unrecoverable plutonium residues will be concentrated for transfer to a DOE-approved waste storage site. In terms of the effect on radiological impact, the new plutonium recovery building is not expected to result in any change to organ doses to persons living in the vicinity of the Plant, either from routine releases or from risk of accidental releases. It will decrease the amount of material being shipped for disposal.

The new facility for treating liquid process waste has been designed to handle the present workload at Rocky Flats, the maximum possible output from the new recovery operation, and a reasonable margin for variation in general Plant waste through 1985. The primary benefit to the general public from the waste treatment facility will be the elimination of any further need for solar evaporation ponds. That means a reduction in the risk of an accidental release from the ponds. The risk of release from the postulated impoundment failure would be zero, resulting in a reduction in risk dose to all organs in those persons who drink water supplied from Great Western Reservoir. The risk dose reduction to the bone is 53%, which is equivalent to 90 mrem. Risk doses to all other persons would not change.

The Federal Water Pollution Control Act Amendments of 1972, established as an ultimate goal the elimination of all routine liquid discharges from the Plant by 1985. Rocky Flats expects to comply with this goal by 1981. This entails the design and construction of facilities for recycling all sanitary and process wastewater. There are two major construction projects designed to attain this goal. The first is the Water Control and Recycle project. This project will involve facilities for treating and totally recycling all sanitary effluent, cooling tower blowdown, and backwash from water treatment filters. The project, when completed, will involve purification of treated sanitary wastes through a reverse-osmosis system. The second related project is the process-waste treatment portion of the new plutonium recovery and waste treatment facility. After treatment, all aqueous process wastewater will be recycled. The effect of these two systems is to eliminate all routine waterborne emissions from the Plant. The result would be a possible reduction in organ doses of up to 84% for persons drinking water supplied from Great Western Reservoir. Organ doses to all other persons would not be affected.

With regard to actions relating to on-site, plutonium-contaminated soil, approximately 400 cubic yards of soil are now being removed. The soil, which is located in the southeast area of the security-fenced portion of the Plant site, was contaminated from activities that occurred as a result of plutonium-bearing oil leaking from drums between 1959 and 1969. Some of the released plutonium was spread, primarily by the wind, over both on-site and off-site land. An area of about one acre on site containing the highest levels of plutonium (greater than 5,000 d/m/g) has been removed recently, resulting in a reduction in the organ doses of up to 7% for persons living within 50 miles of the Plant.

1.5.3 <u>Relocation</u> - Summary of Section 5.3

Relocation of all Plant activities to one or more other sites has been considered, as has relocation of only the radioactive-materials processing functions, leaving the nonradioactive operations.

Complete relocation would be followed by total decontamination, demolition, and restoration of the existing site. The benefit would be a reduction in organ doses for persons living within 50 miles of the Plant to 5% or less of the doses from routine operations and an elimination of the risk dose from accidental releases. The maximum doses presently received from normal Plant operation are the following fractions of doses from natural background radiation: 0.00011 for whole body, 0.010 for liver, 0.021 for bone, and 0.0045 for lungs. However, new facilities at a new site or sites would be constructed. The total cost for new facilities and site restoration was estimated at $1.52 billion in 1976 dollars, with escalation to a midpoint of 1984 adding another $710 million for a total of $2.2 billion in 1988 when the project would be completed. Any environmental benefits gained by the Denver area residents by the transfer of operations would be environmental losses to the alternative community. A short-term economic benefit to the Denver area of $405 million would result from demolition of existing structures and restoration of the current site. The annual revenue loss to the region would be $114.8 million.

The radioactive-materials processing functions now conducted at Rocky Flats could be relocated to another site, leaving only those functions involving nonradioactive materials. This would require new facilities at a new site and partial decontamination of the existing site. The total cost was estimated to be $1.4 billion in 1976 dollars. Escalation of this cost to a midpoint of 1984, with completion in 1988, would add another $600 million for a total cost of $2 billion. Benefits would be the same as for complete relocation, that is, a reduction in organ doses to 5% or less of the doses from routine operations and an elimination of the risk dose from accidental releases. Annual revenue loss to the region would be approximately $70.6 million, including both direct and induced income and expenditures. About a 63% percent reduction in personnel and a 50% reduction in local Plant purchases would be expected.

1.5.4 Termination of Operations - Summary of Section 5.4

Terminating operations at Rocky Flats, either by placing the Plant in a standby mode or by partial or total decontamination, demolition, and removal, involves many factors and potential impacts. Placing the Plant on standby would cost an estimated $17.8 million, but it would reduce doses from normal operation and accidents. The effect on organ doses would be a reduction of only 6% or less for routine releases. The risk dose from accidental releases would be reduced but by an undefined amount. The annual revenue loss to the region would be approximately $61 million in direct and induced revenues. Complete shutdown, decontamination, and partial demolition of the Plant is estimated to cost approximately $332 million and would reduce area revenues by approximately $114 million per year. Complete demolition of the Plant and total restoration of the site to a near natural condition would include an estimated cost of $526 million, and a local revenue loss of $114.8 million per year. Benefits would be the same as for complete relocation: a reduction in organ doses to 5% or less of the doses from routine operations and an elimination of the risk dose from accidental releases.

1.5.5 Other Actions - Summary of Section 5.5

Other potential alternatives to current Plant operations have been considered. These include (1) various actions regarding plutonium-contaminated soil, (2) the structural integrity of Plant buildings, (3) additional land acquisition, and (4) surface-water control.

Actions concerning control of plutonium in soil fall into two general categories: (1) removal of part or all of the existing plutonium, and (2) containment of the existing plutonium in place. Containment methods being considered include plowing, which transfers surface material to greater depths and reduces the concentration in the soil. This minimizes air or waterborne resuspension and dispersion. In cases of high plutonium concentrations, soil removal followed by plowing may be required. Depending on the method or methods used, costs may vary from $40 per acre for simply plowing, fertilizing, planting, and restoring the surface, to over $11 per square foot ($480,000 per acre) if soil removal, crating, and shipment off site are required. The total cost of removing plutonium from the soil in the area presently covered by the asphalt pad and from the pond sediments is estimated at $61 million. All off-site soil in the vicinity of the Plant is within the limits of the proposed EPA guidance (30 d/m/g). Therefore, no soil removal is required.

The most comprehensive soil removal alternative considered in this impact statement would be to remove all soil with plutonium levels above the State guideline of 2 d/m/g both on and off the site. This would involve about 3,000 acres excavated to a depth of about three inches at a cost of $1.5 billion. The effects of this action would be resultant organ doses of 18% to 87% of the estimated current level for persons drinking water supplied from Great Western Reservoir, 16% to 56% for persons drinking water supplied from Standley Lake, and 13% to 16% for all other persons within the 50-mile radius considered. These organ doses are currently very small fractions of the organ dose from natural background radiation. In addition, the removal of off-site soil above 2 d/m/g would reduce the organ doses to persons living on that ground, by a factor of up to about five. This additional benefit would affect only those persons living directly on the ground to be excavated according to this alternative. Removal of soil from only the most highly contaminated on-site areas and deep-plowing the remaining areas would give resultant organ doses of 28% to 89% of their current estimated amount. The cost of this project is estimated to be $72.4 million, which is 5% of the cost of total soil removal as previously described. If 500 d/m/g were chosen as a guide for soil removal, the area requiring decontamination would be approximately 50 acres at a cost of $72.3 million. The effect is a reduction of organ doses ranging from 74% to 96% of that currently projected.

Plowing the 3,000 acres believed to contain plutonium above the State guideline is estimated to cost $120,000 with a resulting reduction in the organ doses similar to the reduction that would be obtained for removal of all soil with plutonium levels above 500 d/m/g and with plowing in the remaining areas above the State guidelines. Removal of all radioactive material buried on site is estimated to cost $38 million but with no reduction in dose to the Denver-area population. Neither cost estimate includes decontamination of the asphalt pad and the holding ponds.

A project is currently underway to reevaluate the structural integrity of Plant buildings against possible damage from natural phenomena such as high winds, earthquakes, and tornadoes. These evaluations will be used in considering future actions which are beyond those identified in this EIS.

Approximately 4,000 acres of additional land was purchased in 1975 to provide an extension of the buffer zone and to minimize the problems that arise when residential communities expand to encroach on existing industrial facilities. Purchase of additional adjacent land (1,000 acres) containing plutonium exceeding the State guideline would cost an estimated $5 million. The effect of purchasing the additional land would be to prevent persons from residing on that land and thus from receiving organ doses which could result from the plutonium in the soil. No benefit in terms of a reduction in the organ dose would be received by any other persons from this action.

The FY 1978 budget includes a surface-water control project at Rocky Flats. The project, which is estimated to cost $2.8 million, consists of a series of canals and three dams downstream of Plant buildings. The system, as built, is designed to impound water from the worst-postulated 100-year storm and thus contain materials carried by flood waters. The project is expected to affect only the risk dose to persons drinking water supplied from Great Western Reservoir, by an amount equivalent to that for the waste treatment facility, i.e., a 90 mrem reduction in the risk dose to the bone.

1.6 RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

1.6.1 Cumulative Environmental Effects - Summary of Section 6.1

Current use of the land represents a limitation on alternate use of the 6,550 acres that constitute the Plant site. Restoration of the site upon decommissioning would include consideration of long-term uses; therefore, land used by the Plant does not necessarily limit future land-use options.

Several actions are under active consideration or are being implemented to ensure long-term productivity of the land. In addition to changes in Plant design and operation to further reduce radioactive and nonradioactive effluents (e.g., filter plenum improvements and the water recycle program), a land management plan is under development for the Plant site. Development of this plan involves the review and recommendations of Federal, State, and local agencies.

1.6.2 Decommissioning - Summary of Section 6.2

The primary mission of the Rocky Flats Plant is to produce components for nuclear weapons and to provide support activities as required by national defense policies. If there comes a time that the needs of national defense no longer involve Rocky Flats, the Plant could be used for some other government purpose, such as research, development, or production work. Other potential uses for the site, such as agricultural, industrial, or residential development would depend on the amount and cost of decontamination and other preparation that would be required.

1.7 RELATIONSHIP TO LAND-USE PLANS

1.7.1 Land-Use Plans - Summary of Section 7.1

State, county, and city land-use plans for the area in the vicinity of the Rocky Flats Plant were reviewed, and possible Plant influences on these plans were evaluated. The review covered comprehensive land-use plans where available, and zoning maps for Adams, Boulder, and Jefferson Counties, and the cities of Arvada, Boulder, Broomfield, Lafayette, Louisville, Superior, Westminster, and Wheat Ridge.

Most of the area in the immediate vicinity of the Plant is planned primarily for agricultural use or for open space. Small areas adjacent to the southern and western Plant boundaries are planned for industrial use. Two miles east of the Plant, several areas are planned for low-density residential development.

1.7.2 Plant Influence on Land Use - Summary of Section 7.2

There is no conflict between current Plant activities and current zoning obtained from the municipalities; however, there is extensive discussion about acceptable guidelines for plutonium levels in soil and the required remedial actions when such levels are exceeded. The State of Colorado has established a guideline concerning land preparation, prior to construction, for areas containing plutonium above 2 d/m/g (0.01 $\mu Ci/m^2$). Proposed EPA guidance names a level of 0.2 $\mu Ci/m^2$. Three lawsuits by landowners have been filed alleging that Plant operations have damaged land near the Rocky Flats site. The owners want to use the land for residential development, but the land has not been rezoned for residential use partly because it allegedly contains plutonium above the State's guideline. The offsite plutonium concentration in samples taken to a depth of 5 cm is in the range between 0.002 and 0.06 $\mu Ci/m^2$. Samples collected down to 0.3 cm contained plutonium in the range from 0.0004 to 0.03 $\mu Ci/m^2$.

1.8 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

1.8.1 Energy and Natural Resources - Summary of Section 8.1

Various natural and energy resources are consumed for utilities and transportation necessary for daily Plant operations. During the 1977 fiscal year, the following resources were expended: 104,050 megawatt hours of electricity; 637 million cubic feet of natural gas; 101,396 gallons of gasoline, excluding employees' personal transportation; 335,000 gallons of residual fuel oil; 19,353 gallons of diesel fuel; 40,876 gallons of propane; and 113 million gallons of water. While evaporated water is eventually returned to the environment through the natural hydrological cycle, it becomes unavailable to the immediate vicinity. Requirements for most of these resources are expected to increase slightly in the future, but efforts are being directed toward the conservation and most efficient utilization of these resources.

1.8.2 Manpower Resources - Summary of Section 8.2

Although usually considered a benefit, the employment required for Plant operation is a commitment of an important resource. The Plant employment, approximately 2,800 people during 1977, has declined over recent years from a maximum of 3,750 people in 1972. This drop has resulted from a reduction in production schedules and from budgetary limitations. Additional labor has been and will continue to be needed for periodic construction projects. The construction force over the past five years has averaged approximately 300.

As a result of the proximity of the Rocky Flats Plant to the Denver metropolitan area, these commitments of manpower benefit the overall economic and social well-being of the region, and do not place a burden on the available labor pool.

1.8.3 Financial Resources - Summary of Section 8.3

The initial cost of constructing Plant facilities and the periodic modifications made to these facilities have resulted in large expenditures of Government monies. Operation of the Plant is responsible for the expenditure of considerable sums of additional Government funds. Operating cost of the Plant, for example, is about $70 million annually. Construction costs of the Plant to date are approximately $250 million. The cost of additional facilities being constructed will raise this figure to more than $400 million in the near future. The financial resources for Rocky Flats have been from Federal funds designated for support of the national defense program.

1.9 ENVIRONMENTAL TRADE-OFF ANALYSIS

A complete benefit-risk analysis of the national defense program is beyond the scope of this Statement. The alternative of terminating operations is discussed without addressing its effect on national security. Portions of the Plant's operations and facilities, particularly those involved in processing plutonium, are highly specialized.

1.9.1 No Change in Current Activities - Summary of Section 9.1

The operation of the Plant is responsible for several socioeconomic benefits, on a local level, including direct and induced employment and the economic effects associated with increased disposable income in the region. These direct and induced employments constitute an annual revenue of more than $114.8 million to the local economy plus the employment of about 2,800 people. Operation of the Rocky Flats Plant involves the direct expenditure of nearly $70 million dollars annually.

Direct and induced employment as a result of the Plant, plus workers' families, have created additional community requirements such as increased housing, additional school enrollment, and increased demand for municipal services; however, because of the Plant's proximity since 1951 to several population centers, none of these requirements have placed a significant, additional burden on the affected communities.

The risks from Plant operations are derived from doses received by persons living in the vicinity of the Plant from routine radioactive releases and from possible exposure to radioactive releases from accidents. All of these risks are virtually imperceptible, however, since the organ doses are very small fractions of doses to corresponding organs from natural background radiation.

1.9.2 Completion of Changes Currently Underway - Summary of Section 9.2

Modification to existing operations are being implemented or are planned. Most of these modifications, which include construction of new facilities and actions to better control Plant effluents, will further reduce the levels of radiation exposure. New plutonium recovery and waste treatment facilities are being constructed at a cost of $190 million. A program for totally recycling Plant water is underway at a cost of $3.1 million, and a project to remove plutonium-contaminated soil from an on-site area has cost $470,000.

The cost-benefit evaluation of the impact on the Denver-area population from normal Plant operations and potential accidents indicates that the radiation doses are small compared to the doses received from natural radiation. Completion of planned actions will further reduce radiation exposure from Plant operations to the area population. This evaluation also indicates that the economic benefits to the region from Rocky Flats are substantial.

1.9.3 Relocation - Summary of Section 9.3

Relocation of the Plant would cost approximately $2 billion. The resultant doses would be 5% or less of present doses, with the continued possibility of an accident risk dose. Socioeconomic benefits which would be lost to the Denver area include 2,800 Plant jobs and 6,500 induced or secondary jobs.

1.9.4 Termination of Operations - Summary 9.4

Three modes were considered: (1) Standby; (2) Complete Shutdown, Partial Decontamination; and (3) Complete Shutdown, Complete Demolition, and Decontamination. The costs are $17.8 million, $332 million, and $526 million, respectively. The doses for the Standby mode would be 45% to 94% of the current value, with the continued possibility of an accident risk dose. For either of the Complete Shutdown modes, the dose will be 5% or less of the current level with no accident risk possibility. Though small, the added risk dose due to possible resuspension of contaminants during implementation of any of these alternatives is not considered.

The socioeconomic benefits for Standby mode include the retention of 6,080 direct and secondary jobs and $65 million in revenue.

1.9.5 Other Potential Alternatives - Summary of Section 9.5

Other potential alternative actions include removal or containment of plutonium-contaminated soil, at costs ranging from $120,000 to $1.5 billion. The resultant doses would be 25% to 90% of the present level. Socioeconomic benefits of Plant operations would be retained.

2. BACKGROUND

This Chapter provides a description of the Rocky Flats Plant---its purpose, location, history, and appearance. Included is detailed information on both man-made and natural features of the site. Operations within the Plant's boundaries are discussed, as are the resources and raw materials that make these operations possible. To further an understanding of the Plant's environmental impact, Chapter 2 contains background information about Rocky Flats' environmental monitoring and emergency preparedness programs.

In response to public review and comment on the DEIS, Chapter 2 has been updated and revised. Major additions and changes are summarized as follows:

- Demography given in Section 2.3.3 has been reevaluated to a 50 mile radius from the center of the Plant using planning data from the Denver Regional Council of Governments.

- The sections on Geology and Seismology were combined and updated as Section 2.3.4. It begins with a discussion of Rocky Flats Plant structural stability and seismic design criteria. New information on the possible activity of the Golden Fault has been added (2.3.4.6) and the relationship of the Derby earthquakes to the Rocky Mountain Arsenal deep well injection pumping is also discussed (2.3.4.7). Information on mineral resources in the vicinity of the Plant was added.

- The section on Materials Movement in the Hydrologic System (2.3.5.3) includes the hydrological test well monitoring program and Section 2.3.7, Materials Movement and Wind Erosion, was added. Information on the Environmental Monitoring Program has been updated to reflect current monitoring and measuring conditions. Tables on effluent stack, ambient air, and water sampling detection limits have been updated (2.10).

- Information on the soil sampling methods used by various agencies and the use of these methods in evaluating soil data is provided in Section 2.3.9.3. Also, additional plutonium-in-soil data has been added. The evaluation of the results with the use of median values for specific parcels is shown to reduce the area of land with plutonium concentrations greater than the State Guidelines.

- New information on the behavior of transuranics in soil is presented in the summary of Colorado State University Studies in Section 2.10.4.2 and Appendix A-2.

- The EPA Rocky Flats Cattle Study has been included in the review of terrestrial studies of off-site researchers.

- Sections on the Plant's personnel protection systems and programs have been expanded. Health and Safety aspects of handling beryllium and other metals have been added in Sections 2.5.1.2 and 2.5.5.2, and for handling selected solvents in Sections 2.5.2.1 and 2.6.2.4.

- A discussion of HEPA filter efficiency, testing, and maintenance has been added in Section 2.7.1. Efficiencies of a four-stage plenum are given. Adequacy of the selective alpha air monitors to detect a release is discussed in Section 2.5.1.2. Mention is made of the doubly contained, inspectable process waste piping in Section 2.7.3.1.

- The Plant's security and nuclear inventory system and the Colorado Emergency Response Plan for the Rocky Flats Area are discussed in greater detail in Sections 2.11 and 2.12. The issue of restricted air space over the Plant is reviewed in Section 2.6.

2.1 HISTORY

Prior to the construction of the Rocky Flats Plant, nuclear weapons components were manufactured primarily at Los Alamos, New Mexico, and to a lesser degree at Richland, Washington. In 1950 these facilities lacked the capability to meet the production requirements specified by the United States Government. As a result, plans to expand that capability were formulated. A search for a site to build a new facility was conducted in 1951. A site other than Los Alamos was strategically desirable to maintain a dual production capability. Site selection criteria were defined by the U.S. Atomic Energy Commission (AEC). Over thirty-five possible sites were investigated in the vicinity of nine cities before the Rocky Flats site in Jefferson County, Colorado, was selected; it best met the site selection criteria (The Austin Co., 1951). The U.S. Government then approved the construction in 1951 of the Rocky Flats Plant as an addition to the nation's nuclear weapons production complex. Responsibility for administrative control was assigned the AEC, and the Dow Chemical Company was awarded a contract as Rocky Flats' first prime contractor responsible for Plant operations.

Limited operations began in 1952 within a total site area of 2,520 acres. All Plant buildings and facilities were constructed inside a controlled area of less than 400 acres encircled by a security fence. These operations soon involved 700,000 square feet of building floor space in 20 structures. At the completion of a major expansion in 1957, an additional 10 buildings increased the total space to 900,000 square feet. There are presently more than 1.7 million square feet in over 100 buildings now constituting the Rocky Flats Plant. Additional construction of waste treatment facilities now underway will bring the total to 2.1 million square feet inside the security fenced area. The overall site was enlarged to its present size of approximately 6,550 acres by addition of a buffer zone in 1974 and is encompassed by a boundary fence on the property line, as shown in Figure 2.1-1.

As a result of the Energy Reorganization Act of 1974, the U.S. Energy Research and Development Administration (ERDA) succeeded the AEC in 1975 as the Government agency responsible for administrative control at Rocky Flats. ERDA was in turn succeeded by the U.S. Department of Energy (DOE) in October 1977. Organizationally, this responsibility is delegated to the Albuquerque Operations Office (ALO), which oversees a nationwide nuclear weapons production complex. This complex is administered by several DOE area offices. The Rocky Flats Area Office (RFAO), under the direction of an on-site Area Manager, is DOE's day-to-day contact with those operating the Rocky Flats Plant and with various construction contractors. Dow Chemical Company operated the Plant until July 1, 1975, when the Atomics International Division of Rockwell International became the new prime contractor.

Plant employment averaged around 2,800 during 1977. Sixty were DOE employees; the remainder made up the prime contractor's work force. There have been construction workers onsite throughout much of the Plant's existence. From 1970 through 1977, the number of construction workers averaged 300, and that number will probably remain relatively constant through 1980.

2.2 PLANT DESCRIPTION

The Rocky Flats Plant is a Government-owned facility with a primary mission of producing plutonium components for nuclear weapons. The site is used primarily to assist in fulfilling U.S. nuclear weapons production requirements that are imposed on DOE by the Congress and the President as a part of the overall national defense policy. This EIS does not assess the environmental impacts of the U.S. policy to produce nuclear weapons but rather focuses on the site specific environmental impacts of conducting nuclear weapons production activities at the Rocky Flats Plant and reasonable alternatives for the conduct of such activities. Key production activities involve the fabrication not only of plutonium but also of uranium and nonradioactive metals--principally beryllium and stainless steel. Parts made at the Plant are shipped elsewhere for final assembly. When a nuclear weapon is determined to be obsolete, components fabricated at Rocky Flats are returned to the Plant. These parts then undergo special processing to recover plutonium and americium.

Another major effort involves chemical processing to recover plutonium from all scrap material. These activities, the fabrication of radioactive and nonradioactive metals, and the recovery of plutonium receive support from various disciplines such as nuclear safety, engineering, health physics, environmental sciences, and research

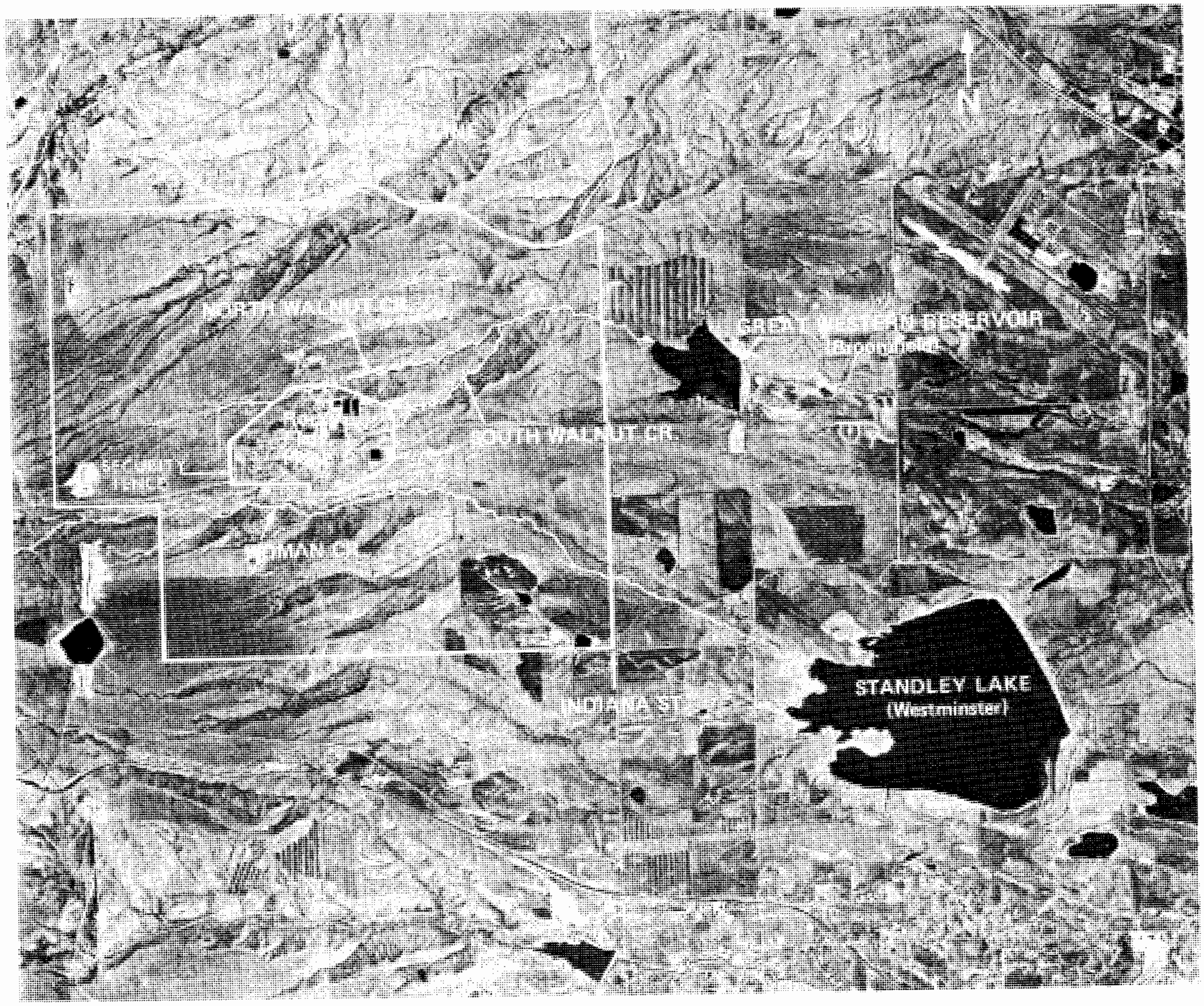


Figure 2.1-1 Location of the
Rocky Flats Plant Boundaries

and development. These and other functions are supported by still other activities. Research and Engineering (R&E), for example, depends upon a variety of capabilities. Production-oriented R&D work involves metallurgy, machining, assembly, nondestructive testing, coatings, remote engineering, chemistry, and physics.

Rocky Flats has highly specialized facilities and equipment for handling plutonium. It also has personnel who have extensive knowledge regarding the chemistry and fabrication of plutonium, beryllium, and other materials which require special handling.

2.2.1 Location

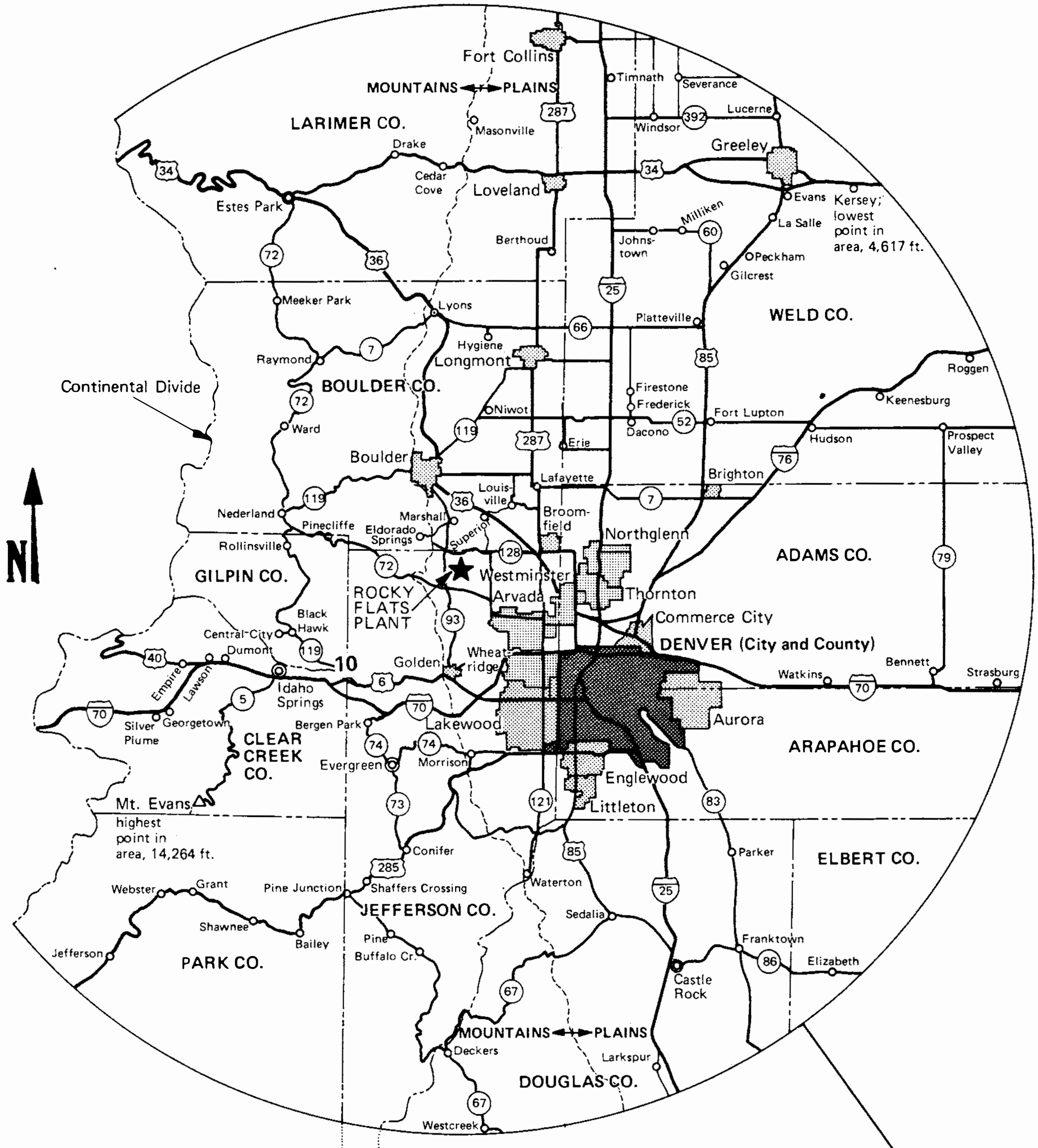
The Rocky Flats Plant covers almost 11 square miles, occupying Sections 1 through 4 and 9 through 15 of R70W, T2S of Jefferson County, Colorado. The facility is centered at 105° 11' 30" west longitude, 39° 53' 30" north latitude. As shown in Figure 2.2.1-1, this location is 16 miles northwest of Denver, Colorado, and 9 to 12 miles from the communities of Boulder, Golden, and Arvada. It is bounded on the north by State Highway 128, on the west by State Highway 93, on the south by State Highway 72 and on the east by Jefferson County Highway 17.

Situated at an elevation of about 6,000 feet, the Plant is on the eastern edge of a geological bench known locally as Rocky Flats. This rocky bench, which is about 5 miles wide in an east-west direction, flanks the eastern edge of the abruptly rising foothills of the Front Range of the Rocky Mountains. The Continental Divide is approximately 26 miles west of the Plant.

2.2.2 External Appearance

The geological bench on which the Plant is situated slopes gradually to the east at an average gradient of 95 feet per mile. The land surface is stony soil formed from the glacial outwash from the mountains to the west. This deposit consists largely of gravel and cobbles intermixed with sand and clay. Boulders, some as large as 2 feet in diameter, are interspersed with the gravel. Low precipitation, drying winds, and a permeable gravel substrate are responsible for the arid Rocky Flats environment that is reflected in the kinds of low-grass prairie vegetation growing in the area. More detailed information about the geology and other natural features of the area is presented in Section 2.3.

Plant buildings are concentrated in a small area (384 acres) surrounded by a security fence. Land between that fence and the site boundaries, encompassing 6,550 acres, serves as a buffer zone between the Plant and the public. A cattle fence on the site perimeter is posted to identify the land as a restricted area. Developments in the buffer zone include firebreaks, holding ponds on three watercourses, environmental monitoring stations, a sanitary landfill area, salvage yard, power lines, wind energy test towers, gravel pits, target range, and access roads.



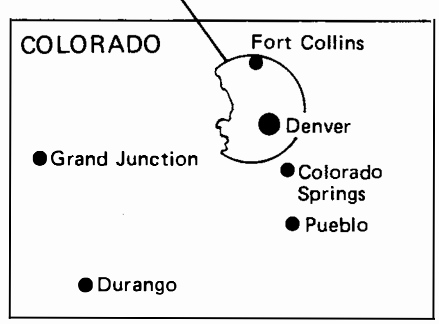


Figure 2.2.1-1 General Location of the Rocky Flats Plant Within a 50-Mile Radius

Two access roads, one from State Highway 93 to the west and one from County Highway 17 to the east, pass through the security fence that encircles the main area of the Plant. Within this central facility are about 100 buildings, none over three stories above the ground. Plant visibility from nearby highways varies, depending on a viewer's location. The most prominent structures are the 155-foot water tower, three building stacks measuring 69, 98, and 151 feet in height, respectively, and the new plutonium recovery and waste treatment facility. Figure 2.2.2-1 is an aerial view of the Plant.

As shown in Figure 2.2.2-2, the Plant is divided into several areas constituting separate operational complexes. Each building within an area is identified by a three-digit number; the first number of the three signifies the area in which the specific building is located. There is no 200 area as such. Numbers in the 200 series are applied to miscellaneous facilities that are distributed throughout the Plant site. Examples are utility structures and parking lots. The major production complexes are in the 400, 700, and 800 areas. The buildings shown in Figure 2.2.2-2 at the north end of the 300 area represent the plutonium recovery and waste treatment complex soon to be completed.

2.2.3 Facilities Utilization

The Rocky Flats Plant includes facilities for the fabrication, assembly, and quality testing of radioactive and nonradioactive components for nuclear weapons; chemical processing and process waste treatment; and research and development. Presently, there is more than 1.7 million square feet of building floor space in over 100 structures. An additional 331,000 square feet will be available when the new plutonium recovery and waste treatment complex becomes operational. Of the current total floor space, fabrication, chemical processing, and assembly facilities account for 41%; laboratories and test facilities occupy 15%; administrative, personnel, and security facilities account for 9%; utility and support services, including radioactive and nonradioactive waste-treatment facilities, occupy 19%; and warehouse and storage areas account for 9%. The remaining area includes permanent facilities for on-site construction contractors, which utilize 2% of available floor space, and miscellaneous facilities and structures that occupy the remaining 5%.

2.3 SITE ENVIRONMENT

To properly assess the environmental impact associated with the Rocky Flats Plant, it is necessary to identify the natural and man-made features of the area, uses made of the land, area population in the Plant vicinity, and how that population is distributed. The next few sections address these items and, where applicable, describe evaluations that have been performed.

Figure 2.2.2-1 Rocky Flats Plant
Aerial View Looking West

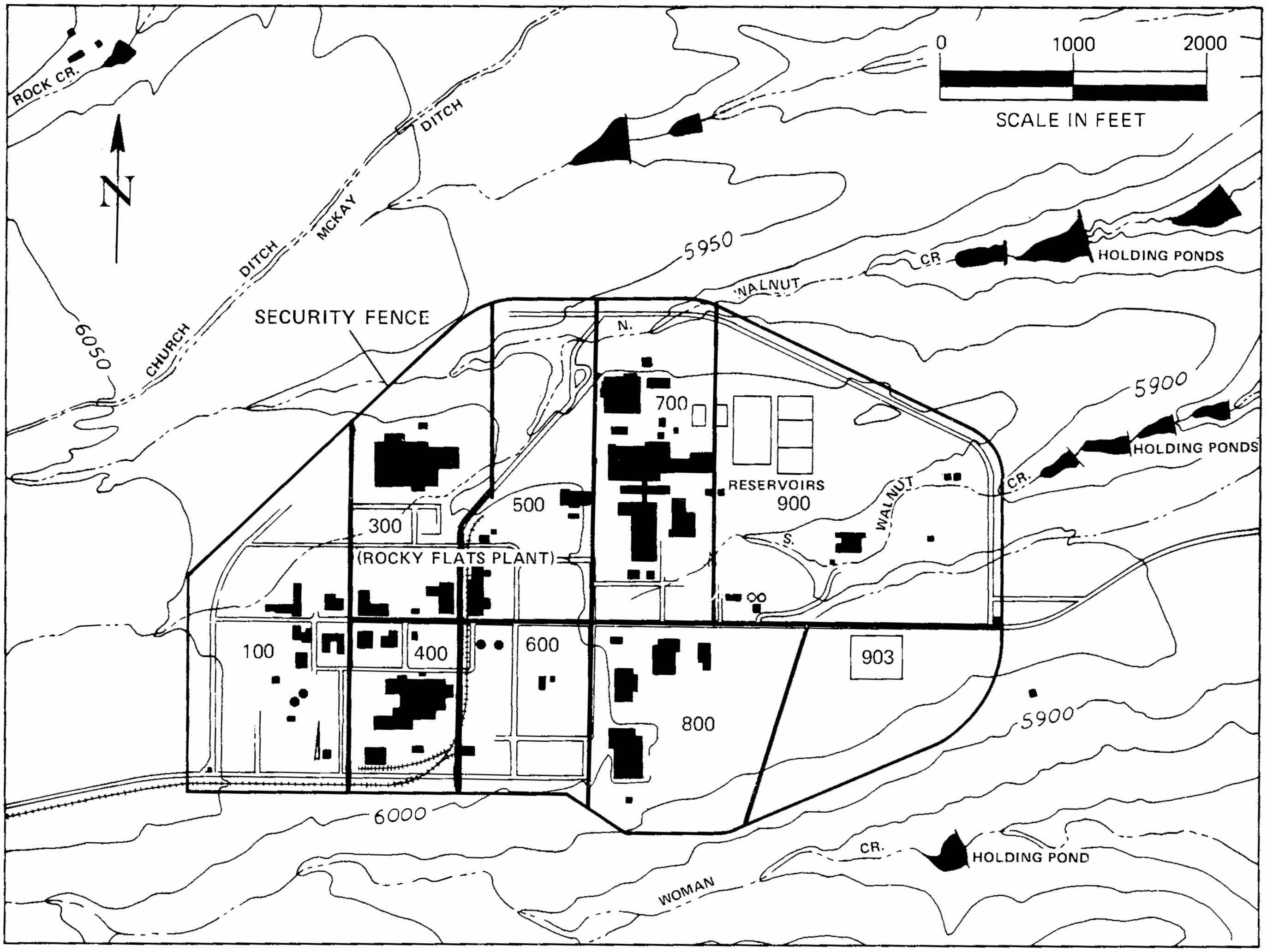


Figure 2.3.2-2 Rocky Flats Plant Site Plan

2.3.1 Regional Historic, Scenic, Cultural, and Natural Features

The impact of the Rocky Flats Plant on historic, scenic, cultural, and natural features in the region has been evaluated. Information was gathered primarily from the State Historical Society of Colorado and the Colorado Department of Natural Resources.

Several rock mounds have been located on the southwestern portion of the site; however, preliminary investigations performed by the Denver Museum of Natural History and the University of Colorado determined that the sites were not significant enough to warrant further investigation. In the northwest part of the site, personnel from the Colorado State University Laboratory of Public Archeology investigated a series of stone alignments; that site was registered with the Colorado State Archeologist and a report was prepared. Preliminary investigation indicates that no present undertaking at the Rocky Flats Plant infringes upon known potentially eligible historic sites. Measures are being taken to verify and assure compliance with the National Historic Preservation Act.

Other historical sites nearest to the Rocky Flats Plant are located in and near the City of Golden, approximately 10 miles south of the Plant. These include the site of Arapahoe City (which was a pioneer placer mining camp and the earliest town in Jefferson County) located just east of Golden; the Colorado School of Mines' first building, built in 1866 in Golden; and the City of Golden itself, which was the territorial capital of Colorado from 1862 to 1867. A complete list of all historical sites in Jefferson County and the surrounding counties within the 50-mile radius of the Plant site is in Appendix K (DoI 1979).

The closest park and recreational area is the Standley Lake area, which is approximately 5 miles from the Plant site. Boating, picnicking, and limited overnight camping are permitted. Several other small parks are present in communities within 10 miles of the Plant's center. The closest major park, Golden Gate Canyon State Park, located approximately 15 miles to the southwest, provides 8,400 acres of general camping and outdoor recreation. Other national and state parks are located in the mountains west of the Plant, but all are considerably farther away.

2.3.2 Current Area Development

To aid in determining the environmental impact of the Rocky Flats Plant, the industrial facilities, public facilities and institutions, and transportation routes within five miles of the Plant are identified. Information about these facilities was obtained from the Colorado Departments of Health, Highways, and Education, and other government agencies.

Land uses in the vicinity of the Rocky Flats Plant were obtained from various land-use plans and zoning maps acquired from State, County, and City planning agencies. These sources show some of the land adjacent to Rocky Flats as being zoned for industrial development. Industrial facilities existing within 5 miles of the Plant boundary are listed in Table 2.3.2-1. There are no prime agricultures as determined by USDA Soil Conservation Service.

TABLE 2.3.2-1

INDUSTRIAL FACILITIES
WITHIN 5 MILES OF THE ROCKY FLATS PLANT BOUNDARY

Name	Description	Number of Employees	Distance and Direction from Plant Security Fence (miles) (Boundary)
The Oil Shale Corporation-TOSCO	Laboratory on 40-acre site	78	2-South
Great Western Inorganics, Inc.	Plant manufacturing and testing inorganic chemicals	16	2-South
Frontier Forest Products	Wholesale and Retail Lumber Yard	14	2-South
Ideal Cement Company	Lightweight aggregate plant	(closed in 1976)	2.4 Northwest
Jeffco Airport and Industrial Park	990-acre industrial park	206	4.8-Northeast

The Rocky Flats Plant is located in a basically rural area. There are no public facilities or institutions such as schools, prisons, or hospitals within five miles of the Plant. The nearest educational facility is the Sierra Elementary School, which is six miles southeast of the Plant. Other schools are located in the same general area, but somewhat farther from the Plant. The closest hospital to the Plant is Boulder Memorial Hospital, 10 miles northwest.

Major transportation routes near the Plant include U.S. Highway 36 (Denver-Boulder Turnpike); Colorado Highways 72, 93, and 128; Jefferson County Highway 17 (Indiana Street); and the Denver and Rio Grande Western Railroad. The Colorado Department of Highways reports that U.S. Highway 36 carried an average of 27,700 cars daily during 1977. That same year, approximately 5,100 cars per day used Colorado Highway 93, which is west of Rocky Flats and is the main commuter route for Plant employees from Boulder and Golden. Jefferson County Highway 17, paralleling the Plant's eastern boundary, is also a major commuter route for employees. The junction of Highway 17 and Colorado 72 southeast of the Plant carried about 3,800 cars daily during 1978. The D&RGW Railroad, which is about 2 miles south of the Plant, is the main line west from Denver. Several trains a day use this line to haul freight.

2.3.3 Demography

Approximately 50% of the area within 10 miles of the Rocky Flats Plant is located in Jefferson County, with the remaining 50% divided between Boulder County (40%) and Adams County (10%). According to the Colorado State Land Use map (1973), 75% of this land was used for agriculture or was unused.

Several ranches are located within 10 miles of the Plant, primarily in Jefferson and Boulder Counties; they are operated to produce crops, raise beef cattle, supply milk, and breed and train horses. According to the 1977 Colorado Agricultural Statistics, 14,200 acres of crops were planted in 1976 in Jefferson County (total land area approximately 475,000 acres). In addition, Boulder County had 56,200 acres planted out of a total land area of 405,760 acres. These crops consisted of winter wheat, corn, barley, dry beans, sugar beets, hay, and oats. Livestock statistics for the two counties included 9,500 head of cattle, 200 pigs, and 400 sheep being raised in Jefferson County, and 34,000 head of cattle, 2,300 pigs, and 6,500 sheep in Boulder County. A comparison of these figures with those acquired two years prior show an increase of acreage for agricultural production while the total land area has declined somewhat because of annexation by cities. In addition, livestock increases are noted in Jefferson County, whereas in Boulder County the number of cattle, pigs, and sheep has decreased from 1975 figures.

The demography data presented in the DEIS has been reevaluated and are presented here to a 50-mile radius from the center of the Plant using planning information from the Denver Regional Council of Governments. Table 2.3.3-1 lists population centers within 50 miles of Rocky Flats, their distance and direction from the Plant, and the recent estimated population according to the Colorado Division of Planning. These population centers have been expanding in recent years, and additional land in Adams, Boulder, and Jefferson Counties has been acquired for residential developments.

A clear growth pattern emerged in the three-county area during the late 1960's and early 1970's, with the three-county population growing approximately 55% from 1965 to 1977. The reason for this growth pattern is the rapid expansion of the Denver metropolitan area and the development of suburban communities. This pattern is expected to hold in the future, although the growth rate should be smaller. Based upon this demographic data, the population distribution within 50 miles of the Plant for 1977, and the projected population distribution for the year 2000 have been estimated. The planning data are shown in Table 2.3.3-2 (DRCOG, 1977).

TABLE 2.3.3-1

POPULATION CENTERS WITHIN 50 MILES OF THE PLANT BOUNDARY

Name	Distance (miles)	Direction	1977 Estimated Population
Arvada	9	SE	90,000
Aurora	21	SE	127,500
Berthoud	29	N	2,100
Boulder	10	N-NW	90,400
Brighton	22	E-NE	11,800
Broomfield	7	E-NE	20,600
Castle Rock	39	S-SE	2,700*
Central City	18	W-SW	300*
Commerce City	15	E-SE	16,300
Denver	16	SE	530,600
Englewood	20	S-SE	33,100
Estes Park	37	N-NW	2,100
Fort Collins	47	N	60,600
Fort Lupton	24	NE	3,500
Georgetown	29	W-SW	750*
Golden	9	S	11,200
Greeley	45	N-NE	55,000
Idaho Springs	20	W-SW	2,100*
Lafayette	10	NE	6,700
Lakewood	12	S-SE	134,300
Leyden	3	S	150*
Littleton	22	S-SE	28,400
Longmont	20	N	38,200
Louisville	7	N-NE	5,000
Loveland	36	N	25,000
Lyons	23	N	1,200*
Morrison	16	S	500
Nederland	17	W-NW	800
Northglenn	11	E	33,100
Platteville	24	NE	1,500
Superior	5	N-NE	300
Thornton	11	E	34,000
Westminster	9	E-SE	45,000
Wheat Ridge	10	S-SE	33,800
Windsor	43	N-NE	3,500

* 1975 Estimates

TABLE 2.3.3-2

POPULATION PROJECTIONS

Year	Denver Metropolitan Area (millions)	50-Mile Radius of Rocky Flats Plant (millions)
1977	1.5	1.8
2000	2.4	3.5

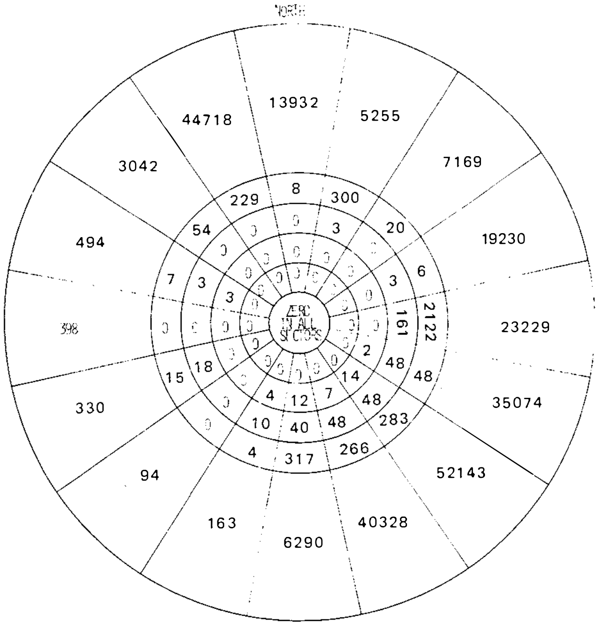
The 1977 population densities in sectors within 10 miles of the Plant are shown in Figure 2.3.3-1. For the area within 5 miles of the Plant, a survey was conducted to determine the actual number of houses. An estimate was then made of the number of people by using an average regional family size of 2.83 (DRCOG 1977) and multiplying this by the number of houses. For the 5- to 10-mile area, the population estimates are based on data obtained from Adams, Boulder, and Jefferson County Planning Departments and the Denver Regional Council of Governments. Each sector consists of portions of one or more regional planning divisions. The percentage of the area of a planning division incorporated into a sector was determined. An even distribution of the population was assumed across a planning division, and the percent was multiplied by the projected division population to obtain the number of people in the sector.

Population estimates for sectors up to 50 miles from Rocky Flats for the year 2000 are illustrated in Figure 2.3.3-2. These distributions are based on projections from the Boulder, Larimer, and Weld County Planning Departments, Colorado Division of Planning, and the Denver Regional Council of Governments. Zero growth is estimated within two miles of the Plant because most of the land is Government owned and within the Rocky Flats boundaries. The nearest residence is two miles northwest of the Plant's center.

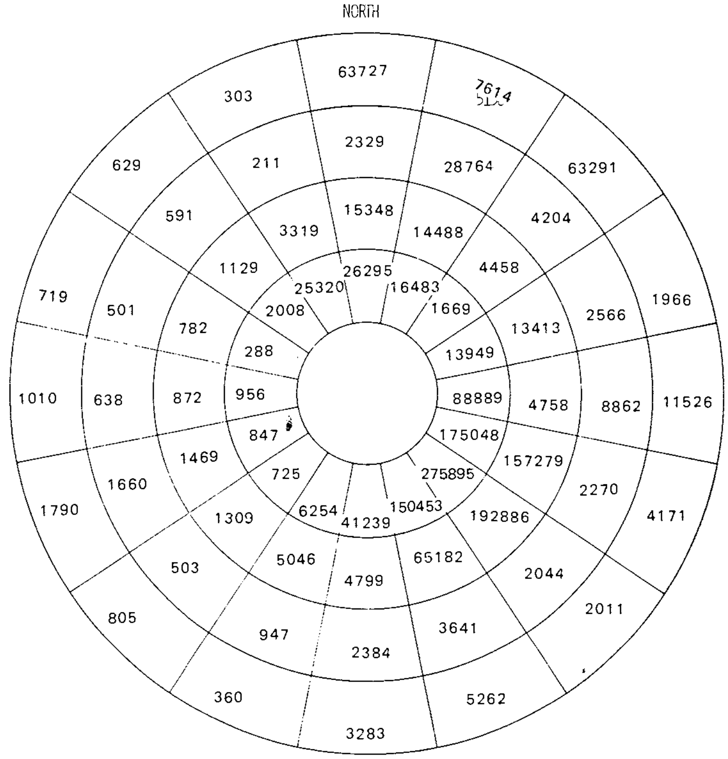
For determining projections for 1980, 1990, and 2000 in sectors which incorporated only one planning division, the percent growth of the division was applied to the sector population. For sectors overlapping two or more planning divisions, an average of the percent growth for the divisions was applied to the sector.

The area within 5 miles of the Plant had a 1977 population of approximately 4,103, or about 52 persons per square mile. This population is projected to increase to 4,674 in 1980; 6,918 in 1990; and 9,241 in 2000; or 60, 88, and 118 persons per square mile, respectively. The most populated sector is to the southeast of the Plant, which is in the direction of Denver. The 1977 estimated population between 10 and 50 miles in this sector was 524,900; it is expected to increase to 680,300 in 1980; to 962,600 in 1990; and to 1,212,600 in 2000.

The only significant shifts of population in the region are caused by college students. The regular enrollment of 21,600 at the University of Colorado in Boulder decreases to a summer session total of approximately 7,800; Denver University drops from 7,300 to 3,400; and Colorado School of Mines in Golden drops from 2,200 to 500; a total decrease in population of 19,400 during the summer months.

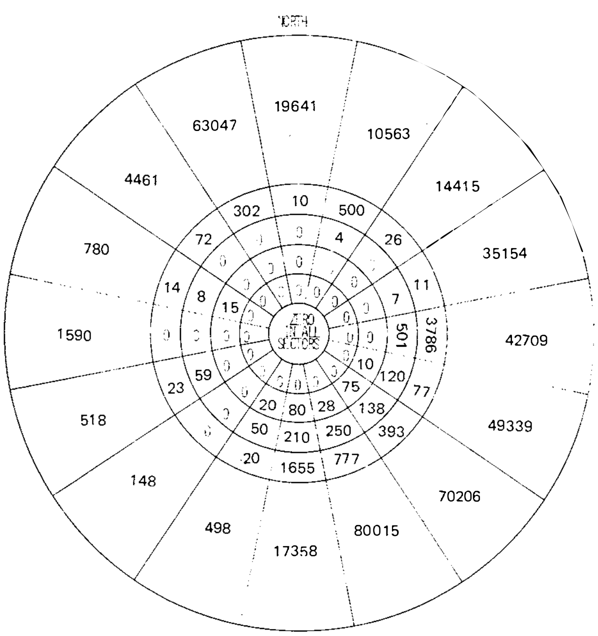


0-10 Miles

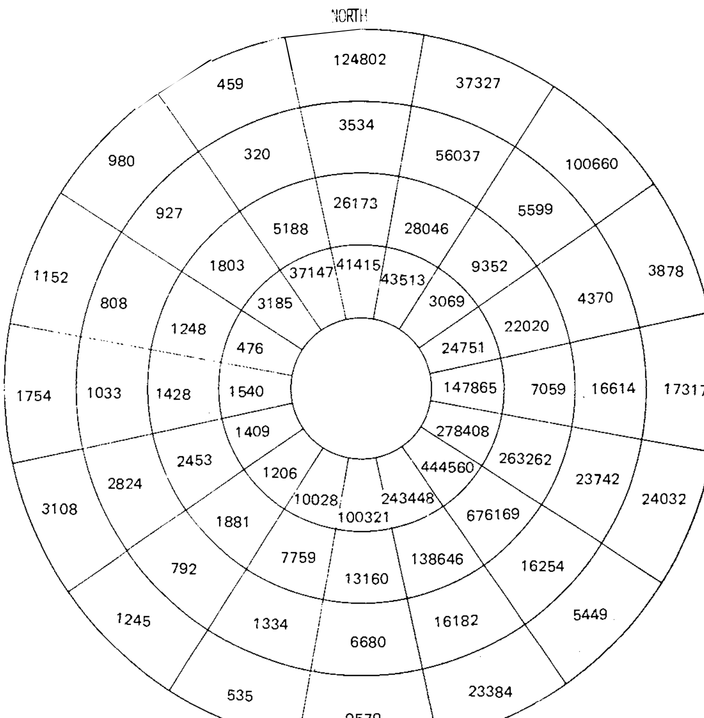


10-50 Miles

Figure 2.3.3-1 Demographic Estimates - 1977



0-10 Miles



10-50 Miles

Figure 2.3.3-2 Demographic Projections - 2000

2.3.4 Geology and Seismology

Information on the geologic, tectonic, and seismologic setting of the Rocky Flats Plant site and surrounding area is also presented. The discussion is based on pertinent, published geologic literature through June 1978, and results of investigations performed specifically for the Rocky Flats Plant site. The investigations include: (1) Seismic and geologic investigations and design criteria by John A. Blume and Associates (Blume, 1972; Blume, 1974), (2) a remote sensing investigation of the Rocky Flats plant site using various types of imagery by EG&G in 1976 (Lackey, 1976), (3) a reflection seismic investigation by T. L. Davis of the Colorado School of Mines in 1976 (Davis, 1976), (4) a soil survey of the Rocky Flats Plant site by the Soil Conservation Service in 1975 (Volume II, Appendix C-3), (5) a hydrology investigation, including geologic mapping, of the Rocky Flats area by R. Theodore Hurr of the U.S. Geological Survey in 1976, (Hurr, 1976), and (6) a review of historical seismicity within 200 miles (320 km) of the Rocky Flats Plant site by Woodward-Clyde Consultants in 1978.

Rocky Flats buildings were constructed over the last 27 years, and applicable structural design criteria were used (as revised) through that period. Seismic design conditions were not emphasized in the Denver area until the late sixties because the Uniform Building Code (UBC) placed Denver in Seismic Zone Zero. However, among the first buildings at Rocky Flats, Buildings 771, 881, and 991 were designed to withstand nuclear blast conditions. As a result, there is little question that these structures are adequate to resist any probable site seismic forces. The other buildings are readily expected to resist the U.B.C. Zone No. 1 earthquake forces in accord with the present Denver area classification.

As a part of the overall DOE risk assessment program, an engineering study is underway to evaluate the effects of earthquakes, tornadoes, and high winds on storage and production structures at Rocky Flats. Following that study, begun in the summer of 1979, systems, equipment and components will be evaluated for resistance to similar forces. The consequences of adverse natural phenomena and of potential accidents will be assessed with their respective probabilities of occurrence to determine a level of risk, including the risk of a plutonium release to the environment. This information will be incorporated in the safety analysis reports (see Section 2.6.2.5) used by DOE to determine appropriate actions such as remodeling and reinforcement. Further, DOE will supplement this EIS, if necessary. Pending the availability of the safety analysis reports, this EIS has analyzed as a worse-case accident to be possible failure of structures, equipment and components to withstand natural phenomenon.

Recently, site specific seismic criteria were used in the design of the new Plutonium Recovery and Waste Treatment Facility, Building 371/374. The seismic criteria developed for Building 371/374 were based on the Nuclear Regulatory Commissions' safety philosophy for nuclear reactors as outlined in 10 CFR 100. In the early 1970's AEC, in conjunction with industry experts, developed the design criteria which eventually became ERDA Manual Appendix 6301 Facilities General Design Criteria, Part

II, B. Plutonium Facilities for any of its future facilities handling and processing plutonium. The criteria included site specific requirements to identify possible impacts from natural phenomena like earthquakes, tornadoes, floods, and high winds which could affect a facility's safety. At that time, the NRC seismic requirements for plutonium processing buildings were not as well developed. The same design considerations have since been incorporated by NRC into Regulatory Guides for commercial plutonium processing and fuel fabrication plants.

Early in the preliminary design phase of Building 371/374, consultants Blume and McDonald were commissioned to establish the site specific parameters. The seismic criteria developed by Blume for Rocky Flats considered two earthquake magnitudes; the Operating Basis Earthquake (OBE) of magnitude 5.6 on the Richter Scale (conditions which would allow an operation to continue safely) and the Design Basis Earthquake (DBE) of magnitude 6.0 (conditions which would allow for a safe shutdown of the facility). Structures designed to withstand the forces produced at either level far exceed the UBC requirements for Zone No. 1.

In response to public comment on the DEIS, it is necessary to discuss the reason for basic differences in plutonium and reactor facility seismic siting criteria. Neither DOE nor NRC apply reactor seismic criteria to facilities such as Rocky Flats. The NRC developed its reactor Seismic Standards based on two major considerations which are not applicable to conditions at Rocky Flats:

1. A large amount of stored energy is present in the form of heat from the fission process and the decay of fission products.

2. Intense radiation fields are generated from direct neutron and gamma radiation associated with the fission process of an operating reactor and also from fission product decay.

The heat from decay of large amounts of fission products continues for a substantial period following reactor shutdown. The availability of extreme heat provides potential for core meltdown if cooling capabilities cannot be maintained. A core meltdown would generate a large radioactive material source term for possible release to the environment. The radiation fields would preclude personnel access to critical components for inspection, maintenance, and repair.

At Rocky Flats, none of the operations or processes present the stored energy hazard inherent with a reactor and its potentially large source term. None of the operations or processes involve or produce radiation fields which would preclude personnel access, or expose persons to rediation in excess of applicable guide values for normal maintenance, inspection or repair activities. Thus the use of reactor design criteria is not warranted and, therefore, not applied.

In 1980, a field study will be initiated to evaluate the capability of the Golden fault and other faults in the Rocky Flats site vicinity. The results of this study will be used to update the Blume seismic criteria if necessary. These evaluations will be incorporated into the Plant Safety Analysis Report (SAR). The Plant SAR and Facilities SAR's deal with operational safety issues and the effects of natural phenomena (such as earthquakes, tornadoes, floods, and lightning) on essential building structures, systems, and equipment at the Plant site. See Section 2.6.2.5 for a discussion of SAR's.

2.3.4.1 Physiography and Geomorphology

The elevation of the Rocky Flats Plant site is approximately 6,000 feet (1,800 m). The Plant site is on the western margin of the Colorado Piedmont section of the Great Plains Physiographic Province (Fenneman, 1931). The Colorado Piedmont ranges in elevation from 4,000 feet (1,220 m) on the east to 7,000 feet (2,130 m) on the west. The Piedmont merges to the east with the High Plains section of the Great Plains Province and is terminated abruptly on the west by the Front Range section of the Southern Rocky Mountain Province.

The Colorado Piedmont is an area of dissected topography and denudation where Tertiary strata underlying the High Plains have been almost completely removed. In a regional context, the piedmont represents an old erosional surface along the eastern margin of the Rocky Mountains. It is underlain by gently dipping sedimentary rocks (Paleozoic to Cenozoic in age), which are abruptly upturned at the Front Range to form hogback ridges parallel to the mountain front. The piedmont surface is broadly rolling and slopes gently to the east with a topographic relief of only several hundred feet (approximately one hundred meters). This relief is due both to resistant bedrock units that locally rise above the surrounding landscape and to the presence of incised stream valleys. Major stream valleys which transect the piedmont from west to east have their origin in the Front Range. Small local valleys have developed as tributaries to these major streams within the piedmont. In the area of the Plant site, a series of Quaternary pediments have been eroded across this gently rolling surface (Figure 2.3.4-1).

The eastern margin of the Front Range a few miles west of the Plant site, is characterized by a narrow zone of hogback ridges and flatirons underlain by steeply east-dipping Mesozoic strata (such as the Dakota Sandstone and the Fountain Formation). The Front Range attains elevations of 12,000 to 14,000 feet (3,600 to 4,200 m) 15 miles (24 km) farther west. The range itself is broad and underlain by resistant gneiss, schist and granitic rocks of Precambrian age (see Figure 2.3.4-2). Some of the relief of the Front Range is a result of erosion during Mid- to Late-Cenozoic time, and some to tectonic uplift. The soft shale and sandstone east of the present mountain front have been removed by erosion. The resistant granitic and metamorphic rocks of the range itself have restricted stream erosion so that deep, narrow canyons are present within the range.

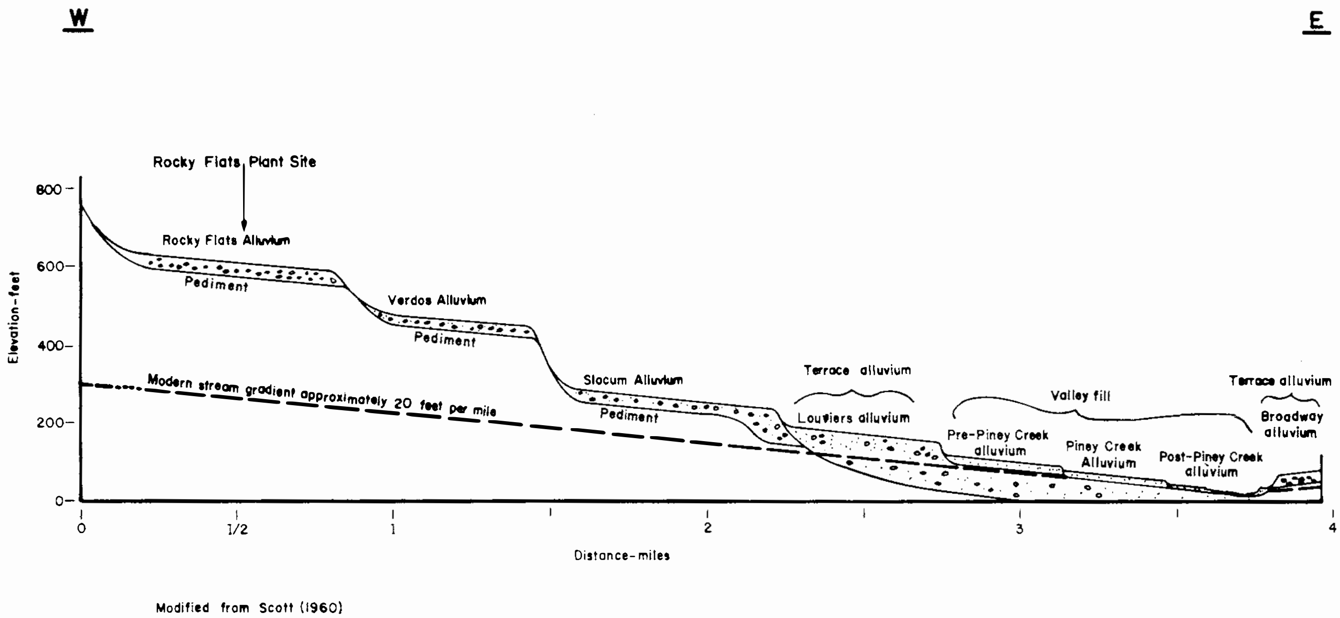


Figure 2.3.4-1 Erosional Surfaces and Alluvial Deposits East of the Front Range, Colorado

SEDIMENTARY ROCKS

ERA	PERIOD / Epoch	AGE Millions of Years	FORMATION	THICKNESS Feet (Meters)	GENERAL LITHOLOGY
CENOZOIC	QUATERNARY		See Figure 2.3.4.-5		
		3			
CENOZOIC	TERTIARY: Pliocene		Not present in the Rocky Flats area		
CENOZOIC	TERTIARY: Miocene				
CENOZOIC	TERTIARY: Oligocene				
CENOZOIC	TERTIARY: Eocene				
		54			
CENOZOIC	TERTIARY: Paleocene		Denver Formation	≈ 600 (≈ 180)	Upper part: Latite flows on Table Mountain, Golden Lower part: Tuffaceous sandstone siltstone, conglomerate
		65			
MESOZOIC	CRETACEOUS Upper		Arapahoe Formation	270 - 450 (80 - 140)	Sand and clay
MESOZOIC	CRETACEOUS Upper		Laramie Formation	750 - 800 (230 - 240)	Upper Unit: Shale Lower Unit: Sandstone
MESOZOIC	CRETACEOUS Upper		Fox Hills Sandstone	40 - 90 (12 - 27)	Sandstone
MESOZOIC	CRETACEOUS Upper		Pierre Shale	7,300 (2,200)	Shale, sandstone and minor silt
MESOZOIC	CRETACEOUS Upper		Niobrora Shale	450 (140)	Shale, minor limestone
MESOZOIC	CRETACEOUS Upper		Benton Shale	500 (150)	Shale, minor bentonite, limestone and siltstone
MESOZOIC	CRETACEOUS Lower		Dakota Group	320 (100)	Sandstone, minor shale, siltstone and conglomerate
		135			
MESOZOIC	JURASSIC		Morrison Formation	300 (90)	Claystone, sandstone and limestone
MESOZOIC	JURASSIC		Ralston Creek Formation	35 - 120 (11 - 35)	Claystone, siltstone and limestone
		180			
MESOZOIC	TRIASSIC		Lykins Formation	400 - 500 (120 - 150)	Siltstone, minor limestone
		225			
PALEOZOIC	PERMIAN		Lyons Sandstone	200 - 250 (60 - 75)	Sandstone, minor conglomerate
		270			
PALEOZOIC	PENNSYLVANIAN		Fountain Formation	800 - 1000 (240 - 300)	Sandstone, conglomerate, and siltstone
		300			
PALEOZOIC	MISSISSIPPIAN		Not present in the Rocky Flats area		
PALEOZOIC	DEVONIAN				
PALEOZOIC	SILURIAN				
PALEOZOIC	ORDOVICIAN				
PALEOZOIC	CAMBRIAN				
		570			
PRECAMBRIAN			Crystalline Basement Complex	Unknown	Metamorphosed sedimentary volcanic and intrusive rocks, mainly schist and gneiss.

Intrusive Rocks

PALEOCENE	62	Ralston Dike	Monzonite

Figure 2.3.4-2 Geologic Time Scale and Stratigraphy in the Rocky Flats Area

Several terraces and pediments in the area of the Plant site have been eroded across both hard and soft bedrock during Quaternary time (Scott, 1963). The Rocky Flats pediment is the most extensive of these, forming a broad flat surface north of Coal Creek. Figure 2.3.4-1 shows a generalized cross section of the Quaternary pediments and overlying alluvial deposits for the Rocky Flats area.

These broad pediments and narrower terraces are covered by thin alluvial deposits of ancient streams which drain eastward into the Great Plains. The sequence of pediments reflects repetitive physical processes associated with cyclic changes in climate. Each erosional surface and stratigraphic sequence deposited on it probably represents a single glacial cycle. The oldest and highest pediment, the Subsummit Surface (Scott, 1960), truncates the hogback ridges of the Front Range. Three successively younger pediments are veneered by alluvial gravels extending eastward from the mountain front. Erosion of valleys into the pediments followed each depositional cycle so that, near the mountain front, stratigraphically younger geologic units occur at topographically lower elevations as narrow terrace deposits along streams draining the Front Range. From oldest to youngest, the three pre-Wisconsin pediment surfaces are the Rocky Flats Alluvium, Verdos Alluvium, and Slocum Alluvium (Scott, 1965). A series of Wisconsin and post-Wisconsin terrace deposits are present at lower elevations along streams that have incised the older pediments (see Figure 2.3.4-1).

The Rocky Flats Plant site is located on a mesa-like surface of Rocky Flats Alluvium. The pediment surface and veneer of Rocky Flats Alluvium, generally 10 to 50 feet (3 to 15 m) thick, have been eroded by Walnut Creek on the north and Woman Creek on the south so that below the Plant site, bluffs along these streams range in height from 50 to 150 feet (15 to 45 m). The gradient of the gently eastward-sloping, dissected Rocky Flats Alluvial surface varies from 0.7% at the Plant site to approximately 2% just east of the Plant.

2.3.4.2 Geologic History

The central Colorado area is part of the North American Craton. During Precambrian time, geosynclinal sedimentary and volcanic rocks were deposited, and later folded, faulted, and were intruded by granitic rocks. The rocks were subjected to at least three periods of metamorphism and are now mainly gneisses and schists (Sheridan et al., 1967; Van Horn, 1976). The Idaho Springs-Ralston shear zone and other zones of northeast-trending cataclastic deformation, northwest-trending faults and breccia reefs, and north-to northwest-trending strike-slip faults with a north to northwest trend developed during the Precambrian (Tweto and Sims, 1963).

The early Paleozoic was characterized by periods of shallow marine deposition, alternating with periods of minor uplift, erosion, or nondeposition (Haun and Kent, 1965). During Pennsylvanian time, the Ancestral Rocky Mountains were formed in approximately the same location as the present Laramie and Front Ranges (Figure 2.3.4-3), while a sea covered the Denver Basin area to the east. The orogeny (period of uplift) resulted in the erosion of most earlier Paleozoic rocks in the vicinity of Rocky Flats; however, a few remnants are preserved deeply buried in the Denver Basin (Scopel, 1964). The coarse clastics of the Fountain Formation were derived from erosion of the Ancestral Rockies and deposited along the edge of the sea, while carbonate and shale were deposited farther east in deeper water (Martin, 1965).

Erosion of the Ancestral Rockies continued during Permian and Triassic time; they were probably leveled by Jurassic time (Haun and Kent, 1965). Throughout the Triassic, Jurassic, and Early Cretaceous, the sea transgressed and regressed across Colorado. A thick sequence of marine and terrestrial units were deposited, some of which are now exposed just west of the Rocky Flats Plant site.

The Laramide orogeny began in the Late Cretaceous with uplift of the Front Range and the other ranges of the Rocky Mountains, along with a rapid increase in subsidence in the Denver Basin (see Figure 2.3.4-3) (Martin, 1965). Upper Cretaceous units in the Denver Basin were deposited as an eastwardly prograding delta. Weimer (1973) postulated the presence of growth faults in the deltaic sediments along the western edge of the Denver Basin. Data from Davis (1976) support an interpretation that growth faults are present in Cretaceous formations west of the Rocky Flats Plant site. Although much of the faulting associated with the Laramide orogeny took place along Precambrian fault zones and foliation trends (Badgley, 1960), many new faults were also formed. The Golden fault was produced by thrusting along the Front Range monocline which folded the Paleozoic and Mesozoic formations to a vertical or slightly overturned position west of the Plant site. Concurrent with uplift of the Rocky Mountains, the Denver Basin was tilted east, assuming its present form (Martin, 1965). The Laramide orogeny resulted in 15,000 to 45,000 feet (5,000 to 14,000 m) of structural relief.

Volcanism associated with the Laramide orogeny began near the end of the Cretaceous and continued into the Paleocene. Remnants of volcanic deposits near Rocky Flats include the Table Mountain flows (within the Denver Formation) near Golden and the Ralston dike (Figure 2.3.4-4) (Van Horn, 1976). Paleomagnetic evidence indicates that the Ralston dike was intruded about 62 million years ago (Hoblitt and Larson, 1975). Hoblitt and Larson (1975) believe that the intrusion was a sill that was later uplifted and rotated 60°E along the Golden fault. The Colorado Mineral Belt developed during and after the Laramide orogeny with intrusion of porphyries and associated ore deposits into the northeast-trending Precambrian structural zone (Tweto and Sims, 1963).

Erosion kept pace with uplift during the Laramide orogeny, and the mountains probably never stood very high above the basins. By late Eocene time, an erosion surface with low relief covered much of the Rocky Mountain region. Detailed studies

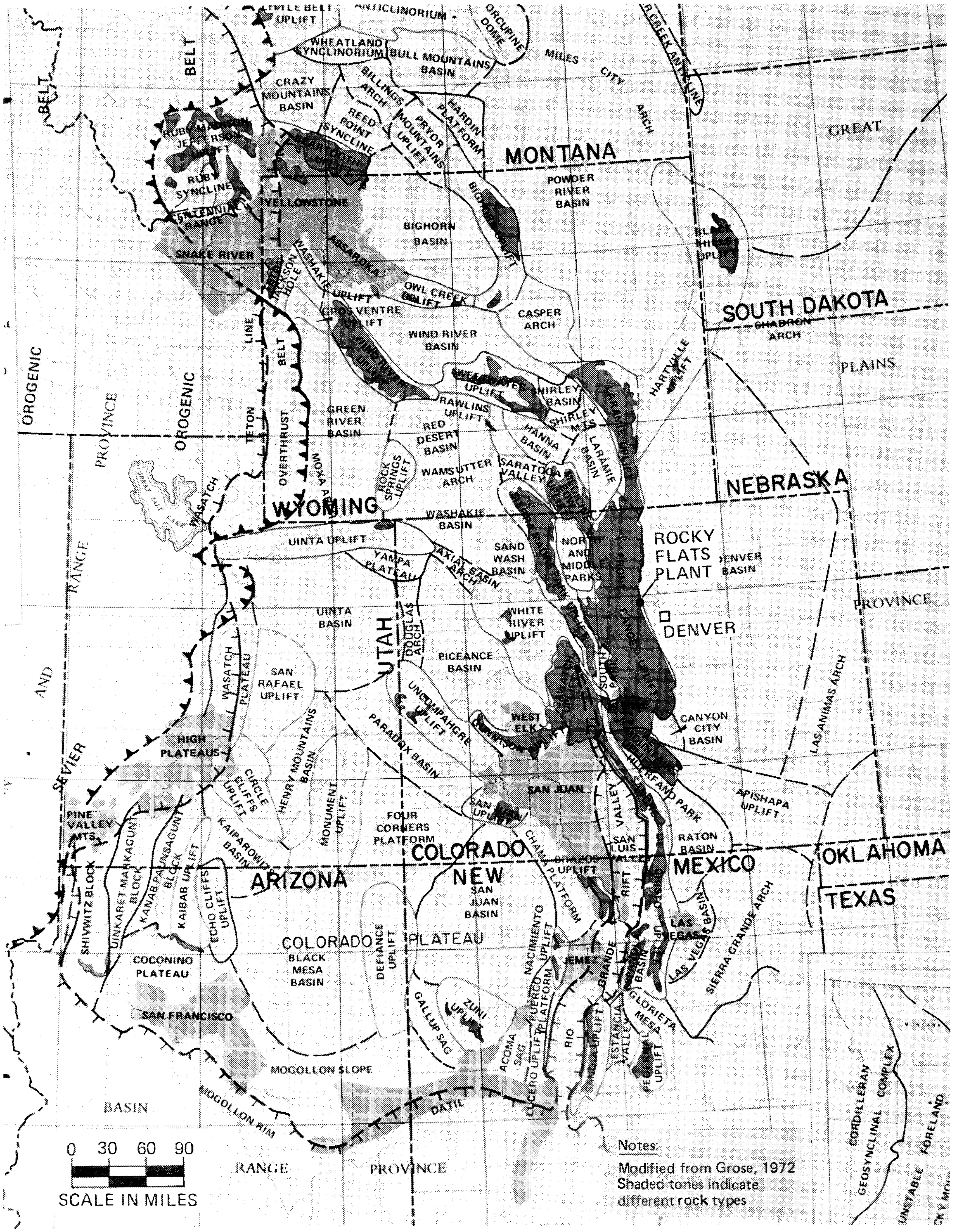


Figure 2.3.4-3 Regional Tectonic Provinces

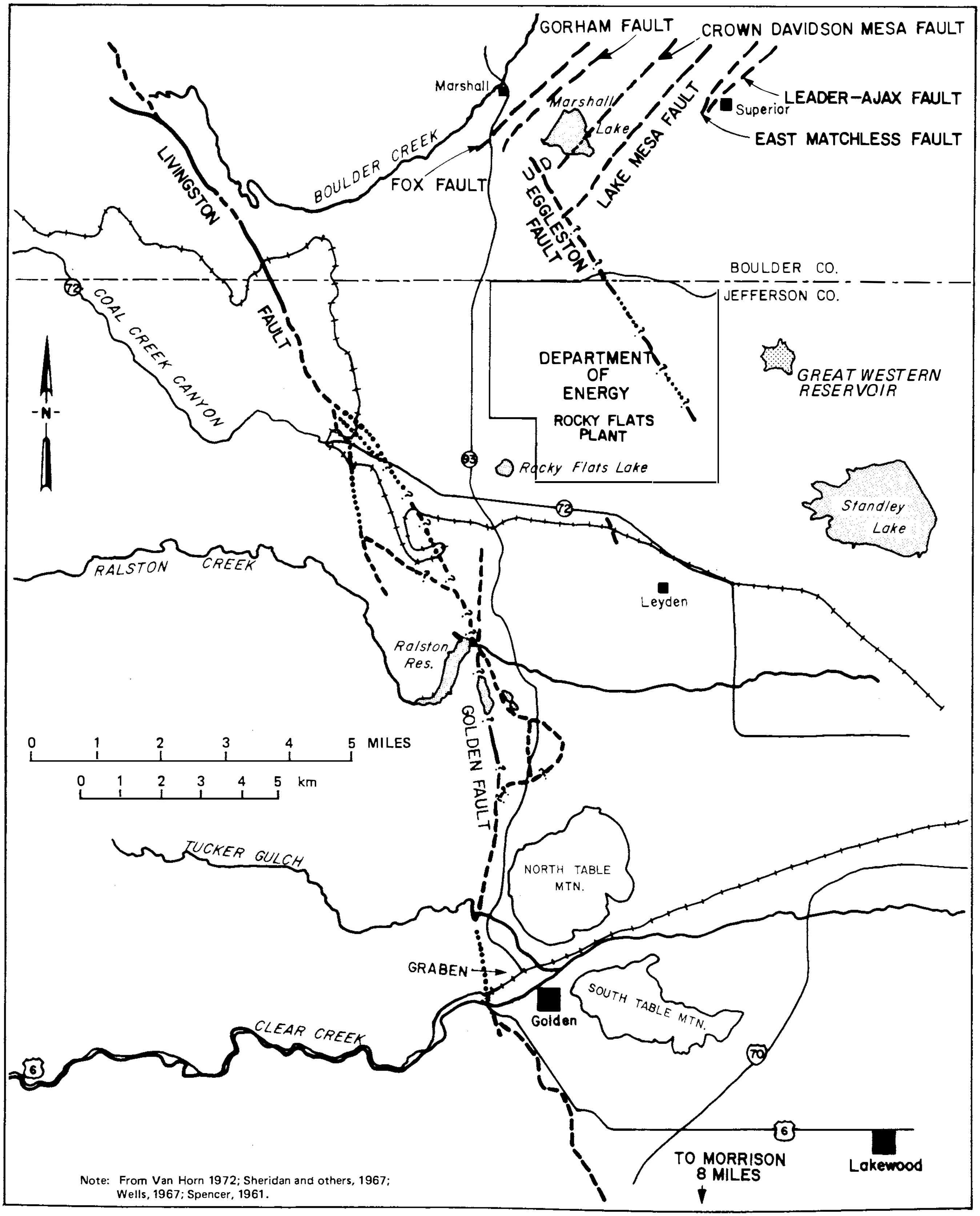


Figure 2.3.4-4 Location of Faults Between Golden and Marshall, Colorado

of displacements on this and later erosion surfaces, Tertiary deposits and paleovalleys (Epis and Chapin, 1975; Scott, 1975; Izett, 1975; Taylor, 1975) have shown that the present Rocky Mountains are largely the result of post-Laramide tectonism. Parts of the Eocene surface were preserved as paleovalleys which were buried under the Wall Mountain Tuff of early Oligocene age and correlative gravels in the South Park area and near Castle Rock (Epis and Chapin, 1975), and by other Oligocene and Miocene volcanics and sediments west of the Front Range (Izett, 1975) and in south-central Colorado (Taylor, 1975). Uplift in the Colorado Rockies since early Miocene has ranged from 5,000 to 10,000 feet (1500 to 3000 m), and block faulting in the Miocene and Pliocene has displaced the Eocene surface hundreds to thousands of feet (hundreds of meters) on many of the faults. Many rivers changed course as a result of this uplift (Scott, 1975). Folding of Miocene deposits has occurred along with faulting in North Park (Izett, 1975). In the western Front Range, Scott (1975) found 1,000 feet (300 m) of late Tertiary displacement on the Kennedy Gulch fault, and 330 feet (100 m) and 2,000 feet (600 m) displacements on faults near Bergen Park. Near the east flank of the Front Range, erosion has removed almost all of the Eocene surface and the amount of post-Laramide uplift is unknown.

During Pleistocene time, the Rocky Flats area was characterized by episodes of erosion, alluvial terrace formation, and soil development related to glacial and interglacial epochs (see Figure 2.3.4-5). Terrace alluvium was deposited from flood discharges that were probably as great as 50,000 ft^3/sec (1400 m^3/sec) flowing from the glaciated headwater basin of Ralston and Clear creeks (Baker, 1974). Relative geologic dating of Quaternary deposits in the Rocky Flats area has been aided by the presence of a volcanic ash deposit in the Verdos Alluvium, dated at about 700,000 years old (Reynolds, 1975; Naesser et al., 1973). This volcanic ash deposit is referred to as the Yellowstone ash.

Quaternary faulting has not been well documented in Colorado, but some faults show evidence of Quaternary activity (Scott 1970; Witkind, 1976; Kirkham and Rogers, 1978). West (1977), working in the Gore Range, established criteria for evaluating active faults and fault scarps. In his evaluation of faults previously described as showing strong evidence of very recent movement, he found that many features formerly reported to be faults were actually caused by landsliding or mass wasting in zones weakened by ancient faulting. He found no conclusive evidence of recent (none in the last million years) faulting.

A graben near the Golden fault in Golden (Figure 2.3.4-4) shows at least two periods of Quaternary movement with a total displacement of 18 feet (5.5 m) (Scott, 1970; Kirkham, 1977). Although the relationship between the graben and uplift of the Front Range along the Golden faults is unknown, the graben does indicate that Quaternary movement has occurred on faults on the east side of the Front Range.

YEARS Before Present	EPOCH	GLACIAL SEQUENCE		DEPOSIT				
1000	HOLOCENE	Gannett Peak Stade	"Valley Fill"	post-Piney Creek alluvium		young alluvial fan	colluvium and landslides	loess and eolian sand
2000		Interstade			(Soil)			
				Piney Creek Alluvium				
3000		Temple Lake Stade			(Soil)			
5000		"Altithermal Interval"		pre-Piney Creek alluvium				
12,000	PLEISTOCENE	WISCONSIN: Pinedale Glaciation	Terrace Alluvium	Broadway Alluvium	(Soil)	old alluvial fan		
60,000		WISCONSIN: Bull Lake Glaciation		Louviers Alluvium				
130,000								
		Sangamon Interglaciation			(Soil)	?	?	
250,000		ILLINOIAN		Slocum Alluvium		?	?	
		Yarmouth Interglaciation			(Soil)	?	?	
600,000		KANSAN		Verdos Alluvium		?	?	
1,000,000		Aftonian Interglaciation			(Soil)	?	?	
1,500,000		NEBRASKAN		Rocky Flats Alluvium		?	?	
	Pleistocene or Pliocene			Pre-Rocky Flats Alluvium				

(Adapted From VanHorn, 1976; Scott, 1965)

Figure 2.3.4-5 Alluvial Deposits in the Rocky Flats Area

2.3.4.3 Stratigraphy

Rocks in the vicinity of the Rocky Flats Plant site range in age from Precambrian to Holocene (Figures 2.3.4-2 and 2.3.4-5). The oldest are the Precambrian gneiss, schist, and quartzite that form the core of the Front Range west of the Plant site. Stratigraphically above these rocks at the Plant site are sedimentary formations which range in age from Pennsylvanian to Paleozoic (see cross section, Figure 2.3.4-6), and surficial deposits which range in age from Pleistocene to Holocene. The Rocky Flats area was generally undergoing erosion during Tertiary time; consequently, any Tertiary rocks that were deposited have been stripped away. Surficial deposits rest unconformably on the eroded surface of folded and faulted bedrock formations (Figure 2.3.4-6). A geologic map of the area within a 5 mile (8 km) radius of the Rocky Flats Plant site is shown on Figure 2.3.4-7. A generalized stratigraphic column for the Rocky Flats vicinity is shown on Figures 2.3.4-2 and 2.3.4-5. Detailed descriptions of stratigraphic units present in the Rocky Flats vicinity are available in various sources, including Hurr (1976), Malde (1955), Spencer (1961), Van Horn (1976), and Wells (1967).

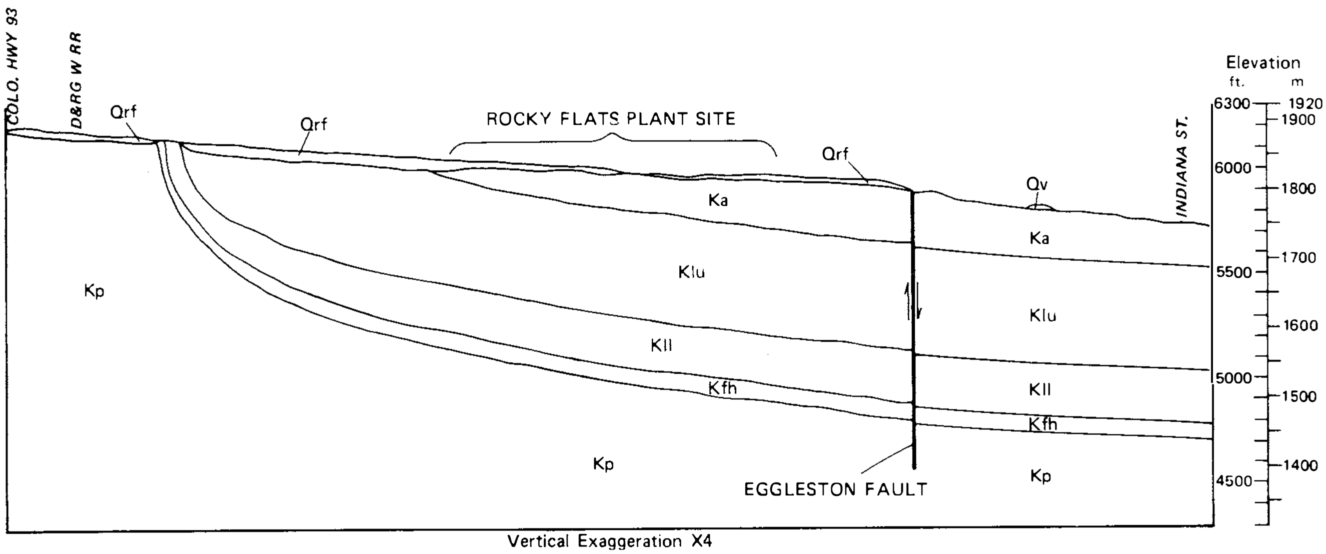
2.3.4.4 Soils

Rocky Flats is situated on the High Plains near the mountains of the Colorado Front Range (see Section 2.3.4.1). Regional soils reflect this altitude and concurrent bedrock changes. Relatively well-developed soils (Ustolls, Argids, and Psamments) are common in the grassy plains; thin, poorly developed rocky soils (Boralfs and Borolls) are common in the forested mountains. The pedocal-pedalfer boundary occurs near the mountain front with calcium carbonate common in soils found to the east.

As discussed, the Plant site is located on Rocky Flats, a gravel veneered pediment that is one of the older in a series of Quaternary alluvial deposits that occur as a narrow piedmont at the boundary between the plains and the Rocky Mountains (see Figure 2.3.4-1).

Soils in the Rocky Flats Plant site area have been mapped and described by the Soil Conservation Service (Amen and others, 1975) and are shown in Appendix C-3. The western part of the Rocky Flats Plant site area generally is underlain by the Nederland soil, a cobbly, gravelly, sandy loam. This is a strongly developed soil that has been described by Amen and others (1975), Malde (1955), Scott (1963), and Machette et al. (1976).

The eastern half of the Rocky Flats Plant site area has a number of different soil types corresponding to the dissection of the Rocky Flats geomorphic surface. The soils are found mainly on hill slopes, and, to a lesser extent, on terraces and on alluvium along streams. Two soils are common: (1) the Denver-Kutch-Midway soil



LEGEND

Qv	VERDOS ALLUVIUM
Qrf	ROCKY FLATS ALLUVIUM
Ka	ARAPAHOE FORMATION
Klu	UPPER LARAMIE FORMATION
Kll	LOWER LARAMIE FORMATION
Kfh	FOX HILLS SANDSTONE
Kp	PIERRE SHALE

Note: From Hurr (1976); see Figure 2.3. 4-7 for location of cross section.

Figure 2.3.4-6 Geologic Cross Section in the Rocky Flats Area association found on slopes and (2) the Nunn clay loam found on a lower erosional surface below the Rocky Flats geomorphic surface. The Denver-Kutch-Midway soils occur on steeply to moderately sloping valley sides.

2.3.4.5 Mineral Resources

In response to public comment on the DEIS, this section on mineral resources that have been developed in the vicinity of Rocky Flats has been added. They include sand, gravel, crushed rock, clay, coal, and uranium (Van Horn, 1972).

Subbituminous coal occurs in several lenticular bodies in the lower part of the Laramie Formation. No coal has been mined in the area since 1950. An estimated 10 million tons of coal has been removed from 13 mines in the Golden quadrangle south of the Plant. Assuming an average thickness of 6 feet of mineable coal, 250 million tons of coal still lie within 1,000 feet of the surface. It was estimated by Spencer (1961) that the total coal production from the Louisville quadrangle North of the Plant was 20 million tons and that few sizable areas remain where coal is of sufficient thickness and quality to justify mining.

There are extensive deposits of sand and gravel in the Rocky Flats area. The Rocky Flats Alluvium has been a source of sand and gravel at the Plant site. Van Horn (1972) estimated that there are about 250 million cubic yards of sand and gravel suitable for concrete and mineral aggregate in the Golden quadrangle. The nearest sand and gravel mine currently operating is located about one mile southwest of the Plant site.

Clay has been mined from both the Laramie Formation and the Pierre Shale in a narrow strip from Coal Creek south to Golden. Three pits in clay and claystone beds of the steeply dipping lower part of the Laramie Formation are presently being mined. The clay produced is best suited for brick, tile, and sewer pipe. Clay from the upper part of the Pierre Shale was mined and treated to form a lightweight aggregate at a plant operated by the Idealite Cement Company near the northwest corner of the Plant site. This operation was closed in 1976.

Several quarries have extracted rock from the Precambrian interlayered gneiss and the Tertiary igneous rock exposed in the Golden quadrangle. Both of these materials have been used for concrete aggregate and riprap. At the present time, rock is being quarried from the Ralston dike, which is about four miles southwest of the Plant site, for use as riprap, concrete aggregate, and road material.

The Schwartzwalder uranium mine, which is four miles southwest of the Plant site, has been the largest vein-type producer of uranium ore in Colorado and ranks among the six largest of this type in the United States. Ore shipments of this high-grade ore have yielded more than 11,500,000 pounds of U_3O_8. Unmined reserves

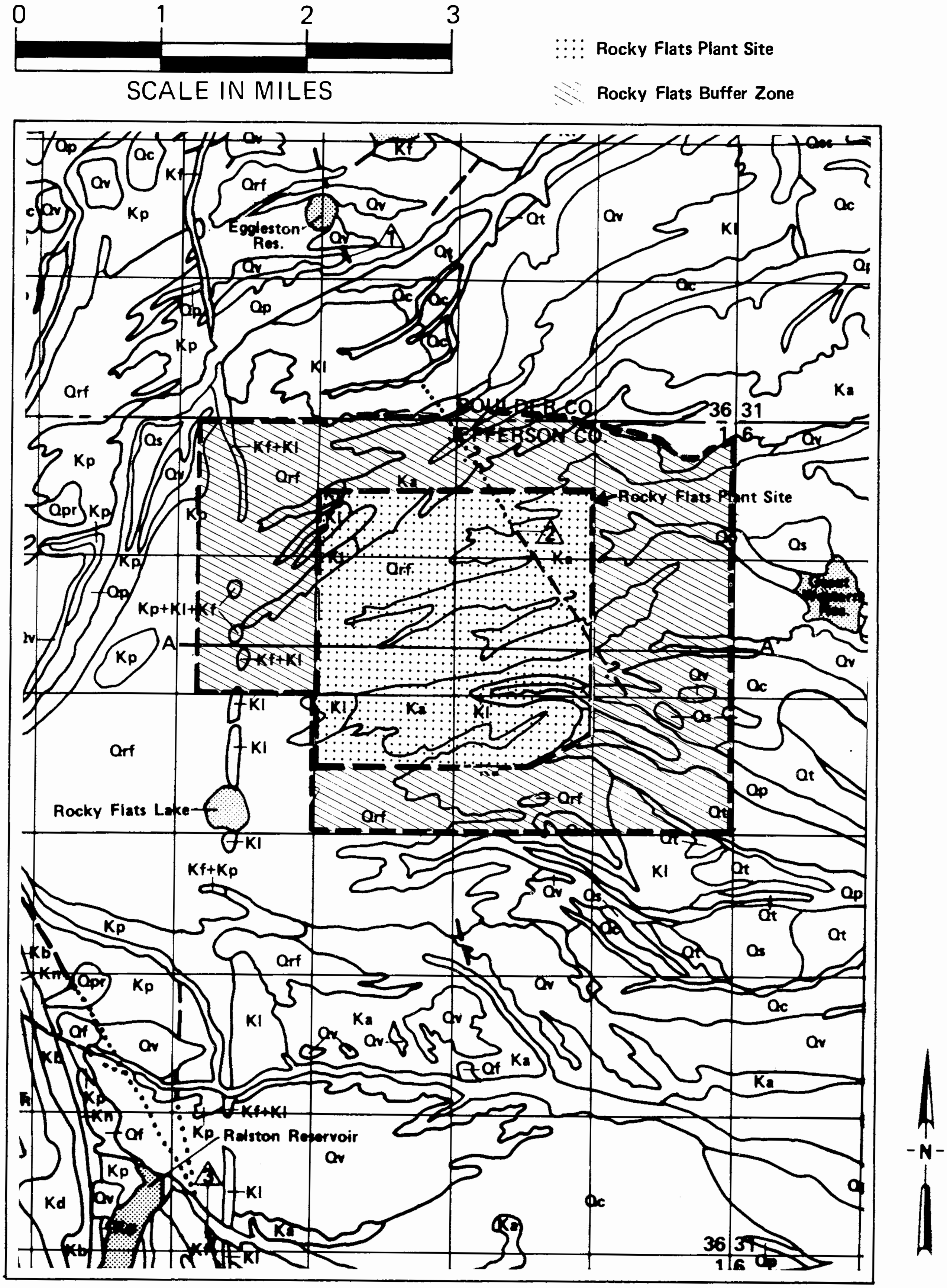


Figure 2.3.4-7 Geologic Map of the Rocky Flats Area

LEGEND FOR FIGURE 2.3.4-7

Qp	Valley fill, (pre-Piney Creek alluvium, Piney Creek Alluvium and post-Piney Creek alluvium)
Qc	Colluvium, talus and landslide deposits
Qes	Loess and eolian sand
Qt	Terrace alluvium (Broadway alluvium and Louviers alluvium)
Qf	Undifferentiated alluvial fan deposits
Qs	Slocum Alluvium
Qv	Verdos Alluvium
Qrf	Rocky Flats Alluvium
Qpr	Pre-Rocky Flats Alluvium
Ti	Ralston dike
TKd	Denver Formation
Ka	Arapahoe Formation
Kl	Laramie Formation
Kf	Fox Hills Sandstone
Kp	Pierre Shale
Kn	Niobrara Shale
Kb	Benton Shale
Kd	Dakota Group
	Fault, dashed where approximate; dotted where concealed
	Contact
A—A′	Location of cross section (Figure 2.3.4-6)
1	Eggleston fault
2	Eggleston fault projection
3	Golden fault
4	Livingston fault

Geology adapted from Chase and McConaghy, 1972; Van Horn 1972; Machette, 1975; Malde, 1955; Sheridan and others, 1967; Wells, 1967; Hunt, 1954; Hurr, 1976 are believed to be sufficient to supply 600 tons of ore per day for the next 10 years.

2.3.4.6 Geologic Structure

Regional Tectonic Setting

The Rocky Flats Plant site is located in the Denver Basin, which is part of the Great Plains Tectonic Province. The Front Range Uplift, which is part of the Southern Rocky Mountain Tectonic Province, is located immediately west of the site. Figure 2.3.4-3 (modified from Grose, 1972) shows the major tectonic provinces and subprovinces within the site region. The Denver Basin and Front Range Uplift are the most significant to the Rocky Flats Plant site and are discussed below. New information on the possible activity of the Golden Fault has been added as a result of public comment on the DEIS.

Denver Basin - The Denver Basin, in which the Rocky Flats Plant site is located, is an extensive sedimentary basin bordered on the west by the Front Range in Colorado and by the Laramie Range in Wyoming (Martin, 1965). The basin extends eastward across Colorado and southeastern Wyoming into western Nebraska and northwestern Kansas (see Figure 2.3.4-3), and is distinctly asymmetric. The eastern flank dips gently toward the axis of the basin, which lies close to and roughly parallel to the mountain front. The western flank is steeply upturned and beds are overturned in places, which may be the result of thrust faulting along the east edge of the Front Range. A broad flexure separates two deeper portions of the basin, which are located near Denver, Colorado and Cheyenne, Wyoming (Finley et al., 1955). During the Laramide orogeny of Late Cretaceous and early Tertiary, the basin was tilted eastward, and the shape of the basin assumed its present form.

More than 13,000 feet (3,900 m) of sedimentary rocks overlie Precambrian basement rocks within the basin. Geologic maps of the subsurface indicate a variable depositional environment marked by successive advances and withdrawals of epicontinental seas. Unconformable contacts, facies changes, and varying sediment thickness also indicate repeated activity in the tectonic features surrounding the basin (Martin, 1965). The Denver Basin is separated from the Front Range Uplift by the Front Range monocline, which is described later.

Front Range Uplift - The Front Range Uplift is a broad northwest-trending crustal block with a relatively flat top and steep sides. Together with its extension into Wyoming where it is called the Laramie Range, and a related structure to the south, the Wet Mountains, the Front Range constitutes a mountain belt up to 60 miles wide and 250 miles long (see Figure 2.3.4-3). The core of the range is composed of complexly folded and faulted Precambrian igneous and metamorphic rocks. Because of the mineralization associated with geologic structure in the Colorado Mineral Belt, the Front Range has been thoroughly investigated (Boos and Boos, 1957; Lovering and

Goddard, 1950; Tweto and Sims, 1963). The contact between the Precambrian crystalline basement rock and the overlying sedimentary rock sequence dips steeply eastward into the Denver Basin just west of the Plant site.

The Front Range Uplift is characterized by complex folding and faulting reflecting several periods of superimposed deformation. Although many of the structures within the Front Range Uplift are related to the Laramide orogeny, the block faulting that produced the uplift is believed to be late Tertiary in age (Epis and Chapin, 1975; Scott, 1975). There is some evidence that the block faulting has continued into the Quaternary (Scott, 1970; Witkind, 1976; Kirkham and Rogers, 1978).

Folds

The dominant fold in the vicinity of Rocky Flats is the Front Range monocline, which parallels the entire east flank of the Front Range Uplift (see Figure 2.3.4-3). The monocline is steeply dipped and locally overturned. The folding is tight and within a short distance, the dip of the beds changes from almost vertical to almost horizontal. The site is situated on the flat-lying beds, just to the east of the monocline (see Figure 2.3.4-6).

Other folds in the vicinity of Rocky Flats are broad and relatively gentle. Spencer (1961) shows structure contours on the top of the Fox Hills Sandstone, which indicate several minor synclines and anticlines in the Cretaceous units in the vicinity of the site. There is no evidence of any Quaternary deposits being involved in any folding or tilting in the Rocky Flats area.

Faults

There are no identified faults underlying the Rocky Flats Plant site, with the exception of a possible projection of the Eggleston fault, which would cut the northeast corner of the buffer zone. Faults present within the Rocky Flats area fall into four categories: (1) faults of Precambrian age, (2) Cretaceous growth faults along the west flank of the Denver Basin, (3) faults related to the Laramide orogeny, and (4) faults related to post-Laramide block faulting. In some cases, there is evidence to indicate that faulting occurred along pre-existing faults (e.g., the location of Precambrian faults controlled, in part, the location of Laramide faults). A description of identified faults in the Rocky Flats area is presented in the following paragraphs. The locations of these faults are shown on Figure 2.3.4-4. Possible faulting associated with fluid injection at the Rocky Mountain Arsenal is discussed in Section 2.3.4.7 (Derby Earthquake Series).

Idaho Springs-Ralston Shear Zone - Precambrian faults have been mapped in the Precambrian metamorphic rocks west of the Plant site, and are generally referred to as shear zones or breccia reefs (Wells, 1967). The closest of these faults to the site is the Idaho Springs-Ralston shear zone, located about 3.8 miles (6 km) to the west. Tweto and Sims (1963) report that the Idaho Springs-Ralston shear zone was formed during the late-Precambrian, and is part of a series of northeast-trending zones traced across central Colorado. The Idaho Springs-Ralston shear zone is not known to have displaced any rocks younger than Precambrian, and there is no evidence to indicate that the fault has been active since Precambrian time. The steeply dipping shear zone trends about N50°E and ranges from about 0.5 mile to 1.5 mile (0.8 to 2.5 km) in width (Wells, 1967).

A map of basement rock three miles north of the site indicates a buried structure that may be a continuation of the shear zone (Spencer, 1961). Magnetic and gravity anomalies related to the shear zone in the Front Range also suggest an eastward continuation of the zone (Behrendt and Bajwa, 1972; and Zietz, 1972). The northeastward extension of the shear zone in the Precambrian basement rock could be the cause of the broad flexure that separates the two deeper portions of the Denver Basin (see discussion under Faults in the Marshall-Superior-Louisville Area).

Livingston Fault - There is a series of northwest-trending faults or breccia reefs mapped in the hills several miles northwest of the site. Wells (1967) reports that these faults originated during the Precambrian and were later activated during the Laramide orogeny. The Livingston fault, a little more than 3 miles (4.8 km) from the site, is the closest of these faults (see Figure 2.3.4-4). The faults generally consist of a zone up to 1.5 miles (1.9 km) wide of subparallel faults characterized by breccia and gouge. Parts of the faults have been recrystallized and locally contain secondary mineral enrichment. There is no geologic evidence to indicate that the Livingston fault has been active during the period of post-Laramide block faulting.

Where the Livingston fault crosses Coal Creek, it is intersected by the Idaho Springs-Ralston shear zone. The Livingston fault branches into five splays, two of which continue to the south and southeast, and may connect with the Golden fault.

Golden Fault - The Golden fault is one of the major frontal faults initiated during the Laramide orogeny and is the closest of the major faults to the Rocky Flats site. The existence of the fault is evident from deletion and displacement of major stratigraphic rock units (Van Horn, 1972 and 1976; Smith, 1964; and Scott, 1972). Boos and Boos (1957) believe the Golden fault is an underthrust with nearly 11,000 feet (3,300 m) of section having been faulted out just west of Golden. Scott (1970) reports a stratigraphic throw of about 8,000 feet (2,400 m) in the same area, where it dips about 70° west. Berg (1962) demonstrates the fault dips steeply to the west, south of Golden.

The trend of the Golden fault generally follows the range front with its mapped location extending from southeast of Morrison to north of Golden (Figure 2.3.4-4). Surface material covers and obscures the actual location and attitude of the fault plane over most of its length. The trace of the Golden fault becomes very indefinite north of Van Bibber Creek, about 5 miles (8 km) south of the site.

Structure in the vicinity of Ralston Reservoir (Figure 2.3.4-4) is complex, with the junction of the Golden and Livingston faults, Ralston dike, and a lobe-shaped, low-angle thrust. This structure is shown by Van Horn (1972) as a low-angle thrust coming out from the Golden fault and displacing the Fox Hills Sandstone about 0.75 mile (1 km) to the east (see Figure 2.3.4-7). This structure could also be described as a gravity slide (Shuck, 1976). Such slides are common in other areas of the Rocky Mountain region (Grose, 1972). A trace of the Golden fault continues northwest from the lobe-shaped thrust and is shown as connecting with two traces of the Livingston fault (Van Horn, 1972; Sheridan et al., 1967; and Wells, 1967). There is evidence from seismic profiling (Shuck, 1976; Money, 1977) and displaced fossil zones in the Pierre shale (Van Horn, 1972), that another trace of the Golden fault continues under and north of the Ralston dike for slightly over a mile (1.6 km), with rapidly decreasing displacements. In outcrops of the Pierre Shale one mile (1.6 km) southwest of Rocky Flats Lake (Figure 2.3.4-7), there is no evidence for this trace of the fault.

Scott (1970) documented the presence of a small graben feature west of Golden that has displaced Quaternary gravels. He attributed the graben to the Golden fault and inferred the entire fault may be active. The graben found by Scott (1970) was trenched by Kirkham (1977) and was shown to have displacements with at least two periods of movement between the Yarmouth and Sangamon interglacial periods (see Figure 2.3.4-5). This is the only known place along the Golden fault zone with evidence of Quaternary movement. Kirkham believes the graben to be on a minor trace in the Golden fault zone, and suggests that other localities with Quaternary faulting might be found along the main trace of the fault or other minor traces within the fault zone. A report by Kirkham and Rogers (1978) concludes that the Golden fault is active. The capability (see the definition of a "capable fault" in the glossary) of the Golden fault is to be determined and will be discussed in detail in the final Safety Analysis Report (SAR) for the Rocky Flats Plant.

<u>Faults in the Marshall-Superior-Louisville Area</u> - A series of northeast-trending faults has been mapped north of the Plant site (Spencer, 1961; Colton and Lowrie, 1973). These faults break the upturned sedimentary beds that comprise the west limb of the Denver Basin into northeast-trending blocks. The major faults within the zone are shown on Figure 2.3.4-4. The faulting is clearly indicated by surface outcrops of Fox Hills Sandstone. The information concerning the location and attitude of the fault planes was obtained, for the most part, from drill holes and exposures of the fault in the coal mines of the area. Relative movement of fault planes has formed horsts and grabens with the cutoff and repetition of the Fox Hills Sandstone. Between the faults, beds are folded into anticlines and synclines. Colton and Lowrie (1973) report that the faults dip steeply to the northwest.

These northeast-trending faults are thought to be related to the Laramide orogeny and are considered by Spencer (1961) as a possible continuation of the Ralston shear zone. Recent basement maps also infer the presence of a buried structure in the Precambrian crystalline basement (Zietz and Kirby, 1972; Behrendt and Bajwa, 1972). A different interpretation (Blume, 1974) is that the faults are not a reflection of corresponding faults in the basement complex, but are related to the folding of the sedimentary rocks around the buried basement structure. During the formation of the Denver Basin in the Laramide orogeny, the presence of this basement structure required adjustment of sedimentary rocks caused by compressive forces. This adjustment could have resulted in the formation of the fault blocks found in the area. Folds observed within the block may be a type of drag fold.

The faults have no geomorphic expression and there is no evidence to indicate that any of the faults has been active in Quaternary time.

Eggleston Fault - The northwest-trending Eggleston Reservoir fault has been mapped by Spencer (1961) just to the north of the Plant site, and projected through the northeast corner of the site by Hurr (1976). The area around Eggleston Reservoir was checked for evidence of Quaternary fault displacement along the fault. The outcrop pattern of the Fox Hills Sandstone indicates the presence of the fault in bedrock at the reservoir; however, there is no evidence to indicate any post-Wisconsin movement of the fault. The right abutment of the Eggleston Dam is a pediment remnant capped by gravel deposits. This gravel deposit, although younger than the Rocky Flats Alluvium, is pre-Wisconsin in age based on criteria that are used to differentiate surficial deposits in the Front Range area, such as soil profile development and stratigraphic succession (Malde, 1955; and Scott, 1965). The terrace surfaces north and south of the reservoir are smooth and concordant and do not show any topographic expression of the existence of an underlying fault.

Hurr (1976) reported evidence for a northwest-trending fault across the northeast corner of the site (Figures 2.3.4-4). The fault was shown by Hurr to be a continuation of the Eggleston fault, although the strike differs from that shown by Spencer (1961). Hurr infers the fault's presence on the basis of an offset spring line and two apparent offsets in the Cretaceous sedimentary rock underlying the Rocky Flats Alluvium (see Figures 2.3.4-6 and 2.3.4-7). A field check of the fault indicated that the inferred fault has no geomorphic expression and there is no apparent displacement or tilting of the pediment and overlying Rocky Flats Alluvium. If the fault does exist, it has not been active since the Rocky Flats Alluvium was deposited. The Eggleston fault and the possible southward projection will be studied and results of this investigation discussed in detail in the Plant SAR.

Valmont Fault - The Valmont fault is described by Scott (1970) as displacing Quaternary deposits. The fault is exposed in a roadcut east of Boulder in the southeast corner of the intersection of 75th Avenue and Valmont Road in Section 24, T1N, R70W. The location is approximately 10 miles (16 km) north of the site. Displacement on the fault was vertical, with about 5 feet (1.5 m) of displacement. It displaced Slocum alluvium of Illinoian or Sangamon age (approximately 250,000 years B.P.) on the south, downward against Fox Hill sandstone on the north. The fault trends N50°E and parallels the early-Tertiary Valmont dike (Scott, 1970). The fault cannot be traced either east or west of the roadcut, and it is not associated with any of the bedrock faults in the area, as mapped by Colton and Lowrie (1973).

The Slocum Alluvium has been dated as 200,000 to 250,000 years old, which serves as the maximum age of faulting. The minimum age of faulting cannot be determined in an absolute sense, but geomorphic evidence indicates that the fault is pre-Wisconsin. A soil profile has developed on the surface across the fault with the gravels in the alluvium strongly weathered. A heavy concentration of caliche has developed in the C horizon of the soil profile, which indicates a soil of pre-Wisconsin age (Baker, 1973). There is no surface expression of the fault. Based on this evidence, the Valmont fault is considered pre-Wisconsin in age and at least 150,000 years old.

<u>Other Possible Faults</u> - Hurr (1976) shows a short northeast-trending fault in a cut along the Denver and Rio Grande Western Railroad, approximately 1.5 miles (2.5 km) south of the site (see Figure 2.3.4-4). The fault is shown to displace Verdos Alluvium, which is approximately 600,000 to 700,000 years old. A careful field check of the area indicated that the apparent displacement might be a channel contact and not a fault. Evidence which suggests a channel contact includes the lack of deformation at the contact and the lack of any geomorphic expression of the feature. The feature will be investigated and the findings discussed in more detail in the Plant SAR.

Ackerman (1974) discussed a possible 30-foot (9 m) step in the contact between the Rocky Flats Alluvium and the underlying bedrock, just north of Rocky Flats Lake (see Figure 2.3.4-4). Ackerman suggests that the down-to-the-east step might be fault related. The step is based on the interpretation of shallow seismic refraction data. Davis (1976), using deep seismic reflection data, did not see any evidence for a fault at this location.

Remote sensing imagery interpretation by EG&G, Inc., for the Rocky Flats Facility identified a series of northwest-trending photo lineaments in the vicinity of the site. The location of these lineaments is shown in the EG&G report (see Appendix C-1). Several types of aerial photographic imagery were used in the lineament analysis: (1) color negative film with scales of 1:14,000, 1:35,000 and 1:38,000; (2) four-camera multispectral photography with scales of 1:19,500 and 1:39,000; and (3) infrared thermal mapping with a high-altitude long-wave-length scan, a low-altitude long-wave-length scan, and a multispectral multiscan.

Lineaments were defined from the photographs by topographic features such as stream orientations and continuity of tributary stream alignments across main drainages. Field investigations were conducted to verify these and other suspected fault-related features. Some evidence of faulting in the Arapahoe Formation was found. A seismic reflection survey conducted by Davis (1976) indicated no appreciable displacements in rock formations at depths exceeding 600 feet (180 m) below the ground surface. This survey indicates that a major fault or shear zone is not associated with the lineaments. The significance of these lineaments to surface rupture at the site will be studied and the results discussed in greater detail in the Safety Analysis Report for the Rocky Flats Plant site.

2.3.4.7 Historical Seismicity

Historically, Colorado has been an area of relatively low seismic activity. Figure 2.3.4-8 shows historical earthquakes that have occurred within 200 miles (320 km) of the Rocky Flats Plant site. With the exception of the Derby earthquakes located northeast of Denver, most of the historical seismicity has occurred within the Southern Rocky Mountain Tectonic Province (see Figure 2.3.4-3). As a result of public comment on the DEIS, the relationship of the Derby earthquakes to the Rocky Mountain Arsenal deep well injection of wastewater has been clarified in this section.

The first reported earthquake in the state occurred in 1870. With the possible exception of an earthquake in 1882 (Modified Mercalli VII), there have been no large damaging earthquakes in the State of Colorado, according to historical records (Hadsell, 1968). Because of the absence of destructive earthquakes, very little instrumentation and research effort had been expended on studying Colorado seismicity until 1962, when a series of perceptible earthquakes occurred at the Rocky Mountain Arsenal (RMA). These earthquakes have been variously called Denver earthquakes, the Derby earthquakes or, the Commerce City earthquakes. Much of the present day knowledge of the seismicity of Colorado is based on instrumentation and research resulting from the Derby earthquakes. Some microearthquake activity has been recorded in the vicinity of the Golden fault southwest of the site. However, the location accuracy of the microearthquakes is poor and it is not possible to relate them to a specific geologic structure (Osterwald et al., 1973).

History of Seismographic Stations in Colorado

The first seismographic station in Colorado was installed in 1909 at Regis College in north Denver by Father Armand W. Forstall. The records obtained were not suitable for determining earthquake magnitude or location, but were a useful source of information on earthquake origin times and to verify other sources of data, such as felt reports.

From 1954 to 1959, the University of Colorado operated a three-component Benioff seismograph in Boulder, Colorado, as part of a general geophysical program. These records are the primary source of instrumental information on earthquakes prior to 1961 (Krivoy and Lane, 1966).

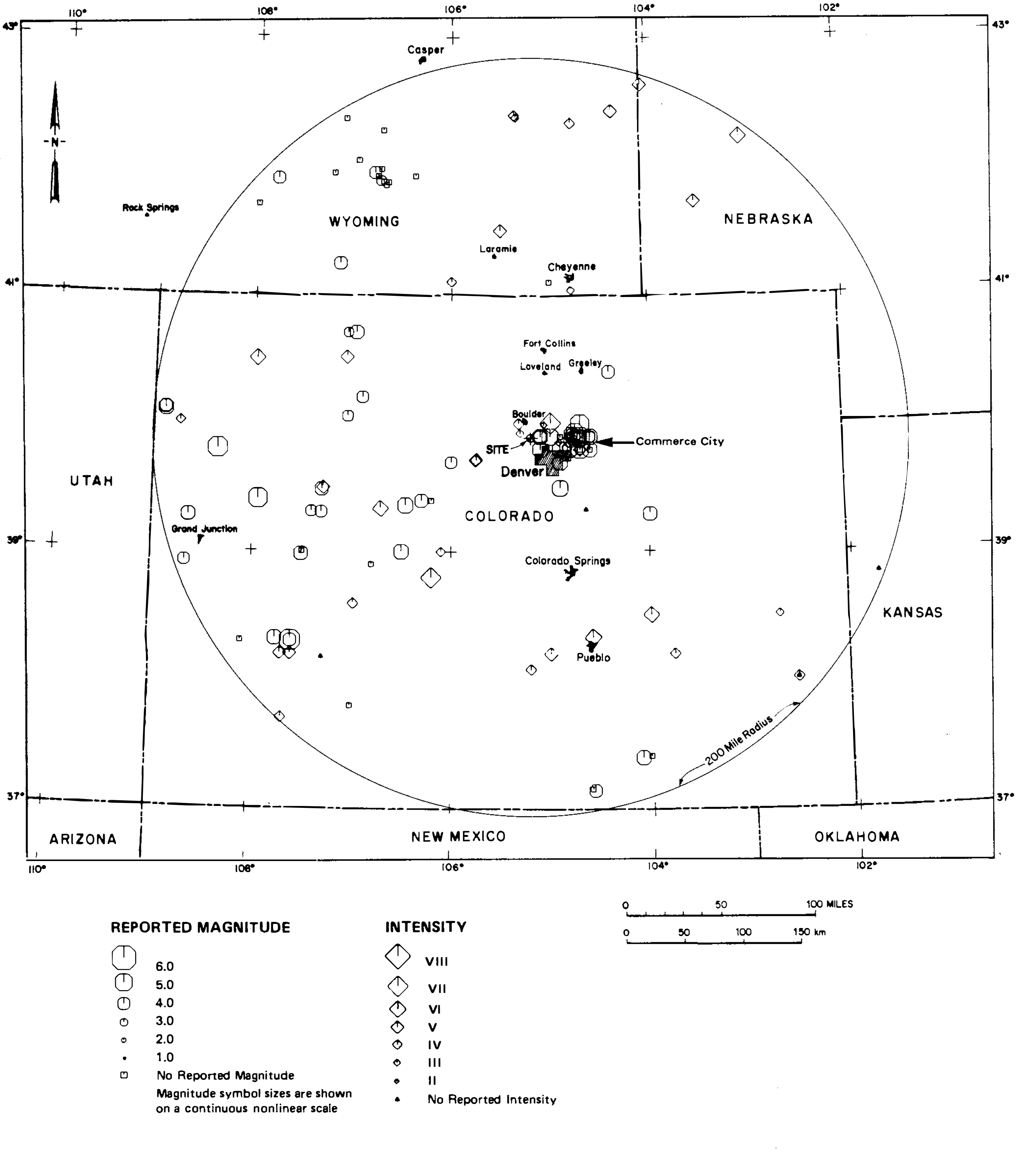


Figure 2.3.4-8 Epicenter Plot of Historical Seismicity Within 200 Miles of the Rocky Flats Plant Site

Since December 1961, the Colorado School of Mines has operated a three-component Benioff seismograph at the Cecil H. Green Observatory in Bergen Park, Colorado. This instrument is capable of detecting earthquakes with Richter magnitudes of one and greater in north Denver, which is the area of the Derby earthquake series. This station has provided much of the seismological instrumental data for the state since 1961.

In January 1966, the U.S. Geological Survey established a dense network of seismographic stations in the vicinity of the Rocky Mountain Arsenal (north Denver area) to obtain accurate hypocentral locations of the earthquakes that had been occurring in the vicinity since 1962. Initially this network was monitored for six hours each day as a field operation, but by 1968, a continuous monitored system had been established. The sensitivity of the seismographic network made it possible to locate earthquakes to within ±1 km accuracy in the vicinity of RMA and to detect events with magnitudes as low as -1. This network was later abolished after the frequency of the Derby earthquakes diminished.

With the increase of interest in earthquake activity in Colorado that resulted from the seismic activity at the RMA, the necessity for a state-wide seismographic network capable of locating earthquakes anywhere in the state was realized; consequently, in 1971 the Colorado School of Mines, in conjunction with the National Oceanic and Atmospheric Administration (NOAA), installed a network of six short-period seismographic stations at various locations throughout the state. A partial map of epicentral locations for 1971, using data from this network, has been published by the Colorado School of Mines (Simon, 1972).

Regional Seismicity Catalog and Epicentral Plot

The historical seismicity within a 200-mile (320 km) radius of the Rocky Flats Plant site is shown on Figure 2.3.4-8 and is included in Table 2.3.4-1 as a catalog. Reported earthquakes from 1870 through 1977 are included if their size is such that (1) the local Richter magnitude is equal to or greater than approximately 3.5 and (2) the maximum intensity is Modified Mercalli III or greater. In addition, if the event is reported in a published source, but without an assigned magnitude or maximum intensity, it is included. Each catalog listing includes data, origin time in GMT (Greenwich Mean Time), location in latitude and longitude, focal depth, maximum intensity (Modified Mercalli) or magnitude, distance to the Plant site, quality of location determination, data source, and comments.

The earthquakes are plotted on Figure 2.3.4-8 according to their instrumentally determined location or location of maximum intensity. Earthquake locations based on maximum intensities are shown as diamonds. Instrumental locations are shown as octagons. The size of the symbol increases with reported magnitude or with the assigned maximum intensity.

TABLE 2.3.4-1

SIGNIFICANT EARTHQUAKES WITHIN 200 MILES OF THE ROCKY FLATS PLANT*
(in chronological order)

Date	Locality	North Latitude	West Longitude	Distance[1]	Azimuth[2]	Intensity[3]	Magnitude[4]
Dec. 1870	Pueblo	38.5	104.0	115.7	145.7	VI	
Nov. 1871	Georgetown	39.7	105.7	29.6	243.6	IV	
Sept. 1880	Aspen	39.3	106.7	89.7	243.4	VI	
Nov. 1882	Louisville(?)	40.0?	105.0?	13.1	55.2	VII	
Nov. 1882	Gunnison	38.6	107.0	131.3	227.8	IV	
Oct. 1888	Rosita	38.1	105.2	123.6	179.9	IV	
Jan. 1889	Glenwood Springs	39.5	107.3	115.0	257.1	V	
Dec. 1891	Axial Basin	40.5	108.0	153.9	286.7	VI	
Aug. 1894	Georgetown	39.7	105.7	29.6	243.6	V	
Mar. 1895	Steamboat Springs	40.5	107.1	108.8	293.3	V	
Nov. 1901	Buena Vista	38.8	106.2	92.3	215.7	VII?	
Nov. 1913	Ouray	38.2	107.7?	178.0	229.8	V	
Oct. 1916	Boulder	40.0	105.0	13.1	55.2	III	
Apr. 1928	Creede	37.8	107.0	173.8	214.5	V	
Feb. 1941	Aspen	39.3	106.8	94.5	244.9	IV	
Aug. 1944	Montrose	38.5	107.9	173.7	237.3	VI	
Sept. 1944	Mt. Gunnison	38.8	107.5	144.3	239.3	VI	
Aug. 1952	Esterbrook, Wyo.	42.5	105.0	180.4	3.3	IV Aug.	
1952 Medicine	Bow, Wyo. 41.9	106.2	148.1	339.7	IV		
Jan. 1954	Bosler, Wyo.	41.5	105.5	112.1	352.1	V	
Jan. 1954	Jelm, Wyo.	41.1	106.0	90.3	332.5	IV	
Jan. 1954	Alcova, Wyo.	42.6	106.7	199.4	337.5	IV	
Feb. 1954	Rangely	40.0	108.8	188.6	273.4	V	
Feb. 1955	Steamboat Springs	40.5	106.7	89.7	298.4	V	
May 1955	Medicine Bow, Wyo.	41.9	106.2	148.1	339.7	IV	
Aug. 1955	Lake City	38.0	107.0	162.5	217.1	VI	
Nov. 1955	Rocky Ford	38.2	103.7	142.0	144.8	VI	
Jan. 1956	Lamar	37.9	102.6	196.4	133.6	V	
Jan. 1957	Esterbrook, Wyo.	42.5	105.0	180.4	3.3	III	
Aug. 1958	Jelm, Wyo.	41.1	106.0	93.4	333.5	IV	
Dec. 1959	Foxpark, Wyo.	41.1	106.2	98.6	328.1	V	
Oct. 1960	Ridgeway	38.3	107.6	169.3	230.3	VI	5.5
Oct. 1960	Aspen	39.2	106.9	102.5	242.8	V	
Jan. 1962	Montrose	38.4	107.8	173.4	234.4	IV	4.4
Feb. 1962	Cimarron	38.4	107.6	164.9	232.1	V	4.7
June 1962	Commerce City	39.8	104.9	17.3	111.3	V	3.1
Dec. 1962	Commerce City	39.8	104.9	17.3	111.3	V	3.6
Dec. 1962	Commerce City	39.8	104.9	17.3	111.3	V	3.8
Jan. 1963	Commerce City	39.8	104.9	17.3	111.3	IV	3.2
Apr. 1963	Commerce City	39.9	104.8	21.4	88.3	V	3.2
Apr. 1963	Commerce City	39.8	104.9	17.3	111.3	IV	3.2
May 1963	Commerce Ctiy	39.8	104.9	17.3	111.3	IV	3.5
June 1963	Simla	39.3	104.0	76.1	122.1		4.4
July 1963	Commerce City	39.8	104.9	17.3	111.3	V	3.7
July 1963	Commerce City	39.8	104.9	17.3	111.3	II	3.1
Nov. 1963	Pueblo	38.3	104.6	114.5	163.4	IV	2.8
Aug. 1964	Dillon	39.7	106.0	44.4	253.0		4.0
Sept. 1964	Wamsutter, Wyo.	41.9	107.8	194.2	316.4		4.1
Jan. 1965	Rocky Flats	39.9	105.3	5.2	276.5	III	2.0
Feb. 1965	Broomfield	39.9	105.1	5.5	83.9		4.6
Feb. 1965	Commerce City	39.8	104.9	17.3	111.3	V	3.2
Mar. 1965	Commerce City	39.8	104.9	17.3	111.3	II	3.1
Apr. 1965	Commerce City	39.8	104.9	17.3	111.3	V	3.4
May 1965	Climax	39.4	106.3	67.6	240.3		4.3
June 1965	Commerce City	39.8	104.9	17.3	111.3	IV	3.1
July 1965	Commerce City	39.8	104.9	17.3	111.3	III	3.1

TABLE 2.3.4-1 (continued)

Date	Locality	North Latitude	West Longitude	Distance[1]	Azimuth[2]	Intensity[3]	Magnitude[4]
July 1965	Denver	39.7	104.9	20.9	129.2		4.6
Sept. 1965	Commerce City	39.8	104.9	17.3	111.3	V	3.8
Sept. 1965	Commerce City	39.8	104.8	22.3	106.3		4.7
Sept. 1965	Commerce City	39.8	104.9	17.3	111.3	V	4.1
Sept. 1965	Castle Rock	39.5	104.9	31.5	149.0		4.8
Sept. 1965	Commerce City	39.8	104.9	17.3	111.3	IV	3.1
Sept. 1965	Commerce City	39.8	104.9	17.3	111.3	V	4.1
Sept. 1965	Commerce City	39.8	104.8	22.3	106.3		4.6
Nov. 1965	Commerce City	39.8	104.9	17.3	111.3	IV	3.5
Nov. 1965	Commerce City	39.8	104.9	17.3	111.3	V	4.5
Nov. 1965	Commerce City	39.9	104.7	26.7	88.6		4.4
Nov. 1965	Commerce City	39.8	104.9	17.3	111.3	V	3.8
Jan. 1966	Commerce City	39.8	104.9	17.3	111.3	V	3.5
Jan. 1966	Commerce City	39.8	104.9	17.3	111.3	V	3.5
Apr. 1966	Fairplay	39.2	106.0	64.0	222.0		4.7
Sept. 1966	Ridgeway	38.3	107.6	169.3	230.3		4.2
Oct. 1966	Trinidad	37.4	104.1	182.0	160.5	VI	4.6
Oct. 1966	Castle Rock	39.3	104.6	52.0	141.5		3.0
Nov. 1966	Glenwood Springs	39.6	107.3	113.5	260.5		3.9
Nov. 1966	Commerce City	39.8	104.9	17.3	111.3	III	3.1
Nov. 1966	Commerce City	39.8	104.9	17.3	111.3	VI	4.3
Dec. 1966	Aspen	39.3	106.7	89.7	243.4	III	3.3
Jan. 1967	Somerset	39.0	107.5	138.4	243.7		4.4
Jan. 1967	Yampa	40.1	107.0	98.7	277.1		3.8
Feb. 1967	Commerce City	39.9	104.8	21.8	93.4		4.3
Apr. 1967	Ridgeway	38.3	107.8	174.9	232.4		4.5
Apr. 1967	Commerce City	39.9	104.8	24.2	81.7	VI	5.1
Apr. 1967	Commerce City	39.9	104.8	23.1	90.1	III	4.4
Apr. 1967	Commerce City	39.9	104.9	15.6	98.4	III	
Apr. 1967	Commerce City	39.9	104.8	22.0	84.2		4.3
Apr. 1967	Commerce City	39.8	104.9	17.3	111.3	V	3.8
Apr. 1967	Commerce City	39.9	104.8	23.1	86.5	VI	4.5
Aug. 1967	Commerce City	39.8	104.9	17.3	111.3		4.3
Aug. 1967	Commerce City	39.9	104.7	26.7	88.6		5.3
Nov. 1967	Commerce City	39.9	104.6	32.1	88.8		3.7
Nov. 1967	Commerce City	40.0	104.7	27.7	74.2		5.2
Nov. 1967	Commerce City	39.9	104.7	26.7	88.6		4.4
June 1968	Redstone	39.3	107.4	124.3	252.0		3.8
May 1969	Wiggins	40.4	104.4	53.1	52.5		4.2
Sept. 1969	Collbran	39.4	107.9	150.2	258.0		5.3
Apr. 1970	Rangely	40.1	108.9	196.6	275.1		4.3
Apr. 1970	Rangely	40.1	108.9	196.6	275.2		4.1
May 1970	Broomfield	39.9	105.1	5.3	84.4		4.3
Jan. 1971	Glenwood Springs	39.5	107.3	115.6	256.7		4.3
Mar. 1971	Steamboat Springs	40.7	107.0	109.0	301.6		4.4
Aug. 1971	Brighton	39.9	104.8	23.0			3.8
Nov. 1971	Glade Park	38.9	108.7	198.0			4.0
Mar. 1974	Steamboat Springs	40.7	107.1	113.0			3.5
Jan. 1975	Loma	39.3	108.6	189.0			3.7
Mar. 1977	Dixon	41.2	107.1	139.0			3.5
Sept. 1977	Carbondale	39.3	107.3	119.0			3.0

* Based on revised Blume report (Blume 1974).
1. Epicentral distance from the Rocky Flats Plant, in miles.
2. Eqicentral azimuth from the Rocky Flats Plant, in degrees east of north.
3. Modified Mercalli Scale.
4. Richter body-wave magnitude.

Data Sources and Location Accuracy - The accuracy of earthquake locations and the completeness of the historical catalog are significantly related to the time period in which the earthquakes occurred. In the last 100 years, there has been a tremendous increase in the population of Colorado, as well as significant advances in the science of seismology. The ability to locate earthquakes, based on felt reports, has improved considerably with the increasing population distribution. Installation of seismographic stations and implementation of the digital computer has greatly aided in locating earthquakes instrumentally in Colorado and the surrounding region.

Prior to the early 1960's, earthquake locations were based primarily on felt reports from published newspaper accounts and other historical documents (Hadsell, 1968). These pre-instrumental earthquakes were assigned geographic locations based on the locations of the maximum reported intensity. Because population size and distribution are such critical factors in reporting of intensities, and since the population of Colorado and neighboring states in the 1800's and early 1900's was relatively small and unevenly distributed, pre-instrumental earthquake locations may contain errors up to ±30 miles (50 km). The principal data sources for the pre-instrumental locations are Hadsell (1968) and Docekal (1970). The sizes of the pre-instrumental earthquakes, expressed as maximum intensity, also may be inaccurate because of the limited and unevenly distributed population and because of possible distortion of felt reports in newspaper accounts of the day.

Although the first seismograph was installed in Colorado and the Rocky Flats region in 1909, instrumentally determined earthquake locations were not possible until 1962 when a sufficient number of seismographic stations were in operation (Hadsell, 1968). The source for the instrumental locations listed in Table 2.3.4-1 is the NOAA Earthquake Data File, which is a compilation of other sources. A minimum location accuracy for such locations is estimated to be 9-12 miles (15-20 km) at a detection level magnitude 3.0 to 3.5.

Colorado Earthquake of November 1882

A great deal of speculation has centered around the location, size, and felt area of the 1882 earthquake. The most definitive reference on this particular seismic event is that of Hadsell (1968), in which an epicentral intensity of VII is assigned to a region north of Denver near latitude 40°N and longitude 105°W, based on reports of the earthquake as published by newspapers in November 1882.

This postulated location is approximately 7 miles (11 km) north of the Rocky Mountain Arsenal and could be as close as 13 miles (21 km) to Rocky Flats. Earlier studies of the seismicity of Colorado had located this earthquake epicenter in Vail Pass, about 100 miles (160 km) west of the location given by Hadsell (1968). The Vail Pass location had been made without information that was available to Hadsell; the location north of Denver can be substantiated with recently available information.

Crude estimates of the magnitude of this seismic event were made using relationships between non-instrumental data, which include epicentral intensity and circular felt area, and instrumentally determined magnitudes for Colorado earthquakes from 1962 to 1967 (Hadsell, 1968). The estimated Richter magnitudes of the 1882 earthquake from these relationships is 5.0 ± 0.5 using epicentral intensity, and 6.7 ± 0.6 using circular felt area. This discrepancy probably reflects the unreliability of felt reports (Hadsell, 1968). However, based on a critical examination of newspaper accounts of the 1882 earthquake, it is felt that the magnitude of this event was approximately 5+ (Hadsell, 1968). The damage reports for the 1882 earthquake as given in local newspapers, are similar to reports for the Derby earthquakes of magnitudes 5 to 5.3 that occurred in 1967 in approximately the same area. The 1882 earthquake is discussed in greater detail in the John A. Blume and Associates report (1974). This will be further investigated and the results of this study will be reported in the Safety Analysis Report for the Rocky Flats Plant.

Derby Earthquake Series

From April 1962 through June 1972, over 1800 earthquakes were located in the vicinity of the Rocky Mountain Arsenal (RMA). Prior to 1962, little seismicity was noted in this area. The possible exception was the 1882 earthquake (discussed previously), which Hadsell (1968) located in the approximate vicinity of the Derby earthquakes (see Figure 2.3.4-8).

The beginning of the Derby Earthquake sequence corresponded to the initiation of pumping fluid into a deep well for waste disposal purposes at the Rocky Mountain Arsenal. A 12,045-foot (3614 m) well was drilled in the Denver Basin by the U.S. Army; the bottom 100 feet (30 m) was drilled into Precambrian crystalline basement rocks. Fluid injection under pressure into this well began March 8, 1962 and continued through September 30, 1963. Gravity feed was initiated in August 1964 and continued until April 1965 when pressure injection recommenced. All fluid injection at the well terminated on February 20, 1966. The first earthquake to be associated with the Derby sequence was recorded 47 days after the beginning of fluid injection in 1962. Including this first Derby Earthquake on April 24, 1962, there have been 1,809 events recorded at Bergen Park through June 23, 1972. Prior to injection stoppage, the largest event recorded was magnitude 3.8, which occurred November 21, 1965. In 1967, however, after injection ceased, there were three events of approximately magnitude (body-wave) 5 or greater (April 10, 1967, M = 4.9; August 9, 1967, M = 5.3; and November 27, 1967, M = 5.2). The energy released by these three events was greater than the total energy released by all previous events in the series.

The first evidence of a correlation between earthquake activity and fluid injection at the RMA well was presented by Pan (1963) and Wang (1965). Evans (1966) demonstrated a spectral and temporal relationship between fluid injection at the RMA well and a series of over 700 minor earthquakes. Subsequent investigators (Healy et al., 1966; Major and Simon, 1968) have corroborated this correlation and postulated the theory that the earthquakes were triggered by injection of fluid and involved a mechanism where hydrostatic increase in fluid pressure was sufficient to reduce the frictional resistance of the crystalline basement rocks to fracturing. While this theory has only been partially substantiated by additional investigations, it has since become accepted that pre-existing tectonic stress played a major role in the earthquake generation at RMA (Simon, 1969) and that a combination of the two factors, pore pressure and tectonic stress, was necessary to produce the Derby Earthquakes.

Following the onset of perceptible earthquakes at RMA, there have been extensive studies of the surficial geology of the Denver Basin, and its structural geology has been inferred from geophysical investigations. Geophysical studies made prior to the construction of the well were corroborated by later studies performed in 1966 and 1967, which indicated that there is no surface evidence of recent faulting in the vicinity of the RMA (De Voto, 1968). Investigation of cores made at the time of drilling yielded evidence of fracturing only in the Precambrian crystalline basement rocks.

Earthquake locations, using the high density USGS network discussed earlier, outline a roughly ellipsodial zone about 2 miles by 6 miles (3 kilometers by 10 kilometers), which includes the disposal well. The long axis of the zone trends N60°W, and local depths of earthquakes range from 2.8 to 3.4 miles (4.5 to 5.5 km). The first motion of compressional wave arrivals is consistent with right-lateral strike slip motion along fault surfaces that are steeply dipping and parallel to the trend of the zone of epicenters (Healy and others, 1966). The point of nearest approach of this zone to the Rocky Flats Plant site is 14 miles (22 km).

2.3.4.8 Geologic Hazards

Minor landsliding has occurred along the steep-sided bluffs of the dissected Rocky Flats Alluvium (Van Horn, 1972, 1976; and Simpson, 1973), and is generally caused by hydration and lubrication of the montmorillonite clay in the Arapahoe Formation (Hurr, 1976). These slides, which are small and local in nature, reflect mass wasting at the margins of Rocky Flats Alluvial exposures, in response to stream entrenchment in the underlying bedrock. This potential for minor sliding along the bluffs around the site is not considered hazardous to the Rocky Flats Plant. No other landslides are present near the Plant site.

Amuedo and Ivey (1978) show the potential for subsidence hazards in the Louisville quadrangle. The only hazard potential identified near the Plant site is associated with surficial and underground clay and coal mines 1.5 miles (2.5 km) west of the Rocky Flats Plant. Subsidence associated with these mines is local in nature, however, and no hazard potential exists for mine-related subsidence at the Plant site. No fluid-related subsidence due to oil, gas, or groundwater extraction has been reported in the area. The potential for such subsidence is considered to be low because of the paucity of oil wells in the area and the thin veneer of Rocky Flats Alluvium overlying bedrock. The alluvium itself is compacted and has sufficient geologic age such that no natural subsidence will occur. No subsidence-related hazards are known to exist at the Rocky Flats Plant site.

Activities by man in the Rocky Flats area are limited to building, road, and canal construction; impoundment of small reservoirs; and excavation of gravel and clay pits. None of these activities poses a hazard to the Plant site. Small reservoirs in the site vicinity either lie downstream to the east, are too small, or are on drainages which would not affect the Plant site should failure occur. A possible seismic hazard related to man-induced earthquakes at the Rocky Mountain Arsenal was discussed earlier.

2.3.5 Hydrology

The hydrology of the Rocky Flats Plant site has been described by Hurr (1976). This section is a summary of Hurr's work. Previous investigations of the area include reports by John A. Blume & Associates (1974) and Engineering-Science, Inc. (ESI, 1974). The hydrology is affected by rainfall patterns and other aspects of climate, which are described in Section 2.3.6, and by the stratigraphy and geologic structures in the area which are described in detail in Section 2.3.4. Only aspects pertinent to the surface and groundwater hydrology are summarized here.

The top of the impermeable Pierre Shale (late Cretaceous age) is approximately 1,000 feet (300 m) below the Plant, and is considered by Hurr (1976) to be the base of the hydrologic system which could be affected by operations at the Rocky Flats Plant site. Three bedrock formations are important to the hydrology of the study site: the Fox Hill Sandstone and the lower Laramie Formation, which are at 600 to 800 feet (185 to 250 m) below the Plant, and the Arapahoe Formation, which directly underlies the surficial deposits at the Plant site (Figure 2.3.4-6).

Surficial deposits at the Rocky Flats Plant that are important to the hydrology are terrace alluvium and valley-fill and are generally less than 50-feet (15 m) thick. The Rocky Flats Alluvium, which underlies the Plant, dominates the topography and hydrology of the Plant area. The Rocky Flats Alluvium is a broad, planar deposit which, in this area, is a thin alluvial fan deposited downslope from the mouth of Coal Creek Canyon. Where the base of the Rocky Flats Alluvium has been exposed by erosion, contact springs are common. The next-to-youngest Quaternary deposits are the Verdos and Slocum Alluviums. These formations are of little hydrologic importance, except south of Leyden, where contact springs at the base of the Verdos Alluvium have provided a municipal water supply for Leyden.

2.3.5.1 Surface Water Hydrology

The surface water system crossing the Plant site supplies water to two reservoirs used for municipal water supply and recharges aquifers used for domestic water supply. Consequently, the accidental release of a contaminant into the surface water system could affect both surface and groundwater quality. (See Figures 2.3.9-2 and 2.3.9-3).

Streams

Five streams occur near the Rocky Flats Plant site. Of these, North Walnut Creek, South Walnut Creek, and Woman Creek drain the Rocky Flats Plant site; all of these are ephemeral. The other two streams in the area are Coal Creek and Rock Creek. North Walnut Creek and South Walnut Creek head west of the Plant and flow eastward into Great Western Reservoir. Great Western Reservoir supplies water to the city of Broomfield. Woman Creek also originates west of the Plant, drains the south portion of the Rocky Flats Plant site, and flows eastward into Standley Lake. Standley Lake provides irrigation storage and the municipal water supply for the city of Westminster. Coal Creek has its headwater in the Front Range and is the largest stream near the Plant. Coal Creek and Rock Creek drain the area north of the Plant. The Rocky Flats site drainage pattern and location of streams is shown in Figure 2.3.9.2.

Six ditches convey water through the area. The South Boulder Diversion Canal carries water southward from South Boulder Creek (north of the Plant site) to Ralston Reservoir, which supplies water to the city of Denver. The water supply for the Rocky Flats Plant is obtained from South Boulder Diversion Canal and Ralston Reservoir. The Last Chance, Church, McKay, and Kinnear Ditch and Reservoir Company ditches divert water from Coal Creek. The Last Chance Ditch delivers water to Rocky Flats Lake and Twin Lakes. Outflow from Rocky Flats Lake is transported out of the area by Smart Ditch. The Church Ditch supplies water to Upper Church Lake and Great Western Reservoir; McKay Ditch supplies water to Great Western Reservoir; and Kinnear Ditch and Reservoir Company Ditch supplies water to Standley Lake.

Precipitation

Precipitation, principally from rainfall and to a lesser extent from snowmelt, produces surface runoff in the Rocky Flats area. Three rainfall gauges were operated by Hurr near the Plant site. Graphs of cumulative precipitation on Walnut Creek and Woman Creek basins, during 14-minute increments for selected storms are shown in Hurr's report (1976). The maximum rainfall intensity for the storms shown was approximately 0.6 inch (15.2 mm) per hour during May 6, 1973. Rainfall intensities for the other storms range from less than 0.1 inch (2.5 mm) per hour to about 0.5 inch (12.7 mm) per hour.

Daily precipitation totals for the Woman Creek, North Walnut Creek, and Rocky Flats precipitation stations are documented (Hurr, 1976). The period of record for rainfall at the Walnut and Woman Creek stations is insufficient for a frequency analysis of rainfall. However, rainfall-recurrence interval data were estimated by Hurr (1976) for the Rocky Flats Plant from a report by the Denver Regional Council of Governments (1972).

Streamflow

The water that moves through stream and man-made channels in the Rocky Flats Plant site results from direct surface runoff following periods of rainfall and snowmelt, baseflow supplied by seeps and springs, and diversions and wastewater from various man-related activities. The network of streams and channels is a potential transmission system for contaminants derived from the Plant site.

Stream-gauging stations, established in 1972 on North Walnut Creek, South Walnut Creek, and Woman Creek have measured outflow from the Plant area. These stations also have provided data for deriving rainfall-runoff relations and for estimating rate of water movement through the network of streams. Daily streamflow for each of the three gauging stations is provided in Hurr (1976). Physical characteristics for the total and subdivided parts of the three basins are listed by Hurr (1976).

North Walnut Creek - Until September, 1974, North Walnut Creek drained an area of 1.24 mi^2 (3.21 km^2) above the gauging station. The natural streamflow was augmented by diversions from Coal Creek through Church and McKay ditches. A new ditch was constructed in September 1974 from SW1/4 NW1/4, Section 10, T2S, R70W, to the center of Section 2, T2S, R70W, where it joined a small tributary to Walnut Creek that enters downstream from the gauging station. In effect, this ditch intercepts all of the flow from the western part of the basin, including the Coal Creek diversion, and diverts the flow around the gauging station. The remaining part of the basin has a combined drainage area of 0.84 mi^2 (2.18 km^2). Three on-channel reservoirs presently regulate flow at the gauging station. Two of these on-channel reservoirs were constructed during 1974; the other was constructed prior to 1972.

South Walnut Creek - The total drainage area of South Walnut Creek above the gauging station is 0.46 mi^2 (1.19 km^2). The eastern sub-basin drains the north-central part of the Plant area and has a drainage area of 0.21 mi^2 (0.54 km^2). This sub-basin has four on-channel retention reservoirs.

Prior to late 1974, effluent from the Plant's laundry and sanitary sewage disposal system was discharged into South Walnut Creek. This discharge, which averaged 6.8 million gallons (25.7 Megaliters) per month during 1971-73, resulted in continuous flow in South Walnut Creek and Walnut Creek below the mouth of South Walnut Creek.

Since late 1974, the practice has been to keep all process wastewater on the Plant site and discharge it by evaporation. Sanitary waste effluent is released into South Walnut Creek after complete testing to verify effluent quality and compliance with applicable standards.

Woman Creek - Prior to July 1973, the area south of the Plant that was drained by Woman Creek above the gauging station was 2.10 mi^2 (5.44 km^2). In July 1973, the gauging station was moved upstream from the on-channel retention reservoir to a site where the total drainage area was 1.77 mi^2 (4.58 km^2). The natural flow of Woman Creek is augmented by diversions from Coal Creek through Kinnear Ditch; this flow is conveyed downstream to Standley Lake. Other sources of flow augmentation are leakage and spillage from South Boulder Diversion Canal, and seasonal pumping to dewater a clay pit. Prior to June 1975, backwash from the Plant's water-supply filter system was also discharged into Woman Creek. Groundwater from the south half of the Plant may also enter Woman Creek at times.

On-Channel Reservoirs - The on-channel reservoirs were surveyed in the spring of 1972 to determine the area and volume (Table 2.3.5-1) of the operating pools. Most of the dams have been raised since 1972 and the area-volume relationship extended. Two additional reservoirs were constructed in 1974 on Walnut Creek. The effect of the reservoirs on the daily flows of Woman Creek, Walnut Creek, and South Walnut Creek was small before the practice began of storing some Plant outflow on the Plant site. The reservoirs were usually full so that inflow and outflow were nearly equal. The most significant effect was the timing and height of peak flows resulting from storms.

TABLE 2.3.5-1
VOLUME OF PLANT RESERVOIRS

Number	Drainage	Retained Storage (gallons)	Retained Storage (acre-feet)
A-1	North Walnut Creek	1,640,000	5.03
A-2	North Walnut Creek	6,670,000	20.47
A-3	North Walnut Creek	14,110,000	43.30
B-1	South Walnut Creek	795,000	2.44
B-2	South Walnut Creek	1,930,000	5.92
B-3	South Walnut Creek	935,000	2.87
B-4	South Walnut Creek	598,000	1.84
C-1	Woman Creek	2,057,000	6.14
--	East Landfill	3,555,000	10.90

Water Budget--Great Western Reservoir - The municipal water supply for part of the city of Broomfield is stored in Great Western Reservoir. An estimated 50 to 75% of the municipal supply was diverted from Clear Creek, and the remaining percentage was equally divided between diversions from Coal Creek and effluent from the Rocky Flats Plant. A water budget of annual reservoir operation (Table 2.3.5-2) provides an estimate of net unmeasured inflow to the reservoir. Net inflow is actual inflow minus reservoir evaporation and seepage. An estimate of average annual evaporation is 300 to 400 acre-feet per year, based on data extrapolated from Ralston Reservoir by Hurr (D. B. Adams, oral communication, 1975). There are no measurements of seepage outflow; however, seepage is estimated to be 50 acre-feet per year. In FY 1975, the net annual inflow was 2,797 acre-feet. Assuming 397 acre-feet of evaporation and 48 acre-feet of seepage loss, the actual inflow was about 3,242 acre-feet.

TABLE 2.3.5-2

ESTIMATED FY 1975 WATER BALANCE FOR GREAT WESTERN RESERVOIR

Inflow			Outflow		
	Acre-feet	Gallons x 10^3		Acre-feet	Gallons x 10^3
Walnut Creek	406	132,315	City of Broomfield	2308	752,177
			Evaporation	300	97,770
McKay Ditch	300	97,770	Release to Creek and Seepage	642	209,228
General Runoff	740	241,166			
Lower Church Ditch	1804	587,924			
Total	3250	1,059,175		3250	1,059,175

2.3.5.2 Groundwater Hydrology

Groundwater aquifers at the Rocky Flats Plant site are the Rocky Flats Alluvium, Valley-Fill, Arapahoe Formation, and Laramie-Fox Hills aquifers. Recharge is from rainfall, snowmelt, and percolation from streams, ditches, and reservoirs. Discharge is by seeps, springs, base flow to the streams, and evapotranspiration. Groundwater also leaves the Rocky Flats Plant site as subsurface flow.

Rocky Flats Alluvium Aquifer

Groundwater in the Rocky Flats Alluvium is recharged by infiltration of water from rain, snowmelt, and surface-water sources. The infiltration rate is high. Moreland and Moreland (1975, Table 5) reported that infiltration rates in the top 5 feet (1.5 m) of soil developed on the Rocky Flats Alluvium range from 0.2 to 6.0 inch

(5 to 150 mm) per hour. Branson and others (1964, Table 2) reported that infiltration rates for stony soil on the Rocky Flats Alluvium range from 3.90 to 7.35 inches (99 to 187 mm) per hour.

The water table in the Rocky Flats Alluvium rises in response to recharge during the spring and declines when recharge eases during the remainder of the year. The hydrograph (Hurr, 1976) shows that, overall, the water table declined from April 1974 to March 1975. Recharge caused the water table to rise from March to June 1975, after which the water table began to decline. Recharge from precipitation caused the rise in water level in October and November. A few of the numerous sharp peaks on the hydrograph were caused by natural recharge, but most are due to recharge from irrigation of a small plot of trees.

The water-level changes caused by irrigation indicate that the effective porosity of the alluvium is about 0.10. Water levels respond to irrigation within 2 to 4 hours when the water level is 10 to 20 feet (3 to 6 m) below land surface. Thus, water percolates through the alluvium at about 5 feet (1.5 m) per hour. If the infiltration rate is 0.5 feet (0.15 m) per hour, then the effective porosity of the alluvium is 0.10.

Groundwater in the Rocky Flats Alluvium flows generally eastward; movement is largely controlled by the topography of the bedrock. The direction of groundwater movement is perpendicular to the water table contours. Hydraulic conductivity of the alluvium is estimated to be about 35 feet (10.7 m) per day. The hydraulic gradient ranges from 0.02 to 0.05. Assuming an effective porosity of 0.10, the pore velocity ranges from 7 to 18 feet (2.1 to 5.5 m) per day.

Groundwater flow in the Rocky Flats area is controlled by buried channels in the bedrock where the alluvium is thickest. Areas where the water table is below the base of the alluvium are outside the boundary of saturated alluvium (Hurr, 1976). The boundary moves as the water table varies in response to seasonal changes in recharge.

Seeps and springs, supplied by groundwater in the alluvium, issue from the alluvium-bedrock contact along the sides of valleys in the area. Frequently the location of seeps are marked by changes in the indigenous vegetation. Various types of grasses, which have a high demand for water and wilt quickly when the supply is restricted, are found at springs and seeps. During spring and early summer, when groundwater discharge is greatest, the grasses are lush and vigorous in contrast to the semiarid vegetation of adjacent areas. Later in the season, as the groundwater discharge decreases, the grasses wilt and turn yellow while the semiarid vegetation continues to thrive because of greater tolerance to water deficiency. Seepage that is not evapotranspired by the plants either contributes to the baseflow of the streams or recharges the Valley-Fill Alluvium.

Valley-Fill Aquifer

Groundwater in the alluvium (Pre-Piney Creek, Piney Creek, and post-Piney Creek alluvium) along the bottom of the valleys in the Rocky Flats Plant area is recharged by precipitation, percolation from streams during period of surface-water runoff, and by seeps and springs discharging from the Rocky Flats Alluvium. Discharge from this Valley-Fill Alluvium is by evapotranspiration and by seepage into other geologic formations and streams. The direction of groundwater flow generally is along the course of the stream. During periods of high surface-water flow, water is lost to bank storage in the alluvium and returns to the stream after runoff subsides.

The Valley-Fill Alluvium is usually better sorted than the Rocky Flats Alluvium and therefore is more permeable. Pore velocity is estimated to range from 15 to 25 feet (4.6 to 7.6 m) per day, depending on the hydraulic gradient. The deposits in the stream channel are usually very coarse and very permeable. Pore velocities in the channel deposits may be several hundred feet per day.

The movement of groundwater into and out of the Valley-Fill Alluvium varies along the length of the valleys. In the upper reaches of the valleys where the Valley-Fill is underlain by the Rocky Flats Alluvium, water moves from the Valley-Fill Aluvium to the Rocky Flats Alluvium. Groundwater discharge to streams does not occur in the upper reaches of the valleys. Downstream, where the valley bottom is below the base of the Rocky Flats Alluvium, water moves from the Rocky Flats Alluvium to the Valley-Fill; groundwater flows from the Valley-Fill aquifers to the streams. Where the valleys have been cut into bedrock, water moves from the streams into the Valley-Fill and then recharges the underlying bedrock formation.

Groundwater discharge by evapotranspiration occurs throughout the valleys. From July to September 1974, streamflow in Woman Creek was observed to fluctuate diurnally (Hurr, 1976); the range was 0.25 to 0.50 ft^3/s (0.007 to 0.014 m^3/s). The fluctuations were caused by diurnal changes in evapotranspiration. Downstream from the point of observation, Woman Creek ceased to flow entirely because of stream flow losses to the Valley-Fill Alluvium and the subsequent evapotranspiration and recharge to the bedrock formation.

Arapahoe Formation Aquifer

The Arapahoe Formation is recharged by leakage from streams and groundwater movement from the overlying alluvial deposits. The main recharge area is under the Rocky Flats Alluvium, west of the Plant area, although some recharge from the Valley-Fill occurs along the stream valleys north and south of the Rocky Flats Plant. Recharge is greatest during the spring and early summer when rainfall and stream flow are the greatest and water levels in the Rocky Flats Alluvium are highest.

Groundwater movement in the Arapahoe Formation is down dip to the east. Hydraulic conductivity is estimated to be about 0.3 to 0.4 feet (0.09 to 0.12 m) per day (Wilson, 1965) and the hydraulic gradient is about 0.03. Assuming an effective porosity of 0.10 to 0.15, the pore velocity is about 0.1 feet (0.03 m) per day. Although there are a few seeps along the sides of some valleys where the Arapahoe Formation crops out, most of the groundwater flows eastward, out of the area.

The effect of faulting on groundwater movement in the Arapahoe Formation is not known. The Eggleston fault (see Section 2.3.4.6) may extend into the Rocky Flats Plant site from the north. Drag along the fault plane could reduce permeability and impede the movement of groundwater through the Arapahoe Formation to the northeast.

Laramie-Fox Hills Aquifer

The lower sandstone unit of the Laramie Formation and the Fox Hills Sandstone are collectively called the Laramie-Fox Hills aquifer. The steeply dipping beds of the aquifer crop out west of the Rocky Flats Plant and quickly flatten toward the east. Recharge to the aquifer occurs along the rather limited outcrop area exposed to surface-water flow and leakage from overlying alluvium.

Within the Rocky Flats Plant site, groundwater movement is to the east or southeast. To the north near Marshall, faulting has disrupted the Laramie-Fox Hills aquifer to the extent that regional patterns of flow are greatly altered. In the southern part of the area, in the vicinity of Leyden, flow patterns are disrupted by the underground gas-storage operations of the Public Service Company of Colorado.

The Laramie-Fox Hills aquifer and the Arapahoe Formation aquifer are separated by several hundred feet of relatively impermeable shale (the upper unit of the Laramie Formation); consequently, there is little, if any, hydraulic connection between the two aquifers. Furthermore, the recharge area for the Laramie-Fox Hills aquifer is considerably west of the Rocky Flats Plant. Therefore, Plant operations, as currently practiced, should have little or no effect on the Laramie-Fox Hills aquifer.

2.3.5.3 Material Movement in the Hydrologic System

Infiltrating Groundwater

The distribution of chemical constituents that enter the hydrologic environment will be controlled largely by existing hydrogeologic conditions. Infiltration from rainfall carries soluble constituents downward in the soil. Particulate matter cannot travel more than a few inches into the soil zone because of adsorption on the soil particles. Possible infiltration is monitored in a series of hydrological test wells. As a result of public comment, the discussion of the test well monitoring program has been expanded.

Dissolved constituents that enter the soil may sorb on clay particles, undergo ion exchange, precipitate when evaporation of the soil moisture occurs, precipitate by chemical reaction, or move to the saturated zone. The sorption-desorption process and ion exchange by elution will not only cause the rate of solute transport to be different from the rate of water movement, but also will cause differential movement of the constituents, depending on their relative participation in the chemical reactions and physical processes. If sorption is high, some chemical constituents may be effectively trapped in the upper part of the soil zone. Precipitates (insoluble material) may be moved into the saturated zone. The total travel time to move material through the soil to the saturated zone could range from hours to months, depending on local precipitation, infiltration conditions, soil type, and the chemical reactions and physical processes that occur. Precipitates deposited by chemical reaction, in most cases, probably will not be mobilized by subsequent infiltration from rainfall. The chemical environment that caused precipitation probably would not be changed by the additional infiltration. Infiltration by water of greatly different chemical characteristics, however, could change the chemical environment enough to allow dissolution and subsequent migration.

Dissolved constituents in the saturated zone are subject to the same processes just described for the unsaturated zone, except that the concentration of dissolved material would be lower. Movement of dissolved constituents in the saturated zone generally follows groundwater flow, although dispersion can be important. Diffusion has minimal effect on the transport of dissolved constituents in the alluvial deposits of the study area.

Plutonium and americium, being relatively insoluble and in particulate form, migrate at an extremely slow rate (Krey, 1974) through the soil and are retained in sediments of ponds and streams (Section 2.3.9.4), (USEPA, 1975). Although the water of the Arapahoe Formation is recharged through surficial alluvium and through infiltration by the creeks north and south of the Plant, there is no evidence that plutonium or americium travel beyond the first 30 cm from the surface. Infiltration into the Arapahoe Formation by particulates, especially plutonium, is therefore not to be expected. Monitoring of 35 shallow test wells (10-50 ft) indicates that plutonium has not moved into the groundwater near the surface, and extensive monitoring at greater depths therefore is not necessary.

Well water in hydrologic test holes is monitored by Rocky Flats, and measurements have been made in shallow and deeper wells in the site vicinity. Several shallow wells about 20 feet deep were drilled in 1960 to monitor for possible movement of materials from the solar evaporation ponds. Another series of shallow wells, about 30 feet deep, was drilled in 1971 to monitor for movement of plutonium from the A-, B- and C-series ponds. An even more extensive series of shallow wells was drilled in 1974 to monitor the constituents of groundwater throughout the Rocky Flats area. All of these wells are used to monitor water in the shallow Rocky Flats Alluvium, which is directly charged at a high rate from surface-water infiltration. In addition to these shallow wells, three deeper wells (about 150 feet deep) were drilled in 1966. One of these wells connects to the Rocky Flats Alluvium to the west of the Plant and the other two into the Arapahoe formation to the east of the Plant. The Arapahoe formation is connected almost directly to the Rocky Flats Alluvium. No on-site wells have been drilled into the deeper Laramie-Fox Hills Aquifer, which does not appear to be connected with groundwater in the Rocky Flats site area.

Samples taken from the wells do not indicate movement of plutonium into the groundwater. Most of these samples show plutonium content below 1 pCi/l of plutonium alpha activity. These concentrations are significantly below the Radioactivity Concentration Guide (ERDA Manual Chapter 0524) level of 1667 pCi/l for plutonium in water, and the EPA Interim Drinking Water Standard of 15 pCi/l alpha, excluding natural uranium. Less than 5 out of more than 100 measurements over a 10-year sampling period, including two at a well into the Arapahoe Formation east of the solar ponds, show levels of 2 or 3 pCi/l. Readings above 1 pCi/l have been caused by contamination of the water samples from sources external to groundwater movement. Improved sampling procedures, more frequent collections, and well-head seals have shown these data to be anomalous. Americium readings in the well water have been approximately equal to the plutonium readings.

To determine if there is any plutonium in off-site groundwater, Rocky Flats has had water samples collected from seven existing off-site wells near the Rocky Flats Plant. These wells are drilled into the Laramie-Fox Hills aquifer, which is the principal off-site groundwater supply aquifer. All of the well samples showed some evidence of plutonium, but the amount was essentially constant and showed no correlation with whether the wells were downslope or upslope from the Plant. The measured plutonium levels were approximately 0.02 pCi/l and apparently resulted entirely from background plutonium. Thus, there is no evidence that the general groundwater available to off-site personnel has been affected in any way by Rocky Flats operations. This is not surprising since most measurements of plutonium mobility in soils like those around Rocky Flats have indicated that the plutonium is tightly held in the soil and moves downward very slowly (see Section 2.9.3).

The hydrologic test wells were drilled to various depths from 10 to 150 feet into the Rocky Flats Alluvium and in some cases into the underlying Arapahoe Formation. The wells are cased with 6-inch-diameter iron or plastic pipe. The well casing is perforated throughout the bottom 10 feet in each well. The wells are cemented at the top to prevent percolation of surface runoff down the side of the casing. Most of the wells are provided with tight fitting covers. The few exceptions had loosely fitting hinged lids which are now sealed with plastic covers. The loose-fitting lids led to contamination of the well from surface materials; this resulted in the anomalous data mentioned above.

Runoff and Stream Flow

Runoff from precipitation may transport dissolved constituents and particulate matter into the streams where the rate of transport will be controlled by flow velocity and channel characteristics. Dissolved constituents and particles that are small enough to be transported in suspension will move at about the same velocity as the stream flow, although there will be some dispersion effects. Coarse particles that are moved as bedload will move much slower than the water. Large particles will be deposited in the stream bed as stream flow recedes, and will not be moved again until the next high flow. In some instances, particles--even small particles--will not be remobilized by a flow velocity that previously transported them, because the flow must exceed some threshold value to scour the particles off the channel bottom. Overall, the time required for dissolved and suspended material to travel a given distance along a stream is longer than the time required for water to travel the same distance. This is due to the ripple-and-pool nature of the streams, as explained in Hurr (1976).

Erosion and Sedimentation

The rate of erosion and transport of soil and rock generally is low. The highest rate occurs in April, May, and June, when stream flow is greatest. Instantaneous point samples of suspended-sediment concentration on Woman Creek indicate highest suspended-sediment concentration occurs during periods of high flow (Hurr, 1976). Maximum suspended-sediment discharge during high flow is estimated to be about 75 to 100 tons (68 to 90 metric tons) per day. Using a specific volume of 15 ft^3 (0.42 m^3) per ton, the suspended-sediment load indicates a maximum removal during high flow of from 0.006 to 0.008 mm of sediment per day from the land-surface area of the drainage basin.

Sediment transported by Walnut Creek and its tributaries accumulates in Great Western Reservoir. A survey and determination made in October 1953 of the stage-capacity relation for the reservoir defined zero capacity at zero stage (altitude of 5,844 feet (1,781.3 m) above mean sea level). Another survey, in September 1973, by the U.S. Geological Survey, showed that sediment accumulation had raised the stage height of zero capacity to 17.5 feet (5.3 m) (altitude of 5,861.5 feet (1,786.6 m) above the mean sea level). Although a direct measure of the volume of sediment accumulated during the 20-year period could not be made because of discrepancies in the initial capacity data, it is estimated that 200 to 300 acre-feet (250,000 to 370,000 m^3) of sediment accumulated in the reservoir. This volume of sediment indicates an average removal rate of about 0.003 mm of sediment per day from the drainage basin over the 20-year period. The Walnut Creek sediment load per unit area is quite similar to the observed sediment load of Woman Creek.

2.3.6 Meteorology

Regional and local climatological characteristics and diffusion meteorology are discussed in this section. The discussions are based on available data from local weather stations. Some climatological and diffusion data are being accumulated on the Plant site with the aid of a meteorological data-collection tower and telemetry system.

2.3.6.1 Regional Climatology

Long-term regional climatology data were obtained from four National Oceanic and Atmospheric Administration (NOAA) stations: Denver, Fort Collins, Greeley, and Boulder. The climatological summaries for these four stations, presented in Tables 2.3.6-1 through 2.3.6-4, illustrate the seasonal and severe weather conditions in the north-central part of Colorado. In general, the region experiences a mild, sunny, semi-arid climate with few temperature extremes.

Thunderstorms, from which damaging local weather can develop (tornadoes, hail, high winds, and flooding), occur about 50 days per year in the area, based on Stapleton International Airport data. The maximum frequency of thunderstorms is in the summer season because of convective heating. The maximum recorded point rainfalls for durations of 5 minutes to 24 hours at Denver are given in Table 2.3.6-5 (USWB, 1963).

Because of the inland location, hurricanes do not reach the area. Localized hurricane-force chinook winds, however, gusting to velocities of approximately 105 mph, have been recorded at the Rocky Flats Plant on four occasions: March 1956, January 1959, January 1972, and November 1972. Wind gusts of up to 150 mph have been recorded at the National Center for Atmospheric Research (NCAR), approximately 7 miles north-northwest of the Plant. The NCAR facility is located immediately adjacent to the foothills south of Boulder, Colorado, and is therefore subject to much higher wind velocities then the Rocky Flats Plant, which is approximately 2 miles east of these steep slopes.

A tornado study by M. E. Pautz (1969) shows that of all tornadoes occurring during the 13-year period of the study, 2% were in Colorado. The study also shows that, during the same period, only five tornadoes were reported in the 1 degree longitude by 1 degree latitude square that contains the Rocky Flats Plant. Other studies indicate that, on the average, tornadoes observed near the Rocky Mountains are smaller and contain less energy than those occurring farther east. For these reasons, discussed more extensively below, it appears that there is a low probability of a tornado occurring at the Rocky Flats Plant and, correspondingly, a low probability of damage.

TABLE 2.3.6-1

CLIMATOLOGICAL SUMMARY

Normals, Means, And Extremes

LATITUDE 39° 45′ N
LONGITUDE 104° 52′ W

(1936 – 1974)

DENVER, CO
ELEVATION: 5283 feet

Month	Temperatures °F: Normal: Daily maximum	Normal: Daily minimum	Normal: Monthly	Extremes: Record highest	Year	Record lowest	Year	Normal Degree days Base 65 °F: Heating	Cooling	Precipitation in inches: Water equivalent: Normal	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Snow, Ice pellets: Maximum monthly	Year	Maximum in 24 hrs.	Year	Relative humidity pct. Hour 05 (Local time)	Hour 11	Hour 17	Hour 23	Wind: Mean speed m.p.h.	Prevailing direction	Fastest mile: Speed m.p.h.	Direction	Year	Pct. of possible sunshine
(a)				15		15					40		40		40		40		40		14	14	14	14	26	15	25	25		25
J	43.5	16.2	29.9	69	1971	-25	1963	1088	0	0.61	1.44	1948	0.01	1952	1.02	1962	23.7	1948	12.4	1962	63	45	48	63	9.2	S	46	SW	1969	72
F	46.2	19.4	32.8	76	1963	-18	1962	902	0	0.67	1.66	1960	0.01	1970	1.01	1953	18.3	1960	9.5	1953	67	44	44	66	9.3	S	49	NW	1953	71
M	50.1	23.8	37.0	84	1971	-4	1962	868	0	1.21	2.89	1944	0.13	1945	1.48	1959	29.2	1961	16.3	1952	69	42	41	65	9.9	S	53	NW	1952	70
A	61.0	33.9	47.5	84	1965	5	1973	525	0	1.93	4.17	1942	0.03	1963	3.25	1967	28.3	1935	17.3	1957	68	38	34	59	10.4	S	56	NW	1960	66
M	70.3	43.6	57.0	93	1974	26	1972	253	5	2.64	7.31	1957	0.06	1974	3.55	1973	13.6	1950	10.7	1950	70	38	36	61	9.4	S	43	SW	1964	64
J	80.1	51.9	66.0	98	1971	36	1969	80	110	1.93	4.69	1967	0.10	1940	3.16	1970	0.3	1951	0.3	1951	72	39	37	62	9.0	S	47	S	1956	70
J	87.4	58.6	73.0	103	1973	43	1972	0	248	1.78	6.41	1965	0.17	1939	2.42	1965	0.0		0.0		72	36	36	59	8.5	S	56	SW	1965	70
A	85.6	57.4	71.6	100	1969	41	1964	0	208	1.29	4.47	1951	0.06	1960	3.43	1951	0.0		0.0		70	37	35	59	8.2	S	42	SW	1972	72
S	77.7	47.8	62.8	97	1960	20	1971	120	54	1.13	4.67	1961	T	1944	2.44	1936	21.3	1936	19.4	1936	72	40	37	63	8.2	S	47	NW	1955	74
O	66.8	37.2	52.0	87	1973	3	1969	408	5	1.13	4.17	1969	0.05	1962	1.71	1947	31.2	1969	12.4	1969	66	36	37	60	8.2	S	45	NW	1958	72
N	53.3	25.4	39.4	78	1973	-2	1961	768	0	0.76	2.97	1946	0.01	1949	1.00	1946	39.1	1946	15.5	1946	70	44	51	67	8.7	S	48	W	1962	65
D	46.2	18.9	32.6	73	1973	-16	1972	1004	0	0.43	2.84	1973	0.04	1946	1.38	1973	30.8	1973	11.8	1973	66	45	52	65	9.0	S	51	NE	1953	68
YR	64.0	36.2	50.1	103	JUL 1973	-25	JAN 1963	6016	630	15.51	7.31	MAY 1957	T	SEP 1944	3.55	MAY 1973	39.1	NOV 1946	19.4	SEP 1936	69	40	41	62	9.0	S	56	SW	JUL 1965	70

Means and extremes above are from existing and comparable exposures. Annual extremes have been exceeded at other sites in the locality as follows: Highest temperature 105 in August 1878; lowest temperature -30 in February 1936; maximum monthly precipitation 8.57 in May 1876; minimum monthly precipitation 0.00 in December 1881; maximum precipitation in 24 hours 6.53 in May 1876; maximum monthly snowfall 57.4 in December 1913; maximum snowfall in 24 hours 23.0 in April 1885; fastest mile of wind 65 from West in May 1933.

(a) Length of record, years, through the current year unless otherwise noted, based on January data.
(b) 70° and above at Alaskan stations.
* Less than one half.
T Trace.

NORMALS - Based on record for the 1941-1970 period.
DATE OF AN EXTREME - The most recent in cases of multiple occurrence.
PREVAILING WIND DIRECTION - Record through 1963.
WIND DIRECTION - Numerals indicate tens of degrees clockwise from true north. 00 indicates calm.
FASTEST MILE WIND - Speed is fastest observed 1-minute value when the direction is in tens of degrees.

TABLE 2.3.6-2

CLIMATOLOGICAL SUMMARY

LATITUDE N40 00 | BOULDER, CO
LONGITUDE W105 16 | ELEVATION 5420

MEANS AND EXTREMES FOR PERIOD 1951-1973

MONTH	TEMPERATURE (°F) MEANS DAILY MAXIMUM	DAILY MINIMUM	MONTHLY	EXTREMES RECORD HIGHEST	YEAR	DAY	RECORD LOWEST	YEAR	DAY	MEAN NUMBER OF DAYS MAX. 90° AND ABOVE	MAX. 32° AND BELOW	MIN. 32° AND BELOW	MIN. 0° AND BELOW
JAN	46.0	21.4	33.7	72	53	9	-22	63	12	0	5	26	2
FEB	48.4	24.1	36.3	79	54	8	-15	51	1	0	3	23	0
MAR	52.4	27.0	39.7	79	71	26	-3+	60	3	0	3	22	0
APR	62.3	35.8	49.1	83+	60	21	5	59	10	0	0	10	0
MAY	72.1	45.8	59.0	93	54	20	22	54	2	0	0	1	0
JUN	82.0	54.4	68.3	104	54	23	30	51	2	7	0	0	0
JULY	87.9	60.3	74.1	104	54	11	42	72	5	14	0	0	0
AUG	86.2	58.8	72.5	101	69	8	43	72	25	10	0	0	0
SEPT	78.1	49.8	63.9	97+	59	6	22	71	19	2	0	1	0
OCT	67.9	40.4	54.1	90	53	1	10	69	13	0	0	6	0
NOV	54.0	29.0	41.6	79	52	4	-2	51	2	0	2	19	0
DEC	47.4	23.5	35.5	75	65	4	-16	72	6	0	3	25	1
YEAR	65.4	39.2	52.3	104+	54	JUL 11	-22	63	JAN 12	33	16	133	3

MONTH	PRECIPITATION TOTALS (INCHES) MEAN	GREATEST MONTHLY	YEAR	GREATEST DAILY	YEAR	DAY	SNOW, SLEET MEAN	MAXIMUM MONTHLY	YEAR	GREATEST DEPTH	YEAR	DAY	MEAN NUMBER OF DAYS .10 or MORE	.50 or MORE	1.00 or MORE
JAN	.63	1.52	62	.98	62	08	10.1	25.1	62	15.0	62	08	2	0	0
FEB	.81	1.53	56	1.03	57	28	12.0	25.6	65	12.0	71	21	2	0	0
MAR	1.54	3.86	70	1.48	52	21	19.5	56.7	70	27.0	70	31	4	1	0
APR	2.11	6.85	57	3.31	57	02	12.0	44.0	57	19.0	59	09	5	1	0
MAY	3.21	9.27	57	3.37	69	07	1.3	6.6	73	4.0	73	01	6	2	1
JUN	2.11	5.34	69	2.65	63	16	.1	2.2	51				5	1	0
JULY	1.82	5.20	65	1.49	69	17	.0						5	1	0
AUG	1.58	7.49	51	3.06	51	03	.0						4	1	0
SEPT	1.66	4.89	61	1.64	71	17	1.7	21.0	71	18.0	71	17	3	1	0
OCT	1.20	5.39	69	1.61	51	05	5.9	49.3	69	13.0	69	12	3	1	0
NOV	1.04	2.15	72	.85	70	13	11.7	26.8	72	15.0	72	01	3	1	0
DEC	.68	1.54	51	.55	72	29	10.6	31.4	67	9.0	72	29	3	0	0
YEAR	18.39	9.27	MAY 57	3.37	MAY 69	7	84.9	56.7	MAR 70	27.0	MAR 70	31	45	10	1

+ ALSO ON EARLIER DATES

TABLE 2.3.6-3

U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU
IN COOPERATION WITH GREELEY CHAMBER OF COMMERCE
CLIMATOGRAPHY OF THE UNITED STATES NO. 20 -- 5-3546-4

CLIMATOLOGICAL SUMMARY

LATITUDE 40° 26' N
LONGITUDE 104° 41' W

STATION GREELEY, COLORADO
ELEV. (GROUND) 4648 ft. msl

MEANS AND EXTREMES FOR PERIOD 1887-1954

Month	Temperature (°F) Means: Daily maximum	Daily minimum	Monthly	Extremes: Record highest	Year	Record lowest	Year	Mean degree days	Precipitation Totals (Inches): Mean	Greatest daily	Year	Snow, Sleet, Hail: Mean	Maximum monthly	Year	Greatest daily	Year	Mean number of days: Precip. .10 inch or more	Temperatures Max: 90° and above	Max: 32° and below	Min: 32° and below	Min: 0° and below	Month
(a)	61	61	61	61		61		61	67	67		60	60		60		30	30	30	30	30	
Jan.	40.5	9.3	24.9	70	1943+	-36	1942	1243	0.31	1.28	1921	3.8	20.5	1899	9.0	1921	1	0	8	31	7	Jan.
Feb.	43.9	13.1	28.5	77	1932	-45	1899	1022	0.39	0.98	1923	5.6	15.0	1923	8.0	1932+	1	0	5	28	4	Feb.
Mar.	52.3	21.8	37.1	84	1910	-30	1932	865	0.76	1.69	1909	6.8	37.0	1906	10.0	1923+	2	0	2	29	1	Mar.
Apr.	62.9	32.1	47.5	89	1910	- 2	1945	525	1.56	2.10	1920	4.2	34.0	1920	11.0	1944	4	0	*	15	*	Apr.
May	71.8	41.8	56.8	96	1942+	18	1909	276	2.36	3.09	1909	0.3	15.0	1908	15.0	1908	6	2	*	3	0	May
June	82.7	50.4	66.6	106	1954	28	1919	66	1.54	2.51	1911	0.2	T	1950+	T	1937	4	10	0	*	0	June
July	89.3	55.4	72.4	107	1936+	34	1908	6	1.57	4.61	1909	T	T	1951+	T	1951+	3	20	0	0	0	July
Aug.	87.7	53.6	70.7	105	1938	35	1895	6	1.06	2.03	1915	0	0	-	0	-	3	15	0	0	0	Aug.
Sept.	79.5	43.6	61.6	99	1954+	20	1926	138	0.88	3.21	1902	0.2	6.0	1895	6.0	1895	2	5	0	2	0	Sept.
Oct.	67.0	32.0	49.5	91	1910	- 8	1905	470	0.93	2.69	1915	1.9	30.0	1906	9.0	1942	2	*	*	16	0	Oct.
Nov.	52.4	19.7	36.1	82	1934+	-18	1952+	867	0.39	0.89	1946	3.7	21.5	1946	10.0	1946+	1	0	3	29	1	Nov.
Dec.	41.5	10.7	26.1	78	1892	-37	1919	1206	0.39	1.02	1938	4.8	34.3	1913	8.0	1925+	1	0	6	31	5	Dec.
Year	64.3	32.0	48.2	107	July 1936	-45	Feb. 1899	6690	12.14	4.61	July 1909	31.5	37.0	Mar. 1906	15.0	May 1908	30	52	24	184	18	Year

(a) Average length of record, years.

T Trace, an anount too small to measure.

+ Also on earlier dates, months or years.

* Less than one half.

TABLE 2.3.6-4

LATITUDE N40 35 — FORT COLLINS, CO

LONGITUDE W105 05 — ELEVATION 5001

CLIMATOLOGICAL SUMMARY

MEANS AND EXTREMES FOR PERIOD 1951-1973

MONTH	TEMPERATURE (°F)													PRECIPITATION TOTALS (INCHES)														
	MEANS			EXTREMES						MEAN NUMBER OF DAYS										SNOW, SLEET						MEAN NUMBER OF DAYS		
										MAX.		MIN.																
	DAILY MAXIMUM	DAILY MINIMUM	MONTHLY	RECORD HIGHEST	YEAR	DAY	RECORD LOWEST	YEAR	DAY	90° AND ABOVE	32° AND BELOW	32° AND BELOW	0° AND BELOW	MEAN	GREATEST MONTHLY	YEAR	GREATEST DAILY	YEAR	DAY	MEAN	MAXIMUM MONTHLY	YEAR	GREATEST DEPTH	YEAR	DAY	.10 or MORE	.50 or MORE	1.00 or MORE
JAN	41.5	13.6	27.6	68	53	12	-32	62	10	0	7	30	5	.42	1.17	62	.86	62	08	7.2	18.7	71	13.0	62	08	1	0	0
FEB	44.9	18.2	31.6	75	54	8	-41	51	1	0	4	27	2	.41	.70	62	.41	61	26	6.4	13.1	55	9.0	56	08	1	0	0
MAR	49.4	22.6	36.1	79	71	26	-23	56	12	0	3	27	1	1.03	3.38	61	1.06	61	18	12.0	32.6	70	17.0	56	14	3	0	0
APR	59.8	32.2	46.1	83+	61	19	-8	59	12	0	1	14	0	1.72	4.42	71	2.18	57	02	6.2	27.5	57	18.0	57	02	4	1	0
MAY	69.6	42.7	56.2	90	69	27	25+	62	1	0	0	2	0	2.70	7.06	61	3.21	61	13	.3	2.0	57	2.0	73	01	5	1	1
JUN	79.5	51.1	65.3	102	54	23	33	51	2	4	0	0	0	1.82	5.27	65	2.71	65	17	.0						4	1	0
JULY	85.5	56.5	71.0	102+	54	11	40	52	8	9	0	0	0	1.49	4.27	61	1.58	61	07	.0						4	1	0
AUG	83.7	54.6	69.2	99	69	8	39+	64	30	6	0	0	0	1.52	7.39	51	3.06	51	03	.0						3	1	0
SEPT	75.0	44.7	59.9	95+	59	6	21	71	19	1	0	1	0	1.19	4.00	61	1.62	71	17	.8	15.0	71	10.0	71	17	3	1	0
OCT	64.7	34.6	49.7	87	67	3	8	69	14	0	0	11	0	1.08	4.85	69	1.67	51	05	2.7	14.7	69	12.0	69	12	3	1	0
NOV	50.5	23.2	36.9	73+	64	8	-17	51	2	0	2	26	1	.62	2.29	73	.80	73	02	6.5	22.0	73	12.0	73	04	2	0	0
DEC	43.2	16.9	30.0	73	57	9	-18+	72	10	0	5	30	2	.40	1.17	73	.82	58	12	5.7	18.1	67	12.0	58	12	1	0	0
YEAR	62.3	34.2	48.3	102+	JUL 54	11	-41	FEB 51	01	20	22	168	11	14.40	7.39	AUG 51	3.21	MAY 61	13	47.8	32.6	MAR 70	18.0	APR 57	2	34	7	1

+ ALSO ON EARLIER DATES

TABLE 2.3.6-5

MAXIMUM RECORDED POINT RAINFALL AT DENVER, COLORADO

(1876-1961, Updated through 1975)

Duration	Amount (inches)	Date
5 min.	0.91	7/14/1912
10 min.	1.36	7/14/1912
15 min.	*1.57	*7/25/1965
30 min.	*1.99	*7/25/1965
1 hr	2.20	8/23/1921
2 hrs	2.54	8/23/1921
3 hrs	2.72	8/23/1921
6 hrs	2.91	8/23/1921
12 hrs	3.90	8/23/1921
24 hrs	6.53	5/21/1876

*Updated values from L. W. Crow, a consulting meteorologist.

A report entitled "Development of a Design Basis Tornado for the Rocky Flats Site, Colorado" (McDonald and Minor, 1972) addresses the probability of tornado occurrence at Rocky Flats. On the basis of this report and the statistical records, it is concluded that if a tornado were to occur at Rocky Flats, it would not have the extreme intensity associated with tornadoes of the Midwest for several reasons. First, thunderstorms build up west of and over the Continental Divide of the Rocky Mountains and also along a line ranging from 50 to 100 miles east of the Divide. Between these two areas, convective activity is usually suppressed because of downward air movement along the east slope of the mountains. Severe tornadoes are associated with "rotating thunderstorms," which usually require at least an hour to develop from convection cells. During this time, a thunderstorm will drift downwind an appreciable distance --probably 40 to 50 miles. Thus, thunderstorm development is inhibited in the region immediately east of the mountains (where the Rocky Flats Plant is located), and those that do form under the normal westerly winds do not have time to develop full tornadic intensity while still near the mountains.

Secondly, the moisture available to serve thunderstorms east of the Rockies comes primarily from the Gulf of Mexico, and travels in the lower layers of the atmosphere. Increases in terrain elevation reduces proportionately the amount of this moisture and the energy stored as latent heat. The net effect is that there is considerably less latent-heat energy available to Colorado tornadic storms than to ones at lower elevations farther east and southeast.

Thirdly, from investigations by Thom (1963), it appears that the paths of tornadoes that do occur in Colorado, particularly those adjacent to the mountains, are shorter and narrower than those of the Midwest. Therefore, if 300-mph winds are assumed characteristic of the most severe tornadoes of the Midwest, it appears that an upper limit of 200 mph is more appropriate for Colorado tornadoes. According to historical records, there apparently are no cases of tornadic winds in excess of 200 mph in the region immediately east of the Rocky Mountains.

2.3.6.2 Local Climatology

The elevation at which the Plant is sited and the slopes of the Rocky Mountains near the Plant modify the regional climate and influence dispersion characteristics.

Figure 2.3.6-1 depicts the monthly mean wind velocities for 1976, peak gusts for 1976, and the 24-year average of peak gusts. As shown in the figure, the average wind velocities are moderate in comparison with the peak gusts. The 24-year average for mean wind velocity was 8.24 mph.

Winds at Rocky Flats, although variable, are predominantly westerly, with stronger winds occurring during winter. Figure 2.3.6-2 shows the wind direction, frequency, and average velocity for each direction, as recorded for 1976. Over a 17-year period (1953 to 1970), west winds occurred 25% of the time; over 50% of the winds had a westerly component. The stronger gusts (greater than 40 mph) also were from the west.

Stapleton International Airport shows the most frequent wind directions as being from the south and southwest. In general, air that has passed over Rocky Flats merges with air that has passed over Denver and moves to the northeast. The South Platte River valley, about 20 miles east of the Rocky Flats Plant, is the terrain feature along which this transition from westerly to northerly flow approaches completion.

Temperature extremes recorded at the Rocky Flats Plant have ranged from 102 °F on July 12, 1971 to -26 °F on January 12, 1963. The 24-year average maximum temperature was 76 °F, the average minimum was 22 °F, and the average annual mean was 49.6 °F. Figures 2.3.6-3, 2.3.6-4, and 2.3.6-5 display the monthly variations in mean, maximum, and minimum temperatures. A plot of heating degree days, showing a 1976 cumulative total of 6,269 degree days, is given in Figure 2.3.6-6.

The relative humidity for the past 23 years averaged 46%, which also was the average for 1976. The 23-year record is 60%, in 1960. Figure 2.3.6-7 shows the average monthly relative humidities for 1976 and for the past 23 years. Figures for monthly and annual average relative humidity as a function of time of day for a Denver weather station were shown previously in Table 2.3.6-1.

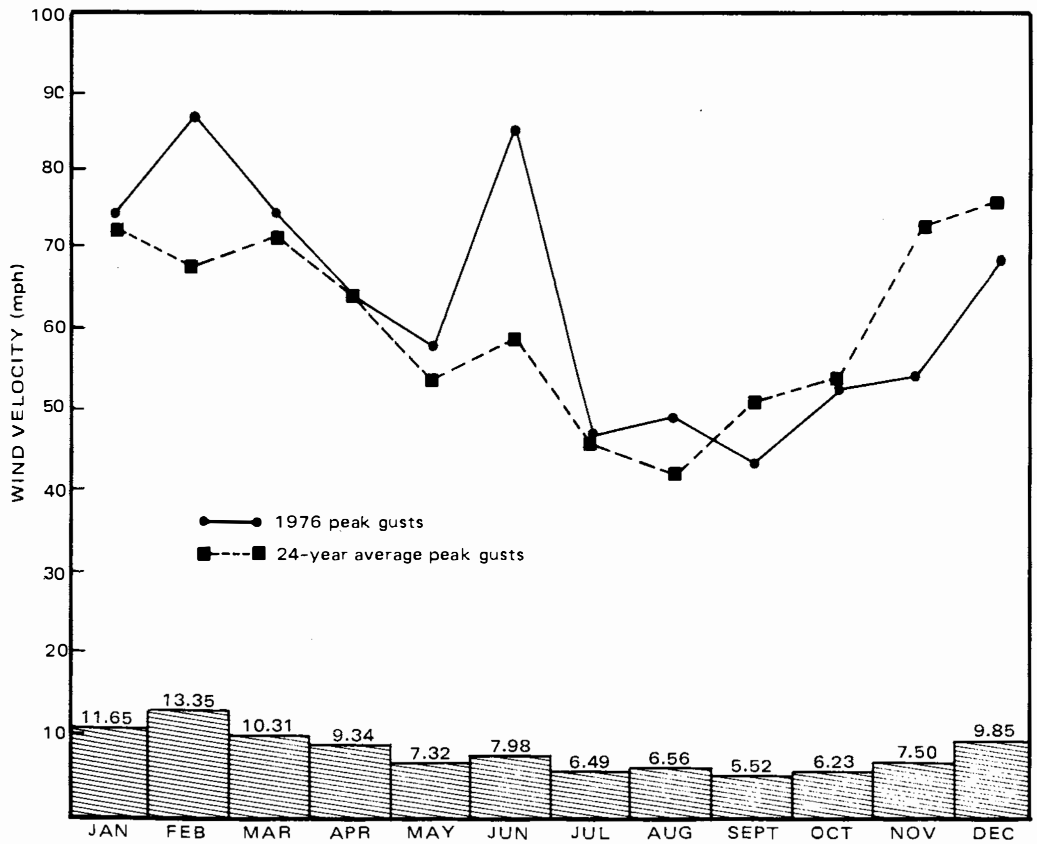


Figure 2.3.6-1 Peak Gusts and Monthly Mean Wind Velocities

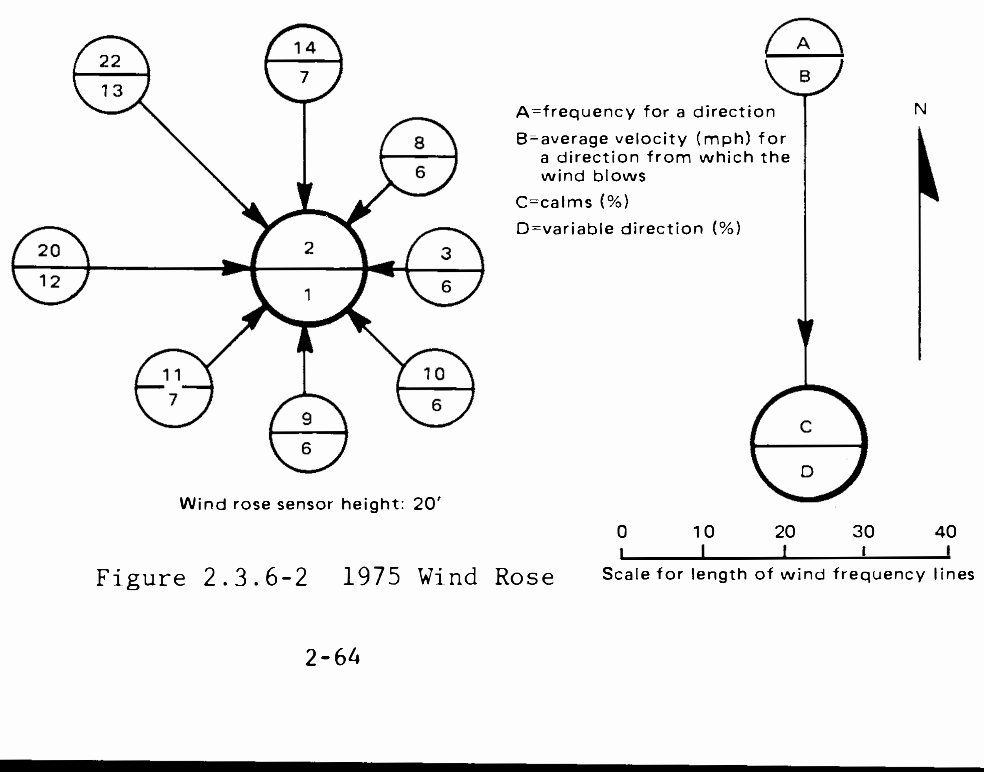


Figure 2.3.6-2 1975 Wind Rose

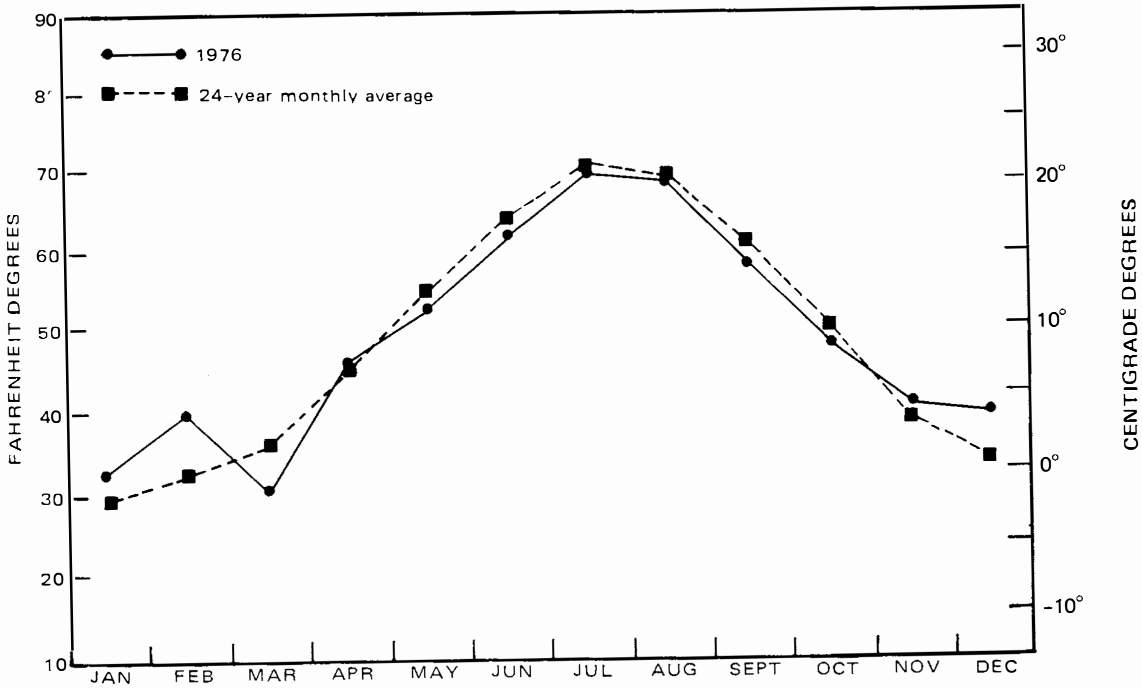


Figure 2.3.6-3 Monthly Mean Temperatures

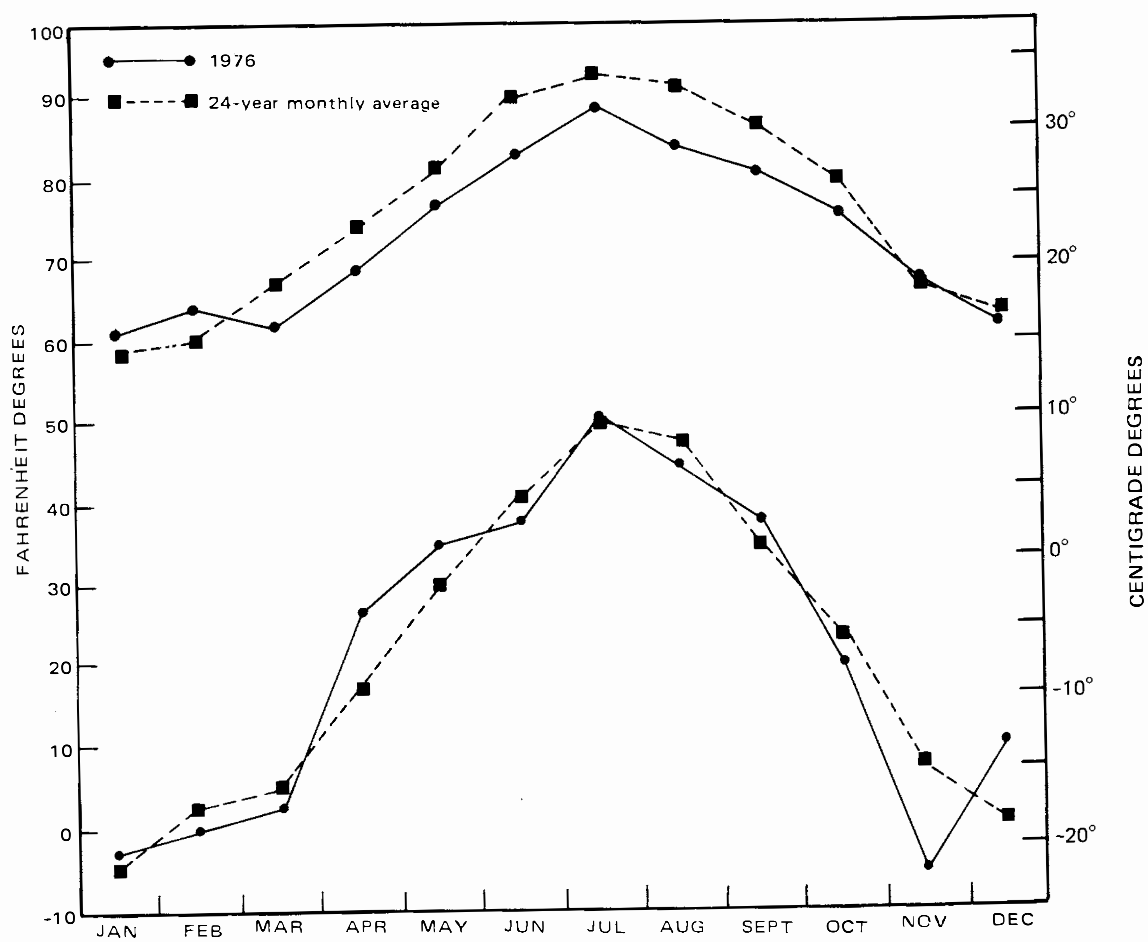


Figure 2.3.6-4 Monthly Maximum and Minimum Temperatures

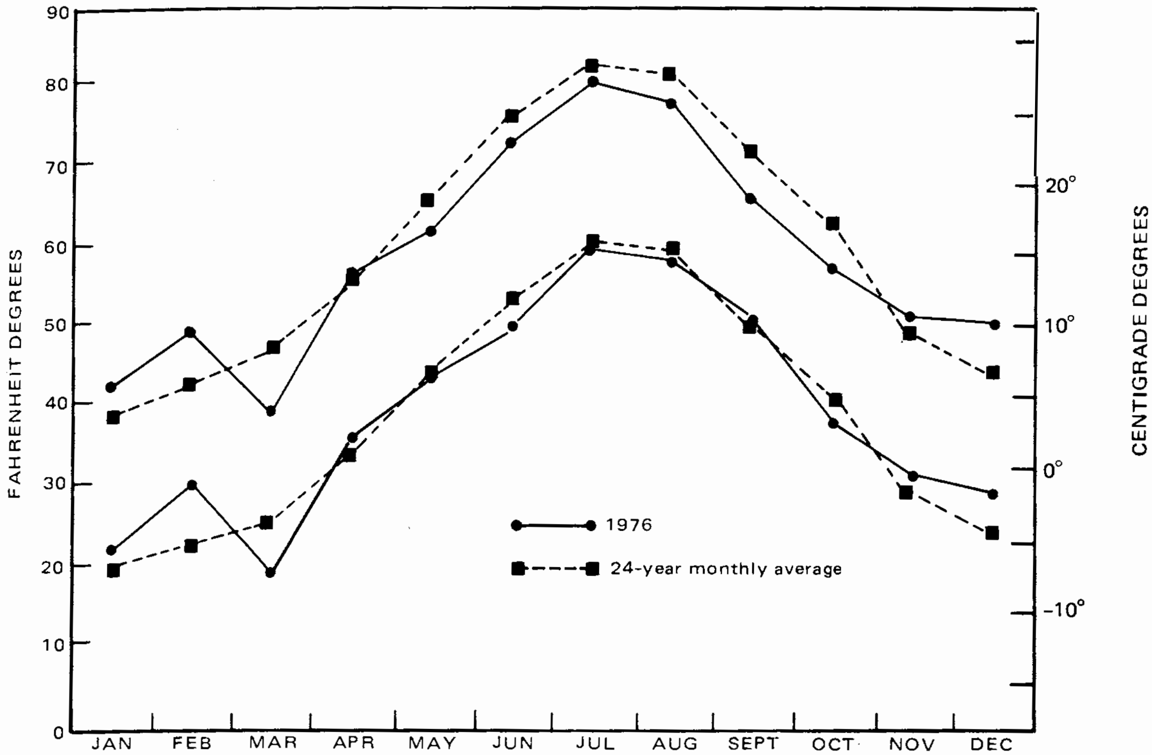


Figure 2.3.6-5 Monthly Averages of Daily Maximum and Minimum Temperatures

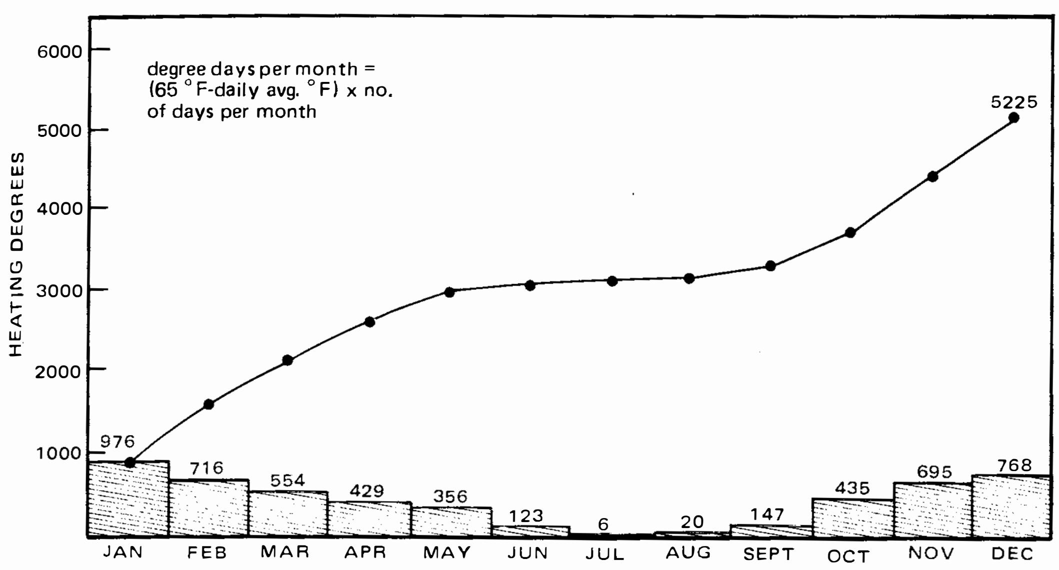


Figure 2.3.6-6 Heating Degree Days

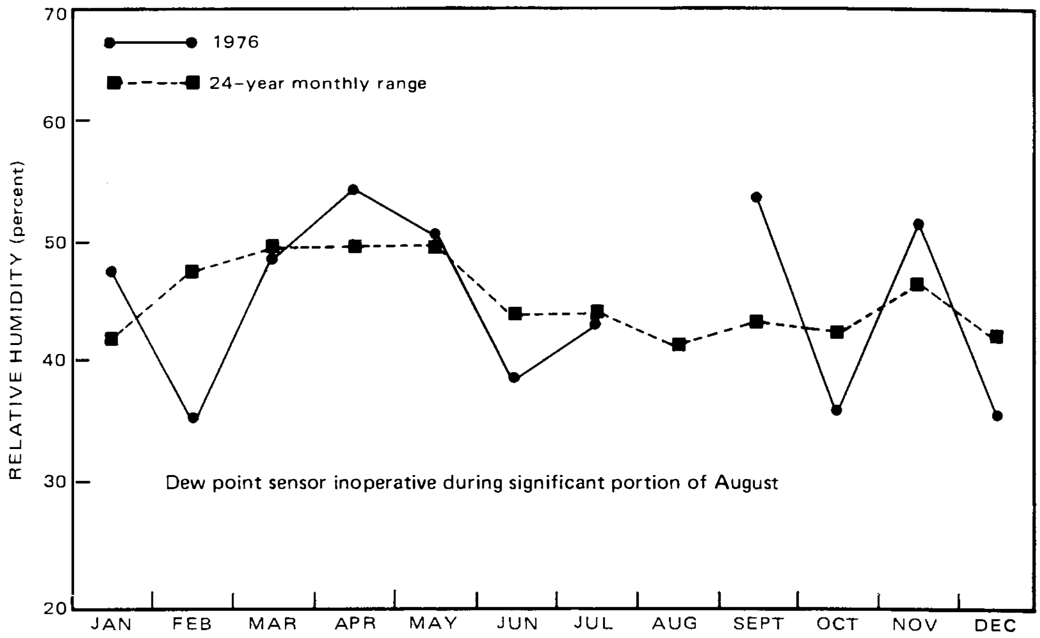


Figure 2.3.6-7 Average Monthly Relative Humidities

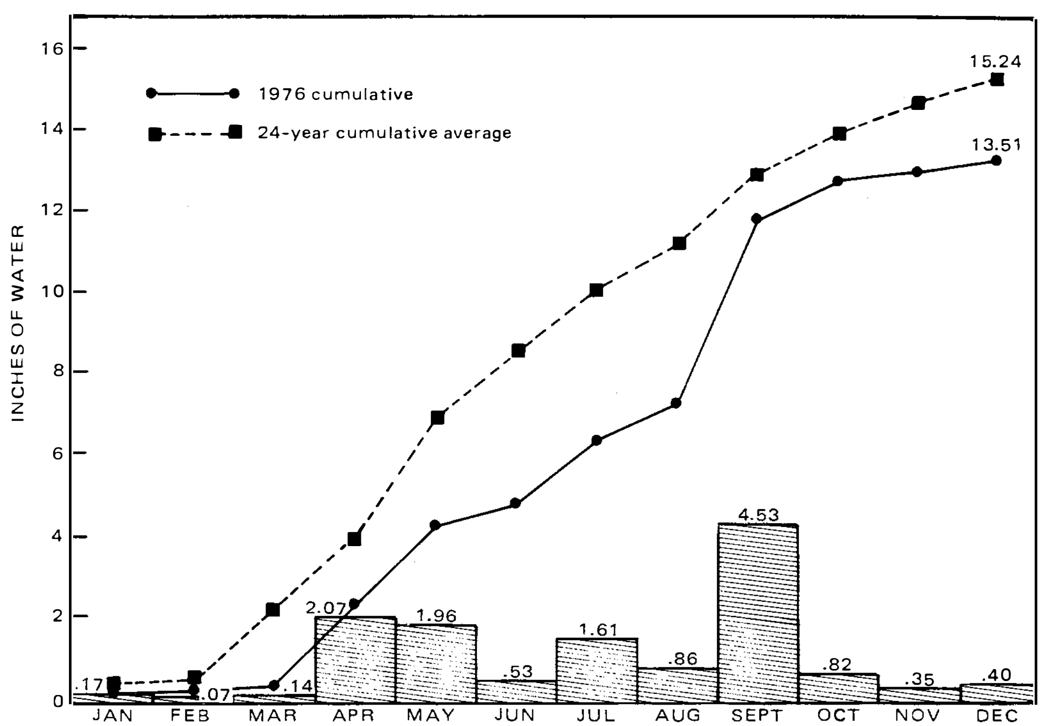


Figure 2.3.6-8 Monthly and Total Precipitation

Annual average precipitation at the Rocky Flats Plant is slightly over 15 inches. The maximum yearly precipitation recorded over a 24-year period was 24.87 inches in 1969 (Table 2.3.6-6). The greatest amount in any one day was 3.40 inches in May 1969. Normally, more than 80% of the precipitation falls from April through September. Figure 2.3.6-8 shows the monthly and total precipitation for 1976, plus the 24-year cumulative average. Heavy runoff sometimes occurs, particularly during thunderstorms and spring thaws, along the creeks that traverse the Plant site. Since the stream beds are considerably lower than the Plant buildings, and the terrain provides excellent drainage, major flooding of Plant facilities is considered practically impossible.

TABLE 2.3.6-6

ANNUAL RAINFALL AT THE ROCKY FLATS PLANT
(inches)

Year	Rainfall	Year	Rainfall
1953	11.26	1965	18.87
1954	7.76	1966	10.24
1955	14.77	1967	22.54
1956	13.42	1968	12.71
1957	22.67	1969	24.67
1958	18.07	1970	18.56
1959	19.65	1971	14.30
1960	13.72	1972	14.78
1961	16.08	1973	21.55
1962	8.26	1974	13.73
1963	12.23	1975	12.22
1964	8.79	1976	13.51

2.3.6.3 Diffusion Meteorology

The dispersive characteristics of the atmosphere are functions of horizontal and vertical air movement and of mixing between and within air masses. These characteristics are defined in terms of wind speed and direction, and thermal (temperature) gradients, which are further categorized into hydrostatic stability classifications. The most commonly used classification system is that of Pasquill (Pasquill, 1961) in which the dispersion parameters are separated into six stability categories (see Table 2.3.6-7).

TABLE 2.3.6-7
CLASSIFICATION OF ATMOSPHERIC STABILITY

Stability Classification	Pasquill Categories	σ_θ* (degrees)	Temperature Change with Height (°C/100 m)
Extremely unstable	A	25.0	>-1.9
Moderately unstable	B	20.0	-1.9 to -1.7
Slightly unstable	C	15.0	-1.7 to -1.5
Neutral	D	10.0	-1.5 to -0.5
Slightly stable	E	5.0	-0.5 to 1.5
Moderately stable	F	2.5	1.5 to 4.0

*Standard deviation of horizontal wind direction fluctuation over a period of 15 minutes to 1 hour. The values are averages for each stability classification.

Technical description and data are contained in Appendix B-1; however, to convey the physical meaning of Pasquill's Stability Classes A through F, drawings depicting the outline of a plume during each stability condition are presented in Figure 2.3.6-9. Most noteworthy is the amount of vertical undulation in the plume. In Type A diffusion (extremely unstable) during a bright sunny day with light winds of variable direction, large convective motions in the atmosphere cause a relatively rapid dispersion of the effluent downward through a large volume of the atmosphere. In Type F diffusion (moderately stable), which usually occurs at night when wind direction is steady, there is almost no vertical motion and no vertical expansion of the plume. Wind meander causes the little dispersion that does take place.

Diffusion meteorology for the Rocky Flats Plant site is based on five years of hourly observations (1960-1964) at Stapleton International Airport (USDC, April 1975), five years (1970-1974) of observations every three hours at Stapleton International Airport (USDC, July 1975), and on hourly observations during three years (1972-1974) at the Rocky Flats Plant (Crow, 1974). The data include joint frequency distributions of wind speed and direction for sixteen 22.5-degree sectors, five wind-speed groups, and six Pasquill stability classes. Tables IV and V of Appendix B-1 present the data for Denver and Rocky Flats, respectively, as determined by Crow (1974). The information is based on a method developed by Turner (1969) for determining the stability category from ordinary surface-weather observations.

Evaluation of these data shows a relatively high incidence of stable (Types E and F) and neutral (Type D) conditions. Type E and F stability categories occur 30 to 40% of the time at both Denver and Rocky Flats, with an associated average wind speed of 3 to 4 meters per second. Type D category occurs 40% to 50% of the time at both locations, with an associated average wind speed of 5 to 7 meters per second. These data also show that winds are predominately from the west over Rocky Flats and from the south and south-southwest over Denver.

PASQUILL "A" STABILITY: LOOPING PLUME

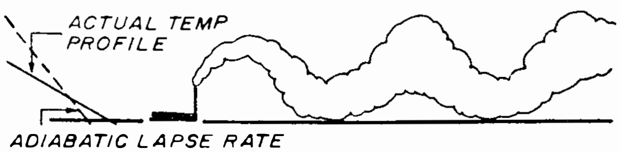
STABILITY: Extremely unstable

WIND SPEED: 3m/sec or less mostly convective turbulence

CONDITIONS: Daytime insolation: mod. to strong

σθ: 25.0°

PASQUILL "B" STABILITY:



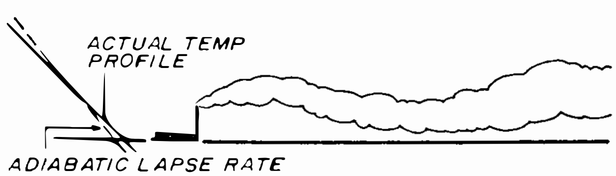
STABILITY: Moderately unstable

WIND SPEED: Less than 4.0m/sec mostly convective turbulence

CONDITIONS: Daytime insolation; strong to mod.

σθ: 20.0°

PASQUILL "C" STABILITY: CONING PLUME



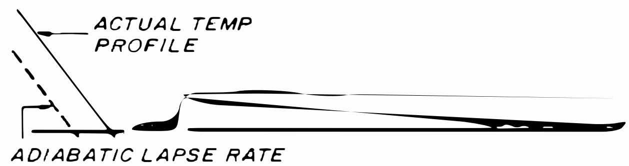
STABILITY: Slightly unstable

WIND SPEED: Less than 6m/sec mixture mechanical & convective turbulence

CONDITIONS: Daytime insolation; mod.-strong

σθ: 15.0°

PASQUILL "D" STABILITY: CONING PLUME



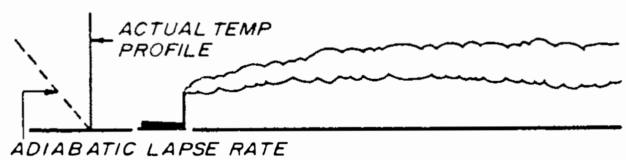
STABILITY: Neutral

WIND SPEED: All, no convective turbulence

CONDITIONS: Daytime insolation; slight

σθ: 10.0°

PASQUILL "E" STABILITY:



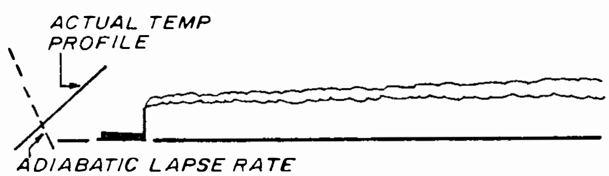
STABILITY: Slightly stable

WIND SPEED: Usually less than 4.5m/sec

CONDITIONS: Night time, moderate outgoing radiation

σθ: 5.0°

PASQUILL "F" STABILITY:



STABILITY: Moderately stable

WIND SPEED: Usually less than 3m/sec

CONDITIONS: Nighttime radiation; strong outgoing radiation

σθ: 2.5°

Figure 2.3.6-9 Plume Behavior at Various Pasquill Stability Classes

The diffusion parameters are used to determine the appropriate diffusion category and wind speed to apply to short-term (instantaneous) airborne effluent releases (thus determining the relative short-term concentration) and to calculate the annual, average, ground-level, relative concentrations as a function of sector and distance from the Plant. The short-term relative concentrations are used to estimate accident doses, and the annual, average, relative concentrations are used to estimate normal operating doses from radioactive emissions as a function of sector and distance from the Plant.

For assessing environmental impact, it is reasonable to choose "expected" or average conditions as accident evaluation bases. Pasquill Type E diffusion and a 3.0 meter-per-second wind speed were chosen to represent expected conditions during short-term airborne effluent releases. These choices, although not worst-case, were conservative since (1) these stable conditions occur somewhat less than 50% of the time and (2) the Plant site constitutes an elevated source term for the high population densities which are at lower elevations than the Plant. The nearest downwind fenceline for the Plant site is approximately 3 km away from and 100 m below the level at which a hypothetical release from an accident could occur. For such an elevated source the Pasquill Type E conditions give a higher concentration at a distance of 3 km than would the use of a more stable weather class. Annual, average dispersion parameters were determined on the basis of the on-site data shown in tables of Appendix B-2.

A complete explanation of the methods used to determine diffusion coefficients, the assumptions used, and results of the calculations for each of the sixteen 22.5-degree sectors at distances from 100 meters to approximately 80,000 meters (50 miles) are presented in Appendix B.

2.3.7 Material Movement and Wind Erosion

Material movement by wind transport, presented here in response to public comment on the DEIS, is severely limited by existent vegetative cover. Estimates by the Soil Conservation Service during 1978, indicate virtually no wind erosion is to be anticipated, given the present vegetative cover. Additionally, studies made by off-site researchers (Whicker, 1977 and Caine, 1978) substantiate these estimates. A summary of Whicker's work is included as Appendix A-2. Only a small fraction (~2%) of the Plant land is bare. These disturbed areas include two clay pits along the western site boundary; and a gravel pit, sanitary landfill, and outside storage area compounds, all northwest of the fenced security area.

Any activities which require disturbance of the soil currently must have the approval of the Plant Environmental Sciences Department. Such activities are (1) monitored for soil contamination, (2) monitored for associated airborne radioactivity, (3) not permitted above a certain wind speed, (4) kept moist to inhibit dust generation, and (5) have soil stabilizer applied between periods of disturbance. Also, disturbed areas are revegetated as soon as practicable subsequent to the soil disturbance.

2.3.8 Background Radioactivity

The background radioactivity in the Rocky Flats vicinity comes from natural and man-made sources. Natural background radiation in the general area is somewhat higher than that in the United States as a whole (Klement, et al., 1972; CDH, 1976). The somewhat higher natural background is due to the elevation of the area and the geologic deposits of naturally radioactive materials such as uranium and thorium. The Denver area doses from natural background radiation are listed in Chapter 3, Table 3.1.2-6.

Man-made releases of long-lived radioisotopes have added to the radiation background. These contributions are a small fraction of the natural background radiation level. Fallout from past nuclear weapons testing has contributed about the same background plutonium levels to the Rocky Flats area as in the rest of the United States. Plutonium concentrations in the ambient air coming from fallout background are about 0.00004×10^{-6} $\mu Ci/m^3$; plutonium concentration in the soil from weapons fallout is about 1.5×10^{-3} $\mu Ci/m^2$ (0.02 d/m/g, assuming a soil density of 1.5 g/cm^3 and a soil sample depth of 10 centimeters). The Colorado Department of Health has established a value of 0.08 d/m/g for background plutonium in soil measured to a depth of 0.3 cm (1/8 inch). This is the average of values for samples taken from sites more than 100 miles from Rocky Flats. HASL Report 249 (Krey and Krajewski, 1972) discusses the differences in isotopes of Rocky Flats plutonium and fallout plutonium that allows separation of the two components.

2.3.9 Plutonium in Soil and Sediment

In addition to the background radiation discussed above, there is radiation from past releases of long-lived alpha activity from Rocky Flats. This radiation is greater near the Rocky Flats facility and drops off quickly with increasing distance from the Plant. The past releases have led to some infiltration of the surface water, pond sediments, and soil in the vicinity of the Plant. In addition to the information provided in the DEIS, a description of soil sampling methods used by various agencies has been added to this impact statement as Section 2.3.9.3.

2.3.9.1 Source of Plutonium in Soil

Concentrations of plutonium in soil around Rocky Flats have been estimated by the Colorado Department of Health, DOE's Environmental Measurements Laboratory, formerly ERDA's Health and Safety Laboratory, the Plant's prime contractor, and by a private organization called the Colorado Committee for Environmental Information

(CCEI). In general, measurements made by the different groups have shown similar results for surface plutonium levels (Krey and Hardy, 1970; Krey and Krajewski, 1972; Martell and Poet, 1972; and Dow, 1972).

Krey and others, (1976) (hereafter referred to as the HASL data) indicate that releases from past operations have amounted to about 11 curies of plutonium, about 99% of which was leakage from steel drums containing contaminated cutting oil during 1959 to 1969. Some uranium was also present in the oil. This estimate was made by comparing the computer program and isopleth data (Figure 2.3.9-1) and includes plutonium effectively dispersed to infinity. The HASL data suggest that of the 11 Ci, 8.6 Ci are on site. Of the amount off site, the HASL data indicate that about 1.5 Ci are included in the area above 0.003 $\mu Ci/m^2$, which extends up to about 5 miles from the Plant boundary. About 1.9 Ci are spread at distances far from the Plant at levels equal to or below the level of plutonium from fallout (0.0015 $\mu Ci/m^2$). Of the total 8.6 Ci included on-site, the HASL data estimate that about 1.7 Ci are included in the area that was covered with asphalt (Krey, et. al., 1976) See Figure 2.2.2-2.

The HASL estimate of the total amount of plutonium dispersed by the oil leaks (11 Ci) is higher than the estimate of the total amount of plutonium available to be dispersed. The potential amount was estimated by Rocky Flats on the basis that the 5,000 gal of oil that leaked from the barrels contained 86 g, or 6.3 Ci, of plutonium. The Rocky Flats estimates of the amount of plutonium actually dispersed beyond the area covered by the asphalt pad also are lower than the HASL estimates. This appears primarily due to the use of different sampling depths by HASL and Rocky Flats personnel. The HASL data indicate that the sampling depth needs to be about 10 centimeters (4 inches) to ensure that 90% of the total plutonium is sampled. The Rocky Flats estimates included the total amount dispersed out to only the 0.013-$\mu Ci/m^2$ isopleth, and thus do not represent the total amount dispersed.

Martell and Poet contend that the plutonium is contained almost wholly within the upper centimeter or two of undisturbed soil. HASL data, taken at a depth of 20 cm, was intended to provide an estimate of the total inventory, including any plutonium found at depths greater than 2 cm. An unambiguous determination of the depth distribution of plutonium is complicated by the presence of fallout plutonium, which must be separated from the Rocky Flats plutonium, and by the difficulty in assuring that soil samples are in "undisturbed areas." For the purposes of this EIS, however, it is assumed that the HASL total inventory samples are representative and thus the larger estimates of plutonium dispersal made by HASL will be used.

The work of Martell and Poet, based on 1-cm (0.4 in.) samples, does not suggest greater plutonium inventories within the 0.003-$\mu Ci/m^2$ contour, but Martell and Poet do suggest that the total inventory from the oil spill beyond the 0.003-$\mu Ci/m^2$ contours is 4 Ci of plutonium (in comparison to the 1.5 Ci estimated by HASL). The estimation of the total inventory in the region of low concentrations depends almost

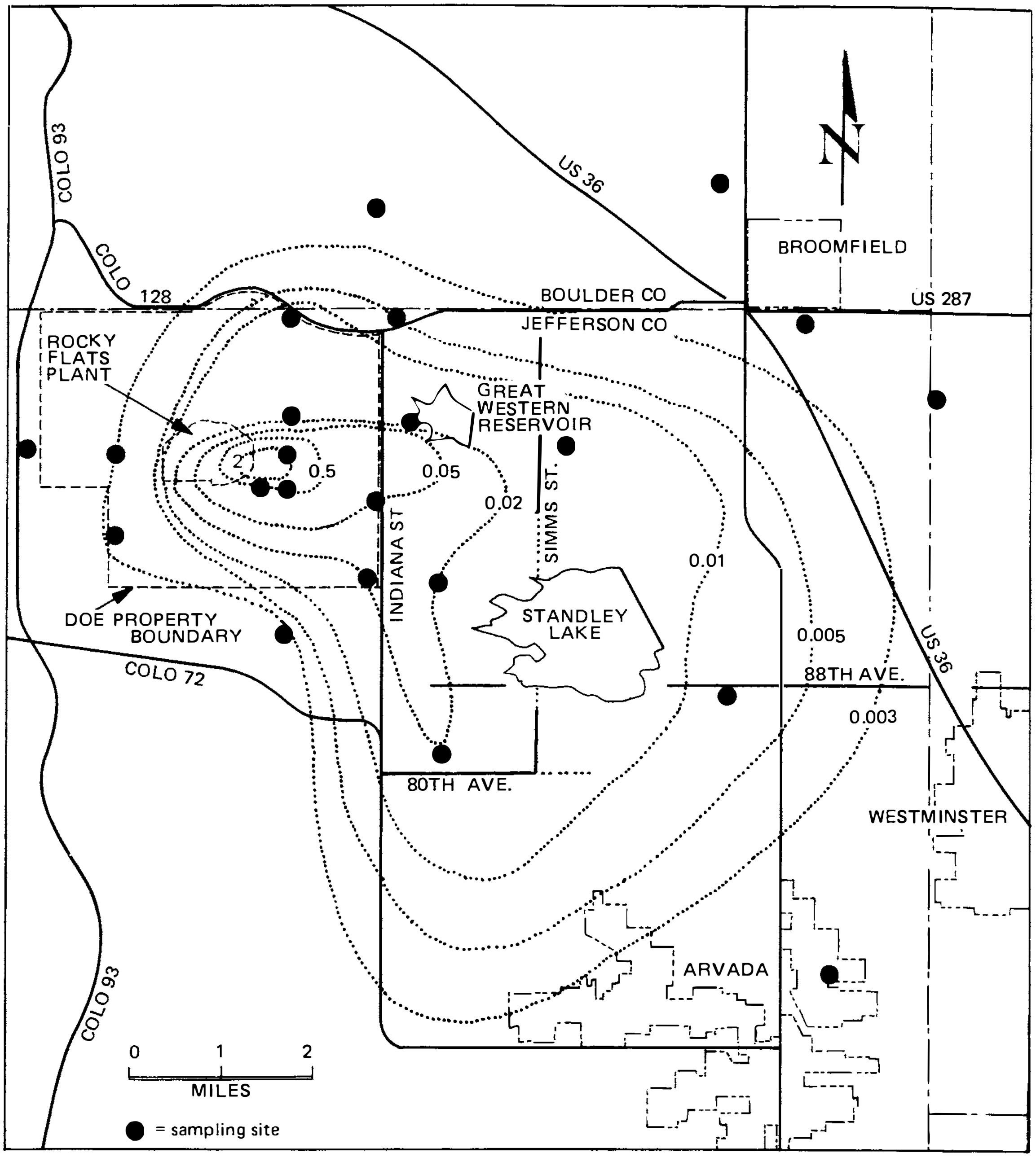


Figure 2.3.9-1 Plutonium-239 Contours Around Rocky Flats ($\mu Ci/m^2$) (adapted from Krey, 1970)

entirely upon extrapolations of concentrations and concentration gradients from areas of higher concentration, since it would require prohibitive amounts of sampling to determine low-level isopleths at great distances. Martell and Poet do not indicate how their estimate was made. The HASL estimates were made on the basis of considerable work to determine appropriate extrapolation factors that best fit the data; it is probably the best estimate available. The HASL estimates will thus be used throughout this Statement to assess impact. It should be noted, however, that soil sampling both on and off site is an ongoing process, with greater accuracy in results being derived as improved technology and more sophisticated equipment become available. The Rocky Flats contractor collects over 50 samples annually from alternate 500-foot sections of a grid in the Plant's exclusion area. The geometry of all samples is carefully controlled by driving a 10- by 10-cm (4- by 4-in.) cutting tool 5 cm (2 in.) into undisturbed soil, then excavating the soil contained within the tool cavity. The soil-analysis program through 1977 also includes the annual collection of samples from 18 degrees of arc on three circles having 1-, 2-, and 5-mi radii concentric with the center of the Plant. The data are reported annually (Annual Environmental Monitoring Report, 1977).

There has been great interest in removing the plutonium contained in the soil under the asphalt pad. For this purpose, budgeting is under consideration for a device which will mine the soil from under the pad and separate the plutonium and the fine soil particles from the remainder of the soil. The plutonium portion would then be sent to disposal or storage, and the large, remaining bulk would be returned to the Rocky Flats environment. Laboratory experimentation has shown this approach to be feasible. Pilot plant work is being planned.

Martell and Poet suggest the possibility that there are higher plutonium levels in areas other than those indicated as being contaminated from the oil leak. This might be explained by major releases other than from the oil leak. This possibility is disputed by Krey of HASL (Krey, 1974). As measured by on-site monitors, past releases from the Rocky Flats facility from both routine and accidental causes, excluding the oil leak, represent only about 1% of the amount released from the oil leak.

Given the number of on-site effluent monitors, it is improbable that releases several orders of magnitude above those reported could have occurred without detection. Further, data from air samplers on the Plant and in the surrounding vicinity, which have been sampling continuously during the Plant's lifetime, do not suggest any major, undetected releases nor do they suggest that the higher levels of resuspended material present in the oil-leak area also exist elsewhere. Nevertheless, continued environmental monitoring programs are being conducted, including mapping radiation levels by air, which can even further define the radiation background in the Rocky Flats area.

In addition to the measured plutonium levels in the environment, there is some americium-241, which is also an alpha emitter. This americium-241 comes from direct releases from the Plant in addition to the decay of plutonium-241, which is a beta emitter. Hence, to ensure conservatism, an americium-241 value equal to 50% of total plutonium alpha activity will be used in estimating future releases.

Plutonium-241 has a relatively short half-life (13 years), so that over a period of about 70 years, most of the beta-emitting plutonium-241 will have decayed to the longer-lived americium-241 (half-life of 433 years). Thus, it is possible that the total alpha activity in the environment will increase over the immediate term. Rocky Flats plutonium has only about 0.36% plutonium-241 by weight, which means that the ratio of americium alpha activity to plutonium alpha activity cannot increase to more than about 0.15. Historically, plutonium-241 weight percentages as high as 0.65 have occurred, but even then an activity increase of no more than 25% is possible. At present, the total activity of americium-241 is about 10% of the total plutonium alpha activity (Martell and Poet, 1972), though the ratio of americium-to-plutonium activity varies in different sample media, suggesting different fractionation or separation of the two elements in the environment. The resuspension of plutonium and americium in soil is discussed in Section 3.1.2.1.

2.3.9.2 Standards for Plutonium in Soil

The only Federal standards now applicable to plutonium in the environment are those for the levels of plutonium in air and drinking water; consequently, there are no official Federal standards with which to compare indicated off-site plutonium levels in soil. In 1974, the EPA was charged with the responsibility of considering whether guidelines were needed to protect the health and safety of the public. In 1977, the EPA released a guidance document in draft form, "Proposed Guidance on Dose Limits for Persons Exposed to Transuranium Elements in the General Environment." The guidance provides screening levels for air (1 fCi/m^3) and for soil (0.2 $\mu Ci/m^2$). These screening levels are values which indicate a need for further testing to determine whether dose limits are exceeded in areas having uncontrolled access. The EPA specifies that the soil testing method shall be adequate to analyze soil to a one-centimeter depth and having a soil particle size of less than two millimeters. The measured concentration is modified by use of an "enrichment factor," which takes into account the contribution of plutonium associated with soil particles in the inhaleable size fractions. Extensive data taken in areas surrounding the Plant indicate that there are no areas which have higher concentrations of plutonium in soil than the EPA soil screening level. Indeed, the highest concentration is about 35% of the EPA limit. Likewise, concentrations of plutonium in air at the Rocky Flats Plant are several orders of magnitude lower than the EPA screening limit for air.

The State of Colorado in 1973 adopted the following radiation control regulation:

"RH4.21 Permissible Levels of Radioactive Material in Uncontrolled Areas

4.21.1 Plutonium. Contamination of the soil in excess of 2.0 disintegrations per minute of plutonium per gram of dry soil or square centimeter of surface area (0.01 microcurie plutonium per square meter) presents a sufficient hazard to the public health to require the utilization of special techniques of construction upon property so contaminated.

Evaluation of proposed control techniques shall be available from the Department of Health upon request."

The Colorado State guideline does not ban construction on land containing plutonium-in-soil concentrations greater than 2 d/m/g (0.01 $\mu Ci/m^2$), but it states that any such land might require "special techniques of construction." On the basis of the State regulations, recent data indicate that about 1,000 acres of land outside of the 6,500-acre Plant site may require special measures prior to construction. These data were obtained from sixty soil samples collected and analyzed by a DOE contractor. Samples collected from plowed ground contained levels of plutonium significantly lower than the State guideline. The remaining 1,000 acres was found to include soil that contained plutonium at concentrations greater than 2 d/m/g. Proper characterization of these lands, however, should be made by evaluation of grouped samples instead of individual samples for a total inventory approach to hazard evaluation. Such an evaluation can be made with median values. The medians for samples typical of the Colorado procedure were 2.0 d/m/g for one parcel and 7.0 d/m/g for another parcel. The same lands sampled to a greater depth (5 centimeters versus 0.3 centimeters) yielded medians of 0.7 and 1.4 d/m/g, respectively. The Colorado Department of Health has designated as a "general area of concern" which is currently defined as the area bounded by Simms Street through Standley Lake on the east; 80th Avenue extended to Highway 72, and Highway 72 to Highway 93 on the south; Highway 93 to the west; and Highway 128 to the north (see Figure 2.3.9-1). Plutonium-in-soil measurements have been made at several locations within the State-designated area of concern. One of these was in the Walnut Creek Development No. 2 which is about one mile east of the eastern Rocky Flats Plant boundary. The measurements indicated plutonium levels of 0.05 to 0.90 d/m/g, which are all less than the State guideline level. Other measurements were made on soil samples from the Good Financial Corporation property just east of Indiana Street and adjacent to the Rocky Flats Plant's east boundary. These measurements indicated plutonium concentrations in the range from 0.0 to 14.1 d/m/g of soil. Nine of the 21 analyses yields levels greater than the State guideline of 2 d/m/g, and the Colorado Department of Health recommended that special techniques be applied during development of the land. These special techniques may involve either deep plowing of the land or removal of the topsoil.

The State measurements to which the guideline is related were made using samples of the agronomic soil (i.e., rocks greater than two millimeters diameter were excluded, but the remaining soil was not treated to retain only the respirable particles).

The adoption of the State guideline of 2 d/m/g plutonium in dry soil by the Colorado Board of Health was based on three items: (1) a review of the literature showed that the suggested value was below any available standards or guidelines; (2) for soils containing concentrations of 2 d/m/g plutonium, air sampling results were not detectably above worldwide fallout; (3) the value provided in the State regulation for plutonium in soil would be significantly different from worldwide plutonium fallout in soil. It was determined that, by using a factor of ten above the maximum worldwide fallout value, the State would not inadvertently condemn any property that might have elevated levels due solely to worldwide fallout. In 1976, three years after adoption of the standard, the Colorado Department of Health prepared a dose assessment evaluation of the State standard and verified that the State had adopted an ultraconservative standard (CDH, 1976).

Both the EPA guidance and the Colorado regulation are based on evaluation of health effects and estimates of health risk. The models for this evaluation were based on work by researchers who have investigated the effects of nuclear weapon detonations in Japan, the effects of radium on radium watch dial painters, the effects of radiation on patients who received radiation treatments, and the effects of plutonium on animals. This research has been reviewed, and the models were developed and reported by the National Academy of Sciences (1972, 1976).

The actual dose calculations on which the EPA guideline and the Colorado regulation are based make use of an implied resuspension factor, i.e., the ratio between the measured soil content and the airborne concentration. Changes in the definition of soil concentration values would require a corresponding change in the implied resuspension factor, as the actual amount of plutonium in the air cannot be changed by arbitrary definitions. Thus, the only valid way to define soil concentrations for comparison with the Colorado guideline is through use of the State soil-measurement technique upon which the guideline is based. These measurements included all the soil in the sample taken, not just the respirable dust fraction. The Colorado State Department of Health, in a 1976 paper, concluded that the present State guideline "can still be considered to be ultraconservative. Further restriction and conservatism by modification of the standard is unwarranted" (CDH, 1976). Similarly, comparison of measured soil concentrations with the EPA guideline requires the use of samples obtained by use of the EPA sampling parameters. The EPA sampling parameters are similar to those of the Colorado Department of Health. The sampling technique of Jefferson County Health Department (JCHD) results in concentrations of plutonium in respirable dust (as defined by JCHD), rather than in soil. The dose estimate model for the EPA guidance does not apply to the JCHD sampling result; concentrations of isotopes in respirable dust cannot be compared with EPA guidance.

The most recent measurements made by the Colorado Department of Health, for the Good Financial Corporation and other land developers, were made using the 0.3 cm (1/8 inch) sample depth as recommended by the State. This is a shallower depth than that routinely used by Rocky Flats personnel, who sample to 2 inches (5 cm) depth. Comparison of results has shown reasonable agreement between the two different sampling techniques. This suggests fairly uniform concentrations of plutonium in the upper few inches of soil. No correlation between soil concentrations and concentrations of isotopes in respirable dust (as defined by JCHD) has been shown. Models have not been published that would relate JCHD concentrations to airborne concentrations and quantities of isotopes that are inhaled.

Several investigators have proposed standards: Healy (1974), 2.25 $\mu Ci/m^2$; Anspaugh, et al. (1974), 6 to 200 $\mu Ci/m^2$; Kathren (1968), 0.04 $\mu Ci/m^2$ for urban areas to 4 $\mu Ci/m^2$ for rural areas. This research is referenced in the background material providing basis for the EPA standard (EPA, 1977).

The studies of C. Johnson and others (1976) have assumed the impact of a standard within Jefferson County only, inasmuch as decisions of the Jefferson County Commissioners have been based on the recommendations of Dr. Johnson, Director of Jefferson County Health Department. Dr. Johnson's work does not recognize the efficacy of health data accumulated by the earlier researchers (National Academy of Sciences, 1972, 1976). There is no health model associated with the sampling of Jefferson County Health Department, which measures concentrations of plutonium in respirable dust, rather than in soil. The measurement is not accepted by the EPA as an appropriate means of evaluating soil concentrations for comparison with the EPA standard because the models representing transport from the soil to the body include factors for expected resuspension, respirability, and body retention. The models are therefore not appropriate to concentrations in so-called respirable dust (EPA, 1978).

2.3.9.3 Soil Sampling

The purpose of soil sampling programs can generally be related to one or more specific objectives. These are as follows: (1) deposit inventories, (2) agricultural availability, (3) resuspension availability, and (4) distribution of contaminant. Use of soil measurements to estimate area inventories or effects requires the selection of a statistically sufficient number of representative sites, with the density of the sites depending on the accuracy sought and the slope of the concentration gradients.

The most useful measure of the concentration of deposited material in soil is related to the amount of radioactivity per unit area. Sampling should therefore be done in such a way so that the weight of the material collected can be directly related to the area sampled and that the depth of the sample is known. The measurements on a weighed aliquot of the sample can then be related to area concentration.

The amount of radioactivity per gram of soil is frequently reported. It cannot be converted to concentrations per unit area unless additional volume-related information is also reported.

If an accumulation of deposits over a period of time is to be estimated, the area to be sampled should be undisturbed for at least that same time interval. A second criterion, that of representativeness of the sample site, depends on the environment and the meteorological and climatological factors for the area. A third criterion, that the deposited material remain in place, generally requires that the area should have living vegetation. Well-developed, grassy areas are well suited to sample collection.

It is desirable to sample a relatively large area to obtain the most representative sample possible. Various procedures require collecting between five and twenty-five cores or subsamples to make up the desired area, with sufficient sample material for processing and analysis.

For total inventory estimates, it is necessary to sample all or most of the deposited material, which means sampling to the necessary depth. If it is possible, it is best to collect a few preliminary soil profiles to determine the depth of penetration of the material sought. It is usually adequate to select a depth containing 90 to 95% of the total. In the Rocky Flats area, this amounts to sampling to depths of 10 to 20 cm.

To evaluate the agricultural availability of a contaminant, it is not necessary to measure the total material deposited but only that amount in the root zone of the crop of interest in the study. In most cases this would be the depth of the cultivated zone. The availability of a contaminant to a plant is rarely 100%. This may mean that the analyses may be conducted on partial extracts of the soil rather than on complete disolutions of the total soil sample.

Following an acute release of a contaminant, surface-soil sampling soon after the event can be used to define the distribution pattern. This would require sampling only the top 5 cm of soil, including the vegetation. Experience has indicated that attempts to sample a shallower depth result in less reproducible results.

The most important facet of soil-sample collection is proper definition of mission and objectives. The objective describes the overall result desired and the mission sets the quality or acceptability of the result. The mission should address such factors as (1) the intrinsic variability of the medium to be sampled, (2) the required accuracy and the number of replicates necessary to provide adequate precision, (3) the choice of procedure needed to minimize cross-contamination, and (4) the cost of sampling, sample preparation, and analysis.

Soil-sampling activities at Rocky Flats have been used to evaluate accidental and/or long-term operational releases of radionuclides. The procedures used have varied considerably, depending on the organization and objectives. These procedures are discussed in the following pages.

The Nuclear Regulatory Commission (NRC) in its Regulatory Guide 4.5 states by way of introduction that "no single soil sampling" method is adequate to sample all soil types at all locations. For example, a method designed to sample cohesive sandy loam soil may not be suitable for sampling the dry loose soil common to some arid areas of the United States. Rocky soils present problems for all sampling methods. Two sampling methods are described by the NRC: the Health and Safety Laboratory (now Environmental Measurements Laboratory) Procedure Manual method and the NAEG (Nevada Applied Ecology Group Reports, such as NVO 178, June 1977) method.

The HASL method requires collection of 10 or more cores for a composite sample. A good pair of sampling tools is an 8.9-cm-diameter top-soil cutter and a 8.3-cm-diameter barrel auger that cuts an 8.9-cm-diameter sample. The top-soil cutter is used to remove the sod to a depth of 5 cm, and the auger takes the remaining sample to the depth desired (20 to 30 cm). The composited samples are screened to remove the greater-than-two-millimeter fraction; the remaining material is then crushed, blended, and pulverized for radiochemical analysis. Results of sampling by this method are reported by Krey and Hardy (1970), Krey and Krajewski (1972, Krey (1974), and Krey, et al. (1976).

The NAEG method uses a steel ring (12.7-cm diameter by 2.5-cm depth). The ring is pressed into the soil and the soil inside the ring is removed with a disposable plastic spoon. Soil is next removed from outside the ring to the 2.5-cm depth, the ring is pressed into the soil another 2.5 cm and another sample is taken. A sample consists of soil taken from a minimum depth of 5 cm.

The Colorado Department of Health recommends collecting soil samples to a depth of 0.3 cm over an area of 30 cm^2. Twenty-five samples are collected into a composite sample from each sector. The composite sample is dried and sieved through a 10-mesh screen (2-mm openings). The fine material is coned and quartered to a 30-g fraction. This fraction is finely ground and mixed using a mortar and pestle. A 2-g fraction of this portion is taken for plutonium analysis. Results have been reported for samples taken in the years 1970 through 1974, (CDH, 1974).

Since 1973, Rocky Flats personnel have collected soil samples using a jig, 10 by 10 cm in area and 5 cm in depth. The jig is pressed into the soil, the surrounding soil is carefully removed, and the soil within the volume of the jig is carefully removed with a scoop and transferred to a sample container. It is common practice to take four subsamples at the four cardinal directions about 10 m apart plus one subsample at the center. The five subsamples are composited in the field. Subsequent sample treatment includes drying, screening through a 10-mesh sieve, weighing both fractions, ball-milling the fine fraction, and weighing out suitable aliquots for radiochemical analyses.

In its document, "Proposed Guidance On Dose Limits For Persons Exposed to Transuranium Elements in the General Environment" (USEPA Publication, September 1977, Annex V, page 11), the Environmental Protection Agency "recommends that for undisturbed sites where soil measurements are taken to evaluate the inhalation pathway, soil samples should be taken to a depth of one centimeter and transuranium element activity be measured in all soil particles less than 2 mm in size. Several individual samples may be composited for a single measurement."

The Jefferson County Health Department recommends sampling only surface dust from an area of 4 m^2. After collection, the sample is disaggregated by ultrasonic vibrator and peroxide solution and separated into a particle size fraction by aqueous sedimentation. The less than 5-μm size is analyzed for plutonium. The concentration obtained is defined by the authors as plutonium in respirable dust (Johnson et al., 1976). The data are not directly comparable to that obtained by other workers who report plutonium concentrations in soil. See Section 2.3.9.2.

2.3.9.4 Radioactivity in Sediments

In addition to releases of plutonium to the atmosphere, there have been past releases of radioactive material from the Plant to water effluents. These latter releases have contributed to an increase in background radiation in ponds and reservoirs on the site and in the immediate vicinity. Since the start-up of Plant operations in 1952 until December 21, 1973, water containing decontaminated process and laundry waste was released through the B-series ponds to South Walnut Creek. This creek joins North Walnut Creek, which flows into Great Western Reservoir. Discharges from cooling water blowdown and steam condensate were discharged to Pond A-1, while filter backwash water from the water treatment facility was discharged to Pond C-1. These ponds are shown in Figures 2.3.9-2 and 2.3.9-3. Most of these discharges have now been stopped (the Plant is working towards a zero total liquid discharge system). However, treated sanitary liquid waste will continue to be discharged to Walnut Creek and Great Western Reservoir until the completion of the reverse osmosis facility. Operations should commence in the early 1980's. While the water that flowed into Great Western Reservoir did not exceed applicable Radioactivity Concentration Guides set forth in ERDA Manual Chapter 0524, dated 1977, it did contain some low-level concentrations of plutonium and uranium. Most of the radioactive materials settled out in the sediment of the ponds, resulting in measurable amounts of radioactivity.

Operating within a contractual agreement with the Division of Biological and Environmental Research of ERDA, Colorado State University personnel analyzed sediment samples and water samples from the on-site ponds (Johnson, et al., 1974). Shown in

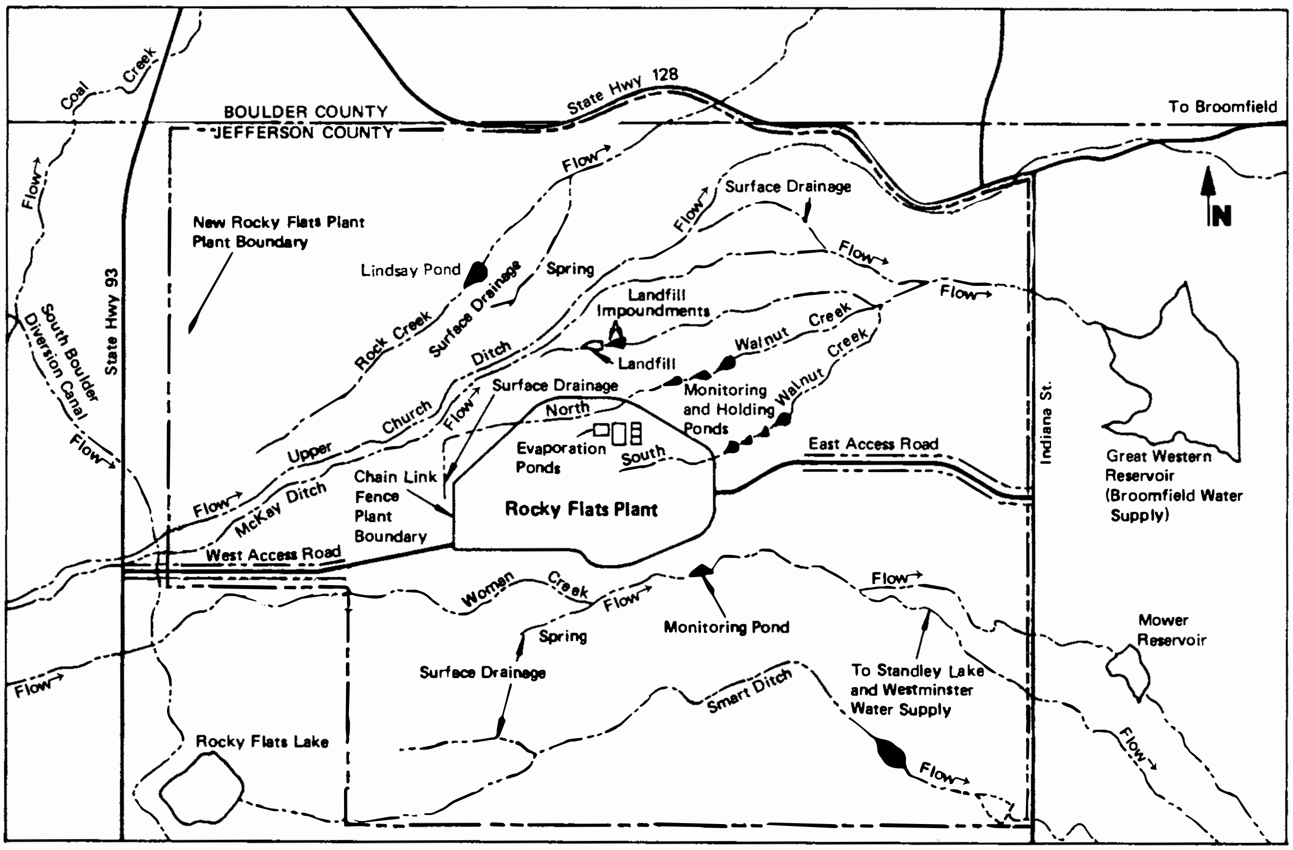


Figure 2.3.9-2 Rocky Flats Site Drainage Pattern

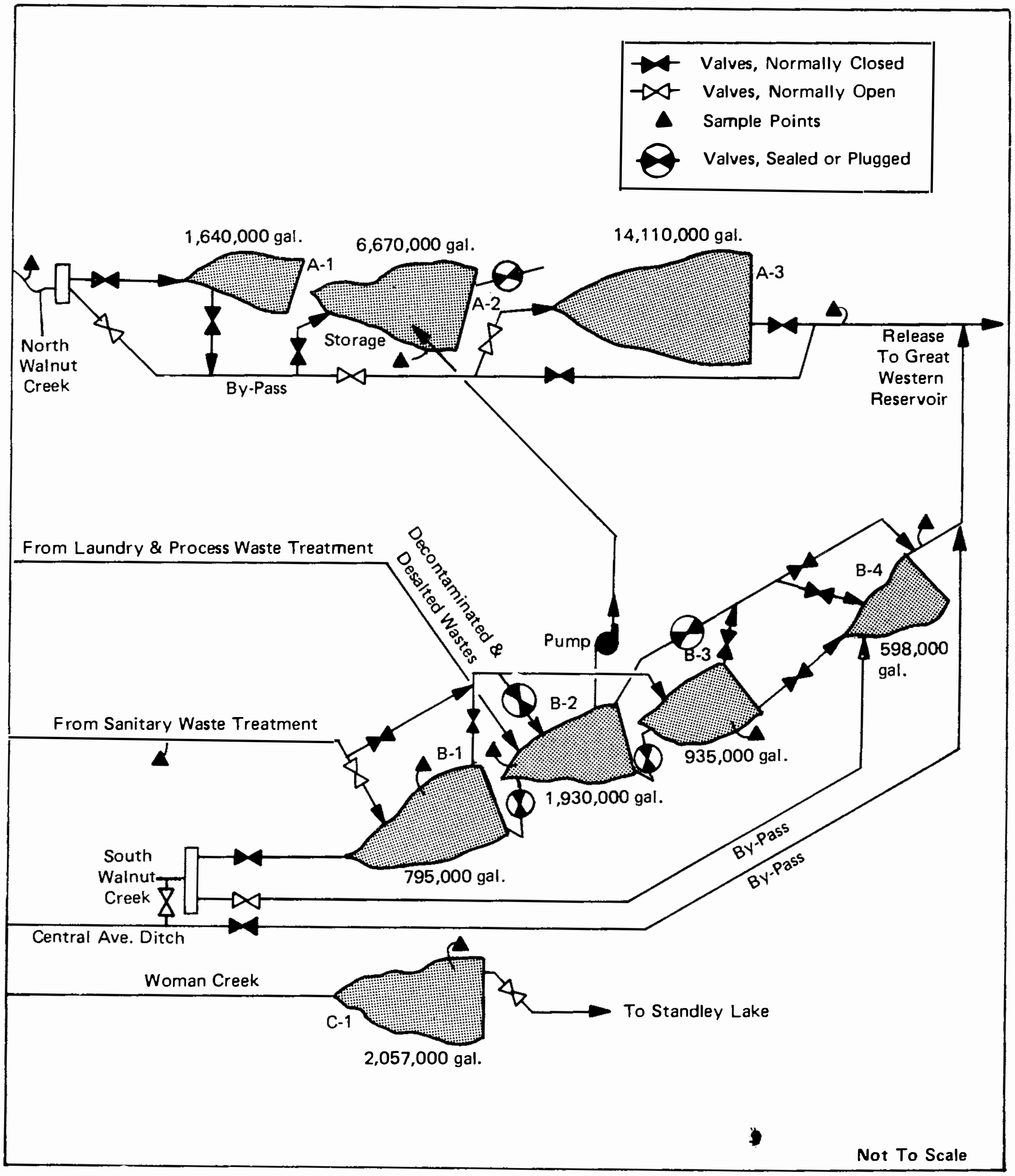


Figure 2.3.9-3 Rocky Flats Plant Holding Ponds

Figures 2.3.9-4 through 2.3.9-9 are the average sediment and water concentrations of plutonium in the on-site ponds existing in 1974 (two have been added since then). As can be seen from these figures, the B-series holding ponds (which did receive process waste) contain the major inventory of plutonium. Estimates of the total inventory based on the CSU study, of plutonium trapped in the sediment of the B-series ponds in the years 1971 and 1973 are shown in Table 2.3.9-1.

TABLE 2.3.9-1

INVENTORY OF PLUTONIUM IN SEDIMENT OF B-SERIES PONDS

Pond	Total Inventory (curies)	
	1971	1973
B-1	0.085	2.9
B-2	0.027	0.04
B-3	0.019	0.04
B-4	0.005	0.005
TOTAL	0.136	2.985

As can be seen in Table 2.3.9-1, the total inventory of plutonium in Pond B-1 increased dramatically between 1971 and 1973. There were no major releases from the Plant during this time, but pond reconstruction activities resulted in disturbances of the bottom sediment of the channel upstream of Pond B-1. This caused much of the upstream sediment to be transferred to the B-1 pond, increasing its total inventory. It is probable that several additional curies of plutonium remain trapped in the sediment between the waste discharge pipe and the inlet of Pond B-1. As can be seen from the figures, however, the plutonium suspended in the water was essentially all redeposited in Pond B-1. This is in agreement with the CSU measurements, indicating that plutonium put into the water will quickly redeposit into the bottom sediments.

The holding pond sediments do not contain plutonium or americium at concentrations sufficiently high to be reclaimed. After the ponds are no longer used to hold effluent from the sewage treatment plant, it may be desirable to remove the accumulated sediments. A plan would then be formulated for removal and disposal of them. Removal would involve the best available control methods to prevent dispersal of the low concentrations of radioactive materials contained in the sediments. The methods of collection and disposal would be similar to those used in cleaning the solar evaporation ponds. Table 2.3.9-2 shows measured releases from pond B-4.

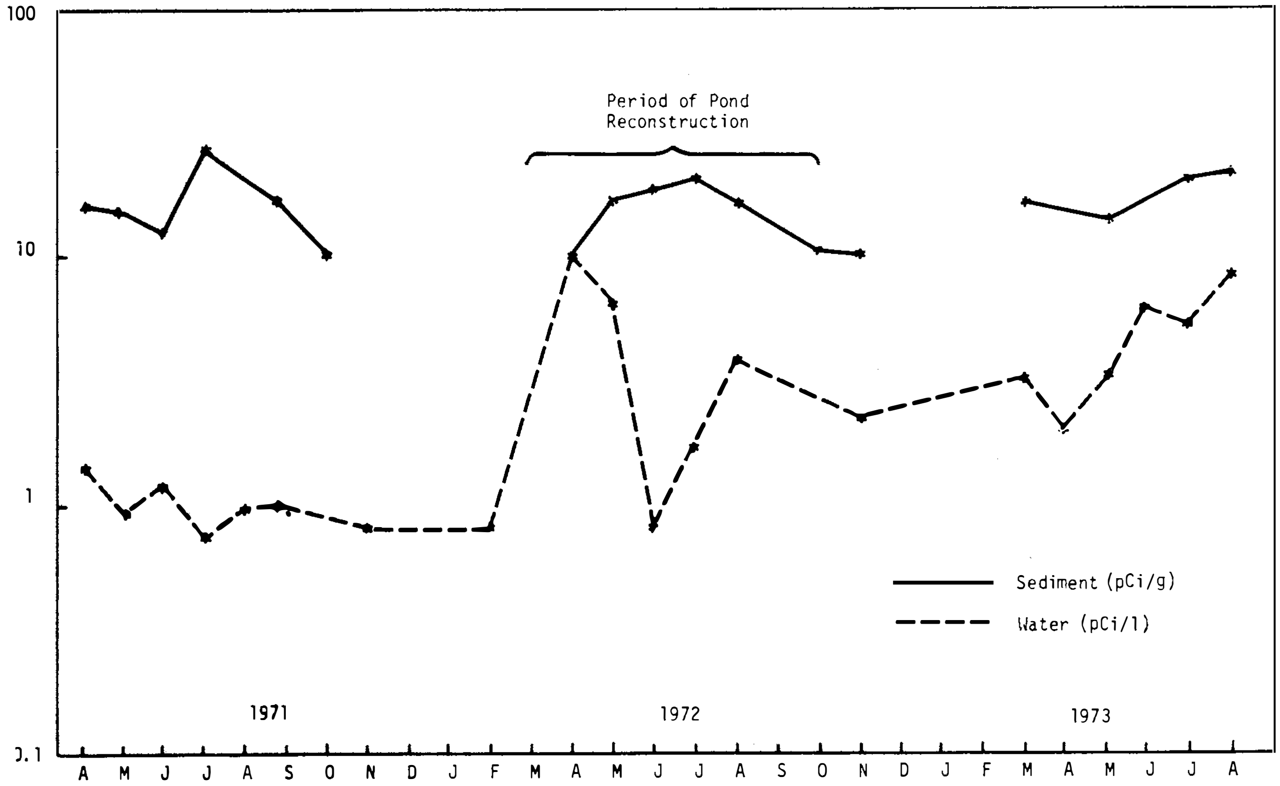


Figure 2.3.9-4 Average Plutonium Concentrations in Sediment and Water of Pond A-1

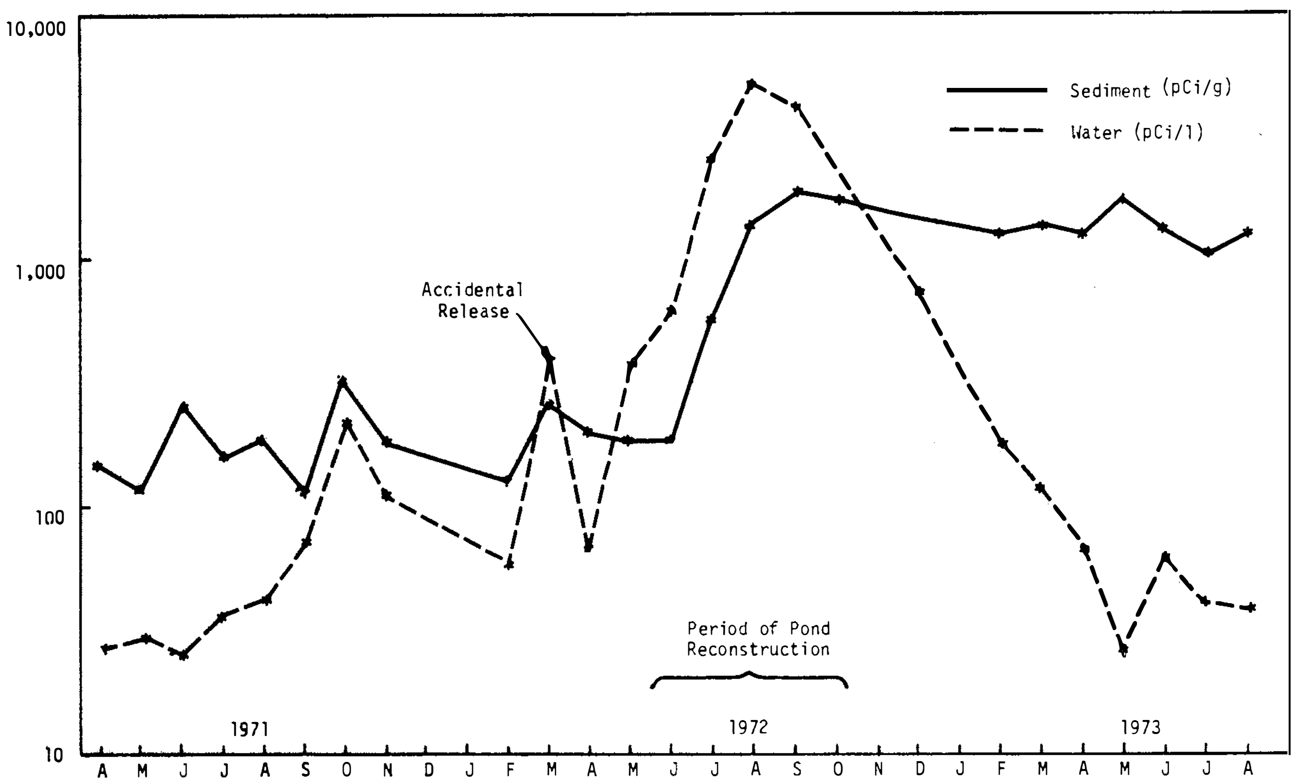


Figure 2.3.9-5 Average Plutonium Concentrations in Sediment and Water of Pond B-1

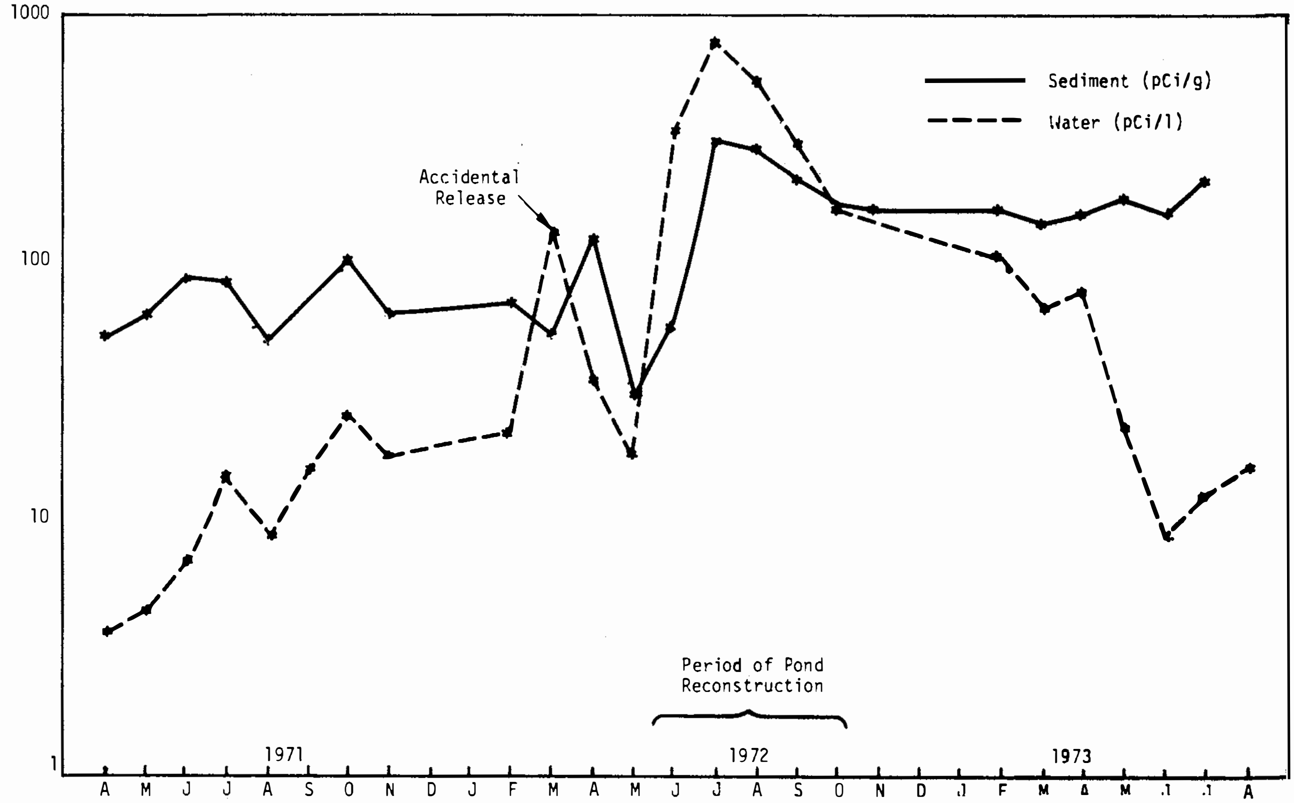


Figure 2.3.9-6 Average Plutonium Concentrations in Sediment and Water of Pond B-2

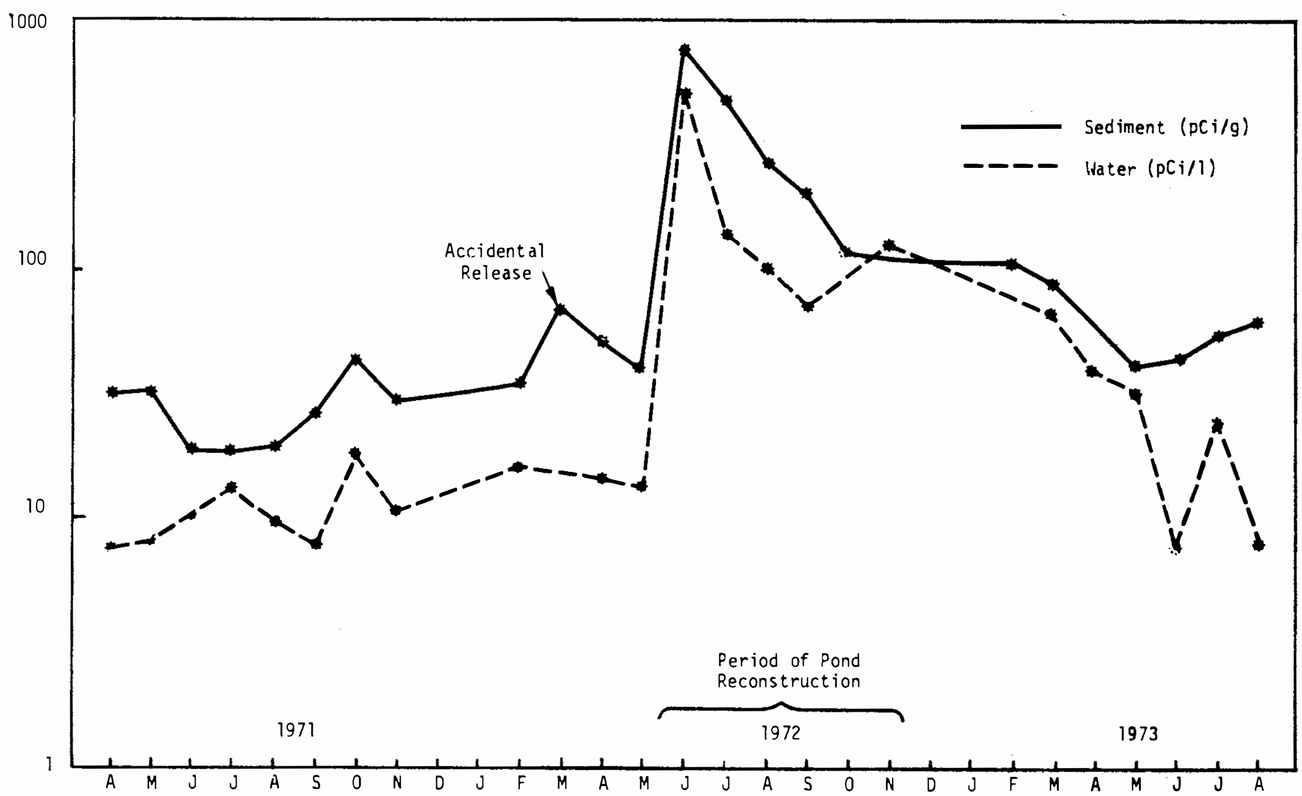


Figure 2.3.9-7 Average Plutonium Concentrations in Sediment and Water of Pond B-3

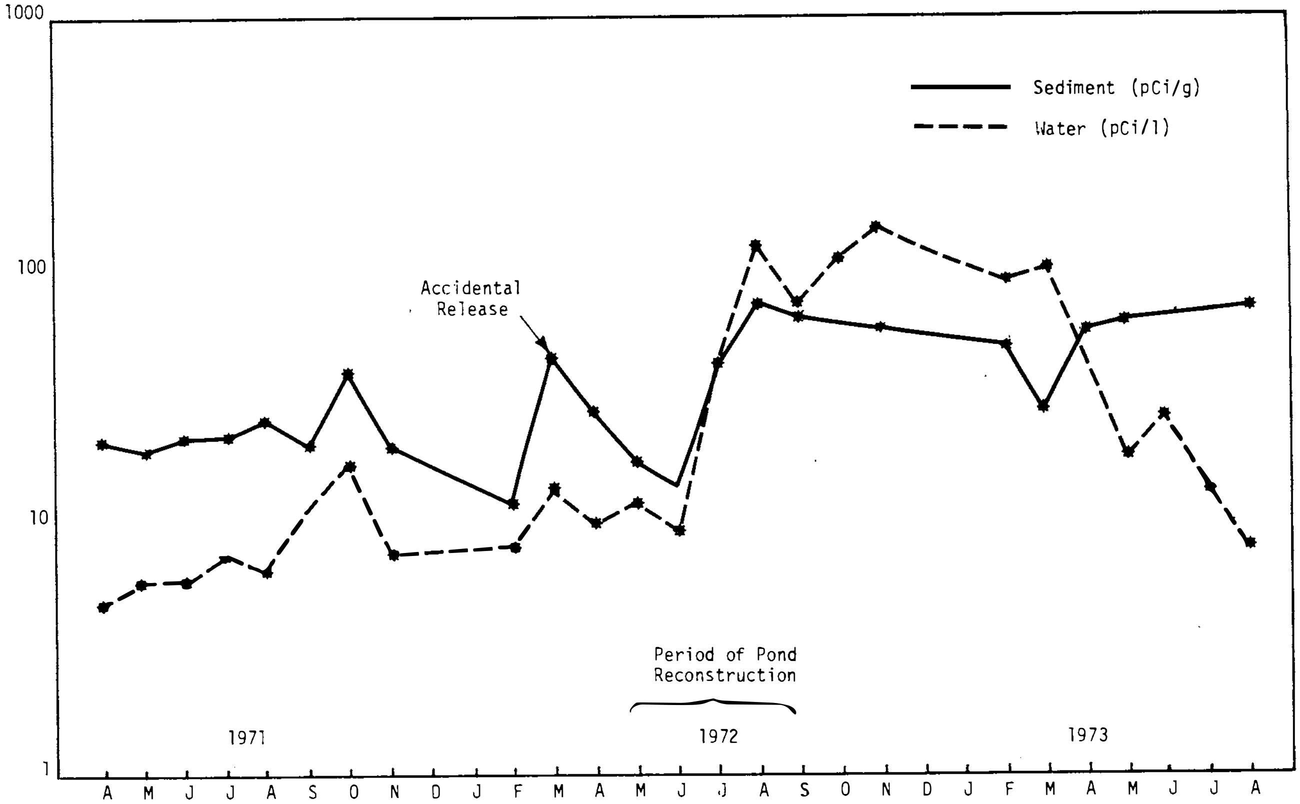


Figure 2.3.9-8 Average Plutonium Concentrations in Sediment and Water of Pond B-4

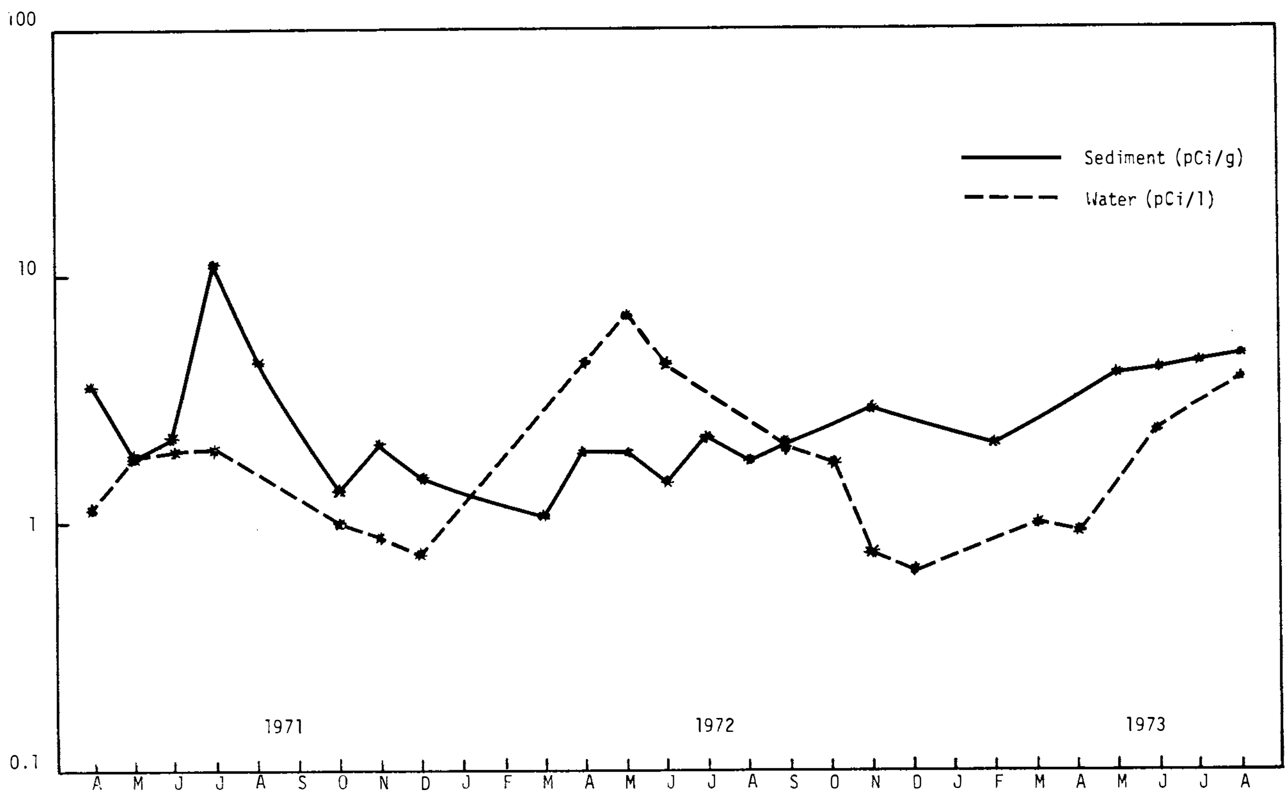


Figure 2.3.9-9 Average Plutonium Concentrations in Sediment and Water of Pond C-1

TABLE 2.3.9-2

RADIOACTIVE RELEASES FROM POND B-4

Year	Plutonium Alpha (μCi)	Americium (μCi)	Alpha Activity** (μCi)
1953	NA*	NA	1126
1954	NA	NA	1226
1955	NA	NA	1099
1956	NA	NA	1653
1957	NA	NA	1863
1958	NA	NA	2796
1959	NA	NA	5800
1960	NA	NA	5900
1961	NA	NA	6110
1962	NA	NA	5500
1963	NA	NA	2360
1964	NA	NA	2620
1965	NA	NA	2630
1966	NA	NA	4227
1967	NA	NA	2765
1968	NA	NA	2982
1969	NA	NA	4384
1970	519	256	3369
1971	860	508	6723
1972	4903	794	10265
1973	4000	NA	8990
1974	391	102	1605
1975	400	123	2188
1976	542	156	2730
1977	464	223	4260

* NA - Not Analyzed

**From 1953 to 1970, the figures represent alpha activity measured after an actinide separation resulting in a mixture of plutonium and uranium, excluding all other actinides. From 1970 through 1976, the figures represent alpha activity derived from specific measurements of plutonium plus uranium plus americium.

Prior to December 21, 1973, all laundry waste water and other process waste water containing plutonium, uranium, and americium concentrations below the radioactivity concentration guides were treated at the sewage treatment plant and held in the B-series pond before releasing to South Walnut Creek. Since this date, only sanitary waste water has been treated at the sewage treatment plant and released to South Walnut Creek. Shortly after December 21, 1973, basins and digesters were throughly cleaned to remove the residual solids which contained plutonium, uranium and americium activity.

The total alpha activity in the release waters typically is much greater than the plutonium alpha activity. The difference between the total activity and the plutonium activity is due to alpha activity from americium and from uranium and its daughters. Uranium activity is due almost entirely to the natural uranium content of the water taken into the Rocky Flats Plant. The continual release of plutonium from the on-site ponds means that there will be some addition of residual radiation in off-site water systems, particularly in Walnut Creek leading from the B-series ponds and in Great Western Reservoir, which receives Walnut Creek water. Measurements by CSU on Walnut Creek at Indiana Street are shown in Figure 2.3.9-10. These measurements indicate some buildup of plutonium in the sediments. The levels are on the order of 10 pCi/g.

Small amounts of plutonium-239 have accumulated in the sediment of Great Western Reservoir. The average plutonium concentration in 20 samples from that sediment is 3.13 ± 2.81 d/m/g (1.4 ± 1.26 pCi/g). That quantity was calculated from samples and analyses by the EPA during 1973 (USEPA, 1973). The plutonium concentration in the Great Western Reservoir sediment is less than 0.1% of that in the B-1 pond suggesting the slow transfer of plutonium downstream. The 1.4 pCi/g level of concentration in Great Western Reservoir sediment is about equal to that of the soil in the area. The source of the plutonium activity in the reservoir sediment may be from airborne deposits as well as waterborne releases. Core sediment studies done in 1974 by Battelle Northwest Laboratories (unpublished) suggest this conclusion. The EPA data, which show sediment activity level increases between 1970 and 1973, appears to correlate with the previously mentioned pond reconstruction.

Given the Great Western Reservoir sediment concentrations and the CSU value for transfer of plutonium from sediment to water, if there were no further additions of plutonium into that reservoir, the expected plutonium concentration in its water would be about 0.014 pC/l. On the basis of a steady input of 1000 μCi/yr into the reservoir, the average water concentration, not counting deposition into the bottom sediments, would be about 0.25 pCi/l. Actual concentrations should be somewhere between these values. Actual measurements over the past five years (1973 through 1977) in Great Western Reservoir have shown an average concentration of plutonium in the water of less than 0.07 pCi/l, but 1978 concentrations are consistently less than 0.02 pCi/l. The DOE Radioactivity Concentration Guide (RCG) for plutonium concentration in water to which the general public may be exposed is 1,667 pCi/l. The recently established EPA drinking water standards limit gross alpha activity to 15 pCi/l. The average plutonium concentration in Standley Reservoir during this same five-year period has been less than 0.04 pCi/l.

The total alpha concentration in the waters of Great Western Reservoir, about 10 pCi/l, is dominated by the radioactivity of the uranium decay chain. Based on Rocky Flats' measurements of Plant intake and discharge water, this uranium alpha content is due almost wholly to the natural uranium content of the water in the general area. For example, in 1972 the uranium alpha content in Ralston Reservoir,

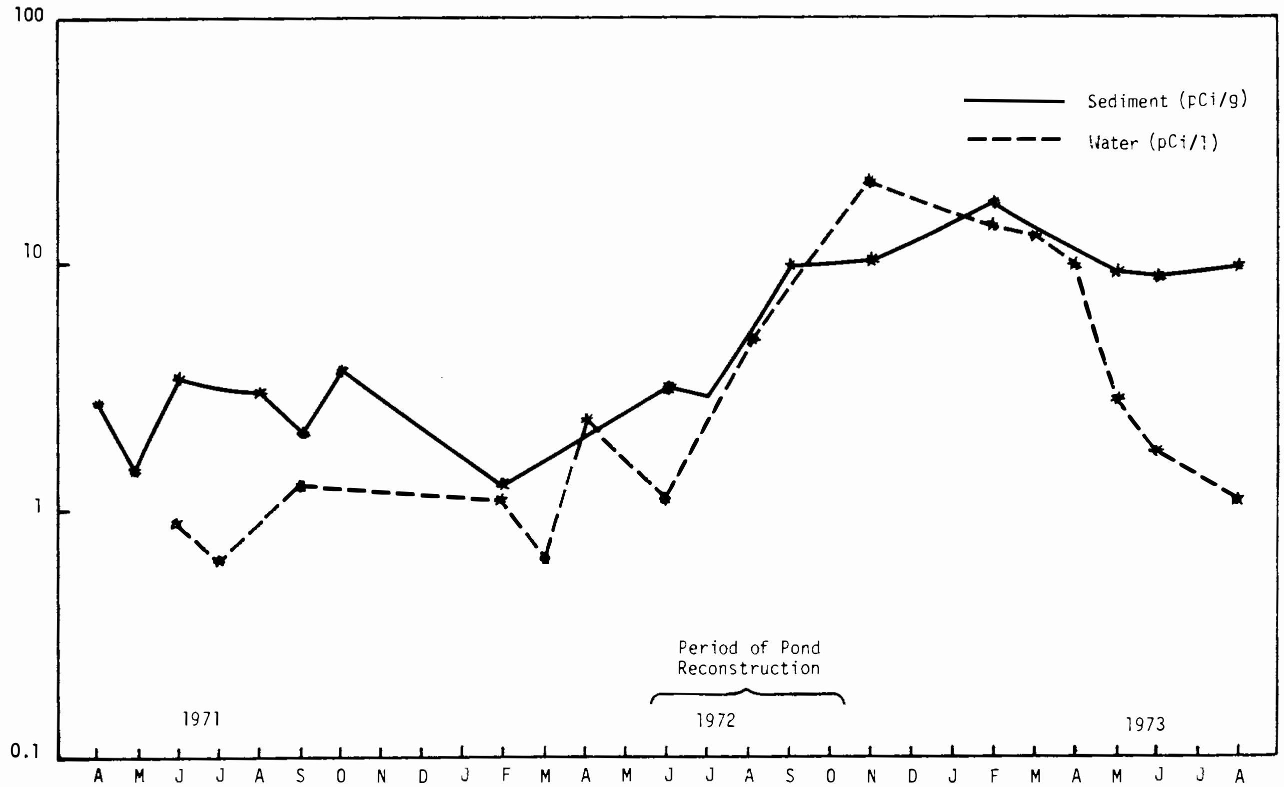


Figure 2.3.9-10 Average Plutonium Concentrations in Sediment and Water of Walnut Creek at Indiana Street

the main source of Rocky Flats raw water, averaged about 20 pCi/l. More recently, in the spring of 1978, it was noted by Rocky Flats and the Colorado Department of Health that the total long-lived alpha activity in Rocky Flats water had dramatically increased. It was found that this increase was caused by elevated concentrations of uranium in raw water from Ralston Reservoir. In fact, two analyses in March 1978 averaged 61 pCi/l, four samples in April 1978 averaged 17 pCi/l, and in May, the concentration dropped to an average of 2 pCi/l. The limit for uranium in water is about four times that for plutonium (Standard for Radiation Protection Annex A, ERDA Manual Chapter 0524, March 30, 1977).

There are measurable levels of americium in Great Western Reservoir. Rocky Flats measurements indicate that americium-241 levels in the water are about equal to those of plutonium. Since the americium level in the soil is about 10% of that of plutonium, there is an indication that americium is more mobile than plutonium in water. Americium is picked up more readily from soil runoff, and reaches a higher equilibrium level in the water in relation to the sediment concentration. As mentioned previously, concentrations of americium-241 in the water will increase in coming years to reach annual, average, background levels of somewhat under 0.1 pCi/l. This will still be well below applicable standards. The most restrictive DOE and Colorado limit for americium concentration is 1,330 pCi/l; the EPA drinking water standard limits alpha activity to 15 pCi/l.

During 1973 there was a level of tritium above background in Great Western Reservoir. That increase came from an accidental release of 100 to 500 curies of tritium to the environment. The release began in April of 1973, and was identified in June 1973. (The natural background level of tritium in the water prior to the accidental release was about 600 pCi/l.) Of the amount released, EPA estimated 56 curies of tritium reached the Great Western Reservoir (USEPA, 1974), leading to initial concentrations (assuming complete mixing) of 12,000 pCi/l. This concentration has decreased as noncontaminated water has flowed into Great Western Reservoir. Measurements taken by Rocky Flats from October through December of 1973 averaged 8,200 pCi/l. By January of 1975, the level of tritium in Great Western Reservoir was 4,000 pCi/l, which is what is expected since Great Western Reservoir contents, on the average, turn over once a year, reducing the average concentration by a factor of two per year. By the end of 1976, tritium levels in the reservoir were at or near the regional background level of approximately 600 pCi/l. The DOE effluent limit for tritium concentration in water to which the general public has access is 1×10^6 pCi/l; the EPA standard for drinking water is 20,000 pCi/l.

2.3.9.5 Other Sources of Radioactivity

There are some amounts of low-level plutonium infiltration into the soil surrounding several on-site buildings. This plutonium is from past leaks, contamination incidents, and burial of radioactive materials on site. For several years, laundry water containing low concentrations of plutonium was allowed to flow into the upper reaches of Walnut Creek. This practice, although long since discontinued, produced measureable amounts of plutonium in stream sediment. Some plutonium-containing soil has been removed and packaged for shipment to DOE waste disposal sites; however, because of safety and cost considerations, removal of all on-site soil containing plutonium has not been attempted. Several thousand gallons of oil containing uranium residues were burned in pits on the east edge of the Plant site during the 1950's. These pits have recently been excavated and the contaminated soil was packaged for shipment.

The Rocky Flats Plant has discontinued on-site burial of any radioactive materials. Rocky Flats is carrying out an extensive monitoring program to locate plutonium deposits for clean up and disposal. Further discussion of these actions appears in Sections 5.2.4 and 5.5.1. On-site plutonium in the environment is controlled to prevent transport by air and water to the surrounding area. Monitoring demonstrates the effectiveness of the controls.

In summary, one major increase in off-site, background plutonium levels resulting from past operations of the Rocky Flats Plant was caused by the oil-leakage incident. This incident dispersed some 2.6 Ci of plutonium off site. Other releases to surface water have resulted in dispersal of much smaller amounts of plutonium off site. A major temporary increase in off-site radiation occurred when about 56 Ci of tritium were released to the Great Western Reservoir. Plutonium fires at the Rocky Flats Plant have not contributed discernibly to the plutonium background in the area.

2.3.10 Ecology

2.3.10.1 Vegetation

The Rocky Flats Plant is located at an elevation of about 6,000 feet above sea level, at the approximate elevation where plains grassland vegetation meets lower montane forest. The present vegetation of the upper plains grassland region has been characterized (Marr, 1964) as consisting primarily of heavily grazed pastures composed of a mixture of herbs and of relatively unpalatable grasses. In isolated, undisturbed sites, there are patches of big and little bluestem, needle grass, and side-oats grama. Prickly pear cactus and yucca are abundant where overgrazing has been extreme. Wild plums and hawthorn are common in the small ravines. The lower montane forest region is characterized by ponderosa pine and common juniper in addition to patches of grasses and flowering herbs. Willows, cottonwood, and river birch grow along streams.

Within the Rocky Flats boundaries, a variety of vegetation thrives. Included are species of flora representative of tall grass prairie, short grass plains, lower montane, and foothill ravine regions. Introduced Eurasian weeds make up a significant portion of the vegetative cover. It is evident that the vegetative cover in the Rocky Flats region has been radically altered by human activities such as burning, timber cutting, road building, and overgrazing for many years. Land within the original 2,520-acre site boundary, however, has not been grazed since 1951 and generally has been undisturbed since that time. Some areas that had to be disturbed have been reseeded with native grass mixtures.

Weber and others (1974) conducted an inventory of the botany at the Rocky Flats site from June through September of 1973. They reported that 327 species of vascular plants, 25 lichens, 15 bryophytes, and one macroscopic green algae species had been observed in the area. An annotated list of species occurring on the Rocky Flats site is given in Appendix A, none being on the endangered species list.

The vegetation of Rocky Flats was mapped in 1974 by the Plant Ecology Laboratory, Institute of Arctic and Alpine Research of the University of Colorado (Clark, 1977). Those studies indicate that the area encompassed by the original site boundary, especially to the east and south of the Plant, is characterized primarily by meadow type habitat, largely blue-grass and wheat-grass. Restricted areas of marsh and stream-bank vegetation occur along the several creeks that traverse the Plant site; higher elevations frequently are relatively dry and barren, characterized by cheat grass and nodding thistle. Weber states that the nodding thistle first appeared in the Rocky Flats area about the mid-1960's and has "exploded over the area, completely dominating fallow and disturbed areas."

West of the Plant site, the substrate is composed largely of rock and coarse gravel; the vegetation is dominated by June grass, Klamath weed, and nodding thistle. This area is pock-marked by low gravel mounds, apparently formed by the activities of pocket gophers (Murray, 1967). These mounds frequently support vegetation that is somewhat different from surrounding areas.

It appears that vegetation is recovering from the grazing that occurred prior to Government acquisition of the land. This is evidenced by the presence of grasses like big bluestem and side-oats grama that are sensitive to disturbances. In 1975, about 4,000 acres surrounding the Plant site were purchased to enlarge the Plant's buffer zone. Much of the area lying between the old and new boundaries had been overgrazed; consequently, it supports a relatively sparse vegetative cover characterized by June grass, cheat grass, and Klamath weed.

2.3.10.2 Wildlife

The ecological changes that have occurred in the Boulder-Denver region during the last hundred years have resulted in major changes in the nature of wildlife communities in the area. Development of the fur trade followed by extensive use of the region for livestock production led to the demise of the beaver, buffalo, and antelope. During the past 30 or 40 years, industrial development has destroyed considerable wildlife habitat and has usurped the natural winter range of elk and deer. These changes are particularly significant to the larger animals. Even some of the medium-sized forms have been affected, as evidenced by the partial elimination of den sites for foxes and river bottom hardwoods for raccoons. In addition, movement to feeding grounds and other special environments has been deterred or prevented by roads, fences, and canals (Quick, 1964).

There are no effective barriers to animal migration or movement on or off the undeveloped areas of the Rocky Flats site which support a variety of animals classically associated with the western prairie regions. No rare or endangered species have been reported or have been found among the wildlife inhabiting or migrating through the area (see Appendix A). The most common large mammal is the mule deer, of which most of the estimated 100-125 appear to be permanent residents of the site. White-tailed jack rabbits and the desert cottontail also inhabit the area. Carnivores occurring in the area include coyote, red fox, striped skunk, and long-tailed weasel. Badger and raccoon are occasionally observed. Muskrat occur in the vicinity of the streams and ponds.

Winsor and others, (1975) initiated a mark-and-recapture program during the summer of 1973 to estimate dynamics and biomass of the small-mammal population. Species captured included deer mouse, thirteen-line ground squirrel, northern pocket gopher, hispid pocket mouse, silky pocket mouse, harvest mouse, meadow vole, and house mouse.

Commonly observed birds include western meadowlarks, horned larks, mourning doves, and vesper sparrow. A variety of ducks (chiefly mallards), killdeer, and red-winged black birds are seen in areas adjacent to site ponds. Mallards and other ducks frequently nest and rear young on several of the ponds. Common birds of prey observed in the area include marsh hawks, red-tailed hawks, Ferruginous and American rough-legged hawks, and great horned owls.

Bull snakes and rattlesnakes are the most frequently observed reptiles. Eastern yellow-bellied racers also have been seen. The eastern short-horned lizard has been reported on the site, but these and other lizards are not commonly observed. The western painted turtle and the western plains garter snake are found in and around many of the ponds.

A list of mammals, birds, amphibians, and reptiles observed on the site is given in Appendix A-1.

2.3.10.3 Aquatic Life

Four streams flow within the Plant boundaries: Rock Creek, North and South Walnut Creeks, and Woman Creek (see Figure 2.3.9-2). Rock Creek is an intermittent spring-fed stream that traverses the northwest portion of the site. Because of its small size and intermittent flow, it is unlikely that this stream contains any significant numbers of fish or benthic organisms. Lindsay Pond, located on Rock Creek, is a small farm pond containing heavy growths of aquatic vegetation and supporting a balanced population of minnows (Redside Dace) and black bass (W-W Services, 1976).

Other ponds (see Figures 2.3.9-2 and 2.3.9-3) are located on Walnut Creek, which itself supports a small population of fathead minnows. Included among the on-site ponds are Holding Ponds A-1, A-2, and A-3 on North Walnut Creek. Zillich (1974) reported collecting fathead minnows in Pond A-1. Pond A-2 receives process wastewater and laundry wastes pumped from Pond B-2. Large algal mats frequently are found in A-2, however, which is probably the result of laundry wastes in the pond providing an adequate supply of nutrients. Pond A-3 is used to hold water during periods of high runoff; it is not maintained as a permanent pond.

South Walnut Creek and Ponds B-1, B-3, and B-4 receive sanitary effluent from the sewage treatment plant; this has a marked effect on the stream and ponds. Zillich found that primary productivity was 27 times higher in Pond B-4 than at locations at Woman Creek, which receives no sewage effluent. Johnson, et al., (1974) reported that, probably as a result of the large pH fluctuations that occur, zooplankton populations were sparse in Ponds B-1 to B-4. The diversity of benthic macroinvertebrates in Pond B-4 was comparable to that of Woman Creek. The number of facultative organisms remained high; even relatively sensitive sideswimmers, mayflies, and caddisflies were present. Pond B-2 receives laundry wastes, which are retained for an average of one month before being pumped to Pond A-2. As might be expected, B-2 supports larger algal populations than other ponds on South Walnut Creek. Efforts by W-W Services (1976) personnel to collect fish from Ponds B-1, B-3, and B-4 proved futile, although they did find many crayfish in Pond B-4.

Woman Creek is an ephemeral stream that receives storm runoff and irrigation waters; it does not receive discharges from Rocky Flats operations. Previously the only discharges to Woman Creek were cooling tower blowdown, which was discontinued in late 1974, and water-treatment-plant filter backwash, which was discontinued in 1975. One holding pond, C-1, is located on the stream. Woman Creek supports an aquatic biota typical of that occurring in small high-prairie streams receiving a minimum of agricultural land runoff and domestic or industrial wastes. Because of the low nutrient content in Woman Creek, the stream supports smaller algal populations than does Walnut Creek with its effluent from sewage treatment. The rocky bottom of Woman Creek supports a relatively diverse biota composed of mayflies, caddisflies, and other forms typical of clean water streams. Redside dace minnows are abundant in the stream and in Pond C-1, and a few bluegill also are present.

In the southeastern part of the most recently acquired site property, there is another farm pond that is fed by Smart Ditch. The pond (identified as Pond D-1) was found to contain fathead minnows.

A list of aquatic organisms known to occur in the streams and ponds of the Rocky Flats area is given in Appendix A.

2.3.10.4 Land Management

The operating contractor at Rocky Flats has supported a number of programs to learn about, protect, and improve the local environs. Test plots of deciduous and coniferous trees were planted to determine species best suited to the Rocky Flats area. Successful varieties were planted as windbreaks. Approximately 50 acres, including old gravel pits, were reclaimed by topsoil placement, seeding, fertilization, and irrigation. A baseline water quality survey of the area was completed (Zillich, 1974). Results of the study indicate that Plant effluents have not been deleterious to invertebrate and fish populations, and that species diversity in Rocky Flats effluent streams is similar to that in unaffected streams.

The cattle fence around the perimeter of the Plant site now prevents grazing by domestic stock; it also aids in preventing unauthorized human intrusions on the former rangeland. Partial recovery of the vegetation from past decades of grazing will probably occur by way of increased vegetative cover, although the land is unlikely ever to be restored to its native prairie condition.

An environmental consideration of particular interest to the local communities and surrounding population relates to the possible uses of the land recently acquired by DOE as an extension of the buffer zone. A total land-use plan is currently under review for this area, which includes all Government-owned property outside the fenced security area. The plan provides a complete description of present condition, identifies current activities on the land, and establishes guidelines for future land use.

The primary purpose of the buffer zone is to preserve a substantial band of unoccupied land in an open, underdeveloped state to minimize the types of problems that often arise from close proximity of industrial facilities to residential communities. Such encroachment is conceivable, especially in light of increased activity in land development because of growth within Denver-area suburbs. Recommendations were solicited from interested parties in government, education, and the private sector, and following further evaluation and discussions, the long-term management program will be formalized and implemented.

2.4 WIND ENERGY TEST FACILITY

A 451-acre site in the northwest corner of the Plant site has been established for a Small Wind Energy Conversion System test facility. The purpose of the facility is to provide the capability for a broad range of testing various designs of small wind energy conversion systems.

The site is still being developed. A general layout of the facility provides five rows of test sites. Two are completed and the remaining three rows are in the planning stage, with installation scheduled for the fall of 1978. The first group of wind turbine generators installed develop about 2 to 15 kW in power output. Later units may produce up to 100 kW. Rotor diameters for the units range from about 13 feet to about 100 feet. To provide 30 feet of ground clearance, test platforms in the 40- to 80-foot height range have been utilized for most generator units. The test platforms will be of several different types including single-post steel or concrete, guyed post, and three- and four-post trussed tower designs.

Each test site consists of four major components: a wind turbine generator mounted on a tower (installed on a concrete test pad) and a shed. Located in the shed is the power distribution and management equipment, as well as the first-stage data collection equipment. There are two major meteorological tower sites located at the test facility for data collection at 10-, 20-, 30- and 40-meter levels. A variety of towers is currently installed at the facility. Energy generated by the wind turbine generators flows to a battery storage system and then to a DC motor coupled to an AC generator. This combination provides power for the data collection system.

A test center occupying approximately 15,000 sq ft is planned for the site to house offices, data storage equipment, and power storage banks. The building will be designed to utilize wind-generated power and solar heating for much of its practical power and heating needs. Power and data cables will be laid underground, adjacent to the access paths, from the test center to the wind turbine generators and meteorological towers. A leach field or sealed septic system will serve the sanitary sewage needs of the test center. Final selection of a system will depend on groundwater levels and on percolation test results. A paved access road approximately 25 feet wide will be constructed to connect the test center with Colorado State Highway 128. A paved parking lot will be located at the test center. A demonstration irrigation plot consists of a well, stock tank, and sprinkling system to irrigate a 40 to 80 foot-diameter plot adjacent to the test center.

This project has no adverse effect on the Denver-area population. Local and national benefits result from the increased employment for the project, the purchase of materials and supplies, and the information that will be obtained, which is applicable to the development of a non-polluting energy source. Since an Environmental Assessment report has been prepared for the Wind Test Site, it will not be discussed further in this Impact Statement.

2.5 MAJOR ACTIVITIES AND FACILITIES

This section is divided into eight parts to describe the chief functions of the Rocky Flats Plant. Beginning with the fabrication of various metals into different shapes for the national weapons programs, these functions continue with the recovery of plutonium and americium from plutonium residues; research into new techniques, equipment, and materials; and special projects in support of other members of the DOE weapons complex. Nuclear weapons are not assembled on site. Materials commonly handled at the Rocky Flats Plant in kilogram quantities include plutonium, enriched and depleted uranium, and americium. Materials handled in gram or milligram quantities for research and analytical activities include curium-244, neptunium-237, thorium-228, and uranium-233. A variety of isotopes are handled in lesser quantities. These are itemized and updated on a regular basis in reports to the Colorado Department of Health. As a result of public comment on the DEIS, this section has been expanded to provide more detail on personnel protection and the health and safety aspects of handling radioactive elements, beryllium, and selected solvents.

2.5.1 Special Features of Plutonium-Handling Facilities

2.5.1.1 Structure and Equipment

Plutonium must be stored and processed under strictly controlled environmental conditions to assure both a high quality product and protection of personnel from toxic effects (Appendix G). Controls are achieved primarily by enclosing the plutonium (and much of the process equipment) inside stainless steel enclosures called glove boxes, which are designed to contain the material and its emissions (see Figures 2.5.1-1 and 2.5.1-2). Elastomeric gloves having a center layer impregnated with lead oxide are attached to the glove boxes to permit the safe handling of plutonium. The glove boxes typically have lead-impregnated glass windows and lead shielding to protect personnel from gamma radiation and X rays. Hydrogenous materials are used where neutron shielding is required. Where possible, glove boxes are connected by closed conveyor lines within which the radioactive material is transported between glove boxes.

The ground-floor fabrication and assembly areas in each plutonium manufacturing building are divided into modules, and each module is separated from adjacent ones by wide corridors. The glove boxes and enclosed conveyors (Zone I), modules (Zone II),

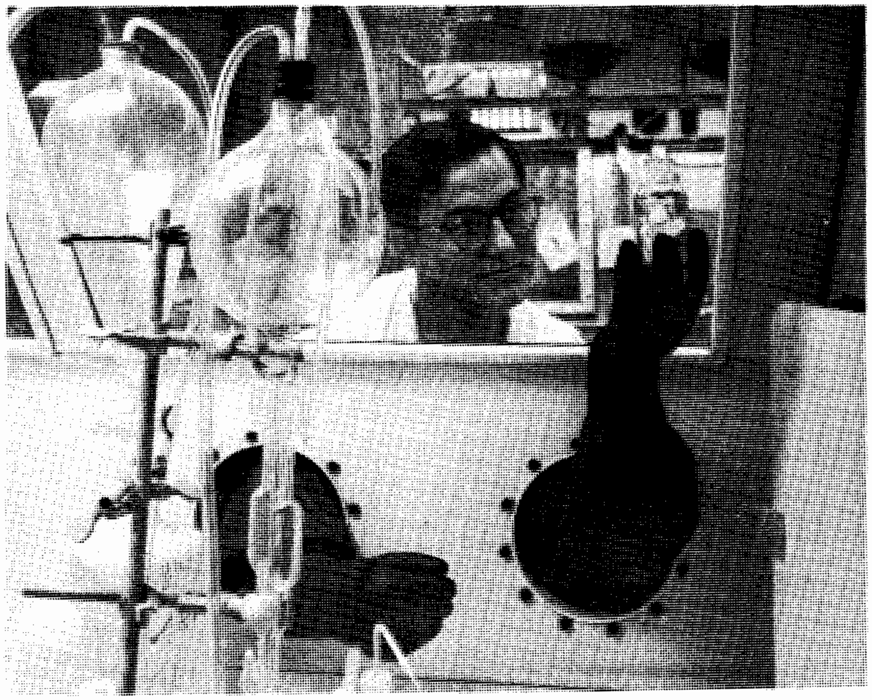


Figure 2.5.1-1 Interior View of Glove Box

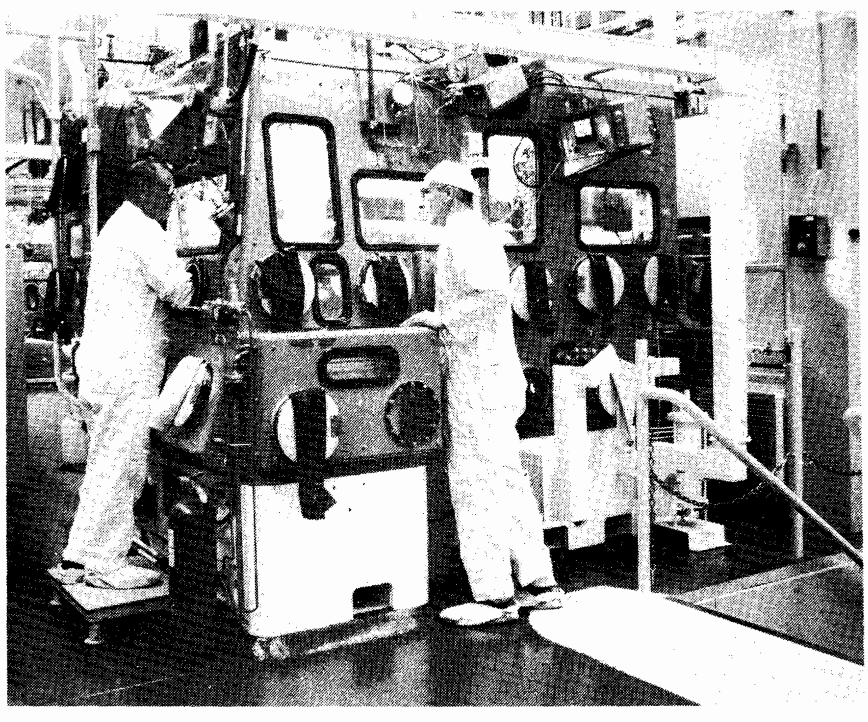


Figure 2.5.1-2 Exterior View of Glove Box

and the corridors and shells of the building (Zone III) provide three distinct barrier stages or zones for containing radioactive materials. The ventilation air pressure in Zone I is negative with respect to that of Zone II; Zone II pressure is negative with respect to Zone III; and Zone III pressure is negative with respect to the outside environment. Thus, air passes from nonradioactive areas to ones that potentially are increasingly more radioactive, i.e., from the outdoors to Zone III to Zone II to Zone I. The air exhausted from all Zone I areas is filtered through at least four stages of HEPA (High Efficiency Particulate Air) filters before it is discharged to the atmosphere. Zone II and Zone III exhaust air is also passed through HEPA filters. This ventilation system is discussed later (Section 2.7.1) in greater detail.

To minimize the possibilities of fire, an inert (nitrogen) atmosphere, containing less than 5% oxygen, is maintained in glove boxes, conveyors, and vaults that may present a fire hazard. This atmosphere is continuously monitored; an alarm sounds if the oxygen level exceeds 5%. Automatic wet-pipe sprinkler systems throughout each facility provide protection against fire. Exceptions occur where nuclear criticality safety considerations preclude sprinkler use or where there is no fire potential. Where water cannot be used, special fire prevention techniques such as inert atmosphere, or fire suppression systems such as carbon dioxide are frequently used. Heat and smoke detectors located at strategic places actuate automatic systems and provide local and Plant-wide alarms and location signals. Manual fire-alarm stations also are located throughout the buildings and are connected to the Plant-wide alarm system. Dual, off-site, electrical power sources, in addition to on-site diesel-electric generators provide power for emergency lighting and for all ventilation control equipment, utilities, and process equipment that must continue to function for safety and for containment of radioactive materials (see Section 3.2.2.4).

2.5.1.2 Radiation and Safety Controls

To detect trends in concentrations of radioactive material in the air in working areas, open-face continuous air filter samplers are located at the Zone II exhaust ducts and work areas. Samplers located near the exhaust ducts are sensitive to abnormal conditions which may develop in the general operating area. Data from these samplers verify that concentrations of alpha-emitting radionuclides are as low as practical and within the guidelines given in ERDA Manual Chapter 0524, i.e., 2.0 pCi/m^3 for plutonium-239 in controlled areas.

To detect unexpected releases and provide for rapid alarm to employees in the area, selective alpha air monitors (SAAM) are located in the air-flow patterns of Zone II. A centralized readout system is used as a means of detecting the location of alarm conditions, as well as possible sampler malfunctions. It provides continuous information from a large area to a health protection work force in a centralized location. Data printouts are used for record keeping purposes. A response to a SAAM alarm in the plutonium facility is as follows: (1) Personnel in the area don respirators. (2) The area is evacuated. Individual judgement is required but, in some cases, more serious situations have been avoided by personnel in respiratory equipment taking action to control the source of contamination. (3) Radiation Monitoring personnel enter the area equipped with at least full-face mask respiratory protection. (4) Possible sampler malfunction is verified or the source of contamination is determined and contained. (5) The level of contamination is determined. (6) The area is cleaned and returned to normal operations.

All employees in plutonium areas who work with radioactive materials are required to wear protective clothing. All employees are required to do self-monitoring when leaving radiation control areas. All employees who have been in radiation control areas must be monitored by a Radiation Monitor before leaving the security control area. Personnel who are required to wear protective clothing are required to shower at the end of the shift.

Selective alpha air monitors are also located in the exhaust stacks of process and research buildings to provide direct monitoring of the effluents at their release point. A detailed description of the system is presented in Section 2.10.1.1. Constant air monitoring throughout the work areas and the stack alarm system provide a highly reliable system for alerting the Plant to an accidental release.

2.5.2 Plutonium Fabrication and Assembly

2.5.2.1 Operations

Plutonium ingots and parts are generally stored in closed containers within vaults. The latest vault built has an inert atmosphere contained within 10-inch-thick concrete walls with windows of laminated glass enclosing gelled water. Material is introduced into and retrieved from the vault by a computer-operated three-axis retriever (Figure 2.5.2-1).

Pieces of plutonium metal are drilled or broken to provide samples for assay in preparation for casting alloys. The plutonium metal for castings is in the form of scrap, buttons, and briquettes. Feed material is melted in a tantalum crucible in a vacuum induction-heated furnace. The molten metal is poured through a tantalum funnel into a coated graphite mold to form an ingot of the required shape and alloy content.

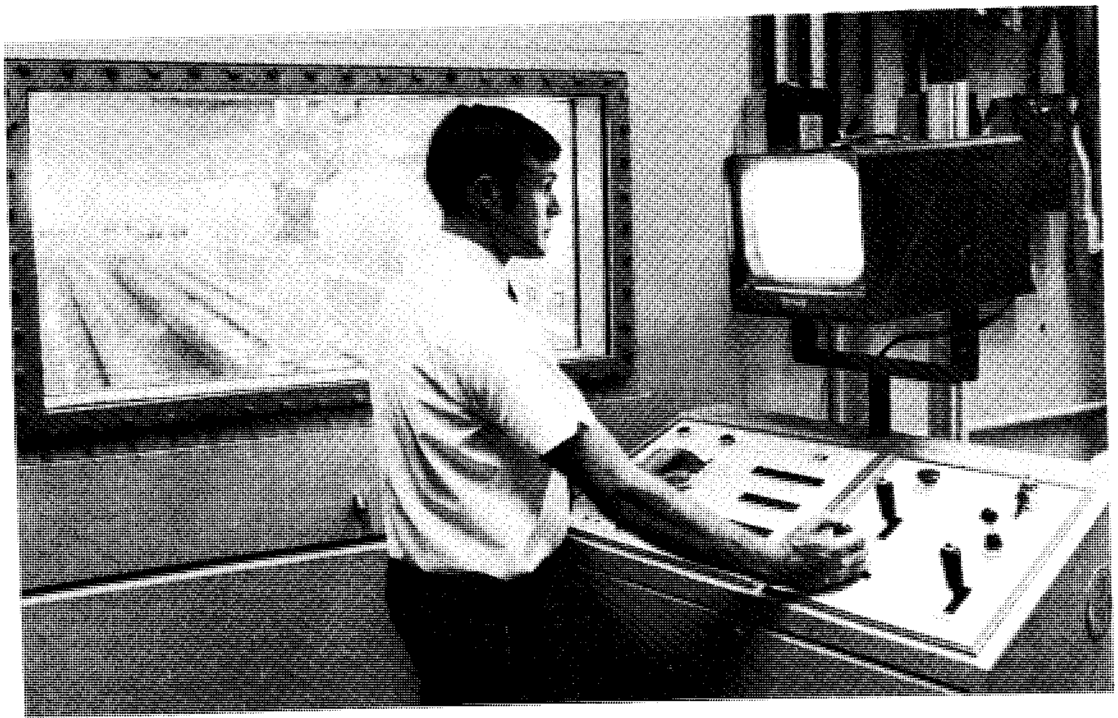


Figure 2.5.2-1 Storage Vault and Retriever

Used molds are recoated in a glove box prior to being reused. Unusable molds and plutonium scrap generated in the process lines are removed from the lines in protective bags. The material is then monitored and shipped in metal drums to other process buildings for recovery or disposal. When no longer usable, molds containing plutonium above specified limits are processed to recover the plutonium. The remaining waste material and molds, monitored to be sure they are below specified plutonium limits, are transferred in sealed containers to a DOE-approved waste storage facility.

Plutonium ingots are processed through metallurgical operations involving reduction rolling, blanking, forming, and heat treating. Metal scrap from these operations is then degreased -- a process for removing oils and greases from metal surfaces, particularly the oily film remaining from forming operations. The scrap is then recycled through the foundry.

Machining operations are performed on engine lathes, jig borers, and numerical control machines. Hydraulic oil coolant for the machines is circulated through 30-micron filters for plutonium removal and, when discarded, is pumped through one-micron filters into storage tanks. From these tanks, the oil is again filtered, then processed and converted into a gel for transfer to a DOE-approved waste storage facility. Carbon tetrachloride is used to wash oil from parts, tools, gloves, and machines, and for degreasing turnings prior to briquetting. Carbon tetrachloride is used in glove boxes. The employees are protected by the glove-box containment from breathing the fumes and coming into contact with the liquid. An estimate of the amount of carbon tetrachloride released to the outside atmosphere, based on the rate of consumption (See Section 2.8), is 0.79 grams per second. This release is well below the limit set by the Colorado Air Pollution Control Act, Regulation Number Eight, of 44.7 grams per second. Used carbon tetrachloride is handled in the same manner as spent oil coolant.

Plutonium parts are ultrasonically cleaned with trichloroethane and, when required, are radiographed. The parts are dimensionally inspected using surface plates, optical comparators, and electronic gauges with laser interferometers. Special glove boxes are used to store, repair, and calibrate gauging equipment. Following inspection the parts are assembled with other components. The term "assembled" includes such operations as cleaning, brazing, marking, welding, weighing, matching, sampling, heating, and monitoring for surface contamination. "Cleaning" refers to such varied methods as wire brushing, ultrasonics, wiping, and vapor degreasing. "Marking" means gritblasting and electromarking. "Inspection" assumes many forms and uses a variety of aids: destructive and nondestructive testing, radiography, visual methods, gauging, ultrasonics, tensile tests, eddy currents, dye penetrants, and acoustic emission. "Welding" may be in the form of Tungsten Inert Gas (TIG), Pressurized Inert Gas Metal Arc (PIGMA), Electron Beam (EB), or resistance welding. "Brazing" refers to metal joining using vacuum induction furnace or electron bombardment techniques.

Plutonium research and the recovery of scrap are described in Sections 2.5.6 and 2.5.7.

2.5.2.2. Health and Safety Aspects of Handling Plutonium

Plutonium is a silvery grey metal which is warm to the touch. It turns quickly to a dull greenish-gold color upon exposure to air. The surface oxide which forms in air is loosely attached to the metal, and is easily brushed from it. The oxide is a very fine powder which adheres to surfaces with which it comes in contact. It is insoluble in water, but it can usually be removed by washing with a detergent solution.

Plutonium-239 isotope emits alpha and gamma radiation. The gamma radiation is of low energy. Workers are shielded from the gamma radiation by means of lead-impregnated glass and lead-impregnated gloves in the glove boxes (Section 2.5.1.1) and by the containers in which the metal is transported and stored. Alpha radiation penetrates only a few hundreths of a millimeter of tissue, and therefore cannot cause physical damage, as long as its source remains outside the human body.

The primary precaution for handling plutonium is to prevent situations in which oxide could be introduced into the body. Workers with open wounds do not work in the plutonium-handling areas. No smoking, eating, or drinking is allowed in the plutonium areas. Plutonium is always contained by glove boxes or special containers in normal operations. To detect possible breach of containment, workers make frequent inspections, including (1) self-monitoring of hands when removing them from a glove box and (2) monitoring of clothing when leaving the plutonium area.

If containment is breached the following precautions are taken:

1. Plutonium oxide is washed from skin and the worker's clothing is removed so that no plutonium oxide will be subsequently ingested or inhaled.
2. If plutonium oxide could be present in the air, a respirator is worn or an air supply is provided.
3. If a wound or laceration occurs, plutonium oxide must be removed. This can usually be accomplished by washing. Plutonium toxicity is discussed in detail in Volume II, Appendix G.

Most plutonium metal in bulk form is not easily ignited. Finely divided or reactive plutonium is combustible. Easily ignited forms include powders, turnings and chips from machining operations, and skull (i.e., the impurity-containing waste from the top of a casting). Many other metals, including steel, are combustible when they are in these forms. Precautionary measures taken to prevent combustion include the following:

1. Inert atmospheres are used in glove boxes.
2. Forms which are readily ignited are converted to stable (i.e., twice burned) plutonium oxide within 24 hours of their formation.
3. Introduction of any combustible into the glove box line is avoided. When it is necessary to use combustible materials in the line, they are carefully controlled.
4. Plutonium metal is stored in special containers in contact with heat detectors.

Nuclear Safety functions control plutonium storage and handling so that a state of self-sustaining fission or nuclear criticality will not occur. The quantity, geometry, and physical form are factors which are considered in establishing nuclear materials safety limits, i.e., the quantities of fissile material of a stated type which may be located in a defined place. The nuclear safety controls are discussed more fully in Section 3.2.2.6.

There are many restrictions, controls, and required procedures which apply to the handling and transport of plutonium, operations involving it, and practices within plutonium areas. These are enumerated in the Rockwell International Health, Safety, and Environment Manual and in operational safety analyses documents. Workers who handle radioactive materials must be certified to ensure that they know and understand the restrictions and procedures. Radiation Monitors (Section 2.6.2.6) provide special assistance in detecting radiation or radioactive material outside normal confinement.

All employees wear personal dosimeters which measure the amounts of external radiation which they receive. Analysis of urine and body counting techniques provide measurement of any internal radioactivity which may be present. (See Appendix H.)

2.5.3 Beryllium Fabrication

2.5.3.1 Operations

Clean, solid-metal, beryllium scrap from commercial sources and other DOE facilities is shipped to Rocky Flats and mixed with scrap from Rocky Flats' processing. The combined scrap is placed in graphite crucibles coated with beryllium oxide (BeO) and melted in a vacuum furnace. The molten metal is poured into a BeO-coated graphite mold and allowed to solidify and cool before being exposed to foundry air. Exhaust streams from the furnaces are pumped through a single-stage roughing filter, and with the room air, through a series of HEPA filters before being vented to the atmosphere. Exhaust stacks are continuously monitored for beryllium.

The ingot is sawed into slabs, called billets, that are machined by a milling operation. Flooding the saw and mill cutter with machining oil prevents airborne contamination. Used oil is combined with a solidifying agent, placed in metal drums, and transferred to a DOE-approved storage site.

A steel "can" is welded around the billet in such a way that the billet is vacuum sealed to protect the beryllium from the atmosphere during subsequent operations. The canned beryllium billet is then heated in an electric furnace that is continuously purged with the inert gas, argon. After being heated, the canned billet is reduced in thickness by rolling and is then annealed.

The steel can is cut away, etched to remove residual beryllium, and sold as scrap. Solid beryllium scrap is recycled back into the casting step. The remaining beryllium is etched, reduced in thickness (rolled), annealed, and cut into the desired shape. Surface oxidation that occurs during rolling is removed by etching each blank with nitric acid. The blanks are once again heated and formed into the desired configuration. Once formed, the parts are air-cooled and undergo a final heat treatment.

The parts are machined in a special machine shop reserved for beryllium work. All machines in this shop are equipped with a high-speed air down-draft system that removes machining chips as they are generated, and collects them in drums that are isolated from the atmosphere. These chips are not exposed to machining oil; consequently, they are clean, dry, and can be reused or sold as scrap to the beryllium industry. Machined parts are "chemically milled" in a solution of phosphoric, chromic, and sulfuric acids. Fumes from this operation are "scrubbed" in a caustic scrubber prior to discharge into the filter plenum.

Some beryllium is welded by melting regions of a part and mixing it with molten aluminum. This work is always done in a protected environment, either inert gas or vacuum. Beryllium is analyzed at the Rocky Flats Plant by certain laboratory operations. Resulting residues are disposed of by packaging and shipping to long-term storage at a DOE-approved site (see Section 2.7.4).

2.5.3.2 Health and Safety Aspects of Handling Beryllium

Many beryllium compounds are toxic and, if inhaled, can give rise to clinical conditions frequently characterized as "beryllium disease." Other terms are sometimes used, such as "beryllium poisoning," "beryllium intoxication," and "berylliosis." Inhalation is the primary mode of beryllium entry into the body, and clinical symptoms may be either acute or chronic. The effects of acute exposure include

1. Skin effects such as dermatitis, conjunctivitis, and ulceration of contaminated lacerations. Healing of contaminated wounds may be incomplete until the beryllium is removed.

2. Upper respiratory effects such as swollen mucous membranes, bleeding, fissures, and ulceration.
3. Lower respiratory effects such as cough, chest pains, and shortness of breath.
4. Chemical pneumonitis and pulmonary edema.

Chronic beryllium poisoning usually affects the respiratory tract and often occurs after a long latent period of 5 to 10 years, or even 20 years or more. The chronic disease is often triggered by a biological trauma such as illness, surgery, or pregnancy. Death may occur after a long duration and is usually caused by pulmonary insufficiency or heart failure. In recent years, long-term steroid therapy has proven effective, and the prognosis of chronic beryllium disease has been altered favorably. Detailed evaluations of beryllium health effects have been performed by the EPA in establishing effluent limits, and literature covering this work is available (USEPA, March 1973).

Protective measures against dust containing beryllium particles require good housekeeping; proper ventilation, including the use of exhaust hoods; immediate availability of respiratory equipment; and performance of certain operations under "wet" conditions. Room-air monitoring and smear samples of floors and fixtures are used to evaluate the effectiveness of the protective measures. Employees in beryllium areas wear protective clothing; they must wash before eating, drinking, smoking, and prior to leaving the work area. These precautions protect employees from inhaling beryllium in quantities exceeding the Occupational Safety and Health Administration's Threshold Limit Value (TLV) of 2 $\mu g/m^3$ of air (time-weighted concentration for an 8-hour day of a 40-hour week). Air samples collected on beryllium operations consistently average less than 10% of the TLV.

In 1972 the National Institute of Occupational Safety and Health (NIOSH) issued a "criteria" document concerning beryllium and listed it as carcinogenic. More recently, NIOSH proposed that the standard of 2 $\mu g/m^3$ be lowered to 0.5 $\mu g/m^3$. Much of the basis for this proposed reduction was the result of a series of reports, Bayliss I and Bayliss II (NIOSH, 1971 and 1972) and papers by T. F. Mancuso (1970) and W. D. Wagner and others, (1969). A later report, Bayliss III, claims on epidemiological grounds that human beings exposed to beryllium incur a lung cancer risk. If accepted, this report strengthens the Government's case. These papers have produced discussion about the carcinogenic potential of beryllium because of the controversial interpretations and data included in the reports (Shapley, 1977). Mancuso's study suggested a slightly higher cancer rate in those persons having prior respiratory illness. Industry has sharply questioned the data and interpretations from these reports. It has been pointed out that the largest number of lung cancer cases in the Bayliss III report occurred among workers employed by the industry five years or less and that four cases that had been classified as being there for approximately 20 years actually worked there a year or less. Moreover, it has been found that of the 47 reported lung cancer cases, some 30 had worked for the beryllium industry less than 1 year, 24 had worked less than 6 months, 17 had worked less than 3 months, and 1 had been hired and terminated the same day.

These studies, which in themselves have questionable statistical validity, have been performed on occupationally exposed persons where the levels of exposure are much higher than environmental levels to which the public might be exposed.

2.5.4 Uranium Fabrication

2.5.4.1 Operations

Depleted uranium, enriched uranium and, intermittently, uranium-233 are handled at Rocky Flats. Depleted uranium has a percentage of uranium-235 smaller than the 0.7% of the total weight. Complete chemical analyses of all uranium alloys are conducted routinely in the Analytical Laboratory, which uses samples of machine turnings, saw chips, or broken parts.

The fabrication of depleted uranium alloys is an important process at Rocky Flats. An electrode consisting of a depleted uranium tube is filled with appropriate alloying material. The tube and contents are arc-melted into a cylindrical copper mold. This mold is water cooled in a closed system. The first-melt ingots become the electrodes for arc remelting into ingots having slightly larger diameters. These ingots are then sawed into billets or pucks for further processing.

Consolidation of recycled, depleted-uranium-alloy scrap is the main function of one of the Plant's foundries. Large ingots for extrusion, rolling, and forging are also cast in this area. Occasionally, shaped castings are made that require only finish machining. This foundry also stores feed uranium and burns waste uranium chips and scrap into an oxide form for DOE-approved, off-site storage. Rough-formed parts or rough castings are turned into finished parts in this general area. After being inspected and before final off-site shipment, finished parts are assembled into a component or are packaged and stored.

Depleted uranium alloys can be rolled, formed, extruded, shearspun, and swaged. Rocky Flats has the capability of machining billets from foundry-supplied ingots, machining test specimens, and mechanically and metallographically testing the specimens. Within this uranium processing area are billet preheating furnaces, vacuum heat-treating furnaces, and ovens capable of annealing and age hardening any of the alloys.

Uranium-233 is occasionally handled at the Rocky Flats Plant. It is handled within glove-box containment because of its specific activity being higher than other uranium isotopes handled at Rocky Flats.

The Plant has the capability for the machining and assembly of enriched uranium. Parts returned to Rocky Flats because of age are disassembled, and the enriched uranium is separated and sent to Oak Ridge, Tennessee for recycling.

2.5.4.2 Health and Safety Aspects of Handling Uranium

Enriched uranium contains alpha-emitting radionuclides. As in all work areas, handling precautions for uranium include the use of facilities having adequate ventilation, as recommended by the American Conference of Governmental Industrial Hygenists (ACGIH) (1974). Air samples and smear surveys are taken to verify the effectiveness of the controls. The radioactivity of depleted uranium is small per unit weight; therefore, the principal concern when working with this material is the element's chemical toxicity. If taken into the body, depleted uranium can cause damage to vital organs. The kidneys may be damaged as a result of uranium entering through a break in the skin. Inhalation may cause lung damage. Employees who handle uranium are required to shower before leaving a uranium area.

2.5.5 Fabrication of Other Metals

2.5.5.1 Operations

Equipment exists at Rocky Flats for rolling, conventional forming, hydroforming, high-energy-rate forming, extruding, heat treating, shearing, machining, electroplating, and inspecting many kinds of nonradioactive metals. In addition to beryllium (discussed previously), stainless steel and aluminum are the principal metals fabricated. Tantalum, titanium, tungsten, copper, cadmium, gold, silver, lead, and nickel are also used at various times for special order work and for research and development.

Forgings, pressings, and bar stock are machined by conventional methods, with a water-base coolant, into finished parts. The equipment used includes numerical control machines, engine lathes, milling machines, drills, and automatic threading machines. Finished parts are welded, electroetched, cleaned, and given nondestructive tests such as X ray, dye penetrant, and leak tests.

Precision machining, and tool grinding shops, located in areas that do not contain radioactive materials, fabricate tools, gauges, fixtures, graphite molds, and cutting tools for all areas of the Plant. These shops work primarily with tool steels and aluminum. They have complete heat-treating facilities, which include a salt bath, furnaces, and oil-quenching tanks, and have the capacity for turning, milling, welding, grinding, and electrical-discharge machining.

Machine shop personnel also work with tool steels and use machine tools to fabricate graphite molds. The tool grinding shop is used for fabricating all types of cutting tools from high-speed steels and carbides.

2.5.5.2 Health and Safety Aspects

Elaborate dust collection systems are used with the machine tools when graphite is cut and tools are ground. Coolants are used to control airborne emissions during the machining of steels and aluminum. Machinists and metallurgical operations personnel use personal protective equipment such as eye and hand protection and safety shoes. Industrial Hygiene surveys operations involving dye penetrants, welding, cleaning, heat treating, and oil quenching to ensure that personnel exposures to toxic or noxious materials are kept well below recommended standards.

2.5.6 Plutonium and Americium Recovery

2.5.6.1 Plutonium Recovery

The primary objective of the plutonium recovery process is the recovery of plutonium from all residues generated during plutonium-related fabrication, assembly, and research operations. Residues normally are solid materials varying in plutonium content from a few percent to almost pure plutonium metal suitable for use in foundry operations.

The success of the overall operation is measured by the purity of the plutonium metal produced, adherence to established operating procedures, the generation of a minimum amount of waste, assurance that discharges to the environment are at the lowest practicable level (ALAP), and that all discharges are well under all applicable EPA, Colorado Department of Health, DOE, and operating contractor emission level limits.

Plutonium recovery processes are divided into two categories, sometimes called "fast" and "slow" recovery. Some relatively pure plutonium residues require only a minimum of processing to produce a plutonium nitrate solution from which the pure plutonium metal can be extracted. This constitutes the "fast" recovery operation. On the other hand, some residues have high plutonium content but require extensive purification. These residues, plus residues having a low concentration of plutonium, require multiple operations to concentrate and purify the plutonium into a suitable nitrate solution. This constitutes the "slow" recovery operation. Both streams are then combined in the part of the process in which the purified plutonium nitrate solution is converted into plutonium metal.

The processing required for low plutonium residues and those residues requiring extensive purification ("slow" recovery) consists of the following operations:

1. Incineration--controlled burning of plutonium-contaminated waste to reduce bulk and convert metal compounds to oxides.
2. Residue Dissolution--acid leaching plutonium residues to get the plutonium into solution for further processing.
3. Laboratory Waste Processing--recovery of plutonium from waste residues of the laboratories that perform sample analyses for production control or in support of development studies.
4. High-Level Ion Exchange--selective anion and cation separations of liquid forms involving plutonium concentrations exceeding 0.005 g/l.
5. Chloride Salt Processing--removing plutonium and americium from molten salt and electrorefining residues.
6. Process Fume Scrubbing--cleaning various by-product gases, such as nitrogen oxide by washing them with caustic liquids to remove radioactivity and to neutralize acidic gases.

The "fast" recovery process encompasses the following steps, which are required to complete the recycling of the high-level plutonium streams and to purify the plutonium to the desired degree. These operations culminate in the conversion of purified plutonium nitrate solution to plutonium metal.

1. Oxide Dissolution--acid dissolution and leaching of plutonium compounds and residues from various sources, yielding a plutonium nitrate solution.
2. Feed Evaporation and Batching--concentration and blending of radioactive feed to achieve desired concentrations of acid, plutonium, and certain key impurities.
3. Precipitation--conversion of plutonium nitrate solution to solid plutonium peroxide.
4. Calcination--conversion of plutonium peroxide to plutonium oxide by heating.
5. Hydrofluorination--conversion of plutonium oxide to plutonium tetrafluoride, using anhydrous hydrogen fluoride vapor.
6. Reduction--conversion of plutonium tetrafluoride to plutonium metal, which is then transferred to storage until needed.
7. Americium Recovery--additional processing to change this radioactive by-product of the plutonium recovery process into oxide form.

A residue storage area is maintained for storing, transferring, and accounting for plutonium content in all materials constituting feed for the operations just noted. This area also includes facilities for packaging residues that are below the limit of recoverable plutonium. The latter residues are transferred to a DOE-approved storage site. The limits for recoverable plutonium vary according to the type of residue involved.

The side streams of waste liquids generated during the recovery operations and having plutonium content below approximately 10^{-3} g/l are treated in the process waste treatment plant (see Section 2.7.3).

2.5.6.2 Americium Recovery

A secondary objective of recovery processes is the recovery of americium, a transuranium element that appears in plutonium materials processed at the Rocky Flats Plant site as the result of the beta decay of ^{241}Pu. The only americium isotope of significant concentration found in plutonium materials processed at Rocky Flats is ^{241}Am. Radiation exposure from the gamma radiation (59.6 KeV) from ^{241}Am is controlled by shielding. Americium is periodically separated from plutonium residues.

Americium is separated from plutonium metal residues by contacting the molten plutonium with a halide salt mixture in an inert atmosphere. The americium is recovered from the resulting salt residue and is sold to the radioisotope pool at Oak Ridge National Laboratory, Oak Ridge, Tennessee.

A quantitative separation of americium from liquid process streams containing plutonium is done by a plutonium peroxide precipitation process. The americium fraction from this process goes to a waste-treatment facility where it is prepared for burial as solid waste.

All americium recovery operations are contained in glove boxes. Shielding from alpha and gamma emissions is provided for each process operation.

2.5.6.3 Safety and Environmental Concerns

Plutonium and americium are handled with great care and with particular attention to the safety of operating personnel. All operations involving plutonium and americium in any form are conducted in glove boxes or other enclosures to prevent direct human contact with the element. The chemicals handled in the chemical recovery process are contained within glove boxes. Strict adherence to operating rules is mandatory (see Section 2.5.1).

Exhaust gas streams are scrubbed to remove by-product gases such as nitrogen oxide or sulfur dioxide. Estimates of maximum possible airborne emissions are given in Section 2.8. Liquid wastes are handled as process waste liquids and are not discharged to the environment (see Section 2.7.3.2).

2.5.6.4 New Recovery Facility

Plutonium recovery operations will be transferred to a new plutonium facility now under construction. The present facility will then be used for research activities and limited plutonium recovery operations for out of the ordinary plutonium residues that require special recovery techniques and cannot be accommodated in the new facility. These residues can come from either research or production operations. The new facility will be a four-level, partially buried structure of reinforced concrete containing about 186,700 square feet of process floor space. This structure will house the physical and chemical operations for recovering and refining plutonium metal and americium oxide, plus a central vault for interim storage and automated retrieval of plutonium metal, in-process solid compounds of plutonium, and other materials.

In the new facility, as in the existing one, plutonium recovery operations will be divided into two general kinds: primary recovery and secondary recovery (comparable to "fast" and "slow" recovery). Primary recovery consists of those steps required to process impure plutonium metal and plutonium compounds to the pure metal. Secondary recovery consists of those processes required to reduce the concentration of plutonium in solutions to the lowest practicable level before they are transferred to the waste treatment facility. The plutonium recovery processes in the new facility will be isolated in glove boxes, canyons, vaults, piping, process equipment, and conveyor systems that are maintained under a controlled environment.

The new facility will include a building for fluorine storage, with a system capacity of approximately 150 pounds. Leak detection capability will be provided. The fluorine will be used to convert plutonium oxide to plutonium tetrafluoride.

Within the primary recovery operations, impure plutonium metal will be either (1) purified through a pyrochemical (molten salt) process or (2) converted to an oxide and then processed (together with other plutonium compounds) through a series of wet and dry chemical steps to produce a plutonium metal button of high purity. The general steps required are comparable to those previously listed for the existing facility.

Secondary recovery likewise will involve cycling various solutions remaining from the primary recovery processes and other sources through additional steps (filtration, ion exchange, precipitation). This will reduce the residual plutonium and americium content to a concentration of 10^{-5} g/l, as determined by precise laboratory analyses, to permit transferring the solutions to the waste treatment facility. Any residues (or solutions) containing plutonium or americium in excess of that limit will be recycled back through the primary or secondary recovery operations.

The modern equipment and improved technology to be used in this facility will minimize any release of plutonium to the environment.

2.5.7 Research and Engineering

Problems involving scientific investigation outside the capabilities of production personnel and equipment are the concern of Research and Engineering (R&E). Research efforts are chiefly directed toward developing and improving the methods by which metal parts are produced for nuclear weapons.

Research in the production-oriented fields of metallurgy, coatings, joining, material evaluation, nondestructive testing, machining, assembly engineering, and chemistry is conducted by many R&E groups in several areas of the Plant.

2.5.7.1 Metallurgy

The Physical Metallurgy group conducts fundamental investigations into the properties and behavior of a number of materials such as plutonium, beryllium, uranium, and several grades of commercial ferrous and nonferrous alloys. The effects of fabrication processes and chemical composition on crystal lattice parameters, microstructure, and mechanical properties are evaluated to characterize the materials and to improve or control the processes. Metallurgical support is provided for the development, process problem solving, and improvement of fabrication processes. Test procedures for material evaluation are developed and implemented.

Laboratory facilities provide capabilities in the areas of X ray diffraction, electron microprobe analysis, transmission and scanning electron microscopy, optical metallography, dilatometry, and mechanical testing. Alloys are melted and heat-treated on a laboratory scale.

Plutonium Metallurgy personnel perform metallurgical studies in the 700 Complex. Group projects encompass conventional casting, rolling, and forming of plutonium and its alloys. In addition, the metals may be fabricated by less conventional techniques such as swaging, high-energy-rate forging, electroshaping, and isostatic pressing. Extensive plutonium alloy studies are performed that require heat-treating, dilatometry, metallography, X ray diffraction, micro- and macrohardness testing, and mechanical testing. Powder metallurgy is also available as a fabrication technique. Plutonium Metallurgy provides Plant-wide metallographic services for plutonium-containing samples.

The activities and operations of the General Metallurgy group involve the fabrication of beryllium, uranium, and stainless steel alloys as a primary concern. Machining, metallography, and mechanical testing also support the fabrication program. Casting operations are done in the Production Foundry and in an R&D facility. Rolling is done in a Production facility and in another building in the 800 area. Other metalworking operations, such as forging, extruding, deep-drawing, shear-spinning, and swaging are also done in the 800 area.

Health and safety aspects of handling plutonium and of plutonium facilities (Sections 2.5.2.2 and 2.5.1.1, respectively), beryllium (Section 2.5.3.2), and uranium (Section 2.5.4.2) apply to R&D just as to Operations.

2.5.7.2 Coatings

The Coatings group develops physical vapor deposition processes. This includes electron-beam and electron-bombardment evaporation, hot hollow cathode ion plating, and other coating techniques. Many materials such as gold, silver, platinum, chromium, molybdenum, tungsten, beryllium, depleted uranium, enriched uranium, plutonium, aluminum, titanium, copper, and stainless steel are employed in this work. The function of the group is to develop coating processes for weapon applications as special order work and support to Production.

The Coatings group has 18 major coating systems. A coating system is composed of a vacuum chamber, a system of vacuum valves and pumps, multiple electrical power supplies, controllers, and instrumentation. These coating systems are located in seven different buildings and occupy about 10,000 square feet of floor space in R&D laboratories and production areas. The deposited coatings are characterized using technologies discussed in Section 2.5.7.1.

Plutonium coating operations are contained inside glove boxes. All other coating operations take place inside steel or glass vacuum chambers. The diffusion pumps, cold traps, and filters on vacuum pump exhausts prevent the escape of deposited materials. Fume hoods with strong air drafts are provided in the laboratory areas for acid-etching operations and cleaning equipment. Waste chemical residues are placed either in special process drains or in special plastic bottles for shipment to on-site processing facilities. All exhaust air from the laboratory areas is filtered before it is released. Air samplers installed in the laboratories detect the presence of airborne contaminants. Should a concentration of contaminants approach preset safety limits, alarms would be activated. The source is identified and corrective action is taken as appropriate. Air sampling is conducted at operations involving toxic materials outside glove boxes to verify that controls are adequate.

2.5.7.3 Joining

This organization is devoted to research and development of processes and equipment to support metal-joining requirements of new weapons programs, to improve existing joining processes, and to support manufacturing on production joining problems.

2.5.7.4 Nondestructive Testing

The Nondestructive Testing (NDT) organization performs the necessary research required to develop advanced nondestructive tests for new weapons systems. It applies developed test methods to new and existing weapons programs, transfers these tests to Nondestructive Testing NDT Operations, and follows up with support to NDT Operations for any process improvements or trouble-shooting that may be required.

2.5.7.5 Machining and Gaging

This organization develops machining techniques for all new weapons programs and supports manufacturing in-process improvement and process troubleshooting. Machining and Gaging R&D is engaged in research on new machining technology to develop surfaces that have greater contour accuracy, improved surface finish, and to develop improved gaging methods. Machining technologies such as electrodischarge machining, electrochemical milling and grinding, and precision lapping have been developed.

2.5.7.6 Operations and Plans

This group is responsible for program planning of R&D activities, budget control, and process development coordination. This department does no technical work.

2.5.7.7 Control Systems Development

This group is responsible for applying microprocessor control technology to production equipment to automate processes. The work is principally electrical and electronic in nature.

2.5.7.8 Chemistry

Chemistry R&D is concerned with (1) evaluating field return units, (2) corrosion experiments with plutonium, (3) the effects of radiation on materials, (4) surface chemistry, (5) radiometric counting systems to assay plutonium in process scrap residues, (6) monitoring instrumentation to prevent unauthorized movement of nuclear materials, (7) environmental sensors, (8) digital logic systems for process control, (9) methods for incinerating radioactive wastes, (10) vitrification, cementing, or coating incinerator ash for long-term storage, (11) methods for concentrating noncombustible liquid wastes, (12) processes for recovering and purifying actinides from waste streams, (13) improved processes for recovering and purifying plutonium by chemical, pyrochemical, and hydriding techniques, (14) metal cleaning and polishing, (15) improved glove-box gloves, gaskets, bags, bag closures, and filters, (16) water recycle systems, (17) containers for packaging, shipping, and storing long-lived transuranic nuclides off site, and (18) new dissolution, precipitation, solvent extraction, and ion-exchange recovery techniques.

2.5.8 Special Order Operations

In addition to war reserve (WR) production, special fabrication, testing, and assembly are provided for weapons development programs. Such special order projects are completed by special engineering and assembly groups. Special order work most often centers around WR prototypes. With DOE approval, however, it may also include work outside WR programs, such as modifications to truck tractors, trailers, railroad cars, and escort vehicles for the safe and secure transportation of nuclear materials.

2.6 SUPPORT ACTIVITIES AND FACILITIES

In close support of the principal Plant activities described in Section 2.5 are the following Plant functions and systems: Quality Engineering and Control; Health, Safety, and Environment; Security; Utility and Maintenance Services; Electricity; Fuel Systems; Inert Gas Systems; Water System; Steam System and Material Shipments.

2.6.1 Quality Engineering and Control

The functions of Quality Engineering and Control (QE&C) are to (1) maintain an effective quality program thru established quality manuals and plans, (2) establish requirements for quality based on design and contract specifications, (3) ensure that procurement and warehousing of materials conform to established requirements, (4) provide the controls over fabrication and assembly procedures, tools and gauges, nondestructive tests, chemical analyses, and shipping necessary to ensure that the products are built and delivered as required, and (5) analyze the causes of inadequate or variable quality to improve the product. These functions require inspecting, testing, calibrating equipment, performing chemical analyses of materials, obtaining corrective action when necessary, and issuing reports. QE&C is divided into five main sections: Quality Engineering, Service Laboratories, Standards Laboratory and Instrumentation Management, Nondestructive Testing, and Quality Acceptance.

2.6.1.1 Quality Engineering

The operating contractor maintains an effective quality program to ensure requisite levels of quality throughout all areas of contract performance. Quality will not be compromised in relation to costs or schedules. Controls are established and maintained through entire manufacturing processes from procurement of raw material to shipment of finished product. Results of inspections, tests, and evaluations are documented and analyzed for preventing or detecting and correcting deficiencies. An auditing program ensures that established quality and operating procedures are being followed.

After design reviews have established material requirements, suppliers are selected on the basis of audit evaluations and past performance. Suppliers are required to submit specified test data with incoming material. When received at Rocky Flats, the material is subject to verification inspection and tests. Any detected nonconformance is reported and appropriate corrective action is taken.

Numerous process control techniques are used as circumstances warrant. All operating procedures are first approved by Quality Engineering. Processes and product are qualified according to predetermined plans. The product is inspected or tested at the start of a production run and at established in-process intervals to ensure continuing competence of people and processes. Statistical quality control methods are available as process control tools. Any defects in the finished product are documented and are analyzed to detect trends or unsatisfactory conditions as a basis for management attention and corrective action.

2.6.1.2 Service Laboratories

There are three main service laboratories:

1. A Plutonium Laboratory measures the plutonium, the impurities, and the alloys in metals, liquids, and oxides. This laboratory can analyze gases and organics by mass spectrometry, gas chromatography, and by infrared and thermal techniques. It can measure the isotopes of plutonium, uranium, boron, and other elements.
2. A General Laboratory analyzes samples of uranium, stainless steel, gas, and environmental and miscellaneous samples. It can also use analytical methods such as atomic absorption, neutron activation, and X-ray fluorescence.
3. A Radiochemical Laboratory analyzes samples from Chemical Operations and measures tracer elements. It also makes microscopic, calorimetric, X-ray diffraction, fluorescent, and special investigations of miscellaneous samples.

More specifically, the service laboratories perform the following functions:

- Assay WR buttons, ingots, and samples for impurities, isotopic content, alloys, and major elements to determine compliance with chemical specifications and process controls; determine impurities in gases for compliance with specifications.
- Determine compliance with chemical specifications of miscellaneous vendor materials, such as glove-box gloves, chemicals, and aluminum.
- Determine plutonium, uranium, and impurities in re-submitted samples and chemical standards, with the required precision and accuracy.
- Measure inventory samples of metals, oxides, solutions, scrap, and sludges for plutonium and uranium content.

- Determine the elements requested in R&D samples for development control.
- Analyze environmental samples for compliance with State and Federal regulations.
- Develop and improve analytical methods for existing and new programs.
- Support other Plant operations such as Production, R&D, and Environmental Sciences with analyses, investigations, and measurements.
- Coordinate exchange programs for plutonium metal and isotope samples, beryllium samples, and plutonium oxide calorimetry samples; participate in uranium-metal sample program. (The exchange programs are with other DOE contractor and vendor laboratories to improve precision measurements, discuss methods and instrumentation, and improve communications.)
- Participate in programs sponsored or supported by DOE such as Safeguards, Half-Life Studies of Radioactive Isotopes, American Society for Testing Materials (ASTM), and Joint (U.S. and U.K.) Working Group (JOWOG), and programs to evaluate precision measurements and develop related analytical methods.
- Maintain efficient laboratory operations by the use of certified equipment and proven methods.

These Service Laboratories have the health and safety features found in all the process buildings: heat, neutron, and alpha radiation detectors, fire and sprinkler system alarms connected to the Fire Department, fire-rated doors, emergency generators, two and four-stage HEPA exhaust filters, eye baths, safety showers, safety glass in most glove boxes, and supplied-air availability.

2.6.1.3 Standards Laboratory and Instrumentation Management

A third section of Quality Engineering and Control is the Standards Laboratory (which includes three separate laboratories: Chemistry Standards, Dimensional Metrology, and Physical Metrology) and Instrumentation Management.

Chemistry Standards calibrates and certifies chemical, isotopic, calorimetric, radiometric, and volumetric measurements. Dimensional Metrology calibrates and certifies measurements of length, angle, surface finish, roundness, and other related conditions. Physical Metrology calibrates and certifies electrical, environmental, and mass measurements and standards. The functions of these three groups are as follows:

- Maintain certified reference standards and measuring equipment for traceable program measurements; maintain laboratories and provide staff suitable for these activities.
- Provide measurement services, such as calibration and control programs, and capability surveys.

- Maintain adequate records of calibration data and equipment status; notify users of the calibration status of their equipment.

The Instrumentation Management group controls instrument purchase, use, and disposal for the Plant, and periodically audits the equipment. Its central management emphasizes documentation of the use, maintenance, and calibration of equipment, to ensure full utilization.

2.6.1.4 Nondestructive Testing

Nondestructive Testing (NDT) provides services for the various manufacturing operations. NDT tests are performed to evaluate product. Groups like Waste Management, Industrial Safety, and Maintenance also use NDT services for the following tests:

1. Dye Penetrant for surface anomalies.
2. Radiography (X ray and gamma) for internal defects, gaps, positions, and measurements.
3. Ultrasonic Scanning for weld penetration, internal defects, bond integrity.
4. Eddy Current for weld penetration, coating thickness.
5. Acoustic Emission for yielding of material under stress.
6. Tensile Testing for specific physical properties of materials.
7. Leak Checking for leak rates.
8. Density Determination of materials.
9. Weighing.
10. Leak, Eddy Current, Pressure, Drop, Tensile, and Burst Tests for Waste Management.

Nondestructive Testing performs the following functions:

- Evaluates test results for compliance with acceptance criteria.
- Maintains records of tests.
- Reports defective conditions.
- Develops testing procedures to meet the demands of specifications.
- Works with design agency NDT groups to ensure continuity in design intent and establishes new techniques and parameters.

2.6.1.5 Quality Acceptance

This section of Quality Engineering and Control is appropriately discussed last, for it acts as the Rocky Flats Plant's agent in certifying the product to the customer. To accomplish its goals, Quality Acceptance is divided into three inspection groups, one each in the 400, 700, and 800 Areas; a Gauge Control and Evaluation Group in the 700 Area; and a Final Quality Acceptance and Certification group in the 400 Area.

Quality Control Inspection

- Provides acceptance inspections of hardware, components, subassemblies, and assemblies; records inspection results.
- Provides inspections for setup evaluation, process control, capability studies, procurement, and special orders.
- Reports defects as directed by Quality Engineering.
- Checks the calibration status of measuring equipment.

Gauge Control and Evaluation

- Participates in pre-production planning to determine gauging requirements.
- Originates tool orders and requisitions for gauges used for process control and final acceptance; obtains design agency approval of gauge designs.
- Conducts measurement capability studies.
- Provides information for written inspection procedures.
- Resolves inspection and gauging problems.
- Reviews specifications for their effect on inspection procedures and equipment.

Final Quality Acceptance and Certification (FQAC)

- Reviews quality evidence for compliance with specifications.
- Ensures that materials or parts to be accepted can be traced to acceptable sources.
- Makes certain that all operations have been satisfactorily performed according to the current written procedures.
- Physically controls procured WR product, Waste Management supplies, and in-process material until required inspections and tests are completed.
- Keeps records of WR product.
- As directed by DOE Quality Assurance Inspection Procedure (QAIP) instruction sheets, acquires the necessary quality evidence and originates the Certificate of Inspection (CI) for product to be submitted to DOE's Quality Assurance Inspection Agency (QAIA).
- As the authorized acceptance agent, signs the CIs certifying to DOE that the product meets specifications.
- Assembles stockpile records for storage per design specifications.

2.6.2 The Health, Safety, and Environment Program

From its beginning in the early 1950's, Rocky Flats has always had a safety program designed to promote personnel safety and protection of the environment. The program is detailed in the Health, Safety, and Environment Manual defining standard safety policies and practices for the following subjects: Accident Prevention, Accident Investigation and Reporting, Chemical Safety, Engineering and Construction, Electrical Safety, Explosives Safety, Fire Safety, General Industrial Safety, Health Sciences, Industrial Hygiene, Land Use, Laser Safety, Material Handling, Mechanical Safety, Metals Safety, Medical Program, Nuclear Criticality Safety, Pressure Safety, Personal Protective Equipment, Radiation Protection, Signs and Warning Devices, Traffic Safety, Training, and Waste Disposal.

The effectiveness of the Health, Safety, and Environment Program is highly dependent upon the skilled and conscientious actions of individual employees and functional groups of the Plant. To have a knowledgeable work force, safety training has always been a part of the operations at the Rocky Flats Plant. Since January 1977, several new certification courses have been developed and implemented to ensure that personnel are thoroughly trained in their areas of responsibility. These certifications provide documented assurance that training and retraining are accomplished as required. Currently over 35 certification or recertification courses are being implemented.

To foster awareness of safety and environmental responsibilities, safety meetings are held monthly by operating and support organizations, area inspections are conducted daily and monthly, and Safety Bulletins are issued as needed. The Plant is now in its third year of having an employees' incentive program that encompasses all areas of health, safety, and environmental performance. Employees are awarded cash equivalent coupons for meeting predetermined goals based upon improving past performance. In addition, safety meetings and periodic all-employee meetings with the General Manager emphasize employee awareness for protecting the Plant and the environment.

The Health, Safety, and Environment Department works with functional groups to ensure that Plant operations are conducted within Federal and State regulations, ERDA Manual Chapter limitations, and DOE and operating contractor guidelines. Potentially hazardous operations are analyzed from the standpoint of worker safety, nuclear criticality safety, radiation protection, fire safety, environmental protection, and industrial hygiene. The formalized safety review program was implemented in April, 1977. Salient features of this review are as follows:

1. Operating personnel perform an Operational Safety Analysis (OSA) on a proposed job. This analysis identifies each part of a total operation, the risks associated with each part, and what will be done to eliminate or minimize the risk. The analysis is reviewed by Health, Safety, and Environment personnel.

2. The OSA is then submitted to an independent safety review committee comprised of employees from a variety of technical disciplines with a chairman and majority members not in the organization originating the OSA. The review committee may require further analysis or changes prior to recommending approval.
3. Approval of the OSA and implementation of the operation can be made at the Director (General Staff) level only. Disagreement with any requirements of the OSA by a Director are resolved first with the Health, Safety, and Environment Director or, if that fails, by the General Manager.

Quality Program Plans have been developed by the various operational, research, and support groups to ensure the reliability of protective devices and systems. Completed quality program plans include those for glove-box gloves, radioactive sources, dosimetry of personnel, nuclear materials safety limits, respiratory protection, High Efficiency Particulate Air (HEPA) filters, industrial hygiene, waste processing, and for material packaging, shipping, and transportation.

The Health, Safety, and Environment Department is divided into the following six groups: Medical, Nuclear and Facilities Safety, Environmental Sciences, Health Sciences and Industrial Safety, Radiation Monitoring, and Fire Protection Engineering. Its functions are discussed briefly in the following sections. The information on the Environmental Sciences programs has been updated since issuance of the DEIS to reflect current conditions, procedures, and practices.

2.6.2.1 Medical

Guided by the basic program defined in ERDA Manual Chapter 0528, the Medical Department provides for the health of Plant employees through periodic physical examinations and emergency medical care. The Medical Department has written agreements with St. Anthony, St. Luke's, and Colorado General Hospitals for the care of radioactively contaminated injured employees.

2.6.2.2 Nuclear and Facilities Safety

The Nuclear and Facilities Safety group is divided into the Nuclear Safety and Safety Analysis groups.

Based on its technical analyses of operations involving fissile material, the Nuclear Safety group establishes stringent controls of geometry, mass, form, volume, and concentration of these materials as safeguards against nuclear criticality incidents. The standards for operation of the critical mass laboratory are prescribed in Chapters 0530 and 0540 of the ERDA Manual.

The Safety Analysis group, as outlined in ERDA Manual Chapter 0531, reviews new building construction and changes to existing buildings for conformance with safety standards. The group reviews Plant projects for facility and equipment designs, reviews standard procedures and other documents, solicits comments from all applicable sources of safety information, and coordinates these comments with Facilities Engineering and Construction. The group reports deficiencies in facilities to management and monitors subsequent corrections. The group also reviews and solicits reviews of the safety of changes in the use of space proposed by Industrial Engineering, consolidating these reviews and presents them to Industrial Engineering.

Safety Analysis personnel also generate Safety Analysis Reports. A Safety Analysis Report (SAR) is a document showing that a facility and its safety-related systems can be operated with reasonable assurance that there is no undue risk to the health and safety of the worker, and that adequate provisions are made for the protection of property and the environment.

Several SAR's are currently being generated, one for the overall Plant site and others for various plutonium facilities. Those safety-related features common to plutonium facilities, and those that cannot be included with a specific facility SAR, are discussed in the Plant Safety Analysis Report. Individual facility SAR's document safety aspects for particular plutonium-handling buildings and those structures within the complex that support this facility.

2.6.2.3 Environmental Sciences

This group routinely monitors and conducts special studies of the air, water, soil, and vegetation of the Rocky Flats Plant environment for radioactive and non-radioactive pollutants. This program is discussed in Section 2.10. The special studies help to understand and quantify the effect of the Plant on its surroundings. Approximately 90,000 samples are collected and analyzed yearly. In addition, ERDA (now DOE) has funded studies by the University of Colorado and Colorado State University concerning the Plant's environmental impact. These are discussed in Sections 2.10.4 and 2.3.10.

The Environmental Sciences group reviews effluent standards and resolves emission irregularities, recommends changes to minimize the environmental impact of new construction, and has prepared a land management plan, currently being implemented, for the buffer zone (see Section 2.3.10.4).

The guides used for decision and planning in environmental control and protection include ERDA Manual Chapters 0510, 0513, and 0524, the EPA Safe Drinking Water Act (40 CFR 141), Primary Drinking Water Regulations for the State of Colorado, NPDES discharge permit (Appendix D), the Colorado Air Pollution Control Regulations, the Guideline for Land Disposal of Solid Wastes (40 CFR 241), and the Resource Conservation and Recovery Act as it pertains to disposal sites for nonhazardous wastes. Several other standards and regulations, some in draft form, are not directly applicable to Rocky Flats are presently used as internal guides.

2.6.2.4 Health Sciences and Industrial Safety

In accordance with standards outlined in ERDA Manual Chapter 0550, the Health Sciences and Industrial Safety group supports Plant operations. Implementation is through the following subgroups: Health Physics (Radiological Safety), Industrial Safety, Industrial Hygiene, and Radiation Instrumentation. Health Physics defines the air sampling program within the buildings, nuclear criticality alarm systems, X-ray equipment, control and accountability for radioactive sources, limits of surface contamination, radiation exposure and shielding requirements, emergency response, personnel protection requirements, and surveillance equipment, and supervises the respiratory protection program. Health Physics personnel monitor Plant employees for lung and systemic burdens using body counting and radiochemical techniques. Standards of operation are outlined primarily in ERDA Manual Chapters 0524, 0502, 0529, 0531; American National Standards Institute (ANSI) Standards 5.1, N16.2, 13.1, N-328, 288.2, N2.3; and the Rocky Flats Emergency Plan.

Industrial Safety supervises the application of a variety of published safety standards for the protection of employees, the general public, and the environment as outlined in ERDA Manual Chapters 0502, 0506, and 0550. The standards are defined by such sources as the American National Standards Institute (ANSI), the U.S. Department of Transportation (DOT), the National Fire Protection Association (NFPA), and the Occupational Safety and Health Administration (OSHA). The Industrial Safety group assists supervisors and employees in maintaining levels of performance consistent with the Plant's safety program. In addition to staff support, the Industrial Safety department is comprised of five Health, Safety, and Environment Area Representatives who act as the liaison between the Plant and all HS&E disciplines. The HS&E Area Representatives coordinate and participate in the development of an Operational Safety Analysis (OSA) for all jobs that have a potential safety impact.

Industrial Hygiene ensures that employee exposure to nonradioactive toxic substances and stress-producing agents is well within established standards. Industrial Hygiene personnel assess worker environmental conditions in such areas as noise, lighting, and the use of solvents and microwave equipment. The group inventories hazardous materials and chemicals used in Plant processes. The applicable ERDA Manual Chapters are 0506, 0550, and ERDA Appendix 6301.

Radiation Instrumentation supports the Health, Safety, and Environment Department's use of the best available instrumentation in that department's many functions and provides the necessary testing, maintenance, and calibration of those instruments. Calibration standards are traceable to the National Bureau of Standards.

2.6.2.5 Radiation Monitoring

Radiation Monitoring provides support to all groups in the Health, Safety, and Environment organization. Radiation Monitoring supports Industrial Hygiene activities and Environmental Sciences in the collection of effluent and environmental air samples. Radiation Monitoring provides the support necessary to implement Health Physics requirements for Radiation Control areas. This includes surveillance for Production, Maintenance, Laboratory, and R&D operations, as well as for Site Survey operations for areas outside the process and laboratory buildings. Radiation Monitoring responsibilities include radiation-safety building indoctrinations, performing contamination surveys of personnel and material, and supporting decontamination operations with recommendations for appropriate control measures. In addition, Radiation Monitoring participates in alarm responses to evaluate radiation levels, supports supplied air operations, performs qualitative respirator fitting, and provides monitoring support for emergency teams.

2.6.2.6 Fire Protection Engineering

Fire Protection Engineering (1) reviews new building construction and changes to existing buildings for conformance with fire safety standards, (2) performs assessments of all buildings and structures and dictates the requirements for levels of fire protection based on DOE criteria such as ERDA Manual Chapters 0550 and 0552, (3) maintains liaison with the Rocky Flats Fire Department to provide for their requirements for all Plant facilities, and (4) maintains liaison with RFAO and ALO Fire Protection personnel to ensure that their requirements are met.

2.6.3 <u>Security</u>

Because of the classified nature of many Plant processes, the value of DOE property, and the safety of personnel charged with Plant operation, Security performs valuable supporting services in the area of access control, Plant and personnel protection, communications, document control, and control of special materials. These security functions are defined in the Rocky Flats Security Manual and are further detailed in Section 2.12.

2.6.4 <u>Utility and Maintenance Services</u>

All Plant utility systems are operated and monitored on an around-the-clock basis by stationary operating engineers. The systems included in this surveillance are

- Water treatment system (Section 2.6.8)
- Sewage treatment control and disposal system (Section 2.9.1)

- o Steam production and distribution system (Section 2.6.9)
- o Building heating, cooling, ventilating, and filtering systems (Sections 2.6.9, and 2.7.1)
- o Inert, air-drying, and exhaust systems (Section 2.6.7)
- o Breathing-air life support systems
- o Plant and instrument air supply systems
- o Building vacuum systems
- o Chilled water and cooling tower systems (Section 2.6.8.2)

A minimum of two utility operators are on duty at all times at the steam plant and in buildings where plutonium is processed. Operators monitoring the water treatment plant and the sanitary sewage plant are certified by the Colorado Plant Operators Certification Board.

Support Operations has charge of the Laundry; the Filter Certification Laboratory; Custodial Services; and the Garage, Trucking, and Labor department. Maintenance of Plant installations and equipment is performed by skilled mechanics, pipefitters, sheetmetal workers, carpenters, painters, and electricians.

2.6.4.1 Laundry

The operating contractor furnishes appropriate clothing and respiratory equipment to Plant personnel wherever it is determined that such clothing and equipment is necessary because of working conditions. The Rocky Flats Plant Laundry provides clean clothing and respiratory equipment to these areas. Laundry personnel launder, sort, repair, fold, check for contamination, and redistribute clothing to 16 locker-room areas throughout the Plant. The clothing includes undershirts and shorts, socks, coveralls, shop coats, booties, caps, and bath towels. Approximately 125,000 to 150,000 pounds of clothing are laundered each month.

Both full-face and half-mask respirators are cleaned and repaired in the Laundry after used cartridges are removed. The cleaned respirators are fitted with certified cartridges and sent to the certification laboratory. Each respirator is then checked for integrity and returned to Radiation Monitoring stations throughout the Plant.

The laundry equipment includes three 400-pound washer extractors and six 100-pound-capacity dryers. Half-mask respirators are cleaned and dried in a spray-type washer with a steam-heated drying hood. Full-face masks are washed in a converted 100-pound clothes washer and dried in a 50-pound dryer with tumbler removed.

The exhaust air from all clothes dryers and washers is exhausted through a HEPA filter plenum. The exhaust stack downstream of the filters is continuously sampled for any possible plutonium release. Laundry water is piped to Pond B-2, unless alpha radioactivity concentrations exceed 1667 pCi/l. In the latter case, it is processed through the process waste treatment plant (see Section 2.7.3 and 4.4.3.1).

2.6.4.2 Filter Certification Laboratory

Air that is exhausted from facilities handling beryllium, plutonium, and uranium passes through various stages of High Efficiency Particulate Air (HEPA) filters. HEPA filter policy and practices are discussed in Section 2.7.1.

The HEPA filters are purchased from various manufacturers. Before any manufacturer starts production of these filters for the Rocky Flats Plant, the media of the filters must be qualified by the Rocky Flats Filter Certification Laboratory. The media is tested for penetration, resistance, thickness, and tensile strength. Before the filters are shipped from the factory, the efficiency and resistance of each one is determined by the manufacturer.

After receipt of the filters at the Rocky Flats Plant, the Filter Certification Laboratory confirms the efficiency and resistance of each one. The laboratory checks each filter for overall penetration and resistance at rated flow and at 20% of rated flow, using procedures developed by the Division of Operational Safety of DOE.

In compliance with Occupational Safety and Health Act Regulation 1910.134, "Respiratory Protection," the Laboratory tests all filter cartridges subsequently fitted to respirator masks. In addition, it maintains control of these cartridges through their lifetime, and leak-checks each respirator mask. Respirator masks are tested for fit on each user.

HEPA filters and respirator cartridges are tested on specially designed equipment utilizing a reproducible, nontoxic, monodispersed, thermally generated aerosol called dioctylphthalate (DOP). The test is done with particles having a diameter of 0.3 μm as it is known that particles of this size have maximum filter penetrability (Spurney, et al., 1969). Penetrability tests show an efficiency of 99.97% for the 0.3-μm particles. All measuring instruments on the test equipment are calibrated and certified by the Rocky Flats Plant's Standards Laboratory, which is officially recognized as a secondary standard laboratory by the National Bureau of Standards.

2.6.4.3 Building Sanitation, Housekeeping, and Services

The Custodial group at the Rocky Flats Plant provides janitorial and general handyman services for approximately 100 buildings encompassing office, cafeteria, locker, shower, laboratory, industrial, and storage space. Labor-saving janitorial equipment and high-quality supplies are provided this group to maintain their services at maximum efficiency.

The sanitation and cleanliness levels throughout these buildings are monitored by the Industrial Hygiene group on a monthly basis. Particular emphasis is placed on the sanitation of rest rooms, locker rooms, shower rooms, drinking fountains, cafeterias, food vending machines, and the Fire Department's living quarters.

2.6.4.4 Garage

The Government-owned inventory of the Garage consists of about 90 vehicles and 100 items of equipment. The Garage provides preventive maintenance, service, and repairs for all automotive and engineering equipment. Radio-controlled dispatching service for efficient utilization of the fleet is also provided.

The preventive maintenance (PM) schedule for the vehicles and equipment is controlled by a computerized program and includes exhaust emission tests per EPA specifications. Details and frequencies of PM inspection are established in accordance with manufacturer and DOE recommendations.

Vehicles are assigned to the various operating departments for the performance of such assigned functions as Plant protection, land and road maintenance, fire protection, mail pickup and delivery, and Plant services. Vehicular mileage averages approximately 600,000 miles per year.

2.6.4.5 Grounds Housekeeping

The Trucking and Labor group at Rocky Flats provides housekeeping and maintenance services for all grounds, walkways, roads, and parking areas.

Drivers operate various vehicles to pick up and deliver material, equipment, and personnel on and off site. They operate snow removal equipment to clean and sand approximately 13 miles of streets and 800,000 square feet of parking areas. In the winter months roughly 900 tons of about a 1.5% salt to sand mixture are used in the sanding operation. They also operate the dumpster trucks for removal of building waste.

Heavy equipment operators operate various pieces of equipment to provide service for groups on the Plant site. They perform such jobs as crane work, backhoe work for excavations, loader work for various jobs, and road grading to keep dirt roads up to standards. The sanitary landfill is maintained by one operator and one piece of equipment. Weed control on 400 acres inside the perimeter fence and along the two access roads also is maintained by the laborers and heavy equipment operators. Weed control operations are discussed in greater detail in Section 2.8.

The Labor group is responsible for maintaining the cleanliness of approximately 1,000 acres of Plant area, maintaining fences around the entire Plant site, loading and unloading freight coming in and going off the site, and moving all furniture and equipment on and off the Plant site. Their assigned responsibilities also include providing help with Plant vehicles; outside housekeeping and beautification; planting and grooming of all lawns, trees, and shrubs; snow and ice removal from walks and building entrances; road and walk repairs with asphalt (approximately 1,000 tons per year); culvert installation and repair; rodent and pest control; and maintenance of ditches for water control.

2.6.5 Electricity

Public Service Company of Colorado provides the Rocky Flats Plant with two independent sources of electrical power, each with 115 kilovolts. The continuous rating of each of these overhead feeders, one of which enters the Plant site from the north and one from the south, is 54 million volt amperes (MVA). The utility company calculates that its capability at the three-phase primary distribution point, in the event of a fault or short (often referred to as the fault-level contribution), is 2,400 MVA from the north feeder and 2,130 MVA from the south feeder. These fault levels may increase in the future.

The peak demand on the electrical system has been approximately 20,000 kW. This figure is expected to increase to nearly 30,000 kW when the new plutonium recovery and waste treatment facility begins full operation. Electrical energy is now being consumed at the rate of 105 million kilowatt-hours per year; this figure will also increase, it is estimated, by about 40% with the added load of the new facility.

At present there are four primary substations. Figure 2.6.5-1 shows a typical, basic, electrical distribution system for one of the primary substations. Each primary substation is double-ended and secondary-selective with automatic transfer capability. In other words, each main substation is constructed so that each half of the transformer can sustain all normally connected loads, and the loads can be transferred if one of the two 115-kV sources should fail. Since both sources of power are available at both ends of each primary substation through manual switching, the substations can also be considered primary-selective in addition to secondary-selective.

Voltage is stepped down at the primary substations to 13.8 kV, and power within the Plant is distributed at that level through 25 miles of lines to the building substations. Most of these building substations are fed through aerial distribution; however, three principal buildings are fed from underground lines. Voltage is stepped down again from 13,800 volts to 2,400 or 480 volts at the building substations. There are now five substations of 2,400 volts each and about fifty 480-volt substations. With the completion of the new plutonium recovery and waste treatment facility, these numbers will increase to 9 and 54 substations respectively.

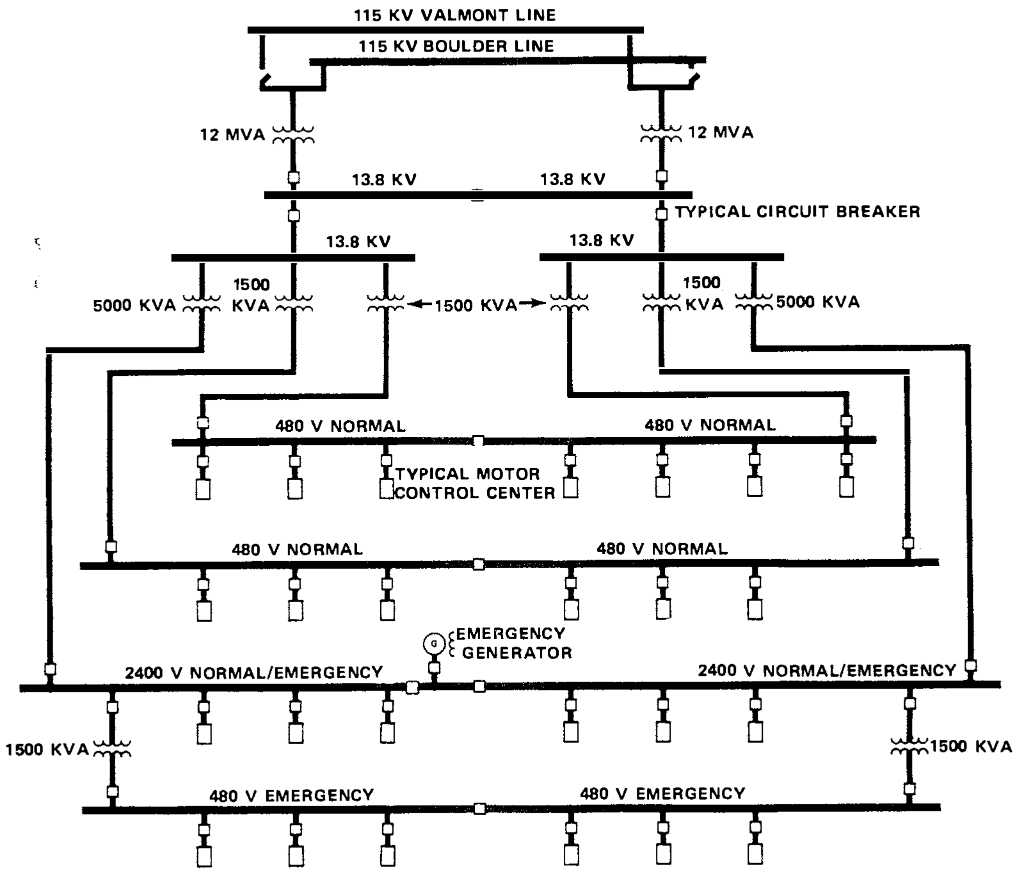


Figure 2.6.5-1 Rocky Flats Plant Typical, Basic, Electrical Distribution System

Transformers at the substations are not protected from the weather; they are designed for use under these conditions. However, the switching gear at each substation is protected from the weather.

Building substations for critical-system loads are double-ended and equipped for manual or automatic secondary-selective operation. In some cases, primary-selective capabilities are also provided. Building substations for noncritical loads are single-ended and primary-selective, with manual transfer switches.

A 2,300-volt series lighting system, automatically turned on and off by photoelectric cells, illuminates the nine exclusion-area fences and the Plant-perimeter security fence. Emergency circuits powered by diesel generators can illuminate every alternate light during a loss of normal power. Streets are illuminated by standard overhead lamps mounted on power-line poles. Like the fence lighting, the street lights and some building lights are automatically turned on and off by light-sensing devices. To improve night visiblity from the east and west guard posts, high-intensity mercury-vapor lamps, mounted about 35 feet high, were placed along the east and west approaches to the Plant's two main gates.

In the event of a total power loss from off-site sources, on-site emergency generators can power critical functions such as ventilation, humidity control, public address capabilities, alarm systems, and building lighting for at least 24 hours.

2.6.6 Fuel Systems

2.6.6.1 Natural Gas

Natural gas is purchased from the Western Slope Gas Company, which is a subsidiary of the Public Service Company of Colorado. Public Service buys almost all of its natural gas from the Colorado Interstate Gas Company. The Rocky Flats Plant purchases its natural gas on an interruptible basis, which means that during periods of high usage or need by the citizens served by the Public Service Company, the Plant's gas-burning equipment is switched to an alternate fuel, such as fuel oil or propane. The gas that the Plant would otherwise consume is then available for non-interruptible purposes such as homes and hospitals.

An eight-inch pipe carries the natural gas, at a pressure of 250 to 300 pounds per square inch (psi), from a metering station south of the Plant to a gas reducing station in the 800 complex. At this station, the pressure is reduced to 65 psi and mercaptan is added at the rate of one pound per million standard cubic feet for early detection of leaks. Western Slope's eight-inch pipeline and Rocky Flats' reducing station are adequately sized for foreseeable needs. Total natural gas consumption at the Plant for FY 1973, 1974, 1975, 1976, and 1977 was 726.3 million, 746.5 million, 746.5 million, 568.4 million, and 637.2 million cubic feet, respectively.

Most fluctuations in natural gas and fuel oil usage at Rocky Flats are the result of variability in natural gas availability to the Plant as an interruptible purchaser. If the total quantity of natural gas and fuel oil used at Rocky Flats were converted to Btu equivalents and then combined, a decreasing usage trend becomes obvious (see Table 2.6.6-1):

TABLE 2.6.6-1
DECREASING USAGE TREND IN ENERGY CONSUMPTION
1973-1977

Year	Billion Btu Used
1973	973
1974	867
1975	841
1976	716
1977	704

This downward trend reflects the energy conservation program initiated at Rocky Flats early in 1974. The conversion factors used to calculate the data shown above are: natural gas, 1031 Btu per cubic foot; fuel oil, 138,700 Btu per gallon (see Section 4.4.2.1).

Natural gas is an inherently clean burning fuel, as indicated in Table 2.6.6-2, and it is the preferred fuel for all Plant uses that are stationary. Because of Rocky Flats' interruptible status, however, and the probable shortage of natural gas in the foreseeable future, greater dependence on other fuel sources is anticipated. Curtailments of natural gas supply have increased, although on a somewhat cyclical basis, and projections of these trends show that as many as 2,000 to 3,000 hours of interrupted service may be expected during the winter months (October through March).

The Engineering Group of the Rocky Flats Plant considers the solar heating alternative for all new facilities. As other heating systems become practical (cost effective) they will also be considered in new designs.

TABLE 2.6.6-2

NATURAL GAS COMPOSITION AND
COMBUSTION PRODUCT EFFLUENT COMPOSITION

NATURAL GAS COMPOSITION

Constituent	Mole %
Helium (He)	0.24
Carbon Dioxide (CO_2)	0.80
Nitrogen (N_2)	9.40
Methane (CH_4)	79.90
Ethane (C_2H_6)	6.82
Propane (C_3H_8)	2.11
Iso-Butane (C_4H_{10})	0.21
Norm-Butane (C_4H_{10})	0.37
Iso-Pentane (H_5H_{12})	0.06
Norm-Pentane (C_5H_{12})	0.05
Hexanes (C_6H_{14})	0.02
Heptanes (C_7H_{16})	0.02
	100.00
Heating Value (Btu/cu ft) based on percent composition	1031

COMBUSTION PRODUCT EFFLUENT COMPOSITION

Constituent	Mole %
Nitrogen (N2)	71.85
Carbon Dioxide (CO_2)	9.89
Water Vapor (H_2O)	18.26
Nitrogen Oxides (NO_x)	260 ppm

2.6.6.2 Fuel Oil

The consumption of fuel oil at Rocky Flats Plant for FY 1973, 1974, 1975, 1976, and 1977 was about 1.6 million gallons, 702 thousand gallons, 514 thousand gallons, 940 thousand gallons, and 335 thousand gallons, respectively (see Section 4.4.2.1). Primary consumption of fuel oil is by the Plant's steam generators, which use Number 6 fuel oil as a backup fuel whenever the supply of natural gas is curtailed. The chemical composition of a typical fuel oil is shown in Table 2.6.6-3. Also shown is the composition of the combustion effluent from boiler operation, using Number 6 fuel oil.

TABLE 2.6.6-3

NUMBER 6 FUEL OIL COMPOSITION AND COMBUSTION PRODUCT EFFLUENT COMPOSITION

NUMBER 6 FUEL OIL COMPOSITION

Fuel Analysis

Constituent		Weight %
Ash*		0.1
Carbon		86.36
Hydrogen		11.54
Sulfur*		1.0
Water and Sediment*		1.0
	Total	100.00
Heating Value (Btu/gal)		138,700
Pounds per Gallon		8.51-7.48

*Value for ash, sulfur, and water and sediment are maximum allowable per purchase specification. Average values since July 1973 are Ash-0.0065%, Sulfur-0.55%, and Water and Sediment-0.75%.

COMBUSTION PRODUCT EFFLUENT COMPOSITION

Constituent	Mole % (Dry)
Carbon Dioxide	13.7
Nitrogen	83.3
Nitrogen Oxides	200 ppm
Sulfur Dioxide	200-400 ppm
Water	2.9

It is anticipated that future curtailments of natural gas may place greater demands on the use of fuel oil at Rocky Flats. To ensure an adequate fuel supply for the Plant's heating systems, the on-site, fuel-oil storage capacity has been increased. Presently serving as the primary storage facilities are two diked tanks, one with a capacity of 792 thousand gallons, the second tank with a capacity of 1.9 million gallons. Fuel oil is pumped or trucked from these tanks to underground day tanks located near the buildings that house steam generators.

2.6.6.3 Other Fuels

Diesel fuel is used to power most of the Plant's emergency electrical generators, as a backup fuel for hot-water-heating boilers in a Research and Development facility, and for diesel-driven vehicles and construction equipment. Individual storage tanks are provided for each stationary engine; mobile equipment is supplied by a storage tank and pumps at the Garage and Fire Station. Total consumption for FY 1974, 1975, 1976, and 1977 was 36,397; 35,852; 21,126; and 19,356 gallons; respectively. Periodic operation of the diesel-powered emergency generators and firing of the R&D facility's heating boilers account for most of the consumption during normal Plant operation. Total storage capacity for diesel fuel is 115,430 gallons.

Gasoline is used as fuel for one of the emergency electrical generators, for various Plant vehicles, and for miscellaneous Plant equipment. A 14,000-gallon underground storage tank and pumps are provided at the Garage. Total consumption of gasoline for FY 1974, 1975, 1976, and 1977 was 86,571; 90,215; 97,979; and 101,390 gallons; respectively. Over 90% of this consumption was from operation of Plant vehicles.

Propane is used as a backup fuel to the preferred natural gas for manufacturing, R&D, and maintenance activities in a major manufacturing building. An 18,000-gallon storage tank is provided near the building to meet anticipated maximum requirements. Consumption of propane for FY 1974, 1975, 1976, and 1977 totaled 10,180; 7,625; 12,204; and 40,876 gallons; respectively.

Future use of diesel, gasoline, and propane is not expected to increase significantly. The DOE contracted with Reynolds, Smith, and Hills of Jacksonville, Florida to perform a complete energy survey and evaluation of DOE facilities including Rocky Flats. The Study projected energy requirements through the year 1985 and included estimates of energy requirements for the year 2000. As a result of the study it was recommended that the best fuel choice for Rocky Flats (other than oil or gas) is coal. Coal-fired boilers that provide steam, space heating and cooling, and electricity have been selected.

2.6.7 Inert Gas Systems

An inert atmosphere (nitrogen and less than 5% oxygen) is used in various glove boxes and storage areas to minimize the possibility of fire. Total nitrogen consumption during FY 1975 was 515.6 million cubic feet; for FY 1976 it was 482.3 million cubic feet. As of August 1976, nitrogen consumption was at the rate of 58,000 to 60,000 standard cubic feet per hour (scfh). With the introduction of the new plutonium recovery facility, this rate may increase by as much as 38,000 scfh.

The protection afforded by an inert atmosphere in specified glove boxes requires a reliable supply of nitrogen gas. This gas is normally supplied from an on-site, liquid-nitrogen production plant that is owned and operated by a commercial supplier. The plant uses a liquefaction-distillation process to separate and liquify nitrogen from air. Underground lines then supply the re-gasified nitrogen to appropriate buildings. Capacity of this supply is about 140,000 scfh.

A secondary supply is a liquid-nitrogen storage facility that receives liquid nitrogen from the on-site plant or by truck or rail shipment from an off-site commercial supplier. At full demand rates, the reserve supply will meet Plant needs for about three days. Limiting Plant operations, however, would extend the reserve supply to eight days.

If nitrogen service were not restored within eight days, the oxygen level in the glove-box system would increase slowly as the result of leakage into the system. The net effect on the glove-box atmosphere would be a gradual return to a normal air atmosphere. This loss of nitrogen would increase the risk of fire, but restricted operations and the removal of plutonium from glove boxes that were affected would minimize the potential hazards. Safety features such as heat detectors, improved storage methods, and frequent inspections by operating and fire safety personnel reduce the danger of fire (see Section 3.2.2.4).

Another inert gas system is the manually controlled argon system used in a plutonium fabrication and assembly building. It consists of a supply tank with distribution headers to various stations. The storage capacity for liquid argon in the plutonium fabrication building complex is sufficient to produce approximately 348,000 cubic feet of gas at standard conditions of temperature and pressure.

Nitrogen gas and argon gas will be used as conveying mediums for solid samples in the closed-carrier transfer systems of a new building. Argon will also be used (1) mixed with fluorine, as makeup in a fluorination process, (2) as an inerting agent in a reduction process, (3) to provide an inert atmosphere for molten plutonium metal that is being purified, and (4) as a purging agent. Argon is used in a facility in which calcium metal is stored. The metal is stored in a drum with a special lid equipped with a fitting to allow the drum to be purged with argon before it is opened and after it is resealed. This minimizes the danger from hydrogen gas accumulation. The drum is stored in a specially designed metal shed to protect it from water from the sprinkler system. Five-gallon buckets of magnesium oxide sand are provided in case of a calcium fire.

Helium is often used in various module process operations, particularly as a pressurizing gas.

2.6.8 Water System

The Plant's water system is a complete water supply, treatment, storage, and distribution system of ample capacity for meeting all existing and anticipated Plant needs. The water system can be considered to have three basic parts: (1) an incoming raw water supply, (2) a raw water system on site and (3) a treated water system on site.

At the Plant, the incoming raw water is passed through a microstrainer filter to remove particulate material. The filtered raw water is then divided into two streams. One enters an on-site raw (filtered but otherwise untreated) water distribution system to disburse water for cooling tower makeup, minor irrigation, and miscellaneous purposes. The second stream passes through lime-alum, sand filtration and activated carbon in the water treatment facility. The resultant treated (potable) water is distributed for domestic, process, and fire protection uses throughout the Plant. Because the system has been sized for fire requirements, it has adequate capacity for all forseeable domestic and process needs.

The total quantities of raw water purchased in FY 1974 through FY 1977 are shown in Table 2.6.8-1 (see also Section 4.4.2.1):

TABLE 2.6.8-1
PURCHASED RAW WATER

FY	Gallons
1974	143,435,000
1975	125,952,000
1976	115,963,000
1977	113,244,000

Of these quantities, approximately one-fourth is used as raw water; the remainder is treated. All treated (potable) water used for domestic purposes is discharged to the sanitary sewer system. As a result, over 56 million gallons was released off site from the sewage treatment plant in FY 1976. The remainder of the water is released through evaporative processes, mainly cooling towers (approximately 30 million gallons), solar ponds, A-series holding ponds, and irrigation. Water usage and losses are more fully described in Section 3.1.1.1. No water is released from the process waste stream. The decrease in raw water purchase from FY 1974 through FY 1977 is accountable to various means of conservation, especially in the cooling tower blowdown process, but also to a reduction in production. Treated water used in Plant production processes is discharged to the process waste system.

2.6.8.1 Raw Water Supply, Storage, and Distribution

All raw water is purchased from the City and County of Denver and is drawn from two Denver-owned sources, Ralston Reservoir and South Boulder Diversion Canal.

The primary year-round source of raw water is Ralston Reservoir, located about 5.5 pipeline miles south-southwest of the Plant site. Ralston Reservoir, which has a capacity of 1,200 acre feet, provides about one-half of the water required by the Plant. It is filled from the drainage basin in which it lies and from Gross Reservoir, by way of the South Boulder Diversion Canal. It normally is utilized by Rocky Flats from around November through April. Maximum and minimum water level elevations at Ralston are 6,046 and 5,946 feet above sea level.

The raw water from Ralston Reservoir is pumped to Rocky Flats through a single 10-inch-diameter, cast-iron supply main. Since this line crosses some rough terrain, Class 250 pipe is used in those portions where high pressures result from variations in elevation. Also, mechanical joints are used in critical sections; bell and spigot joints caulked with lead are used for the remainder. Valves permit isolating the pipe into sections not over 5,000 feet long.

Normally, water is pumped from Ralston Reservoir to a raw-water storage pond just west of the Plant. The pond can be bypassed, however, and the water pumped directly to the Plant. Water is pumped from Ralston Reservoir by two pumps at the base of the dam. Both pumps are in a heated pump room and are two-stage centrifugal pumps rated at 350 gallons per minute at 165 psi when operating at 1,750 rpm. The primary pump is driven by a 75-hp electric motor; the standby pump can be driven by either a 75-hp electric motor or a gasoline engine. The pumps are started and stopped automatically by a pressure switch. The operation of either pump at its rated capacity provides 500,000 gallons per day. Since the controls permit simultaneous operation, capacity can be increased to 1 million gallons per day. When the South Boulder Diversion Canal is in service, power to the Ralston pumps is manually shut off and the pumping station is locked. The station is routinely checked by Utilities personnel.

The South Boulder Diversion Canal, which passes about 1.5 miles west of the Plant, is the secondary source of raw water; it usually is used from about May through October. This canal, which transfers water from Gross Reservoir to Ralston Reservoir, provides about one-half of the water required for the Plant. Gross Reservoir, located on South Boulder Creek in the mountains about 10 miles west-northwest of the Plant, is considerably larger and at a higher elevation than Ralston Reservoir. The Denver Water Board regulates the flow in the canal, normally starting it in the spring and shutting it off in the fall. For this reason, the canal cannot be considered a year-round source, either for the Plant or for Ralston Reservoir. Water drawn from the canal, at an elevation of 6,190 feet, flows by gravity to the Plant or to the raw-water storage pond.

A 10-inch, cast-iron main approximately 500 feet long transmits raw water from the intake on the canal to a point where it intersects the line from Ralston Reservoir. From that point, the Ralston line is used to convey the water from the canal. Therefore, it is not possible to draw water simultaneously from both sources of supply. The capacity of the 10-inch main between the canal and the storage pond would be about 1,400 gallons per minute (gpm) under gravity flow if the pipe had a free outlet. There is a section of 3-inch pipe about 50 feet long, however, that leads into the pond; this reduces the capacity to about 950 gpm. Alternatively, water from the canal can be delivered directly to the Plant, bypassing the pond, at approximately 1,300 gpm (or 1.9 million gallons per day). The intake on the canal is a reinforced concrete structure equipped with trash racks, removal screens, and a shear gate.

The raw water storage pond is located about 0.5 mile west of the water treatment facility. The open, asphalt-lined pond has a nominal capacity of 1.5 million gallons with 1 foot of freeboard. The bottom of the pond is at an elevation of 6,095 feet, and the maximum water level is 6,107 feet. The pond is fed by a 3-inch line tapped into the 10-inch, incoming raw-water main. When the pond is operated as the source of water for the Plant, the water flows by gravity through either or both of two cast-iron mains; one is a 10-inch pipe back to the incoming Ralston line and from there to a junction point near the water treatment facility. The other is a parallel 12-inch pipe to the same junction. The capacity of the 10-inch main is estimated to be 1,100 gpm (or 1.6 million gallons per day). The combined capacity of the two mains is enough to deliver water from the pond to the Plant at a rate high enough to satisfy maximum Plant demand.

Meters at Ralston Reservoir, the canal intake, the pond inlet, the incoming line to the water treatment facility, the line to the cooling towers, and each of the cooling towers make it possible to determine material balances and to check for leaks in the water system. The meters at the treatment building and the distribution line for the cooling towers automatically record their information in the water treatment building. The others are checked according to established schedules.

The Ralston Reservoir pumps can pump raw water directly into the on-site raw water system. Since the pumps can generate a pressure of 195 psi and the on-site system is designed for 150 psi, a pressure-reducing station is installed at the junction of the two systems. The station eliminates the possibility of over-pressurizing the on-site raw water system.

2.6.8.2 On-Site Raw Water System

The on-site raw water system is primarily for the cooling towers, with a small amount used for minor miscellaneous purposes. Raw water for the cooling towers is metered from the supply mains and is passed through the microstrainer to remove major solid impurities. Table 2.6.8-2 lists the components of Rocky Flats' raw water.

From the microstrainers, the water flows into the untreated (raw) water distribution system, bypassing the water treatment plant. (The untreated distribution line consists of 10-inch mains and is being converted from a gravity-flow to a pumped system to accomodate the new plutonium recovery facility.) The untreated water is then piped to the cooling towers for nine buildings. The cooling tower capacities are given in Table 2.6.8-3.

TABLE 2.6.8-2

COMPONENTS OF ROCKY FLATS PLANT RAW WATER

Nonradioactive Component (mg/l)*	Mean	High	Low
Alkalinity:			
Carbonate - CO_3	-	-	-
Bicarbonate - HCO_3	49.6	61.0	34.5
Aluminum Oxide - Al_2O_3	0.46	1.0	0.15
Calcium - Ca	11.8	17.5	5.0
Chloride - Cl	0.6	1.0	-
Chromium - Cr^{+6}	0.05	-	-
Fluoride - F	0.14	0.16	0.12
Hardness - $CaCO_3$	31.0	42.7	23.3
Iron Oxide - Fe_3O_4	3.9	7.0	1.5
Magnesium - Mg	2.2	2.8	1.5
Nitrate - NO_3	0.34	0.55	0.15
Silica - SiO_2	8.1	12.2	4.2
Sodium - Na	10.3	14.2	6.7
Sulfate - SO_4	18.3	28.0	9.5
Total Solids	115.0	279.0	40.0
pH	7.5	8.1	7.2
Radioactive Component (PCi/l)**			
Americium (two samples only)	-	0.008	0.006
Tritium	750	1025	600
Plutonium (two samples only)		0.01	0.006
Uranium	6.8	61.8	0.7

* Nonradioactive component data are from a 1974 study conducted by Engineering Sciences, Inc.

**Radioactive components are from samples analyzed during 1978 by the Rocky Flats Health and Environmental Laboratory.

TABLE 2.6.8-3

COOLING TOWER CAPACITY

Plant Area	Tower Capacity (tons*)
300	6,667
400	600
700	7,350
800	900

* Tons refers to the refrigeration rating of the cooling tower, where one standard commercial ton of refrigeration equals 12,000 Btu/hr.

All of the cooling towers used in the Plant are mechanical-draft wet towers that cool buildings by transferring excess heat to the atmosphere through direct mixing of air and water. Electrically driven fans provide the air flow through the tower. Excess heat is picked up by water as it circulates through cooling coils in the buildings' heating, ventilating, and air-conditioning systems and some of the process heat exchangers. Part of this warm water is evaporated as it mixes with the cooler air flowing through the tower, thus transferring the excess heat to the atmosphere. Cooling tower operation and the evaporation rate consequently are dependent on ambient air temperature and tower heat load. During winter months, the reduced ambient temperature and reduced tower heat load reduce the evaporation rate to approximately one-half that of warm summer months. Table 2.6.8-4 shows the monthly raw water consumption for FY 1975 and demonstrates winter and summer variations in consumption.

TABLE 2.6.8-4

COOLING TOWER RAW WATER CONSUMPTION (FY 1975)

Month	Quantity Used (1,000 gallons)
July, 1974	6,223.8
August	4,867.3
September	2,313.9
October	2,139.8
November	2,038.7
December	1,816.7
January, 1975	1,590.8
February	1,656.9
March	1,701.8
April	1,833.9
May	2,185.7
June	2,857.8
Total Winter (Oct.--March)	10,944.7
Total Summer (April--Sept.)	20,282.4
Total Makeup	31,227.1

During cooling-tower operation, raw water is added to replace (1) water lost by evaporative heat dissipation, (2) water required to maintain cooling-tower water quality, and (3) drift losses from water contained in the air stream. The consumption rates given in Table 2.6.8-4 include water added for blowdown and drift losses, which are both directly related to evaporation rate.

"Blowdown" refers to the continuous or periodic discharge of a portion of the cooling tower water to control the level of solids in the circulating water. As water is evaporated by the tower, the dissolved and suspended solids remain in the circulating water and would eventually reach a level detrimental to tower operation. Because of the high quality of the raw water (see Table 2.6.8-2) and variability of evaporation rate, the frequency of blowdown for the Plant's cooling towers varies, depending on chemical analysis of the tower circulating water. Various chemicals are added to the cooling towers' circulating water systems to prevent biological growth, corrosion, scaling, and other effects that can foul heat-transfer surfaces and degrade performance. Proportional amounts of these chemicals and their reactants are carried with the blowdown water, which is discharged to the sanitary sewage system. Total solids in the cooling tower water is normally maintained at approximately 500 to 700 ppm.

Drift losses from cooling towers also carry proportional amounts of the chemicals and reactants used in treating tower water. In most cases, these water droplets are carried out of the tower with the rising vapor column, but drop to the ground within a few hundred yards of the tower. The chemicals thus deposited on the soil may enter surface and subsurface water as a result of rainfall runoff and other hydrological phenomena. Accurate estimates of total drift loss are not feasible because of the many variables involved, including water circulation rate, evaporation rate, external wind effects, tower design and age, plus blowdown frequency and resultant variations in tower-water quality. Assuming a drift loss rate equal to 0.1% of the total water circulation rate and operation at 500 to 700 ppm total solid concentration, a conservative estimate of drift loss indicates that approximately 4,000 pounds per year of solids may be carried with the drift and deposited on the surrounding soil.

2.6.8.3 Treated Water Supply, Storage, and Distribution

All potable water at the Plant is treated on site. The treated system serves domestic, industrial, and fire protection uses. It has over 2 million gallons of storage capacity in four storage tanks and the water treatment plant's clear-well. The storage is designed so that two separate 4-hour sources of fire protection water are available at all times.

Raw water is treated in the water treatment plant, which has a nominal capacity of 700 gpm (1 million gpd). The Plant has a microstrainer, flocculation tank, three gravity sand filters, two chemical feeders, chlorination equipment, distribution pumps, and facilities for recycling backwash water. Ten million to 16 million gallons of raw water normally are treated each month.

Treated water flows from the water treatment plant to the clear-well. From there, it is pumped into a ground-level tank and then into an elevated tank or the Plant distribution mains, according to demand. Pumping capability for the treated water at the water treatment plant depends upon five electric pumps. A 1,000-gpm pump moves treated water from the clear-well to the ground-level tank, which has a capacity of 500,000 gallons. One 700-gpm and two 500-gpm pumps deliver water from the clear-well or the ground-level tank to either the elevated tank or the Plant's treated-water distribution system. These three distribution pumps cycle automatically to maintain a minimum of 220,000 gallons in the 300,000-gallon-capacity, 155-foot-high storage tank. Normally, only two of these three pumps are on-line at one time. The fifth pump can pump water for fire usage at 1,500 gallons per minute. It pumps from either the clear-well or the ground-level tank to the distribution system. In case of a power outage, there is a 225-kW emergency generator to keep the pumps operational. The generator must be started manually.

In addition to the five electric pumps at the water treatment plant, there are two 2,500-gpm pumps, one diesel-driven and one electric, that can pump water from the two 500,000-gallon fire-water storage tanks located near the east side of the developed Plant site.

The primary supply for the treated water distribution system is the elevated tank. Since there is no check valve in its discharge line, the pressure is maintained between 65 and 72 psi. If the tank is out of service for any reason, water is supplied to the distribution system by the three service pumps (plus the fire protection pump, if necessary), drawing from either the clear-well or the ground-level tank.

Plant distribution of treated water begins with dual, 12-inch, cast-iron mains from both the elevated tank and the service pumps. The mains connect to a multiple-loop, sectionalized main system extending throughout the Plant site. Most of the multiple-loop system consists of 10-inch mains; no section of the loop system has mains smaller than 8 inches in diameter. All major facilities are served by closed loops; consequently, water can be supplied from either of two directions, assuring continued service in the event a line should break. Yard mains that supply outlying buildings and that are not a part of the loop system are of a size commensurate with usage, some being as small as 2 inches.

Although the treated water system provides water for all domestic, industrial, and fire protection uses, the various subsystems are protected to prevent any undesirable cross-contamination or pollution. For example, all drinking water systems are protected with back-flow preventers.

Filter backwash water from the water treatment plant is reprocessed in a facility that has two 60,000-gallon storage tanks, two drying beds, and several pumps. This facility permits reuse of this highly turbid water, so that it is not discharged off site.

2.6.9 Steam System

More than two-thirds of the steam produced at the Rocky Flats Plant is used in the heating, ventilating, and air conditioning (HVAC) systems in the buildings. The remainder is used for process heating. No steam is used for generating electrical power. Effluents from the steam plant are listed in Tables 2.6.6-2 and 2.6.6-3.

The main steam boilers for the Plant are in a building in the 400 area; additional, supplemental steam boilers are in the 700 and 800 areas (Table 2.6.9-1). Generating capacity for each of these boilers is as follows:

400 Area	4 @ 75,000 lb/hr =	300,000 lb/hr.
800 Area	3 @ 24,000 lb/hr =	72,000 lb/hr.
700 Area	1 @ 21,000 lb/hr =	21,000 lb/hr.
	Total	393,000 lb/hr.

TABLE 2.6.9-1

ROCKY FLATS BOILER SPECIFICATIONS

Bldg.	Type	Heat Input Btu/hr.	Fuel Use Rate Per Hour Nat. Gas (ft^3)	Fuel Use Rate Per Hour #6 Oil (lbs)	Stack Height and Internal Dia.	Exit Gas Temperature and Velocity
443	Keeler Water Tube (2 units)	100,000,000	104,000	5,100	80 ft x 5.5 ft	325°F/1,520 fpm
	Erie City Water Tube	100,000,000	104,000	5,100	75 ft x 4.5 ft	300°F/2,300 fpm
	Combustion Engineering Water Tube	100,000,000	104,000	5,100	75 ft x 5.5 ft	315°F/1,520 fpm
771	Babcock & Wilcox Water Tube	25,200,000	27,300	1,460	34 ft x 3 ft	500°F/2,660 fpm
881	Union Iron Works Water Tube (3 units)	28,400,000	30,000	1,590	52 ft x 7 ft (common stack)	500°F/1,300 fpm
991	Cleaver Brooks Fire Tube Hot Water (2 units)	3,360,000	3,500	24 (#2 oil)	32 ft x 1.5 ft (common stack)	400°F/1,700 fpm

The four boilers in the central steam plant produce steam at 300 pounds per square inch gauge (psig) and 475 °F. They are fueled by natural gas, with fuel oil as a backup. The boilers in the 700 and 800 areas are separate, standby sources of steam that can be used for buildings in those areas if the central steam plant boilers or the steam mains have to be shut down for any reason.

Steam distribution lines are located above and below ground. Under normal operating conditions, steam is distributed at 300 psi to pressure-reducing stations located in or near major buildings. Steam is reduced to 125 psi or lower for distribution within buildings. Almost all condensate from the Plant-wide HVAC systems is returned to a 300,000-gallon tank near the central stream plant. The water is used as reserve boiler-feed water. The condensate from process heating also is generally returned to the steam plant. Contaminated condensates are sent to the waste treatment facility.

The entire central steam plant and the steam distribution system is designed and constructed to meet the requirements of (1) the Uniform Building Code, (2) applicable ASME (American Society of Mechanical Engineers) boiler and pressure vessel codes, and (3) applicable NFPA (National Fire Protection Association) fire and explosion protection standards. As such, it has a full complement of built-in safety features, devices, and interlocks that ensure safe, reliable startup, operation, and shutdown under normal and emergency conditions. Since the Uniform Building Code seismic criteria for this region are only slightly less severe than those imposed for the Operating Basis Earthquake (OBE)*, the steam plant and steam lines should sustain no more than minor damage during an OBE. Portable steam generators could be obtained should the steam plant sustain sufficient damage to curtail its service.

If there should be a power failure affecting the central steam plant, the building has a diesel-powered, 500-kW, 480V emergency generator that can keep two of the four boilers operational during the outage. Future plans call for the installation of a second emergency generator of comparable size; the second generator also will be capable of keeping two boilers and auxiliaries operating, bringing the total emergency power capability to a level where all four boilers can be kept in service.

2.6.10 Material Shipments

A variety of radioactive and toxic materials in various physical and chemical forms are shipped to and from the Rocky Flats Plant during the course of normal operations. This section describes what these materials are, how they are shipped, and how safety is ensured during shipment.

2.6.10.1 Materials and Configurations

A summary of materials and their forms for shipment is given in Table 2.6.10-1.

*An earthquake which is not severe enough to preclude continued safe operation.

TABLE 2.6.10-1

TRANSPORTATION OF MATERIALS TO AND FROM ROCKY FLATS PLANT

Material	Form	Shipping Method	Units of Shipment	Total Shipment Miles (per year)**
Americium-241	Oxide	Truck	g	38,900
	Waste	Rail	g	66,980
Beryllium	Metal	Air	kg	255,000
	Scrap	Truck	lb	6,604
Neptunium-237	Metal	Air	g	2,500
	Oxide	Truck	g	1,200
		Air	g	1,300
Plutonium	Metal	Truck	kg	37,300
			g	11,420
	Oxide	Truck	g	12,700
	Metal plus	Truck	kg	35,400
	Oxide		g	57,800
	Nitrate	Truck	g	48,000
	Waste	Truck	g	107,000
		Rail	g	66,980
Plutonium and	Metal	Truck	kg	58,240
Uranium	Waste	Truck	g	3,700
Uranium-233	Oxide	Truck	g	1,600
	Waste	Rail	g	2,364
Uranium-235	Metal	Truck	kg	35,300
		Air	kg	6,500
			g	14,700
	Oxide	Truck	kg	3,200
	Nitrate	Truck	g	740
Uranium-238	Metal	Truck	kg	67,030
		Air	kg	77,000
			g	1,200
Uranium-235	Metal	Truck	kg	2,600
and	Waste	Truck	g	11,800
Uranium-238		Rail	g	13,396
Miscellaneous*	Several	Truck	various	96,000
TOTALS		Truck		636,534
		Air		358,200
		Rail		149,720

*Miscellaneous includes other hazardous materials such as radioactive sources and analytical materials, flammable gases, poisons, chemical, gasoline, and oil, as listed in DOT regulations (49 CFR 172).

**A recent year representative of normal operations.

Information about the exact size and amount of radioactive material in the shipping containers is usually classified, but a breakdown is provided here to indicate whether the shipment contains kilogram amounts or only gram amounts. Shipments of gram quantities of radioactive materials are generally sample foils or laboratory samples going to other laboratories for analysis. While the exact amount of plutonium and other radioactive material shipped is not given, sufficient information is available to provide an adequate basis for an environmental impact analysis.

The figures given in Table 2.6.10-1 and in Tables 2.6.10-2 through 2.6.10-4 reflect current shipment information. Total shipment miles is that actually traveled in a recent year that is considered to be representative of normal operations.

Small amounts of other radioactive isotopes including sources, analytical materials, and gram or milligram quantities of curium-244 and thorium-228 are handled at Rocky Flats. Shipment methods for these materials are handled on a case-by-case basis to ensure compliance with the packaging requirements of 49 CFR Parts 170-178.

Table 2.6.10-2 is a summary of mileages for materials listed in Table 2.6.10-1 that are shipped in kilogram quantities. The locations of facilities that ship and receive plutonium and uranium to and from Rocky Flats are given in Table 2.6.10-3, along with the shipping distances. A similar compilation for shipments of beryllium is given in Table 2.6.10-4.

TABLE 2.6.10-2

MILEAGE SUMMARY FOR KILOGRAM QUANTITIES OF MATERIALS

Material	Form	Shipping Method	Total Shipment Miles (per year)
Beryllium	Metal and Oxide	Truck	6,604
		Air	255,000
Plutonium and Plutonium + Uranium	Metal and Oxide	Truck	130,940
Uranium-235	Metal and Oxide	Truck	38,500
		Air	6,500
Uranium-238 and Uranium-238 + Uranium-235	Metal and Waste*	Truck	81,430
		Air**	83,500

*The waste is transported by truck only.

**Less than 350 grams of uranium-235 contained in uranium that is enriched 20 percent or more.

TABLE 2.6.10-3

FACILITIES SHIPPING AND RECEIVING PLUTONIUM AND URANIUM
(kg quantities)

Location	Shipping Distance* (miles)
Aiken, South Carolina	1,590
Amarillo, Texas	423
Columbus, Ohio	1,229
Livermore, California	1,227
Los Alamos, New Mexico	390
Mercury, Nevada	830
Miamisburg, Ohio	1,212
Oak Ridge, Tennessee	1,309
Richland, Washington	1,195
Tonopah, Nevada	850

*Actual miles traveled, not straight-line distances.

TABLE 2.6.10-4

FACILITIES SHIPPING AND RECEIVING BERYLLIUM

Location	Shipping Distance* (miles)
Albuquerque, New Mexico	417
Amarillo, Texas	423
Elmore, Ohio	1,218
Hazelton, Pennsylvania	1,651
Livermore, California	1,227
Los Alamos, New Mexico	390
Miamisburg, Ohio	1,212
Oak Ridge, Tennessee	1,309
Reading, Pennsylvania	1,644
Sarasota, Florida	1,859

* Actual miles traveled, not straight-line distances.

The following paragraphs discuss only materials used or required for Rocky Flats' operations. Some shipments of materials involved in the nation's weapons program use the Rocky Flats facility as a safe stopover point. Such shipments are not included in these paragraphs because the materials are not processed at this Plant and are not connected with operating requirements of this facility. Any environmental effects associated with their transportation are properly assigned to other facilities and are treated in the environmental assessment of those facilities. Dose assessments for operation of the Plant include consideration of these materials as a part of normal operations, but not as a contribution to transportation dose or hazard.

Materials used for Rocky Flats' operations are shipped by truck, air, and rail. Truck is the mode used most frequently, either commercial truck lines or Government-owned Safe Secure Trailers (SSTs). Shipments of waste with less than 10 nCi of plutonium or other transuranic elements per gram of material are transported by commercial trucks and rail from Rocky Flats to a DOE-approved storage site.

During shipments of nuclear materials, various safeguards are employed. For example, all truck shipments involving strategic quantities of special nuclear materials (SNM) and certain classified, nuclear weapon components having less than strategic quantities of SNM material are transported in Safe Secure Trailers (SSTs) operated by DOE couriers. Strategic quantities of special nuclear materials are defined in ERDA Manual Chapter 2405 as follows:

a. Uranium-235 (contained in uranium enriched 20% or more in the uranium-235 isotope) alone, or in combination with plutonium and/or uranium-233 when (multiplying the plutonium and/or uranium-233 content by 2-1/2) the total is 5,000 grams or more.
b. Plutonium and/or uranium-233 when the plutonium and/or uranium-233 content is 2,000 grams or more.

These shipments are facilitated by the proximity of major highways to Rocky Flats. Interstate Highways 25, 70, and 76 (80S) pass through Denver approximately 16 miles from the Plant. Five miles northeast of the site is U.S. Highway 36 (Boulder-Denver turnpike), and surrounding the Plant, as mentioned previously, are State Highways 72, 93, 128, and Jefferson County Highway 17.

Rail is the method used for shipping waste containing more than 10 nanocuries of plutonium or other transuranic elements per gram of material. These shipments to the Idaho National Engineering Laboratory (INEL) at Scoville, Idaho, are made in Government-owned ATMX-600 Series Rail Cars that have been modified to carry radioactive waste material. In 1969 the Department of Transportation (DOT) issued Special Permit No. 5948 to cover the movement of radioactive waste material in the ATMX Rail Cars. Requests for renewal of the permit are submitted to the DOT for review and reissuance every two years. The latest application for renewal was granted in May 1978. Rail service is provided by a spur of the Denver and Rio Grande Western Railroad (D&RGW).

This spur enters the site from the southwest to provide general freight service. Approximately 480 tons were transported during the first fiscal quarter of 1976 by 30 rail cars that utilized the spur.

Shipments of radioactive material by air are restricted to non-passenger aircraft. Such shipments would leave from either Stapleton International Airport (on the east side of Denver) or the Jefferson County Airport (located approximately 5 miles east of the Plant). Air shipments of plutonium to and from Rocky Flats were terminated in April 1977. Section 502, Title V of Public Law 94-187 (Figure 2.6.10-1), however, does provide for "exempt shipments of plutonium."

2.6.10.2 Transportation Safety

Primary reliance for safety in the shipping of materials to and from Rocky Flats rests on packaging. The Plant's quality assurance program for packaging radioactive material (RI, September 1977) calls for adherence to ERDA Manual Chapter 0529 and DOT packaging requirements 49 CFR Parts 171-178. These criteria specify packaging tests that have been carried out in the laboratory or in the field with conventional and readily available equipment and facilities.

The packaging required by DOT and DOE regulations is based on the type and quantity of radioactive material being shipped. Type A packages are limited to Type A quantities of material (see Table 2.6.10-5). Type B quantities may be shipped in Type B packages. Larger quantities may also be specifically approved for Type B packages. Only small amounts of radioactive material, as defined in 49 CFR Part 173, are exempt from packaging specifications.

Any quantity in excess of a Type A quantity must be shipped in Type B packaging, which provides for adequate dissipation of heat. In addition, there must be no loss of contents at an external pressure of 25 pounds per square inch gauge (psig), which is approximately equal to immersion in water to a depth of 50 feet.

With respect to heat dissipation, regulations require the package to be designed so that the temperature rise from decay heat will not adversely affect the package or the contents and will not cause excessive pressure.

For safety assurance from accidental criticality, control in transportation is required for fissile material (uranium-233, uranium-235, plutonium-238, plutonium-239, and plutonium-241) of more than 15 grams per package or, in homogeneous, hydrogenous solutions and mixtures, of more than 500 grams of plutonium (hydrogen-to-plutonium ratio of 7,600:1) or 800 grams of uranium-235 (hydrogen-to-uranium-235 ratio of 5,200:1) per package. Nuclear criticality safety in transportation is provided by ensuring that the contents of each package of fissile material are subcritical when delivered to a carrier. Another provision is that the package is

Public Law 94-187
94th Congress, H. R. 3474
December 31, 1975

An Act

To authorize appropriations to the Energy Research and Development Administration in accordance with section 261 of the Atomic Energy Act of 1954, as amended, section 305 of the Energy Reorganization Act of 1974, and section 16 of the Federal Nonnuclear Energy Research and Development Act of 1974, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Energy Research and Development Administration. Appropriation authorization.

TITLE V—AIR TRANSPORTATION OF PLUTONIUM

42 USC 5817 note.

SEC. 501. The Energy Research and Development Administration shall not ship plutonium in any form by aircraft whether exports, imports, or domestic shipment: *Provided*, That any exempt shipments of plutonium, as defined by section 502, are not subject to this restriction. This restriction shall be in force until the Energy Research and Development Administration has certified to the Joint Committee on Atomic Energy of the Congress that a safe container has been developed and tested which will not rupture under crash and blast testing equivalent to the crash and explosion of a high-flying aircraft.

"Exempt shipment of plutonium." 42 USC 5817 note.

SEC. 502. For the purposes of this title, the term "exempt shipments of plutonium" shall include the following:

(1) Plutonium shipments in any form designed for medical application.

(2) Plutonium shipments which pursuant to rules promulgated by the Administrator of the Energy Research and Development Administration are determined to be made for purposes of national security, public health and safety, or emergency maintenance operations.

(3) Shipments of small amounts of plutonium deemed by the Administrator of the Energy Research and Development Administration to require rapid shipment by air in order to preserve the chemical, physical, or isotopic properties of the transported item or material.

Figure 2.6.10-1 Excerpt from Public Law

TABLE 2.6.10-5

TYPE A AND TYPE B PACKAGE QUANTITY LIMITS (49 CFR 173)

TRANSPORT GROUP	TYPE A QUANTITY (Curies)	TYPE B QUANTITY* (Curies)
I[a]	0.001	20
II[b]	0.05	20
III[c]	3	200
IV[d]	20	200
V[e]	20	5,000
VI, VII[e]	1,000	50,000
SPECIAL FORM	20**	5,000

*Quantities exceeding Type B are "large quantity" (large radioactive source).
**Except for californium-252, wherein the limit is 2 curies.

a. Group I includes
   Americium
   Curium
   Neptunium
   Plutonium
   Radium-226, -228
   Thorium-228, -230, -231

b. Group II includes
   Uranium-233

c. Group III includes
   Cobalt-60
   Thorium-232 and natural
   Uranium, enriched, natural or depleted

d. Group IV includes
   Tritium

e. Groups V, VI, and VII include nuclides not normally of interest to Rocky Flats.

designed to remain subcritical under all conditions likely to be encountered during transportation, including accidents. In addition, the contents must be limited or the package must be designed so that the number of packages that are permitted in one vehicle or area will be subcritical under all conditions likely to be encountered during transportation, including accidents and handling errors. A crash severe enough to rupture all containment would tend to disperse material, lessening the chance of a criticality. No criticality has ever occurred as the result of a transportation accident.

The possibility that a package will be constructed or used in a manner not in accordance with the design is minimized through the regulatory requirements for quality assurance and for various observations and tests before each shipment. Under DOT regulations and ERDA Manual Chapter 0529, each fabricator of specification containers must register with and is subject to inspection by DOT. Additionally, procedures are in effect for controlling vendor quality and for receiving and accepting waste packaging materials.

The radiation exposure rate from individual packages of radioactive material during normal conditions of transport is limited by DOT regulations. These regulations permit no more than 200 mrem/hr on the surface, which limits direct exposure to a person handling the package. Another restriction is that no more than 10 mrem/hr is permitted at 3 feet from the surface of the package. This limits the radiation level to which persons and property in the vicinity of the package could be exposed. If a package is shipped in a closed truck or rail car under the exclusive-use condition, the radiation level is limited to 10 mrem/hr at 6 feet at any point from the external surface of the truck or car. Another limitation is 2 mrem/hr in the driver's compartment or other normally occupied position in the truck or car. The term "exclusive use" refers to a vehicle that (1) is loaded by the consignor, (2) used exclusively for his freight alone from origin to destination, (3) has sealed doors, and (4) is unloaded by the consignee.

As an indicator of the radiation dose rate from an individual package, DOT regulations require a Transport Index (TI) to be shown on each package. The Transport Index assigned to a package of radioactive material is determined by the highest radiation dose rate, in millirem per hour, at 3 feet from any accessible external surface of the package. For Fissile Class II packages only, the Transport Index number is the greater of the radiation dose at 3 feet or the value calculated by dividing 50 by the number of similar packages that may be transported together. The number expressing the Transport Index is rounded up to the next highest tenth; e.g., 1.01 becomes 1.1. The number of packages stored or handled in one area or loaded on one car or vehicle must be so limited that the sum of their Transport Indexes does not exceed 50. For shipment in Safe Secure Trailers (SST), the Transport Index must not exceed 100. This prevents a large aggregation of packages, each with a significant radiation level, from producing a much higher radiation level than desirable because of additional radiation from all of the packages.

Material shipped from Rocky Flats has little penetrating radiation, and radiation levels at the surface of packages are well below DOT limits. All shipments from Rocky Flats are monitored, and the dose rate is recorded prior to shipment. These records indicate that the dose level 3 feet from the surface of the package, or 6 feet from the surface of "exclusive use" vehicles, never exceeds 10 mrem/hr and is typically less than 1 mrem/hr. Gram-quantity shipments have even lower radiation levels, which are on the order of only 0.1 mrem/hr.

Other DOT regulations deal with surface contamination levels, external temperatures, and warning labels and placards. Levels of removable contamination on the surfaces of packages at Rocky Flats are determined by a wipe test. The regulations consider the level insignificant if activity on the wipe does not exceed 10^{-11} Ci/cm^2 for beta and gamma emitters, and 10^{-12} Ci/cm^2 for alpha emitters. Temperatures are limited at any accessible surface of the container to not more than 122 °F during transport, except that for full-load or exclusive-use shipments, the temperature may be 180 °F. Each package of radioactive material is required by DOT regulations to be labeled on two opposite sides with a distinctive warning label.

The DOT's Hazardous Materials Regulations also provide for safety in routine shipments of hazardous materials other than radionuclides. Included are materials that are flammable, unstable, poisonous, explosive, or corrosive. DOT regulations specify the type of information that must appear on bills of lading and on other shipping papers. Packages are required to be labeled appropriately, and warning placards generally must be placed on the transporting vehicle. This puts the carrier and emergency personnel on notice that they are handling shipments of hazardous materials. The labels and placards also alert appropriate individuals to the fact that applicable state and local regulations and ordinances must be followed. No placards are required or displayed, however, whenever shipments of radioactive materials are accompanied by DOE couriers. The environmental impacts of transporting hazardous materials are discussed in Section 3.3.

Figure 2.6.10-2 identifies the Rocky Flats Model 1518 container (DOT-6M Specification) used for transporting radioactive materials such as plutonium and uranium-235. The authorized maximum content of the Model 1518 container is 4.5 kg of plutonium metal, alloy, or compound; or 13.5 kg of uranium-235 metal or alloy. This is an example of a Type B container which has been approved for shipping greater than Type B quantities of material. All containers used by Rocky Flats are either DOT Specification containers (i.e. DOT-6M) or DOE Certificate of Compliance containers. A Certificate of Compliance is issued by DOE for each container, quantity, or type of radioactive material shipped. In accordance with ERDA Manual Chapter 0529, the DOE Certificate of Compliance is to aid in assuring compliance with all applicable DOT standards.

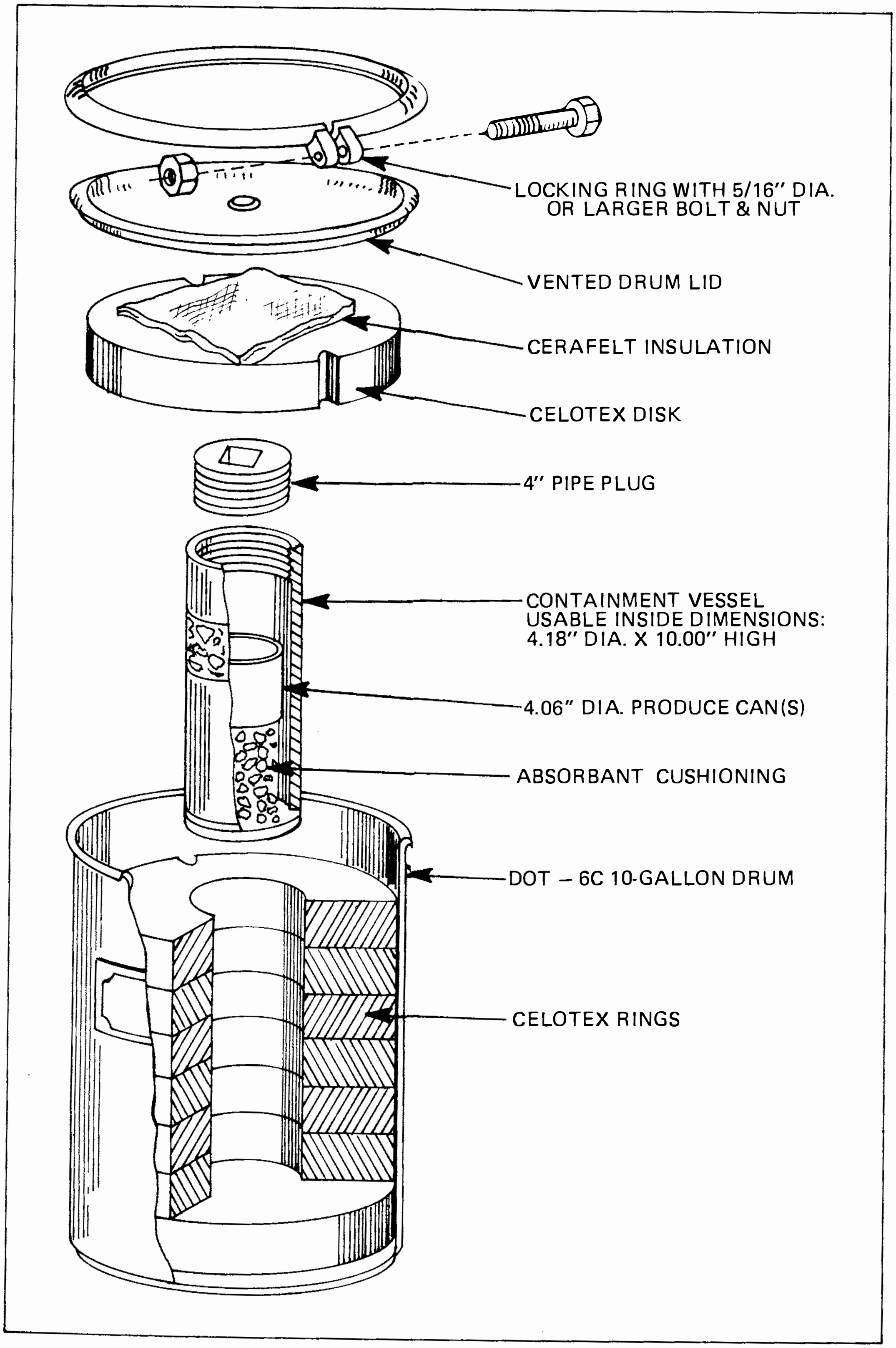


Figure 2.6.10-2 Rocky Flats Plant Model 1518 Shipping Container (DOT-6M Specification)

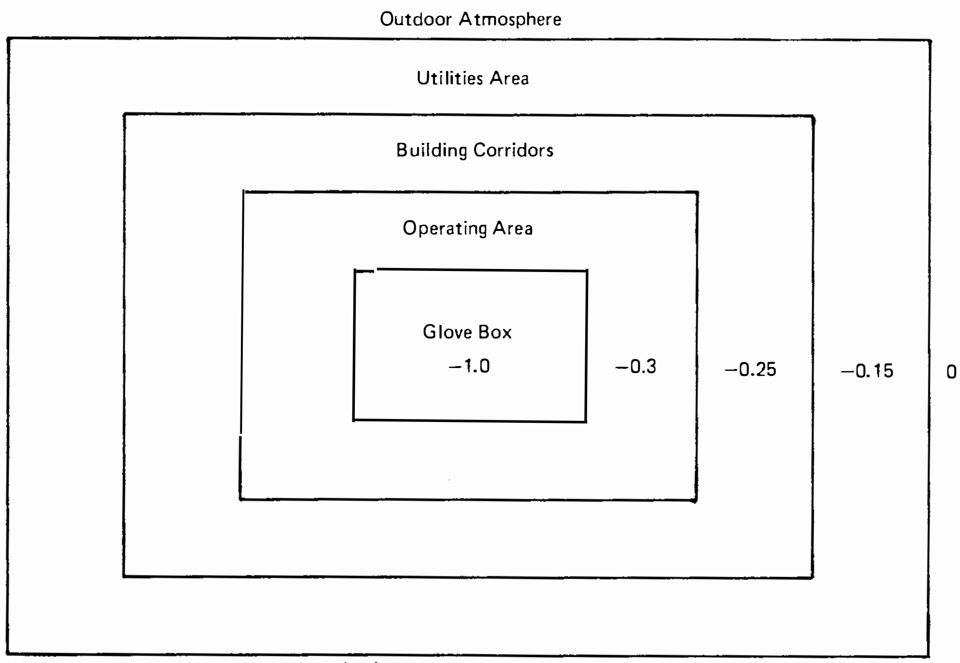
2.7 RADIOACTIVE WASTE SYSTEMS

Operations at the Rocky Flats Plant necessarily involve radioactive contamination of various liquids, solids, and gases. Radioactive materials are handled in accordance with stringent procedures and within multiple containments (physical barriers) designed to minimize the release of contaminants to the environment. The radioactive waste systems include local collection, filtration, liquid processing, or temporary storage facilities for those process wastes known or suspected to have been in contact with radioactive materials. As a result of public comment on the DEIS, more detailed discussion of HEPA filter efficiency, testing, and maintenance has been added in Section 2.7.1. The liquid waste processing system concentrates the unrecoverable plutonium into a solid waste suitable for shipment, along with other contaminated solid wastes, to a DOE-approved storage facility. Solid wastes are concentrated when necessary and packaged for shipment to a DOE-approved storage facility.

2.7.1 Radioactive Airborne Effluent Control Systems

Airborne radioactive effluent is produced when ventilation air or nitrogen gas (the latter used to provide an inert atmosphere in plutonium glove boxes) comes in contact with fine particles of radioactive material. Fine particles, capable of being entrained in these gases, come from handling oxide powder formed during machining of metallic materials, incinerating scrap and waste materials, and from chemical recovery processes. The gases, carrying radioactive particles, are passed through filtration systems where each stage is tested to assure it has a 99.95% filtration efficiency for all radioactive particles, including particles less than 0.1 μm in diameter. The filtration system at the Plant incorporates the best air-cleaning technology known. There are extremely small releases to the environment from process operations, but these releases are well within health and safety guides (USERDA Manual Chapter 0524, 1977, and Colorado State Board of Health, 1978.).

Containment of radioactive materials within a plutonium facility is achieved by ventilation systems designed to maintain pressure differentials between zones and thus control the airflow pattern. Pressure differentials exist not only between the various controlled areas within a process building, but also between any one of the areas and the outside. For example, the pressure in the utilities and office spaces typically is negative by 0.15-inch water column (wc) with respect to outside air; the corridors surrounding the operating areas are 0.25-inch wc less than the outside; the operating areas themselves are 0.3-inch wc less than outside; and the glove-box atmosphere within the operating areas is 1.0-inch wc less than outside. Figure 2.7.1-1 illustrates these differentials. Should any zone be breached, the flow of air would be inward. Thus, any contaminated air would be prevented from bypassing the ventilation filters and reaching the outside atmosphere (see Section 2.5.1).



Note: Values are inches water column (wc).

Figure 2.7.1-1 Ventilation Pressure Differentials

Supply air is filtered, dehumidified, and is heated or cooled to meet the environmental requirements of a given area. The air is then transported by ducts to that area in a carefully controlled manner. Separate exhaust ventilation systems utilizing High Efficiency Particulate Air (HEPA) filters are provided for room air, glove-box enclosures containing dry air, and glove-box enclosures having an inert atmosphere of nitrogen and less than 5% oxygen.

Some non-inerted glove boxes draw air from the room into the box through a HEPA filter. The systems are designed for once-through airflow or for various percentages of air recycle, depending on operating conditions. Rocky Flats uses a minimum of two stages of HEPA filtration for general building air in buildings where plutonium is handled and four stages of filters for air and nitrogen from glove boxes used for plutonium handling. These filtration systems are shown in Figures 2.7.1-2 through 2.7.1-4. Buildings in which only uranium is handled presently use at least one HEPA-filtration stage. Plenums in these buildings are being redesigned to use two HEPA stages, and improved fire control systems are being installed similar to those in use for plutonium areas.

Standby equipment and secondary power supplies are provided to ensure the continuity of operations. Extensive controls record system behavior and guarantee that, in any abnormal situation, ventilation will not be compromised. Ventilation controls are housed in separately ventilated enclosures having outside access to ensure that the controls are accessible for operation during building disruptions. The systems are designed for maintenance accessibility, criticality control, and operation during fire or other unusual conditions, with continued capability for cleanup of contaminated air. Figure 2.7.1-5 shows a typical exhaust plenum that incorporates features for controlling contamination and for detecting and controlling fires. Compartmentalization of work areas reduces the possibility of spreading fire or contamination. Appropriate use of scrubbers, mist eliminators, and high efficiency filters in the building exhaust systems are features designed to prevent radioactive and noxious chemical contaminants from being discharged into the environment.

HEPA filters, used exclusively for final air filtration at Rocky Flats, consist principally of 240 square feet of 15-to-20-mil continuous fiberglass sheet filter media enclosed in a fire-retardant frame. Filters are fabricated to meet rigid Rocky Flats Plant standards for materials of construction, physical characteristics, and efficiency. New HEPA filters are individually tested in the DOE Central Division Filter Certification Test Facility (Section 2.6.4.2). In addition to laboratory tests of filter components, the assembled filters are tested with a thermally generated aerosol of dioctylphthalate (DOP) which has an average particle size of 0.3 μm. This test reveals possible filter media or bypass leakage which might result from improper fabrication. Filters are also tested for total pressure drop and squareness, and are inspected for excessive looseness of packing and for damaged gaskets. All

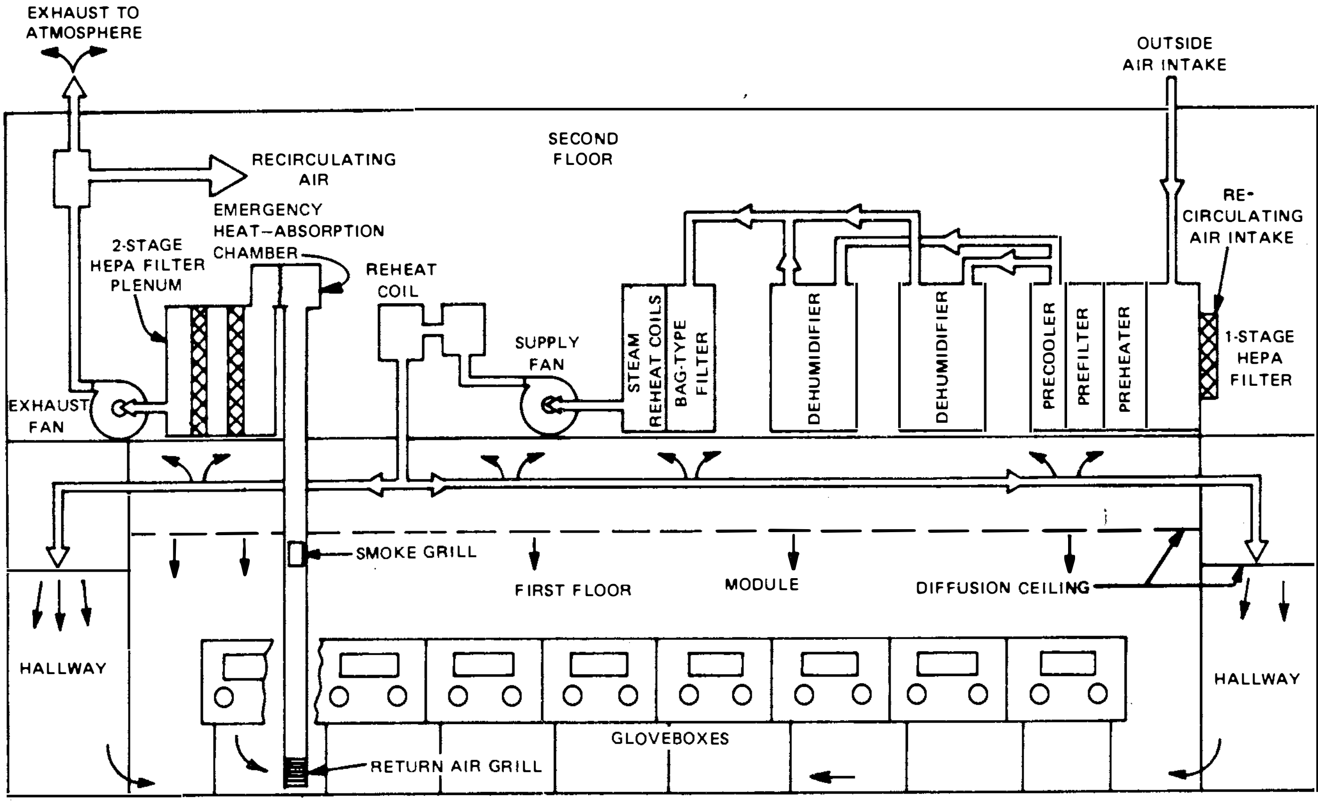


Figure 2.7.1-2 Typical Building Dry Air Ventilation System

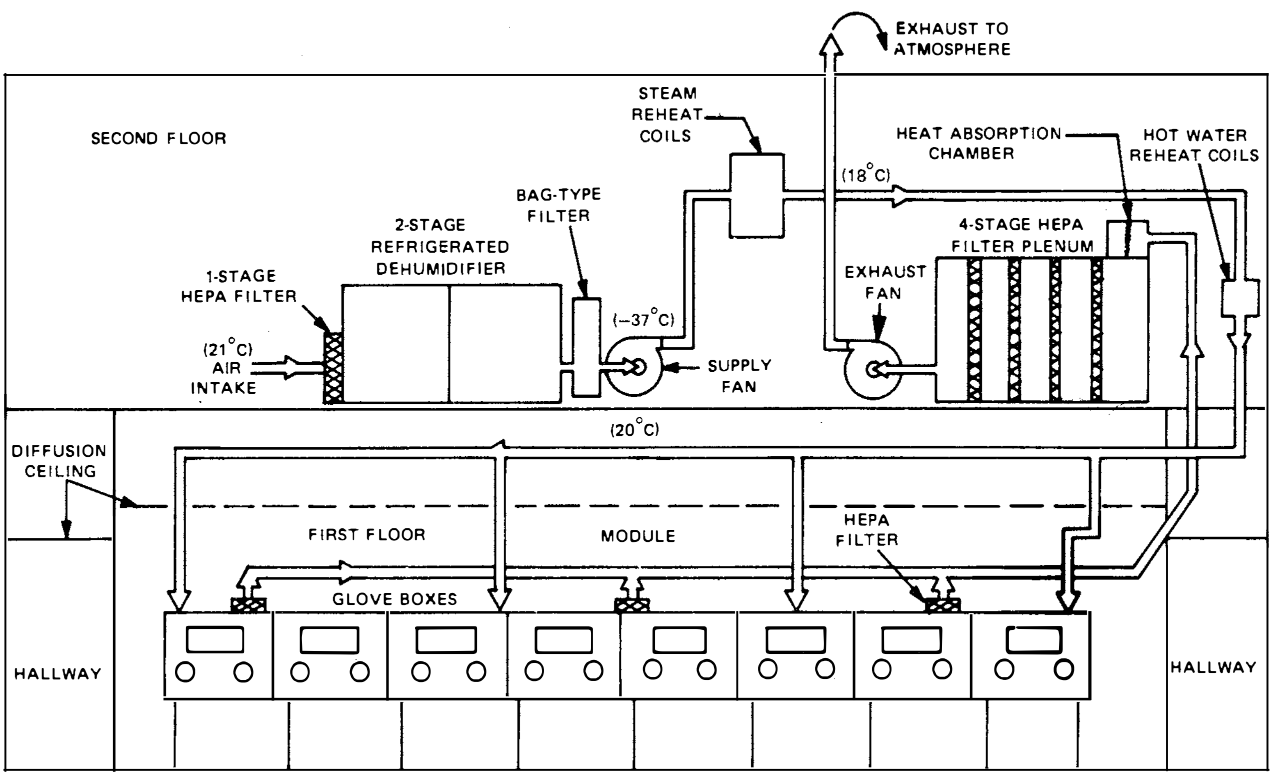


Figure 2.7.1-3 Typical Glove Box Dry Air Ventilation System

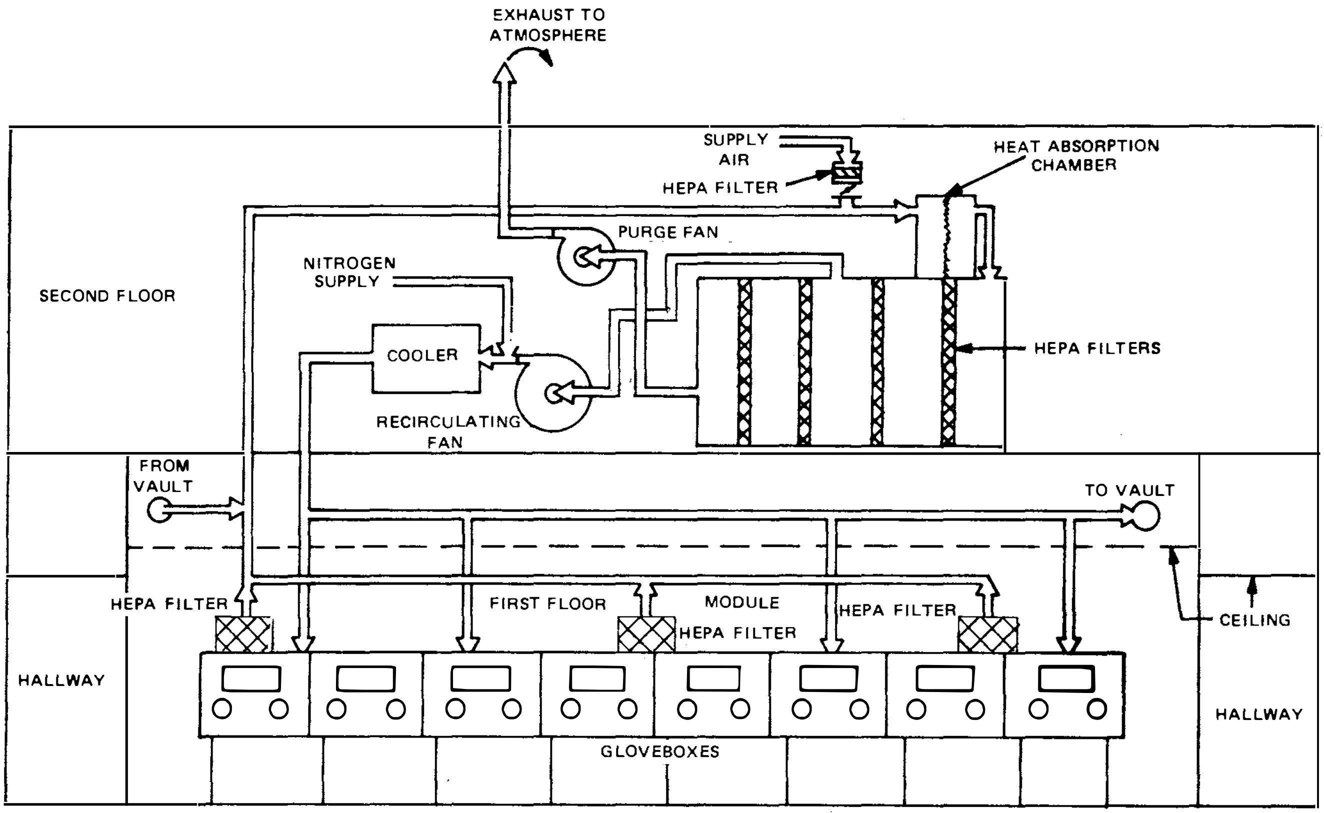
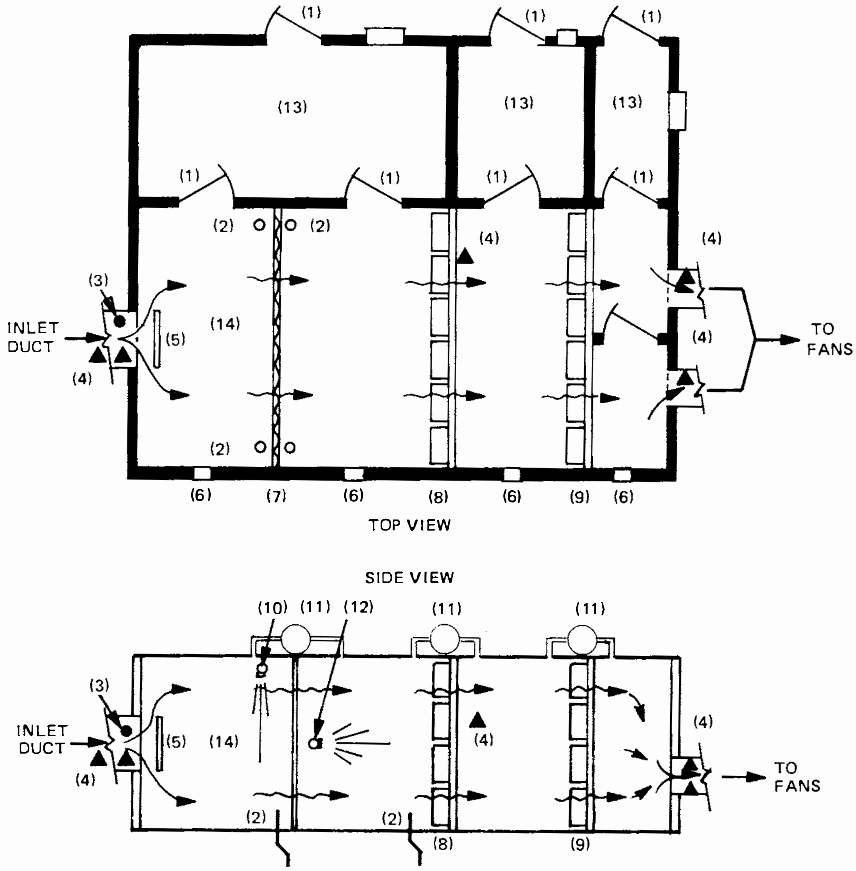


Figure 2.7.1-4 Typical Inert Atmosphere Ventilation System for Certain Glove Boxes and Storage Vaults



(1) AIRTIGHT AIR LOCK DOORS

(2) CRITICALITY DRAINS

(3) AUTOMATIC SPRAY HEAT DETECTOR

(4) TEMPERATURE INDICATING AND RECORDING ALARM HEAT DETECTORS

(5) DEFLECTOR

(6) VIEW PORTS

(7) MIST ELIMINATOR

(8) 1ST STAGE HEPA FILTERS

(9) NEXT STAGE HEPA FILTERS

(10) AUTOMATIC SPRAY

(11) DIFFERENTIAL PRESSURE GAGES

(12) MANUAL SPRAY

(13) AIR LOCK

(14) COOLING CHAMBER

Figure 2.7.1-5 Typical Filter Plenum for Exhaust Air newly installed filter systems are field tested for overall system efficiency or, in the case of large systems, are leak tested to assure an overall system efficiency of 99.95%.

Representative filters from each manufacturer are subjected to Qualified Products List (QPL) Tests prior to installation. These tests include heat and humidity testing. The filters are subjected to a humidity of 95% for 5 minutes and they must maintain an efficienty within 1% of the normal expected operating efficiency of 99.97%. This is to ensure high efficiency despite the humidity (65% maximum) generated by the scrubbers and from condensation. For fire safety, the filter plenum banks in plutonium-handling facilities are designed with sprays directed at the initial filter stage. The plenum banks are devised such that the first stage is expendable and the remaining stages are capable of maintaining the required overall filtering efficiency. The spray, averaging one-fourth gallon of water per square foot of filter, does not damage the filters. Because of the large volume of air passing through the filters, they would dry out rapidly so that any reduction in filtering efficiency would be short lived.

The results of testing installed HEPA filter systems and the reports available from continuous monitoring of all potentially radioactive building effluents show that all filtration systems in plutonium buildings meet the administrative guide of 6×10^{-14} Ci/m^3 of air. Elaborate testing has indicated that a very small quantity of particles of 0.09-μm size may penetrate the filters. An actual particle of 0.09-μm diameter projects to an aerodynamic mean diameter of 0.3 μm when the density of the material is considered. Filters are installed and tested to prevent a penetration of greater than 0.03% (3 particles per 10,000), which represents a decontamination factor of 3.33×10^3 per filter for particles of 0.3-μm aerodynamic diameter.

The cleaning power of filters is quantified by use of several terms: filter efficiency, decontamination factor, and penetration. Filter efficiency is defined as

$$\text{Efficiency} = 100 \left(1 - \frac{Q_d}{Q_e}\right) \%$$

where Q_d is the quantity of particulate downstream of the filter Q_e is quantity upstream or entering the filter. The decontamination factor, DF, is defined as

$$DF = \frac{Q_e}{Q_d}$$

The percent penetration is (100 x 1/DF)%.

To meet the radioactivity concentration guides (RCG) set forth in ERDAM Chapter 0524, Rocky Flats' filtration systems are designed and maintained to assure that effluents will have a plutonium concentration of less than 0.06 pCi/m^3. The number of stages required to achieve this level of decontamination is calculated using an efficiency of 99.95% for the first stage and 99.8% for each subsequent stage. Three stages of filtration, representing a decontamination factor of 10^9, are usually required to achieve the desired level of protection. During normal operation an overall decontamination factor of 10^{12} is achieved for the four-stage systems.

The Rocky Flats systems have been operated and maintained in such a way that applicable emission standards have not been exceeded. Further, Rocky Flats has striven to achieve as-low-as-practical emissions; the building with major emissions has now achieved decontamination factors in the range expected of new plutonium facilities (i.e., 10^9 or better). This has been accomplished largely by using additional filtration stages to achieve the desired decontamination factor. The DF for four stages equals the product of the factors for each stage, i.e., 2000 x 500 x 500 x 500 = 2.5×10^{11}. If 99.95% efficiency per stage were used, the overall DF would be 1.6×10^{13}. Individual filters are accepted only when they have demonstrated an efficiency of 99.97%. However, for design purposes, the efficiency of the installed filter stage is rated and tested at 99.95%. Each successive stage is accorded a lower working efficiency (99.8%) even though the individual stages are tested to assure 99.95%.

Very conservatively figured, if a system consisting of 35 filters for each of four stages were designed to handle an airflow of 26,000 cfm with a challenge of 12 grams of plutonium per 24-hour day, the removal efficiency would be as shown in the Table 2.7.1-1.

TABLE 2.7.1-1

EFFICIENCIES OF A FOUR-STAGE FILTER PLENUM
26,000 cfm through 35-filters-per-stage
plutonium concentrations

Filter Stage	μg/day	pCi/m^3	Stage Efficiency
Before 1st	12×10^6	783,000	
After 1st	6,000	391	99.95
After 2nd	12	0.783	99.8
After 3rd	0.024	1.5×10^{-3}	99.8
After 4th	0.00004	3.1×10^{-6}	99.8

Thus, it can be seen that for this extremely heavy loading (which has been postulated to be a design-basis load, during cleanup, following a glove-box fire in which 500 g of plutonium were consumed), three stages of HEPA filtration would be required to reduce the concentration to less than 0.06 pCi/m^3. The fourth stage is added to all Rocky Flats designs to assure the required containment even if one stage is damaged or in the process of being changed.

The original HEPA filter banks were built with plain, carbon-steel frames and concrete or concrete block enclosures. (A filter bank is a collection of several individual HEPA filters arranged in a matrix.) These very early designs did not always ensure perfect sealing around each filter. Active chemical attack on the filters and frames in buildings having chemical processes impaired cleaning efficiency in the early years of operation. Prior to the installation of plenum water sprays for fire protection, building fires in two buildings caused some warpage in the filter mounting framework. The original system designs for plenum airlocks were such that each filter stage could not be individually isolated during filter changes so that material loosened during the filter changing could escape through the common airlock to a succeeding filter stage. All new plenums have individual airlocks to eliminate this potential leak source.

There have been numerous modifications in the original filter systems to improve their overall efficiency, particularly since 1965, when overall releases from the facility reached a maximum. During 1970 and 1971, for example, the filter framework in the main plenum of the plutonium recovery building was extensively renovated and an additional filter stage was added in the final plenum. This brought the total number of in-line, process-area, filter stages to six. After the effluent from the original four-stage plenum was additionally processed through two more stages, the overall system was comparable to the design goal of modern systems. For plenums in buildings where corrosive materials are handled, special precautions have been taken to reduce chemical attack. Scrubbers have been installed to remove corrosive gases from the air. Since 1971, filter plenum mountings and bolts in these areas have been made of stainless steel and an anticorrosive paint has been applied. No corrosion and no reduction in efficiency has been found. Certain chemicals, such as chlorinated hydrocarbon solvents, do not attack the media of the filters; however, the adhesive lining of the filter is subject to attack and can result in an efficiency decrease. Recent design improvements have been made to assure containment of plutonium during filter changes. As of 1975 the total site release from Rocky Flats had been reduced nearly 1,000 times from 1965 levels, and the system decontamination factors are now 10^{10} to 10^{11} or better for major release points.

The filter systems in buildings handling greater than gram quantities of plutonium have been rebuilt or fully replaced in the last 10 years to further improve filter efficiency. Testing these filter banks in-place has been initiated; they have been tested to an overall efficiency of 99.95%, using a particle size of about 0.3 μm.

A 15-person crew is assigned to filter surveillance and maintenance on a full-time basis. Filters are checked daily using magnahelic gauges to monitor pressure differential. Where necessary there are visual checks for physical deterioration of filters and automatic alarm systems which activate when the pressure differential exceeds a prescribed level. Filters are changed on an "as required" basis which is determined by the degree of loading, the nature of the filtered material, and the type of work activity. Some are changed every two to three weeks, while others may stay in service for several years. Used filters are packaged as radioactive solid waste and sent to a DOE-approved storage site (See Section 2.7.4).

In addition to improvements in existing plutonium buildings, a new plutonium recovery and waste treatment facility is being built to replace most of the functions of the present chemical-recovery and waste-treatment buildings, which account for 80 to 90% of the total site release. The airborne, particulate, radioactive control system for the new building is being designed in compliance with standards published by ERDA for new plutonium facilities. It is expected that when the new building is operational, the total plutonium releases will be substantially reduced. The exhaust-filter mounting frames in the four-stage HEPA filters of the new building will be constructed of stainless steel to minimize surface corrosion which could cause sealing problems around individual HEPA filters.

Many new plenums are designed so that they can be completely isolated during filter change or repair operations. This is particularly true for inerted plenums, which must be returned to normal air atmospheres during maintenance. The new building will use mechanical refrigeration for precise temperature and humidity control to eliminate any moisture condensation in the filter plenums. Moisture in the plenums can hasten vapor phase reactions, which may damage the filters and plenums. Dual scrubbing systems will be used to greatly reduce the chance of chemical fumes from reaching the filters. Flow to the scrubbers will be precisely controlled, and the scrubbers will be operated cold (65° F) to ensure a high absorption efficiency. This flow control will prevent condensation of moisture downstream in the HEPA filter plenums and ductwork. The filter systems in all buildings are continually being reviewed for design improvements or operating procedure changes, which may reduce the potential airborne release of radioactive materials.

Small amounts of tritium handled at the Plant result in the discharge of this isotope. Tritium is not efficiently removed by the HEPA filter systems. In accordance with the DOE policy that releases are "limited to the lowest levels technically and economically practicable" (USERDA, 1977), releases are so low that a tritium control system is considered unnecessary. The principal control of tritium releases is a strict limit on the total amount of tritium that can be contained in materials processed by Rocky Flats, based on specific isotopic analyses of incoming materials. All nonroutine, incoming shipments of special nuclear material are tested for tritium to prevent inadvertent processing of unknown amounts of that element.

2.7.2 Radioactive Airborne Releases

Table 2.7.2-1 is a historical record of airborne alpha activity releases from Plant buildings. The table shows releases from Plant operation and releases from identifiable incidents during Rocky Flats' history.

Considering routine operations, the increase in releases during the first years of the Plant resulted primarily from the increase in total operations and amount of plutonium handled during those years. Releases from the original filter system then reached a relatively constant level of 1,500 to 2,000 μCi/yr, except during 1957, when a fire caused an abnormal release. Beginning in 1962, releases again began to increase slowly as the overall filter-system efficiency began to decrease from chemical corrosion. By 1965, normal operation releases reached a maximum of 5,348 μCi/yr. These releases corresponded to a maximum concentration in the exhaust stacks of the main plutonium buildings of less than 2 pCi/m^3, which is the ERDA standard for plutonium in air breathed by plutonium workers.*

No workers are continually exposed to stack effluents, but the ERDA standard for radiation protection (USERDA, 1977) is used as an administrative guide for stack effluents. The allowed concentration for workers (2 pCi/m^3) is greater than the standard for plutonium levels in air to which the total population may be exposed (0.02 pCi/m^3). This 0.02 pCi/m^3 value is applied administratively as a control for total alpha activity in stack effluents. Dilution provided by dispersion of stack releases to the nearest populated area (see Appendix B-2) is adequate to reduce the effluent concentrations to significantly less than the allowable RCG of 0.02 pCi/m^3. (Using a dispersion factor of 5.04×10^{-7}, which assumes annual average meteorology, a release of 2,000 μCi/yr would yield a maximum, annual, average plutonium concentration of 0.00003 pCi/m^3 at the nearest populated area.) Thus, the maximum Plant release from normal operation has not exceeded any applicable RCG's. During 1965, Rocky Flats began a concentrated effort to reduce all Plant releases to much lower levels. As a part of this effort, the filter systems in the main plutonium buildings were upgraded to include the use of four stages of HEPA filters for process lines ahead of the final two HEPA filter stages in the main plenum. This filter system renovation reduced the total Plant release from around 5,000 μCi/yr to about 500 μCi/yr. Then, following the 1969 Rocky Flats fire (the fire caused a temporary increase in the routine Plant release because of some warpage in the filter plenums), another system renovation was begun to further reduce the Plant release. This system change was finished at the end of 1970.

In addition to system changes designed to reduce emissions to levels as low as economically and technically practical, administrative and operating limits have been

*This RCG is based on the assumption that the plutonium is in a soluble form. Actually, almost all Rocky Flats releases are in the form of insoluble plutonium oxide. The ERDA RCG for insoluble plutonium is a factor of 20 higher; i.e., 40 pCi/m^3 for workers.

TABLE 2.7.2-1

YEARLY ALPHA RELEASES TO AIR FROM PLUTONIUM FACILITIES

Year	Normal Operational Release (μCi)	Release From Incidents (μCi)	Year	Normal Operational Release (μCi)	Release From Incidents (μCi)
1953	2	-	1966	323	-
1954	65	-	1967	397	-
1955	72	-	1968	488	-
1956	229	-	1969	784	856[e] and 20[f]
1957	1595	25618[a]	1970	354	25[g]
1958	3144	3.4×10^6[b]	1971	66	4[h] and <4[i,j]
1959	1435	-	1972	59	<2[k,m]
1960	1321	-	1973*	77	-
1961	1457	-	1974*	22	934[n]
1962	2974	-	1975*	10	-
1963	3903	-	1976*	4	-
1964	2749	10[c]	1977*	4	-
1965	5348	1170[d]			

a. Plutonium fire in production building.

b. Total off-site release from contaminated oil leakage (3.4×10^6 μCi is the amount released from the old site boundaries; in terms of the new boundaries, about 2.4×10^6 μCi is off-site).

c. Chemical explosion in glove box.

d. Glove-box drain plug fire.

e. Plutonium glove-box and building fire in production building.

f. Plutonium fire in tunnel between buildings.

g. Contamination release from spill caused by cleaning plugged drain line.

h. Contamination spread from reduction furnace explosion.

i. Plutonium can explosion, with fire and contamination.

j. Contamination from spill through hole in barrel liner.

k. Incinerator glove-box explosion and fire.

m. Incinerator fire and contamination.

n. Release from control valve failure.

*Releases from July 1973 and in subsequent years represent plutonium releases rather than total long-lived alpha activity.

set in recent years to ensure that total environmental releases are kept well below applicable DOE limits. The DOE policy (called ALAP, or as-low-as practicable (USERDA, 1977), which recommends continuing improvements in control of stack releases, is stated as follows: ". . . operations shall be conducted in a manner to assure that radiation exposure to individuals and population groups is limited to the lowest levels technically and economically practicable." Measurements of radioactive effluent in the release stacks of all buildings in which plutonium is handled are sampled on a continuous basis. If any measurement shows a total long-lived alpha concentration greater than 0.02 pCi/m^3, an immediate investigative report is filed. Actions are initiated to determine the reason for the release level and to plan corrective measures. Administrative limits provide added assurance that total off-site concentrations will be well below the present DOE guide values.

In the years 1975-1977, the yearly stack release has been 10 μCi/yr or less of plutonium.

The isotopic compositions measured for weapons-grade plutonium at Rocky Flats are shown in Table 2.7.2-2. These percentages represent the average composition of Rocky Flats plutonium during the last two years. Plutonium-241 decays to americium-241, which is also an alpha emitter. Thus, the total alpha activity from plutonium releases includes some americium alpha activity. In general, the plutonium processed at Rocky Flats is about 10 years old*; the americium-to-plutonium activity ratio ranges from 0.1 to 0.2. During processing, americium is separated from the plutonium. This can result in a different ratio.

TABLE 2.7.2-2
ISOTOPIC COMPOSITION OF
ROCKY FLATS PLUTONIUM
(July, 1976 through July 1, 1978)

Isotope	Percent By Weight	Alpha Activity (Ci/g)	Beta Activity (Ci/g)
Pu-238	0.01	1.7×10^{-3}	-
Pu-239	93.79	5.8×10^{-2}	-
Pu-240	5.80	1.3×10^{-2}	-
Pu-241	0.36	-	0.37
Pu-242	0.03	1.2×10^{-6}	-
TOTAL		0.073	0.37

Uranium and tritium airborne releases are shown in Table 2.7.2-3. Curium is handled at Rocky Flats and releases have been shown to be negligible. Neptunium and thorium are also handled at Rocky Flats, but in such small quantities as to preclude a significant release.

*Created by reactor about 10 years ago.

TABLE 2.7.2-3
AIRBORNE RELEASES OF URANIUM AND TRITIUM
FROM ROCKY FLATS PLANT

Year	Alpha from U-238 Areas (μCi)	Alpha from U-235 Areas (μCi)	Tritium (Ci)
1957	38	230	-
1958	51	308	-
1959	34	540	-
1960	58	863	-
1961	523	483	-
1962	368	249	-
1963	339	277	-
1964	236	193	-
1965	277	186	-
1966	143	233	-
1967	139	112	-
1968	138	161	Several hundred
1969	167	51	-
1970	190	64	-
1971	58	41	-
1972	42	4	-
1973	63	11	~1000
1974	9	27	~10
1975	28	28	2
1976	12	16	1.2
1977	19	21	0.5

Important filter improvements occurred in 1970; thus, the table reflects a decrease in emissions since 1970. On the basis of 1971 through 1977, it would appear that the expected yearly release of uranium-235 and uranium-238, separately, would be less than 50 μCi/yr.

In past years, Rocky Flats measured total long-lived alpha activity associated with uranium releases, but did not determine activity on a specific isotopic basis. Thus, the alpha activities listed in Table 2.7.2-3, which are reported as activity from uranium-235 and uranium-238 areas include activity from several uranium isotopes. Shown in Table 2.7.2-4 are the isotopes associated with enriched uranium (more than 93% U-235 enrichment) and depleted uranium which are processed by the Rocky Flats facility. As can be seen, most of the activity of the enriched uranium comes from uranium-234 even though uranium-235 is more than 93%, by weight, of the total uranium content. This results from the much higher specific activity of uranium-234 than uranium-235.

TABLE 2.7.2-4

ACTIVITY RATIOS OF ROCKY FLATS URANIUM

Depleted Uranium*	Alpha (Ci/g)	Beta (Ci/g)
Th-231	-	4.9×10^{-9}
Th-234	-	3.4×10^{-7}
U-234	3.7×10^{-8}	-
U-235	4.9×10^{-9}	-
U-238	3.4×10^{-7}	-
Total	3.8×10^{-7}	3.4×10^{-7}
Enriched Uranium**		
Th-231	-	2.0×10^{-6}
Th-234		1.8×10^{-8}
U-234	6.2×10^{-5}	-
U-235	2.0×10^{-6}	-
U-236	2.5×10^{-7}	-
U-238	1.8×10^{-8}	-
Total	6.4×10^{-5}	2.0×10^{-6}

*Depleted uranium is referred to as U-238.
**Enriched uranium is referred to as U-235.

As indicated in Table 2.7.2-3, there have been only two known releases of tritium from Rocky Flats Plant. (The amounts in 1974 through 1977 are residual quantities from the 1973 release.) In 1968, several hundred curies of tritium were released accidentally. Investigations at the Rocky Flats Plant indicate that no threat to human health or safety occurred. In 1973, material contaminated with tritium was inadvertently processed at the Rocky Flats Plant. A determination by Plant and EPA personnel of the total amount of tritium contained in this material indicated that 500 to 2,000 curies of tritium were involved. Of this amount, some 56 curies were released in water effluent from the Plant and some 100 to 500 curies were retained in tanks and ponds on site. Most of the remaining tritium was released to the atmosphere. Residual contamination from the 1973 incident has resulted in a continuing, but decreasing, release of tritium.

All future routine releases will be maintained at a small fraction of applicable ERDA standards. Specifically, Rocky Flats has set an internal guide for tritium that no concentration in the exhaust stack may exceed the DOE RCG for concentrations to which the general public is exposed (specifically 200,000 pCi/m^3). Under this public exposure limitation, about 3,100 Ci of tritium per year could be released without exceeding the internal guide. Dilution factors at the Plant are such that the worst-possible, annual, average, off-site concentrations will be several orders of magnitude below the DOE RCG.

In addition to the above-mentioned limit on airborne effluent concentrations, the Rocky Flats Plant contractor has set an administrative limit of 0.1 curies per month on the total amount of tritium contained in materials processed at the facility. This is not an official or formal limit, but it is being used as an administrative control to restrict tritium releases to a level which will be as-low-as-practicable for the foreseeable workload requirements.

2.7.3 Radioactive Liquid Waste

Liquids subject to radioactive contamination are carefully controlled, collected, and processed to remove contaminants. These contaminants are then concentrated, solidified, if required, and packaged for shipment to a DOE-approved storage facility.

2.7.3.1 Process Liquid Waste Collection

Each building having production, research, or support facilities in which radioactive materials are handled is equipped with a process-waste collection system. This system, which is isolated from the sanitary-waste collection system, collects liquid wastes from such sources as process drains, decontamination showers, laboratory sinks, janitor sinks, and floor drains located in potentially contaminated areas. The process waste collection system also handles the disposal of water used in firefighting in these areas. The collected wastes are held in appropriate tanks pending analysis of the contaminants and determination of treatment. Depending on the origin, the waste may be analyzed for plutonium, americium, uranium, hexavalent chromium, nitrate, pH, fluoride, beryllium, and other contaminants or conditions as appropriate.

The majority of the Plant's process-waste holding tanks are connected by pipeline to the waste treatment facility and the waste storage ponds. Several buildings that produce small volumes of wastes that are not compatible with the waste-treatment decontamination process are serviced by portable tanks or smaller, closed containers. These wastes are transported by truck to the waste treatment facility or the waste storage ponds.

A 1977 amendment to ERDA Manual Chapter 6301 (USERDA, 1977) has required that all process wastewater piping systems bearing radioactively contaminated waste be doubly contained or inspectable. The outer containment guides any leakage from the primary pipe to a collection reservoir. Water sensing devices in these reservoirs alert personnel to the presence of a leak so that it can be repaired and the leakage collected and sent to process wastewater treatment. All process wastewater pipes for radioactive waste, not already doubly contained, are being modified to provide double containment or inspectability.

Organic waste liquids, machine oils, lubricants, and solvents are collected in separate holding tanks and transferred to the waste treatment facility by separate pipeline or container. Highly toxic process waste is shipped intraplant in double containment to contain leaks. Low toxicity materials may be moved in stainless steel dumpster equipment.

All process liquids must be less than the Normal Operational Loss (NOL) Discard Limits for the radionuclides involved before they can be declared waste and transferred to waste treatment. These discard values are established by a contractor committee and approved by DOE. In specific instances, an exemption may be obtained for waste with a particular recovery problem (such exemptions are typically granted three or four times per year). Waste which exceeds these limits must be reprocessed to recover radioactive material which is then recycled into the production stream.

Wastes less than the NOL discard limits, but greater than 100,000 pCi/l total long-lived alpha (TLLα), are transferred to the Plant waste decontamination facility for treatment (Section 2.7.3.2). The 100,000 pCi/l limit is the maximum allowable concentration of soluble Pu-239 allowed for water in controlled areas (see USERDA Manual Chapter 0524, Annex A, 1977).

Wastes less than 100,000 pCi/l total long-lived alpha activity are released to the asphalt-lined solar evaporation ponds where they are stored for future processing. Water from the solar evaporation ponds is now being processed in the new waste treatment facility (Section 2.7.3.3). Sediment from these ponds is handled as contaminated waste. The solar evaporation ponds are currently being cleaned by draining the ponds, partially drying the sludge or mixing it with moisture absorbers, depositing it in appropriate shipping containers, and sending it to an off-site radioactive waste repository. After being cleaned and relined, the solar ponds will be used only for storing cooling tower blowdown water and tertiary treated effluent from the sanitary waste treatment plant. This water will be used as feed water for the reverse osmosis recycling plant. The reverse osmosis product water will be stored in another cleaned and relined solar pond for subsequent use as makeup water for the cooling towers.

Wastes with less than 1,667 pCi/l alpha activity are released to the unlined storage ponds (A-1, A-2, and B-2). The control guide, 1,667 pCi/l, is derived from the Radioactive Concentration Guide (RCG) given in ERDA Manual Chapter 0524. It is the RCG for soluble plutonium-239 in water consumed by an individual in the general population. The ponds are not available to the general population or connected to any public water supply. There are no regulations which apply to this water. The control guide is an internally applied administrative limit. The liquid wastes from Ponds A-1 and B-2 are collected in Pond A-2 and are subsequently removed by natural and spray evaporation. When the new waste treatment facility is operational, these wastes will be processed by it.

2.7.3.2 Process Waste Treatment Facility

The waste treatment operations handle all liquid process wastes that do not meet the requirements for on-site impoundment. The wastes are treated to prepare them for disposal, not for the recovery of plutonium.

The first-stage operation treats the following typical liquid wastes from the plutonium recovery facility: ion column effluent, distillate, americium process effluents, caustic ferric chloride solutions, condensates, basic solutions, and analytical laboratory solutions. Acid wastes are first made basic, and the resulting solids are separated from the liquid. All waste liquids are then combined and treated with a carrier precipitation process. Ferric sulfate, calcium chloride, and a coagulating agent are used to form a precipitate that carries the radioactive contaminants out of solution. This precipitate is then filtered and packaged as sludge in a drum. Aqueous wastes containing plutonium complexing agents are made basic and are then solidified with cement and an absorbent material in specially prepared drums.

The second-stage operation handles all other aqueous process wastes that require treatment and provides further treatment for the first-stage effluent. The second stage consists of two precipitation processes; one is batch and the other continuous. The batch precipitation process is used for all liquids that contain chemicals as well as radioactive materials. The continuous precipitation process may be used for liquids that contain radioactivity but no concentrated chemicals. Both processes utilize the same chemical reagents; the precipitate formed is filtered and packaged as sludge in drums. All treated sludges are handled as radioactive waste and shipped to a DOE approved storage site.

The treated effluents from both processes are held in isolated tanks until samples are analyzed. Via a three-way valving system, liquid waste not exceeding the RCGs specified under ERDA Manual Chapter 0524, and which are chemically contaminated are impounded in the asphalt-lined, solar evaporation ponds. The non-chemically contaminated liquid is impounded in the unlined ponds (A-1, A-2, and B-2, as shown in Figure 2.3.9.3).

Chemically contaminated waste impounded in the asphalt-lined evaporation ponds is transferred to evaporator feed tanks and concentrated by a steam-fired evaporator as capacity permits. The vapors (overheads) from the evaporator are discharged to the atmosphere. The evaporator has a capacity of 230 gallons per hour and operates continuously. Table 2.7.3-1 lists the contaminants and concentrations normally released with the evaporator overheads. The evaporator concentrates (bottoms) are transferred to a double-drum dryer that removes the remaining water. The dried salts are packaged as salt in a box, which is sealed and banded then shipped to a DOE-approved storage site. The waste-treatment-facility process flow is shown in Figures 2.7.3-1 through 2.7.3-4.

TABLE 2.7.3-1
IMPURITIES IN WASTE-TREATMENT EVAPORATOR OVERHEADS

Contaminant	Concentration*
Arsenic	3×10^{-4} ppm
Barium	2×10^{-3} ppm
Beryllium	2×10^{-2} ppm
Cadmium	3×10^{-4} ppm
Chloride	<1.0 ppm
Copper	0.1 ppm
Chromium as Cr^{+6}	<0.05 ppm
Cyanide	0.01 ppm
Fluoride	<0.1 ppm
Iron	0.47 ppm
Lead	2×10^{-3} ppm
Manganese	2×10^{-3} ppm
Nitrate	1.4 ppm
pH	8.9
Phosphate	<0.5 ppm
Silver	3×10^{-5} ppm
Sulfate	<2.0 ppm
Total Alpha Activity	<1.0 d/m/l
Total Solids	5.9 ppm
Tritium	60 μCi/l
Zinc	2×10^{-3} ppm

* Maximum concentrations based on sampling and analysis every two days of evaporator operation.

Contaminated organic liquids, lathe coolant (CCl_4 and oil), and organic solvents are received via a separate pipeline feeding into isolated feed tank systems. Miscellaneous organic solvents and oils received by containers are filtered and transferred into the organic solvent feed tank system. These wastes are processed by blending the liquid with calcium silicate in a continuous mixer to form a solid. The solid is packaged as "grease" in a drum. Figure 2.7.3-5 shows the organic waste process flow.

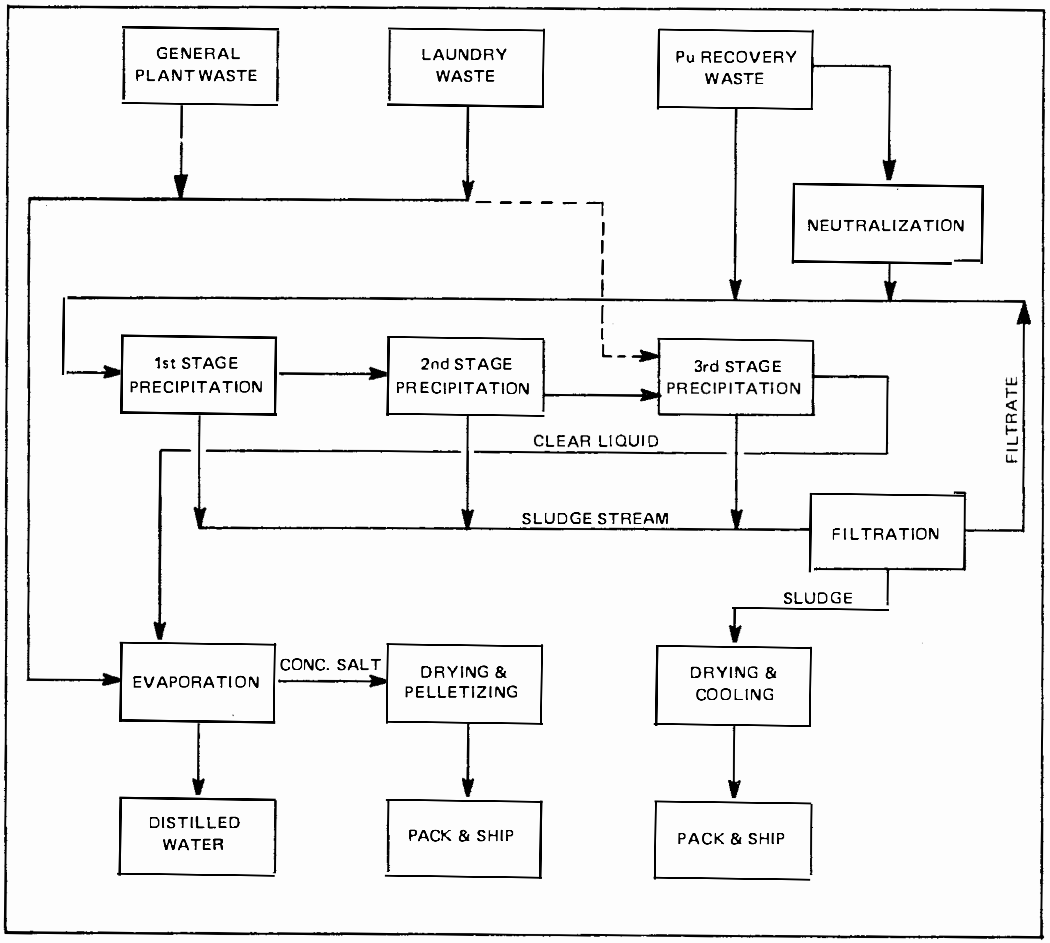


Figure 2.7.3-1 Waste Treatment Flow Diagram

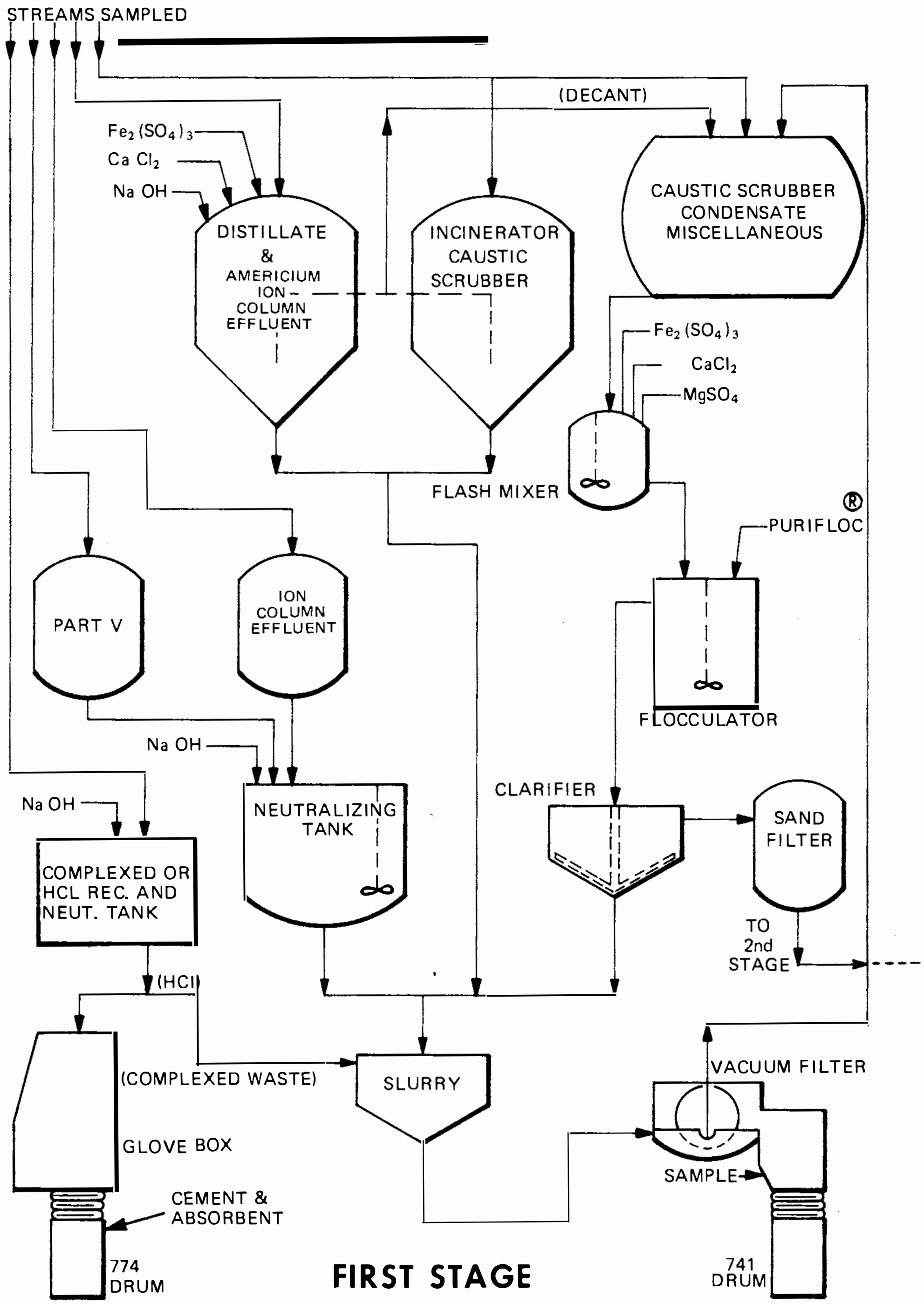


Figure 2.7.3-2 Waste Treatment Process Flow, First Stage

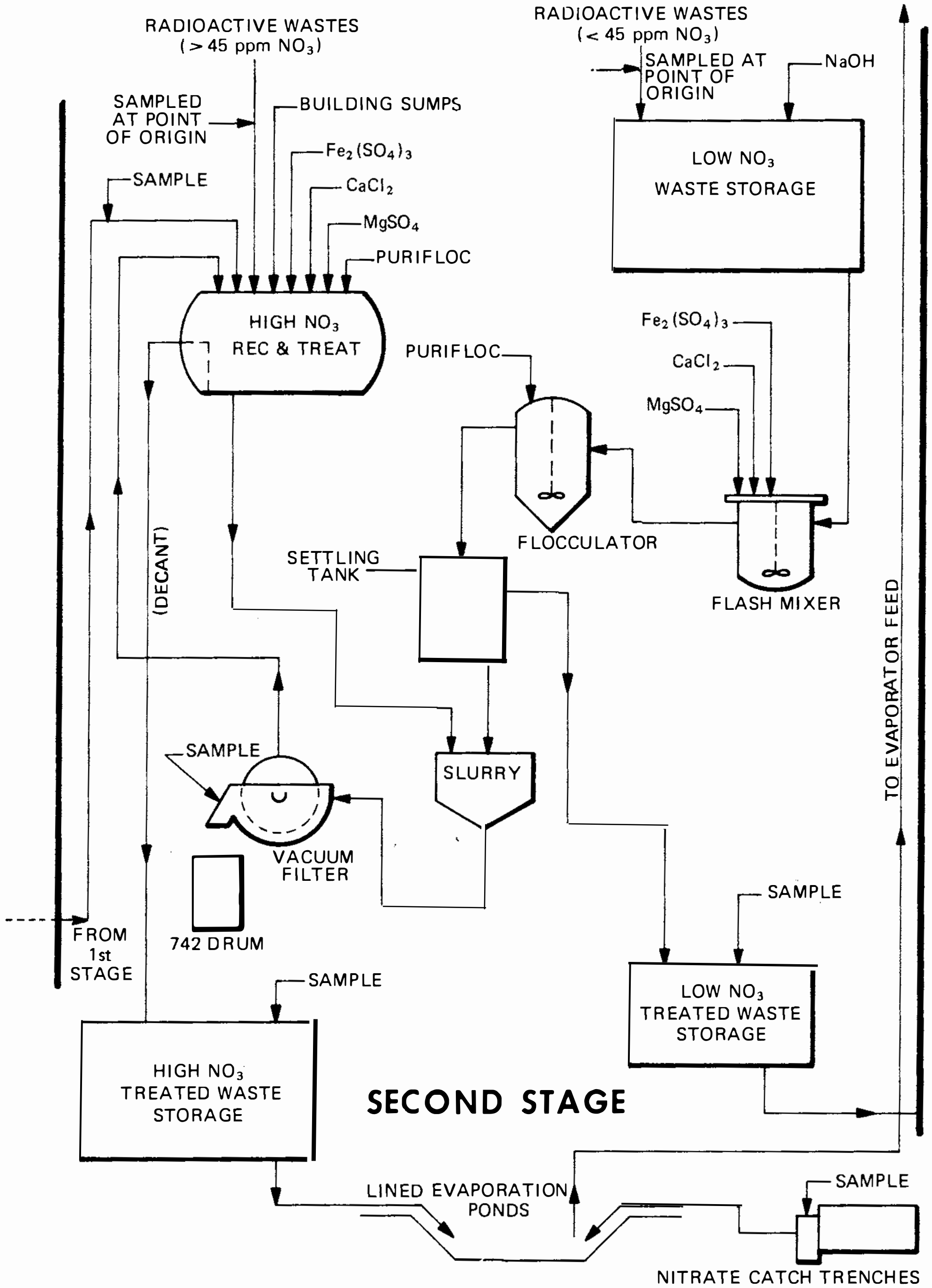


Figure 2.7.3-3 Waste Treatment Process Flow, Second Stage

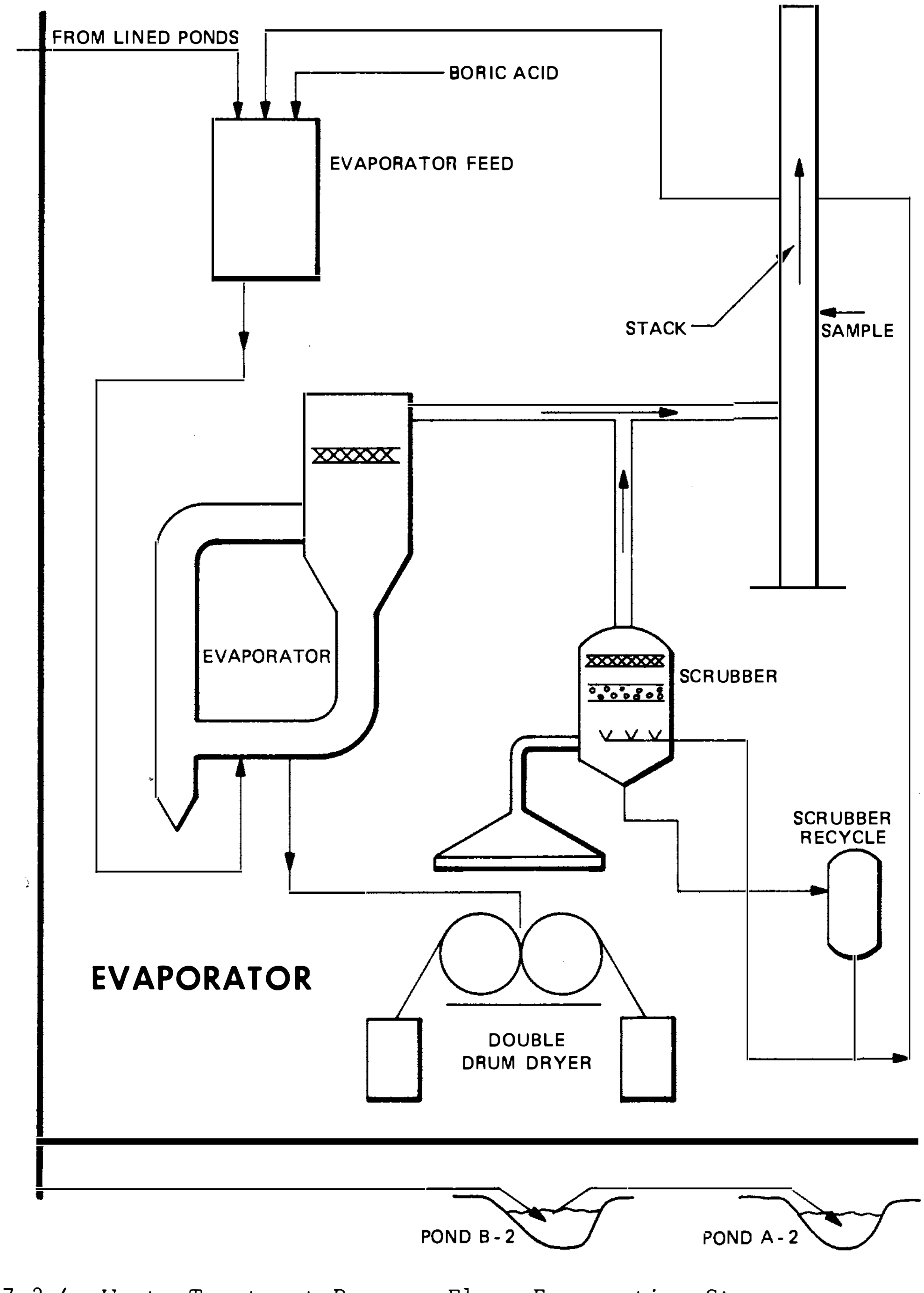


Figure 2.7.3-4 Waste Treatment Process Flow, Evaporation Stage

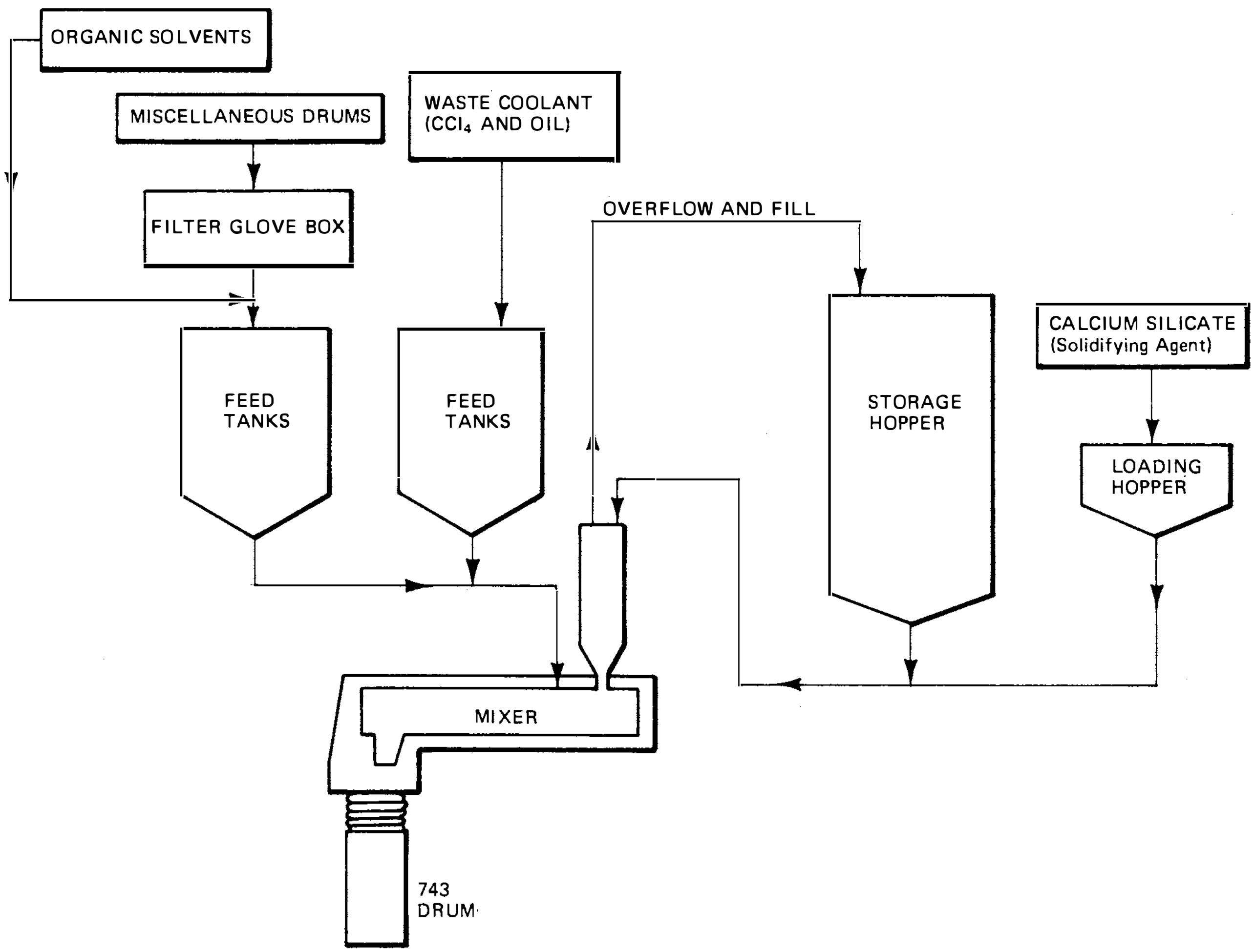


Figure 2.7.3-5 Organic Process Waste Flow

2.7.3.3 New Waste Treatment Facility

A new waste-treatment facility is partially in operation. Chemically polluted liquid process wastes, including some containing radioactive contaminants, will be received by the new waste-treatment facility from the solar evaporation ponds and other buildings when the facility is fully operational.

Prior to being transferred to the waste-treatment facility, all liquid wastes are analyzed to determine their general chemical composition and specific radioactivity. The routing and the processing steps of waste treatment depend upon the chemical composition of the wastes and the amount of residual radioactivity in them. The liquid streams entering waste treatment are stored in tanks according to their composition and intended routing within waste treatment. Liquid waste receiving-storage tanks include those for nitrate (acidic) wastes, basic wastes, laundry wastes, evaporator feed, and second- and third-stage precipitator feed.

Acidic wastes are neutralized with caustic soda (sodium hydroxide) and filtered to remove solids. In general, these neutralized wastes, plus blended basic wastes, are pumped to chemical reaction vessels where a multistage precipitation process begins. The process consists of precipitation, flocculation, and clarification. Effluents from the precipitation stages are analyzed in the clarifier effluent tanks for radioactivity prior to being transferred to the evaporator system.

The solids from each clarifier are filtered out by rotary-drum filters (utilizing vacuum), and are then dried, cooled, and packed in steel drums for shipment as contaminated waste to a DOE approved storage site. The filtrate from the rotary-drum filters is recycled to the first-stage precipitator feed tank.

The supernatant from the third-stage clarifier plus nonradioactive Plant wastes from the evaporator feed tanks are fed to a multiple-effect evaporator. Concentrate from the last effect of the evaporator is fed into a spray dryer. Solids (salts) from the spray dryer are removed by a bag filter and a high efficiency particulate air (HEPA) filter; the salts are then pelletized. Water vapor exhausted from the salt spray dryer is vented through a process filter prior to its release through an exhaust plenum to the environment. Water-vapor exhaust from the sludge dryer is vented through a scrubber prior to its release to an exhaust plenum; scrubber wastewater is recycled back to the basic waste-receiving and blending tanks. The condensate from all stages of the multiple-effect evaporator is used primarily for boiler feed water, and secondarily for cooling-tower water.

2.7.4 Radioactive Solid Waste

In its handling of plutonium and other radionuclides, the Rocky Flats Plant generates radioactive scrap, or residue, and radioactive waste. Scrap is material that can be recycled for productive use; radioactive scrap contains plutonium or enriched uranium that is economically desirable to recover. Waste, on the other hand, has no recoverable value.

A total of about 6,700 cubic yards of plutonium-contaminated waste is currently generated annually. Nearly 1,200 cubic yards of this total is packaged and shipped to an off-site retrievable storage location. This is considered TRU (transuranic) waste, which is waste with more than 10 nanocuries of plutonium per gram (nCi/g). Approximately 5,500 cubic yards per year is packaged and shipped to an off-site non-retrievable location; this is non-TRU (NTRU) waste that has less than 10 nanocuries of plutonium per gram.

2.7.4.1 Radioactive Solid Waste Collection

Removing solid waste from glove boxes involves transferring the waste through a glove-box opening into an 8-mil plastic bag or sleeve clamped to the opening. The bag is then twisted, taped closed, and cut away. This bag is placed in a second bag for added protection. These procedures are supplemented by forced, down-draft ventilation; individually fitted respiratory protection for all personnel; close radiation monitoring surveillance; and protection from external radiation. Because of its origin, all waste of this type is considered by the Department of Transportation (DOT) to be of NOS (Not Otherwise Specified) activity.* Low Specific Activity (LSA) waste has less than 100 nanocuries of plutonium per gram of waste; NOS waste contains more than 100 nCi/g. The more restrictive DOE designations, TRU and NTRU wastes (see previous paragraph) are used as guides for waste handling.

Other contaminated solid wastes result from materials such as clothing, paper used by employees in process or controlled areas (but outside glove boxes), and surgeons' gloves; they are designated LSA if no significant X- or gamma radiation is noted by radiation monitoring surveys and if no measurable plutonium is indicated by drum-counting techniques. These techniques involve detectors designed and calibrated to identify and quantify the radioactive elements in each drum containing contaminated waste.

2.7.4.2 Radioactive Waste Packaging

Most radioactive wastes are sorted and packaged in 55-gallon steel drums manufactured under a quality control program to ensure compliance with Department of Transportation (DOT) specifications. A thick-walled polyethylene drum liner is used to contain TRU wastes inside the drum for retrievable storage. The polyethylene

*A more detailed discussion of Department of Transportation packaging and shipping specifications is given in Section 2.6.10.

liner provides added resistance to corrosion from the contents, increases resistance to tear or puncture, and is a means of containment even if the steel drum corrodes. The plutonium content of each drum is determined by counting gamma radiation in a shielded drum counter that has been calibrated for the type of waste involved. The drum counter utilizes sodium iodide and/or germanium gamma-ray detection systems. These systems record gamma rays emitted by plutonium-239, and the data are correlated with standards to arrive at a plutonium assay. Counting standards are prepared by the standards laboratory using techniques traceable to the National Bureau of Standards. The drums are loaded either onto cargo carriers, which are then placed in ATMX cars, or onto semitrailer trucks. Both the trucks and ATMX cars are gamma-surveyed before they leave the Plant.

Some wastes such as glove boxes, large equipment, and construction materials are too large to fit into a 55-gallon drum. These items are disassembled to reduce the volume (a process called size reduction). The existing size-reduction facility is located in the vicinity of the site for a proposed Advanced Size Reduction Facility, now receiving budgeting consideration. Operations performed in the existing facility are designed to minimize the volume of solid wastes. Personnel routinely performing these operations in the existing facility are required to wear full protective clothing with supplied air. The Advanced Size Reduction Facility will take advantage of the latest technology for remote handling and cleaning of solid waste, thus achieving a greater degree of safety than exists in the present facility.

After disassembly, waste materials are cleaned to remove plutonium and packaged into 0.75-inch-thick plywood boxes. For retrievable storage, the boxes are coated with fire-retardant and fiberglass-reinforced polyester. These boxes are manufactured under a quality control program to ensure compliance with DOT specifications. Each item placed into a plywood box is monitored with a calibrated, portable, sodium iodide detector to detect any significant residual plutonium.

All primary containment packaging for contaminated waste is controlled by Quality Control Plan "Material Packaging, Shipping, and Transportation" (RI, 1977). Specific packaging items are subject to receiving inspection and testing as directed by the operating contractor's Quality Control group.

2.7.4.3 Radioactive Waste Shipping

Rocky Flats uses rail cars and truck trailers to ship wastes at the present time. Drums and uncoated boxes containing NTRU waste such as evaporator salts, sewage sludge, and material contaminated with depleted uranium and beryllium are trucked. All other drums having TRU waste are placed in cargo containers that are loaded into ATMX rail cars, which are specially designed cars owned by DOE. All rail shipments go to the TSA (Transuranic Storage Area) at INEL where the cargo containers are unloaded. All coated boxes are also shipped by ATMX rail car.

Waste drums and boxes are monitored for gamma radiation and alpha contamination by Radiation Monitoring personnel at Rocky Flats prior to their departure from the Waste Management final inspection area. ATMX rail cars are gamma surveyed after they are loaded and prior to leaving the Rocky Flats Plant. After being unloaded at INEL, the rail cars and cargo containers are monitored before being returned to the Plant.

2.8 CHEMICAL AND BIOCIDAL WASTES

The Rocky Flats Plant has over 1,800 different chemicals on the site, of which the majority are present only in laboratory quantities. Chemicals are used throughout the Plant, particularly in Production, Research and Development, Plutonium Recovery, and the laboratories. Table 2.8-1 lists the major chemicals and the consumption of each in 1977. The quantities are typical of annual consumption rates.

TABLE 2.8-1
CONSUMPTION OF CHEMICALS, FY 1977

Chemical	Quantity	Chemical	Quantity
Acetic Acid	25 lbs	Hydrofluoric Acid	558 lbs
Acetone	384 lbs	Hydrogen	6,108 cu ft
Acetylene	66,700 cu ft	Hydrogen Peroxide	1,524 lbs
Argon	8,350,000 cu ft	Isopropanol	48 lbs
Calcium Metal	750 lbs	Mercury	22 lbs
Carbon Dioxide	2,000 lbs	Methanol	65 gals
Carbon Tetrachloride	5,334 gals	Nitric Acid	134,337 gals
Caustic Potash	208,050 lbs	Nitrogen	30,512,383 cu ft
Caustic Soda	2,924 lbs	Nitrous Oxide	1,860 lbs
Chlorine	5,700 lbs	Oxygen	137,536 cu ft
Chromic Acid	200 lbs	Phosphoric Acid	630 gals
Chromic Oxide	256 lbs	Propane	3,400 cu ft
Chromium, Elemental	110 lbs	Sodium Chromate	50 lbs
Cyclohexane	30 gals	Sodium Nitrate	2,000 lbs
Ethanol	85 gals	Sodium Nitrite	100 lbs
Freon 12	24,000 lbs	Sulfuric Acid	1,797 lbs
Freon 13	46 lbs	Toluene	798 gals
Freon 22	2,970 lbs	Tordon 22K	10 gals
Freon R502	125 lbs	1,1,1 Trichloroethane	4,675 gals
Helium	960,000 cu ft	Trichloroethylene	330 gals
Hydrochloric Acid	6,276 lbs	Xylene	10 gals

Wastes resulting from the use of these chemicals are transferred to the waste treatment plant. There they are stored, neutralized, concentrated, and solidified for shipment to a DOE-approved storage facility. Chemicals incompatible with normal waste-treatment processes are handled in special batches. Organic solvents may be burned in a fluidized-bed incinerator. Highly toxic chemicals may require specialized treatment to render them innocuous and allow safe disposal.

Sanitary waste lines (see Section 2.9) collect human wastes and convey them to the sanitary waste (sewage) treatment plant. Conditioning chemicals are added; some organic wastes are biologically degraded to carbon dioxide. The residual solids containing the majority of insoluble organic and inorganic materials are concentrated, dried, and shipped to a DOE-approved storage facility.

Certain nonradioactive but potentially toxic materials used in or resulting from various production processes may enter the ventilation systems; they are subject to monitoring by sampling and analysis and, in some cases, by automatic sensors. Beryllium, carbon tetrachloride, sulfur dioxide, nitrogen oxides, and combustion-product particulates are materials for which ventilation and discharge monitors or samplers are provided. At least one stage of HEPA filters is used to purify ventilation exhaust air in all buildings in which potentially hazardous materials are handled. The release rates for nonradioactive materials consequently are minimized by filtration through systems similar or equivalent to those used to contain radioactive materials. Table 2.8-2 lists the nonradioactive air contaminants, Plant areas from which they originated, and normal average release rates for FY 1975; air contaminants in boiler flue gases are not included in this table (see Section 2.6.6).

TABLE 2.8-2

AVERAGE, NONRADIOACTIVE, AIRBORNE-EFFLUENT DISCHARGE RATES-- FY 1975

(grams per second)

Plant Area	Beryllium	Carbon Tetrachloride	Hydrocarbons	Solvents*
400	5.03×10^{-8}	0.40	3.0×10^{-4}	0.10
500	1.54×10^{-9}	0	0	0
700	1.77×10^{-8}	4.03	7×10^{-2}	0.10
800	3.17×10^{-8}	0.3	1.8×10^{-2}	0.12
900	1.46×10^{-9}	0	0	0

*Primarily acetone.

Biocides are used in cooling-tower water treatment to prevent biological fouling. Other chemicals are required to maintain proper water chemistry. Approximately 882 pounds per year of various water treatment chemicals are consumed in this manner, most of which are transferred with the cooling tower blowdown to the sanitary waste-treatment system.

Biocides and herbicides are used in weed and pest control on the site. The Rocky Flats Plant is a participating member of the Ralston Valley Weed Control District. The district was established to eliminate and control the growth of noxious weeds in northern Jefferson County. Pest control for insects and rodents is also practiced at Rocky Flats. Weed and pest control actions are coordinated with the Jefferson County Extension Service and the Colorado State Department of Agriculture. Plans for application of pesticides and herbicides are prepared in accordance with guidelines issued by the Federal Working Group on Pest Management, and local authorities are advised of the schedule for implementation. Table 2.8-3 lists the biocides and herbicides used in 1977.

TABLE 2.8-3
BIOCIDES AND HERBICIDES
(1977 Program)

I. WEED CONTROL OPERATIONS
   A. Access roads - Sterilize 10 acres with a mixture of Tordon (0.5 lb per acre) and Hyvar XL (4 lbs per acre) or Ureabor (1.5 lbs per 100 square feet).
   B. Security fence - Sterilize 10 acres with a mixture of Tordon (0.5 lb per acre) and Hyvar XL (4 lbs per acre) or Ureabor (1.5 lbs per 100 square feet).
   C. Other areas inside security fence - Treat 100 acres with a mixture of Tordon (0.5 lb per acre) and 2, 4-D Butyl Ester 6 (2 lbs per acre) or Ureabor (1.5 lbs per 100 square feet).
   D. Areas outside security fence
      1. Wheat fields - Spray 300 acres from helicopter with a mixture of Banvel (0.25 lb per acre) and 2, 4-D Butyl Ester 6 (0.5 lb per acre) in a water carrier.
      2. Other selected areas - Spray 2,000 acres from helicopter with a mixture of Banvel (0.25 lb per acre) and 2, 4-D Butyl Ester (0.5 lb per acre).
   E. Weed Killers
      1. Tordon 22K: 4-amino-3-5-6 trichloropicolimic acid (as potassium salt) 24.9%; Inert 75.1% (EPA Reg. No. 464-323 AA)
      2. Hyvar XL: Lithium Salt of Bromacil (5-amino-3 secbutyl-6-methyluracil) 21.9%; Inert 78.1% (EPA Reg. No. 352-346-ZA)
      3. 2, 4-D Butyl Ester: 2-4-dichlorophenoxy acetic acid (butyl ester) 78%; Inert 22% (EPA Reg. No. 148-289)

4. Ureabor (66% sodium borate, 30% sodium chlorate and 2% Bromacil), USDA Reg. No. 1624-90
5. Banvel: 3, 6-dichloro-o-anisic acid 40.6%; Inert 59.4% (EPA Reg. No. 876-25-AA)

II. TREE SPRAY OPERATIONS

A. Approximately 1,000 pine and spruce trees
B. Malathion diluted with water and applied by hand sprayer
C. Malathion 50% diluted (1 oz per gallon water) and applied at the rate of 0.5 pint per tree during two different periods between May and September
D. Malkill - EPA No. 960-123-33537

III. BLACK WIDOW SPIDER KILL

A. Diazinon: 0,0-diethyl 0-(2-isopropyl-6-methyl-4 pyrimidinyl) phosphorothiate 48%; Inert 52%
B. Applied with hand sprayer at rate of 1 gallon of 0.25-0.5% per 1,000 sq ft
C. USDA Reg. No. 100-463

IV. MICE AND RAT CONTROL OPERATIONS

A. Bait boxes (~100) distributed throughout the Plant site, both inside and outside buildings
B. Bait boxes contain Warfarin (0.025%) diluted with grain (1 pound per box)
C. Warfarin - USDA Reg. No. 76-115-AA

2.9 SANITARY WASTES AND OTHER LIQUID EFFLUENTS

This section describes the collection and treatment of sanitary wastes and the flow of surface waters from rain and snowfalls. A brief mention of subsurface water (described earlier in detail in Section 2.3.5) concludes the section.

2.9.1 Sanitary Waste Collection and Treatment

The sewage treatment plant at Rocky Flats is the activated sludge type with a design capacity of 450,000 gallons per day, but it can handle higher peak loads (up to 600,000 gallons) for short durations. Present daily flows usually vary between 150,000 and 250,000 gallons per day in dry weather. In extended wet weather, peak flow rates above 250,000 gallons per day can be experienced because of high infiltration into the system. One of two 70,000-gallon, pre-aeration holding tanks, shown in Figure 2.9.1-1, located upstream from the sewage plant, serves as a surge basin to smooth out peak flows. Table 2.9.1-1 lists the total monthly and peak daily sewage flows for Fiscal Years 1975, 1976, and 1977.

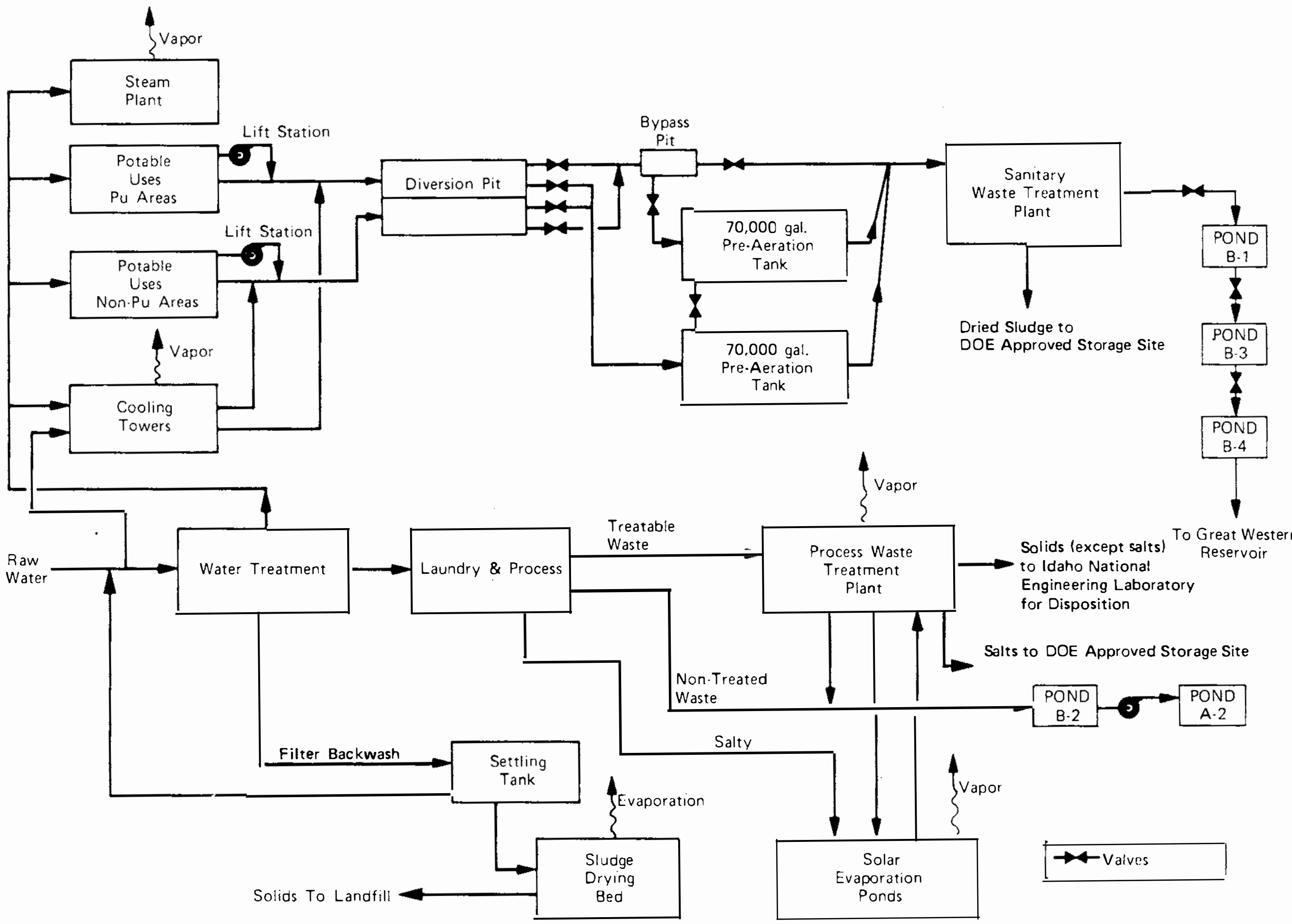


Figure 2.9.1-1 Flow Chart for Aqueous Waste

TABLE 2.9.1-1

SEWAGE FLOWS
(x 1,000 gallons)

	FY 1975		FY 1976		FY 1977	
Month	Total	Max. Daily	Total	Max. Daily	Total	Max. Daily
July	5246*	234*	5251	233		
August	5720	230	4328	239		
September	5145	267	3940	184		
October	5683	258	3924	177	5209	233
November	4950	244	4202	184	4633	211
December	4560	238	5040	211	4532	195
January	4421	225	4930	208	5216	234
February	5200	241	4646	229	3947	184
March	4741	194	4409	256	4435	219
April	5511	184	4803	218	4941	222
May	6120	250	5463	260	5089	223
June	5652	244	5666	258	4740	236
July			5485	234	4788	250
August			5219	273	4960	210
September			5674	292	4339	170
Totals	62,949		72,980		56,829	

*Estimate based on average for year.

A second 70,000-gallon holding tank was added to permit sewage from plutonium areas to be diverted to that tank for retention should some incident cause contamination of the sewage. Either or both of the tanks can be used, as needed, to retain sewage or act as surge basins.

Flow in the sanitary sewer lines is generally by gravity from west to east; however, two major sewage lift stations are required for low-lying buildings. Piping keeps sewage from plutonium and non-plutonium areas separate up to a diversion box located immediately upstream of the holding tanks.

Effluents from the sewage plant flow into Holding Ponds B-1 and B-3 in the eastern portion of the Plant. These ponds are monitored on a regular basis. Water from these ponds flows through Pond B-4 down South Walnut Creek into Great Western Reservoir, one of two water supplies for the city of Broomfield. Improved sampling equipment for influent material was installed in FY 1972, permitting continuous samples to be taken instead of the once-per-day samples formerly taken. Similar sampling equipment was installed in FY 1973 for effluents.

Dissolved oxygen controllers were installed during FY 1973 on the sanitary waste treatment aerator-clarifiers. This addition improved control and decreased the production of nitrates under light loads. During 1973 annual average concentrations of residual chlorine, settleable solids, and turbidity in the sewage plant effluent exceeded standards promulgated that year by the Colorado Department of Health (Dow, 1974). However, during 1974, the Plant's liquid effluent remained within the CDH standards. The addition of a final clarifier and filter in late 1974 provided tertiary treatment, making it possible for Rocky Flats to meet Colorado liquid effluent standards made effective in January 1973, and applicable Federal standards (USEPA, August 1973).

A fourth step, reverse osmosis, will be added to the sanitary sewage treatment process in 1979. The chlorinated sanitary effluent water from tertiary treatment will be pumped to a lined pond, to be used as a storage pond for the feed waters for the reverse osmosis plant. The reverse osmosis pond water is fed to the reverse omosis plant and is again chlorinated. The desired free chlorine concentration is 0.5 mg/l. The re-chlorinated feed water is then processed over a dual bed sand filter, through a water conditioner to remove the calcuim and the magnesium that may be in solution and through a diatomaceous earth filter to remove any colloids larger than 0.5μ. The temperature of the feed water is increased to 25° ± 1°C, and this is followed by acid addition to reduce the pH to 5.6 ± 0.1. The feed water is then pumped to the primary reverse osmosis unit which consists of three stages of hollow fine fiber cellulose triacetate membranes which recovers 87% of the water. The remaining 13% is fed to the secondary reverse osmosis unit which consist of three stages of spiral wound cellulose acetate membranes. Again, 87% of the feed water is recovered for a total water recovery of 98%. The pH of reverse osmosis product water, both primary and secondary, will be increased to 7.0 ± 1.0 and stored in a holding pond until used in the Rocky Flats cooling towers. The reverse osmosis brine will be sent to the process waste treatment plant for evaporation and spray drying. The salts will be packaged and sent to a DOE approved storage site.

New limits for material in the Plant's wastewater are contained in the National Pollutant Discharge Elimination System (NPDES) permit made effective September 6, 1974. The permit's daily limitations have been exceeded 20 times, as shown in Table 2.9.1-2.

Sanitary wastewater is kept separate from all process wastewaters and normally contains no radioactive wastes from the Plant. Routine radiological monitoring of the sanitary waste effluent is performed. The effluent from Holding Pond B-3 (see Figure 2.3.9.3), to which the sanitary wastes are discharged, is also monitored before it is released to Pond B-4 and eventually to Great Western Reservoir. At present, however, the total release of radioactivity from the Rocky Flats site through Pond B-4 is dominated by radioactivity from past buildup in Ponds B-1, B-3, and B-4. The buildup resulted from the release of laundry wastewater effluents, a practice that has been discontinued.

TABLE 2.9.1-2

VIOLATIONS OF NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT

Date	Parameter	Permit Limits	Effluent Concentration	Suspected Cause
10/19/74	Suspended Solids	25 mg/l	53 mg/l	Erroneous Measurement
1/02/75	BOD_5*	25 mg/l	44 mg/l	**
1/03/75	BOD_5	25 mg/l	260 mg/l	**
1/04/75	BOD_5	25 mg/l	68 mg/l	**
1/05/75	BOD_5	25 mg/l	46 mg/l	**
1/06/75	BOD_5	25 mg/l	44 mg/l	**
1/09/75	BOD_5	25 mg/l	52 mg/l	**
1/31/75	BOD_5	25 mg/l	26 mg/l	Unknown
3/24/75	Visible foam	None	Visible foam	High surfactants, source unknown
12/04/75	pH	6-9	5.9	Changing chlorine bottle
3/17/76	BOD_5	25 mg/l	49 mg/l	Unknown
3/18/76	BOD_5	25 mg/l	26 mg/l	Unknown
9/16/76	BOD_5	25 mg/l	49 mg/l	Iron oxide from steam plant
3/04/77	Fluoride	1.7 mg/l	1.9 mg/l	Concrete sealer from Bldg. 371/374
3/05/77	Fluoride	1.7 mg/l	3.0 mg/l	"
3/06/77	Fluoride	1.7 mg/l	3.0 mg/l	"
3/07/77	Fluoride	1.7 mg/l	2.4 mg/l	"
10/28/77	Fluoride	1.7 mg/l	2.0 mg/l	"
12/14/77	BOD_5	25 mg/l	29 mg/l	Unknown
12/15/77	BOD_5	25 mg/l	27 mg/l	Unknown

*BOD_5 - Biochemical Oxygen Demand, 5-day
**Methanol addition in an attempt to denitrify sanitary effluent

Administrative limits have been placed on releases from the B-series holding ponds. No water will be released from Pond B-3 when it contains total alpha activity over 40 pCi/l. With a concentration limit of 40 pCi/l on total alpha activity, the maximum release of total alpha activity would be 12,000 μCi/yr.

Water containing concentrations of total alpha activity in excess of 40 pCi/l will not be released unless specific plutonium analyses are performed and it is determined that the plutonium activity is less than 1% of the current RCG for plutonium in water to be released to the general environment; i.e., unless the plutonium activity is less than 16 pCi/l (1% of the 1,667 pCi/l limit for plutonium). The maximum yearly release of plutonium at the 16 pCi/l concentration limit would be about 5,000 μCi/yr. This is a self-imposed upper limit that is not expected to be approached. Actual, total releases in recent years have been about 500 μCi/yr.

2.9.2 Surface Drainage

Surface drainage includes runoff from rain or snow that falls within the Plant property and also rainfall outside the property that is carried onto the property by natural or constructed drainage courses. Additional surface drainage may at times result from high winds blowing surface water from the various ponds onto the surrounding soil.

Rocky Flats presently has ditches, culverts, and underground piping for collecting and controlling surface water runoff (see Section 2.3.5.1). The runoff is released into three natural drainage basins; North Walnut Creek, South Walnut Creek, and Woman Creek (see Figure 2.3.9-2). The natural channels eventually deliver water to reservoirs that serve as public water supplies for nearby populated areas. Ponds on the channels serve to moderate storm-water peak flows in the lower reaches of the streams and provide water quality monitoring points. Three ponds, A-1, A-2, and B-2, are being used predominately for storage of low-level wastes from the Plant laundry. Piping has been installed to divert natural drainage and storm runoff around these ponds to avoid disrupting waste storage. The wastes stored in these ponds will be transferred to the new waste-treatment facility for processing and disposal when that facility is completed.

Storm water runoff predominantly flows in a west-to-east direction, with the North Walnut Creek and South Walnut Creek flows converging within the Plant boundary. This combined flow continues on to the Great Western Reservoir. The flow in the southern drainage is discharged to Woman Creek, a tributary to Standley Lake. The areas contributing runoff to the natural drainage include approximately 115.5 acres to North Walnut Creek, 245.7 acres to South Walnut Creek, and 20.5 acres to Woman Creek.

To prevent excessive storm runoff from causing overflows of the various retention ponds, several modifications have been made. These modifications were designed to decrease total runoff through the drainage channels and holding ponds and to provide additional retention volume. The A-3 reservoir was added in 1974 and is capable of containing approximately 43 acre-feet (over 14.1 million gallons) of water. Normal runoff is held and sampled in Pond A-3. Runoff volume never exceeds 10% of A-3's capacity. During heavy storms, the bypass can be opened to allow runoff to flow around A-3. Only grab samples can be taken in this case. The A-3 holding capacity must be maintained as a backup during a storm to capture any accidental releases in the event of a dike failure at the solar evaporation ponds.

McKay Ditch, which takes water from a stream west of the Plant, was re-routed from its original drainage (into North Walnut Creek) to a new ravine feeding Great Western Reservoir. Therefore, water that would have entered North Walnut Creek is diverted to decrease storm-runoff retention requirements of the drainage serving the Plant's central area. A bypass line was added to divert South Walnut Creek flow around Ponds B-1, B-2, and B-3 so as not to disrupt this holding pond system, which is used for sanitary and laundry wastewater effluent. Figure 2.3.9-3 shows the various holding ponds and effluent streams serving the Plant, plus the piping, valves, and pumps for controlling the drainage flow under normal and storm runoff conditions.

Dams at these holding ponds were designed using a rainfall intensity of 14 inches in a six-hour period. The rainfall at Rocky Flats averages approximately 15.5 inches per year, with the peak recorded rainfall occurring in 1969. A severe storm in May of 1969 accounted for 7.15 inches of the record 25.05-inch rainfall that year. One study assumed that this storm represents, as a minimum, the 25-year, 3-day flood (ESI, 1974). This assumption is considered to be quite conservative; using U.S. Weather Services Guides, it was extrapolated to determine the 100-year, 3-day flood as a worst-case design basis for surface runoff control measures. Such a storm would result in runoff-water volumes of 56 acre-feet, 97 acre-feet, and 28 acre-feet on the first, second, and third days of the storm, respectively, for a total three-day runoff of 182 acre-feet (ESI, 1974). A flood control system, presently under construction is discussed in Section 5.5.4.

2.9.3 Subsurface Drainage

The hydrology and groundwater flow characteristics of the Rocky Flats site are described in detail in Section 2.3.5. Most of the groundwater is in the sediment gravel capping the bedrock. In general, the quantities of water involved are small because recharge is low, the rates of groundwater flow are low, and because most of this water is intercepted by the land surface and leaves the site in streams that drain the area. Groundwater can leave the site through the alluvial material in the stream channels and alluvial material capping the bedrock. Because of the close relationship between subsurface and surface water systems and drainage on the site, many of the control measures instituted, such as holding ponds and monitoring, are applicable to both systems.

Plant effluents do not normally enter groundwater sources. Plant process waste liquids are stored in solar evaporation ponds which have a series of liners (natural clay, asphalt, and polyvinyl chloride) that inhibit groundwater leakage and which effectively filter insoluble heavy metals, such as plutonium, from any water which moves through the liners. Only in the event of a major accident or catastrophic failure of a mechanical system or device could significant groundwater contamination occur. Basic design criteria and operating procedures, which require maximum containment of potential contaminants, control and treatment of all process waste streams, and careful storage of waste solutions and materials, minimize the potential for groundwater contamination. Table 2.9.3-1 lists the potential sources of groundwater contamination at Rocky Flats, and shows that, in almost all cases, some loss of integrity of a system or device is required to cause soil and the possibility of subsequent groundwater contamination.

TABLE 2.9.3-1

POTENTIAL SOURCES OF GROUNDWATER CONTAMINATION

Source	Condition
Buildings	
Foundations Footings Pilings Drains Stacks and vents	Interior spillage and pipe leakages through floors; fire, explosion, or natural disasters resulting in loss of facility integrity
Tanks	
Process waste Chemical Fuel	Loss of integrity, overflow, spillage during transfer of liquid
Process waste piping valves, pump stations	Loss of integrity
Solar evaporation ponds	Loss of integrity, overflow
Drums	
Process waste Chemicals (solid, liquid, semi-solid, scrap)	Loss of drum integrity via storage, transporation, and handling accidents, leaky drums
Buried Nonradioactive Solid Waste	Leaching of chemicals, accidental inclusion of radionuclides in solid wastes
Waste Transportation Boxes	Loss of integrity during handling, storage, transportation
Natural Disasters	Can affect integrity of all systems listed above
Buried Contaminated Wastes	Leaching

Solubility of potential contaminants in water is also of importance in groundwater contamination. Table 2.9.3-2 lists the potential contaminants of most interest, and the solubility of their various forms. The only detected incident of significant groundwater contamination occurred from cracks that developed in the asphalt lining of a solar evaporation pond. The result was a release of high-nitrate solutions to the groundwater. These ponds were resealed, and trenches with sump pumps were constructed on the slopes to intercept the groundwater and return it to the pond (see Figure 2.9.3-1).

TABLE 2.9.3-2

SOLUBILITY* IN WATER OF
POTENTIAL GROUNDWATER CONTAMINANTS

Material	Metal	Oxide	Chloride	Nitrate	Fluoride
Americium	i	i	s	s	i
Beryllium	i	i	vs	vs	vs
Chromium	i	i	i	s	i
Lithium	d	s	s	s	sl
Oils			VARIABLE		
Organics (solvents, etc.)			VARIABLE		
Plutonium	i	i	s	s	i
Tritium as T_2O			LIQUID		
Uranium	i	i	s	s	s

* Solubility of salts is a function of pH.
i = insoluble
sl = slightly soluble
s = soluble
vs = very soluble
d = decomposes

Groundwater is periodically monitored by means of 35 hydrologic test wells on site and the information is reported annually in the environmental monitoring report (RI, 1977). Samples taken from the hydrologic test wells over the past several years do not indicate significant contamination of groundwater, even on the Rocky Flats site itself. Most of these samples show concentrations of radionuclides are about the same as local background concentrations in nearby water bodies. Some minor exceptions have been found during the past four years, however.

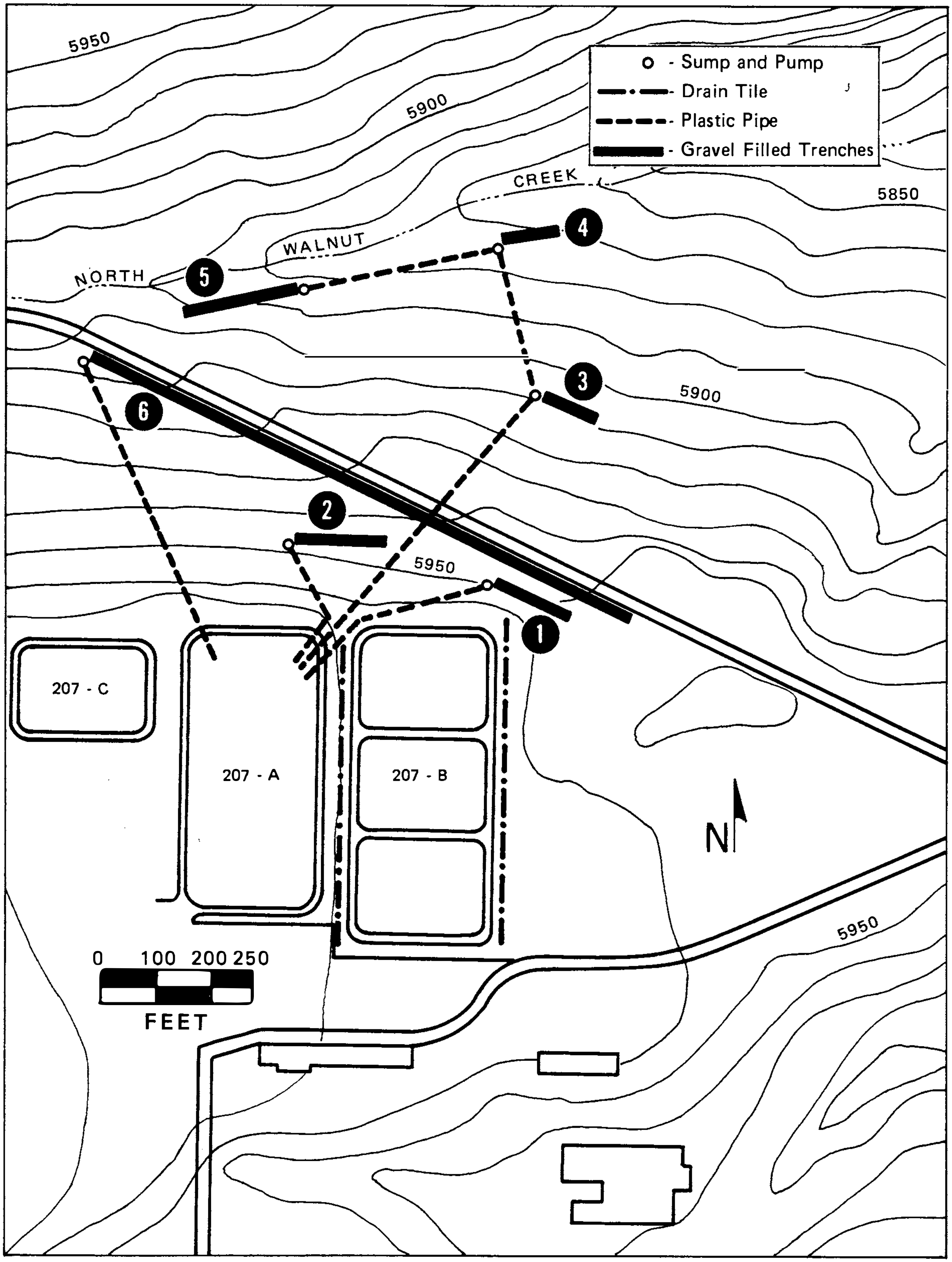


Figure 2.9.3-1 Trenches and Drain Tile Near Solar Evaporation Ponds

The plutonium concentrations in water from the test wells show a range from less than 0.01 to 2.7 pCi/l. Background levels are commonly between 0.02 and 0.1 pCi/l. The anomalous readings were found in two separate wells. One sample out of seven from a deep well (146 feet) contained 1.04 pCi/l plutonium. Although this well is located east of the solar evaporation ponds, which are known to contain plutonium, the analytical value reported is questionable. Only one sample in four years contained an abnormal level and eight other wells in the immediate vicinity did not contain anomalous plutonium concentrations. Three water samples over a four year period from a shallow well (30 feet) contained a maximum of 2.7 pCi/l plutonium. This well is located at the southeast edge of a known plutonium-contaminated soil area. It is possible that windblown dust from the contaminated area got into the well through an improperly sealed well-head. An improved well closure has been installed.

Americium concentrations in water from the test wells have been in the range between <0.01 and 1.0 pCi/l over the past four years. Background concentrations in nearby water are in the range from 0.05 to 0.50 pCi/l. The one anomaly (1.0 pCi/l) came from one sample from a well east of the solar ponds. Subsequent samples, as recent as 1978, have not indicated levels greater than 0.1 pCi/l americium. The one anomalous value is therefore questionable.

The amount of uranium in water samples from these same wells falls in the range between 0.05 and 156 pCi/l. The normal concentration of uranium in water is found to be in the range from 5 to 15 pCi/l. The anomalous uranium levels have been found, for the most part, in water from test wells east of the solar ponds. The one exception is water from a well on the south border of the Plant. Analyses of this water have revealed some of the highest uranium concentrations of any well water on site. The source of uranium has not been located.

Tritium concentrations in water samples from the test wells have, over the past four years, been in the range between 500 and 20,000 pCi/l. These values should be compared to normal background of 500 to 600 pCi/l. The anomalous values are found in samples from wells east of the solar ponds, as was the case for uranium anomalies. It is known that there has been slow leakage from the solar ponds in the past. Since the ponds are being eliminated, it is anticipated that the low-level contamination of groundwater by uranium and tritium will eventually disappear due to removal of the source and dilution of existing waters by annual recharge from precipitation and snow melt.

2.9.4 Sanitary Landfill

The sanitary landfill is located in a draw, 300 yards north of the Plant's north perimeter road. This site was chosen over other candidate sites for several reasons: (1) natural drainage precludes direct input to any public water supplies, (2) it is in proximity to the entire Plant, yet is isolated from the Plant proper, (3) construction of the landfill bank provides protection from prevailing northwest winds, (4) projected Plant needs can be met, and (5) the site permits diversion of natural drainage away from the landfill (see Figure 2.3.9-2).

Sanitary landfill operations began in 1968. In 1974 a major expansion was undertaken. Soil investigations of the existing landfill north of the Plant were first conducted by Woodward-Clevenger and Associates, Inc. (Holliday, 1974) to determine more precisely the landfill content and the extent of groundwater infiltration, if any. This investigation included exploration of three other areas to establish feasibility for future landfill use. Subsequently, additional soil exploration was conducted by Zeff, Cogorno, and Sealy, Inc. Plans included (1) constructing an impervious ring around the existing sanitary landfill, and (2) building holding and sampling structures downstream of the landfill. The construction was completed in December, 1974. The ring intercepts and directs subsurface and surface water away from the landfill; the holding and sampling structure impounds all drainage effluent until it can be properly monitored (Zeff, 1974). The preliminary landfill exploration study is summarized as follows (Zeff, 1974). Nine holes were bored around the perimeter of the existing landfill, and one through the landfill proper. The borings revealed overburden soils, Rocky Flats Alluvium, to depths varying from 12 to 25 feet beneath the existing ground surface. The permeability of the overburden soils is extremely variable and difficult to predict. An average value of 0.001 centimeter per second is reasonable to assume for subsurface permeability rates. Underlying the surficial cover is claystone bedrock, a plastic material of varying hardness, of the Arapahoe formation. Penetration resistance values vary from 50 to over 200 blows per foot. It is known that relatively permeable layers of sandstone and conglomerate exist at the base of the Arapahoe formation. None of these beds were found, however, in any of the borings or test pits. In the vicinity of the proposed sampling structure, downstream of the landfill, four holes were drilled and 17 test pits were dug. Stiff, highly plastic, severely weathered claystone bedrock was found beneath a veneer of topsoil at the proposed sampling structure abutment. This bedrock extended to depths of 4 to 50 feet, where weathered claystone bedrock of variable hardness was encountered. Weathered-to-severely weathered claystones possess a moisture deficiency and exhibit low-to-moderate swelling characteristics upon wetting. Some of the test pits were found to contain lenses of sub-lignite materials up to 6 inches thick. Based on observations made in the field, two types of groundwater flow are probably present at the site. The first and probably dominant flow is through the alluvium above the bedrock surface. The second flow is within the fracture zones of the claystone bedrock; it will probably be of minor concern except during times of heavy runoff. The total amount of groundwater flow is anticipated to be small.

Groundwater is routinely monitored by means of test wells at the landfill, see Table 2.9.4-2 and Figure 2.10.2-1. This information is reported annually in the environmental monitoring report (RI, 1977).

Sanitary landfill operations were initiated in 1968. From August 1968 to February 1970, approximately 1,000 kg of sanitary sewage sludge containing alpha activity was buried in the landfill. This practice is no longer employed. In 1973, surveys disclosed that other isotopes (e.g., tritium), are present in small quantities (Tables 2.9.4-1 and 2.9.4-2).

An estimated 9 million pounds of waste are disposed of annually at the landfill. Materials with less than minimum detectable radioactivity levels, depending on the most practicable method of measurement for the material and operation, are accepted for burial. Increased efforts to control and monitor the refuse deposited in the landfill provide assurance that radioactive wastes are not deposited in the landfill.

TABLE 2.9.4-1

TRITIUM AND TOTAL LONG-LIVED ALPHA ACTIVITIES IN LANDFILL SEEPAGE PONDS 1 AND 2
Annual Average (pCi/l)

	1975		1976		1977	
	Pond 1	Pond 2	Pond 1	Pond 2	Pond 1	Pond 2
Tritium	910 ±708	(a)	1311 ±447	692 ±252	1367 ±1301	841 ±299
Total Long-Lived Alpha	(a)	(a)	10.7 ±5.7	(a)	17.2 ±8.2	(a)

NOTE: Pond 2 is downgradient (east) of Pond 1
(a) Information unavailable

TABLE 2.9.4-2

RADIONUCLIDE CONCENTRATIONS IN GROUNDWATER ADJACENT TO THE LANDFILL
(1977)

Test Hole Location	Plutonium ($x\ 10^{-9}\ \mu Ci/ml$)		Uranium ($x\ 10^{-9}\ \mu Ci/ml$)		Americium ($x\ 10^{-9}\ \mu Ci/ml$)		Tritium ($x\ 10^{-9}\ \mu Ci/ml$)	
	March	Aug.	March	Aug.	March	Aug.	March	Aug.
WS-1	<0.1	<0.1	3.0	3.1	0.1	<0.1	638	(a)
WS-2	0.2	<0.1	7.1	7.1	0.1	0.2	<500	(a)
WS-3	0.2	<0.1	2.9	6.1	0.1	<0.1	<500	(a)

(a) Information unavailable

2.10 ENVIRONMENTAL MONITORING PROGRAMS

A comprehensive, environmental monitoring program is being conducted to determine if the operation of the Plant is causing any adverse effects on its surroundings. The program is designed to provide assurance that the many safeguards are working properly and that concentrations of materials released to the environs are within limits set by appropriate regulatory agencies. The environs are monitored for radioactivity and for chemical and biological pollutants. Air, water, and soil are sampled on the Plant site and in the surrounding region. This section reflects current monitoring and measuring conditions. Tables on stack, ambient air, and water sample detection limits have been updated since issuance of the DEIS.

Ambient air samples taken weekly are analyzed for plutonium. Soil samples are collected annually and analyzed for plutonium.

Water from daily samples and from weekly, monthly, and quarterly composite samples is analyzed for various quality factors in three general categories, (1) radioactivity, (2) chemical elements and compounds, and (3) physical and biological parameters. The specific items for which the samples are analyzed are tabulated later in the section.

The Plant's prime contractor prepares an Annual Environmental Monitoring Report (RI, 1977) that details survey findings in accordance with requirements of ERDA Manual Chapter 0513. The contractor reports the results of the monitoring program at least monthly to the Colorado Department of Health, Colorado Water Conservation Board, Environmental Protection Agency, City of Broomfield officials, Boulder City and County Health Department, Jefferson County Health Department, various DOE offices, and the public. The Colorado Department of Health presents its Rocky Flats environmental data at this public meeting.

Outside agencies conduct independent environmental surveys, both on and off the Plant site. The Colorado Department of Health conducts air, water, and soil sampling programs around the Rocky Flats site (CDH, 1972, 1973, 1974). The DOE Environmental Measurements Laboratory of New York (formerly HASL) maintains particulate air sampling stations in the vicinity of the Rocky Flats Plant, and periodically performs soil sampling and analysis (Krey, et al., 1976). The Jefferson County Health Department has a continuous particulate-air sampler on the site. Samples from this sampler are analyzed by the Colorado Department of Health. The County also samples and analyzes sewage plant effluent monthly. The U.S. Environmental Protection Agency provides additional routine liquid effluent monitoring to determine compliance with NPDES permit.

Radioactivity Concentration Guides (RCGs) have been published (USERDA, 1977) by DOE for the control of radionuclides within and in the vicinity of its facilities. These guides were initially established by the National Council on Radiation Protection and the International Committee on Radiological Protection. The RCGs govern the concentrations of radionuclides in air (RCG_a) and water (RCG_w) accessible for intake by occupationally exposed individuals, and individuals and population groups in uncontrolled areas. The numerical values of the guides are cited later.

All radionuclides in Plant effluents and environmental samples are assumed to be soluble for comparison with appropriate concentration standards. This assumption is an additional safeguard, since the RCGs for most soluble radionuclides are more restrictive than those for insoluble ones. Although the standards for radioactivity relate to concentrations above background, all measurements reported in this Statement include the background radioactivity contribution.

Where mixtures of radionuclides in air and water are present, concentrations are limited in existing regulations such that the sum of the ratios between each radionuclide concentration and the appropriate concentration guide shall not exceed unity. Regulations further state that radionuclide may be considered not present in a mixture if (a) the ratio of the concentration of a nuclide in a mixture to the RCG does not exceed 0.1 and, (b) the sum of such ratios for all radionuclides considered as not present in the mixture does not exceed 0.25. In almost all cases the average specific radionuclide concentrations in air and water were less than one-tenth of the appropriate concentration guides and the sum of the ratios were less than one-fourth. The measured concentrations presented in this impact statement have therefore been compared directly with the RCG's.

The chemical and biological parameters of effluent water from Plant operations are subject to the National Pollutant Discharge Elimination System (NPDES) limits issued by the Environmental Protection Agency.

Sophisticated beta and gamma spectrometry equipment enables the Plant to (1) analyze fission products that may be introduced into the Rocky Flats effluent streams by nonspecification feed material, by spontaneous fission, by research activities, or by any other cause, (2) measure the extent of dispersion of these radionuclides in the Plant environs, and (3) establish present background concentrations of these radionuclides in the Plant environs.

A 200-foot meteorological tower was installed on the Plant site in 1975. It collects accurate climatic and meteorologic data.

2.10.1 Air Monitoring

Two monitoring networks are currently used for detecting and measuring the quantities of radioactive and chemical airborne, particulate material. One network monitors effluents from the exhaust stacks of process and research buildings, thus constituting direct monitoring of these effluents at their release points. The second network monitors ambient air on the Plant site and in the surrounding region. A third network, under construction will automatically monitor nonradioactive particulate and gaseous stack effluents released to the atmosphere as a result of production or other related processes. These effluents, which include chlorinated hydrocarbons, sulfur dioxide, nitrogen dioxide, and steam plant particulates, are presently monitored on an occasional basis.

Other air monitoring at Rocky Flats includes ambient air monitoring conducted by the Colorado Department of Health, the Jefferson County Health Department, and the DOE Environmental Measurements Laboratory (EML).

2.10.1.1 Airborne Emissions Monitoring

Air exhausted from the stacks of process and research buildings is continuously monitored to detect the emissions of radioactive particulates, beryllium, and tritium. In the plutonium processing buildings, at least two and as many as five particle sampling probes are located in each exhaust air duct, downstream from the final stage of filters. At least one particle sampling probe is located in each exhaust air duct in the uranium and beryllium processing buildings. Glass fiber filter media are used to collect the exhaust stream particulate material. Each particulate sample is collected three times each week and radiometrically analyzed, by direct counting, for total long-lived alpha-emitting radionuclides.

Prior to July 1973, all radioactive emissions were determined from long-lived alpha activity. From mid-1973 through 1977, particulate samples from plutonium exhausts were composited weekly and analyzed for plutonium. The radioactive species were determined from radiochemical separation and alpha particle spectrometry. The amount of beryllium was determined by flameless, atomic absorption spectrometry. In 1978, the particulate samples from each exhaust system were composited into monthly samples for specific laboratory analysis following the direct radiometric analysis. These exhaust system composites were analyzed specifically for uranium and beryllium. Composite samples from the plutonium operations are analyzed specifically for plutonium and americium.

Stacks exhausting air from plutonium operations, in addition to being sampled continuously, are equipped with selective alpha monitors (SAAMs) that initiate an audible alarm if the alpha activity in the effluent air reaches the Plant's operating alert levels. These levels have been predetermined for each location and media sampled. The alarm puts people on notice (increased level of awareness) before the limits of standards and regulations are reached. The alarm is sounded at the exhaust duct, in the local ventilation control room, radiation monitoring office, and nearest security post. A data logger in the radiation monitoring office periodically records the information. Whenever an alarm is activated, radiation monitoring and utilities personnel check to ascertain the cause and take appropriate corrective action.

In addition to being sampled for radioactive particulates and beryllium, selected plutonium exhaust ducts are sampled for water vapor, which is analyzed for tritium by liquid scintillation spectrometry. The maximum concentration for a 48-hour period is typically 0.03×10^{-6} μCi/ml. The RCG for soluble tritium in ambient air to the general population is 0.07×10^{-6} μCi/ml.

The concentration of long-lived alpha-emitting radionuclides in exhaust air typically averages less than 4×10^{-15} µCi/ml. The concentration of uranium, plutonium, and americium in the exhaust air from the processing, fabrication, and research facilities is about 3×10^{-15}, 1×10^{-15}, and 0.04×10^{-15} µCi/ml, respectively. For comparison, the RCG for soluble uranium, plutonium, and americium in ambient air accessible to the population at large is 1000×10^{-15}, 20×10^{-15}, and 67×10^{-15} µCi/ml, respectively (1 µCi/ml x 10^{12} = 1 pCi/m^3, i.e., to convert µCi/ml to pCi/m^3, multiply by 10^{12}).

The beryllium concentrations in exhaust air from the Rocky Flats facility typically is about 3×10^{-4} µg/m^3. Beryllium concentrations in ambient, urban air in the United States has been reported to range between 1×10^{-4} and 3×10^{-4} µg/m^3 (Ross and Sievers, 1972; Cholak, 1959). The total amount of beryllium released from the Rocky Flats facility during 1977 was about 5 grams. The Environmental Protection Agency has established a daily beryllium discharge limit of 10 grams per day for each stationary source (USEPA, April 1973).

Stack samples provide the primary record of all atmospheric emissions from the facility. These emission data are analyzed and reported in the Monthly and Annual Environmental Monitoring Report showing the total airborne emissions from the Rocky Flats facility. The sample volumes and detection limits for the stack samples are shown in Table 2.10.1-1. As can be seen from the table, the analytical deletion limits are well below the applicable guide values.

TABLE 2.10.1-1

STACK SAMPLE DETECTION LIMITS

Parameter	Approximate Sample Volume (m^3)	Approximate Detection Limit (µCi/ml)	Guide Values (µCi/ml)
Radioactive:			
Total Long-Lived Alpha	160.0	0.002×10^{-12}	0.02×10^{-12}
Tritium	3	80×10^{-12}	2×10^{-7}
(Radiochemical Analysis)			
Plutonium*	3670	0.00003×10^{-12}	0.06×10^{-12}
Uranium*	1220	0.0002×10^{-12}	3×10^{-12}
Americium*	3670	0.00003×10^{-12}	0.2×10^{-12}
Nonradioactive:			
Beryllium*	1220	0.00004 µg/m^3	$\leq$10 grams per day

*Monthly Composite samples

2.10.1.2 Ambient Air Monitoring

Ambient air is monitored for airborne particulate matter by a network of 49 air sampling stations located both on and off the Rocky Flats Plant site. Each of the air sampling stations contains a vacuum pump that draws a known volume of air through a standard filter.

Wind tunnel studies (Meroney and Chaudhry, 1972; Meroney and others, 1973) of the Plant site and the new plutonium recovery and waste treatment facility were conducted by the Engineering College of Colorado State University. These scale-model tests were used to determine the dispersal routes and trajectories of airborne effluents originating at the Plant, for the most effective placement of air samplers.

There are 23 continuously running high-volume air samplers located on the Plant site inside (or just outside) the security-fenced area (see Figure 2.10.1-1). Most of these samplers, which operate at an average sampling rate of 40 cubic feet per minute (cfm), are positioned rather closely around and downwind of the plutonium processing facilities. Samples are collected weekly, analyzed for total long-lived alpha (TLLα) activity, composited biweekly, and analyzed for plutonium. Atmospheric water vapor is collected weekly from four samplers located in the vicinity of the plutonium processing buildings, and the water is analyzed for tritium.

The concentration of plutonium in ambient air samples collected on the Rocky Flats Plant site typically is 0.0002×10^{-12} µCi/ml. The RCG for ambient air in a controlled area is 0.06×10^{-12} µCi/ml, but Rocky Flats operates within the more restrictive RCG applicable to plutonium in uncontrolled areas (0.02×10^{-12} µCi/ml).

Airborne particulate samples are collected from 14 continuously running, high-volume (drawing approximately 40 cfm) air samplers at the Plant perimeter at distances ranging from two to four miles, as shown on Figure 2.10.1-2. These samples are collected weekly, analyzed for total long-lived alpha activity, composited monthly and, following chemical separation by ion exchange, analyzed radiochemically for plutonium. The plutonium concentration in ambient air 2 miles from the center of the Plant typically is about 0.00002 to 0.00005×10^{-12} µCi/ml, which is statistically indistinguishable from worldwide fallout and which may be compared with Radiation Alert Network data published by the EPA in Radiation Data and Reports (1972-1974), and Environmental Radiation Data (1975-date).

Airborne particulate samples also are collected from 12 continuously running, 40-cfm air samplers located in or near population centers in the general vicinity of Rocky Flats (Figure 2.10.1-2). The samples are collected weekly, analyzed for total long-lived alpha activity, composited monthly, and analyzed specifically for plutonium. The concentration of plutonium in ambient air in local population centers typically is 0.00002×10^{-12} to 0.00005×10^{-12} µCi/ml.

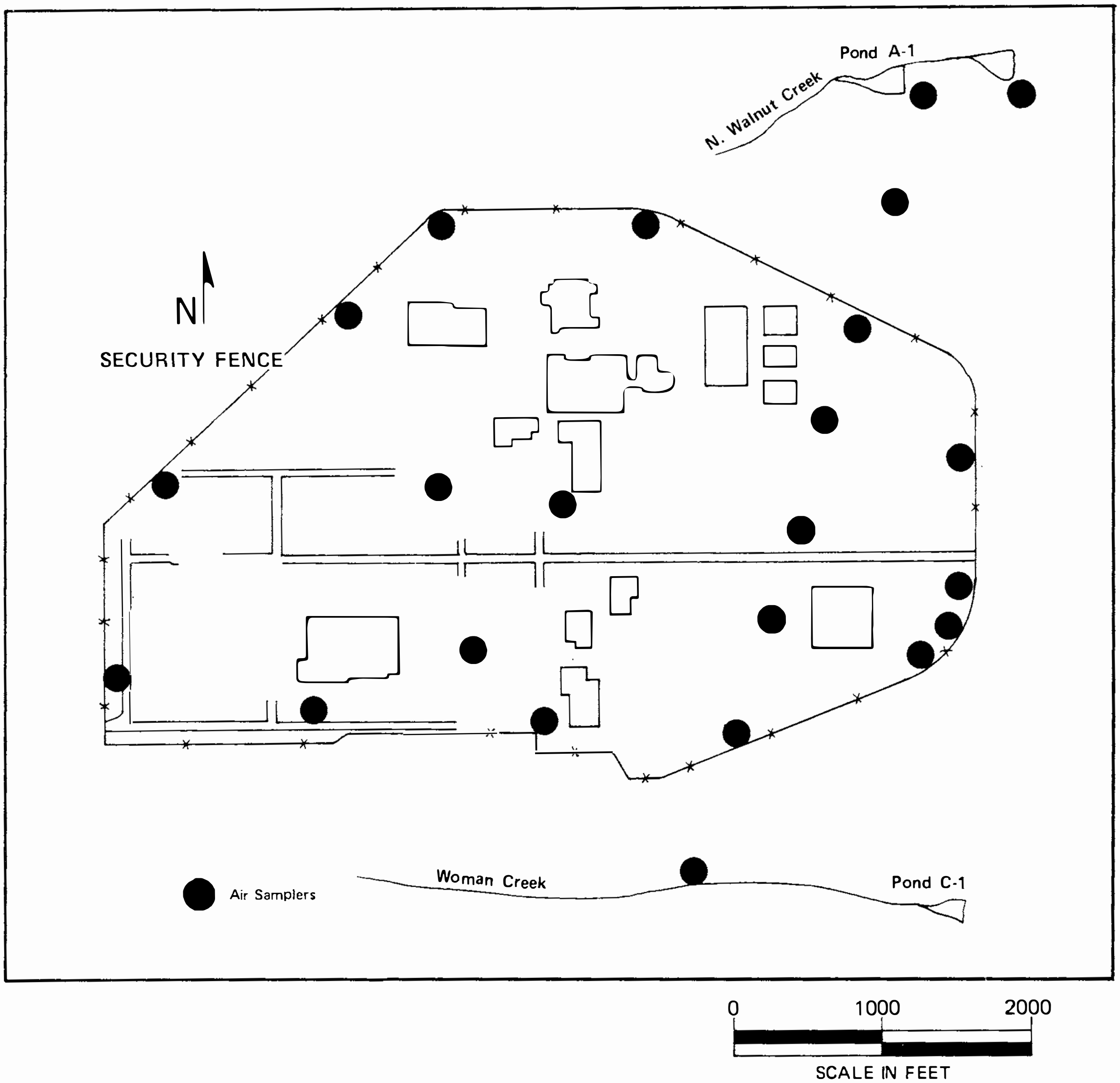


Figure 2.10.1-1 Locations of Onsite Ambient Air Samplers

The 40-cfm air samplers are larger than previously used samplers and sample a greater volume of air to further improve the reliability of the data. The samplers are well suited for use in residential areas, as they are quieter (50 decibels compared with 80) than those used before 1974. Table 2.10.1-2 shows the detection limits of the ambient air samplers.

TABLE 2.10.1-2

AMBIENT AIR SAMPLE DETECTION LIMITS

Parameter	Approximate Sample Volume (m^3)	Approximate Detection Limit (pCi/m^3)
Total Long-Lived Alpha	10,000	0.001
Plutonium-239/240	20,000	0.00002
Total Long-Lived Beta	20,000	0.015

In 1978, an extensive study (Wedding, 1978) was conducted to evaluate the inlet efficiency and filter-media efficiency of the Rocky Flats ambient air samplers. The study concluded that the Rocky Flats-designed sampler is as efficient as the EPA-approved sampler and that the filter media efficiency was 99.8% or greater for trapping particulates of 0.01 to 1.00 μm in size. (See Appendix I).

Plant emergency procedures require the collection of on-site and off-site air samples whenever an airborne radioactivity release is known or suspected. The emergency procedures include taking additional samples downwind of the suspected release. Two site survey vehicles equipped with air-sampling equipment and 110-volt generators are available for air-sampling duty around the clock.

2.10.1.3 Ambient Air Monitoring by Others

The Colorado Department of Health operates five, on-site, continuous air sampling stations (see Figure 2.10.1-3), one of which is operated jointly with the Jefferson County Health Department. The samples are collected on alternate days and analyzed for long-lived alpha and beta radionuclides. Samples in which the total alpha activity exceeds 0.04×10^{-12} μCi/ml are analyzed specifically for plutonium. A regional air-sampling system of 16 stations provides additional surveillance in the vicinity of Rocky Flats and in the metropolitan Denver area. Four other stations are located at sites within the State but remote to the Rocky Flats Plant.

The DOE Environmental Measurements Laboratory (EML) of New York City operates three air sampling stations - one at the east security fence, one at the original east perimeter (cattle) fence, and one at the intersection of the east access road

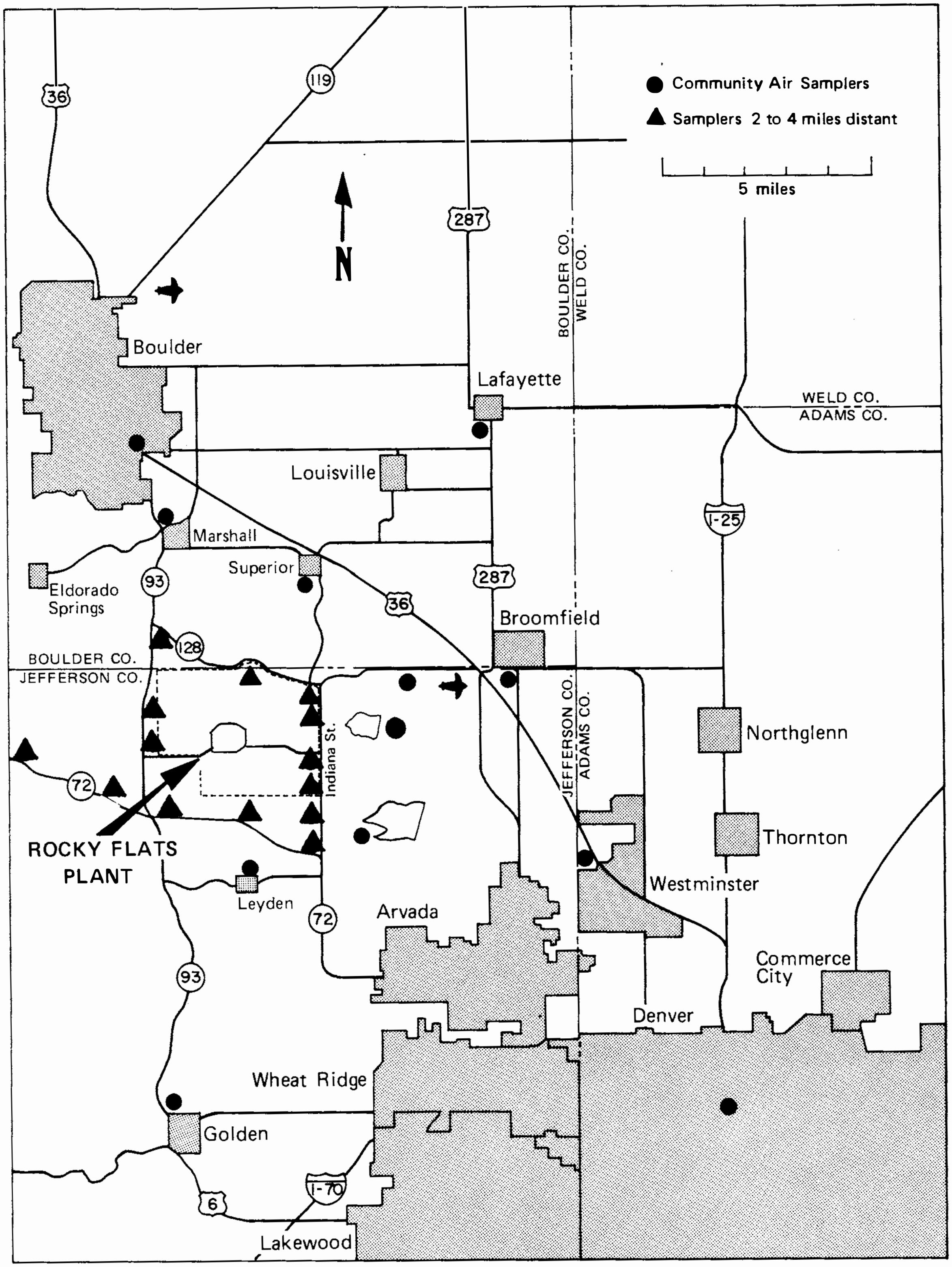


Figure 2.10.1-2 Locations of Offsite Ambient Air Samplers

and Indiana Street. Samples from these stations are collected every week and analyzed radiochemically by EML for plutonium. The results are published in their environmental quarterly reports.

2.10.1.4 Meteorological Monitoring

Meteorological data have been collected at Rocky Flats since the Plant became operational in 1952. The instruments used prior to 1975 (all of which were located in or near the 100 complex) included the following:

Wind direction and speed recorder -- Bendix Friez Model 141-5 Microbarograph -- Bendix Friez Model 500029-1
Hygrothermograph -- Bendix Friez Model 594
Recording rain gauge -- Bendix Friez Model 775

Data from these instruments, combined with various meteorological observations from other stations, were used to develop local climatological information and descriptions of site dispersion characteristics. Comprehensive measurements of meteorological characteristics are made routinely by National Weather Service personnel at Stapleton International Airport, which is located on Denver's east side. These data, including atmospheric stability measurement, are available for use if needed. Extensive weather data are also available from the National Center for Atmospheric Research (NCAR) at Boulder, Colorado.

In the first quarter of 1975, a 200-foot meteorological monitoring tower was installed in the southwest quadrant of the Rocky Flats Plant site. The system became operational in May of 1975. This is a fully instrumented tower that records digital data at 10-minute intervals onto a nine-track magnetic tape. The following data are collected and recorded by the system:

1. Julian days
2. Hours and minutes
3. Temperature at 200 feet, 100 feet, and 20 feet
4. Temperature difference (temperature at 200 feet minus temperature at 20 feet)
5. Dew point temperature
6. Solar radiation
7. Wind direction at 200 feet and 20 feet
8. Barometric pressure
9. Average and peak wind speed at 200 feet and 20 feet
10. Precipitation

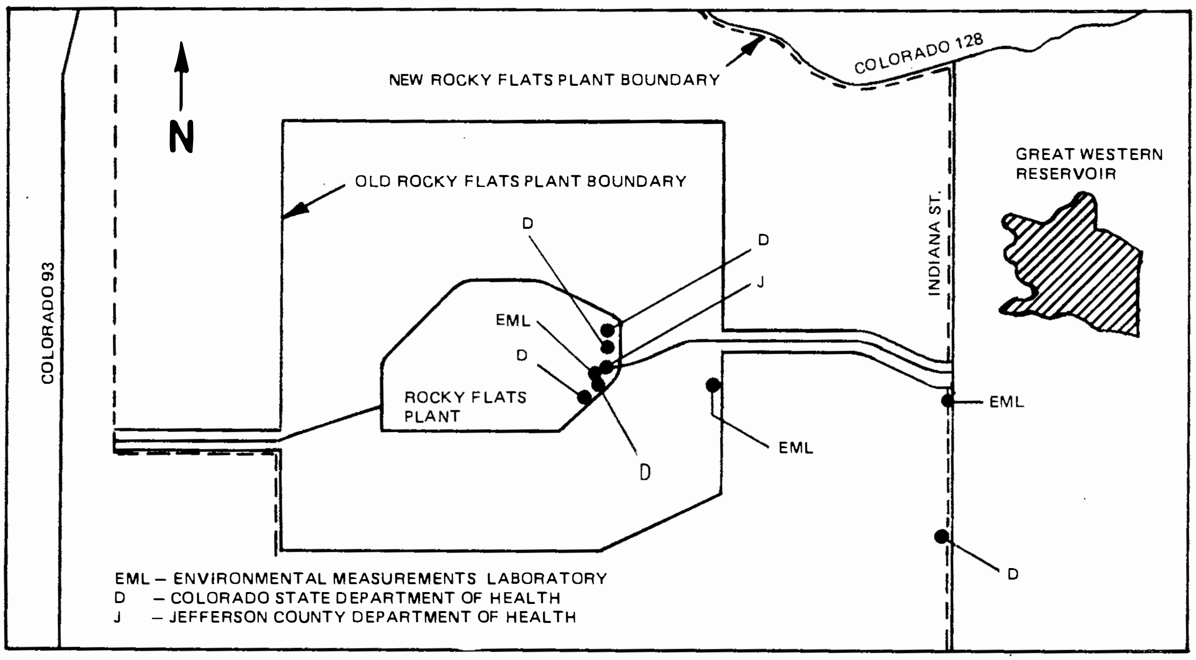


Figure 2.10.1-3 Air Samplers Operated by Others

On-site data obtained from this system provide the detailed, continuous information needed to verify joint frequency distributions of Pasquill diffusion categories by wind speed and direction, thus allowing additional evaluation of actual short-term and long-term site meteorological dispersion characteristics. This information permits a more accurate determination of the dispersal of Plant gaseous and airborne particulate effluents.

In addition to the three meteorological towers at the wind energy project mentioned in Section 2.4, there is a 120-ft. portable meteorological tower presently located on Woman Creek, one mile west of Indiana Street.

2.10.2 Water Monitoring

Two basic water-monitoring programs are conducted -- one involves effluents leaving the Rocky Flats Plant; the other involves regional water systems off the Plant site. The Colorado Department of Health also monitors the Plant effluents.

2.10.2.1 Plant Water Flow and Control

The flow of water from Rocky Flats is generally from west to east. Surface runoff water, including any waterborne effluents, is carried from operational areas of the site by North and South Walnut Creeks on the north, and by Woman Creek on the south (see Figure 2.3.9-2). These are designated as drainage basins A, B, and C, respectively. South Walnut Creek is considered the main, waterborne-effluent release route and flows into Great Western Reservoir, which is part of the water supply for the city of Broomfield. Woman Creek flows east through Government property into Standley Lake, which is part of the water supply for the city of Westminster and portions of the Thornton-Northglenn area. Upper Church Ditch, McKay Ditch, Smart Ditch, and several minor branches of Walnut, Woman, and Rock Creeks also traverse or rise on the Government property.

As shown in Figure 2.3.9-3, there are several holding ponds on Government property in the three major watercourses. On North Walnut Creek are three ponds (identified as Ponds A-1, A-2, and A-3), having a total capacity of 22,420,000 gallons. Four ponds (B-1, B-2, B-3, and B-4) are located on South Walnut Creek; they have a total capacity of 4,258,000 gallons. One pond (C-1), with a capacity of 2,000,000 gallons, is located on Woman Creek. These holding ponds are the monitoring points for all drainage that traverses or rises on operational areas of the Plant site, and for all liquid effluents that are discharged from the Plant.

A project was recently initiated for surface water control at the Rocky Flats Plant. The purpose of this project is to provide facilities to divert, collect, and store all surface runoff water originating within or flowing through the security fenced area of the Rocky Flats Plant site. The project consists of three flood retention dams, two bypass canals that route non-Plant flood flows around two of the dams, and interceptor canals to catch runoff from the Plant site and convey it to retention facilities. Additional information on this system is also given in Section 5.5.4. The dams are for surface-water runoff retention only and are expected to be dry most of the time. In the event that impounded flood water is found to be contaminated, the flood pool will be contained for water analysis, and a decision made as to whether water recycling is required. It is not anticipated that retention time would be sufficient to establish a saturated zone in the embankments. Hydrologic investigations include the preparation of flood hydrographs for 100-year three-day return precipitation flood events, Bureau of Reclamation thunderstorm events, and probable maximum precipitation (PMP) storms. The dams will be designed to safely pass the PMP flood via spillways and to retain the amount of water projected for the 100-year storm. The dam designed for North Walnut Creek (A-4) will retain a maximum of 82 acre-feet. South Walnut Creek dam retention (B-5) will be 72 acre-feet, and Woman Creek dam retention (C-2) will be 50 acre-feet.

Sanitary wastes are routed through the sewage treatment plant where they are subjected to primary treatment, an activated-sludge secondary treatment, a tertiary treatment, and mixed media filtration. Cooling-tower blowdown water and steam condensate from process and laboratory facilities also are routed through the sewage treatment plant. The effluent from the sewage treatment plant is held in Ponds B-1 and B-3 where it is sampled and analyzed prior to discharge. Discharged water passes through Pond B-4 and into South Walnut Creek. The ponds provide effluent residence time to promote the settling of solids.

Laundry water which has less than 1,667 pCi/l total long-lived alpha activity (the ERDA Manual Chapter 0524 Annex A RCG for plutonium-239 in water) is transferred to Pond B-2 and subsequently to the larger Ponds A-2 and A-1. Ponds A-1, A-2 and B-2 are isolated from the natural drainage water courses and are used exclusively to impound Plant wastewaters for evaporation.

Water flow in the vicinity of the landfill is described in Section 2.9.4. Two earthfill dams are located in the draw below the working face of the landfill. The upper impoundment (the smaller of the two) collects seepage from the landfill. The seepage, after analysis, is distributed on the ground north of the landfill or impounded with the treated process-waste effluent. The second impoundment is held in reserve for collecting water during periods of abnormally high precipitation or other unusual conditions. Water downstream from the second impoundment flows into North Walnut Creek.

2.10.2.2 Plant Water Monitoring

Incoming raw and treated water, water at several locations on the Plant site, and all effluent streams leaving the Plant site are sampled and analyzed. Water is monitored continuously and samples are collected from crucial locations. Grab samples are taken where it is necessary to test for certain chemical and biological conditions that might deteriorate rapidly if the effluent sample material were stored in a continuous-sample collection reservoir. Table 2.10.2-1 gives the elements or conditions tested for, and the frequency of sampling by sample location in the waterborne effluent monitoring program. Table 2.10.2-2 presents the same information listed by the elements or conditions tested for, and the sampling locations. Table 2.10.2-3 shows the detection limits for analysis of samples from the on-site ponds. The detection limits are much less than the applicable ERDA or NPDES permit standards.

In the tables, the "11 elements" parameter in the column entitled Elements or Condition, represents an atomic absorption analysis for Ba, Be, Ca, Cd, Cr, Hg, K, Mg, Na, Se, and Si. The "31 elements" parameter indicates an emission spectroscopy analysis for Ag, Al, B, Ce, Co, Cr, Cs, Cu, Fe, Ge, Li, Mn, Mo, Ni, Nb, P, Pb, Rb, Sb, Sn, Sr, Ta, Te, Th, Ti, Tl, U, V, W, Zn, and Zr.

The concentrations of plutonium and tritium in the effluent water of Pond B-4 typically are 1 pCi/l and 850 pCi/l, respectively. Concentrations of other radionuclides are comparably low, typically less than one percent of the ERDA Radioactivity Concentration Guides. The appropriate RCG for soluble plutonium-239 in water is 1,667 pCi/l and for tritium it is 1,000,000 pCi/l. The EPA Drinking Water standard sets a limit of 20,000 pCi/l for tritium and 15 pCi/l for total long-lived alpha activity. Discharges from Pond B-3 are controlled by withholding discharges until the total long-lived alpha activity is less than 40 pCi/l. The analyses of the Pond B-4 water define the total radioactivity in water released from Rocky Flats.

Water from the 35 hydrologic test holes on the Plant site is sampled to determine if there is any detectable movement of chemicals or radioactive materials of Plant origin into the water-bearing strata underlying the site. Three of the holes are approximately 150 feet deep, and two others are about 260 and 300 feet deep, respectively. They provide information on water movement in bedrock formations. The remainder range from less than 10 to 50 feet deep, and are located generally near the solar evaporation ponds, downstream from the holding ponds, and east of the Plant (see Figure 2.10.2-1 and Section 2.9.3).

Samples are taken at 5-month intervals from all test holes in which there is water; the samples are analyzed for the elements and conditions listed in Tables 2.10.2-1 and 2.10.2-2. Samples analyzed for plutonium may also be analyzed for other constituents such as, nitrate, total solids, fluoride, and pH. Historically, the samples have indicated that there is no apparent movement of plutonium into the Plant's groundwater; however, some nitrate has appeared in the holes surrounding the solar evaporation ponds.

TABLE 2.10.2-1

WATER MONITORING PROGRAM

Location	Element or Condition	Frequency
Water Treatment Plant Raw Water	Am, Be, Cd, Cr, F^-, ^3H (Tritium), Hg, Polychlorinated Biphenyls (PCBs), Pu Suspended Solids, Total Dissolved Solids	Quarterly Grab
	Uranium	Weekly
Water Treatment Plant Treated Water	Free Available Chlorine	Daily
	Total Bacteria, Fecal, Total Coliform	Four Days per Week -- Rotate Buildings
	Ag, Alkalinity, Gross Alpha, As, B, Ba, Be, Gross Beta, Ca, Cd, Cl^-, Color, Cr, Cu, Cyanide, F^-, Fe, Hardness, Hg, Linear Alkyl Sulfonates, Mg, Mn, Na, NH_3, NO_3^- (as N), P, Pb, ^{226}Ra, Se, $SO_4^=$ ^{90}Sr, Total Dissolved Solids, Turbidity, Zn	Five Months
	Uranium	Weekly
	Tritium	Yearly
	Endrin, Lindane, Methoxychlor, Toxaphene 2,4-D, 2,4,5-TP Silvex	Every 3 years
Sewage Treatment Plant Influent	Gross Alpha	Daily
	Gamma, ^3H	Weekly Grab
	Pu	Only if Gross Alpha (GA) > 40 pCi/l
	pH, F^-	Daily
Sewage Treatment Plant Effluent	F^-, ^3H, Gamma, NO_3^- (as N), P, pH, Pu Total Residual Chlorine, Total Suspended Solids	Daily
	Total Chromium, Color, Oil and Grease, Turbidity	Wednesday Grab
	Biochemical Oxygen Demand (BOD), Fecal and Total Coliform	Three Days per Week
	Kjeldahl N, NO_2	Daily
Sewage Treatment Plant Effluent Upon Entering South Walnut Creek	Dissolved Oxygen	Three Days per Week
Pond A-1 Bypass	Gross Alpha Gross Beta, ^3H, NO_3^- (as N)	Daily
Pond A-3	Gross Alpha, Gross Beta, Gamma, ^3H, NO_3^- (as N), pH	Before and During Dumping
	Pu, U, Am	During Dumping

TABLE 2.10.2-1 (Continued)

Location	Element or Condition	Frequency
Pond B-3	Gross Alpha, Gross Beta, pH, Tritium, Gamma	Three Days Per Week
Pond B-4	Gross Alpha, Total Residual Chlorine	Daily
	Gamma, ^{3}H	Weekly Grab
	Am, Gross Beta, Pu, U	Weekly Composite
	Chemical Oxygen Demand, NH^{3}, NO_3^- (as N), Suspended Solids	Quarterly Grab
	11 elements, 31 elements, F^-, P, Total Solids, ^{90}Sr,	Quarterly Composite
	^{131}I, ^{89}Sr, ^{134}Cs	Quarterly
Pond C-1	Gross Alpha	Daily
	Gamma, ^{3}H	Weekly Grab
	Am, Gross Beta, Pu, U	Weekly Composite
	pH, Total Dissolved Solids	Two Days Per Month
	Chemical Oxygen Demand, NO_3^- (as N)	Monthly Grab
	Cr, Cyanide, Oil and Grease, PCBs, Phenol, Linear Alkyl Sulfonates	Quarterly Grab
	As, Cl^-, 11 elements, 31 elements, F^-, P, $SO_4^=$, Total Solids, ^{90}Sr	Quarterly Composite
Waste Treatment Facility Pond	Gross Alpha, ^{3}H, NO_3^- (as N)	Weekly Grab
	Pu	Only if GA > 40 pCi/l
Landfill Pond 1	Gross Alpha	Daily
	Gamma, ^{3}H	Weekly Grab
	^{90}Sr	Weekly Composite
	Be, Cd, Chemical Oxygen Demand, Cr, 31 elements, Hg, PCBs, Phenol, Total Solids	Monthly Grab
	Pu	Only if GA > 40 pCi/l
Landfill Pond 2	Gross Alpha, ^{3}H, NO_3^- (as N), Gamma	Weekly Grab
Landfill Bypass	Gross Alpha, ^{3}H, NO_3^- (as N), Gamma	Weekly Grab
Lined Solar Evaporation Pond	Gross Alpha, Am, Be, Gross Beta, Curium, Cyanide, ^{3}H, NO_3 (as N), pH, Pu, ^{90}Sr, Total Dissolved Solids, ^{235}U, ^{238}U, ^{234}U	Monthly
Sumps 1, 2, and 3 (below Solar Ponds)	Gross Alpha, Gross Beta, ^{3}H, NO_3^- (as N)	Weekly

TABLE 2.10.2-1 (Continued)

Location	Element or Condition	Frequency
Hydrology Test Holes	Gross Alpha, Am, As, B, Be, Gross Beta Ca, Cd, Cl, Cr, Conductivity, Cu, F^-, Fe, ^3H, Hardness, K, Li, Mg, Mn, Mo, Na, NH_3, NO_2, NO_3^- (as N), P, Pb, Pu, SO_4, ^{90}Sr, Total Dissolved Solids, U, Zn Gamma	Five Months
Test Hole 2 (Landfill)	^{90}Sr	Quarterly
Test Hole 46 (Landfill)	^3H	Quarterly
Holding Tank Test Holes (31)	Conductivity, pH, NO_3^- (as N), Total Dissolved Solids	Five Months
Building Footing Drains (10)	Gross Alpha, Conductivity, NO_3^- (as N), pH, Total Dissolved Solids	Five Months
	Pu	Only if GA > 40 pCi/l
Walnut Creek at Indiana	Gross Alpha, Gamma, ^3H, NO_3^- (as N), Ph	Daily
	Gross Beta	Weekly Grab
	Am, Pu, ^{90}Sr, U	Weekly Composite
	Cyanide, Cr, Oil and Grease, PCBs, Phenol Linear Alkyl Sulfonates	Quarterly Grab
	As, Cl^-, 11 elements, 31 elements, F^-, P, SO_4, Total Solids	Quarterly Composite
Broomfield, Boulder, & Westminster Water Taps	Am, Pu, U, Tritium	Monthly Composite
Six Other Communities Water Taps	Am, Pu, U, Tritium	Quarterly Grab
35 Off-site Waters	Am, Pu, U, Tritium	Annual Grab

TABLE 2.10.2-2

ELEMENTS OR CONDITIONS MONITORED BY LOCATIONS

Element or Condition	Location
Alpha, total long-lived	A-3; Walnut Creek; Sewage Plant Influent; B-3, B-4; C-1; Water Plant Treated Water; Solar Ponds; Sumps; Waste Treatment Plant Pond; A-1 Bypass; Hydrology Test Holes; Footing Drains; Landfill Pond 1; Landfill Pond 2; Landfill Bypass
Alkalinity	Water Plant Treated Water
Americium	Walnut Creek; A-3; B-4: C-1; Reservoirs; Water Taps; Off-Site Waters; Water Plant Raw Water; Solar Ponds; Hydrology Test Holes
Ammonia (NH_3)	B-4; Water Plant Treated Water; Hydrology Test Holes
Arsenic (As)	Walnut Creek; C-1; Reservoirs; Water Plant Treated Water; Hydrology Test Holes
Bacteria	Water Plant Treated Water, Sewage Plant Effluent
Barium (Ba)	Water Plant Treated Water
Beryllium (Be)	Water Plant Raw Water; Water Plant Treated Water; Solar Ponds; Hydrology Test Holes; Landfill Pond 1
Beta, gross	A-3; Walnut Creek; B-4; C-1; Water Plant Treated Water; Solar Ponds; Sumps; A-1 Bypass; Hydrology Test Holes
Biochemical Oxygen Demand (BOD)	Sewage Plant Effluent
Boron (B)	Water Plant Treated Water; Hydrology Test Holes
Cadmium (Cd)	Water Plant Raw Water; Water Plant Treated Water; Hydrology Test Holes; Landfill Pond 1
Calcium (Ca)	Water Plant Treated Water; Hydrology Test Holes
Chemical Oxygen Demand (COD)	B-4; C-1; Landfill Pond 1

TABLE 2.10.2-2 (continued)

Element or Condition	Location
Chloride (Cl^-)	Walnut Creek; C-1; Reservoirs; Water Plant Treated Water; Hydrology Test Holes
Chlorine (HOCl, NH_2Cl)	Sewage Plant Effluent; B-4; Water Plant Treated Water
Chromium (Cr)	Sewage Plant Effluent; Water Plant Raw Water; Water Plant Treated Water; Landfill Pond 1
Color	Sewage Plant Effluent; Water Plant Treated Water
Conductivity	Hydrology Test Holes; Holding Tank Test Holes; Footing Drains
Copper (Cu)	Water Plant Treated Water; Hydrology Test Holes
Cyanide (CN^-)	Walnut Creek; C-1; Reservoirs; Water Plant Treated Water; Solar Ponds
Dissolved Oxygen (DO)	Sewage Plant Effluent Upon Entering South Walnut Creek
Eleven Elements (Ba, Be, Ca, Cd, Cr, Hg, K, Mg, Na, Se, Si)	Walnut Creek; C-1; Reservoirs; B-4; Landfill Pond 1
Fecal and Total Coliforms	Sewage Plant Effluent; Water Plant Treated Water
Fluoride (F^-)	Sewage Plant Effluent; Walnut Creek; B-4; C-1; Reservoirs; Water Plant Raw Water; Water Plant Treated Water; Hydrology Test Holes
Gamma	Sewage Plant Effluent; A-3; Walnut Creek; Sewage Plant Influent; B-4; C-1; Landfill Pond 1, Hydrologic Test Holes
Hardness	Water Plant Treated Water; Hydrology Test Holes
Iron (Fe)	Water Plant Treated Water; Hydrology Test Holes
Kjeldahl Nitrogen	Sewage Plant Effluent
Lead (Pb)	Water Plant Treated Water; Hydrology Test Holes

TABLE 2.10.2-2 (continued)

Element or Condition	Location
Linear Alkyl Sulfonates (LAS) (Detergents)	Water Plant Treated Water
Lithium (Li)	Hydrology Test Holes
Magnesium (Mg)	Water Plant Treated Water; Hydrology Test Holes
Mercury (Hg)	Water Plant Raw Water; Water Plant Treated Water; Landfill Pond 1
Molybdenum (Mo)	Hydrology Test Holes
Nitrate (NO_3^-) as N	Sewage Plant Effluent; A-3; Walnut Creek; B-4; C-1; Reservoirs; Water Plant Treated Water; Landfill Pond 2; Landfill Bypass; Solar Ponds; Sumps; Waste Treatment Pond; A-1 Bypass; Hydrology Test Holes, Holding Tank Test Holes; Footing Drains
Nitrite (NO_2^-)	Sewage Plant Effluent; Hydrology Test Holes
Oil and Grease	Sewage Plant Effluent; Walnut Creek; C-1; Reservoirs
PCBs (Polychlorinated Biphenyls)	Walnut Creek; C-1; Reservoirs; Water Plant Raw Water; Landfill Pond 1
pH	Sewage Plant Effluent; A-3; Walnut Creek; C-1; Solar Ponds; Holding Tank Test Holes; Footing Drains
Phenol	Walnut Creek; C-1; Reservoirs; Landfill Pond 1
Phosphorous (P)	Sewage Plant Effluent; Walnut Creek; B-4; C-1; Reservoirs; Water Plant Treated Water; Hydrology Test Holes
Plutonium (Pu)	Sewage Plant Effluent; A-3; Walnut Creek; B-4; C-1; Reservoirs; Water Taps; Off-site Waters; Water Plant Raw Water; Landfill Pond 1; Solar Ponds; Hydrology Test Holes; Footing Drains
Potassium (K)	Hydrology Test Holes
Radium (^{226}Ra)	Water Plant Treated Water
Selenium (Se)	Water Plant Treated Water

TABLE 2.10.2-2 (continued)

Element or Condition	Location
Silver (Ag)	Water Plant Treated Water
Sodium (Na)	Water Plant Treated Water; Hydrology Test Holes
Strontium (^{90}Sr)	Walnut Creek; B-4; C-1; Water Plant Treated Water; Test Hole 2; Landfill Pond 1; Solar Ponds; Hydrology Test Holes
Sulfate ($SO_4^=$)	Walnut Creek; C-1; Reservoirs; Water Plant Treated Water; Hydrology Test Holes
Surfactants	Walnut Creek; C-1; Reservoirs
Suspended Solids (SS)	Sewage Plant Effluent; B-4; Water Plant Raw Water
Thirty-one Elements (Ag, Al, B, Ce, Co, Cr, Cs, Cu, Fe, Ge, Li, Mn, Mo, Nb, Ni, P, Pb, Rb, Sb, Sn, Sr, Ta, Te, Th, Ti, Tl, U, V, W, Zn, Zr)	Walnut Creek; B-4; C-1; Reservoirs; Landfill Pond 1
Total Dissolved Solids (TDS)	C-1; Water Plant Raw Water; Water Plant Treated Water; Solar Ponds; Hydrology Test Holes; Holding Tank Test Holes; Footing Drains
Total Solids	Walnut Creek; B-4; C-1; Reservoirs; Landfill Pond 1
Tritium (^3H)	A-3; Walnut Creek; Sewage Plant Influent; Sewage Plant Effluent; B-4; C-1; Reservoirs; Offsite Waters; Water Plant Raw Water; Test Hole 46; Landfill Pond 1; Landfill Pond 2; Landfill Bypass; Solar Ponds; Sumps; Waste Treatment Pond; A-1 Bypass; Hydrology Test Holes
Turbidity	Sewage Plant Effluent; Water Plant Treated Water
Uranium (U)	A-3, Walnut Creek; B-4; C-1; Reservoirs; Water Taps; Offsite Waters; Water Plant Raw Water; Water Plant Treated; Solar Ponds; Hydrology Test Holes
Zinc (Zn)	Water Plant Treated Water; Hydrology Test Holes

TABLE 2.10.2-3

WATER SAMPLE DETECTION LIMITS

Parameter	Typical Sample Volume (ml)	Typical Detection Limit (pCi/l)	Rocky Flats Guide Values for Effluents (pCi/l)
Radioactive			
Americium-241	1,000	0.10	≤1330 (USERDAM 0524, 1977)
Plutonium-239/240	1,000	0.10	≤1667 (USERDAM 0524, 1977)
Total Long-lived Alpha	25	5.0	≤ 15 (USEPA, 1977)
Tritium	1,000	500	20,000 (USEPA, 1977)
Uranium-233/234/238	1,000	0.40	≤10,000 (USERDAM 0524, 1977)
Gross Beta	25	5.0	≤ 50 (USEPA, 1977)
Nonradioactive		(mg/l)	(mg/l)
BOD_5	10	1.0	≤25
Dissolved Oxygen	300	1.0	≥ 2
Fecal Coliforms	10-100	0	400 organisms/ 100 ml (7-day) 200 organisms/ 100 ml (30-day)**
Fluoride	20	0.2	≤1.7
Oil and Grease	500	0.1	≤10
pH	NA***	0 - 14**	6.0 - 9.0**
Phosphorus as P	50	0.2	≤ 8
Residual Chlorine	10	<0.1	≤0.1
Total Chromium	5	0.05	≤0.1
Total Nitrogen	10	0.2	≤20
Total Suspended Solids	100	2.0	≤25

*pCi/l = μCi/ml x 10^9

**mg/l not applicable.

***NA - Not applicable.

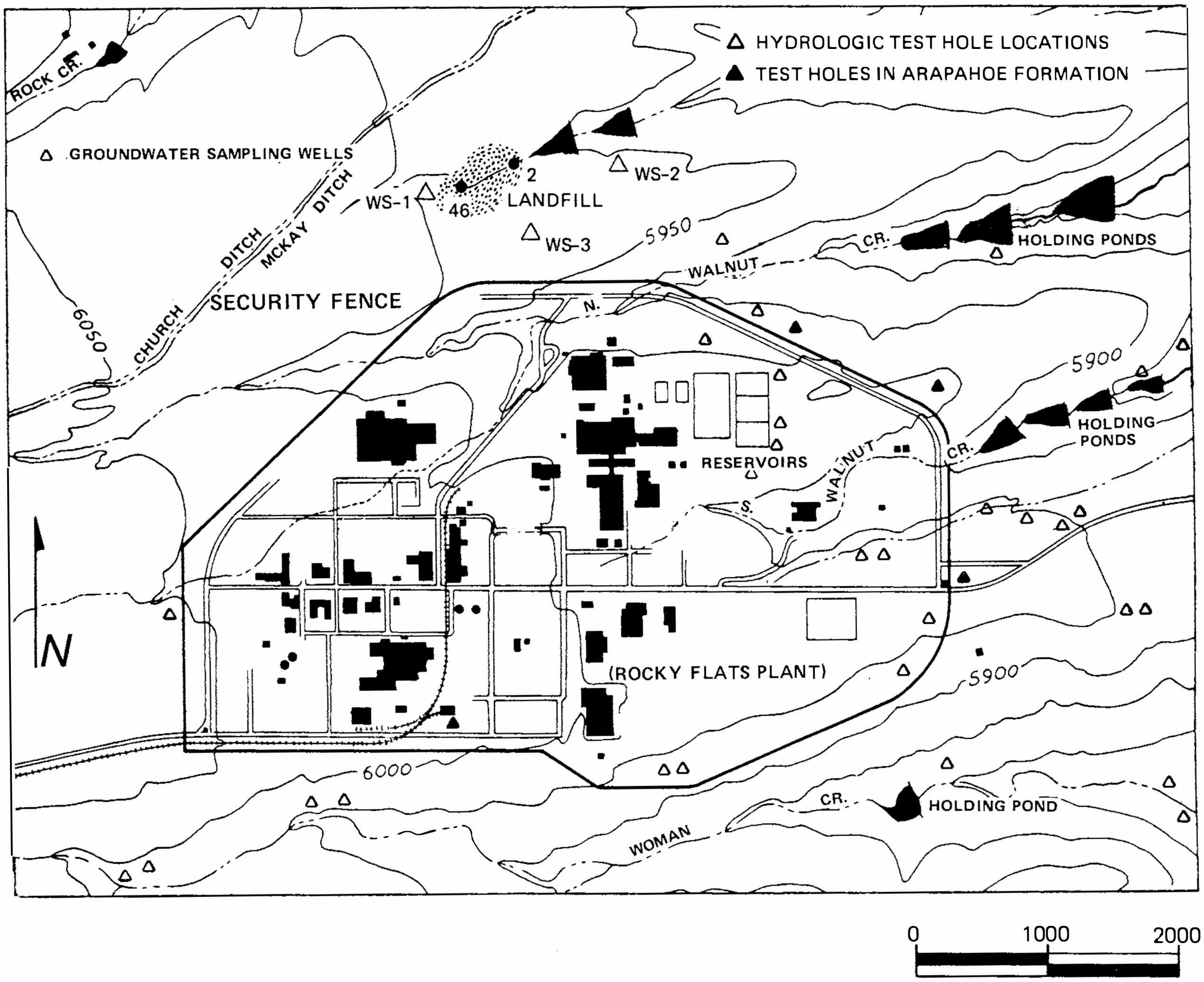


Figure 2.10.2-1 Location of Ground Water Sampling Test Holes

2.10.2.3 Regional Water Monitoring

Surface water samples are taken from several water bodies in the general vicinity of the Rocky Flats Plant. Samples are taken from Walnut Creek, Great Western Reservoir, and Standley Lake, in addition to tap water from nine communities.

Walnut Creek is continuously sampled at Indiana Street; the samples are analyzed for the various radionuclides, elements, and conditions listed in Table 2.10.2-1. In 1977, the average, annual, concentration of plutonium in this water was less than 0.01% of the RCG_w, and the concentration of americium was less than 0.01% of the RCG for soluble americium-241 in public water supplies.

Weekly samples of raw and treated water are taken from the Broomfield and Westminster filter plants, composited monthly, and analyzed for plutonium, uranium, and americium. Additionally, grab samples are collected weekly from Great Western Reservoir and Standley Lake and analyzed for tritium and nitrate. A water sample is taken weekly from the tap water supply of Boulder. This sample is composited monthly and analyzed for plutonium, uranium, and americium. Quarterly, tap-water grab samples are collected in six additional communities (Arvada, Denver, Golden, Lafayette, Louisville, and Thornton). These samples are analyzed for plutonium, uranium, and americium. Sampling sensitivity is given in Table 2.10.2-3 for effluent water, except for plutonium, for which the minimum detectable amount is 0.02 pCi/l.

The concentration of plutonium in water from the city water-supply reservoirs typically is <0.02 pCi/l*, as compared to an RCG_w of 1,667 pCi/l for plutonium. The amount of plutonium in the tap water samples is comparably low. The USEPA standard for finished (processed) drinking water is 15 pCi/l total long-lived alpha (USEDA, 1977).

The RCG_w for tritium in public waters is 1×10^6 pCi/l, while the EPA standard (USEPA, 1977) for finished water is 20,000 pCi/l. The concentration of tritium in Standley Lake typically is about 600 pCi/l, which is statistically indistinguishable from background concentrations. For additional comparison, the most recent standard for tritium in drinking water is that of the EPA, which is 20,000 pCi/l. Standley Lake and Great Western Reservoir typically have tritium concentrations that are less than 5% of this standard.

The concentration of tritium in Great Western Reservoir averaged 700 pCi/l during 1977. Tritium was released in Plant effluent water during 1973 as the result of processing a shipment of plutonium scrap that, unknown to Rocky Flats personnel, had been contaminated with tritium by another DOE facility.

*Larger samples and extended counting times were used to reduce the detection limits for these analysis as compared to the limits shown in Table 2.10.2-3.

An AEC committee, appointed to investigate the incident, reported there was no damage to public or private property, and the on-site tritium contamination levels were not of public health significance (AEC, 1973). The EPA also conducted an investigation and also concluded that the tritium release did not present a public health hazard (USEPA, 1974). Despite the small concentrations noted, procedures were established to detect tritium and other radionuclides in all incoming shipments and in Plant effluents. These radionuclides are in addition to those previously included in the monitoring program.

Water samples are collected annually from approximately 35 regional lakes, streams, and reservoirs up to 20 miles from the Rocky Flats Plant. These samples are analyzed for uranium, plutonium, americium, and tritium. Historically, the samples have contained concentrations of radionuclides that are typical of natural background plus worldwide fallout from nuclear weapons testing.

2.10.2.4 Water Monitoring by Other Agencies

The Colorado Department of Health samples the Plant effluent at the junction of Walnut Creek and Indiana Street three times each week, and analyzes the samples for total alpha and beta activity, for tritium, and for nitrate concentrations. Individual samples having total alpha concentrations in excess of 40×10^{-9} μCi/ml are analyzed specifically for plutonium. Plutonium analysis is routinely performed on monthly composite samples from these locations. Rocky Flats' holding ponds and the Broomfield water supply are also monitored weekly for total alpha, total beta, tritium, and nitrate. In addition, water samples are routinely collected from municipalities, lakes, and streams in the vicinity of the Plant, and analyzed for total alpha activity, natural uranium, and plutonium. Additional sampling for all parameters listed in the NPDES permit is periodically performed collectively by the Colorado Department of Health and the Jefferson County Health Department.

2.10.3 Soil Sampling

2.10.3.1 Soil Sampling by Operating Contractor

Soil samples are collected annually at alternate intersections of a 500-foot grid in the exclusion area of the Plant. These samples are analyzed specifically for plutonium. The minimum detectable concentration (MDC) of plutonium in these dry-weight samples is 0.03×10^{-6} μCi/g, which is equivalent to 0.06 d/m/g. See Section 2.3.9.3 for a discussion of soil sampling methods.

Soil samples also are collected annually from approximately 60 locations on the circumference of three circles having radii of 1, 2, and 5 miles from the center of the Plant (RI, 1975). Using a special tool to control the geometry of the samples, 500 cm^3 (30 in^3) of soil are collected from the top 5 cm (2 in.) at each location. The soil samples are analyzed for plutonium.

During the investigation of plutonium contamination that resulted from oil-drum leakage, the contractor collected soil samples semiannually from 75 off-site locations within a 315-sq mi area around the Plant. In addition, spot samples were taken from areas in which plutonium contamination was known to exist. The estimated total quantity of plutonium in soil outside the present Rocky Flats site boundary, based on DOE Environmental Measurements Laboratory data, is 2.4 Ci. This quantity includes plutonium occurring some distance from the site at very low concentrations. The concentration of plutonium in air adjacent to this soil, as determined by the air sampling network, indicates that only a small fraction of the plutonium is being re-entrained in moving air. More information is given in Section 2.3.9.2.

2.10.3.2 Soil Sampling by Other Agencies

Every year the Colorado Department of Health samples soil in the Rocky Flats Plant environs, in addition to making an annual determination of plutonium in Colorado soil from worldwide fallout (CDH, 1973). In the past, the Colorado Department of Health and, as mentioned previously, the DOE Environmental Measurements Laboratory have conducted independent surveys of the distribution of plutonium in soil surrounding the Plant (Krey and Hardy, 1970; Krey, et al., 1976). The Jefferson County Health Department also has done some soil sampling (Johnson, et al., 1976).

2.10.4 Ecological Research and Monitoring

Rocky Flats research personnel are involved in many environmental study projects. Included among these are studies of meteorology soil deposition and re-entrainment mechanisms; particle size; stack and sewage effluents; filtration; and fish, algae, and bacteria.

Plant personnel are developing a comprehensive ecological monitoring program. This program will create an ecological data base to assist in detection of future changes in the local environs.

Physical and ecological changes will be ascertained by various methods. Photographic records will be kept to document any gross changes in the vegetational communities over large areas, to record land use, and to characterize the aquatic and terrestrial permanent study areas. Specific ecological changes in vegetation patterns will be determined by assessments of species diversity.

Routine limnological determinations will assess the physical and chemical conditions of various bodies of water on the Plant site. Small mammal trapping and game animal observations will provide yearly estimates of population dynamics and site use by the animals.

2.10.4.1 Investigation of Plutonium in Aquatic Systems by Off-Site Researchers

Under contract with the Plant contractor, Colorado State University conducted independent studies of the effects of plutonium on various aquatic systems at Rocky Flats. This research was designed to identify and quantify any biological pathways for the movement of plutonium in the watercourses at the Rocky Flats Plant.

There were experiments to determine the factors by which bacteria concentrate plutonium from water. Also, the kinetics for transferring plutonium from water to sediments, algae, and freshwater fish were investigated.

The final report covering the period from January 1971 to December 1973 was published in 1974 (Johnson, et al., 1974). The results of the study are given in greater detail in Section 2.3.10.3.

2.10.4.2 Terrestrial Studies by Off-Site Researchers

Colorado State University Studies

The Department of Radiology and Radiation Biology, Colorado State University, in its fifteenth annual progress report discusses terrestrial radioecological studies at Rocky Flats from 1972 through 1977 (Whicker, 1977). This report was completed subsequent to issuance of the DEIS and is discussed here and added as Appendix A-2, in response to public comment on plutonium distribution. The study included numerous subprojects designed to elucidate plutonium distribution patterns and assist in hypothesizing mechanisms influencing those patterns. Most investigations were conducted on two 7500-m^2 study plots labeled as Macroplots 1 and 2. Macroplot 1 was situated about 200 m southeast (downwind) of the former oil drum storage area (see Section 2.3.9.1). Macroplot 2 was established 1,400 m south of the oil drum storage area.

The main objectives of the CSU terrestrial research (Little, 1976) included

1. Determining principal ecological compartments for plutonium
2. Determining the size of plutonium fractions existing within the major compartments
3. Postulating mechanisms of plutonium transport, based on observed data

Soil, litter, vegetation, arthropods, small mammals, nesting mourning doves, mule deer, and snakes were sampled for plutonium analysis and estimation of compartmental mass. Sample analysis was by liquid scintillation counting in the CSU laboratory, or by alpha spectrometry in commercial laboratories (Little, 1976).

Plutonium concentration on soil particles with less than a 2000 μm diameter averaged 1900 d/m/g at Macroplot 1 and 92 d/m/g at Macroplot 2 for depths of 0-3 cm

(Little and Whicker, 1978). Mean concentrations for depths of 0-21 cm were 570 d/m/g and 22 d/m/g for Macroplots 1 and 2, respectively. Plutonium concentrations were inversely proportional to distance downwind from the plutonium source (oil drum storage area), depth of sample, and soil particle size. Postulated primary mechanisms of environmental dispersion included attachment of plutonium oxide to soil particles, wind movement of soil particles and associated plutonium from the source, and weathering and penetration of deposited particles into soil.

More than 99% of the total ecosystem plutonium of both plots was contained within the soil (Little, 1976). The balance existed in plant and animal compartments. In Macroplot 1, average plutonium concentrations were 63.4 d/m/g for standing vegetation, 12.6 d/m/g for arthropods, and 14.4 d/m/g for small mammals. Bone, liver, and lung of small mammals averaged 0.64, 18.6, and 7.93 d/m/g, respectively (Little, 1976).

Mourning dove nestlings were collected from an approximately 500,000 m^2 (124 acres) area south and southeast of the security-fenced industrial area (Whicker, 1976). Liver, lung, and bone samples contained less than detectable amounts of plutonium in 15 of 24 cases, and no sample contained more than 1 d/m.

Sampling of snakes in the Macroplot 1 area was designed to describe plutonium concentrations at the carnivore level of the food chain (Geiger and Winsor, 1977). Of 27 samples of lung, liver, and bone, 20 contained $\leq$0.1 d/m/g Pu-239 and none exceeded 1.0 d/m/g.

Beginning in 1975, investigations were conducted to evaluate mule deer as a plutonium transport vector. Information was gathered on population dynamics, movement and use patterns, food habits, ingestion rates of plutonium-burdened soil and vegetation, and plutonium burdens of deer tissues (Arthur, 1977; Hiatt, 1977). The hypothesis was that mule deer ingest plutonium associated with soil and vegetation and excrete most of the radionuclides with fecal material at surrounding locales. Calculations based on data collected at Rocky Flats indicate that for a 66.2 kg animal, spending 365 days per year in the Woman Creek area, the most probable, overall, annual plutonium intake is 7.14×10^{-2} μCi (Arthur, 1977).

Tissue samples were collected from eight mule deer killed in accidents or predation in the Rocky Flats area. Plutonium results were compared with results from five control deer taken outside the Rocky Flats area (Hiatt, 1977). Lung, liver, muscle, testes, and metacarpal analysis of Rocky Flats deer in addition to lung, liver, and metacarpal analysis of control deer revealed plutonium concentrations near or below the detection limits of the radioanalytic technique in all cases. Five of seven lung samples from Rocky Flats deer contained detectable plutonium, with maximum estimated lung burden being 6.1 d/m.

Probable total dispersal through excretion for deer grazing on Macroplot 1 was estimated to be 7.0×10^5 d/m/yr (Hiatt, 1977). Calculations included estimates of seasonal deer use, and an assumption that 100% of the nuclide would be excreted within 5.2 km of the plot.

An additional study by Whicker at Rocky Flats, as noted in the CSU fifteenth annual report, was conducted to estimate the effects of pocket gopher soil excavation activities on (1) the potential for wind dispersal of plutonium, and (2) the vertical soil plutonium profile on Macroplot 1. Whicker summarizes as follows: "Pocket gophers generally confined activities to the upper 30 cm of soil. During 7 months, the rodents cast about 3000 kg of subterranean soil to the surface, which contained about 50 μCi of plutonium. Mound soil concentrations averaged 39 d/m/g. Mean undisturbed soil profile concentrations decreased from 167 d/m/g at 0-10 cm depth to 10 d/m/g at 20-30 cm depth. The data shows that pocket gophers effect vertical redistribution of plutonium in soil, with a small degree of horizontal dispersion as an implied consequence" (Whicker, 1977).

The radioecological study also included a search for pathological effects of plutonium alpha particles on small mammals (Whicker, et al., 1977). Prior to sacrifice for plutonium analysis, some mammals were submitted to diagnostic radiography during a search for skeletal lesions. Routine necropsy was performed for pathologic conditions, and lung sections were microscopically examined for evidence of cancerous conditions. Analyses of mammals from Macroplot 1 included 189 necropsies, 96 microscopic examinations, and 70 skeletal X rays. All examinations were negative for the pathological objectives. The study concluded: "If any small mammals do suffer from lesions similar to those induced by plutonium, we may never observe them. It is possible that individuals suffering from disease, advanced sufficiently to be perceived by our methods, may not be trappable. We have held some animals in captivity in an effort to check the above possibility. Fourteen mammals from Rocky Flats and 24 from the Fort Collins area have been examined with negative results. It seems obvious that these data, and related data comparing life spans in the laboratory, will be far too few to detect differences."

The three-year summary report of the CSU group discusses general conclusions in regard to radioecological work done at Rocky Flats (Whicker, 1977). That summary is included as Appendix A-2 to this Environmental Impact Statement.

EPA Rocky Flats Cattle Study

In 1973, the U.S. Atomic Energy Commission's Rocky Flats Area Office funded a project to purchase, and have analyzed, 10 cattle (Smith and Black, 1975). The cattle were from a herd grazed on a 900-acre pasture that was adjacent to the eastern edge of the Rocky Flats Plant but is now a part of the buffer zone. The cattle included five aged cows which had been purchased by the owner five or six years earlier and grazed on the pasture from mid-May to the end of October each year. Also included were five calves born on the pasture during late May or early June of 1973. The cattle received no supplemental feed while on this pasture; their drinking water came from Walnut Creek. The remainder of the year, the cattle grazed in wheat, alfalfa, or corn fields near Brighton, Colorado, where they were supplemented with locally harvested hay and corn ensilage.

The cattle were shipped by semitrailer truck to the U.S. Environmental Protection Agency's National Environmental Research Center at Las Vegas for sacrifice and sampling. The LFE Environmental Analysis Laboratories Division of Richmond, California, conducted the radionuclide analysis with support services provided by Reynolds Electrical and Engineering Company. The analyses were for tritium, strontium-89, uranium, plutonium-239, and americium-241. The data were compared to data from cattle herds grazing on and around the Nevada Test Site (NTS) and herds at Searchlight and Reno, Nevada. The Rocky Flats cattle had tissue concentrations similar to the cattle from NTS grazing area and another test area about 35 miles northwest of NTS known as the Roller Coaster grazing area. The levels of uranium and plutonium found in the Rocky Flats cattle were statistically the same as those found from fallout in autopsy tissue samples from the general U.S. human population (Campbell, et al., 1973).

Four of the five cows were very aged (18 years old), and all of the cattle had undergone considerable stress from the transportation to Las Vegas during a severe blizzard. No characteristically abnormal pathology was reported.

The maximum plutonium concentration in edible tissues from the Rocky Flats cattle, if ingested by humans at the rate of 500 grams per day for 50 years, would contribute an estimated bone dose of only 0.02 rem from consumption of liver and 0.001 rem from consumption of muscle. This is a small fraction of the estimated background dose to the bone which is 11.9 rem per 70 years in the Denver area (see Table 3.1.2-6). The geometric mean values of uranium in the tissues was slightly higher than the amount found in the other beef cattle groups located in other areas. This is to be expected from cattle grazing in the Colorado Front Range, which has higher levels of naturally occurring uranium in the soil. No other anomalies were observed.

<u>University of Colorado Studies</u>

The University of Colorado (CU) received an ERDA research grant to inventory and catalog the vegetation at the Rocky Flats site. The taxonomy and vegetation mapping is complete. Appendix A-1 lists plant and animal life observed at Rocky Flats. Results are discussed in Section 2.3.10.

University of Colorado personnel have studied the phenomenon of needle ice formation and its effect on the redistribution of plutonium in soils. The purpose of the needle ice project was to determine if needle ice formation (and the associated frost heave) increased the erodability of the soil by changing surface roughness and surface soil density. Predictions were made, based on the study, as to the times and conditions which would maximize such effects, but no empirical evidence was obtained to support these predictions (Caine, 1978).

2.10.4.3 Vegetation Sampling

For several years, vegetation samples were collected twice yearly from about 40 locations on the Plant site and more than 50 locations off site. These collections, normally made in June and September, were taken from an area of about 315 square miles around the Plant, generally along public rights-of-way. The vegetation consisted primarily of native grasses and volunteer feed grain crops. Root systems were not collected. The unwashed samples were analyzed specifically for plutonium. The minimum-detectable plutonium concentration was 0.01 pCi/g (dry weight). The average concentration of plutonium in the vegetation samples collected in 1972 at distances ranging from less than 1 mile to 5 miles was 0.33 pCi/g (dry). The average for samples collected at a distance greater than 5 miles was 0.21 pCi/g, which is not significantly different.

There is no established standard for plutonium concentration in vegetation. There is difficulty in obtaining reliable test results, especially at the low concentrations which are observed. Radionuclides in vegetation make so small a contribution to the dose that it is mathematically insignificant to the total dose. For these reasons, vegetation is now sampled only in conjunction with research programs.

2.10.5 <u>Other Related Studies</u>

2.10.5.1 Wind Tunnel Studies

Wind tunnel studies of the Plant site and the new plutonium recovery and waste treatment facility were conducted by Colorado State University. These tests of scale models were used to determine the dispersal routes and trajectories of airborne effluents originating at the Plant. A goal was a subsequent determination for the most effective placement of air samplers. Study results indicated that the ambient air monitors will detect airborne radioactive releases.

2.10.5.2 Hydrology Studies

A detailed hydrology study of the Rocky Flats Plant site was completed by the Water Resources Division of the U.S. Geological Survey (Hurr, 1976). A summary of the results are included in Section 2.3.5. Additional supplementary data are being collected from on-site surface gauging and precipitation stations.

2.10.5.3 Soil Classification Survey

The U.S. Department of Agriculture, Soil Conservation Service, conducted a soil classification and soil resource survey and is preparing a detailed soil classification report for the Rocky Flats Plant site as part of their overall effort in Jefferson County. Portions of the preliminary draft report relating to Rocky Flats were discussed in Section 2.3.4.4.

2.10.5.4 Virus-in-Water Monitoring Program

A sampling and analysis program to detect viruses in Plant influent and effluent water was conducted by the Carborundum Company. The program involved the following:

1. One sample of raw water and one sample of treated water at the water treatment plant
2. One sample of the influent to the sewage treatment plant
3. Two samples at sites in the reverse osmosis system
4. Two samples after an electrolysis treating process
5. Two samples of the chlorinated discharge from the treatment process; one for enteric viruses and one for Adeno virus.

Nine samples were taken as identified above. In Samples 1-4, above, the resulting concentrate was assayed for enteric viruses (Polio, Echo, and Coxsackie B). Of the two concentrates produced from Sample 5, one was split so that two separate assays could be performed--part for the Polio, Echo, and Coxsackie B viruses, and part for Reo virus. The second concentrate was obtained using the same equipment but was assayed with procedural modifications for Adeno virus. Results of the program were negative; no viruses were found to exist in the samples taken (McGee, 1975). This virus study was done in connection with the new reverse osmosis facility. Virus are normally associated with high turbidity and suspended solids. Both of these are normally low in Plant effluent, therefore no virus problems are expected.

2.10.5.5 Aerial Radiological Survey

Aerial radiological surveys of the area surrounding the Rocky Flats Plant were conducted by EG&G, Inc., under an ERDA contract. The Aerial Radiological Measuring System (ARMS), which measures terrestrial, gamma-radiation exposure rates, was used. The ARMS was also used to survey other ERDA facilities. A high-sensitivity detection system measures gamma radiation for gamma energy analysis and total gamma count rate. The data were then processed by computer into a map showing isoexposure contours three feet above the ground. A 200-square mile aerial survey was made of the area outside the perimeter fence of the Rocky Flats Plant. The survey indicated that the concentration and relative abundance of radioactive isotopes are consistent with normal terrestrial background radiation. The three-foot level exposure rates mapped during the survey were mostly in the 14 to 22 μR/hr range. The detailed survey within the Plant perimeter showed exposure rates from 20 to 100 μR/hr. These higher rates, recorded near or over Plant buildings, were caused by radioactive material within the buildings and by outside storage areas used in the past. Gamma radiation from such materials is primarily in the low-energy region (less than 500 keV).

2.11 EMERGENCY PLANS

Rocky Flats has comprehensive emergency plans that provide guidance and procedures which are designed to protect (1) life and property within the facility, (2) the health and welfare of surrounding metropolitan communities, and (3) the defense interests of the nation during any credible emergency situation. Mutual assistance and coordination with Federal, State, and local agencies is assured on a cooperative basis. In response to public comment on the DEIS, more detailed information has been provided on the State emergency response plan for the Rocky Flats area, and its interface with on-site emergency response programs.

2.11.1 Department of Energy Emergency Organization

The DOE-RFAO Manager coordinates activities for emergencies affecting off-site personnel or property. He is responsible for maintaining liaison with the supporting Federal, State, and local agencies. The DOE-RFAO emergency organization is under the direction of the RFAO Manager, who also is responsible for off-site activities of DOE support groups. The DOE-RFAO Manager may obtain further assistance through the Interagency Radiological Assistance Plan (IRAP). The IRAP provides that each of the signatory Federal agencies will assist one another in the event of a major emergency involving radioactivity. The DOE coordinates its response under the IRAP. In the event of a serious radiological emergency at Rocky Flats, technical and logistical assistance can be obtained from the participating agencies.

2.11.2 Contractor Emergency Organization and Responsibilities

2.11.2.1 Staff Management Responsibilities

The Rocky Flats Plant General Manager is directly responsible for assuring that an adequate emergency planning and response program is maintained. The General Manager's Staff is responsible for ensuring appropriate emergency response planning and training within the scope of their operational responsibilities.

2.11.2.2 Program Administration

The Plant Emergency Planning Program is administratively coordinated through the Safeguards and Security Department.

The Shift Superintendent on duty is designated as the Emergency Director during an emergency situation. He is responsible for determining the extent and severity of the emergency; ensuring that all possible steps are taken to protect life and property; ordering any immediate operational actions required to bring the situation under control, including coordination of off-site assistance; and providing management and appropriate staff groups with prompt notifications and continuing assessments and information concerning resolution of the situation.

Building Superintendents are responsible for coordinating operational emergency planning for their respective buildings, establishing and training local emergency response groups, establishing and maintaining communications systems and emergency equipment, and for the dissemination of Plant and building emergency plans to employees. In the event of an emergency situation, the Building Superintendent serves on the Shift Superintendent's staff.

Department supervisors have emergency planning and action responsibilities commensurate with normal daily operations. These include, but are not limited to, (1) hazard evaluations of work areas and the formulation of operational emergency procedures for their departments, (2) training of local response teams and department employees, and (3) providing immediate direction of emergency activities and support of Plant response teams.

Plant Emergency Response teams are comprised of specialized personnel who are trained and knowledgeable in meeting emergency situations. These include such fields of expertise as fire fighting, Plant security and nuclear materials protection, medical, radiation monitoring and health sciences, nuclear safety, and environmental sciences. The groups are further supported by expertise in industrial safety, industrial hygiene, communications, utilities, and transportation. These response groups are responsible for providing the direction and appropriate action required to resolve any emergency situation.

The Emergency Planning Review Committee is composed of the Health, Safety, and Environment Director; the Safeguards and Security Director; a Shift Superintendent Representative; the Emergency Planning Coordinator, and a representative of the DOE. The Committee is responsible for

1. Ensuring preparation and updating of the Rocky Flats Emergency Plan

2. Reviewing all emergency plans, procedures, equipment, and facilities for compliance and compatibility with each other and with the Rocky Flats Emergency Plan
3. Making recommendations to the General Manager's Office concerning emergency planning and readiness
4. Coordinating and evaluating tests and exercises to ensure emergency readiness

2.11.3 Rocky Flats Emergency Plan

The Rocky Flats Emergency Plan is designed to provide necessary guidance to meet the most probable local, state, or national emergency situations. The plan interfaces with County, State, and Federal emergency plans to meet the following objectives:

1. Take necessary measures to prevent any disasters that may be averted.
2. Provide procedural guidance during an emergency situation that will prevent or minimize injury or loss of life or property within the facility or in the surrounding metropolitan community.
3. Provide for recovery from the emergency situation and reestablish normal conditions and operations.

While the plan is an integrated compilation of various emergency plans, the on-site, off-site, and National Preparedness components of the plan will be described individually for purposes of clarity.

2.11.3.1 On-Site Emergencies

General

The Rocky Flats Emergency Plan expresses the philosophy that the Rocky Flats Plant be as self-sufficient as possible in handling emergency situations within the facility. Assistance may be requested from outside sources, however, if required. Written agreements are in effect with St. Anthony Hospital systems, St. Luke's Hospital, and the University of Colorado for medical assistance. A written agreement is in effect with the Jefferson County Sheriff's Office, Golden, Colorado, for law enforcement support. Since the Rocky Flats Plant is a Federal facility, additional support is also available from the Federal Bureau of Investigation.

Types of Emergencies

The Rocky Flats Emergency Plan provides procedural guidance for the following emergency situations: bomb incident or threat, chemical spills, radioactive or toxic material releases, nuclear criticality incident, fire, flood, earthquake, high winds or tornado, utilities failure, vehicular or aircraft accident, winter storms, riots or demonstrations, terrorist attack, and security alarm response.

Emergency Control Center (ECC)

The ECC is a designated area in the Plant administration building that serves as the Shift Superintendent's Office. The area is committed solely for emergency operations if such need arises. During the emergency situation, a designated cadre of management and response group personnel assume immediate responsibility for emergency operations and activities. The ECC is fully equipped with on-site and off-site radio communications, telephone communications, building plans, emergency procedures, and closed circuit TV scanning systems.

During a civil emergency, the ECC is expanded to include the national Emergency Radio Systems (ERS). The ECC is then designated as the Emergency Operating Center (EOC) within State or Federal civil defense guidelines.

Emergency Control Station (ECS)

An ECS is a location, designated by the Shift Superintendent, near the emergency scene. It serves as a local control point for direction of on-scene emergency response activities. The ECS is staffed with building superintendents and/or supervision and appropriate response group supervision as designated by the Shift Superintendent. Radio and/or telephone communcation links are established between the ECC and the designated ECS.

Notifications

There are various means of notification of an emergency situation within the Plant. Examples are the Plant telephone system, fire alarm telephone boxes, guard patrol telephone boxes, two-way radios, and the Plant public address system. A special one-way telephone system is dedicated exclusively to the notification of appropriate management personnel, informing them simultaneously of emergency situations.

Emergency Response Facilities

The Rocky Flats medical facility consists of a hospital that includes a surgery room, treatment rooms, X-ray facility, five-bed ward, decontamination room, and medical laboratory. The hospital is staffed by three doctors, four nurses, one X-ray technician, and a medical secretary. On-site ambulance, rescue, and emergency medical technician (EMT) services are provided by the Rocky Flats Fire Department. Within the written agreement with St. Anthony Hospital systems is provision for the "Flight for Life" helicopter air-ambulance service.

Rocky Flats maintains an on-site contamination-control equipment and supplies trailer. This mobile unit contains stores of protective clothing, tools, emergency lights, and radiation monitoring supplies. The unit can be moved to an emergency scene to provide support in addition to the equipment available in each building.

A description of the Plant Protection Force and the Fire Department is presented in Section 2.12, Safeguards and Security.

Evacuation Procedures

Evacuation procedures are included in Plant and building emergency plans. The decision to evacuate a building or area will be made by management. Evacuation routes and personnel assembly areas are designated for each building or area. The location of all personnel must be accountable by supervision. Re-entry may be authorized only by the Shift Superintendent. Total Plant evacuation would be accomplished according to Rocky Flats National Preparedness Plan procedures.

Atmospheric Release Advisory Capability (ARAC)

In cooperation with Lawrence Livermore Laboratory (California), Rocky Flats subscribes to an Atmospheric Release Advisory Capability (ARAC). The purpose of this system is to provide atmospheric dispersion projections in the event of an abnormal release of radioactive or other toxic substances to the atmosphere. The Rocky Flats ARAC system includes a computer which is capable of providing immediate dispersion projections to a distance of approximately 10 kilometers (6.2 miles) from the Plant. The system also provides for communication with the ARAC Central Facility, where sophisticated atmospheric models will extend the dispersion projections up to 80 km (50 miles) from the Plant. These sophisticated projections include corrections for terrain, as well as weather data from several observation stations. This provides detailed information for historical analyses and possibly for post-emergency guidance for the extremely low concentrations which might be found at greater distances.

2.11.3.2 Off-Site Emergencies

There are two types of off-site emergency situations that require Rocky Flats' response: (1) an off-site radiological incident involving non-Rocky Flats facilities, personnel, or material; (2) a potential or real condition resulting from a Rocky Flats emergency situation, causing an inadvertent release of radioactive or other toxic material that could affect surrounding communities, the Denver metropolitan area, or other areas of the State of Colorado.

Off-Site Radiological Assistance

Through DOE-RFAO at Rocky Flats, the Rocky Flats Radiological Assistance Plan interfaces with the Department of Energy Radiological Assistance Plan, the Interagency

Radiological Assistance Plan (IRAP), and the Joint Nuclear Accident Coordinating Center (JNACC).

DOE Radiological Assistance Plan

The Radiological Assistance Plan assigns nationwide and regional responsibilities, establishes lines of communication, identifies resources, and provides general guidance for handling radiological incidents. In addition, it encourages State and local governments and private industry to develop their own radiological emergency capabilities and plans. The Rocky Flats Plant is located in Radiological Assistance Region 6 whose Regional Coordinating Office is the Idaho Falls Operations Office. In the event of a radiological emergency at Rocky Flats, the total resources of DOE and its contractors can be called upon. The plan and implementing instructions issued by Idaho have been coordinated with representatives of the State of Colorado.

Interagency Radiological Assistance Plan (IRAP)

The IRAP was developed by the Interagency Committee on Radiological Assistance as a means for providing rapid and effective radiological assistance in the event of a radiological incident. Through IRAP, participating Federal agencies can coordinate their activities with those of state and local health, police, fire, and civil defense agencies. The IRAP provides operating guidelines and a training program. It coordinates existing competencies, responsibilities, and relationships to provide effective action at the lowest possible administrative level. Agencies participating in the IRAP are as follows: Department of Energy (DOE); Department of Agriculture; Department of Commerce; Department of Defense (DOD); Department of Health, Education, and Welfare; Department of Labor; Department of Transportation; Environmental Protection Agency; Interstate Commerce Commission; National Aeronautics and Space Administration; Defense Civil Preparedness Agency; and the Postal Service.

Joint Nuclear Accident Coordinating Center (JNACC)

The DOE and DOD have agreed to assist one another in the event of an accident involving radioactive materials. To provide such assistance, the two organizations have established a Joint Nuclear Accident Coordinating Center (JNACC). Located in Albuquerque, New Mexico, this facility is manned by DOE and DOD personnel. Records are maintained of the specialized capabilities and equipment of each agency, wherever located. These records are available in an emergency. The center is manned 24 hours a day and has telephone contacts with over 300 DOE and DOD radiological assistance teams. If there were a radiological accident at Rocky Flats, these agencies would be available through the JNACC to provide whatever assistance is appropriate.

Rocky Flats Radiological Assistance Team

The Rocky Flats Radiological Assistance Team is a support function continuously maintained in a state of readiness. The team consists of Health Physics personnel, Radiation Monitoring personnel, and electronic technicians knowledgeable in radioactive material detection and control. The team is equipped with a mobile trailer unit containing radiation-monitoring and air-sampling equipment and supplies. Assistance may be initiated from the following sources: (1) a request from the DOE Idaho Falls Regional Control Office, through the DOE-RFAO in support of the DOE Assistance Plan, (2) a request from a member of IRAP, and (3) notification by any individual cognizant of a possible radiation hazard. Upon receipt and evaluation of the notification, the Shift Superintendent will dispatch sufficient team members and equipment as the situation warrants. The Shift Superintendent also provides notification to Rocky Flats Management of the situation and of actions that have been taken.

2.11.4 Colorado Radiological Emergency Response Plan

The information described below has been extracted from, and reflects the DOE understanding of, the existing working Draft Plan dated July 1978.

2.11.4.1 Plan Activation and Responsibilities

In the event of an incident at the Rocky Flats Plant involving the release of radioactive material that may endanger the health and safety of the general public, the Colorado Radiological Emergency Response Plan would be activated. This plan describes concepts of emergency operations and assigns responsibilities to public and private safety and medical agencies. The plan represents agreements between the State of Colorado, Adams County, Boulder County, Jefferson County, the City and County of Denver, the United States Government through its agent, the Department of Energy, and the operating contractor. The plan is published under the authority of the Colorado Disaster Emergency Act of 1973 and is consistent with other laws and regulations of the State of Colorado and the United States of America. The State plan is prepared and administered by the Colorado Division of Disaster Emergency Services. The Colorado Department of Health derived action criteria utilized in the Radiological Emergency Response Plan for Rocky Flats. These criteria are called Protective Action Guides (PAG).

2.11.4.2 Notifications

Immediately upon the occurrence of an incident requiring implementation of the State plan, the Shift Superintendent on duty at the Rocky Flats Plant will initiate, at the direction of DOE-RFAO management, the State plan notification procedures. This is done via the Colorado network of the National Warning System (NAWAS) to the primary State warning point (State Patrol) and via the Jefferson County Sheriff's

Department to Jefferson County. From these two communication points, an elaborate "fan-out" procedure provides for notification to State, County, and local emergency agencies, the State and County Emergency Operating Centers, hospitals, and the Governor's Office.

2.11.4.3 Incident Assessment and Criteria for Action

On-site incident conditions at Rocky Flats will be evaluated by contractor and DOE personnel for potential radiological hazards, and results will be reported to the Colorado Department of Health (CDH). Off-site assessment will be performed by CDH radiological health personnel, and those results also will be reported to the Colorado Department of Health. All radiological readings will be forwarded to CDH representatives at the Colorado Emergency Operating Center (EOC).

Recommendation for action is based on the Protective Action Guide (PAG) (CDODS, 1979) shown in Table 2.11.4-1. The PAG is the projected dose, to individuals in the population, that warrants taking protective action. The dose is a function of the size of the release, distance from the Plant, and weather conditions.

TABLE 2.11.4-1
ROCKY FLATS PROTECTIVE ACTION GUIDE
(rem per incident based on a 70-year dose commitment)

Category	Mineral Bone
I[a]	<6
II[b]	6-30
III[c]	>30

a. Category I requires increased surveillance.
b. Category II requires increased surveillance, the protective action of "Duck and Cover" procedures, and consideration of access control of the affected area to preclude radiation exposure.
c. Category III requires, in addition to the requirements of Category II, consideration of mass evacuation of the populace to preclude radiation exposure.

The PAG does not imply an acceptable dose. However, if the maximum credible accident occurred (Section 3.2.4.2), and the population took no protective action, then fewer than two additional deaths per 10,000 people living to age 70 would occur. If protective action were taken, the effect would be lower.

For further information, see the Colorado Department of Health's report draft, entitled "Factors, Equations, and Considerations Used in Selecting the Protective Action Guide for the State of Colorado Rocky Flats Emergency Response Plan" (CDH, 1977).

2.11.4.4 Command and Control

The Governor of the State of Colorado will exercise overall control of State forces through the Division of Disaster Emergency Services. The Colorado EOC will be activated immediately upon receipt of notification and will be the primary control point for the State.

The sheriff and the county commissioners of all affected counties will exercise control of county forces. County EOC's will be activated upon notification and will be the primary control point for each county.

DOE and the contractor will exercise control over Rocky Flats forces. Such control will be maintained from the Rocky Flats EOC.

An order to evacuate an area having radiological contamination will normally be made by the Governor upon the advice of the Colorado Department of Health. Should the radiological hazard present an immediate threat to the health of the populace, those areas designated by DOE-RFAO or the Colorado Department of Health will be immediately evacuated, and the areas will be controlled to limit re-entry pending further response actions. Control actions may include restrictions on food and drinking water.

2.11.4.5 Communications

The National Warning Systems (NAWAS), the Colorado Law Enforcement Emergency Radio System (CLEER), and commercial telephone will be used to disseminate notifications of an incident. Direction and control coordination will be maintained by linking State, County, Rocky Flats EOC's, and on-scene control points together on the State Local Government Civil Defense Network. Each law enforcement agency will maintain their own communications. Medical and health aspects will be coordinated through the St. Anthony Hospital Communications Center.

2.11.4.6 Public Warnings

The decision to issue warnings and the content of warning messages will be made by the Colorado Department of Health, Division of Radiation and Hazardous Wastes Control. If Civil Defense warning sirens are located in affected areas, the sirens will alert the population to tune to emergency broadcast stations. Warning messages, including evacuation instructions, will be disseminated via commercial public broadcasting stations and by public safety vehicles with loudspeakers.

2.11.4.7 Radiological Exposure Control

If an area is determined to constitute a radiological hazard, all emergency forces will proceed through established control points. All personnel entering the controlled area will be issued dosimeters, if needed, and will be registered at the control point. After the allowed exposure time has elapsed, personnel must return to the control point to have dosimeters read. If the maximum allowable exposure has been reached, personnel will not be allowed to re-enter the area. If airborne radiological hazards exist, all personnel shall follow proper respiratory requirements established by the Colorado Department of Health.

2.11.4.8 Evacuation and Traffic Control

Should an incident result in a potentially hazardous release of contamination, a controlled area will be established around the existing or projected location of contamination. This action will control access to the area and control evacuation if deemed necessary. All vehicles approaching the controlled area will be advised of the hazard or, if conditions warrant, denied access to the area. Traffic on main arteries will be re-routed so as not to pass through a controlled area or interfere with emergency operations. In the event of evacuation, control point personnel will establish evacuation routes and direct evacuees to designated reception areas.

2.11.4.9 Medical Services

Rocky Flats personnel will be treated at St. Anthony's Hospital or St. Luke's Hospital in accordance with written agreements between Rocky Flats and those facilities. During evacuation general population personnel will be screened at an off-site controlled area for contamination. Contaminated vehicles will not be permitted to leave the controlled area, and contaminated personnel will be transferred to ambulances or buses at control points. Personnel who have indications of contamination will be directed or taken to neighborhood schools or to Camp George West, Golden, Colorado where decontamination facilities will be established. The University of Colorado Medical Center will coordinate the utilization of other hospitals for the treatment of incident victims.

2.11.4.10 Public Information

The DOE-RFAO and its contractor are responsible for all information relating to an on-site incident at Rocky Flats. The Colorado Department of Health, DOE-RFAO, and the contractor will coordinate public information to avoid releasing conflicting information that may unnecessarily alarm the public. Information and news releases to appropriate media for warning and evacuation purposes shall be coordinated by the Colorado Department of Health.

2.11.4.11 Exercise and Evaluation

The State Plan will be exercised annually. Assessment of the plan by all agencies involved has, after a number of revisions, resulted in concurrence that the plan is well-developed and ready to be exercised. Exercises may be announced or unannounced. Announced exercises will be for training purposes; unannounced exercises will be for evaluation purposes. Each exercise will be accomplished in accordance with an exercise plan that will be published separately. A critique of each exercise will be held within one week of the exercise to evaluate the results and review recommendations. The critique will serve as the basis for annual review and revision of the plan.

2.11.4.12 Federal Assistance Resources

In addition to the Rocky Flats and Colorado State emergency resources, the availability of additional assistance through the Federal Emergency Radiological Assistance programs is recognized and incorporated as part of the Colorado State Plan.

2.11.5 Rocky Flats Tests and Exercises

Tests and exercises of the Rocky Flats Emergency Plan and procedures are conducted periodically on a selected basis. Such exercises are coordinated by the Shift Superintendent's Office and the Emergency Planning Coordinator. The exercises are designed to determine procedural adequacy and employee training and performance. Post-test critiques are conducted to determine efficiency and to modify procedures as required.

The emergency response indoctrination and training programs include first aid, radiological control, and the use of emergency equipment. Periodic refresher courses are given to ensure that emergency response teams and key personnel remain fully trained and capable of handling any emergency situation.

Emergency equipment is periodically inspected and tested to ensure such equipment is continuously available and operable. Tests include activation of emergency warning and communications systems, and transportation and control equipment. Exercises have included the participation of off-site emergency support groups such as medical and law enforcement.

The Rocky Flats emergency preparedness program is under continuing review by the Rocky Flats Plant Manager and the Emergency Planning Review Committee. Procedural changes are made immediately, as required. All procedures are reviewed, updated, and/or revalidated annually.

2.11.6 National Preparedness

The Federal Preparedness Agency (FPA) and the Defense Civil Preparedness Agency (DCPA) have overall responsibility for civil defense and survival in the event of an enemy attack, major natural disaster, or catastrophic man-caused emergency condition. These agencies plan the training and warning systems, evacuation shelter programs, and care and rehabilitation programs for communities that may be affected by a major disaster.

The Region 6 Headquarters for DCPA, located in a hardened underground facility at the Denver Federal Center, serves as the regional Emergency Operating Center (EOC). The DOE-RFAO at Rocky Flats has assigned individuals to serve as official representatives at this center.

To support the civil defense effort, Rocky Flats maintains a National Preparedness Plan as part of the overall Rocky Flats Emergency Plan. Alerts and warnings of impending disaster would be received through the National Warning System (NAWAS). Upon receipt of an alert, the Rocky Flats Emergency Radio System (ERS) would be activated, providing a communications link to all Federal agencies throughout the country.

Other support measures include plans for evacuating all Rocky Flats personnel to an emergency relocation area, an on-site civil defense shelter program, and a vital records protection plan to assist in the recovery and resumption of Plant operations during the post-disaster rehabilitation period.

2.12 SAFEGUARDS AND SECURITY

The Safeguards and Security function at Rocky Flats is an integrated program designed for the protection of nuclear material from loss, theft, or diversion by unauthorized persons; the protection of classified information from compromise, espionage, theft, or loss; and the protection of government property from sabotage, theft, loss, or other harm. In response to public comment, the Plant's security and nuclear inventory systems are discussed in greater detail than presented in the DEIS.

The Safeguards and Security organization includes, but is not limited to, the following functions:

1. Plant Protection
2. Fire Department
3. Emergency Planning
4. Security Procedures
5. Personnel Access Control
6. Classified Document Control & Records Management

7. Technical Security
8. Nuclear Materials Control and Accountability
9. Utilities

The objectives of the Safeguards and Security Program include

1. Continuous study to detect and evaluate potential threats against all government assets at Rocky Flats
2. The development of protective measures to counter the range of credible threats
3. Assessing the effectiveness of protective measures
4. The enforcement of Safeguards and Security requirements through administrative and civil procedures
5. Maintenance of appropriate planning against all reasonable contingencies

The Department of Energy (DOE) applies an in-depth approach to protection measures. Such measures include physical security methods, personnel administrative controls, and material accountability procedures to meet the responsibilities previously specified. The Safeguards and Security Program is dynamic in nature. It provides for a continuous review of protective measures to ensure maximum efficiency within the professional state-of-the-art and to ensure compliance with all DOE requirements.

The remainder of this section provides a descriptive review of the measures in effect for the protection of nuclear material and, concurrently, classified information. Such detail, however, will not be presented as to jeopardize or compromise security operations.

The physical security program is designed within the following concepts:

1. To isolate Plant facilities containing Special Nuclear Material from all other administrative or support facilities.
2. To physically and administratively restrict access to Special Nuclear Material to those persons who posses a Security Access Authorization (clearance) and who have an operational or official need for access.
3. To detect and thwart any attempt at unauthorized access to, or removal of, Special Nuclear Material within a facility.
4. To maintain an adequate, well-trained, and equipped Plant Protection force with immediate response capability to meet any overt or covert attack against the facility.
5. To coordinate with Federal, State, or local law enforcement agencies for pursuit and recovery of nuclear materials in the event that earlier protective measures are unsuccessful.

The physical security systems, designed to conform to the above concepts, utilize physical barriers, electronic alarm and detection systems, personnel access control procedures, an armed security force, and trained operating personnel.

2.12.1 Physical Barriers

The Rocky Flats facility consists of 6,500 acres of Federal government-owned property. This property is fenced with barbed wire, and "No Trespassing" signs are posted. The Plant is located at the center of the property, with two access roads crossing the property. One road is from Highway 93 located to the west and one is from Indiana Street to the east. The terrain surrounding the Plant is rough, serving as a natural barrier to normal vehicular traffic.

2.12.1.1 Plant Perimeter

The Plant is surrounded by a security fence, which is topped with barbed wire and lighted during hours of darkness. A road inside the fence permits vehicular patrol by armed guards and immediate response capability in the event of an incident such as attempted intrusion.

The two main gates serve as normal entrance points into the Plant from the access roads. The electrically operated gates are manned 24 hours a day by armed guards who open and close the gates by means of remote control.

All persons entering the Plant must have an appropriate security badge. Persons other than employees must be identified, logged in by a guard, and issued a temporary badge before being permitted to enter the Plant.

All vehicles entering the Plant are subject to search prior to entering, or while within the perimeter fence.

Two-way radio and telephone communication are maintained between the main gate guard posts and the Plant Protection Central Dispatch Station. Closed-circuit television provides monitoring of main gate operations by the Central Dispatch Station. There are other additional features in the protective system that would also alert protective forces in the event of an attempted entry by unauthorized intruders.

A double fence is planned for the northern part of the Plant and is scheduled for completion in 1980.

2.12.1.2 Internal Security Area

Inside the Plant perimeter, the "island security" concept is utilized. There are four types of internal security areas for the protection of classified information and nuclear material:

1. Special Nuclear Material Protected Area
2. Special Nuclear Material Access Area
3. Classified Exclusion Area
4. Classified Limited Area

Special Nuclear Material Protected Area

An SNM Protected Area is a security area that surrounds facilities which contain specified quantities of special nuclear material and may contain classified information. It is surrounded by a chain link security fence, topped with barbed wire. The fences are lighted during hours of darkness.

The entrances to SNM Protected Areas are security posts manned by armed guards. There are two or more guards in these areas at all times. Internal areas are also under guard patrol. No personal vehicles are permitted within an SNM Protected Area. Access to the area is controlled by a coded badge system, based upon security clearance and operational need. All visitors to an area must have proper authorization for access and are logged in at the area guard post. Uncleared visitors are under the continuous escort of a security-cleared employee. Uncleared vendors and construction personnel are under continuous guard escort. All personal lunch boxes, briefcases, packages, and other items are inspected when entering or leaving an SNM Protected Area.

All personnel and government vehicles are radiometrically searched by stationary radiometric scanning devices. Personnel or vehicles required to utilize emergency or non-routine portals are scanned by guards using portable scanning equipment. In the event a radiometric alarm is activated, the Protected Area Portals are secured and the person or vehicle is detained by the guard until the cause of the alarm condition can be determined. If the condition cannot be resolved by the guard, specially trained health science personnel are brought in to perform a detailed radiometric and physical search. When the cause of the alarm is located, the Nuclear Materials Control Manager is notified to investigate any material, parts, or other items that may be discovered. If a person or vehicle should penetrate the Protected Area barriers in an unauthorized manner, the Plant perimeter barrier gates would be secured and Plant Protection forces would be alerted to immediately apprehend such person or vehicle. Any further action would be accomplished under activation of emergency plans.

Special Nuclear Material Access Areas

SNM Access Areas are located within SNM Protected Areas. They contain specified quantities of special nuclear material and may contain classified information and material. SNM Access Areas are primarily buildings where Special Nuclear Material is processed or stored. These buildings are constructed of reinforced concrete or other material resistant to penetration. All non-routine and emergency portals are locked and continuously alarmed. Appropriate hardware permits emergency egress from within the buildings if the need should arise. During non-operational hours, all doors are locked and alarmed, and internal areas are under armed guard patrol. During normal working hours, access to the buildings and areas is controlled administratively by supervision, in accordance with written all-inclusive Building Rules that are strictly observed.

Classified Exclusion and Limited Areas

Classified Exclusion Areas are security areas that contain only classified matter, and less than specified quantities of Special Nuclear Material. The barriers, access controls, and guard protection are similar to those described for SNM Protected Areas, with two exceptions: (1) radiometric searches are not required, and (2) physical searches are required only on a random basis.

Exclusion areas contain security interests of such nature that mere access to the area constitutes access to those interests. Limited areas contain security interests that are administratively controlled by guards or security-cleared individuals.

2.12.1.3 Vaults and Vault-Type Rooms

Vaults and vault-type rooms are utilized for the storage of classified information and Special Nuclear Material. Vaults are constructed to DOE regulatory requirements, usually of reinforced concrete, with Government-approved doors and locking mechanisms. Vault-type rooms are of penetration-resistant construction, with approved locking mechanisms, and are internally protected with electronic space alarm systems. Such areas utilized for storage of Special Nuclear Material have locking mechanisms that require the presence of two security-cleared, authorized persons before access can be accomplished. Records are maintained of all persons having access to storage areas.

Vaults and vault-type rooms are located inside buildings that are designated as Special Nuclear Material Access Areas or within Classified Security Areas, depending upon the nature of the security interest being protected.

2.12.1.4 Alarm Systems

There are various alarm systems used for security protection purposes, along with certain operational alarm systems that serve to alert both security and operating personnel, as the situation may dictate.

1. The building alarm systems are designed to detect any attempt at unauthorized entry into any processing or manufacturing building through a door or other opening.
2. Vault-type room alarm systems are designed to detect any attempted penetration of the room perimeter.
3. Radiometric scanning alarm systems are designed to detect any attempt by unauthorized persons to remove certain quantities of nuclear material from a security area. This capability must be qualified, in that scanning sensitivity may be affected by the form of the material, possible shielding, and other considerations. It must be realized, however, that the current systems are considered to be the best, within the state-of-the-art and technological limits.
4. The fire detection alarm system is designed to provide immediate notification of fire conditions to the Fire Department and the Security Department.
5. Operations-related alarm systems include, but are not limited to, nuclear criticality alarms and air monitoring alarm systems (see Section 2.5.1).

All alarm systems are maintained and tested in accordance with DOE requirements.

2.12.2 Material In Use

2.12.2.1 Classified Information

Classified information may be contained in various forms; e.g., documents, parts, and assemblies. At all times, classified information that is not in approved storage either is in the custody of personnel who possess necessary Security Access Authorization (clearance), or it is protected from unauthorized access within DOE regulatory security measures. All such information is located within the security areas previously described.

2.12.2.2 Special Nuclear Material

Special Nuclear Material not in storage may be in various forms; e.g., raw material, parts, and waste. All material either is in the custody of personnel who possess the necessary Security Access Authorization, or it is protected from unauthorized access within DOE regulatory security measures. Such material is located within SNM Access Areas previously described.

2.12.3 Transportation On Site

2.12.3.1 Classified Information

Classified documents are transmitted within and between internal security areas through the classified mail service, hand-carried by authorized personnel, or transmitted by armed guard courier. A receipt system provides unique accountability of each document.

Classified parts and material may be transported between internal security areas only by armed guard in locked security vans or by cleared employees under armed guard escort. Continuous radio communication is maintained between the guards and the Plant Protection Central Dispatch Station while the material is enroute between security areas.

2.12.3.2 Special Nuclear Material

Special Nuclear Material is transported between security areas by armed guards utilizing locked security vans. Two-way radio communication is maintained between the vans and the Plant Protection Central Dispatch Station at all times while material is in transit. In the event of any interruption of the shipment for any reason, appropriate Plant Protection response procedures will be placed in effect.

Low-level nuclear waste material is transported between security areas by the Plant trucking service, escorted by armed guards utilizing Plant Protection patrol vehicles. The protective capabilities in effect for those shipments are the same as the measures used for SNM transported in security vans.

2.12.4 Transportation OffSite

2.12.4.1 Classified Information

Classified documents are transmitted to other facilities through the Document Control Department, using DOE- and other government regulatory requirements) designated methods, mail channels, and procedures.

2.12.4.2 Special Nuclear Material

All shipments of nuclear material are controlled through the Rocky Flats Traffic Department. Specific procedures are described in Section 2.6.10.

2.12.5 Personnel Security

2.12.5.1 Access Authorization

All personnel who have access to classified information or nuclear material must possess active Security Access Authorizations (clearances). Prior to having access, each employee is thoroughly investigated by the Office of Personnel Management or the FBI to determine the individual's reliability, stability, and character fitness. These clearances are reviewed at 5-year intervals. The DOE's Albuquerque Safeguards and Security Section reviews all investigative results and appropriately grants Access Authorizations. All Access Authorizations are periodically reinvestigated and updated.

2.12.5.2 Visitor Control

All visitors to Rocky Flats who require access to classified information and/or Special Nuclear Material must have an appropriate visit request submitted through the Safeguards and Security Department. The request must specify the visitation dates, level of security clearance, and the purpose of visit to indicate an official need for access. This information is reflected on the individual's visitor identification badge.

2.12.5.3 Security Education

All personnel are required by DOE to have an initial security indoctrination outlining their security responsibilities and job duties. Each employee receives recurring security education through various media.

2.12.5.4 Security Badging System

The security badging system is administered by the Safeguards and Security Department. Badges are issued to every person entering the Plant to provide a means of establishing and verifying identity, the security clearance level held by the individual for access to classified information, and the official need for access to areas containing nuclear material operations. All badges are prepared by the Access Control Office and are accountable. Badges are color coded and security area coded according to the person's need and clearance status. The badges are of unique design and are periodically changed according to DOE regulation.

2.12.6 <u>Plant Protection Force</u>

2.12.6.1 Responsibilities

The Plant Protection Force is responsible for

1. Maintaining the integrity of the Plant and its operations against sabotage, overt or covert attack, or other damage or harm to the facility
2. Enforcement of government security regulations pertaining to the protection of classified information, nuclear material, and government assets from loss, theft, diversion, or other harm
3. Enforcement of Plant rules and regulations as set forth by Rocky Flats management
4. Provide assistance in the event of national, natural, or local emergency situations

2.12.6.2 Staffing

The Plant Protection Force has in excess of 100 uniformed personnel to provide 24-hour protective and administrative service to the facility. All personnel are on continuous call in the event of an emergency situation. As additional support, an auxiliary force composed of employees, is also maintained. The Plant Protection Central Station serves as the control point for all operations.

2.12.6.3 Equipment

The Plant Protection Force is well equipped to meet any emergency situation or hostile threat to the facility. Equipment and facilities include

1. Weaponry, including firearms such as revolvers, rifles, shotguns, and automatic weapons.
2. Vehicles, including patrol cars, shipment vans, and armored personnel carriers.
3. Riot equipment, including helmets, masks, batons, and tear gas dispensers.
4. Bomb disposal unit, consisting of a cart for removing suspect items and a trailer for final disposal.
5. Two-way radio communication within the facility and with local law enforcement agencies.
6. On-site pistol and rifle firing range.

2.12.6.4 Training

All Plant Protection guards receive extensive training with all available weaponry. All guards must fulfill DOE qualification requirements on the firing range prior to being permitted to carry a weapon. In addition, special class and field training in riot and mob control is provided through the cooperation of the Jefferson County Sheriff's Department. Volunteer members also comprise Bomb Technician Teams and Special Weapons and Tactics (SWAT) teams within the department.

2.12.6.5 Plans and Procedures

All guards have specific written orders or guidance to govern their performance during normal operations. At the start of a shift, guards are briefed concerning any special or temporary conditions relating to their duties during that shift.

Plans and procedures related to unusual situations, i.e., riots, demonstrations, terrorist attack, bomb threat, and other emergencies, have been prepared and approved to be put into effect as the need may dictate. These plans and procedures define appropriate responsibilities and actions to be taken and are incorporated into the overall Rocky Flats Emergency Plan.

2.12.7 Technical Security

2.12.7.1 Responsibilities

The Technical Security Group is responsible for coordinating the installation and maintenance of security detection and surveillance systems i.e., alarm systems, radiometric scanning systems, closed circuit television systems, communication systems such as telephone and radio, and access control devices such as magnetic cardkey or badge reader systems.

The Technical Security group is also responsible for performing continuous physical and electronic inspections of telephones, conference rooms, public tour routes, computer terminal stations, and other areas. The purpose is to detect any tampering or surreptitious listening devices or electronic emanations that could result in espionage, sabotage, or other harm to the facility, thereby disclosing classified information to unauthorized persons or jeopardizing nuclear material.

The Technical Security group also provides support to the Plant engineering groups in the design and installation of new security systems.

2.12.7.2 Security Surveys

Annually, the entire security program at Rocky Flats is reviewed by a team of Albuquerque Headquarters DOE security representatives. All areas of the security program are reviewed for compliance with DOE Headquarters and local directives. Surveys typically address such areas as guard force operations, lighting, alarm systems, classified document control and accountability, physical protection of calssified materials and special nuclear material, badging and access authorization procedures. Formal evaluations are prepared relative to each of these areas of security concern and are discussed in detail with the contractor. Security survey reports are forwarded to DOE Headquarters for their review and concurrence. Such surveys may include the direct participating of DOE Headquarters security representatives operating in conjunction with Albuquerque DOE security survey team members. Formal surveys are supplemented by day-to-day monitoring activities routinely carried out by Rocky Flats DOE Area Office representatives.

2.12.8 Fire Department

2.12.8.1 Responsibilities

As a unit of the Safeguards and Security Department, the Fire Department is responsible for

1. Answering any fire alarm and extinguishing any fire
2. Performing preventative maintenance inspections of all buildings and areas within the Plant for potential fire hazards
3. Ensuring the maintenance of fire fighting equipment at the Central Fire Station and other equipment located throughout the Plant
4. Maintaining the classroom and field education and training program in fire fighting techniques, first aid, and other specialized training
5. Providing mutual aid to surrounding metropolitan communities, if requested and approved through the DOE

2.12.8.2 Staffing

The Fire Department has 25 members who provide 24-hour service on a platoon schedule. As additional support, volunteer employees in manufacturing buildings comprise Fire Brigades.

2.12.8.3 Equipment

The Fire Department equipment consists of

1. Two pumper trucks
2. One water tanker truck
3. One fully equipped ambulance
4. One fully equipped rescue vehicle
5. One "brush" truck, used primarily for grass fires
6. Two general purpose vehicles.

Plant buildings are equipped with various types of fire detection and extinguishing equipment. Major buildings are equipped with sprinkler systems.

2.12.8.4 Training

All members of the Fire Department are continuously receiving training in all aspects of fire-fighting techniques, including specialized methods for radioactive material fires. Members are also trained in first aid and as Emergency Medical Technicians (EMT) for health and safety purposes related to possible accidents.

2.12.9 Nuclear Materials Control

2.12.9.1 Material Control System

Special nuclear materials (SNM) are located in specific areas throughout the Plant site. Each area is assigned an account number under which all transactions are observed and recorded. The areas are under the management of operating supervisors, custodians, or other individuals responsible for the safety, the use, and the internal control of SNM. These individuals verify and report each transfer to or from their areas. Materials are controlled within an account in either piece-part or bulk form. Serialized items or piece parts are each assigned a unique identification number. These numbers are used to aid in the control of SNM. Bulk materials are converted to piece parts prior to shipping to another account or before inventory. Multiple copy material transfer forms are filled out and signed by the responsible individual before each transfer. One copy is sent to Material Control Records personnel who check the correctness of the data and record the transaction; other copies accompany the material. Receipts of material are documented by the signature of the receiver who immediately verifies the identification of the material and, in some cases, the quantity of SNM. Once more, copies are sent to Material Control Records personnel who again verify the data. Thus, through the Material Control operations, all transfers are checked independently and repeatedly as the material moves through the facility.

Plutonium from other DOE facilities is held in secure areas. This material is serially verified and assayed as it is received. All SNM measurements are reported to the Nuclear Materials Control Department for proper review and encoding. The accountability of the special nuclear material removed from a vault during a definite time period may be verified by examining the records.

2.12.9.2 System Monitoring

Special Nuclear Materials are under continual accountability review. Transactions are reviewed to ensure the validity and propriety of material movement and disposition. The accounting system and its methods of operation are outlined in appropriate DOE directives. Holders of special nuclear materials operate according to established written procedures. These are compiled in manuals, are distributed throughout the Plant site, and are updated as necessary. The manuals are prepared from DOE directives or recommendations and serve as references for guidance in the proper handling of special nuclear material. Periodic reviews of the areas are made to ensure that operations are consistent with established directives and procedures.

The contractor maintains an internal audit staff whose responsibilities also include the review of all systems, including special nuclear material control, to ensure that operations are conducted efficiently and according to prescribed methods and procedures.

2.12.9.3 Material Accountability

Data Processing System

Information on all DOE-controlled special nuclear materials is maintained in the Nuclear Materials Management and Safeguards System (NMMSS). The NMMSS is a DOE centralized automatic data processing system that receives and stores pertinent information regarding nuclear materials. The system also provides periodic reports for management purposes to all DOE organizations in connection with nuclear materials inventory and financial management programs, nuclear material contract administration activities, and safeguards activities.

Rocky Flats Nuclear Materials Control Department

The Rocky Flats Plant Nuclear Materials Control Department maintains its own computerized nuclear materials accountability system. Outputs from the Rocky Flats computer are used as input to the NMMSS, which in return provides reports to Rocky Flats. All source and special nuclear materials received at Rocky Flats are subject to control by the Plant accountability function.

Accountability System

The nuclear materials accountability system consists of a double-entry accounting function utilizing computer storage capabilities for maintaining permanent records of all in-plant material activities and account balances.

The computer is programmed to review all incoming data for the purpose of ensuring validity of information and accuracy of item and/or material identification. Input information incongruent with programmed data is automatically rejected by the system and entered on a visual record with an explanation of its unacceptability.

Valid discrepancies such as encoding errors may be corrected by members of the Nuclear Materials Control Department and reentered into the computer.

Invalid discrepancies such as incorrect item identifications, inaccurate material description codes, and attempts to activate material movement between unauthorized areas are investigated and corrected by Plant operating personnel.

Items subject to off-site transfer must be recorded properly in the computer storage banks prior to preparation of the final shipping papers. A list of the parts or components to be shipped is tape encoded, introduced to the computer by means of the proper program, and a tabulation is made of all pertinent data. Copies are forwarded where necessary.

Upon shipment, identities of the items shipped and all relevant information are removed from the storage banks and transferred to permanent files. Should items be returned to Rocky Flats for any reason, data may be withdrawn from these files and reactivated in the computer storage banks.

Material Balance Accounts

Material Balance Accounts are a required part of the accountability system. Each individual material balance area or account, while independent in itself, is part of the overall Plant control system. The aggregate of all material in the separate accounts always equals, in weight, the total amount reflected by the overall Plant control account.

Plant-wide movements have no effect on the overall Plant material balances; however, internal movement between account area does affect both the sending and receiving accounts.

Differences within single operating accounts resulting from inventories or measurement of externally received material are activities requiring adjustment of the overall Plant control account. Failure on the part of the accountant to post external activity to either the control account or to the individual material balance account causes an imbalance that will be detected during the physical inventory reconciliation.

On a periodic basis, special nuclear materials are physically inventoried to verify the actual amount of material on hand versus the amount shown through accounting procedures and records to be on hand. The Physical Inventory is the quantity of nuclear material determined to be on hand by physically ascertaining its presence using techniques that include sampling, weighing, and analysis. The Book Inventory is the quantity of nuclear material reflected by accounting records such as general and subsidiary ledgers. In nuclear materials accounting, it has historically been the beginning physical inventory adjusted for receipts and removals for a given reporting period. The Inventory Difference (ID) is the algebraic difference between the nuclear material Book Inventory (BI) and the Physical Inventory (PI); i.e., ID=BI-PI. Inventory Difference (ID) was formerly referred to as Book Physical Inventory Difference (BPID) and Material Unaccounted For (MUF). Problems may arise in this area because of the difficulty in accomplishing an accurate physical inventory. The conditions of material resulting from processing, errors in measurement, and many other circumstances can cause problems that are manifested in apparent material shortages or gains. The ID figures do not represent stolen or diverted special nuclear materials but do require investigation. The processing of materials often causes line and tank SNM holdups that are difficult to measure. Representative samples and reliable assays are difficult to obtain for heterogeneous materials. The multitude of material measurements, each with a degree of error, can cause differences that contribute to an overall ID shortage or gain.

Oxides and fine heterogeneous residues are normal to some processing operations. Collecting homogeneous samples for reliable measurement is extremely difficult. Variations in material quantities caused by such conditions are investigated by the Nuclear Material Control Department and are evaluated against statistically determined standards.

Any differences between the book and physical inventories are investigated by the Nuclear Materials Control Department and reconciled by Plant supervisors, custodians, or account holders by review of the circumstances.

Quality Control Measurement Data

The Standards Laboratory is responsible for ensuring the accuracy of instruments and/or methods used for measuring special nuclear material. This department is composed of technicians who continually monitor the devices and methods employed, and evaluate the accuracy of each. Its functions are as follows:

1. Methods used by service laboratories for analyzing samples containing special nuclear materials are tested regularly with compounds of known or synthesized composition.
2. Specific instruments used for nondestructive measuring are tested for accuracy against "standards" of established value prepared especially for use with each method.

Measurement control programs are in effect for all measurement systems utilized for inventory and accountability of special nuclear materials at Rocky Flats. Measurement control programs are as follows:

1. Scales and balances are maintained in good working condition and are routinely calibrated in compliance with an established program.
2. Analytical quality control programs for routine data are analyzed statistically to determine and maintain accuracy and precision of the methods.
3. Key sample variability control programs are carried out to determine the uncertainty associated with sampling methods.
4. Control programs for volume, temperature, and pressure measurements are in effect to maintain precision and accuracy. Routine checks of calibration are also made.
5. Calibration programs for non-destructive assay (NDA) measurements are maintained. Non-destructive assay equipment is calibrated with appropriate standards and is monitored periodically to ensure proper functioning within established control limits.
6. Sample Exchange Programs are carried out between laboratories and facilities to assure that analytical results are at the current state of the art.

7. Inventory Weight Verification Programs are maintained by the Nuclear Materials Control group to determine, on a statistical basis, that weighed items reported on inventory are correct.

Inventories

Special Nuclear Materials are physically inventoried at Rocky Flats monthly, with the exception of a few approved vault storage areas and Chemical Recovery areas which are inventoried quarterly. Normally one day is required for cleanup and a second day to record the physical inventory. Each material balance account or area (MBA) is shut down, cleaned, and the SNM material is measured and recorded on physical inventory sheets by the MBA supervisor or his designated custodian. There are over 100 individual MBA's in existence for reporting into the Nuclear Materials Control System.

Each individual part, piece, unit, or batch has a unique identification number that must be reported along with type of material, description, net weight, assay, element weight, isotopes (where required), and isotopic weight (where required). The physical inventory is encoded on magnetic tape and introduced into a sophisticated computerized system that maintains a perpetual book inventory in the data base.

Each item identification number physically inventoried is matched to the perpetual book inventory. Any unmatched items are reconciled by trained Nuclear Material Control Accountants. All items are normally accounted for within three working days following the physical inventory.

After possession of individual items has been verified, physical inventory weights are compared to the computer perpetual inventory weights, and inventory differences (ID) are determined by utilization of the basic balance formula = Beginning Inventory (BI) + Receipts (R) - Shipments (S) - Ending Inventory (EI) = Inventory Difference (ID). Inventory differences are routinely obtained within five working days following physical inventory. Inventory differences may occur for the following reasons:

Type of Inventory Difference	Explanation
1. Measurement of material in process (this item accounts for the largest amount of the total cumulative Inventory Difference)	Inventory Differences that result from changes in material form between measurements involved in an inventory balance. Causes of these differences can be a. Substitution of measured values for values based on calculations. b. Measurements made after materials separation from impurities.

Type of Inventory Difference	Explanation
2. Remeasurement of items on inventory	Inventory Differences that result from remeasurement during an inventory of material quantities previously reported. Causes of these differences can be a. Improved measurement equipment b. Use of different measurement methods c. Human errors in making measurement
3. Process holdup differences	Differences (between present and previous reporting periods) on material holdup quantities that are part of the flow or process and subject to cleanout.
4. Equipment holdup differences	Differences (between present and previous reporting periods) on material holdup quantities that are part of the processing equipment or are difficult to remove.
5. Measurement adjustments	Differences brought about by improved measurement quality control and calibration programs. An example is the detection of a previously unknown bias in a measuring device.
6. Rounding	Accumulated fractional differences due to mathematical rounding of values to fit required formats and reporting units.
7. Recording and reporting errors	Differences attributed to recording and reporting errors such as arithmetic errors, data transmission errors, and transposition errors.
8. Shipper-receiver adjustments	Differences resulting from adjustments made by the receiver of quantities originally reported at the shippers' values. These differences occur because of measurements made by different instruments by different facilities.

Inventory differences greater than the control limits alert Safeguards and Security personnel. Process operations in the Material Balance Account cease until reconciliations can be made.

The Nuclear Materials Control System for current batch accountability will be replaced during 1979. The new system will be a near real time system with terminal input from process areas. This system will provide updated material book balances on a daily basis. The same double entry accounting procedures in existence at Rocky Flats since the start of operation will be integrated in the near real time system.

Reporting

Summary reports of special nuclear material activity and inventories are routinely forwarded to DOE and to the contractor management after the physical inventories are completed and the accounts are closed.

All reports are prepared and submitted by Nuclear Materials Control Department members. These reports reflect the composition of ending inventories, account adjustments, and material activity between the Rocky Flats Plant and other DOE contractors and Nuclear Regulatory Commission (NRC) licensees.

Appraisals

Twice yearly, the Rocky Flats nuclear materials control and management systems are subject to appraisal by survey teams from the Albuquerque Operations Office of DOE. These appraisals consist of audits of the material accounting system. This includes inventory verification, determination of accuracies in the facilities records and reports plus review of measurement programs, analytical capabilities, scale and balance programs, calibration programs, sampling procedures and statistical methods. These audits also involve a review of the materials management program, including the forecasting, utilization and control procedures for nuclear material. The effectiveness of these ALO appraisals is assessed by DOE Headquarters. This assessment consists of routine reviews of reports of the ALO surveys and may include direct participation with the ALO survey team at Rocky Flats.

Safeguards Committee

The Rocky Flats Plant Safeguards Committee is composed of top-line managers who periodically examine the effectiveness of safeguards and security methods. The committee recommends or directs changes, corrections, improvements, modification, or complete installation of new measures if conditions so merit. They review all areas and methods relative to the physical protection of the Plant, the adequacy of SNM storage vaults, and the evaluation of monitoring systems. The committee investigates any circumstance bearing on the safeguards and security of nuclear material.

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3. ENVIRONMENTAL IMPACTS

This chapter considers the environmental impact from continued operation of the Rocky Flats Plant. Both the beneficial and adverse impacts associated with utilization of natural resources, alterations to the existing environment, and biological effects of nonradioactive and radioactive effluents are discussed. The impacts of nonradioactive and radioactive effluents during normal operations and postulated accidents are considered.

A number of changes in Chapter 3 have been made in response to comments received on the DEIS. In addition to corrections of typographical errors and rewording for clarification, the following summarizes the major changes made:

- References to laws, regulations, guides, and standards have been updated.

- The source terms for normal operation have been reviewed and revised based on current operations, procedures, and measured data.

- The dose calculations have been completely redone using updated and documented methodologies. Organ doses were calculated for 70 (rather than 50) years, a revised demography was used, and factors were calculated to convert doses for adult reference man to doses to infants, children, and adult females. Some calculations of population dose were done using a hypothetical high-density population near and downwind of the Plant. Presentation of the organ doses has been expanded to show doses to individuals for sixteen directions and at eight distances from the Plant for routine releases and for probability-weighted accident releases, and at nine distances downwind for each of the postulated maximum credible releases. The use of the total body doses as the primary dose has been deemphasized. The dose measurements presented in the DEIS have been recalculated and the results are presented in this FEIS. The results of the recaluculation confirm the finding presented in the DEIS, namely, that the dose to the general population is very small and will result in no significant adverse environmental impact.

- The accident scenarios were reevaluated. A maximum credible accident for beryllium has been added. The probability of impoundment failure was increased from 0.001/year to 0.01/year, assuming the ponds would not withstand a 100-year flood. The calculation of the release from an impoundment failure was corrected. The amount of plutonium which becomes airborne in a fire was reduced, as described in Section 3.2.2.4. Information in the DEIS concerning past chemical explosions was not documented and was deleted, because its reliability was doubtful. The criticality accident scenarios were revised to include a maximum probable accident, as well as the metal and solution maximum credible accidents. The magnitude of the maximum credible solution criticality was increased to account for the continued operation of the existing plutonium recovery and reprocessing facility. Releases of fission products, plutonium, and americium from criticality accidents were recalculated.

- Effects of transportation, including accidents, were completely reevaluated using methods from the Nuclear Regulatory Commission's environmental statement on transportation of radioactive materials. An analysis of a transportation accident in a densely populated urban area was added.

3.1 NORMAL OPERATION

Impacts attributable to normal operation of the Rocky Flats Plant can be divided into two categories--nonradiological and radiological. The nonradiological impacts include those related to (1) the utilization of natural resources, (2) alterations to the environment, and (3) potential biological effects resulting from the release of nonradioactive materials. Radiological impacts are those related only to potential biological effects resulting from the release of radioactive materials. This differentiation is maintained to provide maximum definition of the radiological impacts that are of primary interest in the evaluation of the Rocky Flats Plant.

Plant utilization of natural resources takes several forms. Water, fossil fuels, metals, chemicals, and electricity are used, and consumed in most cases, in the normal course of operation. In this respect, Rocky Flats is like any other industrial facility. The extent and impact of this utilization are described and evaluated in this section as one of the nonradiological impacts of the continued operation of Rocky Flats.

Plant-related alteration of the environment includes changes to the topography, hydrology, geology, meteorology, and to plant and animal populations that would characterize the Plant site if the facility did not exist. There also are ecological effects of released materials, which are considered in a separate discussion. The age of the Rocky Flats Plant (about 25 years old) and of other industrial and residential developments in the area makes it difficult to define the impacts which can be attributed specifically to the Rocky Flats Plant; consequently, the evaluations and impact assessments of Plant-related alterations to the environment are often qualitative rather than quantitative.

All substances foreign to the natural environment can be defined as contaminants or potential pollutants. To determine its characterization as a pollutant, each contaminant must be considered with respect to its release rate, concentration, and toxicity to life systems. This determination is in turn related to the transport media and mechanisms by which contaminants enter the surrounding environment and ultimately interact with the various ecological systems.

In the process of transport, all contaminants are subject to some degree of dispersion. This action reduces their concentration as they are carried from the release point by natural systems. Contaminants in air and water leaving the Plant will mix with larger air and water masses, resulting in reduced concentration. Contaminants entering ecological systems may be subject to further dilution or reconcentration depending on the affinity of various species for different contaminants. Some contaminants are further subject to reaction and changes in physical and chemical form as they migrate through the natural systems.

In estimating quantities of pollutants following specific transport pathways, overestimates are used (i.e., "conservatism") to assure that the maximum environmental impact will be available for use in the decision-making process. Administrative guides or internally imposed limits are applied to processes producing effluents. These guides specify the amounts of pollutants which may be discharged in order to minimize the amount of pollutant (per the ALAP policy) and to assure compliance with the law, when applicable laws exist. Legislation, regulations, and standards exist which limit the release of various contaminants. State and Federal agencies enforce these limits.

Release limits for the Rocky Flats Plant are embodied in several regulations. Concentration limits for nonradioactive contaminants in water have been established through an "Authorization to Discharge Under the National Pollutant Discharge Elimination System" (an NPDES permit), administered by the U.S. Environmental Protection Agency (EPA) and the Colorado Department of Health (CDH). A copy of the Rocky Flats permit is included in this Statement as Appendix D. Limits for nonradioactive materials in air are established by regulations applicable to all industrial facilities. These regulations are issued by the EPA and implemented through State regulations. Radioactivity Concentration Guides (RCG's) for radioactive materials have been recommended by the International Committee on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP). These guides were adopted as limits by the AEC and ERDA and continued in effect by DOE. The Federal Radiation Council was established by Executive Order in 1959. In 1970 the EPA was assigned the responsibility for defining standards. Unless exempt, Federal facilities including the Rocky Flats Plant must comply with pollution control standards established pertinent to Federal environmental statutes including the Clean Water Act, Safe Drinking Water Act, Clean Air Act, Resource Conservation and Recovery Act, and the implementing regulations adopted by state and local governments.

The effect of radioactive materials on life systems necessitates specific analysis of each radioactive isotope. The decay products of each isotope must be analyzed in addition to the radiation types and energy levels, dispersion mechanisms, chemical toxicity, radiotoxicity, and its short- and long-term effects on the ecological systems and populations both in the immediate Plant vicinity and for many miles around the site. This type of detailed analysis is applied to normal releases and to accidental releases. A complete discussion of these evaluations is presented in Sections 3.1.2, 3.2.4, and Appendices F and G.

Nonradioactive solid wastes are deposited in a sanitary landfill on the Plant site. The operation of the landfill is subject to the EPA regulation "Guidelines for the Land Disposal of Solid Waste," Code of Federal Regulations, Title 40, Part 241, 1974. The landfill is not used for hazardous materials, and its operation is not greatly affected, therefore, by the more recent (1976) "Resource Conservation and Recovery Act." Only domestic, nonradioactive, nonprocess, solid wastes may be deposited in the landfill. Radioactive wastes, subject to special packaging, strict control, and monitoring, are stored temporarily on site and shipped to a DOE-approved storage facility. The transportation of these solid wastes is described and potential transportation impacts are evaluated in Section 3.3.

3.1.1 Nonradiological Impacts

The nonradiological impacts attributable to the Rocky Flats Plant under normal operating conditions fall into three general categories: (1) utilization of natural resources, (2) alterations to the physical environment, and (3) biological effects of contaminant releases. Sections 3.1.1.1 through 3.1.1.3 discuss the Plant's impacts in each of these areas, considering both the beneficial and adverse effects.

3.1.1.1 Utilization of Natural Resources

The utilization of natural resources by the Rocky Flats Plant involves the consumption of fossil fuels, metals, chemicals, and electricity. Water resources are also involved during the normal course of operation. The systems, processes, and uses of these resources by the Plant are described in Sections 2.6.5 through 2.6.9.

Water

The Rocky Flats Plant purchased approximately 113 million gallons of water in FY 1977 from the Denver Water Board. This compares with 116 million gallons in FY 1976, 126 million gallons in FY 1975, 143 million gallons in FY 1974, and 161 million gallons in FY 1973. Figure 3.1.1-1 shows the Plant water balance for FY 1977 and the various water flows through the Plant. Of the total 113 million gallons purchased, 72% entered the treated water system, 26% was used as raw water in makeup for the Plant's cooling towers, and the remainder went to irrigation or evaporation. Almost all (91%) of the makeup water was evaporated by the towers and may be lost as a water source to the immediate region. Blowdown from the cooling towers is now sent to the sanitary treatment plant. Prior to late 1974 it was discharged to Woman Creek or to Walnut Creek.

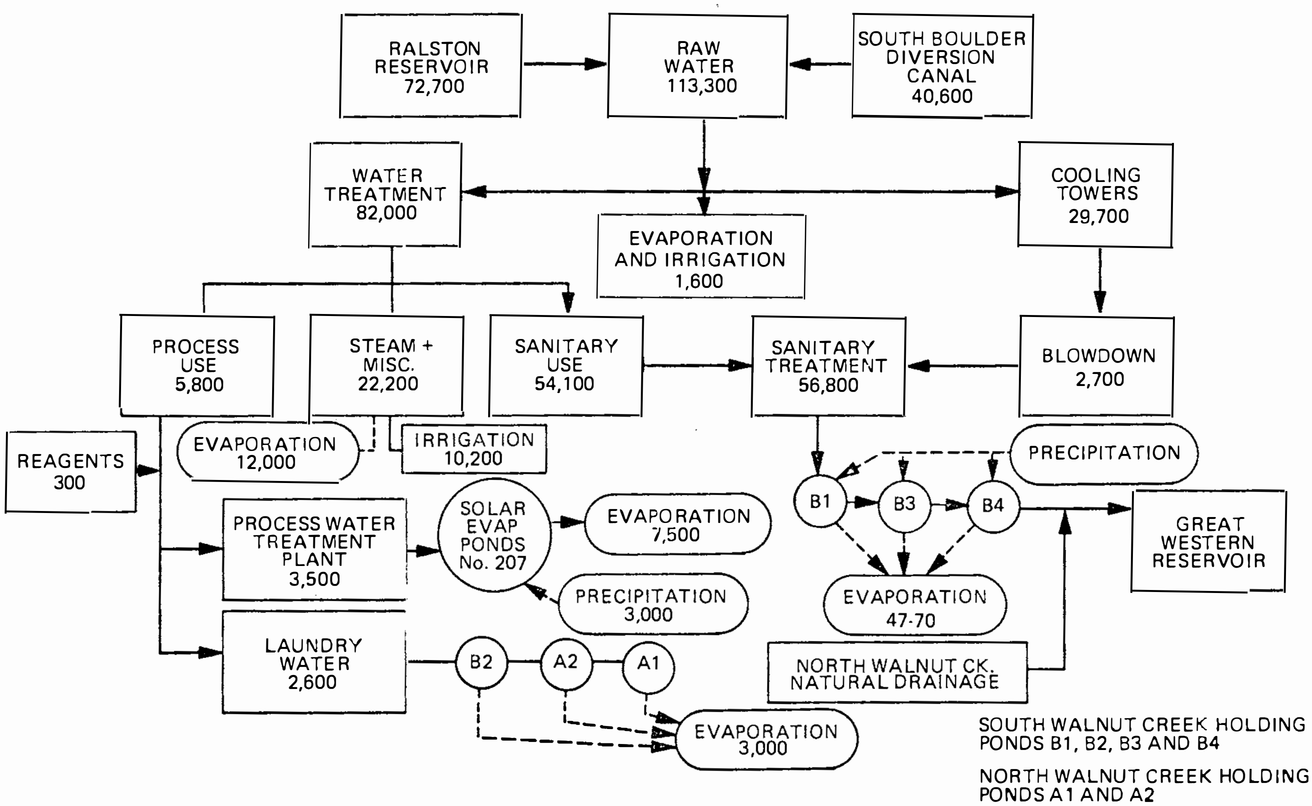

Figure 3.1.1-1 Estimated Rocky Flats Plant
FY 1977 Water Balance
(all flows in 1,000 gal per year)

Water from the water treatment plant is used for processes, sanitary waste, steam production systems, and in miscellaneous services. Approximately 66% of the treated water is used for domestic purposes and enters the sanitary waste treatment system that discharges to the B-series holding ponds on South Walnut Creek. Process water accounts for less than 10% of the treated water used. Process wastewater is treated in the process waste treatment facility for the removal of radioactive contaminants. Treated wastewater is evaporated in the solar evaporation ponds. Process wastewater that meets Radioactivity Concentration Guides (RCG's) as defined by ERDA MC0524 (USERDA, 1977) without treatment is stored in Ponds B-2 on South Walnut Creek and A-1 and A-2 on North Walnut Creek. Evaporation concentrates the remaining contaminants, which settle into the sediment of these ponds.

Irrigation water is used at the Plant primarily during the summer months. The water requirements of vegetation and the dry climate during the irrigation season prevent any significant portion of this water from entering groundwater flow. This water is lost to the region as a water source through evaporation from the soil and plants. It is believed, however, that enhancement of on-site vegetation more than compensates for this water use. This vegetation improves soil stability and reduces erosion, minimizing transport of contaminants from the soils into the natural drainages.

Water used by the cooling towers in dissipating building heat for climate control serves two purposes. It provides benefits in working conditions for the employees and it eliminates the discharge of this waste heat to natural water sources, the only other cooling medium that could be used to provide this service.

Operation of the Plant's heating boilers also requires water. Under ideal conditions, the system is a closed cycle with all water being returned to the boilers for reuse. Boiler blowdown, periodic maintenance, pressure relief valves, and steam leaks from valves and other equipment, however, allow part of the steam to escape to the atmosphere. This results in approximately 12.0 million gallons of water being lost annually from the steam plant alone. Additional water is lost because of evaporation from cooling towers, solar evaporation ponds, and holding ponds. Steam heating is the only feasible heating method for the Plant. Neither electric heat nor direct fuel-fired heating is acceptable for efficiency, cost, or safety reasons.

About 50% of the water initially purchased for Plant use (approximately 56.8 million gallons in FY 1977) is discharged via holding ponds B-1, B-3, and B-4 to South Walnut Creek. This flow then combines with the natural drainage from North Walnut Creek as a tributary to Great Western Reservoir. This reduces the amount of water the City of Broomfield would otherwise have to procure from other sources.

A total water-recycle plan is nearly completed. When that project is finished, all process and laundry wastewater will be treated and distilled to create a supply of high-purity water. Sanitary wastes, presently treated in the sanitary waste-treatment plant and discharged to Walnut Creek, will also be recycled. Sewage treatment involves a recently completed tertiary step and a reverse osmosis process now nearly operational. Completion of these changes will mean that no Plant wastewater will leave the site except by evaporation. This plan will eliminate liquid discharges to Great Western Reservoir. The implementation of the total water-recycle plan will allow Rocky Flats to comply with the 1985 zero discharge of pollutants requirement as set forth in the Water Pollution Control Act of 1972. In addition, the plan will further reduce the possibility of any accidental release of contaminants, either chemical or radioactive.

Natural Gas

Natural gas is the primary fuel source for operation of the Plant's heating boilers and for other process uses. Rocky Flats purchased approximately 637 million cubic feet of natural gas from the Western Slope Gas Company during FY 1977. This compares with 568 million cubic feet in FY 1976, 746 million cubic feet in FY 1975 and 1974, and 726 million cubic feet in FY 1973.

The Plant's natural gas supply is on a interruptible basis; i.e., during periods of high gas demand by residential customers, the Plant's supply may be curtailed or discontinued. This occurs primarily during the winter months, although natural gas shortages are expected to increase curtailment periods in the next few years. The consumption of natural gas does represent the loss of a natural resource that cannot be replaced, as is the case for all fossil fuels. The use of natural gas to produce heating steam is, however, more efficient than electric heating, and thus represents the minimum consumptive impact consistent with Plant safety and energy requirements. Since natural gas supplies are becoming less available, a coal-fired plant is receiving budgetary consideration for the 1980's.

Other Fossil Fuels

Fuel oil, diesel fuel, gasoline, and propane are utilized at Rocky Flats as backup fuel supplies for heating boilers, fuel for stationary and mobile combustion engines, and fuel for process uses.

Heavy fuel oil (grade #6) is the primary backup fuel supply for the Plant's heating boilers. Approximately 335,000 gallons were consumed in FY 1977 for this service, compared with 940,000 gallons in FY 1976; 514,000 gallons in FY 1975; 702,000 gallons in FY 1974; and 1.6 million gallons in FY 1973. Energy conservation measures and mild winters contributed to the reduced consumption in FY 1974, 1975, and 1977. Consumption of fuel oil is anticipated to increase as natural gas shortages occur, but accurate estimates are not feasible because of the many factors affecting Plant energy requirements. Consumption of #6 fuel oil does represent the loss of an irreplaceable resource. As a backup fuel supply for the heating boilers, however, it is more efficient than electric heat, and it constitutes the minimum consumptive impact consistent with Plant safety and energy requirements.

Gasoline and diesel fuel are used in stationary and mobile combustion engines used to power equipment and vehicles. This resource consumption is unavoidable given present engine technology. Conservation measures have been implemented to minimize this impact. Diesel fuel consumption was reduced by almost 1,800 gallons from FY 1976 to FY 1977, while gasoline consumption increased about 3,000 gallons.

Electricity

Electricity is purchased from the Public Service Company of Colorado. Rocky Flats used approximately 104,000 megawatt hours (MWH) in FY 1977. This compares with usage of approximately 105,000 MWH in FY 1976; 106,000 MWH in FY 1975; 103,000 MWH in FY 1974; and 112,000 MWH in FY 1973. Electricity is used for lighting, electric-motor-driven pumps and other process equipment, controls, and instrumentation. Consumption is anticipated to increase as new facilities, improvements, and more automation are added to the Plant. Estimates made in 1971 show as much as 167,750 MWH may be required by FY 1983. This is probably an overestimate, since energy conservation measures, including curtailment of nonessential lighting, less air conditioning, and newer, more efficient equipment, will reduce consumption. A new substation has been constructed to handle new loads. The major new load will be the new plutonium recovery and waste treatment facility. This facility will require appreciable heating and ventilating equipment and will provide increased safety for both employees and the general public. The existing electrical supply capacity from Public Service Company of Colorado appears adequate for all existing and anticipated loads. Increased Plant requirements for electricity may be considered as impacting the overall electrical requirements of the utility system; however, the general increase in population and consequent residential and industrial power demands far exceed the additional requirements for Rocky Flats alone. A 1974 report published by the Colorado Division of Commerce and Development (Neill and Baughn, 1974) shows an overall, estimated increase in electric power consumption of 6.9% from 1974 to 1975 for Colorado and total consumption of 11.7 million MWH for 1975. Rocky Flats' electrical power consumption constitutes less than 1% of this estimated total consumption, a percentage that will remain relatively constant through 1983.

Metals and Chemicals

Various metals and chemicals are consumed in research and development, production, fabrication, manufacturing, and waste processing. The transformation and consumption of these materials is unavoidable in the conduct of operations at Rocky Flats, as is the case for most industrial facilities.

Much of the Plant's chemical consumption occurs in waste processing and plutonium recovery operations. These activities are directed towards maximum recovery of essential and valuable materials and maximum protection of the environment. Plutonium recovery and other waste treatment processes inherently minimize contamination of the environment by capturing these materials for reuse or by solidifying wastes into a form suitable for long-term storage. The consumption of these materials is justified by the reduced contaminant releases realized by their use in waste treatment processes. The quantities of major chemicals used during FY 1977 are summarized in Section 2.8.

Land Use

Land areas of possible concern are east and southeast of the Plant. The concerns generally are the close proximity of a large population in case of an accident, the amount and degree of soil contamination attributed to plutonium, and the possibility of an impoundment failure causing contamination of Great Western Reservoir, which is the main water supply for the City of Broomfield. Sections 2.3.9, 3.1.2, and 3.2 provide detailed discussions and information relating to these concerns and should be referred to for additional background information.

In 1975, the U.S. Government purchased approximately 4,000 acres around the original 2,520-acre Rocky Flats Plant site. This acquisition expands the buffer zone and prevents industrial or residential development from encroaching on the Plant. The buffer zone provides an additional safety margin in the event of an abnormal occurrence at the Plant. Information concerning the use of adjacent lands is contained in Chapter 7.

3.1.1.2 Alterations of the Environment

Alteration of the environment includes consideration of impacts to the site and immediate region in the areas of topography, geology, hydrology, meteorology, and ecology. These areas of interest are discussed more fully in Sections 2.3.4 through 2.3.6, 2.3.10, and Appendices A, B, and C.

Topography

The topography of the Rocky Flats Plant site consists of a west-to-east, sloping, alluvial fan that drops relatively sharply on the east edge and four natural drainage channels, Walnut and Rock Creeks, located north and Woman Creek and Smart Ditch south of the site.

The construction and operation of the Plant has not altered the existing topography significantly. No major excavation or fill operations have resulted in significant elevation or contour changes to the site. Most structures have been built at existing grade elevations, a few with basements, with columns driven to bedrock for foundation support. Topographical changes have resulted from the construction of roadways, fences, underground piping and drainage channels around buildings and roadways, and rerouting McKay Ditch.

The natural drainage channels have been altered by the construction of dams, ditches, and ponds to retain the water temporarily. This retention allows settling of suspended solids from Plant effluent streams and natural drainages. The benefits associated with these retention and settling ponds are judged to outweigh the topographic alterations resulting from dam and pond construction.

A landfill area (see Section 2.9.4 for more information) north of the Plant for the disposal of solid, nontoxic, nonradioactive waste materials constitutes a topographic alteration. As waste materials are placed in the landfill excavation, the area is backfilled and compacted. The landfill will be exhausted and its use discontinued when its surface contours match those of the surrounding topography. A groundwater diversion system and dam downstream of the landfill have been constructed to minimize groundwater flow through the landfill and consequently potential groundwater contamination. Extensive analysis of the landfill in the early seventies disclosed small amounts of low-level radioactivity, primarily tritium. Deposit of radioactive waste in the landfill is prohibited, and all materials delivered to the landfill are monitored for radioactivity before disposal. Dams have been built to capture precipitation runoff from the landfill area to further minimize potential ground- and surface-water contamination. These are topographic alterations, but their benefits are estimated to outweigh the topographic impact.

Geology

The geology of the Rocky Flats Plant site is characterized by a thin topsoil layer underlain by Rocky Flats Alluvium, a gravel that consists mostly of quartzite boulders and clay. This surficial material is underlain by 25 to 270 feet of the Arapahoe formation (see Section 2.3.4) which, in turn, is underlain by 100 to 800 feet of the Laramie formation. A detailed description of the geology of the site and region is presented in Section 2.3.4 and Appendix C.

The Rocky Flats Plant has no significant impact on the geology of the site or region. Most major structures are supported by columns driven to bedrock; consequently, structural loads do not impact the weaker, less stable topsoil and alluvium of the site. Some permanent disturbance of soils and subsurface geological features is unavoidable and is characteristic of all man-made structures. The Rocky Flats site was initially selected based partially on soil stability, avoiding geologic features and soils subject to significant impact.

Hydrology

The hydrology of the Rocky Flats Plant site is characterized primarily by surface and groundwater flow following the topography and geology from west to east. Groundwater originates from surface and subsurface sources in the elevated areas west of the site. It flows through the alluvial gravel, emanating as surface springs east of the Plant and, for the most part, joins surface drainage channels that connect with Standley Lake and Great Western Reservoir. Groundwater elevations below the surface vary considerably from season to season, with maximum levels and flow during spring runoff and winter precipitation periods. The alluvial gravel is a relatively porous structure that does not readily retain water; consequently, groundwater flow rates are high. This lack of water retention is evidenced by the rather sparse and dry vegetation characteristic of the Rocky Flats area. The surface drainage channels are Rock Creek, North Walnut Creek, South Walnut Creek, Woman Creek, and several ditches. North and South Walnut Creek join and flow into Great Western Reservoir. Woman Creek drains to Standley Lake. Natural surface water flow occurs primarily during winter and spring from precipitation runoff and groundwater surface springs. Without Plant water discharges, all natural drainages would be dry a portion of the year. Woman Creek is dry during summer periods. A more detailed discussion of hydrology in the Rocky Flats area is given in Section 2.3.5 and in a report by Hurr (Hurr, 1976).

The Rocky Flats Plant has caused alterations to the hydrological characteristics of the site. Regional effects are not as evident because of the many water sources, both natural and man-made, used to supply the Denver metropolitan area.

The natural drainages that could conceivably receive Plant effluent have been dammed, as previously discussed, to provide settling basins. Surface areas occupied by buildings and roadways tend to concentrate rainfall runoff, which causes higher flow rates over remaining exposed soils. This can cause increased erosion if other measures, such as additional vegetation plantings, are not introduced to mitigate this effect. Several species of evergreens and other shrubs, as well as grass, have been planted to provide soil protection within the security fence. The settling basins also serve to prevent excessive carryover of erosion materials into the natural drainages. The solid materials remain as sediment in the holding ponds.

McKay Ditch (also identified as Zang Ditch in some other documents) was rerouted to a course and drainage paralleling the Upper Church Ditch. This eliminated flow through the Plant site from this drainage source that previously entered into North Walnut Creek. The new routing continues as a tributary to Great Western Reservoir, but reduces the potential for heavy storm runoff flow through North Walnut Creek. The subsequent hazard of flooding the holding ponds and of carryover of sediment from these ponds into Great Western Reservoir also is reduced.

Foundation structures, especially large basement-type structures, tend to disturb groundwater flow and level by impeding and interrupting natural groundwater courses. The highly porous nature of the Rocky Flats alluvial gravel, however, results in little, if any, impact of this nature for the Rocky Flats Plant. Groundwater is able to move rapidly around such structures through the porous alluvial material. Ground- and surface-water flow have also been altered around and downstream of the sanitary landfill. An impermeable dike has been constructed around the western end and sides of the landfill to cause groundwater and surface water to flow around rather than through the compacted fill and solid waste material. Also, a dam has been constructed downstream of the landfill to retain runoff originating in the landfill and to retain groundwater flow circumventing the impermeable dike. These measures are intended primarily to prevent contamination of groundwater and surface water in the area.

In most cases, alterations to hydrological characteristics of the site have been made to minimize the overall environmental impact of the Plant, especially with regard to contaminant migration via water courses to the downstream, populated areas. The benefits derived from alterations to the natural hydrological characteristics are thus judged to outweigh the adverse impacts of these alterations.

Meteorology

The meteorology of the Rocky Flats Plant site is characterized by high variability of wind direction depending on the time of day. The average annual wind speed is less than 9 miles per hour. However, peak gust wind speeds during front range down-slope wind storms can be high. During these storms, winds from the west-northwest have been measured in excess of 100 miles per hour. The proximity of the site to the Front Range of the Rocky Mountains has a strong relationship to this phenomenon. High winds are relatively frequent occurrences; yet, tornadoes are rare in the area. The climate is relatively dry with annual precipitation of only 15 inches per year. A detailed description of the site meteorology is provided in Section 2.3.6 and Appendix B.

The Plant has little impact on area meteorology. Any influence would be limited to downwind distances on the order of the characteristic size of the Plant area within the security fence (~1 mile). Such influences could dilute the downwind concentrations of effluent plumes from Plant buildings (Slade, 1968), a fact which has been conservatively omitted from all dose calculations. The Plant's cooling towers are the major mechanisms that provide any on-site meteorological influence. Under other conditions and in other locations, these towers might represent a meteorological impact. The persistent winds, dry climate, and dispersed location of small towers around the site proper, however, result in rapid plume rise and in dilution and dispersion of the released water vapor in the atmosphere. During episodes of dense air pollution near the center of Denver, there is little or no exchange of air between Rocky Flats and the central portion of the Denver metropolitan area.

Ecology

Comprehensive ecological descriptions of the Rocky Flats Plant area are found in Section 2.3.10 and Appendix A.

The facility does occupy land that would otherwise be available for native plant and animal life. Revegetation of disturbed areas is difficult because of frequent high winds, low rainfall, and, in many areas, rocky soil, but it has been successful in some areas. Natural revegetation has resulted in some recovery of overgrazed areas. Most of the site, excluding the area enclosed by the security fence, is open grassland with native and introduced species.

Vegetation within the Plant confines has been enhanced in both variety and quantity by planting as previously discussed. As a result of Plant discharges, there is continuous water flow in South Walnut Creek and downstream.

3.1.1.3 Biological Effects of Nonradioactive Contaminant Releases

The release of nonradioactive contaminants to the air, water, and soil of the Rocky Flats Plant site and region constitutes a potential pollution source that must be evaluated in terms of potential biological effects on all life forms. Quantitative evaluation is based on the continuous monitoring and analysis of Plant effluents and comparison with concentration limits established by State and Federal authorities. These limits are indicative of potential harm to the human population. They do not necessarily represent effects on other life systems. Consequently, additional evaluation of a more qualitative nature is required to adequately define and assess the overall impact of contaminant releases on other life forms. This subsection discusses and assesses the impact of such releases in both quantitative and qualitative terms, as appropriate.

The release of nonradioactive contaminants is governed primarily by concentration limits established by Federal agencies for each of the two primary transport media, air and water.

Contaminants in Effluent Waters

Release limits for nonradioactive contaminants in water effluents are embodied in the Rocky Flats Plant's "Authorization to Discharge Under the National Pollutant Discharge Elimination System" (FWPCA, 1972), commonly known as the NPDES permit. By law, an NPDES permit was required by July 1, 1977, for all water effluent sources other than publicly owned treatment works. This requirement is defined in the Federal Water Pollution Control Act Amendments of 1972. In accordance with Section 402 of the Act, the NPDES permit specifies effluent limitations for each point source. The permit is issued by the regional administrator of the U.S. Environmental Protection Agency (EPA) and administered by the Colorado Department of Health, Water Pollution Control Division. A copy of the Rocky Flats' NPDES permit is included in this Statement as Appendix D.

Prior to implementation of the NPDES permit, the Plant's water effluent limitations were governed by standards of the U.S. Public Health Service (USPHS) and the Colorado Department of Health (CDH). The USPHS Drinking Water Standards of 1962 were the primary guidelines followed at Rocky Flats. The Water Pollution Control Commission of the CDH is, however, the agency responsible for administration of the USPHS guidelines. In some cases, the CDH established standards of its own. The basic Colorado standards were revised effective September 1, 1971 (CDH, 1971). These revised standards for water sources are summarized in Table 3.1.1-1 along with chemical guidelines delineated by the USPHS in the Drinking Water Standards of 1962 (USPHS, 1969). In addition, the Water Pollution Control Commission compiled classifications and corresponding standards for the major water sources of Colorado. Although Walnut Creek and Woman Creek were not classified, the most restrictive stream classification standards were used as guidelines. Some of the limits established for drinking water by the USPHS and CDH do not relate directly to health hazards, but rather to the acceptability of the water as to taste, odor, and color.

Tables 3.1.1-2 through 3.1.1-5 list the monthly, average, nonradioactive contaminants contained in Plant effluents as measured in holding pond waters from 1971 through September 1974. Examination of Tables 3.1.1-2 through 3.1.1-5 shows that the monthly average effluent contaminant concentrations from the holding ponds were generally within the limits for classified streams. These limits served as guidelines for the period preceding implementation of the NPDES permit in 1974.

Tables 3.1.1-6 through 3.1.1-8 list the nonradioactive effluents from October 1974 through December 1977. As stated in the NPDES permit (Appendix D), the effluent limits enacted on September 4, 1974, were superseded less than 30 days later by more stringent requirements. Examination of Tables 3.1.1-6 through 3.1.1-8 shows that these limits have rarely been exceeded. The limits were exceeded primarily during the first two months following implementation of the permit and resulted from operational adjustments during start-up of the new sanitary, tertiary treatment facility.

TABLE 3.1.1-1
WATER QUALITY STANDARDS

PRIOR TO NPDES PERMIT
(WATER POLLUTION CONTROL COMMISSION COLORADO DEPARTMENT OF HEALTH)

I. BASIC (NON-RADIOACTIVE) STANDARDS APPLICABLE TO ALL WATERS OF THE STATE

A. All waters capable of treatment or control prior to discharge into any waters of the state shall receive secondary treatment with disinfection or its industrial waste equivalent.

Waters shall be free from substances attributable to municipal, domestic, or industrial wastes that:

B. Will either settle to form unsightly, putrescent or odorous bottom deposits or will interfere with the classified use of the water;

C. Create unsightly floating debris such as oil, grease, or scum;

D. Will produce objectionable odor, color, taste, or turbidity, or objectionable aquatic life;

E. May, in sufficient level, concentrations or combinations prove deleterious to human or animal life.

II. ADDITIONAL WATER QUALITY STANDARDS (MOST RESTRICTIVE FROM CLASS A, B_1, C, AND D_1)

A. General (Colorado Department of Health)

Parameter	Limits	Classification
Fecal Coliform Bacteria	<1000/ml	A, B_1
Dissolved Oxygen	6 mg/l	B_1
pH	6.5-8.5	B_1
Turbidity	Not to impair natural and developed fisheries	B_1
Total Dissolved Solids	Less than 500 mg/l (annual volume-weighted average)	A, B_1
Toxic Materials (Biocides, Pesticides, etc.)	Free From	All
Temperature (°F)	70	B_1
Sodium Adsorption Ratio	Review of Commission	C, D_1
Taste & Odor	Free From	A, B_1

B. Chemical (mg/l)

Parameters	CDH A, B_1	Suggested Maximum (USPHS)	Grounds for Rejection (USPHS-CDH)
Alkyl Benzene Sulfonate	-	0.500	-
Arsenic	0.05	0.010	0.05
Barium	1.00	-	1.00
Cadmium	.01	-	0.01
Chloride	-	250.	-
Cr^{6+}	0.05	-	0.05
Copper	0.05	1.00	-
Carbon Chloroform Extract	-	0.200	-
Cyanide	0.20	0.010	0.20
Fluoride	-	1.2	2.4
Iron	-	0.300	-
Lead	0.05	-	0.05
Manganese	-	0.050	-
Nitrate	-	45.0	-
Phenols	-	0.001	-
Selenium	0.01	-	0.01
Sulfates	-	250.	-
Silver	0.05	-	0.05
Zinc	-	5.00	-

A Colorado guideline for the Biochemical Oxygen Demand (BOD) - the amount of oxygen needed to allow for natural, biological oxidation of organic matter - has been established, primarily as a measurement of sewage treatment effectiveness. The BOD guideline for Rocky Flats is 30 mg/l.

TABLE 3.1.1-2

NONRADIOACTIVE WATER EFFLUENTS
JANUARY THROUGH DECEMBER, 1971

Sampling Point and Parameter Measured (1)	Guide Value	Jan.	Feb	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
I. N. Walnut Ck., Pond A													
pH	6.5-8.5*	7.8	7.6	7.5	7.8	7.9	8.0	7.8	9.2	8.5	7.6	7.8	7.7
Nitrate (NO_3^-)	45.0	11.1	13.7	19.6	29.7	85.0	20.1	23.0	23.4	36.3	52.9	58.9	78.6
Phosphate (PO_4^{-3}) (2)	N.A.	0.6	1.1	0.6	0.7	0.6	0.6	0.6	0.6	0.6	0.4	0.6	0.6
Fluoride (F^-)	1.0	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.5	0.4
Total Solids	500.0*	173	101	164	183	393	233	-	-	300	384	429	438
Chromium (Cr^{+6})	0.05	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
II. S. Walnut Ck., Pond B-4													
pH	6.5-8.5*	7.3-8.0	7.4-7.6	7.2-7.9	7.2-7.8	7.6-8.4	7.7-8.5	7.2-8.2	7.1-9.6	7.2-7.9	7.1-8.1	7.2-7.7	7.2-7.8
Nitrate (NO_3^-)	45.0	16.7	6.2	9.4	8.4	5.5	3.8	3.4	4.1	3.6	7.2	7.1	4.9
Phosphate (PO_4^{-3}) (2)	N.A.	10.9	9.2	6.3	4.3	12.5	13.3	8.9	7.9	15.4	20.7	22.6	17.2
Fluoride (F^-)	1.0	0.5	0.4	0.4	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.7	0.4
BOD_5	30.0*	5.4	9.9	4.5	6.4	5.8	7.3	-	8.2	7.9	6.7	4.2	6.0
Dissolved Oxygen (3)	6.0*	26.3	10.8	10.8	11.0	9.9	10.3	4.4	4.4	5.3	6.2	8.8	9.2
Total Solids	500.0*	400	681	406	392	456	368	-	-	260	309	393	332
Chromium (Cr^{+6})	0.05	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
III. Woman Ck., Pond C-1													
pH	6.5-8.5*	7.8	7.7	7.5	7.5	8.0	7.8	7.8	8.4	8.5	8.2	8.1	7.7
Nitrate (NO_3^-)	45.0	0.5	0.9	0.4	0.4	0.3	0.3	0.3	0.6	1.2	1.3	1.5	0.9
Phosphate (PO_4^{-3}) (2)	N.A.	0.6	1.3	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Fluoride (F^-)	1.0	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.3	0.4	0.8	0.4
Total Solids	500.00*	243	212	205	249	272	188	-	-	175	227	185	194
Chromium (Cr^{+6})	0.05	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

NOTES

(1) All concentrations are monthly averages based on analysis of pond grab water samples in milligrams per liter (mg/l) except pH.
(2) No standards had been established for phosphate in 1971.
(3) Dissolved oxygen limit is a minimum requirement.
* Limits for pH, Biochemical Oxygen Demand (BOD_5), Dissolved Oxygen, and Total Dissolved Solids are Colorado Department of Health Standards. All other limits are U.S. Public Health Service standards for drinking water.

TABLE 3.1.1-3

NONRADIOACTIVE WATER EFFLUENTS
JANUARY THROUGH DECEMBER, 1972

Sampling Point and Parameter Measured (1)	Guide Value	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
I. N. Walnut Ck., Pond A													
pH	6.5-8.5*	7.5	7.8	8.5	8.3	8.2	8.5	8.8	8.8	9.0	8.9	8.1	7.9
Nitrate (NO_3^-)	45.0	59.0	54.7	38.5	58.6	14.9	19.1	12.7	9.1	7.8	4.3	74	70
Phosphate (PO_4^{-3}) (2)	N.A.	<0.6	<0.6	<0.6	<0.6	<0.6	1.9	<0.8	1.0	1.0	<2.2	0.9	<0.3
Fluoride (F^-)	1.0	0.9	0.8	0.7	1.1	0.5	0.8	0.9	0.8	1.3	1.3	0.82	0.54
Total Solids	500.00*	361	308	324	369	178	239	261	239	251	241	516	537
Chromium (Cr^{+6})	0.05	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
II. S. Walnut Ck., Pond B-4													
pH	6.5-8.5*	7.4	7.2	7.5	7.8	7.6	7.6	7.7	7.7	7.9	8.3	7.9	8.0
Nitrate (NO_3^-)	45.0	6.2	3.6	2.5	2.5	2.6	1.8	3.9	3.5	5.0	2.2	2.9	5.1
Phosphate (PO_4^{-3}) (2)	N.A.	21.0	21.4	20.9	18.5	14.3	18.0	17.6	12.0	11.3	14.4	13.7	14.3
Fluoride (F^-)	1.0	0.7	0.9	0.8	0.9	0.7	0.6	0.6	0.6	0.6	0.9	0.7	0.48
BOD_5	30.0*	7.8	10.5	5.7	6.9	4.3	3.1	7.8	14.4	11.9	-	11.2	4.5
Dissolved Oxygen (3)	6.0*	-	8.5	8.3	11.1	6.8	3.3	5.3	4.7	4.2	-	6.7	9.7
Total Solids	500.00*	392	434	461	420	374	364	373	310	354	315	402	442
Chromium (Cr^{+6})	0.05*	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
III. Woman Ck., Pond C-1													
pH	6.5-8.5*	7.7	7.4	7.7	7.9	7.9	7.8	8.0	8.3	8.2	8.1	8.2	8.2
Nitrate (NO_3^-)	45.0	1.4	0.9	0.3	0.3	0.2	0.3	<0.9	<0.2	0.2	<0.2	0.35	0.8
Phosphate (PO_4^{-3}) (2)	N.A.	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.9	<0.6	0.7	0.6	0.7	<0.3
Fluoride (F^-)	1.0	0.7	0.8	0.7	0.8	0.6	0.5	0.6	0.5	0.5	<0.6	0.5	0.38
Total Solids	500.00*	236	188	-	235	226	132	132	151	192	192	214	224
Chromium (Cr^{+6})	0.05	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

NOTES

(1) All concentrations are monthly averages based on analysis of pond grab water samples in milligrams per liter (mg/l) except pH.
(2) No standards had been established for phosphate in 1972.
(3) Dissolved oxygen limit is a minimum requirement.
* Limits for pH, Biochemical Oxygen Demand (BOD_5), Dissolved Oxygen, and Total Dissolved Solids are Colorado Department of Health Standards. All other limits are U.S. Public Health Service standards for drinking water.

TABLE 3.1.1-4

NONRADIOACTIVE WATER EFFLUENTS
JANUARY THROUGH DECEMBER, 1973

Sampling Point and Parameter Measured (1)	Guide Value	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
I. N. Walnut Ck., Pond A													
pH	6.5-8.5*	7.9	7.8	8.2	8.0	8.1	8.1	8.1	8.1	7.8	7.8	7.9	7.7
Nitrate (NO_3^-)	45.0	62.5	70.5	65.7	84.7	42.5	41.4	17.6	<2.7	<5.8	12.3	19.0	34.0
Phosphate (PO_4^{-3}) (2)	N.A.	0.7	<0.6	<0.8	2.0	1.0	0.7	<0.06	<0.7	<0.6	<0.6	<0.6	<0.6
Fluoride (F^-)	1.2	0.75	0.76	0.44	0.35	0.58	0.67	0.59	0.57	0.5	0.6	0.6	0.49
Total Solids	500.00*	448	390	340	298	310	404	426	407	470	274	372	381
Chromium (Cr^{+6})	0.05	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
II. S. Walnut Ck., Pond B-4													
pH	6.5-8.5*	7.8	7.8	8.0	8.1	8.3	8.6	8.1	8.4	8.1	7.9	8.0	7.6
Nitrate (NO_3^-)	45.0	1.8	2.6	4.3	9.7	11.2	6.4	5.2	3.7	<7.6	10.4	11.4	15.4
Phosphate (PO_4^{-3}) (2)	N.A.	14.8	14.5	13.4	6.2	3.2	2.0	2.0	3.7	1.7	2.3	<2.4	10.3
Fluoride (F^-)	1.2	0.64	0.81	0.46	0.47	0.66	0.72	0.58	0.46	0.4	0.6	0.4	0.43
BOD_5	30.0*	14.9	6.4	7.2	<10	<5.4	<7.0	9.5	15.9	5.1	16.7	9.4	8.2
Dissolved Oxygen (3)	6.0	9.3	8.6	8.36	9.2	9.4	6.1	5.4	3.3	6.0	7.3	7.8	7.5
Total Solids	500.00*	229	445	431	405	383	481	452	416	392	507	586	486
Chromium (Cr^{+6})	0.05	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
III. Woman Ck., Pond C-l													
pH	6.5-8.5*	8.1	8.0	8.2	7.9	8.2	8.6	9.3	9.1	8.9	8.5	8.2	7.8
Nitrate (NO_3^-)	45.0	0.8	0.7	0.49	1.0	1.7	0.8	1.1	<0.5	<1.0	0.5	<0.4	<0.71
Phosphate (PO_4^{-3}) (2)	N.A.	0.7	0.9	<0.7	<1.2	1.1	<0.6	<0.6	<0.7	<0.6	<0.6	<0.6	<0.6
Fluoride (F^-)	1.2	0.52	0.7	0.44	0.34	0.58	0.53	0.48	0.53	<0.4	0.4	0.4	0.31
Total Solids	500.00*	226	250	204	157	132	188	176	144	216	230	283	259
Chromium (Cr^{+6})	0.05	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

NOTES

(1) All concentrations are monthly averages based on analysis of pond grab water samples in milligrams per liter (mg/l) except pH.
(2) No standards had been established for phosphate in 1973.
(3) Dissolved oxygen limit is a minimum requirement.
* Limits for pH, Biochemical Oxygen Demand (BOD_5), Dissolved Oxygen and Total Dissolved Solids are Colorado Department of Health Standards. All other limits are U.S. Public Health Service standards for drinking water.

TABLE 3.1.1-5

NONRADIOACTIVE WATER EFFLUENTS
JANUARY THROUGH SEPTEMBER, 1974

Sampling Point and Parameter Measured (1)	Guide Value	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul. (5)	Aug.	Sep. (2)
I. N. Walnut Ck., Pond A										
pH	6.5-8.5*	7.9	7.7	7.9	7.5	7.5	I. F.(4)	I. F.	I. F.	I. F.
Nitrate (NO_3^-)	45.0	16.3	37.5	<11.0	<7.4	<7.2	I. F.	I. F.	I. F.	I. F.
Phosphate (PO_4^{-3}) (2)	N.A.	<0.7	<2.0	<1.2	1.7	<2.0	I. F.	I. F.	I. F.	I. F.
Fluoride (F^-)	1.2	<0.3	-	0.28	0.38	0.52	I. F.	I. F.	I. F.	I. F.
Total Solids	500.00*	271	<20.7	<35	60	58	I. F.	I. F.	I. F.	I. F.
Chromium (Cr^{+6})	0.05	<0.005	<0.005	<0.005	<0.005	<0.005	I. F.	I. F.	I. F.	I. F.
II. S. Walnut Ck., Pond B-4										
pH	6.5-8.5*	7.8	7.9	7.8	7.3	7.7	7.0	7.8	7.6	7.5
Nitrate (NO_3^-)	45.0	14.6	8.0	<6.1	<9.1	<17.9	<5.6	<2.3	<2.39	3.0
Phosphate (PO_4^{-3}) (2)	N.A.	5.8	5.8	5.4	3.2	4.8	4.9	<1.32	1.32	2.4
Fluoride (F^-)	1.2	0.5	-	0.46	0.76	0.62	0.80	0.49	0.53	0.44
BOD_5	30.0*	5.5	9.5	8.5	11.2	4.4	14.0	26	24	35
Dissolved Oxygen (3)	6.0*	8.5	8.3	6.6	2.3	3.5	4.2	8	12	17
Total Solids	500.00*	482	<30.1	<20	<43	34	67	28	17	28
Chromium (Cr^{+6})	0.05	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	<0.08	<0.05
III. Woman Ck., Pond C-1										
pH	6.5-8.5*	7.8	8.1	8.2	7.7	7.8	7.5	8.7	9.0	8.5
Nitrate (NO_3^-)	45.0	1.4	<5.0	<5.0	<5.0	5.0	5.0	1.15	<0.23	0.69
Phosphate (PO_4^{-3}) (2)	N.A.	<0.6	1.4	<1.1	1.5	<1.2	<1.7	-	-	-
Fluoride (F^-)	1.2	0.4	-	0.42	0.6	0.63	0.7	-	-	-
Total Solids	500.00*	256	<6.9	7	21	<28	23	13	306	155
Chromium (Cr^{+6})	0.05	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	-

NOTES (1) All concentrations are monthly averages based on analysis of pond grab water samples in milligrams per liter (mg/l) except pH.

(2) NPDES permit went into effect Sept. 4, 1974. Established limit of 8 mg/l, daily average, for phosphorus. Pond samples were replaced at this time by samples from discharge point stipulated in the NPDES permit and identified in Table 3.1.1-6.

(3) Dissolved oxygen limit is a minimum requirement.

(4) I. F. – insufficient flow for sampling and analysis.

(5) Beginning July, 1974, samples taken from outfall ponds A-3, B-4, and C-1, rather than pond grab water samples, in preparation for implementation of NPDES permit.

* Limits for pH, Biochemical Oxygen Demand (BOD_5), Dissolved Oxygen, and Total Dissolved Solids are Colorado Department of Health Standards. All other limits are U.S. Public Health Service Standards for drinking water.

TABLE 3.1.1-6
NONRADIOACTIVE WATER EFFLUENTS
(October 1974 through December 1975)

Sampling Point and Parameter Measured	Discharge[1] Limit	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
I. Discharge 001																
Total Suspended Solids																
(mg/l) –Daily Avg.	15.0	21.0	8.23	5.1	4.0	3.9	4.5	4.2	2.6	3.1	2.0	2.4	4.3	4.5	3.7	2.8
–Daily Max.	25.0	53.0	45.0	15.0	10.0	10.0	14.0	14.0	11.0	14.0	2.0	14.0	17.0	13.0	11.0	9.0
Total Phosphorus (P)																
(mg/l) –Daily Avg.	8.0	9.0	2.6	3.75	2.94	1.0	1.9	1.3	1.9	0.5	0.5	0.5	0.4	0.7	0.6	0.7
–Daily Max.	N.A.	6.8	8.0	4.0	5.0	3.0	4.3	2.7	8.0	1.0	2.0	0.8	0.7	1.4	1.0	2.1
Total Nitrogen –30 Day Avg.	20.0												10.3	13.8	12.1	9.4
Nitrate (as N)*																
(mg/l) –Daily Avg.	10.0	3.0	6.09	11.2	12.39	8.48	7.6	10.1	7.5	5.5	6.9	6.4				
–Daily Max.	20.0	7.4	9.0	19.0	16.0	13.0	17.0	14.0	17.0	13.0	11.0	14.0				
Fluoride																
(mg/l) –Daily Avg.	N.A.	0.56	0.72	0.38	0.27	0.37	0.6	0.45	0.4	0.4	0.4	0.3	0.2	0.3	0.3	0.3
–Daily Max.	1.7	0.7	0.8	0.5	0.4	0.6	1.1	0.6	0.6	0.6	0.5	0.4	0.5	0.6	0.4	0.4
Total BOD_5																
(mg/l) –Daily Avg.	10.0	19.0	10.80	8.0	9.23	6.5	4.9	3.5	5.4	4.0	4.4	4.7	4.7	3.8	4.7	3.7
–Daily Max.	25.0	43.0	43.0	8.0	32.0	10.0	9.0	9.0	9.0	13.0	13.0	10.0	18.0	7.0	10.0	8.0
Total Residual Chlorine																
(mg/l) –Daily Avg.	N.A.	<0.1	<0.1	0.1	0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	0.1
–Daily Max.	0.1	<0.1	<0.1	0.1	0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	0.1	0.1
Dissolved Oxygen																
(mg/l) –Daily Avg.	4.0	11.0	8.08	8.0	7.3	7.23	7.1	6.46	6.0	5.3	5.4	5.7	6.0	6.3	7.0	7.5
–Daily Min.	2.0	1.8	1.7	7.0	–	–	–	5.0	5.0	5.0	5.0	5.0	6.0	6.0	6.0	7.0
Total Chromium																
(mg/l) –Daily Avg.	0.05	<0.05	0.05	0	0.05	0.06	0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
–Daily Max.	0.1	<0.05	0.1	0	0.1	0.1	0.1	0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Oil and Grease																
(mg/l) –Daily Avg.	N.A.	3.0	0.9	0	1.12	0.4	0.3	0.35	0.21	0.3	0.2	0.2	0.3	0.2	0.1	0.2
–Daily Max.	10.0	4.0	2.1	0.5	4.2	0.6	0.5	0.8	0.3	0.4	0.3	0.2	0.4	0.4	0.1	0.2
Fecal Coliforms (organisms/100ml)																
–7 Day Avg.	400	Neg.	Neg.	0	0	0	0	0	0	0	0	0	0	0	0	0
–30 Day Avg.	200	Neg.	Neg.	8.52	0	0	0	0	0	0	0	0	0	0	0	0
pH																
–Min.	6.0	7.3	7.3	6.2	6.4	6.3	6.3	6.2	6.5	7.0	6.4	6.5	6.0	6.5	6.7	5.9
–Max.	9.0	8.1	8.4	7.6	7.4	7.5	7.5	7.6	7.4	7.8	7.2	7.1	6.8	7.8	7.6	7.5
Flow (× 10^6 liter)	N.A.	20.0	29.0	20.5	16.8	19.3	17.6	20.9	23.8	21.4	19.9	16.4	14.9	14.9	15.9	19.1
II. Discharge 002 (A-3)																
Nitrate (as N)																
–Daily Avg.	10.0	1.0	I.F.	1.0	I.F.	I.F.	2.0	4.0	4.7	2.4	1.0	2.0	I.F.	I.F.	<1.0	1.0
–Daily Max.	20.0	1.0	I.F.	1.0	I.F.	I.F.	2.0	5.0	5.0	3.0	1.0	2.0	I.F.	I.F.	<1.0	1.0
Flow (× 10^6 liter)	N.A.	2.6	I.F.	0.6	I.F.	–	–	–	–	–	–	–				
III. Discharge 003 (C-1)																
Nitrates (as N)																
(mg/l) –Mon. Avg.	N.A.	<1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.23	<1.0	<0.23	<1.0	<1.0	<1.0	0.1
–Mon. Max.	N.A.	<1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.23	<1.0	<0.23	<1.0	<1.0	<1.0	0.1
Total Dissolved Solids (mg/l) Monthly Composite	N.A.	116	15.0	168	243	248	203	162	163	102	162	110	64.0	81.5	146	146
Chemical Oxygen Demand (mg/l) Monthly Composite	N.A.	13.0	43.0	7.0	8.0	12.0	8.0	13.0	14.0	20.0	22.0	19.0	8.0	11.0	12.0	13.0
pH –Min.	N.A.	7.8	8.0	7.8	7.7	7.7	8.1	7.9	7.7	7.5	7.6	8.2	7.9	7.4	8.2	7.9
–Max.	N.A.	8.7	8.0	8.1	8.1	8.0	8.3	8.0	8.3	8.6	8.6	9.1	8.0	8.3	8.4	8.0
Flow (× 10^6 liter)	N.A.	–	–	16.1	11.0	11.0	–	–	–	–	–	–				

Notes

[1] Discharge limits per NPDES permit.

Key

N.A. – Not Applicable – –no data available

I.F. – Insufficient flow for sample analysis

Discharge 001 samples are taken at the outfall of the sewage treatment plant, except total residual chlorine, which is sampled at the outfall at pond B-4, S. Walnut Ck.
Discharge 002 samples are taken at the outfall of pond A-3, N. Walnut Ck. Flow is by precipitation runoff only, however, as no plant discharges directly by this source.
Discharge 003 samples are taken at the outfall of pond C-1, Woman Ck. Flow is by precipitation runoff only, however.
*Prior to September 1975, the NPDES Permit limits were set for Nitrate (as N). Values after September represent values for Total Nitrogen.

TABLE 3.1.1-7
NONRADIOACTIVE WATER EFFLUENTS
(Jan 1976 through December 1976)

Sampling Point and Parameter Measured		Discharge[1] Limit	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
I. Discharge 001														
Total Suspended Solids														
(mg/l)	-Daily Avg.	15.0	2.1	2.3	2.3	2.6	2.3	<2.0	<2.0	<2.0	<2.2	<2.4	<2.0	<2.0
	-Daily Max.	25.0	4.0	6.0	5.0	9.0	7.0	<2.0	<2.0	<2.0	7.0	15.0	<2.0	<2.0
Total Phosphorus (P)														
(mg/l)	-Daily Avg.	8.0	1.1	1.0	1.1	1.1	0.9	0.9	<1.1	<1.3	<1.0	<1.1	<0.9	1.2
	-Daily Max.	N.A.	1.8	2.1	1.9	2.4	1.6	1.8	1.9	1.8	1.6	2.1	1.5	2.4
Total Nitrogen														
(mg/l)	(30-Day Avg.)	20.0	9.3	6.4	9.7	10.0	7.9	<10.2	<4.0	<6.5	11.3	5.9	7.0	13.0
Fluoride														
(mg/l)	-Daily Avg.	N.A.	0.3	0.3	0.4	0.4	0.4	0.3	<0.3	<0.4	0.4	<0.4	<0.4	0.4
	-Daily Max.	1.7	0.4	0.4	0.4	0.6	0.5	0.4	0.3	0.4	0.6	0.5	0.5	0.5
Total BOD_5														
(mg/l)	-Daily Avg.	10.0	4.5	6.7	9.7	1.9	2.9	<1.9	<2.0	<2.0	<6.6	3.2	<0.1	<2.5
	-Daily Max.	25.0	13.0	15.0	49.0	4.0	23.0	7.0	5.0	5.0	49.0	6.0	5.0	4.0
Total Residual Chlorine														
(mg/l)	-Daily Avg.	N.A.	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	-Daily Max.	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dissolved Oxygen														
(mg/l)	-Daily Avg.	4.0	7.4	6.9	6.8	7.3	7.1	6.8	6.6	<6.7	6.8	<7.1	<7.1	7.9
	-Daily Min.	2.0	7.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	7.0	6.0	7.0
Total Chromium														
(mg/l)	-Daily Avg.	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.1	<0.1	<0.05	<0.05	<0.05	<0.05
	-Daily Max.	0.1	<0.05	<0.05	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Oil and Grease														
(mg/l)	-Daily Avg.	N.A.	0.1	0.2	0.2	0.4	0.4	0.3	0.3	0.2	0.1	0.4	0.2	<0.2
	-Daily Max.	10.0	0.2	0.3	0.4	0.5	0.5	0.4	0.4	0.3	0.1	0.5	0.3	<0.3
Fecal Coliforms														
(organisms/100 ml)														
	-7-Day Avg.	400	0	0	0	0	0	0	0	0	0	0	0	0
	-30-Day Avg.	200	0	0	0	0	0	0	0	0	0	0	0	0
pH	-Min.	6.0	8.1	7.0	7.0	7.1	7.3	7.2	6.9	<7.3	7.3	7.3	7.0	6.4
	-Max.	9.0	8.1	7.6	7.8	7.8	7.8	7.8	7.6	7.7	7.7	7.6	7.4	7.4
Flow ($\times 10^6$ liter)		N.A.	18.9	17.6	16.7	18.2	20.7	21.4	21.4	20.3	21.5	19.6	--	17.2
II. Discharge 002 (A-3)														
Nitrate (as N)														
	-Daily Avg.	10.0	<1.0	1.0	3.0	5.0	4.0	<2.0	2.0	3.0	<3.5	4.3	2.7	5.0
	-Daily Max.	20.0	<1.0	1.0	3.0	6.0	6.0	2.0	2.0	3.0	5.0	6.0	3.0	5.0
pH	-Min.	6.0							7.8	7.8	7.7	7.9	8.0	7.8
	-Max.	9.0							7.8	7.8	7.9	8.1	8.2	7.9
III. Discharge 003 (C-1)														
Nitrates (as N)														
(mg/l)	-Daily Avg.	N.A.							<0.1	<0.1	1.4	<0.1	0.1	0.3
	-Daily Max.	N.A.							<0.1	<0.1	1.4	<0.1	0.1	0.3
	-Mon. Avg.	N.A.	<0.1	0.1	<0.1	1.0	0.3	<1.0						
	-Mon. Max.	N.A.	<0.1	0.1	<0.1	1.0	0.3	<1.0						
Total Dissolved Solids														
(mg/l)	-Daily Avg.	N.A.							131	118	104	162	226	248
	-Daily Max.	N.A.							141	134	112	178	226	250
	Monthly Composite	N.A.	153	150	143	70	121	158						
Chemical Oxygen Demand														
(mg/l)	-Daily Avg.	N.A.							2.0	12.0	21.0	9.0	7.0	8.0
	-Daily Max.	N.A.							2.0	12.0	21.0	9.0	7.0	8.0
	Monthly Composite	N.A.	5.0	9.0	3.0	11.0	26.0	14.0						
pH	-Min.	N.A.	7.7	7.9	8.1	8.2	7.9	8.0	8.1	8.7	8.8	8.8	8.6	8.2
	-Max.	N.A.	8.3	8.3	8.3	8.3	8.9	9.2	9.0	8.7	9.2	9.1	8.7	8.5

Notes

[1] Discharge limits per NPDES permit.

Discharge 001 samples are taken at the outfall of the sewage treatment plant except for total residual chlorine, which is sampled at the outfall of Pond B-4, S. Walnut Creek.

Discharge 002 samples are taken at the outfall of pond A-3, N. Walnut Creek. Flow is the precipitation runoff only, however, as no plant discharges directly by this source.

Discharge 003 samples are taken at the outfall of pond C-1, Woman Creek. Flow is the precipitation runoff only, however, as no plant discharges directly by this source.

Key

N.A. - Not Applicable
-- No data available.

TABLE 3.1.1-8
NONRADIOACTIVE WATER EFFLUENTS
(January 1977 through December 1977)

Sampling Point and Parameter Measured	Discharge[1] Limit	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
I. Discharge 001													
Total Suspended Solids													
(mg/l) –Daily Avg.	15.0	<2.6	<2.0	<2.6	<3.5	<3.2	<2.0	<2.0	<2.5	<3.1	<4.3	<3.8	<3.4
–Daily Max.	25.0	12.0	<2.0	8.0	18.0	15.0	<2.0	<2.0	6.0	7.0	13.0	16.0	10.0
Total Phosphorus (P)													
(mg/l) –Daily Avg.	8.0	1.2	1.6	2.0	1.7	1.7	2.1	2.3	2.3	2.4	3.0	2.8	3.5
–Daily Max.	N.A.	2.3	2.5	3.4	2.8	2.3	4.4	4.2	4.2	4.9	4.4	5.5	6.0
Total Nitrogen													
(mg/l) (30-Day Avg.)	20.0	13.5	13.9	<11.5	<9.1	9.0	<9.5	<9.5	11.2	11.6	<13.4	13.2	<13.4
Fluoride													
(mg/l) –Daily Avg.	N.A.	0.4	0.4	0.8	0.4	0.3	<0.3	0.5	<0.5	0.5	0.5	0.5	0.4
–Daily Max.	1.7	0.5	0.5	3.0	0.5	0.5	0.5	0.6	0.6	0.8	2.0	0.8	0.6
Total BOD_5													
(mg/l) –Daily Avg.	10.0	6.6	5.8	3.4	<3.9	<3.2	<2.9	<2.2	<2.8	<1.4	5.2	<5.2	10.0
–Daily Max.	25.0	15.0	14.0	12.0	7.0	10.0	7.0	5.0	7.0	7.0	18.0	11.0	29.0
Total Residual Chlorine													
(mg/l) –Daily Avg.	N.A.	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
–Daily Max.	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dissolved Oxygen													
(mg/l) –Daily Avg.	4.0	7.8	8.3	8.4	7.9	7.2	6.8	6.8	6.7	6.7	6.8	7.6	7.4
–Daily Min.	2.0	7.0	7.0	7.0	7.0	6.0	6.0	6.0	6.0	6.0	5.0	7.0	6.0
Total Chromium													
(mg/l) –Daily Avg.	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
–Daily Max.	0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Oil and Grease													
(mg/l) –Daily Avg.	N.A.	0.9	0.6	0.6	0.8	0.6	0.5	0.5	0.5	0.6	0.4	0.3	0.3
–Daily Max.	10.0	1.5	1.4	0.8	1.2	0.8	0.6	0.6	0.6	1.6	0.6	0.5	0.4
Fecal Coliforms (organisms/100 ml)													
–7-Day Avg.	400	0	0.5	0	0	0	0	0	0	0	0	0	0
–30-Day Avg.	200	0	0.1	0	0	0	0	0	0	0	0	0	0
pH –Min.	6.0	6.6	6.7	6.9	6.8	6.8	6.7	6.6	6.1	6.8	6.8	6.9	6.8
–Max.	9.0	7.3	7.4	7.5	7.4	7.5	7.8	7.7	7.7	7.6	7.6	7.6	7.5
Flow (× 10^4 liter)	N.A.	22.1	14.9	16.8	18.7	19.3	17.9	18.1	18.8	16.4	16.0	11.4	18.0
II. Discharge 002 (A-3)													
Nitrate (as N)													
–Daily Avg.	10.0	7.0	7.0	7.0	5.8	3.0	1.0	<5.0	<0.3	<0.3	<1.0	<0.3	0.3
–Daily Max.	20.0	7.0	7.0	7.0	7.0	4.0	1.0	9.0	<0.3	<0.3	<1.0	<0.3	0.3
pH –Min.	6.0	7.7	8.0	8.0	7.7	8.0	8.1	7.6	7.4	7.4	8.2	7.4	8.1
–Max.	9.0	7.7	8.0	8.5	8.2	8.4	8.1	7.8	7.4	7.7	8.2	7.4	8.1
III. Discharge 003 (C-1)													
Nitrates (as N)													
(mg/l) –Daily Avg.	N.A.	<0.1	<0.1	<0.1	0.1	<0.3	<0.3	<0.3	<0.3	<0.3	0.9	<0.3	<0.3
–Daily Max.	N.A.	<0.1	<0.1	<0.1	0.1	<0.3	<0.3	<0.3	<0.3	<0.3	0.9	<0.3	<0.3
Total Dissolved Solids													
–Daily Avg.	N.A.	260	178	184	151	158	150	158	108	93	148	206	220
–Daily Max.	N.A.	268	241	226	157	174	163	172	125	98	161	220	223
Chemical Oxygen Demand													
–Daily Avg.	N.A.	28	6.0	9.0	15	5.0	15	18	14	26	11	21	13
–Daily Max.	N.A.	28	6.0	9.0	15	5.0	15	18	14	26	11	21	13
pH –Min.	N.A.	8.3	8.4	8.3	8.0	8.5	8.2	8.5	7.0	7.4	7.2	8.3	7.9
–Max.	N.A.	8.6	8.6	8.5	8.3	8.6	8.8	8.6	8.3	9.1	9.4	8.4	8.0

Notes

[1] Discharge limits per NPDES permit.

Key

N.A. – Not Applicable

Discharge 001 samples are taken at the outfall of the sewage treatment plant except for total residual chlorine, which is sampled at the outfall of Pond B-4, S. Walnut Ck.

Discharge 002 samples are taken at the outfall of pond A-3, N. Walnut Ck. Flow is the precipitation runoff only, however, as no plant discharges directly by this source.

Discharge 003 samples are taken at the outfall of pond C-1, Woman Ck. Flow is the precipitation runoff only, however, as no plant discharges directly by this source.

Overall, the Rocky Flats Plant has succeeded in minimizing the release of nonradioactive contaminants in effluent waters. The Plant does not constitute a significant, nonradioactive, water pollution source, and it does not represent a direct threat to human health from nonradioactive contaminants in effluent waters.

Contaminants in Effluent Air

Release limits utilized for nonradioactive contaminants in air during normal Plant operations are those specified in regulations issued by the State, under the State Implementation Plan. The nonradioactive, airborne contaminants released by the Rocky Flats Plant include sulfur dioxide, nitrogen oxides, and unburned hydrocarbons from the various Plant boilers (see Tables 2.6.6-2, 2.6.6-3, and 2.8-2). Also included are beryllium, carbon tetrachloride, hydrocarbon vapors, and trace quantities of other materials and chemicals from various manufacturing facilities. Chemicals used at Rocky Flats are listed in Table 2.8-1.

Of these potential pollutants, beryllium presents the greatest potential health hazard because of its toxicity and because of the relatively large quantities handled by the Plant. As discussed in Section 2.5.3.1, all facilities in which beryllium is processed are equipped with exhaust air filtration systems. These systems utilize HEPA (High Efficiency Particulate Air) filters, cyclone separators, and oil impinger prefilters. In addition, all effluent exhaust systems are isokinetically sampled on a continuous basis. Effluent beryllium concentrations from appropriate buildings are determined using the atomic absorption method (Bokowski, 1968). Table 3.1.1-9 lists the monthly and annual amounts of beryllium released from 1971 through 1977. Releases through December 1977* have been well below the applicable EPA limits and do not represent a significant environmental impact.

An automated flue-gas monitoring system is being installed to monitor sulfur dioxide, carbon monoxide, and unburned hydrocarbons emanating from the various Plant heating boilers. When natural gas is used during boiler operation, flue-gas contaminants are minimized and no sulfur dioxide is produced because of the lack of sulfur compounds in natural gas. As discussed in Section 2.6.6.1, and as shown in Table 2.6.6-2, a maximum nitrogen oxide concentration of 260 ppm results from boiler operation with natural gas. Operation using the backup fuel supply, #6 fuel oil, does result in higher contaminant release, and the presence of sulfur in the fuel produces some sulfur dioxide in the flue gas. Maximum concentrations of 400 ppm nitrogen oxides and 420 ppm sulfur dioxide have been recorded while burning fuel oil. Emission rates of carbon monoxide and unburned hydrocarbons average less than 15 ppm and 2.5 ppm, respectively. Other nonradioactive air contaminant releases from manufacturing facilities are characteristically low because of sophisticated, exhaust-air filtration systems used to trap radioactive materials, as described in Section 2.7.1.

*A recent (February, 1978) fire released ~14.5g of beryllium. See Section 3.2.1 for an analysis of the impact of a hypothetical maximum credible beryllium fire.

TABLE 3.1.1-9
BERYLLIUM RELEASES
(grams)

	1971	1972	1973	1974	1975	1976	1977
Jan.	0.823	0.16	0.23	0.71	0.39	0.44	0.19
Feb.	2.092	0.18	0.28	0.39	0.62	0.25	0.32
Mar.	1.239	0.22	0.13	1.20	0.40	0.18	0.66
Apr.	0.699	1.2	0.22	0.87	0.31	0.18	0.52
May	0.619	0.15	0.09	3.17	0.70	0.28	0.22
June	0.370	0.38	0.14	1.38	0.20	0.34	0.24
July	4.491	0.24	0.33	2.29	0.38	0.24	0.31
Aug.	0.802	0.37	0.34	0.22	0.18	0.30	0.28
Sept.	0.881	0.41	0.55	0.23	0.15	0.22	0.54
Oct.	0.519	0.25	3.32	0.15	0.63	0.20	0.44
Nov.	0.094	0.37	0.75	0.20	0.42	0.39	0.26
Dec.	4.201	0.32	0.70	0.18	0.81	0.68	0.95
Total	16.83	4.25	7.08	10.99	5.19	3.70	4.93
Standard(1)	3,650	3,650	3,650	3,650	3,650	3,650	3,650
% of Stand.	0.46	0.12	0.19	0.30	0.14	0.10	0.14
Concentration(2)							
C avg.	0.0013	0.0002	0.0015	0.0023	0.0004	0.0003	0.0003
C max.	0.209	0.054	0.144	0.43	0.40	0.015	0.158
Standard(3)	0.01	0.01	0.01	0.01	0.01	0.01	0.01
% of Stand.	13.0	2.0	15.0	23.0	4.0	3.0	3.0

1. Maximum permissible limit established by the EPA is 10 grams per day per stationary source.

2. Concentrations in micrograms per cubic meter ($\mu g/m^3$) based on stack samples
   C avg - average monthly concentration
   C max - maximum single sample concentration

3. Standard in $\mu g/m^3$ applies to average monthly concentration in ambient air. (The Rocky Flats' self-imposed internal goal for beryllium in air is 0.005 $\mu g/m^3$, one-half the official standard.) The permissible exposure level of 2.0 $\mu g/m^3$ for an eight-hour time-weighted average (with a ceiling concentration of 5.0 $\mu g/m^3$ for a 10-minute exposure) is used by OSHA. The maximum permissible exposure level is 25 $\mu g/m^3$ for a 30-minute peak concentration. The EPA standard for a 30-day exposure to the general public is 0.01 $\mu g/m^3$.

All emissions are within regulations of the State of Colorado as amended in 1977, for emissions for which applicable regulations exist.

Normal operation of the Rocky Flats Plant results in small releases of contaminants in effluent air. Comparison with established limits show these releases to be below the applicable limits; consequently, they do not represent a significant environmental impact or threat to human health.

Effects on Other Life Forms

The effects of nonradioactive contaminant releases on life forms other than man are, at best, difficult to quantify. Both the diversity of species and complex interrelationships between species and between aquatic and terrestrial environs require long-term ecological monitoring programs.

Several studies have been carried out at Rocky Flats to assess the biological impact on the aquatic and terrestrial ecosystems. These studies have been conducted by Rocky Flats, by universities under contract to ERDA (now DOE), and by other government laboratories. Table 3.1.1-10 summarizes these past and continuing studies. A detailed description of these programs and their findings to date is presented in Sections 2.10.4.1, 2.10.4.2, and 4.1.3.

The most extensive study of nonradiological impacts was conducted on the aquatic environs from July 20 through August 17, 1973 (Zillich, 1974). This period was chosen because streams at that time of the year are normally at low flow; consequently, the impact of waste discharges would be most evident. The following discussion summarizes this study and its results and is indicative of the nonradiological impact that normal Plant operation has on aquatic life forms.

The biotic parameters were subdivided by trophic levels as follows: the primary producers or green plants, the primary consumers (essentially the aquatic macroinvertebrates), and the secondary consumers such as fish and man. The three major subgroups within the primary producers studied were phytoplankton, rooted aquatics, and periphyton. These plant populations are nutrient dependent and often fluctuate drastically in response to minor changes in water quality. The periphyton populations were considered most indicative of impact variations in primary production. The periphyton populations were much higher at sites receiving waters from the wastewater treatment plant.

A comparison of periphyton growth in Woman Creek, which receives only surface-water runoff from precipitation, and in Walnut Creek, which does contain nutrients from sanitary waste effluents, indicated that 15 times more primary production occurred in Walnut Creek than in Woman Creek. If the discharge of nutrients were to continue

TABLE 3.1.1-10

SPECIAL ENVIRONMENTAL STUDIES AT ROCKY FLATS*

Colorado State University:

- Studies of Deer near Rocky Flats
- Plutonium Levels in Terrestrial Ecosystems
- Plutonium Levels in Aquatic Systems
- Restoration and Revegetation of Soil
- Wind Tunnel Studies of Plume Dispersion

University of Colorado:

- Plutonium Transport by Needle Ice
- Plutonium Transport by Pollen
- Vegetation Mapping

ERDA Health and Safety Laboratory (now called Environmental Measurements Laboratory):

- Resuspension of Plutonium
- Vertical Transport of Plutonium
- Horizontal and Vertical Distributions of Plutonium and Americium in the Soil
- Interrelations of Soil and Airborne Plutonium Concentrations
- Time Trends in Plutonium Concentrations in Air Near Rocky Flats

EPA - Las Vegas:

- Plutonium in Cattle near Rocky Flats
- Studies of Plutonium in People Living near Rocky Flats

Rocky Flats:

- Pond Ecology Studies
- Remote Sensing for Ecological Monitoring
- Ecological Monitoring
- Plutonium in Soil Particle Size Studies
- Plutonium Solubility in the Environment
- Chromosome Aberrations in Plutonium Workers
- Plutonium Transport through Soil
- Soil Decontamination
- Plutonium, Strontium, and Cesium in Background
- High Altitude Fallout Study

Battelle Pacific Northwest Laboratories:

- Resuspension and Particle Size of Plutonium in Soil

Oak Ridge National Laboratory:

- Particle Size of Plutonium in Soil

U. S. Geological Survey

- Hydrological Mapping of Groundwater

*References to environmental studies concerning Rocky Flats are given in Section 2.13.

at the level present during the study, the elevated algae growths could eventually lead to filtering and taste or odor problems in Great Western Reservoir. To alleviate this possibility, Broomfield treats the reservoir, as needed, with copper sulfate to reduce algae growth.

Phosphorus, the key element for the promotion of such growth, was more abundant in Walnut Creek than in other streams in the vicinity of the Plant site at the time of the study. Phosphate concentrations have been reduced since the study was conducted; consequently, the primary production should now be less. All laundry waste is now being impounded and no longer leaves the Plant site. In addition, 80% of the remaining phosphorus that was being discharged from the sewage-treatment plant is being removed by a recently installed, phosphorus-removal treatment system.

The primary consumers, macroinvertebrates such as snails, clams, mayflies, and crayfish are excellent monitors of long-term water quality. The better the water quality, the more diverse the macroinvertebrate populations tend to be. It is most significant that the diversity of macroinvertebrates in Walnut Creek, which was made up almost exclusively of Rocky Flats Plant waste discharges, was comparable to that in Woman Creek, a stream receiving essentially no discharges. Even relatively sensitive sideswimmers, mayflies, and caddisflies are present in Walnut Creek. This is indicative of a continuously high-quality discharge. The diversity and ratio of sensitive to insensitive organisms was better than in any other Denver-area stream studied by the Federal Water Pollution Control Administration [now incorporated into the Environmental Protection Agency (USDI, 1967)].

Secondary consumers such as fathead minnows, green sunfish, and western white suckers were found inhabiting Walnut Creek. Viable eggs, fry, and adult fathead minnows in spawning condition were observed in all drainages leaving the Plant site. This is significant because fatheads have been the most widely studied fresh water fish for determining the effects of potential pollutants on fish reproduction (Arthur and Eaton, 1971; Mount, 1968; Brungs, 1971; Brungs, October 1971; Brungs, 1969). The reproduction of these fish in Rocky Flats wastewater is a good indicator of the quality of the Plant's wastewaters.

Native fish from Great Western Reservoir and introduced fish held in live cages in Walnut and Woman Creeks were analyzed for chlorinated hydrocarbons. The results gave no reason for concern when compared to current Food and Drug Administration guidelines. Even the flesh of all fish held in South Walnut Creek at the Pond B-4 outfall were below 2.5 ppm for all solvents and polychlorinated biphenyls (Zillich, 1974).

In summary, the data indicate that nonradiological effluents from Plant operation have had no significant, detrimental impact on the aquatic environment.

3.1.2 Radiological Impact Assessment

The radiological impact from routine operations results from low-level, chronic releases from Plant buildings and on-site contaminated areas. The source term has been reviewed and revised since issuance of the DEIS based on current operations, procedures, and measured data. The assessment of the impact of these releases on persons residing within 50 miles of the Plant will be made in this section.

The assessment of the radiological impact on off-site persons involves the following steps. First, the source term must be determined. The source term is the amount of each radionuclide released from the Plant site, in units of curies per year. The radiological source term from future, normal operation of Rocky Flats consists of airborne and waterborne sources. Secondly, the amount of each radionuclide delivered, via the various pathways, to persons residing at various distances and directions from the Plant must be determined. The pathways pertinent to routine releases are inhalation of both the initial, unsettled airborne material and the material resuspended into the air from the soil, food and water ingestion, and irradiation by radionuclides deposited on the ground (called ground plane irradiation). The third step is to determine the dose received by a person from exposure to the radionuclides. Computer codes and equations based on recommendations of the International Commission on Radiological Protection are used to calculate doses to a person who inhales or ingests radionuclides. Since plutonium and some other radionuclides are not uniformly distributed in the body, the dose to a person will be determined for both the total body, and also the liver, bone, and lungs, which are the organs of major concern for plutonium and other radionuclides which comprise the source term. Perspective for the impact of the doses is provided by a comparison with the organ doses received by a person from natural radiation sources (called background radiation) and by an estimate of the risk of cancer mortality. The use of the total body doses as the primary dose has been deemphasized as a result of comments on the DEIS.

This section presents the results of detailed calculations. For a complete description of these calculations, see Appendix F. It is intended that the information provided in Appendix F will allow a person with no knowledge of radiation dosimetry but with mathematical skills to reproduce any dose value presented in this Chapter.

3.1.2.1 Radiological Source Terms for Airborne Releases

The airborne sources include releases from Plant buildings and the continued resuspension of plutonium from on-site soils in the vicinity of the past oil drum leakage (described in Section 2.3.9.1).

The radioactive airborne releases from past operation are discussed in Section 2.7.2. These releases were used in the development of the airborne source term for future operations. Table 3.1.2-1 shows the total airborne source term used to describe all future, normal operations of the Plant. The values in this table are considered to be overestimates.

TABLE 3.1.2-1

ANNUAL AIRBORNE SOURCE TERM FROM FUTURE NORMAL OPERATION OF ROCKY FLATS

Radionuclide	Release from Plant Buildings (μCi)	Resuspension From Soil (μCi)	Total (μCi)
Tritium (^{3}H)*	5×10^{6}	--	5×10^{6}
Uranium-234	106	**	106
Uranium-235	4	**	4
Uranium-236	0.4	**	0.4
Uranium-238	89	**	89
Thorium-231*	4	--	4
Thorium-234*	89	--	89
Plutonium-238	2	103	105
Plutonium-239	80	3,503	3,583
Plutonium-240	18	794	812
Plutonium-241*	509	22,374	22,883
Plutonium-242	2×10^{-3}	7.1×10^{-2}	7.3×10^{-2}
Americium-241	50	880	930
Miscellaneous Alpha Emitting Radionuclides	1	0	1

*Beta Emitter

**Some uranium was also released as a result of leakage from the oil drums stored outdoors (See Sec. 2.3.9.1). The uranium source term is negligible in comparison to the plutonium and americium source terms.

The source term for tritium from Plant buildings for future, normal operation is five curies per year (5×10^{6} μCi/yr). As shown in Table 2.7.2-3, the annual tritium releases for 1975-1977 were below five curies. The Plant has established an administrative limit of 0.1 Ci per month on the total amount of tritium which may be received for chemical processing at the facility. Based on the 1975-1977 releases and the administrative limit, the five curie source term is not expected to be exceeded in the future.

The annual uranium source term from Plant buildings is 100 μCi/yr of uranium alpha activity from depleted uranium plus 100 μCi/yr of uranium alpha activity from highly enriched uranium. The source term for each uranium isotope presented in Table 3.1.2-1 was calculated from the 100 μCi/yr source terms and the isotopic composition for uranium presented in Table 2.7.2-4. Thorium-231 and thorium-234 are daughter products of uranium. The activities of these beta emitting isotopes are equal to the activities of the respective parent uranium isotopes. Table 3.1.2-1 also includes these two isotopes as part of the uranium source term. Past releases of alpha activity from depleted uranium and enriched uranium facilities are shown in Table 2.7.2-3. As described in Section 2.7.2, major effluent filtration improvements were made in 1970. The history of releases since 1970 is considered to be indicative of probable future releases. Annual releases from depleted and enriched uranium facilities from 1971-1977 were all below 100 μCi, which is used as the source term.

The source term for plutonium alpha activity from Plant buildings is 100 μCi/yr. The activities of the plutonium isotopes listed in Table 3.1.2-1 were calculated from the isotopic composition of Rocky Flats plutonium, as given in Table 2.7.2-2. With the exception of plutonium-241, which is a beta emitter, the summation of the remaining plutonium isotopes yields the 100 μCi/yr total of plutonium alpha activity. Past airborne releases from plutonium facilities are shown in Table 2.7.2-1. The effluent filtration system improvements made in 1970 also resulted in reduced emissions from plutonium facilities. The 100 μCi/yr source term is based on the annual releases from 1971-1977 and on the administrative controls described in Section 2.7.2.

The source term for americium alpha activity from Plant buildings is 50 μCi/yr. Americium-241 is present in Rocky Flats plutonium as the result of radioactive decay of plutonium-241. Rocky Flats plutonium is, in general, about 10 years old*, which results in an americium-to-plutonium activity ratio of from 0.1 to 0.2. During processing, americium is separated from the plutonium, and this separation can result in a ratio for materials released different from the ratio which existed in the mixture.

Americium concentrations were measured in the effluent from a facility where americium has been handled in the chemically separated form. The americium to plutonium alpha activity ratio in the effluent did not exceed 0.42. The 50 μCi/yr source term for americium is based on an americium-to-plutonium alpha activity ratio of 0.5 and the plutonium source term of 100 μCi/yr.

In addition, a source term of 1 μCi/yr of miscellaneous alpha emitting isotopes was included. This source term includes additional isotopes of thorium, curium, neptunium, and uranium which are handled at Rocky Flats. The total amounts of these materials (gram quantities) are much smaller than for plutonium or uranium; therefore the expected source term is much smaller than that for plutonium or uranium. Measurements of curium before effluent filtration have substantiated this expectation.

The source term from resuspension of plutonium in on-site soil is 4400 μCi/yr of plutonium alpha activity. Extensive field measurements and calculations have been performed on reentrainment (resuspension) of the plutonium from a Rocky Flats test site (Michels, 1973). These measurements indicate that the fraction of the plutonium

*Created by reactor about 10 years ago.

in soil which will be reentrained each year is about 6.3×10^{-4}. Using this fraction, the plutonium source term from the on-site plutonium not covered by the asphalt pad (~6.9 Ci) was calculated to be about 4400 µCi/yr. The activities of the plutonium isotopes in Table 3.1.2-1 were calculated from the isotopic composition in Table 2.7.2-2.

Americium is present in the soil as the result of plutonium-241 beta decay. On the basis of measurements of the on-site americium-to-plutonium alpha activity ratio, the americium activity will not exceed 0.2 times the plutonium alpha activity. Based on the maximum ratio and a plutonium source term of 4400 µCi/yr, the americium source term was calculated to be 880 µCi/yr.

3.1.2.2 Radiological Source Term for Drinking Water

Feasible mechanisms for transport of radioactive materials of Rocky Flats origin to drinking water supplies are (1) the surface water drainage systems (waterborne source) and (2) deposition onto the water bodies from the air (airborne source).

Waterborne radionuclide concentrations are determined by tracing the flow of water effluents from the Plant to nearby reservoirs which serve as raw water supplies to population areas. As described in Section 2.3.5.1, and depicted in Figures 2.3.9-2 and 2.3.9-3, surface runoff and treated sanitary effluents from Rocky Flats flow exclusively through two water courses, Walnut Creek and Woman Creek, which flow into Great Western Reservoir and Standley Lake, respectively. Therefore, radionuclides in Rocky Flats waterborne effluents may be present in community drinking water obtained from these two reservoirs. Additionally, the airborne deposition of radionuclides of Plant origin onto nearby reservoirs is considered to be a possible contributor to the radiological impact of future normal operations.

Great Western Reservoir and Standley Lake receive water from Rocky Flats drainage systems. In population areas supplied by Great Western Reservoir and Standley Lake, measured concentrations of radionuclides in tap water were used to calculate dose commitments from future normal operations. These concentrations represent maximum expected values attributed to Rocky Flats origin and are presented in Table 3.1.2-2. Samples of Broomfield and Westminster tap water were used for plutonium, americium, and uranium. Samples from Great Western Reservoir and Standley Lake were used for tritium concentration measurements. The concentrations for plutonium and americium in drinking water from Great Western and Standley Reservoirs are based on a review of tap water data from the years 1974 through 1977. Averages for these years are in all cases less than 0.1 pCi/l without background correction. The source term is therefore the maximum expected concentration, an intentional overestimate. More recent data show plutonium concentrations in tap water of ~0.02 pCi/l or less. In the case of tritium, an estimated regional background of 500 pCi/l was subtracted (Rockwell, 1978).

TABLE 3.1.2-2

MAXIMUM EXPECTED RADIONUCLIDE CONCENTRATIONS IN TAP WATER RESULTING FROM FUTURE NORMAL OPERATIONS

	Concentration (pCi/l)	
Isotope	Great Western Reservoir	Standley Lake
Pu-239 and Pu-240	0.1	0.1
Am-241	0.1	0.1
Uranium	2.0	2.0
Tritium	200	100

No other regional water supplies receive water from the Rocky Flats drainage systems. Therefore, the concentrations of radionuclides of Rocky Flats origin can result only by deposition onto these water bodies from airborne radionuclides. A report (Denver Water Department, 1975) prepared for the Colorado State Legislature Metropolitan Water Studies Committee gives the current and projected water requirements and resources for the Denver metropolitan area. The following is a list of major reservoirs that serve as water supplies for the Denver metropolitan area: Gross Reservoir, Ralston Reservoir, Dillon Reservoir, Homestake Reservoir, Eleven Mile Reservoir, Lake Cheesman, and Standley Lake. Additionally, surface water sources include the South Platte River, Clear Creek, St. Vrain Creek, Boulder Creek, South Boulder Creek, and Cherry Creek. With the exception of Standley Lake, these reservoirs and streams do not receive water from the Rocky Flats drainage systems. Therefore, the only mechanism for transport of radionuclides from Rocky Flats to other Denver metropolitan water supplies is the airborne pathway. Concentrations of radionuclides in water supplies other than Standley Lake were determined by modeling airborne releases (see Appendix F).

3.1.2.3 General Methodology for Dose Calculations

For this Impact Statement the primary emphasis is placed on the dose received by a person (reference man) living in the vicinity of the Plant for a period of 70 years. This dose will be called the 70-year dose from 70 years of Plant operation. The unit of dose equivalent is the rem. In this Impact Statement, the terms "dose" and "dose equivalent" are used interchangeably. The dose in rem is the product of 1) the energy absorbed in a unit mass of the absorbing material, 2) a quality factor, which adjusts the value for the relative biological effect from different types of radiation, and 3) a distribution factor, which adjusts for possible nonuniform distribution of energy deposition in an organ or tissue. One rem of dose to a tissue or organ from X ray or gamma radiation is therefore equivalent in biological effect to one rem of alpha radiation to the same tissue, when appropriate quality and distribution factors are used. Rem doses from all types of radiation are directly additive for a given mass of tissue or organ. Reference man refers to the adult male with organ masses and intake rates defined by ICRP Publication #23 "Report of the Task Group on Reference Man" (ICRP, 1975). The doses to individuals other than reference man are also considered, using organ masses and intake rates derived from ICRP Publication #23.

The 70-year dose from 70 years of Plant operation to a person living within 50 miles of the Plant is the sum of doses received via inhalation, food and water ingestion, and ground plane irradiation. The following are some of the considerations for the determination of the contribution to the total dose from each of the pathways.

For the inhalation pathway, a person was assumed to inhale radionuclides both from the airborne chronic release and from radionuclides deposited on the ground and then resuspended. The amount of the resuspended material inhaled over the 70 years is equal to 0.86 of the amount inhaled from the chronic release (see Appendix F for the derivation of this factor). For Am-241 there is an additional contribution, since Am-241 is produced from beta decay of deposited Pu-241. The contribution from resuspension of this Am-241 is equal to 4.7×10^{-3} times the airborne source term for Pu-241 (see Appendix F for the derivation of this factor). The dispersion of the airborne release to locations within 50 miles of the Plant was determined by multiplying the total airborne source term (in units of activity released per second) by the dispersion factor (χ/Q, in units of sec/m^3), discussed and tabulated in Appendix B-2. The product is the radionuclide concentration in air at the point of interest, in units of curies per cubic meter (Ci/m^3). Comparison with measured concentrations shows that this method of calculation overestimates the concentration of airborne radionuclides (Rockwell, 1978). The dose to the organs of a person inhaling air with that radionuclide concentration can be calculated by use of dose conversion factors, generated from the DACRIN computer code (Houston et al., 1974). The DACRIN code, developed by Battelle-Pacific Northwest Laboratories, is based on a model recommended by the ICRP in the report of the Task Group on Lung Dynamics (ICRP, 1966), updated by recommendations in ICRP Publication #19 (ICRP, 1972). Dose conversion factors generated by the DACRIN code are presented in Appendix F.

For analysis of the food ingestion pathway, it is first necessary to estimate the fraction of a person's diet which could be affected by effluents from Rocky Flats. Uptake through roots, intake of forage by grazing animals, intake of feed grains by animals, and deposition on vegetables and fruit were all considered for the food pathway. The only significant pathway of radionuclides to food was found to be via airborne releases, which then can be deposited directly on vegetation or on soil. It was assumed that the fraction of the diet which contributes to the dose was produced at the location of each consumer. This assumption tends to be conservative, since most sites of major food production in the 50-mile vicinity of the Plant are farther from the Plant site than the locations of the major population centers. Modeling of the uptake by plants and animals and generation of subsequent dose conversion factors for doses to the organs of consumers is accomplished by the FOOD computer code (and a derived code PABLM) developed by Battelle-Pacific Northwest Laboratories (Baker, 1977).

For the water ingestion pathway, the drinking water source terms, presented and discussed in Section 3.1.2.2, were used for persons consuming water supplied from Great Western and Standley Reservoirs. For all other persons, dispersion modeling of airborne releases was used to determine the extent of contamination of other water supplies. See Appendix F for details of this calculation. Dose conversion factors for water ingestion were derived from basic principles (see Appendix F) using data drawn from ICRP Publications #2 and 19 (ICRP, 1959 and ICRP, 1972) and from the EPA Summary Report "Proposed Guidance on Dose Limits for Persons Exposed to Transuranium Elements in the General Environment" (USEPA, 1977).

For the dose from ground plane irradiation, the method of calculation was to determine the ground surface concentration (curies per square meter) as a function of time for a chronic release, multiply that function by the dose conversion factor generated by the EXREM computer code (Trubey and Kaye, 1973), and then integrate the dose over 70 years. Refer to Appendix F for the derivation of the function and the details of the calculation. The dispersion of the released material to locations at various distances and directions from the Plant was accomplished, as for the other pathways, by the multiplication of the airborne source term by the χ/Q dispersion factor, accompanied by deposition at the location of interest. No depletion of the plume was assumed until it reached the location of interest. This conservative assumption was used for all pathways.

The dose to a person at a given distance and direction from the Plant is the sum of the doses from all of these pathways.

3.1.2.4 Impact Assessment for Normal Operations

The 70-year organ doses (rem) from 70 years of exposure to routine Plant releases to reference man were expanded from the DEIS to show doses to individuals for sixteen directions and at eight distances from the Plant, and are presented in Table 3.1.2-3. Each value in this table is the sum of doses from inhalation, food and water ingestion, and ground plane irradiation.

Although the values in Table 3.1.2-3 are for reference (adult) man, values for other individuals can be obtained in this FEIS as compared to the DEIS. Table 3.1.2-4 presents values of the ratio to reference (adult) man for males and females who begin the 70-year exposure at an age less than 20 years and for adult females. When the ratios are composited in proportion to the dose contribution from each pathway, the composite ratio is 1.35 or less for any organ and for any individual. Therefore, one can apply the values presented for reference man to all other individuals with a maximum possible underestimate of 35%.

TABLE 3.1.2-3

THE 70-YEAR DOSE TO REFERENCE MAN FROM 70 YEARS OF NORMAL PLANT OPERATION FROM CHRONIC RELEASES

Direction	Distance (miles)	Organ Dose (rem) to Reference Man: Total Body	Liver	Bone	Lungs
N	2-3	8.6×10^{-5}	1.1×10^{-2}	2.5×10^{-2}	1.1×10^{-2}
	3-4	4.5×10^{-5}	5.7×10^{-3}	1.3×10^{-2}	5.7×10^{-3}
	4-5	2.9×10^{-5}	3.7×10^{-3}	8.2×10^{-3}	3.6×10^{-3}
	5-10	2.0×10^{-5}	2.6×10^{-3}	5.8×10^{-3}	2.6×10^{-3}
	10-20	7.3×10^{-6}	9.1×10^{-4}	2.0×10^{-3}	9.0×10^{-4}
	20-30	2.8×10^{-6}	3.3×10^{-4}	7.5×10^{-4}	3.3×10^{-4}
	30-40	1.7×10^{-6}	1.9×10^{-4}	4.3×10^{-4}	1.9×10^{-4}
	40-50	1.2×10^{-6}	1.3×10^{-4}	2.9×10^{-4}	1.3×10^{-4}
NNE	2-3	8.3×10^{-5}	1.1×10^{-2}	2.4×10^{-2}	1.1×10^{-2}
	3-4	4.4×10^{-5}	5.6×10^{-3}	1.3×10^{-2}	5.5×10^{-3}
	4-5	2.8×10^{-5}	3.5×10^{-3}	8.0×10^{-3}	3.5×10^{-3}
	5-10	2.0×10^{-5}	2.5×10^{-3}	5.7×10^{-3}	2.5×10^{-3}
	10-20	7.2×10^{-6}	8.9×10^{-4}	2.0×10^{-3}	8.8×10^{-4}
	20-30	2.8×10^{-6}	3.3×10^{-4}	7.5×10^{-4}	3.3×10^{-4}
	30-40	1.7×10^{-6}	1.9×10^{-4}	4.3×10^{-4}	1.9×10^{-4}
	40-50	1.2×10^{-6}	1.3×10^{-4}	2.9×10^{-4}	1.3×10^{-4}
NE	2-3	3.8×10^{-4}	4.8×10^{-2}	1.1×10^{-1}	4.8×10^{-2}
	3-4	2.0×10^{-4}	2.6×10^{-2}	5.8×10^{-2}	2.6×10^{-2}
	4-5	1.3×10^{-4}	1.7×10^{-2}	3.8×10^{-2}	1.7×10^{-2}
	5-10	9.4×10^{-5}	1.2×10^{-2}	2.7×10^{-2}	1.2×10^{-2}
	10-20	3.5×10^{-5}	4.4×10^{-3}	1.0×10^{-2}	4.4×10^{-3}
	20-30	1.4×10^{-5}	1.7×10^{-3}	3.9×10^{-3}	1.7×10^{-3}
	30-40	8.2×10^{-6}	1.0×10^{-3}	2.3×10^{-3}	1.0×10^{-3}
	40-50	5.7×10^{-6}	7.1×10^{-4}	1.6×10^{-3}	7.0×10^{-4}
ENE	2-3	4.5×10^{-4}	5.7×10^{-2}	1.3×10^{-1}	5.7×10^{-2}
	3-4	2.4×10^{-4}	3.1×10^{-2}	6.9×10^{-2}	3.0×10^{-2}
	4-5*	1.0×10^{-3}	5.1×10^{-2}	1.2×10^{-1}	2.1×10^{-2}
	5-10*	9.7×10^{-4}	4.5×10^{-2}	1.0×10^{-1}	1.5×10^{-2}
	10-20**	5.9×10^{-4}	3.6×10^{-2}	8.2×10^{-2}	5.8×10^{-3}
	20-30	1.6×10^{-5}	2.1×10^{-3}	4.7×10^{-3}	2.1×10^{-3}
	30-40	9.7×10^{-6}	1.2×10^{-3}	2.8×10^{-3}	1.2×10^{-3}
	40-50	6.8×10^{-6}	8.5×10^{-4}	1.9×10^{-3}	8.4×10^{-4}

*Considered to drink water supplied from Great Western Reservoir
**Considered to drink water supplied from Standley Lake

TABLE 3.1.2-3 (continued)

Direction	Distance (miles)	Organ Dose (rem) to Reference Man Total Body	Liver	Bone	Lungs
E	2-3**	1.0×10^{-3}	9.3×10^{-2}	2.1×10^{-1}	6.3×10^{-2}
	3-4**	8.1×10^{-4}	6.4×10^{-2}	1.5×10^{-1}	3.4×10^{-2}
	4-5**	7.2×10^{-4}	5.2×10^{-2}	1.2×10^{-1}	2.2×10^{-2}
	5-10**	6.7×10^{-4}	4.6×10^{-2}	1.1×10^{-1}	1.6×10^{-2}
	10-20**	5.9×10^{-4}	3.6×10^{-2}	8.3×10^{-2}	6.3×10^{-3}
	20-30	1.8×10^{-5}	2.2×10^{-3}	5.0×10^{-3}	2.2×10^{-3}
	30-40	1.0×10^{-5}	1.3×10^{-3}	3.0×10^{-3}	1.3×10^{-3}
	40-50	7.3×10^{-6}	9.1×10^{-4}	2.2×10^{-3}	9.5×10^{-4}
ESE	2-3**	1.1×10^{-3}	1.1×10^{-1}	2.4×10^{-1}	7.5×10^{-2}
	3-4**	8.6×10^{-4}	7.0×10^{-2}	1.6×10^{-1}	4.0×10^{-2}
	4-5**	7.5×10^{-4}	5.6×10^{-2}	1.3×10^{-1}	2.6×10^{-2}
	5-10**	6.9×10^{-4}	4.9×10^{-2}	1.1×10^{-1}	1.9×10^{-2}
	10-20**	6.0×10^{-4}	3.7×10^{-2}	8.6×10^{-2}	7.3×10^{-3}
	20-30	2.1×10^{-5}	2.6×10^{-3}	5.9×10^{-3}	2.6×10^{-3}
	30-40	1.2×10^{-5}	1.5×10^{-3}	3.4×10^{-3}	1.5×10^{-3}
	40-50	8.5×10^{-6}	1.1×10^{-3}	2.4×10^{-3}	1.1×10^{-3}
SE	2-3	4.4×10^{-4}	5.6×10^{-2}	1.3×10^{-1}	5.5×10^{-2}
	3-4	2.3×10^{-4}	3.0×10^{-2}	6.7×10^{-2}	3.0×10^{-2}
	4-5	1.5×10^{-4}	1.9×10^{-2}	4.3×10^{-2}	1.9×10^{-2}
	5-10	1.1×10^{-4}	1.4×10^{-2}	3.1×10^{-2}	1.4×10^{-2}
	10-20	4.0×10^{-5}	5.0×10^{-3}	1.1×10^{-2}	5.0×10^{-3}
	20-30	1.5×10^{-5}	1.9×10^{-3}	4.4×10^{-3}	1.9×10^{-3}
	30-40	9.0×10^{-5}	1.1×10^{-3}	2.6×10^{-3}	1.1×10^{-3}
	40-50	6.3×10^{-6}	7.8×10^{-4}	1.8×10^{-3}	7.8×10^{-4}
SSE	2-3	3.0×10^{-4}	3.8×10^{-2}	8.6×10^{-2}	3.8×10^{-2}
	3-4	1.6×10^{-4}	2.0×10^{-2}	4.5×10^{-2}	2.0×10^{-2}
	4-5	1.0×10^{-4}	1.3×10^{-2}	2.9×10^{-2}	1.3×10^{-2}
	5-10	7.3×10^{-5}	9.3×10^{-3}	2.1×10^{-2}	9.2×10^{-3}
	10-20	2.6×10^{-5}	3.3×10^{-3}	7.5×10^{-3}	3.3×10^{-3}
	20-30	1.0×10^{-5}	1.3×10^{-3}	2.9×10^{-3}	1.3×10^{-3}
	30-40	6.0×10^{-6}	7.4×10^{-4}	1.7×10^{-3}	7.4×10^{-4}
	40-50	4.2×10^{-6}	5.1×10^{-4}	1.2×10^{-3}	5.1×10^{-4}

*Considered to drink water supplied from Great Western Reservoir
**Considered to drink water supplied from Standley Lake

TABLE 3.1.2-3 (continued)

Direction	Distance (miles)	Organ Dose (rem) to Reference Man Total Body	Liver	Bone	Lungs
S	2-3	1.7×10^{-4}	2.2×10^{-2}	4.9×10^{-2}	2.2×10^{-2}
	3-4	8.9×10^{-5}	1.1×10^{-2}	2.6×10^{-2}	1.1×10^{-2}
	4-5	5.7×10^{-5}	7.2×10^{-3}	1.6×10^{-2}	7.1×10^{-3}
	5-10	4.0×10^{-5}	5.1×10^{-3}	1.1×10^{-2}	5.1×10^{-2}
	10-20	1.4×10^{-5}	1.8×10^{-3}	4.0×10^{-3}	1.8×10^{-3}
	20-30	5.3×10^{-6}	6.5×10^{-4}	1.5×10^{-3}	6.5×10^{-4}
	30-40	3.1×10^{-6}	3.7×10^{-4}	8.3×10^{-4}	3.7×10^{-4}
	40-50	2.1×10^{-6}	2.5×10^{-4}	5.6×10^{-4}	2.5×10^{-4}
SSW	2-3	1.2×10^{-4}	1.6×10^{-2}	3.6×10^{-2}	1.6×10^{-2}
	3-4	6.4×10^{-4}	8.2×10^{-3}	1.8×10^{-2}	8.1×10^{-3}
	4-5	4.1×10^{-5}	5.2×10^{-3}	1.2×10^{-2}	5.1×10^{-3}
	5-10	2.9×10^{-5}	3.6×10^{-3}	8.2×10^{-3}	3.6×10^{-3}
	10-20	9.9×10^{-6}	1.2×10^{-3}	2.8×10^{-3}	1.2×10^{-3}
	20-30	3.7×10^{-6}	4.4×10^{-4}	1.0×10^{-3}	4.4×10^{-4}
	30-40	2.1×10^{-6}	2.5×10^{-4}	5.5×10^{-4}	2.4×10^{-4}
	40-50	1.5×10^{-6}	1.6×10^{-4}	3.7×10^{-4}	1.6×10^{-4}
SW	2-3	1.1×10^{-4}	1.4×10^{-2}	3.2×10^{-2}	1.4×10^{-2}
	3-4	5.8×10^{-5}	7.2×10^{-3}	1.6×10^{-2}	7.1×10^{-3}
	4-5	3.5×10^{-5}	4.5×10^{-3}	1.0×10^{-2}	4.5×10^{-3}
	5-10	2.5×10^{-5}	3.1×10^{-3}	7.1×10^{-3}	3.1×10^{-3}
	10-20	8.4×10^{-6}	1.0×10^{-3}	2.4×10^{-3}	1.0×10^{-3}
	20-30	3.0×10^{-6}	3.6×10^{-4}	8.2×10^{-4}	3.6×10^{-4}
	30-40	1.8×10^{-6}	2.0×10^{-4}	4.5×10^{-4}	2.0×10^{-4}
	40-50	1.2×10^{-6}	1.3×10^{-4}	3.0×10^{-4}	1.3×10^{-4}
WSW	2-3	6.6×10^{-5}	8.3×10^{-3}	1.9×10^{-2}	8.3×10^{-3}
	3-4	3.3×10^{-5}	4.2×10^{-3}	1.0×10^{-2}	4.2×10^{-3}
	4-5	2.1×10^{-5}	2.6×10^{-3}	5.9×10^{-3}	2.6×10^{-3}
	5-10	1.4×10^{-5}	1.8×10^{-3}	4.1×10^{-3}	1.8×10^{-3}
	10-20	4.9×10^{-6}	6.0×10^{-4}	1.4×10^{-3}	6.0×10^{-4}
	20-30	1.8×10^{-6}	2.1×10^{-4}	4.7×10^{-4}	2.1×10^{-4}
	30-40	1.1×10^{-6}	1.1×10^{-4}	2.5×10^{-4}	1.1×10^{-4}
	40-50	7.6×10^{-7}	7.3×10^{-5}	1.7×10^{-4}	7.3×10^{-5}

TABLE 3.1.2-3 (continued)

Direction	Distance (miles)	Organ Dose (rem) to Reference Man Total Body	Liver	Bone	Lungs
W	2-3	3.0×10^{-5}	3.9×10^{-3}	8.7×10^{-3}	3.8×10^{-3}
	3-4	1.5×10^{-5}	1.9×10^{-3}	4.3×10^{-3}	1.9×10^{-3}
	4-5	9.5×10^{-6}	1.2×10^{-3}	2.7×10^{-3}	1.2×10^{-3}
	5-10	6.6×10^{-6}	8.2×10^{-4}	1.9×10^{-3}	8.2×10^{-4}
	10-20	2.3×10^{-6}	2.7×10^{-4}	6.0×10^{-4}	2.6×10^{-4}
	20-30	8.9×10^{-7}	9.0×10^{-5}	2.0×10^{-4}	8.9×10^{-5}
	30-40	5.7×10^{-7}	4.9×10^{-5}	1.1×10^{-4}	4.8×10^{-5}
	40-50	4.3×10^{-7}	3.2×10^{-5}	7.3×10^{-5}	3.1×10^{-5}
WNW	2-3	3.9×10^{-5}	4.9×10^{-3}	1.1×10^{-2}	4.9×10^{-3}
	3-4	1.9×10^{-5}	2.4×10^{-3}	5.5×10^{-3}	2.4×10^{-3}
	4-5	1.2×10^{-5}	1.5×10^{-3}	3.4×10^{-3}	1.5×10^{-3}
	5-10	8.3×10^{-6}	1.0×10^{-3}	2.3×10^{-3}	1.0×10^{-3}
	10-20	2.8×10^{-6}	3.3×10^{-4}	7.5×10^{-4}	3.3×10^{-4}
	20-30	1.1×10^{-6}	1.1×10^{-4}	2.5×10^{-4}	1.1×10^{-4}
	30-40	6.5×10^{-7}	6.0×10^{-5}	1.4×10^{-4}	5.9×10^{-5}
	40-50	4.9×10^{-7}	3.9×10^{-5}	8.8×10^{-5}	3.8×10^{-5}
NW	2-3	9.8×10^{-5}	1.3×10^{-2}	2.8×10^{-2}	1.2×10^{-2}
	3-4	5.0×10^{-5}	6.3×10^{-3}	1.4×10^{-2}	6.3×10^{-3}
	4-5	3.1×10^{-5}	4.0×10^{-3}	9.0×10^{-3}	3.9×10^{-3}
	5-10	2.2×10^{-5}	2.8×10^{-3}	6.2×10^{-3}	2.7×10^{-3}
	10-20	7.4×10^{-6}	9.2×10^{-4}	2.1×10^{-3}	9.1×10^{-4}
	20-30	2.5×10^{-6}	3.2×10^{-4}	7.2×10^{-4}	3.1×10^{-4}
	30-40	1.5×10^{-6}	1.7×10^{-4}	3.9×10^{-4}	1.7×10^{-4}
	40-50	1.1×10^{-6}	1.1×10^{-4}	2.6×10^{-4}	1.1×10^{-4}
NNW	2-3	9.3×10^{-5}	1.2×10^{-2}	2.7×10^{-2}	1.2×10^{-2}
	3-4	4.8×10^{-5}	6.1×10^{-3}	1.4×10^{-2}	6.1×10^{-3}
	4-5	3.0×10^{-5}	3.9×10^{-3}	8.7×10^{-3}	3.8×10^{-3}
	5-10	2.2×10^{-5}	2.7×10^{-3}	6.1×10^{-3}	2.7×10^{-3}
	10-20	7.6×10^{-6}	9.4×10^{-4}	2.1×10^{-3}	9.3×10^{-4}
	20-30	2.9×10^{-6}	3.4×10^{-4}	7.7×10^{-4}	3.4×10^{-4}
	30-40	1.7×10^{-6}	1.9×10^{-4}	4.3×10^{-4}	1.9×10^{-4}
	40-50	1.2×10^{-6}	1.3×10^{-4}	2.9×10^{-4}	1.3×10^{-4}

TABLE 3.1.2-4

THE RATIO OF THE 70-YEAR DOSE FROM 70 YEARS OF CHRONIC PLANT RELEASES FOR MALES AND FEMALES WHO BEGIN EXPOSURE AT AGES LESS THAN 20 YEARS AND FOR ADULT FEMALES TO THAT FOR REFERENCE MAN

(Values are for Pu-239 unless noted otherwise)

Pathway	Start Exposure As	Ratio to 70-Year Dose for Reference Man: Total Body	Liver	Bone	Lungs
Inhalation	Adult Female	1.10	1.15	1.34	1.14
Inhalation	10-year-old Female	1.05	1.10	1.28	1.15
Inhalation	Newborn Female	0.95	0.99	1.16	1.14
Inhalation	10-year-old Male	1.11	0.79	0.93	1.02
Inhalation	Newborn Male	1.02	0.55	0.84	1.04
Ingestion	Adult Female	0.83 0.84*	0.90	1.02 1.02**	0.83
Ingestion	10-year-old Female	0.84 0.89*	0.91	1.03 1.03**	0.84
Ingestion	Newborn Female	1.81 1.07*	1.65	1.79 1.80**	1.81
Ingestion	10-year-old Male	0.94 1.03*	0.96	0.95 0.97**	0.94
Ingestion	Newborn Male	1.47 1.17*	1.43	1.51 1.51**	1.47
Ground Plane Irradiation	All Categories	1.00	1.00	1.00	1.00

*Values for ^{3}H (tritium)

**Values for Am-241 (americium)

The maximum reference man, defined as the hypothetical individual receiving the largest doses to all organs, would reside in the ESE sector (which is the sector for maximum annual airborne radionuclide concentration) at a distance of two miles from the Plant. He would drink water supplied from Standley Lake and eat food (only that fraction of his diet grown locally) grown at his residence. The contribution to his total dose by all pathways is shown in Table 3.1.2-5 for both average and maximum intake rates. For bone, liver, and lungs, more than 70% of the dose results from inhalation, of which about 50% results from breathing resuspended material. The dose to the total body is dominated by the tritium in the food, water, and air. Tritium contributes 95% of the dose to the total body for food ingestion, 57% for water ingestion, and 1% for inhalation.

The accumulated organ dose over 70 years is less than 1.0 rem for all individuals. It is informative and valid to compare these doses with corresponding doses received by Denver area residents from natural radiation sources. Table 3.1.2-6 presents the annual and 70-year organ doses from background radiation for the Denver area, based on data in NCRP #45 "Natural Background Radiation in The United States" (NCRP, 1975). The fraction of the background doses for the maximum reference man for average intake, obtained by dividing values in Table 3.1.2-5 by corresponding values (total for 70 years) in Table 3.1.2-6 are 0.00011 for the total body, 0.010 for the liver, 0.020 for the bone, and 0.0043 for the lungs. For persons residing at other locations, the

TABLE 3.1.2-5

70-YEAR ORGAN DOSES FROM 70 YEARS OF PLANT OPERATION TO THE MAXIMUM REFERENCE MAN BY PATHWAYS

Pathway	70-Year Organ Dose (rem) for Average Intake			
	Total Body	Liver	Bone	Lungs
Inhalation	5.59×10^{-4}	7.46×10^{-2}	1.68×10^{-1}	7.41×10^{-2}
Food Ingestion	9.98×10^{-6}	6.45×10^{-5}	1.42×10^{-4}	9.88×10^{-6}
Water Ingestion	5.45×10^{-4}	3.05×10^{-2}	7.05×10^{-2}	5.45×10^{-4}
Ground Plane Irradiation	1.46×10^{-5}	1.46×10^{-5}	1.46×10^{-5}	1.46×10^{-5}
Total	1.13×10^{-3}	1.05×10^{-1}	2.39×10^{-1}	7.47×10^{-2}

Pathway	70-Year Organ Dose (rem) for Maximum Intake			
	Total Body	Liver	Bone	Lungs
Inhalation	7.55×10^{-4}	1.01×10^{-1}	2.27×10^{-1}	1.00×10^{-1}
Food Ingestion	1.97×10^{-4}	4.79×10^{-4}	9.73×10^{-4}	1.97×10^{-4}
Water Ingestion	7.57×10^{-4}	4.21×10^{-2}	9.74×10^{-2}	7.57×10^{-4}
Ground Plane Irradiation	1.46×10^{-5}	1.46×10^{-5}	1.46×10^{-5}	1.46×10^{-5}
Total	1.54×10^{-3}	1.44×10^{-1}	3.25×10^{-1}	1.01×10^{-1}

TABLE 3.1.2-6

DENVER AREA DOSES (REM/YEAR) FROM NATURAL RADIATION BACKGROUND

Source	Total Body*	Liver*	Bone	Lungs
Cosmic Radiation	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}
Cosmogenic Radionuclides	7.0×10^{-4}	7.0×10^{-4}	8.0×10^{-4}	7.0×10^{-4}
External Terrestrial	7.2×10^{-2}	7.2×10^{-2}	5.7×10^{-2}	7.2×10^{-2}
Inhaled Radionuclides	-	-	-	1.0×10^{-1}
Radionuclides in the Body	2.7×10^{-2}	2.7×10^{-2}	6.0×10^{-2}	2.4×10^{-2}
Total for 1 Year	1.5×10^{-1}	1.5×10^{-1}	1.7×10^{-1}	2.5×10^{-1}
Total for 70 Years	10.5	10.5	11.9	17.5

*The values for total body and liver are considered to be the same as the values reported for the gonads (without the 0.8 shielding factor for the external terrestrial source) in NCRP #45.

fraction of the background dose is less than these values. The impact of routine operation of the Rocky Flats Plant on persons residing continuously in the vicinity, as compared to the impact from doses received from unavoidable, natural sources, is therefore minimal.

For a person (reference man) living in the vicinity of the Plant for only one year (and then presumably moving away), it is possible to calculate a dose commitment over 70 years from one year of intake or exposure to ground plane irradiation. Values are presented in Table 3.1.2-7 as the ratio of the 70-year dose from 70 years of exposure to the 70-year dose commitment from one year of exposure, for each of the pathways.

TABLE 3.1.2-7
RATIO OF THE 70-YEAR DOSE FROM 70 YEARS OF EXPOSURE TO THE 70-YEAR DOSE COMMITMENT FROM ONE YEAR OF EXPOSURE

		Ratio of 70-Year Dose to 70-Year Dose Commitment			
Pathway	Radionuclide	Total Body	Liver	Bone	Lungs
Inhalation	Pu-239	36.7	42.0	38.0	68.0
	Am-241	40.7	42.5	38.5	68.0
	Tritium	70.0	70.0	70.0	70.0
Ingestion (Food & Water)	Pu-239	35.6	40.5	40.3	36.6
	Am-241	40.2	43.0	39.1	37.3
	Tritium	70.0	70.0	70.0	70.0
Ground Plane Irradiation	Pu-239	35.3	35.3	35.3	35.3
	Am-241	32.9	32.9	32.9	32.9

For radionuclides that are retained in the body for a long period of time (with an effective half-life of tens of years or more), the ratio of the 70-year dose from 70 years of exposure to the 70-year dose commitment from one year of exposure is about 36 to 43, while for radionuclides such as tritium with a short residence time (effective half-life is 12 days), the ratio approaches 70.

For the consideration of the effects of chronic releases, the dose to the individual has been emphasized and presented for sixteen directions and at eight distances from Rocky Flats. These doses are independent of the population distribution or growth in the 50-mile vicinity. Any person in the vicinity of the Plant can determine the upper limit of the dose that he could receive from 70 years of routine operations at Rocky Flats. (The risk from accidents will be considered in the next section of this chapter.)

To consider the effects of routine releases on population, the population distribution was determined for year 1977 and was projected for year 2000, and the population per sector and distance intervals was determined (see Figures 2.3.3-1 and 2.3.3-2 in Chapter 2). The area demography data have been updated from the DEIS using more recent data which reflect increased growth southeast of the Plant. When these population distributions are multiplied by the corresponding organ doses per person (reference man) in Table 3.1.2-3 and then summed, the result is the population dose in man-rem for that population for 70 years of exposure from routine Plant operations. The population doses from such a calculation are presented in Table 3.1.2-8.

TABLE 3.1.2-8

POPULATION DOSE (MAN-REM) FROM 70 YEARS OF ROUTINE RELEASES FOR POPULATION GROUPS BASED ON YEAR-1977 DEMOGRAPHY AND ON PROJECTED YEAR-2000 DEMOGRAPHY

Population Group	Dose (man-rem) to the Population Group over 70 Years: Total Body	Liver	Bone	Lungs
1977	1.4×10^2	1.2×10^4	2.7×10^4	7.6×10^3
2000	2.7×10^2	2.2×10^4	5.0×10^4	1.3×10^4

These doses were calculated based on the assumption that all the population in a distance range received a dose equal to that received by a person at the nearer distance. For example, for a population residing at 40 to 50 miles from the Plant, all persons were considered to receive a dose as if they were at a distance of 40 miles.

Even the revised projected population demography for the year 2000 does not indicate a high density adjacent to the Rocky Flats Plant on the east. If one postulates a higher density population of 11.4 persons per acre or 7296 persons per square mile for the east through south-southeast sectors for distances 2 to 5 miles from the Plant, the impact on the population dose can be determined for a maximized situation. This value of 7296 persons per square mile is based upon multiplying the average family size by the average number of housing units in currently developed Planned Unit Developments in the City of Westminster, and developing the entire sector to this density. This is a conservative assumption, since there is no allowance for any open space or industrial areas. Note that the population density of 7296 persons per square mile is a factor of at least 1.56 greater than the density for any section of the 1977 population demography as presented in Figure 2.3.3-1. Table 3.1.2-9 shows the percent increase in the population bone dose for year-2000 demography if the hypothetical high density east of the Plant were to occur instead of the projected demography.

TABLE 3.1.2-9

INFLUENCE OF A HYPOTHETICAL HIGH DENSITY* POPULATION EAST OF THE ROCKY FLATS PLANT ON YEAR-2000 POPULATION BONE DOSE

Population Demography	Population 70-Year Bone Dose (man-rem)	Percent Increase
Year-2000 as Projected	5.00×10^4	-
Year-2000 with high density* in eastern** sectors at 2-3 miles	5.40×10^4	8.0
Year-2000 with high density* in eastern** sectors at 2-4 miles	5.71×10^4	14.2
Year-2000 with high density* in eastern**sectors at 2-5 miles	5.99×10^4	19.8

*7296 persons per square mile
**E, ESE, SE, and SSE sectors

The unit of dose equivalent, the rem, is an indirect measure of potential health effects. Attempts have been made to assess the risk in terms of health effects or genetic damage that might result from dose commitments made to general populations. The National Academy of Sciences in the BEIR Report (NAS, 1972) assumed a no-threshhold model of dose-to-effect relationship to derive quantitative risk estimates. The BEIR Report does not imply that health effects will be observed at all dose levels. The Report states that, in the absence of sufficient data to prove a true relationship, a no-threshhold linear model should be adopted as a conservative estimator of potential risk. It must be emphasized that the interpolated risk estimates of the BEIR model rest on conservative assumptions; there is no experimental basis for choosing between these estimates and an estimate of zero risk. The National Council on Radiation Protection and Measurements (NCRP) has warned Federal agencies against making quantitative health effect estimates based on population dose, when individual exposures are low relative to the RCG's. This Environmental Impact Statement presents risk assessments based on the BEIR Report to reflect all possible potential risks.

It should be noted that effects of irradiation from external sources, Japanese survivors of the atomic bomb in particular and irradiated spondylitics, were heavily weighted in arriving at risk estimates in the BEIR report. The BEIR Report makes estimates of absolute risk and relative risk. The lowest is the absolute risk model with a 30-year plateau, referred to as the "absolute model." The highest is the relative risk model with a lifetime plateau, referred to as the "relative model." In the tables on pp. 169 and 171 of the BEIR Report (NAS, 1972), excess deaths from cancers other than leukemia for the U.S. population, per 0.1 rem per person per year (20 million man-rem per year), are predicted as 1,210 by the "absolute model" and 8,340 by the "relative model."

The fraction of different cancer types given in the BEIR Report, along with the assumption that liver cancers will be induced in direct proportion to their incidence in the Hiroshima-Nagasaki survivors, was used to calculate the cancer mortality risk values shown in Table 3.1.2-10. Also shown in Table 3.1.2-10 are the single number, estimate values considered by EPA (USEPA, May 1974) and the Colorado Department of Health (CDH, 1976) to represent the cancer mortality risk, which is within the BEIR Report risk range.* Final values chosen for this report are also shown in Table 3.1.2-10. The values chosen for this Environmental Impact Statement are not meant to imply official mandating or recommendation of any particular cancer risk estimate, but are chosen as reasonable estimates of potential cancer risks so as to clearly present risk data.

Note that also shown in Table 3.1.2-10 are potential genetic effect risks based on the BEIR Report data. The uncertainties in the genetic risk estimates are large, but Newcombe (1975) suggests that the true risk values are near the lower end of the BEIR Report range. The population dose to be used in conjunction with these genetic risk numbers should be that to the reproductive organs, of which dose to the gonads of man is the primary concern. Based on the best estimates of deposition of actinides in gonads (Durbin, 1973 and Richmond and Thomas, 1975) the dose to the gonads will be less than the total body dose (i.e., no concentration of actinides in gonadal tissue is assumed). There is some controversy on this issue, but the use of total body dose as a pessimistic estimate of gonadal dose has been supported by NRC staff and is consistent with dose conversion values used by ERDA in the LMFBR statement (USERDA, 1975). Potential genetic effects in this EIS will be calculated using total-body doses and assuming 300 effects per 10^6 man-rem as shown in Table 3.1.2-10. This treatment is considered conservative, but again is not meant to represent an official recommended value for genetic risk.

When one multiplies the values of risk of cancer mortalities or genetic defects per man-rem, given in Table 3.1.2-10, by the values of the 70-year dose for the year-1977 or the year-2000 population groups, given in Table 3.1.2-8, the result is the possible number of effects for that population group over 70 years from a continuous 70-year exposure from routine releases from the Rocky Flats Plant. The results of this calculation are presented in Table 3.1.2-11.

The possible number of effects, given in Table 3.1.2-11, totals less than 1 for the 1977 population group, consisting of 1.8 million persons, over a time period of 70 years, and 1 for the year-2000 population group of 3.5 million persons. It can be shown that the possible health effects over 70 years in any population which is beyond the 50 mile distance from the Plant and which may be affected by radioactive effluents from the Plant is much less than the values presented in Table 3.1.2-11. As stated in the conclusion to Appendix G-1, by R. C. Thompson and W. J. Bair of Battelle-Pacific Northwest Laboratories, since these values are already so small, "...it

*Note that the BEIR Report, page 170, does indicate that the relative risk model, on which the higher numbers in the range of risk values are based, might generate elevated risk estimates due to the projection of high relative risk data of young people into the over-50-year-old age group in which the spontaneous cancer rate is very high.

TABLE 3.1.2-10

RISK ESTIMATES PER MAN-REM OF DOSE

Estimated By	Cancer Mortalities per Man-Rem: Total Body	Liver	Bone	Lungs
BEIR Report[1]	9.0×10^{-5} to 4.5×10^{-4}	1×10^{-6} to 7×10^{-6}	2×10^{-6} to 1.7×10^{-5}	1.6×10^{-5} to 1.1×10^{-4}
Colorado State Health Department[2]	-	2×10^{-6}	6×10^{-6}	4.0×10^{-5}
USEPA[3]	2×10^{-4}	-	6×10^{-6}	2.0×10^{-5}

Estimated By	Genetic Effects per Man-Rem (Total Body Dose[7]): Specific Defects[5]	Complex Defects[6]	Total
BEIR Report	5.0×10^{-5} to 5.0×10^{-4}	1.0×10^{-5} to 1.0×10^{-3}	6.0×10^{-5} to 1.5×10^{-3}
USEPA	-	3.0×10^{-4}	-
Newcombe[4]	-	-	1.0×10^{-5}

	Risk of Effect per Man-Rem Used in this Statement[8]: Total Body	Liver	Bone	Lungs
Cancer Mortalities	2.0×10^{-4}	2×10^{-6}	6×10^{-6}	4.0×10^{-5}
Genetic Defects	3.0×10^{-4}	-	-	-
Total Risk	5.0×10^{-4}	2×10^{-6}	6×10^{-6}	4.0×10^{-5}

1. (NAS, 1972)
2. (CDH, 1976)
3. (USEPA, May 1974)
4. (Newcombe, 1975)
5. Includes dominant, chromosomal, and recessive diseases
6. Includes congenital anomalies, anomalies expressed later, constitutional and degenerative diseases.
7. The dose to gonadal tissue is considered, for this impact statement, to be equal to the dose to the total body.
8. Based on the more conservative values from CDH and U.S. EPA or on a reasonable estimate of the median of the range of values from the BEIR report.

TABLE 3.1.2-11

ESTIMATED MAXIMUM NUMBER OF POSSIBLE EFFECTS (CANCER MORTALITIES PLUS GENETIC DEFECTS) TO THE YEAR-1977 AND TO THE YEAR-2000 POPULATION GROUPS OVER 70 YEARS FROM 70 YEARS OF EXPOSURE TO ROUTINE RELEASES FROM THE ROCKY FLATS PLANT

Population Group	Estimated Maximum Number of Possible Effects over 70 Years: Total Body	Liver	Bone	Lungs	Total
1977	0.07	0.025	0.16	0.30	0.57
2000	0.14	0.044	0.30	0.52	1.00

is perhaps unnecessary to stress that they are based upon conservative estimates of exposure, multiplied by conservative estimates of risk from this exposure, and that whether the actual risk approaches these numbers, or is zero, can in no way be inferred from our present knowledge."

3.2 PLANT ACCIDENTS*

The buildings and systems that handle both radioactive and other toxic materials have been constructed to prevent the occurrence of accidents and the spread of contamination if an accident occurs. Accidental releases to the environment, although very improbable, are possible. Section 3.2 summarizes the accident analyses and anticipated effects of each type of potential accident on the environment.

Most types of accidents that have the potential for significant releases to the environment can be determined by considering possible sources of material, breaches of containment, and forces for dispersion. On this basis, spills, mechanical or administrative failures, impoundment failures, fires, explosions, criticality accidents, aircraft impacts, tornadoes, high winds, and earthquakes were considered as possible causes of radioactive releases.

For each of these accidents an estimated maximum credible** release and probability of occurrence was reevaluated and recalculated in response to public comment on the DEIS. Also, a maximum credible accident for beryllium was added, the probability of impoundment failure was increased assuming the ponds would not withstand a 100-year flood and the amount of plutonium which becomes airborne in a fire was reduced. The criticality accident scenarios now include a maximum probable accident and the magnitude of the maximum credible solution criticality was increased. In some cases, where sufficient information was available (e.g., aircraft crashes), maximum probable and expected releases have been estimated. This Statement does not attempt to evaluate all possible accident scenarios that might occur, but, by considering maximum credible accidents, presents conservative estimates of the largest releases that might occur for each type of accident.

To clarify the meaning of the various terms used in the accident analyses, consider the following example. (Note: the data values are arbitrary for purposes of explanation and do not refer to any actual type of accident.) Suppose four differ-

*The accident analyses appearing in this section do not establish compliance with the detailed design criteria for new radioactive material handling facilities. The applicable detailed design criteria are specified in ERDA Manual Chapters (e.g. ERDAM 6301, General Design Criteria) and compliance with these criteria is established in detailed Safety Analysis Reports.

**The U.S. Nuclear Regulatory Commission (USNRC, 1978) recommends a cutoff value of 10^{-7} for realistic probabilities and permits a value of 10^{-6} for conservatively estimated probabilities. The smaller value of 10^{-7} is used for all cases in this EIS; that is, accidents with a probability of occurrence of less than 10^{-7} per year are not considered credible.

ent accident scenarios are evaluated, and the analysis shows that the probabilities of occurrence per year are $1x10^{-9}$, $4x10^{-7}$, $3x10^{-5}$, and $2x10^{-4}$, with corresponding releases of 50, 10, 3, and 1 Ci of plutonium. Then the second accident is the maximum credible accident, since it produces the largest release among those accidents with a probability greater than 10^{-7} per year. The first accident has a probability of $1x10^{-9}$ and is therefore not considered credible, while the third and fourth have smaller consequences and therefore are not maximum cases. The maximum probable accident is the fourth, since it has the largest probability of occurrence. The expected release for this set of accidents is found by summing the products of probability times release for each case:

$$\text{Expected release} = (1x10^{-9})(50) + (4x10^{-7})(10) + (3x10^{-5})(3) + (2x10^{-4})(1)$$
$$= 3x10^{-4}\text{Ci/year}$$

Each of the accidents considered is discussed below, followed by a summary of the accident likelihoods and expected accident releases (likelihood times release). Accident likelihood estimates are made on the basis of past Rocky Flats operating data, in addition to statistics from studies of other facilities handling radioactive or other hazardous material. A list of past reportable accidents for Rocky Flats is given in Appendix H.

3.2.1 Accidents Involving Nonradioactive Hazardous Materials

In this section a fire involving beryllium is postulated and analyzed as the maximum credible accident for nonradioactive materials. Beryllium is toxic and is handled in kilogram quantities at Rocky Flats (see Section 2.5.3.1 and 2.5.3.2). Other materials, in the quantities used at Rocky Flats (see Table 2.8-1), do not constitute a hazard to the public.

Specific data regarding the probability of accidents and releases in beryllium-handling facilities have not been generated, as they have for plutonium. Overestimates have been used for the maximum credible release. Based on previous experience, the maximum credible accident would be a fire in a heavily-loaded filter plenum system during which the HEPA filters were breached. Such a system might contain as much as 10 kg of dust, a small fraction of which would be beryllium. An even smaller fraction would be released from the stack as beryllium oxide particles in the respirable size range.

For the accident scenario, 10 kg of pure beryllium was assumed to burn over a 30 minute interval. One kilogram of beryllium oxide in the respirable size range was assumed to be released from the stack. Using Table B-2-1 of Appendix B, a maximum short-term concentration of about 7.7 $\mu g/m^3$ near the Plant boundary was obtained. This is well above the 0.01 $\mu g/m^3$ 30-day-average EPA standard, but it is below the short-term exposure of 25 μg/m^3 which has been established as the 30-minute peak concentration above the acceptable ceiling concentration for an 8-hour occupational exposure.

3.2.2 Accidents Involving Radioactive Materials

3.2.2.1 Spills of Radioactive Materials

One possible source of radioactive release to the environment is the spilling of radioactive material. This might result from the dropping of radioactive material, the tipping of containers holding radioactive materials, or leaks in containers. Spills in this section are meant to encompass only the simple, unintentional release of material from its container or controlled area. The dispersal of material from a driving force such as fire or explosion is treated separately in later sections. Only spills of radioactive materials are considered since the consequence of spilling nonradioactive materials (considering the quantities used at Rocky Flats; see Table 2.8-1) would be much smaller. Since radioactive materials are handled extensively within the Rocky Flats facility, some spills of material are inevitable. If spills occur, they most likely will occur in glove boxes or other areas having a contained air flow. In these areas air is highly filtered before release to the environment. These types of spills will result in no detectable increase in total Plant release. Spills of materials outside of glove boxes and controlled process areas might cause a small increase in the total release, since the air would pass through fewer filter stages than the glove-box air flow.

Room air from all uranium- and beryllium-handling buildings will pass through at least one High Efficiency Particulate Air (HEPA) filter, and room air from plutonium-handling buildings passes through at least two HEPA filters before release to the environment (see Section 2.7.1). Air from glove boxes containing plutonium will pass through at least four HEPA filters prior to release. Thus, even major spills of radioactive material will result in minor releases of radioactivity to the environment. Historically, most spills of radioactive material, even those requiring fairly extensive in-building cleanup, did not cause sufficient increase in the building emission rate for the release to be distinguished from normal fluctuations. As normal building releases have been reduced dramatically over the years, however, it has been possible to correlate effluent monitor records with major contamination events (see Table 2.7.2-1). Thus, the plutonium release from a plugged drain line in 1970 and a plutonium barrel-liner leak in 1971 resulted in releases to the environment of about 25 and 4 μCi of plutonium alpha activity, respectively. Since 1972, there have been no events in this category that have caused detectable increases in environmental release.

On the basis of past Rocky Flats operational history, spills of radioactive material will occasionally occur. The environmental release from past events has been quite small, typically less than 10 μCi of plutonium alpha activity. For the purposes of this Statement, a pessimistic assumption of 0.5 contamination events per year was made with an expected release of 10 μCi of plutonium alpha activity. A major contamination event was assumed to release up to 100 μCi of plutonium alpha activity. There have not been any contamination events that have resulted in environmental releases of 100 μCi; consequently, such a release likelihood is considered small, perhaps less than once in 20 years (0.05/year).

The preceding discussion has excluded consideration of the release of up to eleven curies of radioactivity caused by leakage of plutonium-contaminated oil from storage barrels (see Section 2.3.9.1). The storage area was outside the confines of any building or secondary containment. This incident is not used in the estimate of possible future releases because plutonium and plutonium-contaminated materials are no longer stored outside of buildings.

3.2.2.2 Mechanical or Administrative Failure

Accidental releases of radioactive materials to the environment were assumed to be possible as a result of a mechanical or administrative failure. There are many administrative and system-protective features incorporated in the Plant design to prevent such an occurrence, but a mechanical or administrative failure may occur. There has been one such environmental release during Rocky Flats' operating history, resulting from a design error in the filter system. This incident occurred in 1974 and resulted in a release of 934 μCi (see Table 2.7.2-1). As a result of that release, several corrective actions have been taken, including improved administrative controls on any changes affecting the operation of the exhaust system. In addition, system and monitoring changes have been implemented either to prevent a repeated occurrence or to detect abnormal releases much sooner. It might be expected that, given the system improvements that have been implemented since the accidental release, the future probability of similar releases will be less than implied by past operating history. For purposes of this Statement, however, a release source term of 1,000 μCi of plutonium alpha activity with a likelihood of 0.05 per year was assumed. The estimates of probability and amount of release are slightly greater than is actually expected. A recent EPA report (USEPA, 1975) places the probability of a failure of valves or piping within a uranium fabrication plant which would result in an environmental release at about 0.004 per year. This probability was estimated on the basis of 490 plant years of fuel fabrication experience within the U.S.

Postulation of a scenario for a maximum credible administrative failure is not meaningful; if a specific, credible scenario were known, appropriate system and administrative controls would be modified to prevent the incident or to mitigate its consequences. To provide an example, however, of the maximum credible release that can be expected for some undefined administrative failure, a maximum source term was calculated based on a filter plenum bypass similar to that which occured in 1974. The maximum release that might occur from a failure of the exhaust system can be estimated on the basis of the maximum filter loading. Maximum releases would thus result from releases of process-contaminated air without passage through the usual HEPA filter system. The maximum loading of plutonium in the exhaust duct was calculated based on a 750-gram loading of the first filter stage in 120 days. The analysis conservatively assumed 8-hours-a-day, 5-days-a-week operation yielding an air load of 3.13 $\mu Ci/m^3$. Assuming a typical exhaust flow rate for a filter plenum of 14,000 cubic feet per minute and a filter bypass occurring for 15 minutes before corrective action is taken, a total release of 19,944 µCi would occur. Releases of air at this radioactivity level for a longer period of time without corrective action being taken would require simultaneous failure of many independent systems and is much less likely to occur. The likelihood of a maximum release of 20,000 µCi to the air will be taken as one-tenth of the likelihood of any appreciable release, or 0.005 per year. This likelihood is comparable to the EPA-estimated probability of an appreciable release from a uranium fabrication plant (USEPA, 1975).

In addition to accidental releases of radioactive material to the air, accidental releases of liquid effluents might also be postulated. Note, however, that process water is no longer released off site (all process waste is now impounded on site), so mechanical or administrative failures that might result in the release of contaminated liquid waste will no longer cause an off-site release. The only present release of Plant water from the site is from the sanitary treatment plant. Sanitary waste contains only low levels of radioactive contamination. Even if some major piping error occurred, which could result in major contamination of the sanitary waste effluent, this effluent is released in batches after direct sampling to determine the radioactivity level. The probability of a major liquid release because of mechanical or administrative errors in the Plant is therefore small, and any future expected release from this mechanism would be negligible. This is particularly true since the Rocky Flats facility is being modified for a total liquid-recycle operation scheduled for 1979.

There have been past releases of tritium from Rocky Flats. In particular, the processing of metal scrap contaminated with tritium in 1973 led to the release of several hundred curies of tritium to the air and Plant waste streams. Since the 1973 incident, new administrative controls have been initiated and new equipment purchased to permit the identification of any non-specification radioisotopes in feed material handled by Rocky Flats. Because of these new controls, a repeat of the 1973 incident is highly unlikely. In addition, the source term from routine Plant operation has been set at a conservative level of 5 Ci/yr of tritium to account for the processing of materials containing tritium contamination (see Section 2.7.2).

3.2.2.3 Impoundment Failure

As discussed previously, the water in several on-site ponds contains radioactivity. The actual level of radioactivity in these waters is low, even though the pond sediment contains an appreciable inventory of radioactive material. For instance, the B-series ponds contain several curies of plutonium trapped in the pond sediment, but the concentration of plutonium alpha activity in the water of these ponds is less than 40 pCi/l. Further, the pond capacities are small, and even if the entire contents (excluding the sediments) of the B-series ponds were to be released from an accidental breaching of all of the ponds, the total amount of material released would be less than 500 μCi of plutonium alpha activity. The impoundment failure scenario does not include estimates of impacts in terms of dose acquired as a result of sediment release. Of the small fraction of the sediments which might be released, major portions would reside in the stream bed, the sediment of reservoirs, and in drinking water treatment plant filters.

The other major source of radioactive material contained in water stored on site is material in the solar evaporation ponds. There are three solar evaporation ponds designated as 207A, 207B (divided into three sections), and 207C. The ponds are asphalt-cement structures constructed near the top edge of a hill having about a 15 degree slope. A landslide of the hill could rupture one or more ponds and release contaminated wastewater into North Walnut Creek. North Walnut Creek ultimately empties into Great Western Reservoir, a water supply for the City of Broomfield.* Typical concentrations of radioactive material in the solar evaporation ponds and the total capacity of the ponds are shown in Table 3.2.2-1. The actual concentration of material will vary somewhat from pond to pond and will vary even more as a function of time. The mean concentration values, however, are averaged over several years and are reasonable values for environmental assessments.

TABLE 3.2.2-1
RADIOACTIVE MATERIAL CONCENTRATIONS
IN THE SOLAR EVAPORATION PONDS**

Material	Mean Concentration (pCi/l)	Concentration Range (pCi/l)
Americium	1,350	450 - 2,700
Plutonium	1,440	1,200 - 2,000
Uranium	8,000	2,300 - 14,000

**Total capacity of the ponds is 16 x 10^6 gallons (60.6 x 10^6 liters).

If a landslide or other release mechanism were to occur, the solar ponds most likely to rupture would be 207A and 207B-north. This result is based on the fact that leakage has occurred from these ponds only, and both are situated at the hill's

*The City of Broomfield has recently (September, 1978) received a grant of $750,000 for pumping and pipeline revisions to permit the entire city to use water from Denver in case an accident at Rocky Flats should make it necessary to discontinue use of water from Great Western Reservoir.

top edge. This means the soil under these ponds would be wet and more susceptible to sliding than the soil below the other ponds. The operating level of waste solution in these two ponds is 6,936,000 gallons; their overflow capacity is 8,584,000 gallons.

A simple rupture of the solar evaporation ponds would result in no off-site release, since water from these ponds would flow into North Walnut Creek upstream of the A-series holding ponds. The largest of the A-series holding ponds is of sufficient size to hold the capacity of all the solar ponds; consequently, any contamination would be trapped on site. For an environmental release off site, there would have to be a rupture of the A-series ponds in addition to the solar evaporation ponds. Such an occurrence would require a major driving force such as an earthquake or tremendous rainfall. If, however, all of the material in the solar evaporation ponds were released to the environment, the total release would be the product of the concentrations in Table 3.2.2-1 and the total capacity, as shown in that table. This release would be about 87,000 μCi of plutonium, 82,000 μCi of americium, and 485,000 μCi of uranium. Of this total release, most would deposit on the ground before reaching Great Western Reservoir. Much of the remainder would become trapped in the Reservoir's sediment or be removed by the City of Broomfield's water-treatment plant prior to the water being consumed by people.

This analysis assumes that all of the released material is consumed by Broomfield residents. This clearly overestimates the actual impact. The probability of an off-site release of the total inventory of the solar evaporation ponds is small. (Note that a surface runoff system under construction at Rocky Flats would hold the total site runoff in a design 100-year storm. This system, when implemented, will even further reduce the probability of any off-site release from an impoundment failure.)

Rainfalls such as the maximum recorded in the Rocky Flats area are not apt to cause the rupture of the many different ponds that would have to be involved. Thus, while an exact probability estimate was not made, it is likely that the probability is much less than 10^{-2} per year.

The new waste-treatment facility, scheduled to be in operation in 1980, will provide total recycle for Rocky Flats process wastewater. The facility will minimize the potential for accidental release of radioactivity to Great Western Reservoir. The water in solar evaporation ponds will be processed and the ponds will be used for storing purified water from the sanitary wastewater recycle plant (see Section 2.7.3.1).

3.2.2.4 Fire

Fire Prevention and Control

Accidental fires in Rocky Flats facilities are a major concern because of the pyrophoric nature of finely divided plutonium in air. Since past fires at Rocky Flats have resulted in small environmental releases, these fires have received considerable attention. As a result of these fires, extensive system improvements have been made to guard against future fires, but the handling of plutonium involves some risk of fire.

There have been two fires that have caused major damage to production buildings at Rocky Flats. These occurred in 1957 and 1969 and resulted in estimated environmental releases of 25,618 and 856 μCi of plutonium, respectively (see Table 2.7.2-1). In addition, there were three isolated fires that caused detectable releases in 1965, 1969, and 1972. Those fires resulted in releases of about 1,170; 20; and less than 2 μCi of plutonium, respectively.

Following the major building fires of 1957 and 1969, extensive improvements were made to minimize the possibility and potential consequences of future fires. Postulated fires involving nonradioactive or construction materials, along with the most effective fire-fighting techniques for these fires, are well defined in publications of the National Fire Protection Association and Factory Mutual's Loss Control Data Sheets. The theory involved in combatting these types of fires is generally to release combustion products to the atmosphere as quickly as possible to expedite fire fighting. In a fire involving plutonium, the theory is reversed. Emphasis is placed on containment of the fire and products of combustion with minimal release to the atmosphere. Major emphasis is placed on minimizing the probability of a fire. Examples include using nitrogen atmospheres, minimizing combustible loading in any given area, and assuring that fire detection and suppression systems are capable of detecting and containing a fire if one should start. These criteria have been implemented throughout the Rocky Flats fire protection systems and operating procedures. Their effectiveness is graphically illustrated by comparison of the releases attributed to the 1957 and 1969 fires, respectively. While the quantity of plutonium involved in the 1969 fire was much greater, the release was smaller than in the 1957 fire. The 1957 fire released approximately 25,618 μCi of plutonium alpha activity, while the 1969 fire, which was much more costly as an industrial accident, released only 856 μCi of plutonium alpha activity. This serves to demonstrate the success of system improvements that were initiated following the 1957 fire.

The system improvements made after the 1957 and 1969 fires are listed in Table 3.2.2-2. The initial improvements were aimed primarily at stopping the spread of a fire once it started and at preventing the release of potentially contaminated combustion products. Following the 1969 fire, system improvements emphasized the reduction of combustible material loading and containment. Subsequent Plant modifications and administrative controls were aimed primarily at reducing the probability of a fire starting and at automation of fire protection systems. Prior to 1957, it was not considered permissible to use water to any extent to fight fires involving plutonium because of the danger of producing a criticality. The necessity to use water to control the 1957 fire resulted in a later reevaluation of this philosophy. The controlled use of automatic water, fire suppression systems was included in the design of a new plutonium facility, Building 707, in 1967. After the 1969 fire, extensive investigations and experiments were conducted in an attempt to define more effective fire prevention measures in addition to improvements in fire suppression systems. Automatic water, fire suppression systems were added to filter plenums and to plutonium operating and process areas. Criticality concerns were addressed through the exclusion of sprinklers within the glove boxes, strict enforcement of fissile material limits, curbing to prevent accumulations of water in low places (e.g., stairwells), and fire-fighting personnel training. Evaluations of organizational and management policies related to the fire safety program were also conducted to ensure maximum program effectiveness. As a result, several program changes were implemented to further minimize the risk of fire through administrative controls. One change involved increased frequency of fire system inspection. Included among the other changes were maximization of response and capability to contain fires through improved detection alarm systems and personnel training.

TABLE 3.2.2-2
FIRE PROTECTION IMPROVEMENTS IMPLEMENTED SUBSEQUENT TO THE 1957 AND 1969 FIRES

Improvements Subsequent to 1957 Fire

1. Glove-box Construction - Metal strips were placed between glove-box windows to prevent fire from spreading in plexiglas glove boxes.
2. Atmosphere Control - The humidity in glove-box lines was controlled.
3. Plutonium Storage and Handling - Plutonium metal in different forms was separated in production and stored separately inside metal cans.
4. Fire Detection - A fire-detection system of heat sensors was placed in all storage areas.
5. Fire Fighting Methods - Methods were developed for controlling plutonium fires through use of inert gas, carbon dioxide, and magnesium oxide sand. The use of water on plutonium fires was still questionable because of possible problems involving nuclear safety.
6. Filter-Bank Water Spray System - Water spray systems were built for main filter plenums. (Booster plenums were not so equipped, which resulted in problems in the May 11, 1969, fire. The booster plenums now have water spray systems.)
7. Fire Mains - Stand pipes and hose connections were added in production areas.

TABLE 3.2.2-2 (Continued)

8. Utilities - Electrical utilities were relocated to avoid penetrating ventilation ducts. Dampers were placed in ventilation intake systems to preclude blowbacks in the event of an explosion. Spark-arrest screens were installed, and a system for spraying water on filters was added. A fire detection system was placed in the filter banks.
9. Multiple Exhaust Filters - As an alternative to a recommendation to provide multiple exhaust filtration, other changes were implemented. Although Rocky Flats is still using single-source filtration, the size of the exhaust plenums has been reduced and the number of such plenums has been increased. The existing large filter banks were divided into a series of smaller plenums with noncombustible partitions.
10. Modular Containment - A plutonium production facility designed subsequent to 1957 included modular separation of plutonium processing operations.

<u>Improvements Subsequent to 1969 Fire</u>

1. Heat detection systems were installed throughout all glove boxes and conveyor lines as required.
2. Major combustible loading was almost entirely eliminated by removal of large quantities of combustible radiation shielding. Removal was made possible by discontinuing the use of glove boxes for storage. Combustibles are restricted inside glove boxes, and all production materials are now enclosed in tight-fitting containers.
3. Inerting glove boxes and conveyor lines that contain material such as small pieces of plutonium and machining chips was accomplished by providing nitrogen atmosphere containing less than 5% oxygen. (Glove boxes and lines containing only final massive forms of plutonium are not necessarily inerted, because there have been no recorded cases of spontaneous ignition of massive forms of plutonium).
4. Ventilation systems were completely revised and improved to ensure their integrity in providing necessary fire protection.
5. Internal walls and doors in all major production buildings have been upgraded to provide proper fire cutoffs and area separation.
6. The external walls of these building were upgraded and sealed. These measures help protect against contamination being released to the external environment in the event of a possible fire.
7. Wet pipe sprinkler protection was provided to obtain 100% coverage in all production areas.
8. Improvements to the Plant's underground water system, with additional storage and pumping capacity, were completed.

TABLE 3.2.2-2 (Continued)

9. Plant alarm systems were upgraded to relay information from other updated fire protection measures. These upgradings enhance instant response to any possible emergency on the site.
10. Extensive studies of solvents used in all areas containing fine plutonium pieces were done, and some solvents have been replaced with less reactive solvent types.

In conjunction with investigations and research conducted by the contractor and the AEC following the 1969 fire, a comprehensive assessment was conducted under AEC contract by Factory Insurance Association, an organization with over 80 years of experience in fire safety. In 1970, arrangements were made with the Factory Insurance Association and Factory Mutual Systems, the largest underwriters of improved risk fire insurance, to inspect AEC facilities against highest industrial standards. The intent was to provide fire protection systems in which the minimum protection level is at least equal to the "Highly Protected Risk" category of insurance underwriters. [This program has been included in ERDA Manual Appendix 0552. Inspections are to be conducted periodically (at approximately five-year intervals) at major DOE facilities, including Rocky Flats.]

Two surveys have been made by the Factory Insurance Association (FIA) at the Rocky Flats Plant. The initial survey was completed in 1970 and was comprehensive from the standpoint of capital-loss fire protection. It resulted in 105 recommendations. A second survey of the Rocky Flats Plant was undertaken by FIA during September and October, 1974. Results of that survey were noted in a report dated January 23, 1975. The following is quoted from the introduction to the report:

> "The survey is a reinspection of the Rocky Flats Plant and reflects the major changes in fire prevention and protection which have been accomplished since the original survey by the Factory Insurance Association conducted during the Fall of 1969. Most of the recommendations outlined in the report of the earlier survey have been accomplished resulting in a well protected plant having good loss prevention programs."
>
> ". . .new buildings have been constructed utilizing superior protection and prevention criteria."

Those recommendations not completed at the time of the second survey were either in the construction phase or were covered by an approved exemption. Exemptions were granted only where noncompliance would not result in undue hazard to life, off-site contamination, vital program impairment, or probable fire loss in excess of one million dollars. It should be noted that only six exemptions to the FIA recommendations were granted by ERDA for Rocky Flats. The second survey report contains 48 recommendations. As of December 31, 1977, 42 recommendations had been completed, 2 were in progress, and 4 were in the 6 previously discussed exceptions. Recommendations regarding the 1969 fire's cause-effect relationship have been implemented.

The FIA also stated, "There have been a number of significant changes in the basic organization of the Loss Prevention programs in the Plant since the original survey." These changes have been directed at ensuring adequate independence of the loss-prevention department, fire department, criticality safety group, Plant security, health physics, and radiation monitoring, such that adequate authority and control is maintained to ensure safety and security for all aspects of Plant operation. A number of committees and groups have also been established to audit the performance and provide direction to the various speciality groups. These audit organizations include the Executive Safety Committee, Office of Chief Auditor, Nuclear Safety Committee, and Operational Safety Review Panel Subcommittees.

An intensive full-scale testing program to understand better the causes and effects of facility fires was also implemented following the 1969 fire. Full-size glove boxes utilizing the same materials as used in production glove boxes were burned to establish which materials contributed to the fire and which materials might be replaced with less combustible materials. The tests also determined how materials could be more adequately protected if a suitable replacement could not be found. Tests were performed on HEPA filters and other ventilation components to determine effects of heat and smoke. The tests were used to (1) study smoke removal for rapid access to fires, (2) verify the effectiveness of water sprays in reducing fire exhaust air temperatures such that the filters would not be damaged, and (3) determine the effects of water sprays on the filter media. Information gathered in the experimental program resulted in many of the system and component improvements summarized in Table 3.2.2-2.

As evidenced by the independent FIA survey, the Rocky Flats facilities meet or exceed all nationally recognized fire protection standards. The facilities are well protected from fire to the extent that the worst fire that can be postulated in any of the facilities can be controlled, extinguished, or contained without creating an unacceptable hazard to employees or the general public.

The continuing philosophy practiced at the Rocky Flats facilities to reduce fire hazard is to maintain the combustible loading as low as possible. Rocky Flats maintains strict control over construction materials and requires the use of fire-resistive or noncombustible materials. Interior combustible loading is kept to a minimum. Also, fire extinguishers are located in strategic places for use by production workers, and process buildings are fully protected by automatic sprinkler systems having water supplies adequate in pressure and capacity to handle the water demand of the most severe, credible, fire accident. Where sprinklers are not installed, for such reasons as no combustibles or criticality concerns, heat detection or products of combustion (POC) detection is employed. In some cases, a combination of heat/POC detection and special fire suppression is used in lieu of sprinklers or to supplement sprinkler protection. For the protection of essential processes (e.g., filter plenum final exhaust), additional features are installed to ensure minimal release of combustion products. These systems include heat detectors, an automatic water spray to cool the air entering the final exhaust plenum and thus protect the integrity of the high efficiency filters, and a manual water-spray system upstream of the first HEPA filter if the automatic spray system should fail. Automatic actuation of this protection is backed up with redundant water supplies, emergency power supplies, and administrative control via central, electronic, monitoring systems. Plenum sprinkler systems are tested every 60 days. Adjacent to heat probes in the plenum ducts are heaters which are turned on to cause temperature increases up to 190°F. The system is monitored for triggering of the probe and sprinkler system. The water is shut off prior to testing.

In other areas, such as glove boxes, where sprinklers are not allowed for criticality reasons but fire is possible because of the pyrophoric nature of plutonium, protective features are supplemented by nitrogen inerting, which automatically maintains a 5% or less oxygen atmosphere in the glove boxes.

Construction design incorporates noncombustible building materials. Modular construction within buildings consists of 1 and 2 hour fire-resistive walls to localize and limit the spread of accidental fires. Concrete canyons are incorporated to isolate the more hazardous operations. Within the modules discussed above, glove boxes are chosen for their fire resistance and consist primarily of stainless steel having laminated or wire safety glass, leaving minimal combustibles (usually only the elastomeric gloves). Ducts and plenums of the heating, ventilating, and air-conditioning systems are heavy gauge metal, and the HEPA filters are made of glass-asbestos fiber or of equivalent inorganic material within a frame of fire-retardant-treated wood or metal.

Fire loading in all buildings (except a few warehouse buildings) is considered light to moderate with very few having a moderate loading. In line with existing policy, all fire protection installations are designed for moderate fire loading or better depending on the individual analysis made.

Credible fires at these facilities, with primary concern placed on plutonium-handling facilities, are not expected to exceed a 30-minute duration, with the exception that warehouse storage may be expected to last 1 to 2 hours. Under either condition, the manual and automatic fire suppression is believed to be more than adequate to extinguish or control the fire.

There is a fully manned and equipped fire department on site with the capability to respond to any facility within 2 to 5 minutes. As stated in the latest FIA survey, "This is an excellent, private, fully paid fire department maintained on the Plant premises." Fire department manpower is supplemented by trained Plant security guards and by fire brigade members in individual buildings.

Postulated Fire Accidents

As a result of system and operational improvements, both the probability of a fire and the severity of an environmental release associated with a fire have been greatly reduced in comparison to the Rocky Flats operation prior to 1957 or 1969. Since the 1969 fire, there have been no fires that have spread beyond the immediate containing area. As a result of system and operational improvements, a probable fire accident is difficult to postulate. Therefore, it will be assumed, for purposes of this Environmental Impact Statement, that the maximum probable fire accident is the same as the maximum credible fire accident.

Given the many fire prevention, detection, and suppression systems and procedures incorporated into the Rocky Flats Plant, a major facility fire (that is, a fire resulting in extensive building damage with greater than $1 million in property loss) is considered highly unlikely. For such a fire to occur, the automatic fire detection and wetpipe sprinkler systems must fail in some manner such that the fire burns uncontrolled, reaches the HEPA filters without being cooled by the plenum spray systems, destroys the filters, and releases plutonium-contaminated combustion products and filter loadings to the atmosphere. Based on a detailed study conducted by an independent consultant (TERA, 1976), the probability of such a series of events is less than 10^{-7} per year and thus is considered incredible. This study included a reliability analysis of the automatic fire detection and sprinkler systems. It took into account the probability of the mechanical failure of essential components, frequency of inspection, testing, malfunction rates, and redundancy of systems and components where applicable. The fire detection and suppression systems are expected to function as designed to protect the HEPA filter systems. A probability of 0.0001 per year was derived for a maximum credible fire (TERA, 1976, Chapter V) using very conservative assumptions.

Experiments to determine the amount of plutonium that becomes airborne in a fire involving various media have been conducted by several investigators (Hilliard, 1963; Mishima, 1964; Mishima, 1966; Felt, 1967; Schwendiman, et al., 1968; Mishima and Schwendiman, 1970; Mishima and Schwendiman, April 1973; Mishima and Schwendiman, August 1973). For plutonium in solid metallic forms, airborne quantities of $5 \times 10^{-5}\%$ to 0.03% by weight were found for burn temperatures of up to 1000°C (1832°F) in air atmospheres (Mishima and Schwendiman, 1970). Mishima and Schwendiman (1970) also reported that plutonium compounds in powder forms, when heated to 1000°C, resulted in release values of $2 \times 10^{-5}\%$ to $4 \times 10^{-4}\%$, with the larger value at the higher oxygen concentration and at a temperature of 700°C (1292°F). Values of $1.5 \times 10^{-3}\%$ to 0.24% have been reported (Stewart, 1963) for burning plutonium metal or alloys in essentially standard atmospheric oxygen concentrations of 20.8% with nitrogen constituting the remainder of the atmosphere. The value 0.24%, equal to the largest value reported in the literature for plutonium burning in air, was used to calculate the amount of airborne plutonium from the maximum credible fire accident. This is a factor of 8 greater than the 0.03% reported for more recent experiments on solid forms of burning plutonium (Mishima and Schwendiman, 1970).

In the DEIS, a value of 2.1% by weight was used for the airborne amount of burning plutonium. However, according to the reference (Stewart, 1963, Table 5, Experiment No. 12), this value is for plutonium metal burning in a pure oxygen atmosphere, a condition which is not applicable to glove boxes at Rocky Flats. The 0.24% value used in this FEIS is the largest experimental value for plutonium burning <u>in air</u>.

Although it is not plausible to define the specific mechanism that could result in a maximum credible fire, it is necessary to theorize such an event to determine the upper bounds of environmental release that may be anticipated from a fire. Therefore, for purposes of the EIS, a scenario is presented for a maximum credible fire, even though the specific mechanisms are highly improbable.

The postulated maximum credible fire was assumed to occur in a plutonium machining area. The glove boxes in which the operations are conducted are inerted with nitrogen; hence, the probability of a fire starting in a glove box is small. It was postulated, however, that a failure of a pipeline supplying machining coolant oil to the glove box occurs outside the glove box and releases oil to the floor. Through some undefined mechanism (e.g., a static spark or electric short circuit), the oil is ignited. This fire then ignites the elastomeric gloves, which are rapidly burned off, allowing access to the glove-box interior. The maximum amount of plutonium involved would be a single 3-kilogram piece and 1 kilogram of chips or turnings on the bottom of the box, together with a maximum of 5 to 6 gallons of machining oil. Amounts of fissile and hydrogenous materials in glove boxes are limited to assure criticality safety. Exposed to an in-rush of air, flames, and products of combustion through the now-open glove ports, oil in the box is ignited and burns rapidly along with the 1 kilogram of plutonium chips in the bottom of the box. The oil-fire flames could also engulf the 3-kilogram solid plutonium form, causing additional plutonium oxide to form. The speed at which the oil in the box burns causes a localized pressure increase in the box that forces flame and plutonium-contaminated combustion products back through the open glove port into the room. The rapidly rising heat and gases from the oil fire on the floor, combined with the effluents from the glove box, could be exhausted through the smoke grill near the ceiling into the room's air exhaust duct, through two stages of HEPA filters, and out to the atmosphere (refer to Figure 2.7.1-2).

During the progress of the fire, wet pipe sprinkler systems would have been activated and heat sensors in the filter plenum would have activated cooling chamber sprays, lowering the exhaust air temperature below 200°F, and the filter would not be damaged. Once the gloves had burned off, the rapid in-rush of heat and air would activate additional alarms, and the glove box would be isolated from the conveyor by an automatic fire door. Fans in the nitrogen inerting system would cease recirculation, nitrogen flow would be increased as controls attempted to restore the inert atmosphere, and the exhaust fan speed would increase in an attempt to maintain the pressure differential between zones. The reaction of the inerting, heating, and ventilation control system creates a once-through system at a 50% increased flow rate, but all glove-box exhaust gases still pass through four stages of HEPA filters. If temperatures of the plenum cooling chamber exceed 190°F, the cooling-chamber water spray system would be actuated to cool the gases and protect the filters.

The speed at which the glove-box ventilation system reacts to the fire is estimated to result in a 3 to 5-minute period between sensing of the fire and full system actuation. A 3 to 4-minute period would elapse before the room sprinkler system is activated by high room-air temperature, and a 2 to 3-minute period would elapse between receipt of the alarms at the fire department control station and arrival on the scene of fire department personnel. Thus, a period of 5 to 9-minutes would have elapsed before all automatic systems actuated to contain the fire and before fire department personnel arrived to extinguish the fire. For purposes of this evaluation, it is assumed that in less than three minutes, the glove box would have been breached, and 0.24% of the plutonium chips and 0.24% of the solid plutonium form would have become airborne and would have been forced out into the room. It is assumed that 50% of this total source plates out on walls, duct work, and other surfaces, resulting in 4.8 grams (0.35 curies) of plutonium alpha activity reaching the two-stage, room-air, exhaust HEPA filters. This fractional amount of plate-out is consistent with the assumed plume deposition velocity for plutonium particulates of 0.001 m/sec and the deposition area available in typical production areas (100 m^2). It is further assumed that the first HEPA filter stage achieves a 99.9% efficiency, and the second stage has a 99.8% efficiency. (See Section 2.7.1 for data on HEPA filter efficiency.) This results in a decontamination factor of 500,000 for the two-stage, room-exhaust, HEPA filters. Thus, the release to the atmosphere would be approximately 0.70 μCi of plutonium alpha activity.

The credibility of such a fire beginning and developing as described is highly questionable. The assumed piping system failure is improbable and must occur without detection, either by failure of the alarmed level controls on the oil storage tank or failure of operating personnel to notice the leak in their immediate work area. In addition, an ignition source of sufficient energy and duration to ignite the oil must be present. The particular type of oil involved is a high-flash-temperature oil selected specifically to be difficult to ignite. In reality, the probability of this sequence of events is very small, and the maximum credible fire accident as postulated is conservative. Additional conservatism is present in the source term and mechanism by which the plutonium reaches the filters. No credit is taken for scrubbing plutonium out of the combustion gases by the room sprinklers or by the plenum-cooling chamber sprays. These effects alone could reduce the source term to a small fraction of that postulated. In addition, the amount of plutonium that becomes airborne and is dispersed into the room (assumed to be 0.24% each of the chips and the plutonium sphere) is conservative.

3.2.2.5 Explosion

The probability of a major explosion within the Rocky Flats facility is low, since there are no major sources of chemical explosive force within the facility. The components handled at the facility are, by themselves, insufficient to permit a nuclear explosion. The Plant makes only some parts of weapons and never has complete weapons on site. Unlike conventional, light-water-reactor reprocessing and fabrication facilities, hydrogen gas is not used in furnaces nor in other major steps. Hydrogen is used in research activities, but the total amount of hydrogen involved is not sufficient to produce an explosion which could destroy the building or breach the HEPA filter system.

Other chemicals or materials that could potentially explode are available only in small quantities. The largest potential explosive force is that associated with the natural gas used in parts of the Rocky Flats facility. Natural gas is not supplied to plutonium-handling glove-box systems or other parts of plutonium processing areas. All high-pressure vessels in plutonium-handling areas are located in facilities that will contain any rupture in the pressure system. It does not appear credible, therefore, that an explosion could occur that would cause complete breaching of the containment system of a plutonium-handling building.

Minor explosions that would result in the release of some radioactive material to the environment are credible. Past releases from explosions (see Table 2.7.2-1) have been contained within the buildings. The largest of these releases was 10 μCi of plutonium alpha activity. Future releases from any in-plant explosions are apt to be small. These explosions will not be of sufficient force to destroy the integrity of the HEPA filter system. On the basis of past history, the expected explosion release term should be 10 μCi or less, with a likelihood of occurrence of somewhat under 0.2 per year being assumed. Releases larger than 10 μCi are possible, but quantities in excess of 100 μCi are unlikely, given an intact HEPA filter system. Since no releases of this magnitude have occurred from explosions in approximately 25 years of operating history, the likelihood of such an occurrence is apt to be less than 0.05 per year. The maximum credible explosion release is taken to be 100 μCi with a likelihood of 0.05 per year.

Releases to the environment that might result from major fires initiated by explosions are included in the maximum accidental release from fire as described in the previous section.

3.2.2.6 Criticality

Although process configurations and administrative procedures are carefully designed and monitored with criticality control in mind, the formation of a critical mass, accompanied by the evolution of ionizing radiation and fission products, is always a possibility when handling plutonium or highly enriched uranium. The total number of fissions for each of the 26 criticality accidents recorded in the literature (AEC, 1971) ranges from $\sim 3 \times 10^{15}$ to 4×10^{19}. Other evaluations have conservatively selected $\sim 10^{18}$ fissions as representative (AEC, December 1974). None of these recorded criticality accidents occurred at the Rocky Flats Plant. These reports of process plant accidents indicate that an inadvertant criticality is most likely to occur during those operations in which plutonium is processed in solution.

The systems and processes at Rocky Flats were reviewed to determine the maximum probable and maximum credible criticality accidents. Safety considerations and evaluations of processes and equipment directly related to criticality are discussed below. Maximum credible criticality accidents for metal and solution are then postulated and evaluated. A maximum probable criticality accident is also described.

Nuclear Criticality Safety Considerations

Given the many system and administrative controls that exist at the Rocky Flats Plant, the likelihood of an accidental criticality is remote. Nuclear criticality safety is achieved by physically controlling the parameters that influence criticality: mass, geometry, reflection, interaction, density, moderation, concentration, and neutron absorbers (neutron poisons). The following are examples of features and controls provided at Rocky Flats for preventing a criticality accident:

1. A double-contingency criterion is used in which at least two unlikely and independent conditions must exist simultaneously before a criticality accident is possible. One exception, which is permitted within the limitations defined in ANSI N16.4, is the primary solution-storage tanks where Raschig rings (strong neutron absorbers) serve as the primary nuclear criticality control, and strict administrative procedures serve as the secondary method for criticality prevention.
2. Wherever possible, the equipment shape and dimensions are such that material being processed cannot create a criticality hazard. If such prevention is not possible because of process requirements, strict administrative procedures and material limits serve as criticality controls.
3. With few exceptions, glove-box floors are level and at a common height to prevent accumulation of liquids and materials in low areas. Dams and drains are installed to prevent fissile material, if mixed with a liquid, from accumulating in an unsafe (critical) geometry.

4. Curbs are installed at stairwells, elevator shafts, and doors to modules (compartmentalized work areas). This prevents the entry of liquid containing fissile material that might accumulate in an unsafe geometry.
5. Interaction between fissile material in storage arrays is controlled by racks permanently positioned at safe distances from each other. Interaction during material transfer is controlled by carrier, container, and cart spacing design.
6. Piping and tanks for process liquid systems are designed to be safe for the most reactive concentrations. No credit has been taken for the less reactive concentrations that are normally in the system.
7. Safeguards such as carrier design, drains, and dams are provided for protection against criticality in the event of a fire. Filter plenums are also provided with drains to Raschig-ring-filled tanks to prevent unsafe accumulations of sprinkler water.
8. Neutron reflection is considered in the design of all process equipment. Full reflection by a liquid spill is prevented by criticality overflow drains and curbs. Criticality analyses must show the equipment to be subcritical when normal reflection is combined with possible additional reflection.
9. The accidental introduction of moderating material (such as liquid from a broken line) is prevented by design, where necessary. Criticality analysis of each process area must demonstrate that safety is maintained; if there could be both moderation and reflection, the equipment must remain safe under the combined effects.
10. The inadvertent transfer of fissile solutions is prevented (or the criticality consequences are eliminated, depending upon the situation), by such devices as (1) check valves, (2) barometric legs, (3) overfill alarms with automatic shutoff, (4) locks, (5) safe geometry, and (6) fixed nuclear poisons, such as Raschig rings.
11. Strict administrative controls specify the handling procedures for all fissile material. Testing, monitoring, and enforced replacement schedules ensure the continued reliability of the protective devices. The Raschig-ring-filled vessels used for storing and handling fissile solution are on (1) a calibration inspection schedule, (2) a Raschig ring inspection schedule, and (3) a gamma survey schedule to detect excessive material buildup.

The effectiveness of the system design and administrative controls for criticality safety is further demonstrated by the fact that there has never been a criticality accident of any nature at the Rocky Flats Plant.

Postulated Criticality Accidents

At various stages of processing, plutonium is in the form of metal, dry or wet oxides or other compounds, or solutions of various concentrations. Reviews show that processes and equipment involving the metal or solid forms are designed to meet the double-contingency criterion and that a criticality in these areas is not likely. For purposes of this EIS, however, a maximum credible metal criticality was assumed to result from the inadvertent stacking of plutonium metal ingots. The probability of a metal-stacking incident is reduced by strict administrative controls that limit the amount of material in an area. Also, carriers are used that cannot hold more than one ingot, and the dimensions of the carriers provide adequate spacing in the event of abnormal conditions such as conveyor breakdown.

The primary solution-storage tanks are the only equipment where the double contingency criterion cannot be demonstrated to exist under all circumstances. Therefore, for a solution criticality accident analysis, that area was selected for the evaluation of the maximum credible nuclear excursion. In addition, since these tanks contain the largest volumes of fissile solution, an accidental criticality would produce more fissions than one occurring in a smaller volume. The hypothetical means by which Raschig-ring-filled vessels containing fissile solutions can become unsafe are:

1. Formation of voids in the tank from settling or breaking of the rings.
2. Placing a tank in service with insufficient Raschig rings.
3. An undetected slow buildup of a fissile sludge in a tank or slow deterioration of the rings, or both.

Condition 1, alone, is not a credible means of causing an excursion because (a) the tempered-glass rings are unlikely to break and (b) past experience shows them to be longlasting. Tanks are reinspected and recalibrated every six months in order to check for settling of the rings, formation of voids, or sludge buildup. In addition, a sample of the Raschig rings is removed from the tank and tested for mechanical strength and boron content. The tanks are drained of solution and gamma-scanned at periodic intervals to detect sludge buildup.

Conditions 1 and 2 each would produce an excursion with similar characteristics --a spike or burst of fissions, followed by a slowly decreasing rate of solution boiling. The excursion finally would be quenched by evaporation. The magnitude of the spike and the power level of the boiling solution would depend mainly on the volume of the solution and the rate at which the solution was pumped into the tank or the rate at which the rings settled. The amount of additional solution pumped into the tank would depend on the pumping rate and time required to shut the valves. If the rings settled, the unpoisoned volume above the critical volume would produce the same effect as volume added after criticality is reached.

Condition 3 would produce an excursion characterized by a slow rise in power (fission rate) over a period of hours. The rate of power rise would depend on the rate of ring deterioration or sludge buildup, and the magnitude of the power would depend on the state of deterioration of the rings and the rate of heat transfer to the surroundings. The early stages of this type of excursion may pass unnoticed by personnel in the vicinity until a radiation monitor discovers an increase in background radiation level or the criticality alarm is sounded.

Estimates of the results of an excursion for the three conditions are based on the maximum fission-producing values of the following variables: tank volume, pumping rate, solution concentration, degree of reflection, and sludge buildup or ring deterioration.

The parameters of an excursion that are of importance in evaluating the environmental consequences are:

1. Total Fissions--this is the basis for the amount of radioactive fission products created.
2. "Steady State" Power Level--this determines the time factor (dilution) of the radioactive material released and the radiation level during the major part of the excursion time.

For analytical purposes, the metal criticality was represented by the stacking of plutonium metal ingots. A calculation using the PAD code (described in Stratton, et al., 1971) gave the total number of fissions from this accident as 8×10^{17}; this value was rounded up to 1×10^{18}. There could be vaporization of some of the plutonium involved (a maximum of 500 g, assuming that all of the fission energy was used to heat and vaporize the metal and that the excursion was not terminated by disassembly). A transmission factor of 2×10^{-6} (see Section 3.2.2.4 and Section 2.7.1) was used for the two-stage, room-air HEPA filters, assuming that the glove box would be breached, resulting in a release of $(500)\ (2 \times 10^{-6}) = 0.001$ g of plutonium. No credit was taken for material deposited inside the building. The plutonium activity represented by this release was calculated using the data of Table 2.7.2-2, and the americium activity was taken as 20% of the plutonium alpha activity (see Section 2.7.2).

The amounts of fission products created during the excursion were calculated with the ORIGEN code (Bell, 1973), using a fast (high energy) neutron spectrum. Based on a range of 5 to 30 complete changes of air per hour for a building, a value of 5 minutes was selected as the release time for fission products. Included in the release were fission products actually released at 5 minutes, as well as in-growth from nonreleased precursors, calculated using the data of Meek and Rider, 1974. Nuclides released in amounts less than 1 mCi were not included in the source term, and 25% of the halogens and 100% of the noble gases were assumed to be released to the environment (USNRC, April, 1977). Solid fission products were assumed to be vaporized in the same ratio as for the plutonium metal and to pass through two stages of HEPA filters with a transmission factor of 2 x 10^{-6}.

The final source term for the hypothetical metal criticality accident is shown in Table 3.2.2-3.

TABLE 3.2.2-3

RADIONUCLIDE RELEASE FROM A MAXIMUM CREDIBLE METAL CRITICALITY ACCIDENT

Nuclide	Release (Ci)	Nuclide	Release (Ci)
Br-82m	$2.95x10^{-2}$	I-134	$1.02x10^{2}$
Br-83	1.94	I-134m	$8.83x10^{1}$
Br-84	$1.23x10^{1}$	I-135	$1.28x10^{1}$
Br-84m	2.78	I-136	$1.40x10^{2}$
Br-85	$5.55x10^{1}$	I-136m	$2.25x10^{1}$
Br-86	8.35	I-137	1.00
Br-86m	$2.04x10^{-3}$	Xe-133	2.07
Br-87	$1.19x10^{1}$	Xe-133m	$1.96x10^{-1}$
Br-88	$2.68x10^{-3}$	Xe-135	$2.63x10^{1}$
Kr-83m	7.60	Xe-135m	$1.49x10^{2}$
Kr-85m	6.51	Xe-137	$2.03x10^{3}$
Kr-87	$3.75x10^{1}$	Xe-138	$7.77x10^{2}$
Kr-88	$2.40x10^{1}$	Xe-139	$1.11x10^{2}$
Kr-89	$4.49x10^{2}$	Xe-140	$6.74x10^{-3}$
Kr-90	$1.14x10^{1}$	Pu-238	$1.70x10^{-6}$
I-130	$2.63x10^{-3}$	Pu-239	$5.81x10^{-5}$
I-130m	$8.38x10^{-2}$	Pu-240	$1.34x10^{-5}$
I-131	$2.70x10^{-1}$	Pu-241	$4.44x10^{-4}$
I-132	$3.02x10^{1}$	Pu-242	$1.18x10^{-9}$
I-133	4.20	Am-241	$1.46x10^{-5}$

For the solution criticality, the maximum credible accident of those evaluated would result in a total of approximately 2.2 x 10^{20} fissions. This analysis conservatively assumed that no manual action was taken to stop the reaction and that nearly all of the 2200 liters of solution in the largest Raschig-ring-filled tank had to be evaporated. The fission product release was calculated using the same assumptions as for the metal criticality, except for the use of a thermal (low energy) neutron spectrum. It was also assumed that 0.05% of the 22 kg of plutonium in the solution became airborne (USNRC, 1977), resulting in a release of 22 μg of plutonium. The corresponding plutonium and americium activities were calculated as for the metal excursion. The complete source term for the hypothetical solution criticality accident is shown in Table 3.2.2-4.

TABLE 3.2.2-4

RADIONUCLIDE RELEASE FROM A MAXIMUM CREDIBLE SOLUTION CRITICALITY ACCIDENT

Nuclide	Release (Ci)	Nuclide	Release (Ci)
Br-80	4.76×10^{-2}	I-133	9.59×10^{2}
Br-80m	2.85×10^{-3}	I-134	2.27×10^{4}
Br-82	3.13×10^{-1}	I-134m	2.03×10^{4}
Br-82m	1.17×10^{1}	I-135	2.73×10^{3}
Br-83	3.52×10^{2}	I-136	2.70×10^{4}
Br-84	2.36×10^{3}	I-136m	4.68×10^{3}
Br-84m	6.60×10^{2}	I-137	1.90×10^{2}
Br-85	1.12×10^{4}	Xe-131m	1.12×10^{2}
Br-86	1.63×10^{3}	Xe-133	4.60×10^{2}
Br-86m	3.93×10^{-1}	Xe-133m	4.10×10^{1}
Br-87	3.60×10^{3}	Xe-135	6.00×10^{3}
Br-88	8.35×10^{-1}	Xe-135m	4.99×10^{4}
Kr-83m	1.38×10^{3}	Xe-137	4.50×10^{5}
Kr-85m	1.32×10^{3}	Xe-138	1.86×10^{5}
Kr-87	8.31×10^{3}	Xe-139	1.98×10^{4}
Kr-88	5.36×10^{3}	Xe-140	1.24
Kr-89	1.05×10^{5}	Pu-238	3.76×10^{-8}
Kr-90	2.64×10^{3}	Pu-239	1.28×10^{-6}
I-128	6.75×10^{-1}	Pu-240	2.96×10^{-7}
I-130	1.32	Pu-241	9.74×10^{-6}
I-130m	1.67×10^{1}	Pu-242	2.59×10^{-11}
I-131	5.59×10^{1}	Am-241	3.23×10^{-7}
I-132	6.63×10^{3}		

As previously stated, all criticality accidents in processing plants involved fissile solution rather than metal or some other solid compound (AEC, 1971). Therefore, the maximum probable criticality accident was chosen to be a solution criticality similar to the maximum credible solution criticality, except that the total number of fissions is 1×10^{18} (a factor of 220 smaller). The radionuclide release for the maximum probable accident may be calculated by dividing the values in Table 3.2.2-4 by 220.

The selection of the value 1×10^{18} for the total number of fissions was based on data from accidents which have occurred at other facilities, published recommendations (USNRC, 1977; AEC, December, 1974), and data from the French CRAC experiments (Lécorché and Seale, 1973). These experiments have provided extensive and precise data concerning the consequences of criticality accidents.

In addition to the release source terms given in Tables 3.2.2-3 and 3.2.2-4, a criticality accident would expose Plant personnel in the immediate vicinity to the prompt gamma and neutron radiation emitted by the fission burst. However, considering the geometric attenuation of this radiation, removal by interactions with air, and the low population density around the Plant (zero population up to 2 miles), the off-site population dose from direct radiation would be smaller than from the exposure to fission products by at least a factor of 0.001.

Likelihood of Criticality Accident

There has never been a criticality accident at the Rocky Flats Plant. In support of this statement, environmental sampling has never shown the presence of sufficient quantities of fission products to indicate a criticality accident. In the absence of any past history of criticalities, it is exceedingly difficult to estimate the probability of an accidental criticality in the Rocky Flats Plant. Factors that require consideration include the production flows of fissile material, the reactivity (measure of the deviation from a critical mass) at each station, the accessibility of water moderator at each dry operation, the possibility of multiple batching, and the likelihood of errors in flow routing.

An estimate has been made of the probability of an accidental criticality in fuel fabrication plants (Selby et al., 1973). From four reported incidents relating to fuel fabrication operations, and the estimated 432 (increased to ~490 through 1975) plant-years of production involving uranium and plutonium fuel fabrication, a probability of $\sim 8 \times 10^{-3}$ criticality accidents per plant-year has been derived. In a separate study of a general fuel reprocessing facility based on a fault-tree approach, the likelihood of criticality has been estimated to be approximately 3×10^{-3} per year. However, the larger value of 8×10^{-3} per year will be used for the maximum probable criticality accident. The probability of a metal criticality is considerably smaller and will be taken as 8×10^{-4} per year. The probability of the maximum credible solution criticality was estimated as $\sim 1 \times 10^{-8}$ per year, using a fault tree. To assure conservatism and to be consistent with the definition of credible, a probability of 1×10^{-7} per year was used in the calculations.

3.2.2.7 Aircraft Hazard

An analysis of the hazards associated with potential aircraft crashes at the Rocky Flats site is contained in a Rocky Flats report (see Appendix E-1). This section summarizes the principal findings of that analysis.

The probabilities of an aircraft crashing into any of the plutonium areas at Rocky Flats were found to be:

	Probability of a Crash (per year)
Large Aircraft:	4.6×10^{-6}
Small Aircraft:	2.8×10^{-4}
TOTAL	2.9×10^{-4}

These values were determined by taking into account the air traffic operations associated with the Jefferson County (Jeffco) Airport (located approximately 5 miles from the site), the Stapleton International Airport (located approximately 20 miles from the site), long-distance flights passing over the site, and rotor craft operations over the site. Small aircraft operations from the close-in Jeffco Airport comprise not only the bulk of the likelihood of a crash, but also comprise the bulk of the hazard in terms of expected yearly release quantities, even given the greater damage associated with large aircraft.

Should an aircraft strike a plutonium area at Rocky Flats, a release of radioactivity to the environment would occur only if all or part of the aircraft penetrates all barriers around the plutonium (walls, roof, ceiling, and other containment within the building) and if this is followed by plutonium being entrained (prior to covering) by air currents and dispersed to the outside atmosphere. Taking into account the magnitude of the impact and the penetrability of the barriers, the probabilities of release of various amounts of plutonium were computed and are given in Table 3.2.2-5 (the probabilities include the likelihoods of crashes). Shown in Table 3.2.2-5 are all crashes with likelihoods greater than 10^{-7} per year; events with even smaller probabilities could occur, but they are outside of the credible range of events being considered for this Environmental Impact Statement. The probability-weighted amount released, given by the sum of the product of the amounts released and their probabilities, is approximately 27 μCi/yr. The largest credible release is 7.3 curies, with an associated probability of occurrence of 1.3×10^{-7} per year.

TABLE 3.2.2-5

PROBABILITIES OF RELEASE OF VARIOUS AMOUNTS OF PLUTONIUM FROM AIRCRAFT CRASHES

Amount of Plutonium Released (grams)	(curies)	Probability* Per Year
<0.5	<0.04	3.9×10^{-5}
0.5-3	0.04-0.22	8.5×10^{-6}
5	0.36	1.8×10^{-6}
10	0.73	3.4×10^{-7}
15-25	1.09-1.82	2.7×10^{-7}
50-70	3.64-5.09	5.8×10^{-6}
100	7.27	1.3×10^{-7}

*Probability per year is based on discrete analysis of some 309 accident pathways involving various quantities of plutonium.

Restricted Air Space

In 1975 the Federal Aviation Administration (FAA) conducted a study to determine if the production and storage of nuclear material or other potentially dangerous substances constitute justification for special use air space. They concluded that the likelihood of an air crash releasing significant quantities of radioactivity from an ERDA (now DOE) facility is so small that it could be considered negligible. They stated that the minimum safe altitude requirements of FAR 91.9 provided an adequate degree of protection to ground operations in the event of an aircraft power failure. The subject of aircraft crash probabilities is covered in detail in Appendix E-1.

ERDA pointed out that restricting air space would prevent flyovers from becoming commonplace. This would increase the awareness of the guard force to possible surveillance flights or other intrusions. The FAA's position was that, whether prohibited air space is designated or not, guard forces would be alerted whenever aircraft were detected at sufficiently low altitudes to cause a security concern. They agreed that, should such flights become commonplace, numerous false alarms within the security system would likely render the alerts ineffective.

The FAA asked ERDA to provide data on overflights. A study conducted at Rocky Flats from August 1 through September 11, 1976, indicated only four flights per day were less than 2,000 feet above ground level.

The FAA judged that the number of flights below 2,000 feet was not sufficient to justify prohibited air space. Thus DOE and FAA have concurred that safety of facilities on the ground from hazards of overflying aircraft is not sufficient justification, and no further action to obtain a restricted air space at Rocky Flats is planned.

3.2.2.8 Tornadoes

Hypothetical accidents involving tornadoes can be postulated that would cause the environmental release of radioactive materials. Studies to date, however, indicate that the Rocky Flats location is such that possible tornadoes will not be of sufficient magnitude to cause loss of containment in major plutonium process buildings.

A study for the Rocky Flats site (McDonald and Minor, 1972) has summarized Colorado tornadoes as follows: "An investigation of the influence of the Rocky Mountain Range on meteorological conditions at the Rocky Flats site revealed that the orographic situation can be expected to have direct influence on the occurrence and intensities of tornadoes at the site. Specifically, the presence of the mountain range and the altitude of the site above sea level can be expected to influence the amount of moisture present in the air, the rate of inflow or converging air layers, and atmospheric instabilities, all of which are related to the production of severe storms and tornadoes. These meteorological and orographic considerations lead to the observation that tornadoes are less frequent and less severe in the areas immediately adjacent to the mountains. This observation is supported by statistical data on tornado occurrences and intensities for the State of Colorado."

Existing plutonium facilities at Rocky Flats have been designed to withstand maximum wind speeds of 100 to 150 mph, and all buildings have a low profile, 2 stories or less, that will minimize structural damage. Seasonal chinook winds of 50 to over 100 mph experienced at the Rocky Flats site require exceptional Plant housekeeping and tie-down of materials that could become wind-blown missiles. These precautions reduce potential missile damage to structures. All plutonium processing areas have compartmentalized work areas, glove boxes, air filters, and plenums as containment barriers within each building. These features provide an added containment factor if a building's outer wall should fail or be penetrated; these barriers must also be breached if plutonium is to reach the environs.

A recent Rocky Flats study (see Appendix E-1) indicates that there is a small probability that a maximum site tornado might cause a release of 0.04 to 0.22 curies of plutonium from some of the older buildings on site. This study indicates a probability ranging from 6.3×10^{-8} per year to 1.0×10^{-7} per year of a release caused by a tornado, with a maximum release of 0.22 curies. For purposes of this Statement a most likely release of 0.07 curies with a probability of 1×10^{-7} and a maximum release of 0.22 curies with a release probability of 6.8×10^{-8} was assumed*.

3.2.2.9 High Winds

As mentioned previously, the Rocky Flats facility is in a location that experiences seasonal high winds (known as chinook winds in the area, but more properly classified as down-slope wind storms). Wind velocities of 50 to about 125 mph have been measured at the Rocky Flats site. These winds have never resulted in significant structural damage to the Plant buildings, nor caused missiles to penetrate any of the buildings, nor resulted in contamination release to the environment. There exists, however, some probability that even higher winds could occur that would cause damage to some of the older buildings on site. A recent Rocky Flats study (see Appendix E-1), using a conservative, theoretical basis for estimating the likelihood of wind velocities higher than those measured at the site, has estimated the probabilities of an environmental release occurring as a result of high winds. This study indicates that, on the basis of extrapolations to high wind speeds, a wind speed of 158 to 206 mph could cause a release of 9 grams (0.65 curies) of plutonium with a probability of 9.2×10^{-5} per year. The most likely release would be 3 grams (0.22 curies) with a probability per year of 2.7×10^{-4}. These release values are overestimates but have been used for this EIS.

3.2.2.10 Earthquakes

Evaluations of the geological, seismological, and geophysical characteristics of the Rocky Flats site were made to determine the potential earthquake exposure of the

*The probability of the maximum tornado release is slightly less than the cutoff value of 1×10^{-7}.

area. Seismic design criteria for the Rocky Flats site are dominated by the earthquake series at the Rocky Mountain Arsenal. An earthquake of magnitude 5.6 on the Richter Scale is predicted at a distance of 16 miles with a focal depth of 3.1 miles once every 33 years. This earthquake is predicted to generate a peak horizontal acceleration of the claystone bedrock at the Rocky Flats site of 0.07 g's. A Design Basis or Safe Shutdown earthquake of magnitude 6.0 at the same location as the previously mentioned earthquake has been postulated. Such an earthquake would generate a peak horizontal acceleration of 0.14 g's. Response spectra and criteria for vertical motions for these earthquakes have also been described (Blume, 1974).

Most buildings at the Rocky Flats Plant have been constructed in accordance with the seismic requirement of the Uniform Building Code in effect at the time. However, the new plutonium recovery and waste treatment facility, which was designed in accordance with the more conservative seismic site criteria developed by Blume (Blume 1974).

The largest recent earthquake in the Rocky Flats area occurred in August, 1967, in the Rocky Mountain Arsenal area and had a 5.3 magnitude. The tremor was felt at Rocky Flats, but caused no damage to any Plant buildings. It is expected that the low profile and the structural, lateral stability provided by the wind design loading will minimize structural damage caused by earthquake-induced loading.

An evaluation of existing plutonium-handling buildings against the Blume criteria will be conducted to determine the seismic forces the buildings can withstand. All of these buildings will be studied to predict their capabilities to resist the site criteria seismic excitation of magnitude 6.0 or any magnitude earthquake having similar characteristics. The results of this investigation will be incorporated in Safety Analysis Reports. These documents will be published separately from the EIS and will contain descriptions of each major facility.

Under maximum credible earthquake conditions, all solar evaporation ponds could be ruptured in addition to all holding ponds. Should that happen, all waste solutions could enter Great Western Reservoir. This worse-case accident has already been discussed, however, in Section 3.2.2.3.

Additional seismological data are being reviewed to determine whether any of the conclusions presented in the DEIS are incorrect and to determine whether the data indicate any significant adverse environmental impact. The result of this seismolofical study will be publically available upon completion. Further, if the findings of the seismological study results in conclusions significantly different than those stated in the DEIS, then DOE will supplement this EIS.

3.2.3 Accidental Release Summary

Based on previously presented material, the total, expected, accidental release amounts and the related probabilities are summarized in Table 3.2.3-1. The table gives the maximum probable accident releases in addition to maximum credible accident releases as appropriate. Expected annual release amounts are determined by multiplying the release amount by the associated probability of occurrence. All amounts shown as microcuries of plutonium alpha activity were calculated using the plutonium isotopic composition given in Table 2.7.2-2. Besides the plutonium alpha activity, there will also be plutonium-241 beta activity and americium-241 alpha activity. For brevity, these activities are not shown in Table 3.2.3-1, but were included in all environmental dose assessments. The amount of plutonium-241 beta activity is that given in the isotopic composition listing in Table 2.7.2-2, while americium-241 activity was assumed to be equal to 20% of the total plutonium alpha activity. The 20% value is about the maximum amount of americium activity that could build up in any of Rocky Flats' plutonium. For the one waterborne release, the americium and uranium activity are shown separately in a footnote. The exact isotopic composition of uranium in the waterborne release is not known, but all uranium alpha-emitting isotopes of concern have nearly identical dose conversion factors; consequently all uranium was treated as uranium-238. Table 3.2.3-2 shows the expected release of fission products from criticalities.

3.2.4 Radiological Impact Assessment

The dose measurements presented in the DEIS have been recalculated and revised and the results are presented in this FEIS. The results of the recalculation confirm the finding presented in the DEIS, namely, that the dose to the general population is very small and will result in no significant adverse environmental impact. Since this conclusion is the same as that arrived at in the DEIS, DOE has concluded that it would be unnecessary to distribute revised sections for additional public review prior to finalizing the EIS.

The assessment of the impact of accidental releases from the Rocky Flats Plant deals in two ways with the potential impact on persons living within 50 miles of the Plant. First, a "risk dose" was determined for individuals as a function of direction and distance from the Plant, analogous to the values in Table 3.1.2-3 for routine releases. The "risk dose," as defined for this Impact Statement, refers to the dose equivalent over 70 years which a person would receive from probability-weighted annual accidental releases. The risk dose is equal to the sum of the dose from the postulated release from each accident multiplied by the probability per year that each accident might occur. The concept of a risk dose is used to present an estimate of the risk to a person from the consequences of accidental releases, averaged over a period of time. No member of the population will receive any dose from accidental releases unless an accidental release actually occurs.

TABLE 3.2.3-1

SUMMARY OF EXPECTED ANNUAL RELEASES OF PLUTONIUM FROM POTENTIAL ACCIDENTS AT ROCKY FLATS

Release Mechanism	Amount of Material Released* (μCi of plutonium alpha activity)	Probability of Release (per year)	Expected Annual Release (μCi/yr of plutonium alpha activity)
Maximum Probable Spill Incident	10 (air)	0.5	5 (air)
Maximum Credible Spill Incident	100 (air)	0.05	5 (air)
Maximum Probable Mechanical Failure	1,000 (air)	0.05	50 (air)
Maximum Credible Mechanical Failure	20,000 (air)	0.005	100 (air)
Total Impoundment Failure**	87,000 (water)	0.01	870 (water)
Maximum Probable Fire	0.7 (air)	0.0001	7×10^{-5} (air)
Maximum Credible Fire	0.7 (air)	0.0001	7×10^{-5} (air)
Maximum Probable Explosion Event	10 (air)	0.2	2 (air)
Maximum Credible Explosion Event	100 (air)	0.05	5 (air)
Maximum Probable Criticality ***	0.007 (air)	0.008	5.8×10^{-5} (air)
Maximum Credible Solution Criticality***	1.6 (air)	1×10^{-7}	1.6×10^{-7} (air)
Maximum Credible Metal Criticality***	73.2 (air)	0.0008	0.059 (air)
Typical Aircraft Accident	4.4×10^{5} (air)	0.00006	26 (air)
Maximum Credible Aircraft Accident	7.3×10^{6} (air)	1.3×10^{-7}	0.95 (air)
Maximum Probable Tornado Release	7.3×10^{4} (air)	1.0×10^{-7}	0.007 (air)
Maximum Credible Tornado Release	2.2×10^{5} (air)	6.8×10^{-8}	0.015 (air)
Maximum Probable Wind Release	2.2×10^{5} (air)	2.7×10^{-4}	60 (air)
Maximum Credible Wind Release	6.5×10^{5} (air)	9.2×10^{-5}	60 (air)
		Total	314 (air) 870 (water) (plus 820 americium, 4850 uranium, fission products from Table 3.2.3-2, and Pu-241 and Am-241 activity)

*The beta activity of Pu-241 and the alpha activity of Am-241 were also included in the dose calculations although they are not shown in this summary table.

**An impoundment failure would also release 82,000 μCi of americium and 485,000 μCi of uranium.

***Fission products would also be released from a criticality. See Table 3.2.3-2 for the expected annual release.

TABLE 3.2.3-2

SUMMARY OF EXPECTED ANNUAL RELEASES OF FISSION PRODUCTS FROM POTENTIAL CRITICALITY ACCIDENTS AT ROCKY FLATS

Nuclide	Expected Release* (Ci/yr)
Br-80	1.74×10^{-6}
Br-80m	1.04×10^{-7}
Br-82	1.14×10^{-5}
Br-82m	4.50×10^{-4}
Br-83	1.44×10^{-2}
Br-84	9.59×10^{-2}
Br-84m	2.63×10^{-2}
Br-85	4.53×10^{-1}
Br-86	6.61×10^{-2}
Br-86m	1.60×10^{-5}
Br-87	1.41×10^{-1}
Br-88	3.26×10^{-5}
Kr-83m	5.64×10^{-2}
Kr-85m	5.33×10^{-2}
Kr-87	3.33×10^{-1}
Kr-88	2.15×10^{-1}
Kr-89	4.19
Kr-90	1.05×10^{-1}
I-128	2.46×10^{-5}
I-130	5.02×10^{-5}
I-130m	6.76×10^{-4}
I-131	2.25×10^{-3}
I-132	2.66×10^{-1}
I-133	3.83×10^{-2}
I-134	9.09×10^{-1}
I-134m	8.11×10^{-1}
I-135	1.10×10^{-1}
I-136	1.10
I-136m	1.89×10^{-1}
I-137	7.73×10^{-3}
Xe-131m	4.08×10^{-3}
Xe-133	1.84×10^{-2}
Xe-133m	1.65×10^{-3}
Xe-135	2.40×10^{-1}
Xe-135m	1.94
Xe-137	1.80×10^{1}
Xe-138	7.40
Xe-139	8.11×10^{-1}
Xe-140	5.06×10^{-5}

*The expected release (release x probability of release) values in this column were obtained by multiplying the releases from the maximum credible metal criticality in Table 3.2.2-3 by 0.0008, the releases from the maximum credible solution criticality in Table 3.2.2-4 by 1×10^{-7}, and the releases from the maximum probable criticality accident (the values in Table 3.2.2-4 divided by 220) by 0.008 and summing the three products.

The second approach to the assessment of impact is to consider the impact resulting from an actual occurrence of the postulated accidents. This assessment involves the calculation of the dose equivalent commitments to persons downwind from the accident.

Each of the methods pertains to doses to the organs of reference man, namely, total body, liver, bone, and lungs. The dose to the thyroid was also determined for criticality accidents, for which the isotopes of iodine are part of the source term.

Accidental releases are considered to occur over a relatively short period of time. This type of release is called acute, as compared to a chronic release which occurs continuously. For the assessment of impact to persons downwind from actual accidental releases, the calculations are based on an acute release. For the calculation of a risk dose from accidental releases, the concept requires that the expected release term be treated either as a chronic release (over 70 years) or as an acute release at the start of each of the 70 years. The dose to the organs, in both assessments, is the sum of contributions from all significant pathways, i.e., inhalation, food ingestion, water ingestion, ground plane irradiation, and irradiation from airborne radionuclides (plume shine). Details of the dose calculation methodology are given in Appendix F.

3.2.4.1 Assessment of Risk Dose

The values of the risk dose, in units of rem, for reference man living in the vicinity of the Rocky Flats Plant continuously for 70 years are given in Table 3.2.4-1 as a function of the direction (sector) and distance from the Plant. Comparison of values in this table with corresponding values in Table 3.1.2-3 for routine releases indicates that the values of the risk dose are 2 to 4 times lower than doses from routine releases. The risk dose to the thyroid is included here because of iodine releases from the postulated criticality accidents. No iodine is released during normal operation.

Comparison with the 70-year background dose to the organs, Table 3.1.2-6, indicates that these values of the risk dose are a very small fraction of the dose received by persons from background radiation. For the person living at a distance of 2 miles in the ESE direction, these fractions are 0.000070 for the total body, 0.0023 for the liver, 0.0045 for the bone, 0.0013 for the lungs, and 0.00016 for the thyroid (taking the thyroid background to be that of the total body). For persons living at other distances or in other directions, these fractions are even smaller. The risk to persons living within 50 miles of the Rocky Flats Plant, from exposure to the postulated accidental releases as measured by the risk dose, is therefore imperceptible.

TABLE 3.2.4-1

70-YEAR RISK DOSE TO REFERENCE MAN FROM POSTULATED ACCIDENTAL RELEASES

Direction	Distance (miles)	Total Body	Organ Risk Dose (rem) to Reference Man: Liver	Bone	Lungs	Thyroid
N	2-3	1.5×10^{-4}	5.1×10^{-3}	1.1×10^{-2}	4.9×10^{-3}	3.6×10^{-4}
	3-4	7.6×10^{-5}	2.8×10^{-3}	6.2×10^{-3}	2.7×10^{-3}	1.9×10^{-4}
	4-5	4.5×10^{-5}	1.8×10^{-3}	4.1×10^{-3}	1.8×10^{-3}	1.2×10^{-4}
	5-10	3.0×10^{-5}	1.4×10^{-3}	3.0×10^{-3}	1.3×10^{-3}	8.3×10^{-5}
	10-20	7.9×10^{-6}	5.2×10^{-4}	1.2×10^{-3}	5.0×10^{-4}	2.7×10^{-5}
	20-30	2.2×10^{-6}	2.1×10^{-4}	4.8×10^{-4}	2.1×10^{-4}	9.0×10^{-6}
	30-40	1.2×10^{-6}	1.3×10^{-4}	3.9×10^{-4}	1.2×10^{-4}	5.0×10^{-6}
	40-50	8.1×10^{-7}	9.2×10^{-5}	2.1×10^{-4}	8.9×10^{-5}	3.3×10^{-6}
NNE	2-3	1.6×10^{-4}	5.3×10^{-3}	1.2×10^{-2}	5.1×10^{-3}	3.8×10^{-4}
	3-4	7.8×10^{-5}	2.9×10^{-3}	6.4×10^{-3}	2.8×10^{-3}	1.9×10^{-4}
	4-5	4.7×10^{-5}	1.9×10^{-3}	4.3×10^{-3}	1.8×10^{-3}	1.2×10^{-4}
	5-10	3.1×10^{-5}	1.4×10^{-3}	3.1×10^{-3}	1.3×10^{-3}	8.6×10^{-5}
	10-20	8.2×10^{-6}	5.4×10^{-4}	1.2×10^{-3}	5.2×10^{-4}	2.9×10^{-5}
	20-30	2.3×10^{-6}	2.2×10^{-4}	5.0×10^{-4}	2.2×10^{-4}	9.3×10^{-6}
	30-40	1.2×10^{-6}	1.4×10^{-4}	3.1×10^{-4}	1.3×10^{-4}	5.2×10^{-6}
	40-50	8.4×10^{-7}	9.6×10^{-5}	2.2×10^{-4}	9.2×10^{-5}	3.5×10^{-6}
NE	2-3	3.8×10^{-4}	1.2×10^{-2}	2.8×10^{-2}	1.2×10^{-2}	8.9×10^{-4}
	3-4	1.9×10^{-4}	6.8×10^{-3}	1.5×10^{-2}	6.7×10^{-3}	4.6×10^{-4}
	4-5	1.1×10^{-4}	4.5×10^{-3}	1.0×10^{-2}	4.4×10^{-3}	2.9×10^{-4}
	5-10	7.4×10^{-5}	3.3×10^{-3}	7.4×10^{-3}	3.2×10^{-3}	2.0×10^{-4}
	10-20	1.9×10^{-5}	1.3×10^{-3}	2.9×10^{-3}	1.2×10^{-3}	6.5×10^{-5}
	20-30	5.5×10^{-6}	5.3×10^{-4}	1.2×10^{-3}	5.1×10^{-4}	2.2×10^{-5}
	30-40	3.0×10^{-6}	3.2×10^{-4}	7.2×10^{-4}	3.1×10^{-4}	1.2×10^{-5}
	40-50	2.0×10^{-6}	2.3×10^{-4}	5.1×10^{-4}	2.2×10^{-4}	2.2×10^{-6}
ENE	2-3	4.6×10^{-4}	1.5×10^{-2}	3.3×10^{-2}	1.4×10^{-2}	1.1×10^{-3}
	3-4	2.2×10^{-4}	8.2×10^{-3}	1.8×10^{-2}	8.0×10^{-3}	5.6×10^{-4}
	4-5	6.6×10^{-4}	7.2×10^{-2}	1.7×10^{-1}	5.8×10^{-3}	8.7×10^{-4}
	5-10	6.1×10^{-4}	7.1×10^{-2}	1.6×10^{-1}	4.4×10^{-3}	7.7×10^{-4}
	10-20	2.3×10^{-5}	1.5×10^{-3}	3.5×10^{-3}	1.5×10^{-3}	7.9×10^{-5}
	20-30	6.6×10^{-6}	6.3×10^{-4}	1.4×10^{-3}	6.2×10^{-4}	2.7×10^{-5}
	30-40	3.5×10^{-6}	3.9×10^{-4}	8.7×10^{-4}	3.7×10^{-4}	1.5×10^{-5}
	40-50	2.4×10^{-6}	2.7×10^{-4}	6.2×10^{-4}	2.6×10^{-4}	9.9×10^{-6}

TABLE 3.2.4-1 (Continued)

Direction	Distance (miles)	Total Body	Organ Risk Dose (rem) to Reference Man Liver	Bone	Lungs	Thyroid
E	2-3	5.9×10^{-4}	1.9×10^{-2}	4.3×10^{-2}	1.9×10^{-2}	1.4×10^{-3}
	3-4	2.9×10^{-4}	1.1×10^{-2}	2.4×10^{-2}	1.0×10^{-2}	7.2×10^{-4}
	4-5	1.7×10^{-4}	7.0×10^{-3}	1.6×10^{-2}	6.8×10^{-3}	4.5×10^{-4}
	5-10	1.1×10^{-4}	5.2×10^{-3}	1.2×10^{-2}	5.0×10^{-3}	3.2×10^{-4}
	10-20	3.0×10^{-5}	2.0×10^{-3}	4.0×10^{-3}	1.9×10^{-3}	1.0×10^{-4}
	20-30	8.5×10^{-6}	8.2×10^{-4}	1.8×10^{-3}	7.9×10^{-4}	3.4×10^{-5}
	30-40	4.6×10^{-6}	5.0×10^{-4}	1.1×10^{-3}	4.8×10^{-4}	1.9×10^{-5}
	40-50	3.1×10^{-6}	3.5×10^{-4}	8.0×10^{-4}	3.4×10^{-4}	1.3×10^{-5}
ESE	2-3	7.3×10^{-4}	2.4×10^{-2}	5.3×10^{-2}	2.3×10^{-2}	1.7×10^{-3}
	3-4	3.5×10^{-4}	1.3×10^{-2}	2.9×10^{-2}	1.3×10^{-2}	8.8×10^{-4}
	4-5	2.1×10^{-4}	8.6×10^{-3}	1.9×10^{-2}	8.3×10^{-3}	5.5×10^{-4}
	5-10	1.4×10^{-4}	6.3×10^{-3}	1.4×10^{-2}	6.1×10^{-3}	3.9×10^{-4}
	10-20	3.7×10^{-5}	2.5×10^{-3}	5.5×10^{-3}	2.4×10^{-3}	1.2×10^{-4}
	20-30	1.0×10^{-5}	1.0×10^{-3}	2.3×10^{-3}	9.7×10^{-4}	4.2×10^{-5}
	30-40	5.6×10^{-6}	6.1×10^{-4}	1.4×10^{-3}	5.9×10^{-4}	2.3×10^{-5}
	40-50	3.8×10^{-6}	4.3×10^{-4}	9.8×10^{-4}	4.2×10^{-4}	1.6×10^{-5}
SE	2-3	5.6×10^{-4}	1.8×10^{-2}	4.1×10^{-2}	1.8×10^{-2}	1.3×10^{-3}
	3-4	2.8×10^{-4}	1.0×10^{-2}	2.3×10^{-2}	9.8×10^{-3}	6.9×10^{-4}
	4-5	1.6×10^{-4}	6.7×10^{-3}	1.5×10^{-2}	6.5×10^{-3}	4.3×10^{-4}
	5-10	1.1×10^{-4}	4.9×10^{-3}	1.1×10^{-2}	4.7×10^{-3}	3.0×10^{-4}
	10-20	2.9×10^{-5}	1.9×10^{-3}	4.3×10^{-3}	1.8×10^{-3}	9.7×10^{-5}
	20-30	8.1×10^{-6}	7.8×10^{-4}	1.8×10^{-3}	7.6×10^{-4}	3.3×10^{-5}
	30-40	4.4×10^{-6}	4.7×10^{-4}	1.1×10^{-3}	4.6×10^{-4}	1.8×10^{-5}
	40-50	3.0×10^{-6}	3.4×10^{-4}	7.6×10^{-4}	3.2×10^{-4}	1.2×10^{-5}
SSE	2-3	4.5×10^{-4}	1.5×10^{-2}	3.3×10^{-2}	1.4×10^{-2}	1.0×10^{-3}
	3-4	2.2×10^{-4}	8.0×10^{-3}	1.8×10^{-2}	7.8×10^{-3}	5.4×10^{-4}
	4-5	1.3×10^{-4}	5.3×10^{-3}	1.2×10^{-2}	5.1×10^{-3}	3.4×10^{-4}
	5-10	8.7×10^{-5}	3.9×10^{-3}	8.7×10^{-3}	3.8×10^{-3}	2.4×10^{-4}
	10-20	2.3×10^{-5}	1.5×10^{-3}	3.4×10^{-3}	1.5×10^{-3}	7.7×10^{-5}
	20-30	6.4×10^{-6}	6.7×10^{-4}	1.4×10^{-3}	6.0×10^{-4}	2.6×10^{-5}
	30-40	3.5×10^{-6}	3.8×10^{-4}	8.5×10^{-4}	3.6×10^{-4}	1.4×10^{-5}
	40-50	2.3×10^{-6}	2.7×10^{-4}	6.1×10^{-4}	2.6×10^{-4}	9.7×10^{-6}

TABLE 3.2.4-1 (Continued)

Direction	Distance (miles)	Organ Risk Dose (rem) to Reference Man: Total Body	Liver	Bone	Lungs	Thyroid
S	2-3	3.7×10^{-4}	1.2×10^{-2}	2.7×10^{-2}	1.2×10^{-2}	8.6×10^{-4}
	3-4	1.8×10^{-4}	7.1×10^{-3}	1.5×10^{-2}	6.4×10^{-3}	4.4×10^{-4}
	4-5	1.1×10^{-4}	4.3×10^{-3}	9.7×10^{-3}	4.2×10^{-3}	2.4×10^{-4}
	5-10	7.1×10^{-5}	3.2×10^{-3}	7.1×10^{-3}	3.1×10^{-3}	1.9×10^{-4}
	10-20	1.9×10^{-5}	1.2×10^{-3}	2.8×10^{-3}	1.2×10^{-3}	6.3×10^{-5}
	20-30	5.2×10^{-6}	5.0×10^{-4}	1.1×10^{-3}	4.9×10^{-4}	2.1×10^{-5}
	30-40	2.8×10^{-6}	3.1×10^{-4}	6.9×10^{-4}	3.0×10^{-4}	1.2×10^{-5}
	40-50	1.9×10^{-6}	2.2×10^{-4}	4.9×10^{-4}	2.1×10^{-4}	7.9×10^{-6}
SSW	2-3	3.3×10^{-4}	1.1×10^{-2}	2.4×10^{-2}	1.0×10^{-2}	7.8×10^{-4}
	3-4	1.5×10^{-4}	5.7×10^{-3}	1.3×10^{-2}	5.5×10^{-3}	4.0×10^{-4}
	4-5	9.7×10^{-5}	3.9×10^{-3}	8.8×10^{-2}	3.8×10^{-3}	2.5×10^{-4}
	5-10	6.4×10^{-5}	2.9×10^{-3}	6.5×10^{-3}	2.8×10^{-3}	1.8×10^{-4}
	10-20	1.7×10^{-5}	1.1×10^{-3}	2.5×10^{-3}	1.1×10^{-3}	5.7×10^{-5}
	20-30	4.7×10^{-6}	4.6×10^{-4}	1.0×10^{-3}	4.5×10^{-4}	1.9×10^{-5}
	30-40	2.6×10^{-6}	2.8×10^{-4}	6.3×10^{-4}	2.7×10^{-4}	1.0×10^{-5}
	40-50	1.7×10^{-6}	2.0×10^{-4}	4.5×10^{-4}	1.9×10^{-4}	7.1×10^{-6}
SW	2-3	3.6×10^{-4}	1.2×10^{-2}	2.6×10^{-2}	1.1×10^{-2}	8.4×10^{-4}
	3-4	1.8×10^{-4}	6.4×10^{-3}	1.4×10^{-2}	6.3×10^{-3}	4.4×10^{-4}
	4-5	1.1×10^{-4}	4.3×10^{-3}	9.6×10^{-3}	4.1×10^{-3}	2.8×10^{-4}
	5-10	7.0×10^{-5}	3.1×10^{-3}	7.0×10^{-3}	3.0×10^{-3}	1.9×10^{-4}
	10-20	1.8×10^{-5}	1.2×10^{-3}	2.7×10^{-3}	1.2×10^{-3}	6.2×10^{-5}
	20-30	5.1×10^{-6}	5.0×10^{-4}	1.1×10^{-3}	4.8×10^{-4}	2.1×10^{-5}
	30-40	2.8×10^{-6}	3.0×10^{-4}	6.8×10^{-4}	2.9×10^{-4}	1.2×10^{-5}
	40-50	1.9×10^{-6}	2.1×10^{-4}	4.9×10^{-4}	2.1×10^{-4}	7.8×10^{-6}
WSW	2-3	1.9×10^{-4}	6.1×10^{-3}	1.4×10^{-2}	5.9×10^{-3}	4.4×10^{-4}
	3-4	9.2×10^{-5}	3.4×10^{-3}	7.6×10^{-3}	3.3×10^{-3}	2.3×10^{-4}
	4-5	5.5×10^{-5}	2.2×10^{-3}	5.0×10^{-3}	2.2×10^{-3}	1.4×10^{-4}
	5-10	3.7×10^{-5}	1.6×10^{-3}	3.7×10^{-3}	1.6×10^{-3}	1.0×10^{-4}
	10-20	9.6×10^{-6}	6.4×10^{-4}	1.4×10^{-3}	6.1×10^{-4}	3.2×10^{-5}
	20-30	2.7×10^{-6}	2.6×10^{-4}	5.9×10^{-4}	2.5×10^{-4}	1.1×10^{-5}
	30-40	1.5×10^{-6}	1.6×10^{-4}	3.6×10^{-4}	1.5×10^{-4}	6.1×10^{-6}
	40-50	9.8×10^{-7}	1.1×10^{-4}	2.5×10^{-4}	1.1×10^{-4}	4.1×10^{-6}

TABLE 3.2.4-1 (Continued)

Direction	Distance (miles)	Total Body	Organ Risk Dose (rem) to Reference Man: Liver	Bone	Lungs	Thyroid
W	2-3	1.1×10^{-4}	3.5×10^{-3}	7.9×10^{-3}	3.4×10^{-3}	2.5×10^{-4}
	3-4	5.3×10^{-5}	1.9×10^{-3}	4.3×10^{-3}	1.9×10^{-3}	1.3×10^{-4}
	4-5	3.2×10^{-5}	1.3×10^{-3}	2.9×10^{-3}	1.2×10^{-3}	8.3×10^{-5}
	5-10	2.1×10^{-5}	9.4×10^{-4}	2.1×10^{-3}	9.1×10^{-4}	6.0×10^{-5}
	10-20	5.5×10^{-6}	3.7×10^{-4}	8.2×10^{-4}	3.5×10^{-4}	1.9×10^{-5}
	20-30	1.5×10^{-6}	1.5×10^{-4}	3.6×10^{-4}	1.4×10^{-4}	6.3×10^{-6}
	30-40	8.3×10^{-7}	9.1×10^{-5}	2.0×10^{-4}	8.7×10^{-5}	3.5×10^{-6}
	40-50	5.6×10^{-7}	6.4×10^{-5}	1.5×10^{-4}	6.2×10^{-5}	2.3×10^{-6}
WNW	2-3	1.7×10^{-4}	5.5×10^{-3}	1.2×10^{-2}	5.3×10^{-3}	4.0×10^{-4}
	3-4	8.3×10^{-5}	3.0×10^{-3}	6.8×10^{-3}	2.9×10^{-3}	2.1×10^{-4}
	4-5	4.9×10^{-5}	2.0×10^{-3}	4.5×10^{-3}	1.9×10^{-3}	1.3×10^{-4}
	5-10	3.3×10^{-5}	1.5×10^{-3}	3.3×10^{-3}	1.4×10^{-3}	9.0×10^{-5}
	10-20	8.6×10^{-6}	5.7×10^{-4}	1.3×10^{-3}	5.5×10^{-4}	2.9×10^{-5}
	20-30	2.4×10^{-6}	2.3×10^{-4}	5.2×10^{-4}	2.3×10^{-4}	9.8×10^{-6}
	30-40	1.3×10^{-6}	1.4×10^{-4}	3.2×10^{-4}	1.4×10^{-4}	5.4×10^{-6}
	40-50	8.8×10^{-7}	1.0×10^{-4}	2.3×10^{-4}	9.7×10^{-5}	3.6×10^{-6}
NW	2-3	3.1×10^{-4}	1.0×10^{-2}	2.3×10^{-2}	9.8×10^{-3}	7.3×10^{-4}
	3-4	1.5×10^{-4}	5.6×10^{-3}	1.2×10^{-2}	5.4×10^{-3}	3.8×10^{-4}
	4-5	9.0×10^{-5}	3.7×10^{-3}	8.2×10^{-3}	3.6×10^{-3}	2.4×10^{-4}
	5-10	6.0×10^{-5}	2.7×10^{-3}	6.0×10^{-3}	2.6×10^{-3}	1.7×10^{-4}
	10-20	1.5×10^{-5}	1.0×10^{-3}	2.2×10^{-3}	9.6×10^{-4}	5.1×10^{-5}
	20-30	4.4×10^{-6}	4.3×10^{-4}	9.7×10^{-4}	4.2×10^{-4}	1.8×10^{-5}
	30-40	2.4×10^{-6}	2.6×10^{-4}	5.9×10^{-4}	2.5×10^{-4}	1.0×10^{-5}
	40-50	1.6×10^{-6}	1.8×10^{-4}	4.2×10^{-4}	1.8×10^{-4}	6.7×10^{-6}
NNW	2-3	2.2×10^{-4}	7.1×10^{-3}	1.6×10^{-2}	6.8×10^{-3}	5.1×10^{-4}
	3-4	1.1×10^{-4}	3.9×10^{-3}	3.7×10^{-3}	3.8×10^{-3}	2.6×10^{-4}
	4-5	6.3×10^{-5}	2.6×10^{-3}	5.7×10^{-3}	2.5×10^{-3}	1.6×10^{-4}
	5-10	4.2×10^{-5}	1.9×10^{-3}	4.2×10^{-3}	1.8×10^{-3}	1.2×10^{-4}
	10-20	1.1×10^{-5}	7.3×10^{-4}	1.6×10^{-3}	7.0×10^{-4}	3.7×10^{-5}
	20-30	3.1×10^{-6}	3.0×10^{-4}	6.7×10^{-4}	2.9×10^{-4}	1.3×10^{-5}
	30-40	1.7×10^{-6}	1.8×10^{-4}	4.1×10^{-4}	1.7×10^{-4}	7.0×10^{-6}
	40-50	1.1×10^{-6}	1.3×10^{-4}	2.9×10^{-4}	1.2×10^{-4}	4.6×10^{-6}

3.2.4.2 Impact of Maximum Credible Accident

An assessment more pertinent than the hypothetical risk dose is the assessment of the consequences to downwind persons if an accidental release were actually to occur. This assessment is considered here for each of the types of maximum credible accidents, for which the source terms are presented in Table 3.2.3-1, column 2, and in Table 3.2.3-2. The 70-year dose commitment to reference man downwind from each of the maximum credible accidents is presented in Table 3.2.4-2.

Each release was considered to occur under dispersion conditions represented by Pasquill E stability category with a wind speed of 3.0 meters per second. These dispersion conditions are conservative, even for releases caused by high winds or tornadoes. The values in Table 3.2.4-2 pertain to the centerline of the plume and, therefore, are the maximum doses for a person encountering the plume. Additionally, no credit is taken for changes in the terrain downwind from the Plant or for depletion of the plume by fallout.

The dose values at a distance of 1.2 miles represent the dose to the maximum individual, who was considered to be at the Plant boundary. The food he eats was also considered to be produced at the Plant boundary. For the criticality accidents, control of affected food and other agricultural products was assumed if the dose to the thyroid via the food pathway would exceed 1.5 rem for maximum intake for the infant, as proposed by the Food and Drug Administration (USHEW, 1978). The food affected by the maximum credible solution criticality would be controlled within 50 miles downwind and out to 30 miles for the maximum credible metal criticality accident, based on the proposed FDA criterion (when the altitude of the terrain relative to the release point is not included in the consideration of the plume dispersion). The State of Colorado "Radiological Emergency Response Plan for Rocky Flats," described in Section 2.11.4, calls for food and agricultural control when the dose to the thyroid (for all pathways) exceeds 25 rem.

Of the postulated maximum credible accidents, the greatest impact results from the aircraft crash, for which the bone dose ranges from 690 rem for the maximum individual to 5.8 rem to a reference man living 40 miles downwind. Also of interest are the criticality accidents, from which releases of the isotopes of iodine can result in significant thyroid doses. For the solution criticality the thyroid dose to the adult reference man ranges from 10 rem at 1.2 miles to 0.034 rem at 40 miles, assuming that affected food supplies are controlled. If the affected food is not controlled, the thyroid dose to the adult reference man who produces nearly all his own food, especially milk, would range from 4300 rem at 1.2 miles to 38 rem at 40 miles downwind. Almost 80% of this dose results from intake of affected milk and 17% from above-ground vegetables. For the calculation of the dose from the food pathway, the release was assumed to occur at a time which allows a maximum transfer to man for each type of food.

TABLE 3.2.4-2

THE 70-YEAR ORGAN DOSE COMMITMENTS TO REFERENCE MAN DOWNWIND FROM POSTULATED MAXIMUM CREDIBLE ACCIDENTS

(Dose at the Centerline of the Plume and at the same Altitude as the Plant)

Accident Type	Distance Downwind (miles)	70-Year Organ Dose Commitment (rem) Total Body	Liver	Bone	Lungs
Spill	* 1.2	3.1×10^{-5}	3.8×10^{-3}	9.4×10^{-3}	2.2×10^{-3}
	2	1.4×10^{-5}	1.7×10^{-3}	4.2×10^{-3}	1.0×10^{-3}
	3	7.6×10^{-6}	9.3×10^{-4}	2.3×10^{-3}	5.6×10^{-6}
	4	5.1×10^{-6}	6.2×10^{-4}	1.5×10^{-3}	3.7×10^{-4}
	5	3.7×10^{-6}	4.5×10^{-4}	1.1×10^{-3}	2.7×10^{-4}
	10	1.5×10^{-6}	1.8×10^{-4}	4.4×10^{-4}	1.1×10^{-4}
	20	6.0×10^{-7}	7.3×10^{-5}	1.8×10^{-4}	4.4×10^{-5}
	30	3.6×10^{-7}	4.4×10^{-5}	1.1×10^{-4}	2.7×10^{-5}
	40	2.6×10^{-7}	3.2×10^{-5}	7.9×10^{-5}	1.9×10^{-5}
Mechanical Failure	* 1.2	6.2×10^{-3}	7.5×10^{-1}	1.9	4.3×10^{-1}
	2	2.8×10^{-3}	3.4×10^{-1}	8.4×10^{-1}	2.0×10^{-1}
	3	1.5×10^{-3}	1.9×10^{-1}	4.6×10^{-1}	1.1×10^{-1}
	4	1.0×10^{-3}	1.2×10^{-1}	3.1×10^{-1}	7.4×10^{-2}
	5	7.4×10^{-4}	9.0×10^{-2}	2.3×10^{-1}	5.4×10^{-2}
	10	2.9×10^{-4}	3.6×10^{-2}	8.9×10^{-2}	2.1×10^{-2}
	20	1.2×10^{-4}	1.5×10^{-2}	3.6×10^{-2}	8.7×10^{-3}
	30	7.3×10^{-5}	8.9×10^{-3}	2.2×10^{-2}	5.3×10^{-3}
	40	5.2×10^{-5}	6.3×10^{-3}	1.6×10^{-2}	3.8×10^{-3}
Impoundment Failure	1.2	-	-	-	-
	2	-	-	-	-
	3	-	-	-	-
	* 4	1.4×10^{-3}	1.6×10^{-1}	4.0×10^{-1}	1.4×10^{-3}
	5	1.4×10^{-3}	1.6×10^{-1}	4.0×10^{-1}	1.4×10^{-3}
	10	-	-	-	-
	20	-	-	-	-
	30	-	-	-	-
	40	-	-	-	-
Fire	* 1.2	2.2×10^{-7}	2.6×10^{-5}	6.6×10^{-5}	1.5×10^{-5}
	2	9.6×10^{-8}	1.2×10^{-5}	2.9×10^{-5}	7.0×10^{-6}
	3	5.3×10^{-8}	6.5×10^{-6}	1.6×10^{-5}	3.9×10^{-6}
	4	3.5×10^{-8}	4.3×10^{-6}	1.1×10^{-5}	2.6×10^{-6}
	5	2.6×10^{-8}	3.2×10^{-6}	7.9×10^{-6}	1.9×10^{-6}
	10	1.0×10^{-8}	1.2×10^{-6}	3.1×10^{-6}	7.4×10^{-7}
	20	4.2×10^{-9}	5.1×10^{-7}	1.3×10^{-6}	3.1×10^{-7}
	30	2.5×10^{-9}	2.1×10^{-7}	7.8×10^{-7}	1.9×10^{-7}
	40	1.8×10^{-9}	2.2×10^{-7}	5.5×10^{-7}	1.3×10^{-7}

*Maximum individual.

TABLE 3.2.4-2 (Continued)

Accident Type	Distance Downwind (miles)	70-Year Organ Dose Commitment (rem) Total Body	Liver	Bone	Lungs
Explosion	* 1.2	3.1×10^{-5}	3.8×10^{-3}	9.4×10^{-3}	2.2×10^{-3}
	2	1.4×10^{-5}	1.7×10^{-3}	4.2×10^{-3}	1.0×10^{-3}
	3	7.6×10^{-6}	9.3×10^{-4}	2.3×10^{-3}	5.6×10^{-4}
	4	5.1×10^{-6}	6.2×10^{-4}	1.5×10^{-3}	3.7×10^{-4}
	5	3.7×10^{-6}	4.5×10^{-4}	1.1×10^{-3}	2.7×10^{-4}
	10	1.5×10^{-6}	1.8×10^{-4}	4.4×10^{-4}	1.1×10^{-4}
	20	6.0×10^{-7}	7.3×10^{-5}	1.8×10^{-4}	4.4×10^{-5}
	30	3.6×10^{-7}	4.4×10^{-5}	1.1×10^{-4}	2.7×10^{-5}
	40	2.6×10^{-7}	3.2×10^{-5}	7.9×10^{-5}	1.9×10^{-5}
**Aircraft Impact	* 1.2	2.2	270	690	160
	2	1.0	120	310	74
	3	5.6×10^{-1}	68	170	41
	4	3.7×10^{-1}	45	110	27
	5	2.7×10^{-1}	33	82	20
	10	1.1×10^{-1}	13	32	7.8
	20	4.4×10^{-2}	5.3	13	3.2
	30	2.7×10^{-2}	3.2	8.1	1.9
	40	1.9×10^{-2}	2.3	5.8	1.4
Tornado	* 1.2	6.8×10^{-2}	8.3	21	4.8
	2	3.0×10^{-2}	3.7	9.2	2.2
	3	1.7×10^{-2}	2.0	5.0	1.2
	4	1.1×10^{-2}	1.4	3.4	8.1×10^{-1}
	5	8.1×10^{-3}	1.0	2.5	6.0×10^{-1}
	10	3.2×10^{-3}	3.9×10^{-1}	9.6×10^{-1}	2.3×10^{-1}
	20	1.3×10^{-3}	1.6×10^{-1}	4.0×10^{-1}	9.6×10^{-2}
	30	8.0×10^{-4}	9.8×10^{-2}	2.4×10^{-1}	5.8×10^{-2}
	40	5.7×10^{-4}	7.0×10^{-2}	1.7×10^{-1}	4.2×10^{-2}
High Wind	* 1.2	2.0×10^{-1}	24	61	14
	2	9.0×10^{-2}	11	27	6.5
	3	5.0×10^{-2}	6.1	15	3.6
	4	3.3×10^{-2}	4.0	10	2.4
	5	2.4×10^{-2}	2.9	7.3	1.8
	10	9.4×10^{-3}	1.2	2.9	6.9×10^{-1}
	20	3.9×10^{-3}	4.7×10^{-1}	1.2	2.8×10^{-1}
	30	2.4×10^{-3}	2.9×10^{-1}	7.1×10^{-1}	1.7×10^{-1}
	40	1.7×10^{-3}	2.1×10^{-1}	5.1×10^{-1}	1.2×10^{-1}

*Maximum individual.
**See Table 3.2.4-4 for the effect of altitude toward the most populated sector.

TABLE 3.2.4-2 (Continued)

Accident Type	Distance Downwind (miles)	Total Body	70-Year Organ Dose Commitment (rem) Liver	Bone	Lungs	Thyroid
Solution	* 1.2	4.4	4.4	4.4	5.1	10
Criticality	2	1.8	1.8	1.8	2.1	4.4
	3	0.85	0.85	0.85	1.0	2.3
	4	0.50	0.50	0.50	0.60	1.4
	5	0.33	0.33	0.33	0.40	0.97
	10	7.9×10^{-2}	7.9×10^{-2}	7.9×10^{-2}	0.10	0.31
	20	1.9×10^{-2}	1.9×10^{-2}	1.9×10^{-2}	2.7×10^{-2}	9.8×10^{-2}
	30	9.6×10^{-3}	9.5×10^{-3}	9.6×10^{-3}	1.4×10^{-2}	5.2×10^{-2}
	40	6.3×10^{-3}	6.3×10^{-3}	6.3×10^{-3}	8.8×10^{-3}	3.4×10^{-2}
Metal	* 1.2	1.9×10^{-2}	2.0×10^{-2}	2.2×10^{-2}	2.3×10^{-2}	4.5×10^{-2}
Criticality	2	7.6×10^{-3}	8.2×10^{-3}	9.1×10^{-3}	9.3×10^{-3}	2.0×10^{-2}
	3	3.7×10^{-3}	4.0×10^{-3}	4.5×10^{-3}	4.6×10^{-3}	1.0×10^{-2}
	4	2.2×10^{-3}	2.4×10^{-3}	2.7×10^{-3}	2.8×10^{-3}	6.3×10^{-3}
	5	1.4×10^{-3}	1.6×10^{-3}	1.8×10^{-3}	1.8×10^{-3}	4.4×10^{-3}
	10	3.5×10^{-4}	4.1×10^{-4}	5.1×10^{-4}	5.0×10^{-4}	1.4×10^{-3}
	20	8.6×10^{-5}	1.1×10^{-4}	1.5×10^{-4}	1.4×10^{-4}	4.4×10^{-4}
	*** 30	6.4×10^{-5}	8.6×10^{-5}	1.1×10^{-4}	9.2×10^{-5}	1.2×10^{-2}
	*** 40	4.3×10^{-5}	5.9×10^{-5}	7.7×10^{-5}	6.2×10^{-5}	8.3×10^{-3}

*Maximum individual.
***No food control at these distances.

Doses to other individuals in the population can be derived from the values for reference man by consideration of the values in Table 3.2.4-3, which presents the ratios of the 70-year dose commitments from acute releases to individuals exposed as newborn males and females, as 10-year old males and females, and as adult females, to that for reference man. For accidents other than criticalities and impoundment failures, greater than 99% of the dose to all the organs results from the inhalation pathway. The values for inhalation, therefore, are the controlling values. The high values for the newborn male and female for the ingestion pathway result from an increased absorption from the gastrointestinal tract by a factor of 100 during the first year for plutonium and americium, following the considerations of the EPA (USEPA, 1977). Since the ingestion pathway contributes less than 1% of the dose for exposures to plutonium and americium, increasing this contribution by a factor of 30 for the newborn female increases the total organ dose by less than a factor 1.30. Similarly, for the newborn male the total organ dose is less than a factor of 1.25 greater than that for reference man for exposures to plutonium and americium. Therefore, it can be inferred that the dose values for reference man represent a reasonable assessment of the dose received by any other category of individual from acute releases of plutonium and americium. The high values for the thyroid of the newborn male and female for both inhalation and ingestion result from an increased metabolism of iodine during the first year by a factor of 2.3. This factor reflects a 70% uptake by the thyroid of the infant (USHEW, 1978) compared to a 30% uptake by the thyroid of reference man (ICRP, 1959). The contribution to the total dose to the thyroid from the postulated criticality accidents is in the range of 60% to 70% from inhalation, 25% to 32% from plume shine irradiation, 5% to 7% from ground plane irradiation, and less than 1% from water ingestion, if the affected food is controlled and not available for consumption. The total ratio of the thyroid dose to infants compared to reference man is about 1.34 for the newborn male and 1.26 for the newborn female. If the affected food were not controlled, the ingestion pathway would contribute more than 99% of the thyroid dose, and the thyroid dose to infants would be 5.76 times the thyroid dose of reference man for the newborn male and 5.24 for the newborn female.

To determine the possible impact to populations from the maximum credible release, the wind was considered to blow toward the sector with the maximum population. This is the southeast sector, the one towards Denver. To obtain more reasonable dispersion values, the altitude of the Plant relative to that for this sector was considered, as well as Pasquill stability category D in addition to category E (see Section 2.3.6.3). The centerline plume dose was used to estimate the dose to all persons in the sector, an approach which results in an overestimate of a population dose by about a factor of 3, since the plume width (at $\pm 1\sigma$) at 2 miles is 400 meters or 0.39 of the sector width at that distance and is 5500 meters at 40 miles or 0.27 of the sector width for Pasquill D conditions.

TABLE 3.2.4-3

COMPARISON OF THE 70-YEAR DOSE COMMITMENTS FOR INDIVIDUALS OTHER THAN REFERENCE MAN TO THAT FOR REFERENCE MAN FROM ACUTE RELEASES

(Values are for Pu-239 unless noted otherwise)

		Ratio to Reference Man of 70-Year Dose Commitment					
Pathway	Start Exposure as	Total Body	Liver	Bone	**	Lungs	Thyroid*
Inhalation	Adult Female	1.10	1.18	1.36		1.14	1.07
	10-Year-Old Female	0.83	0.97	1.08		1.12	1.28
	Newborn Female	0.08	0.07	0.08		0.35	1.43
	10-Year-Old Male	0.72	0.73	0.73		1.32	1.28
	Newborn Male	0.07	0.06	0.07		0.35	1.56
Ingestion	Adult Female	0.84	0.89	1.03	1.02	0.84	0.82
	10-Year-Old Female	0.90	0.97	1.18	1.17	0.90	1.44
	Newborn Female	30.2	28.4	30.0	30.6	30.2	5.24
	10-Year-Old Male	0.79	0.83	0.82	0.82	0.79	1.48
	Newborn Male	22.4	23.0	23.9	24.4	22.4	5.76
Ground Plane Irradiation	All categories	1.00	1.00	1.00		1.00	1.00
Plume Shine	All categories	1.00	1.00	1.00		1.00	1.00

*Values calculated for I-131.
**Values for Am-241.

Table 3.2.4-4 presents the comparison of the 70-year bone dose commitment to reference man and to the 1977 population in the southeast sector for both Pasquill D and E categories, with a wind speed of 3.0 meters per second for both categories. If one were to use a wind speed of 6.6 meters per second for Pasquill D conditions, as indicated by data from Table 5 of Appendix B-1, the values for Pasquill D conditions would be lowered by the ratio of the wind speeds 6.6/3.0, i.e., by a factor of 2.2.

TABLE 3.2.4-4

THE 70-YEAR BONE DOSE COMMITMENT TO REFERENCE MAN AND TO THE 1977 POPULATION IN THE SOUTHEAST SECTOR FOR DOWNWIND EXPOSURE TO THE POSTULATED MAXIMUM CREDIBLE RELEASE

		70-Year Bone Dose Commitment			
Distance from Plant (miles)	Approximate Altitude Below Plant (meters)	To Reference Man (rem)		To SE Sector 1977 Population (man-rem)	
		Pasquill D	Pasquill E	Pasquill D	Pasquill E
2	100	51	24	7.1×10^2	3.3×10^2
3	100	42	33	2.0×10^3	1.6×10^3
4	100	33	34	9.2×10^3	9.6×10^3
5	150	17	9.5	8.9×10^5	4.9×10^5
10	200	7.2	4.2	2.0×10^6	1.2×10^6
20	200	3.7	4.1	7.1×10^5	8.0×10^5
30	200	2.4	3.4	4.8×10^3	6.8×10^3
40	200	1.7	2.8	3.4×10^3	5.6×10^3
				3.6×10^6	2.5×10^6

Since the calculated population bone dose is greater for Pasquill category D than for category E, the risk estimates for the population are based on Pasquill category D. The population organ doses and risk estimates for these conditions are given in Table 3.2.4-5. The total possible number of mortalities over 70 years as a consequence of this maximum credible release is 66 (or less) for a population of over 525,000.

TABLE 3.2.4-5

THE 70-YEAR DOSE COMMITMENT TO THE 1977 POPULATION IN THE SOUTHEAST SECTOR FOR DOWNWIND EXPOSURE TO THE MAXIMUM CREDIBLE RELEASE AND THE ESTIMATED EFFECTS

(Pasquill D conditions, 3.0 m/s wind speed, with approximate terrain towards SE)

Distance from Plant (miles)	Approximate Altitude Below Plant (meters)	1977 Population	70-Year Organ Dose Commitment (man-rem) Total Body	Liver	Bone	Lungs
2	100	14	2.3	2.8×10^2	7.1×10^2	1.7×10^2
3	100	48	6.6	8.0×10^2	2.0×10^3	4.8×10^2
4	100	283	3.0×10^1	3.7×10^3	9.2×10^3	2.2×10^3
5	150	52,143	2.9×10^3	3.6×10^5	8.9×10^5	2.1×10^5
10	200	275,895	6.5×10^3	8.0×10^5	2.0×10^6	4.8×10^5
20	200	192,886	2.3×10^3	2.9×10^5	7.1×10^5	1.7×10^5
30	200	2,044	1.6×10^1	1.9×10^3	4.8×10^3	1.2×10^3
40	200	2,011	1.1×10^1	1.3×10^3	3.4×10^3	8.0×10^2
		525,324	1.2×10^4	1.5×10^6	3.6×10^6	8.7×10^5
Cancer Risk (Mortalities) per man-rem			2×10^{-4}	2×10^{-6}	6×10^{-6}	4×10^{-5}
Genetic Defects per man-rem			3×10^{-4}			

Maximum Denver Area Impact Over 70 Years from the Maximum Credible Release

	Total Body	Liver	Bone	Lungs
Cancer Mortalities	2.4	2.9	22	35
Genetic Defects	3.6			

It is of interest to speculate about the impact of the maximum credible release on a hypothetical population for higher density residential conditions at and beyond two miles downwind and southeast from the Plant. Table 3.2.4-6 presents the analysis of the population bone dose to the year 2000 population as projected, and to the year 2000 population plus the hypothetical higher population density in the southeast sector at distances 2-3 miles, 2-4 miles, and 2-5 miles. The hypothetical higher density is set at 7296 persons per square mile, as for the similar calculation for routine releases (see Table 3.1.2-9). The impact is to increase the population dose in that sector by up to 16.8%. Of course, the dose per person, as presented in Table 3.2.4-2, is not affected by population densities or distribution and is the value of primary interest when assessing the impact to persons living downwind from an accidental release.

TABLE 3.2.4-6

IMPACT OF THE MAXIMUM CREDIBLE RELEASE ON THE PROJECTED POPULATION IN THE YEAR 2000 WITH A HYPOTHETICAL HIGH POPULATION ADJACENT TO THE PLANT FOR THE SECTOR OF MAXIMUM POPULATION (SOUTHEAST)

Distance from Plant (miles)	Projected Year 2000 Population SE Sector	Hypothetical Population From 2 to 5 Miles*	70-Year Population Bone Dose** for Year 2000 Population Plus (as is)	Hypothetical Population at 2-3 miles	2-4 miles	2-5 miles
2	75	7,162	3.79×10^3	3.62×10^5	3.62×10^5	3.62×10^5
3	138	10,025	5.73×10^3	Unchanged	4.17×10^5	4.17×10^5
4	393	12,892	1.28×10^4	"	Unchanged	4.19×10^5
5	70,206	Unchanged	1.19×10^6	"	"	Unchanged
10	444,560	"	3.21×10^6	"	"	"
20	676,169	"	2.50×10^6	"	"	"
30	16,254	"	3.82×10^4	"	"	"
40	5,449	"	9.09×10^3	"	"	"
Total	1,213,244	1,242,717	6.97×10^6	7.33×10^6	7.74×10^6	8.15×10^6
Percent Increase				5.1%	11.1%	16.9%

*For a population density of 7296 persons/mile^2.

**Calculated for Pasquill D conditions, 3.0 m/s wind speed with approximate relative altitude towards Denver.

To address the question about the impact on the health of an individual from the postulated accidental releases, the assessment can be approached in two ways, as was done for routine releases. One way is to estimate the risk of cancer mortality over 70 years. The risk of cancer mortality can then be compared to risk of mortality from common accidents. The second way is to compare the dose that could be received from accidental releases with the dose each person receives from natural, unavoidable (background) radiation. Note that even though the uptake from accidental releases may occur in a relatively short period of time, the dose to organs such as the total body, liver, and bone is received almost uniformly over the 70 years because of the long residence time for plutonium and americium in these organs. Comparison to the chronic 70-year background dose is, therefore, appropriate for these organs. For the lungs and thyroid (for iodine uptake from criticalities) the dose is delivered shortly after uptake. For these organs, comparison with the two- and one-year background dose for lungs and thyroid, respectively, is appropriate.

The risk of cancer mortalities (plus genetic defects) per man-rem of dose (or per rem of dose to one person) is given in Table 3.1.2-10. When these values are multiplied by the 70-year dose commitments for corresponding organs, the result is the risk of cancer mortality (plus genetic defects) for the individual or population over 70 years. When this multiplication is done for values for the maximum individual for the postulated maximum credible accident (Table 3.2.4-2), the maximum values of risk to an individual of cancer mortality (plus genetic defects) over 70 years are obtained. These values are presented in Table 3.2.4-7. One can generate risk values for the individual at any other distance and direction of interest by the same procedure.

TABLE 3.2.4-7

RISK OF CANCER MORTALITY OVER 70 YEARS TO THE MAXIMUM REFERENCE MAN FROM POSTULATED MAXIMUM CREDIBLE ACCIDENTAL RELEASES

Accident Type	Risk of Cancer Mortality Over 70 Years Following an Actual Occurrence: Total Body	Liver	Bone	Lungs	Total*	Actual Risk**
Spill	1.6×10^{-8}	7.6×10^{-9}	5.6×10^{-8}	8.8×10^{-8}	1.7×10^{-7}	6.0×10^{-7}
Mechanical Failure	3.1×10^{-6}	1.5×10^{-6}	1.1×10^{-5}	1.7×10^{-5}	3.3×10^{-5}	1.2×10^{-5}
Impoundment Failure	7.0×10^{-7}	3.2×10^{-7}	2.4×10^{-6}	5.6×10^{-8}	3.5×10^{-6}	2.5×10^{-6}
Fire	1.1×10^{-10}	5.2×10^{-11}	4.0×10^{-10}	6.0×10^{-10}	1.2×10^{-9}	8.4×10^{-12}
Explosion	1.6×10^{-8}	7.6×10^{-9}	5.6×10^{-8}	8.8×10^{-8}	1.7×10^{-7}	6.0×10^{-7}
Aircraft Impact	1.1×10^{-3}	5.4×10^{-4}	4.1×10^{-3}	6.4×10^{-3}	1.2×10^{-2}	1.1×10^{-7}
Tornado	3.4×10^{-5}	1.7×10^{-5}	1.3×10^{-4}	1.9×10^{-4}	3.7×10^{-4}	1.8×10^{-9}
High Wind	1.0×10^{-4}	4.8×10^{-5}	3.7×10^{-4}	5.6×10^{-4}	1.1×10^{-3}	1.0×10^{-7}
Solution Criticality	2.2×10^{-3}	8.8×10^{-6}	2.6×10^{-5}	2.0×10^{-4}	2.4×10^{-3}	1.7×10^{-8}
Metal Criticality	9.5×10^{-6}	4.0×10^{-8}	1.3×10^{-7}	9.2×10^{-7}	1.1×10^{-5}	6.2×10^{-7}

*Does not include the risk of thyroid cancer, which is generally not fatal.

**The actual risk is the total risk following an actual occurrence multiplied by the probability of occurrence over 70 years.

†Includes genetic defects.

These risk values can be compared to the risk of death from common accidents, presented in Table 3.2.4-8. For all types of possible maximum credible releases, the total resulting mortality risk to the maximum individual is less than the risk of the average person being killed by a common accident over 70 years. The risk to individuals farther removed from the Plant is correspondingly less than the risk to the maximum individual and than the risk from common accidents.

TABLE 3.2.4-8

RISK OF DEATH FROM COMMON ACCIDENTS

Type of Accident	Death Rate*	Risk per Person in One Year	70-Year Risk Per Person
All Accidents	48.4	4.84×10^{-4}	3.39×10^{-2}
Motor-Vehicle Accidents	21.5	2.15×10^{-4}	1.51×10^{-2}
Falls	7.0	7.0×10^{-5}	4.9×10^{-3}
Drowning	3.8	3.8×10^{-5}	2.7×10^{-3}
Fires, Burns	2.9	2.9×10^{-5}	2.0×10^{-3}
Poisoning by Solids and Liquids	2.2	2.2×10^{-5}	1.5×10^{-3}

*Deaths per 100,000 population based on official 1975 national statistics (National Safety Council, 1977).

The actual risk is also presented in Table 3.2.4-7 for each of the maximum credible accidents. The actual risk is the total risk over 70 years to the maximum reference man from an actual occurrence of the accident multiplied by the probability that the accident would occur within the 70-year period. These values indicate that even a person residing at the Plant boundary (1.2 miles from the center of the Plant) and constantly downwind over 70 years has less than one chance in 60,000 of contracting a fatal cancer initiated by a postulated maximum credible accident, compared to one chance in 30 of being killed by a common accident over the same 70 years.

Comparison of the 70-year dose commitments from accidental releases with the 70-year dose from natural background radiation sources is a more direct comparison, since such a comparison avoids the multiple assumptions and extrapolations inherent in deriving a cancer risk from a radiation dose (see Appendix G-1). The comparison is between the 70-year dose commitments presented in Table 3.2.4-2, for reference man at various distances downwind from the Plant, and the 70-year background doses to the organs, presented in Table 3.1.2-6. For all postulated maximum credible accidents except the aircraft crash, tornado, and high wind (158 to 206 mph), the 70-year background dose is greater than the 70-year dose commitment received by reference man at any off-site location downwind for the total body, liver, and bone doses. The aircraft crash, which results in the maximum postulated release, results in a bone dose to the maximum individual at 1.2 miles which exceeds the 70-year background bone dose by a factor of 58. The bone dose to reference man exceeds the background bone dose by a factor of 26 at 2 miles, a factor which steadily decreases to 1.1 at a downwind distance of 20 miles. The organ doses resulting from the tornado and high wind postulated releases exceed the corresponding background organ doses only slightly (within a factor of 3) for individuals other than the maximum individual and only at close-in locations.

When one contemplates these risks, one should also keep in mind the probabilities associated with the postulated accidents, as given in Table 3.2.3-1. Converting the occurrences per year to years per occurrence, one obtains the values of expecting one occurrence of the maximum credible release from an aircraft impact at the crucial spot in 7.7 million years, one release from a tornado in 10 million years, one maximum credible solution criticality every 10 million years, and so on. The likelihood of a significant release is, therefore, quite small.

All of the doses from hypothetical accidents (except for criticality) were calculated assuming no action was taken to avoid exposure to the released radionuclides. In fact, if a serious accident were to occur, there are a number of mitigating actions which could be taken to reduce the consequences. Some of the possible actions to reduce exposure to released radioactive materials are (1) warning people to stay indoors for a period of time to avoid exposure to the radioactive cloud; (2) controlling contaminated food supplies (except, as discussed, for criticality accidents); (3) providing alternate drinking water supplies; (4) decontaminating ground and property; and (5) in the case of a criticality accident, administering iodine compounds to inhibit uptake of radioactive iodine. A thorough discussion of the cost and effectiveness of a variety of mitigating actions is given in Chapter 11 of Appendix VI of the Reactor Safety Study (USNRC, 1975).

3.2.4.3 Future Impact of Past Releases

Persons living on soil contaminated from past releases will receive a dose from the radionuclides in the soil. Possible pathways are breathing resuspended radionuclides, ingesting food grown on the soil, ingesting some of the soil itself, and being irradiated by ground shine. This section presents the assessment of the dose to individuals living for 70 years on soil contaminated to levels indicated in Figure 2.3.9-1, which shows the contours of the off-site plutonium contamination as measured by Krey (Krey and Hardy, 1970). The data of Krey and Hardy overestimate off-site concentrations of plutonium in soil. The best data presently available (Section 2.3.9.2) indicate that about 1000 acres of land exceed the 0.01 $\mu Ci/m^2$ level. These lands at present are uninhabited. If they were to be developed, the disturbances caused by development would result in reduction of the concentration of plutonium in the soil.

The 70-year dose to a person living constantly on a contour representing off-site soil contamination is presented in Table 3.2.4-9. These values are similar to those for reference man living in the east-southeast sector for routine chronic releases (Table 3.1.2-2) and are at least a factor of 50 lower than the 70-year dose from background radiation, even for the 0.01 $\mu Ci/m^2$ contour.

TABLE 3.2.4-9

THE 70-YEAR DOSE TO REFERENCE MAN LIVING CONSTANTLY ON OFF-SITE SOIL CONTAMINATED FROM PAST RELEASES

	70-Year Organ Dose (rem) to Reference Man			
Contour ($\mu Ci/m^2$)	Total Body	Liver	Bone	Lungs
0.01	0.0012	0.11	0.26	0.053
0.005	0.00062	0.054	0.13	0.027
0.003	0.00037	0.032	0.078	0.016

It is interesting to note the fraction of the dose contributed by each pathway. These values are presented in Table 3.2.4-10. The ingestion of soil at an assumed rate of one gram per day contributes a significant fraction of the total dose (except for lungs), a contribution which is probably near zero for most persons. Also, the plutonium was considered to be soluble for the calculation of the dose to the total body, liver, and bone via inhalation, while plutonium which has been subjected to air-oxidation and weathering for several years is likely to be insoluble. Calculation of the dose to the total body, liver, and bone assuming insolubility would lower the calculated dose to those organs via inhalation by a factor of 2. For details of the dose calculation methodology, see Appendix F.

TABLE 3.2.4-10

FRACTION OF THE DOSE FROM EACH PATHWAY

Pathway	Total Body	Liver	Bone	Lungs
Inhalation	0.32	0.51	0.47	0.98
Soil Ingestion	0.36	0.49	0.53	0.008
Ground Shine	0.32	0.004	0.002	0.007
Food Ingestion	<0.001	<0.001	<0.001	<0.001

3.3 ENVIRONMENTAL IMPACT OF TRANSPORTATION

This section discusses the environmental impact associated with the transport of materials to and from the Rocky Flats Plant. Effects of transportation from both routine operation and accidents were completely reevaluated, as a result of comments on the DEIS, using methods from the NRC's environmental statement on transportation of radioactive materials. An analysis of a transportation accident in a densely populated urban area was added. The analyses were based on transportation requirements as summarized in Section 2.6.10.1, Table 2.6.10-2. These transportation requirements are representative of requirements in future years and, while the exact number of any particular type of shipment may vary in future years, no marked change in the overall transportation requirements is expected.

3.3.1 Nontoxic Effects of Transportation

3.3.1.1 Traffic Aspects

There are about 500 shipments by truck of radioactive materials and about 850 shipments by truck of chemicals and nonradioactive materials to and from the Rocky Flats Plant each year. This total of about 1,350 shipments by truck per year will be spread over a considerable portion of the United States (some 30 different locations in the United States ship to or receive from Rocky Flats); consequently, the expected number of trucks per day on any particular road in the U.S. (except those roads near Rocky Flats) is less than one. According to the Federal Highway Administration, the average number of trucks per day on the highway in any specific section of the U.S. generally varies from about 100 to 10,000 (AEC, 1972). The general truck traffic, therefore, is not significantly affected by Rocky Flats shipments. Even on roads near the Plant there will be only a few shipments per day, and the impact of transport requirements will not be significant. Furthermore, the gross shipment weights of the materials transported to and from Rocky Flats are such that trucks can stay within weight restrictions of the states; there is no need for overweight permits and no anticipated excessive loads on bridges or roads.

The number of rail shipments, about 100 per year both inbound and outbound, is insignificant in comparison to total rail traffic throughout the nation. Special rail cars (ATMX) are used for waste shipments.

The annual number of air shipments of radioactive material (since April, 1977, no plutonium has been shipped by air) is less than 200, and the number of beryllium shipments is about 200. The overall number of shipments is minute in comparison to the total number of air shipments in the U.S. per year and is significant only for the Jefferson County (Jeffco) Airport near the Plant. Even at Jeffco Airport, the number of flights involving Rocky Flats shipments is only a small fraction of the total yearly flights.

3.3.1.2 Fuel Consumption

The principal use of natural resources represented by transportation is the consumption of fuel. The total travel miles represented by the Rocky Flats transportation requirements are about 637,000 truck miles; 358,000 air miles; and 150,000 rail miles. The AEC (AEC, 1972) gave the average diesel fuel consumption of large intercity trucks as 2.1 miles/gallon. The truck miles represent a fuel usage of about 303,000 gallons of diesel fuel. This consumption is small in comparison to the 2.9 billion gallons of diesel fuel consumed by trucks in 1972. The air and rail transport miles also represent fuel usage, but over most of these miles the airplane or train would also carry other cargo; consequently, the total fuel consumption should not be assigned to the Rocky Flats shipment. Even if the entire train and plane fuel consumption were assigned to Rocky Flats, the additional fuel consumption would be only about 204,000 gallons. This amount is also a small fraction of the total U.S. fuel usage.

3.3.2 Toxic Effects of Transportation

3.3.2.1 Nonradiological Effects

The chemical effluents that result from burning the total amount of truck fuel and one-third of the train and plane fuel (about 371,000 gallons) are given in Table 3.3.2-1. (It was assumed that about one-third of the train and plane fuel useage is directly attributable to Rocky Flats.) These effluents are based on an EPA Air Pollutant Emission Factors (USEPA, 1972) compilation. The emissions shown in Table 3.3.2-1 represent only about one part in 10^4 to 10^5 of the total emissions from general transport in the country. Since these emissions are widely dispersed over the country, their impact on the environment would be small.

Thermal effluents from transportation requirements are limited to the heat released from combustion of fuel in the truck, train, and airplane engines. This heat release is again only about one part in 10^4 to 10^5 of the heat released by general transport in the country and, because of its dispersed nature, should cause no detectable effects.

TABLE 3.3.2-1
CHEMICAL EFFLUENTS FROM THE
YEARLY TRANSPORT OF ROCKY FLATS MATERIALS

Effluent	Quantity (tons)
Particulates	4.08
Sulfur Oxide (SO_x)	9.52
Carbon Monoxide (CO)	28.7
Hydrocarbons (CH_x)	8.16
Nitrogen Oxide (NO_x)	40.9

Major transportation accidents involving fires may result in the release of beryllium oxide to the air. Beryllium is recognized as a hazardous air pollutant under regulations published by EPA pursuant to Section 112 of the Clean Air Act (36 CFR 5931). Under the EPA standards for beryllium, each single source in the U.S. is permitted to discharge 10 grams of beryllium per day, whereas the expected yearly release of beryllium from Rocky Flats transportation accidents, spread over the entire U.S., is only 50 grams per year. The additional exposure of the population to beryllium from expected accident releases is expected to be negligible in comparison to nationwide daily releases.

The consequences to a maximum individual under the worst accident conditions (complete burning of a total shipment of beryllium) will be considered next. The maximum concentration (at 3.5 miles) to which an individual would be expected to be exposed would be about 7.6×10^{-8} g/m^3, or 0.076 μg/m^3. The EPA has established an ambient-air quality standard of 0.01 μg/m^3 in the air. This standard, however, is for a 30-day average whereas the maximum expected concentration will persist only for a short time. The National Academy of Sciences has reported that no acute illnesses have occurred where peak concentrations do not exceed 25 μg/m^3 (NAS, 1953). No damage in laboratory animals has been noted from exposure below 4 μg/m^3 (USEPA, 1969). It would appear that the maximum short-term concentration is below that which would cause acute effects, and because of the limited duration of the exposure, no long-term effects are expected.

There is a possibility, on the basis of experimental data on animals, that beryllium is a carcinogen (see Section 2.5.3.2). If this is applicable to humans, there might be some potential cancer risk associated with beryllium releases, just as there may be some potential cancer risk associated with low level radioactive releases. Epidemiological studies to date, however, have not provided any evidence of a relationship between exposure to beryllium and the occurrence of human cancer (IARC, 1972); consequently, any potential cancer risk to man from the releases discussed above cannot be quantified.

3.3.2.2 Radiological Effects

The radiological effects from transportation associated with Rocky Flats come from two distinct sources. First, there is the external penetrating radiation received by humans in proximity to normally operating transport vehicles or packages held in storage; and secondly, there is internal exposure resulting from radionuclide releases caused by transportation accidents. The risk of this internal exposure over a long period of time, called the "risk dose," is determined by evaluating the probability of a particular accident occurring, multiplying by the consequence (dose) to the population if that particular accident did occur, and summing over all possible accidents.

The methodology used to evaluate the radioactive releases of Rocky Flats transportation is essentially that of the U.S. Nuclear Regulatory Commission's environmental statement on transportation of radioactive material (USNRC, 1977). Site specific data were used whenever the nationwide data of the NRC document were not applicable. Although plutonium can be shipped by air from Rocky Flats (Section 2.6.10.1), the doses were calculated assuming that no such shipments take place. (Currently no plutonium is shipped by air.) The probabilities of accidents (Appendix F) are such that shipment of radioactive materials by truck instead of air results in an increase in the risk dose to the U.S population. The dosimetric methodology is the same as for Plant operations and accidents. Both methodologies are fully explained in Appendix F.

Normal Operations

The radiological effects of normal transportation associated with Rocky Flats are not limited to the area surrounding the Plant, but are spread throughout the country, as can be seen from Table 2.6.10-3. Thus it is appropriate to discuss the population dose to the entire United States rather than limiting the population to that immediately surrounding the Plant.

Dose is considered to several portions of the population. These are the population sharing the transportation link; the population off, but near, the transportation link; the population surrounding the vehicle while stopped; warehouse personnel; and transportation vehicle crew. Based upon the DOT external dose rate limit of 10 mrem/hr at six feet from the exterior of an exclusive use vehicle, the 70 year dose to the U.S. population from 70 years of Rocky Flats transportation is 4900 man-rem. This total body external exposure is negligible in comparison to the 1.2×10^9 man-rem total body natural background received by the U.S. population in 70 years.

The population dose from normal Rocky Flats transportation is considered to have a health effect upon the entire United States population. Based on the health risk factors of Table 3.1.2-10, and assuming that external penetrating radiation will deliver the same dose to all of the body organs, 70 years of transportation will result in an increase of 1.2 cancer fatalities and 1.5 genetic defects across the country.

A breakdown by shipping mode of the external dose to the population is as follows:

Truck	4000 man-rem
Delivery Vehicle*	480 man-rem
Air	360 man-rem
Rail	62 man-rem

*Transportation of air shipments between airport and facility

Over 80% of the population dose is received from transport truck shipment. This is due to several factors. Trucks account for almost 70% of the radioactive transportation mileage associated with Rocky Flats and this transportation mode is in much closer proximity to the general public than are rail or air shipment modes.

Some individuals in the population are more closely associated with Rocky Flats transportation, through working in close proximity to radioactive shipments or living close to regularly used shipping routes. The worst case individual living near transport routes would most likely be someone who lives near the gate of the plant. It is possible that he could be an average distance of 30 meters from each truck shipment as it passes. The total dose to this individual would be only 0.0015 rem in 70 years.

On the roadways, it is possible that a truck driver unassociated with Rocky Flats could follow a truck carrying radioactive materials for one entire trip. The dose to someone following 30 meters behind a Rocky Flats transport truck for an average trip is 0.0008 rem. The possibility of one individual following radioactive shipments for more than this amount was considered incredible.

In the calculation of population dose due to normal operations, truck drivers were considered as part of the general population. However, much of the truck transportation is via DOE-owned vehicles operated by DOE personnel. Assuming that the dose rate at the driver's position is limited to 0.002 rem per hour as specified in DOT regulations and, as pointed out in Section 2.6.10.2, that most shipments have an external dose rate an order of magnitude lower, the annual dose to a driver making 30 average trips per year is 1.4 rem. The limit for an occupational worker is 5 rem per year. For a delivery vehicle driver making one half of all deliveries, the annual dose would be 0.5 rem.

Individuals who work in the transportation industry but are not considered radiation workers receive a larger proportion of the population dose than do other individuals. This is because of their need to handle and work in close proximity to the radioactive packages. The proportion of the population dose resulting from each transportation mode that is received by these individuals is shown below:

Truck	83%
Air	94%
Delivery Vehicle	41%
Rail	9.1%

The portion of the population dose associated with rail shipments is low because of the large distance between cargo and crew, while that associated with Delivery Vehicles is lower than for Air or Truck because of the close proximity to the population on urban streets, which results in a higher proportion of that dose being received by the general population.

Transportation Accidents

The packages used to transport materials in support of Rocky Flats operations are designed to prevent the loss or dispersal of their contents under "design basis" accident conditions in addition to normal conditions of transport.* However, under certain abnormal conditions, releases of radionuclides or toxic chemicals to the environment could occur. Causative factors leading to potential releases include

*The release in the Springfield, Colorado, yellowcake spill (Mattson, 1977), which resulted from the collision of a truck with several horses on the highway, is not typical of accident releases for material transported in approved shipping containers. The material involved in that incident was natural uranium ore concentrates, which are specifically exempted from many of the transportation regulations which apply to materials containing a higher concentration of radioactivity. This incident was not related to the Rocky Flats Plant.

improperly closed containers, immersion in deep water, or accidents. Because of stringent quality control requirements, the likelihood of improper closure has been estimated in the range of 10^{-4} to 10^{-5} per package (AEC, 1972).* Moreover, the release fraction in the event of improper closure is likely to be small. The risk associated with improper closure, then, is estimated to be lower than that associated with accidents. Immersion in deep water is likely to occur only as the result of a severe accident and is estimated to be considerably less probable than an accident leading to a simple release; thus, the analysis of abnormal releases in transportation will be confined to accidents.

Although there have never been any radioactive releases from transportation associated with Rocky Flats, a risk dose can be calculated. Based upon the transportation model used in this Statement (Appendix F) and accident probabilities and release fractions from the NRC's FEIS on tranportation (USNRC, 1977), the results in Table 3.3.2-2 were calculated. These doses are the result of the inhalation pathway. Food and water pathways are difficult to quantify because of the inhomogeneity of food and water sources along transportation routes. From routine Plant releases it is evident that these exposure pathways are of minimal importance, especially if tritium is not included. The ground plane dose pathway was also considered, found to be small (3.0 man-rem) in comparison to the dose from the inhalation pathway, and not included.

TABLE 3.3.2-2

POPULATION RISK DOSE FROM 70 YEARS OF ROCKY FLATS TRANSPORTATION

	(man-rem including resuspension)			
	Total Body	Lung	Liver	Bone
Truck	60	11000	7000	17000
Rail	0.81	180	110	250
Delivery Vehicle	0.60	640	520	14
Air	0.067	72	0.068	1.6
	61	12000	7600	18000

Dispersion estimates were based upon a year or more of meteorological data from sites near White Sands, New Mexico, and Aiken, South Carolina, as presented in the NRC document. The risk dose to the U.S. population is small in comparison to the organ doses received by the same population from natural background. The 70 year background organ doses to the U.S. population are 2.7×10^9 man-rem to the lung, 1.8×10^9 man-rem to the bone, and 1.2×10^9 man-rem to the liver and total body (derived from NCRP, 1975). Health effects to the population from the risk dose are predicted from the risk estimate of Table 3.1.2-10. The 70 year risk of all types of cancer considered in this Statement is 0.63 cancer deaths. A similar calculation predicts

*An actual audit of closure faults on approximately 6,000 packages revealed no instance of complete loss of container integrity (Brown and Heaberlin, 1974).

0.018 genetic effects. This cancer risk spread over the entire U.S. population is 2.8×10^{-9} per person, compared to 3.4×10^{-2} per person for the risk of death from common accidents, according to official 1975 statistics (see Table 3.2.4-8).

It is important to determine the dose to individuals at various distances down wind from an accident. The risk dose is applicable to the general population, but not if one wishes to consider the consequence to the population actually affected by a particular accident. This analysis was done for the maximum credible transportation accident, which is a fire involving a truck loaded with Rocky Flats plutonium. A plume rise of 100 meters was assumed, resulting in the organ doses shown in Table 3.3.2-3. No credit was taken for evacuation of the downwind population, nor for decontamination of the soil, which could lower the 70 year dose by a factor of two (if decontamination is effected soon after the accident). (Appendix F contains explanations of additional assumptions, many of which add to the conservatism of these calculations.)

TABLE 3.3.2-3

DOSE OVER 70 YEARS (INCLUDING RESUSPENSION) TO AN INDIVIDUAL DOWNWIND FROM THE MAXIMUM CREDIBLE TRANSPORTATION ACCIDENT

Distance (miles)	(Dose in Rem) Total Body	Lung	Liver	Bone
0.06* (100 meters)	0	0	0	0
1.2	0.010	0.77	1.3	3.2
2	0.042	3.0	5.0	13
3	0.058	4.2	7.0	18
3.55* (maximum)	0.060	4.4	7.2	18
4	0.058	4.4	7.2	18
5	0.054	4.0	6.6	17
10	0.034	2.4	4.0	10
20	0.017	1.3	2.2	5.2
30	0.011	0.84	1.4	3.4
40	0.0082	0.62	1.0	2.6

*The maximum ground level air concentration of material released from an elevated source occurs at a distance from the source because of the drift which takes place before the plume reaches the ground.

By assuming a uniform population density downwind from the accident, it is possible to predict the resulting health effects. The increase in bone cancer out to 50 miles is 140 cases for a high density population zone, 26 for medium density, and 0.22 for low (see Appendix F).

There are accidents that are of very low probability, but very high consequence if they do occur. Separate consideration of these is important. One such accident is the maximum credible accident outlined above if it were to occur in a densely populated city such as New York or downtown Denver. Such an accident was analyzed in an assessment for transportation through large cities (DuCharme, 1978). Correcting for specific details of Rocky Flats transportation, such as isotopic composition and amounts (from this document's transportation model), the 70-year population organ dose commitments are as follows:

Total Body	1.4×10^4 man-rem
Lung	1.0×10^6 man-rem
Liver	1.7×10^6 man-rem
Bone	4.1×10^6 man-rem

These population doses lead to a prediction of an increase of approximately 70 cancer deaths and four genetic defects for a 70 year exposure period. A similar analysis for a Rocky Flats enriched uranium shipment yields a cancer death increase smaller by a factor of 0.01, and a genetic defect increase which is smaller by a factor of 0.001.

The decontamination costs of such an accident would be expected to be quite high. An estimate of this figure is contained in the large city transportation assessment (DuCharme, 1978). When corrected for Rocky Flats transportation, the decontamination cost is approximately $170 million. These health effect and decontamination cost estimates should be kept in perspective by consideration of the low probability of such an event occurring. The probability of an extreme truck accident occurring in a high density zone is once in 3.3 million years for Rocky Flats transportation.

3.4 ECONOMIC, SOCIAL, AND SECONDARY IMPACTS

The operation of the Rocky Flats Plant, as with any large industrial complex, has direct and indirect socioeconomic impacts associated with it. In addition, other impacts such as aesthetics, noise, and technological achievements are attributed to the Plant and its operation. Discussions of these follow.

In evaluating the socioeconomic impacts of the Rocky Flats Plant, a general assessment of the existing and projected population, land use, and socioeconomic characteristics in the vicinity of the Plant was performed. The primary socioeconomic impacts evaluated for the Plant included the potential effects on land-use planning in the area, the direct and induced employment as a result of the Plant, and the economic effects associated with increased disposable income and direct expenditures for goods and services necessary for the Plant. In addition, an evaluation of the aesthetic impact of Rocky Flats was performed as was an evaluation of noise with respect to the surrounding area.

3.4.1 National Defense

The Rocky Flats Plant is a key facility for producing components for nuclear weapons. A requirement for the work performed at Rocky Flats will continue as long as the need for an up-to-date nuclear weapons stockpile is an established requirement of the national defense policy.

Benefits resulting from a national defense policy based on an up-to-date nuclear weapons stockpile are not directly quantifiable, and in any event are beyond the scope and function of this Statement. The establishment of national defense policies and the method of implementation are the responsibility of the President and the Congress of the United States; consequently, a discussion and evaluation of the impact of Rocky Flats on national defense, either adverse or beneficial, is neither appropriate nor relevant to this Statement.

3.4.2 Employment

In evaluating the socioeconomic impacts of the Rocky Flats Plant, the direct employment and residential distribution of employees was determined. In addition, the secondary employment induced by the direct employment was calculated. This employment information provided a basis for determining the impacts of Rocky Flats on the surrounding communities, schools, and businesses.

3.4.2.1 Direct Employment

The Rocky Flats Plant employed approximately 2,800 people during 1977, excluding construction workers, plus approximately 30 college students and teachers during the summer. Approximately 60 of the full-time personnel are employed by DOE. This direct employment has declined over recent years, from a maximum of 3,750 people in 1972, because of reductions in production schedules and because of budgetary limitations. Employment projections for the Plant through 1985, however, range from 2,600 to 3,400 people. Beneficial programs derived from the direct employment include apprenticeship programs, on-the-job training for the disadvantaged, General Education Development (G.E.D.) qualification training, tuition reimbursement for formal education, scholarship programs, matching grants to educational institutions, plus other educational incentives.

The majority of Rocky Flats' employees reside within 20 miles of the Plant in the various population centers. Table 3.4.2-1 shows the residential distribution of Rocky Flats' employees with respect to these various communities. Over 50% of the employees live in three cities: Arvada, Boulder, and Denver.

According to the Denver Regional Council of Governments, the average family size in the Denver metropolitan area is 2.83 people. Thus, the total population associated with the 2,800 employees of Rocky Flats is approximately 7,924 people. Considering the residential distribution shown in Table 3.4.2-1 and the cities' populations as presented in Section 2.3.3, the population segment consisting of Plant employees and their families is less than 5% in most cities. The highest percentage increase in population based on direct employment from the Rocky Flats Plant was in Louisville, where the population increase was approximately 11%. In all cases, direct employment from the Plant provided additional job opportunities for the populace in surrounding cities without placing a burden on the various private and public services such as housing, medical services, police and fire protection, water, and sanitary disposal services.

TABLE 3.4.2-1

RESIDENTIAL DISTRIBUTION OF ROCKY FLATS EMPLOYEES

City	Approximate Number Of Employees That Reside In City
Boulder	515
Arvada	510
Denver	505
Longmont	230
Golden	155
Westminster	115
Louisville	105
Broomfield	100
Lakewood	85
Lafayette	85
Wheat Ridge	75
Northglenn	60
Thornton	60
Erie	25
Aurora	20
Berthoud	20
Littleton	10
All Others	100
TOTAL	2,775

3.4.2.2 Secondary Employment

Secondary or indirect employment opportunities are usually created or induced by the presence of direct employment in a community. These induced employment opportunities develop mainly in service-oriented occupations, such as retail goods and services, transportation, and recreational activities.

For the determination of secondary employment associated with direct employment at Rocky Flats, an analysis of the induced employment with respect to direct employment for the Denver metropolitan area was performed. An employment multiplier was determined to project total employment from direct employment at the Rocky Flats Plant; i.e., a change in the direct employment is projected theoretically to induce a change in the secondary employment by the amount of the multiplier times the change in the direct employment. The method used to perform this analysis has been utilized on several large industrial projects in the United States and is described in the Nebraska Business Research Bulletin No. 63 (Thompson, et al., 1958). Considering the industries in the Denver metropolitan area and the distribution of employees in these industries, the multiplier for the region was calculated to be 2.3.

Utilizing this multiplier, the total secondary employment associated with the Rocky Flats Plant is approximately 6,440 people (2,800 x 2.3). Thus, the direct and secondary employment is calculated to be 9,240 people. These secondary employees do not necessarily have the same residential distribution as the direct employees, since many families acquire services from surrounding communities. It would be difficult to assess the impact these secondary employees have on each of the communities; however, because of the size of the communities considered, no significant impact would be expected.

3.4.3 Economy

The economic impact of the Rocky Flats Plant was evaluated by assessing the increased disposable income in the region from the Plant's payroll and the direct expenditures for goods and services supplied to the Plant. Each of these items will be discussed along with their associated economic impact, if any.

3.4.3.1 Disposable Income

The Rocky Flats Plant generates an annual payroll of nearly $40 million, distributed to approximately 2,800 employees. Taxes and nondiscretionary wage deductions (such as Federal and State taxes and social security) were estimated at 24.3% of the payroll; thus, the total disposable income for Rocky Flats employees is approximately $30,280,000.

In determining the impact of disposable income, it is necessary to consider how the income is spent. The close link between levels of employment and levels of total disposable income allows the use of the value derived for the employment multiplier (Section 3.4.2.2) as an income multiplier. Additions to numbers of employed persons in the area typically will produce approximately proportional additions to area disposable income. From the income multiplier, the Marginal Propensity to Consume (MPC) was calculated ($1 + \text{multiplier} = \frac{1}{1-MPC}$)(Thompson et al., 1958). Using the employment multiplier of 2.3 as an income multiplier, the MPC was calculated to be 0.697. This implies that the average person in the chain of spending money (Rocky Flats employees' disposable income) will, in each successive spending round, spend 69.7% of the funds in the local area, and that the remaining 30.3% will be saved or spent outside the area. The successive spending of the 69.7% (the amount received in the previous period) forms a geometric progression, the final sum of which is 3.3 times greater than the original amount of income introduced into the local economy. Thus, for the total, disposable, annual income of $30,280,000 for Rocky Flats employees, the total amount spent over successive periods will be approximately $100 million.

As an indication of the impact on local business, it is useful to compare current levels of retail sales with current levels of disposable income in the Denver metropolitan area and then evaluate the magnitude of sales associated with Rocky Flats employees' disposable income. Using statistics acquired from the Denver Regional Council of Governments, the gross personal income for Adams, Boulder, Denver, and Jefferson counties in 1975 was approximately $7.3 billion. Thus, the projected disposable income for the area was approximately $5.5 billion assuming 24.3% for taxes and non-discretionary wage deductions. The retail sales for these four counties totaled approximately $6.8 billion for the 1975 fiscal year. The $100 million of disposable income associated with the Rocky Flats Plant is about 2% of the total disposable income for the area. Thus, 2% of retail business is attributable to Rocky Flats employees.

3.4.3.2 Direct Expenditures for Goods, Services, and Utilities

Annually the Rocky Flats Plant spends about $33 million for goods, services, and utilities necessary for Plant operation. During the 1978 fiscal year, a total of approximately 32,000 orders was placed with 4,800 vendors for a total expenditure of over $28 million. Of this total expenditure, approximately 29% ($8.3 million) was for purchases within Colorado from 2,900 vendors. In addition, $5 million annually is spent locally for utilities. Included in the above totals are 1,198 purchase orders, having a total value of over $1 million, issued to minority vendors.

3.4.4 Aesthetics

The aesthetic impact of the Rocky Flats Plant was determined by considering the size, shape, and location of Plant structures, and the terrain, highways, and land use in the general vicinity of the site.

As stated in Section 2.2.2, most of the Plant buildings are one or two stories high, with the most prominent structures being a water tower and three stacks.

Plant structures generally are visible from the north, east, and south; however, because of the rolling terrain in the vicinity of the Plant and the distance from the Plant to public access, these structures do not dominate the scenery. The terrain to the west is slightly higher than the Plant, thus making the Plant more visible from that direction.

In addition, since much of the land in the vicinity of the site is used either for agricultural, open space, or industrial purposes, Rocky Flats does not have a significant aesthetic impact on the surrounding area.

3.4.5 Noise

Primary noise sources for Rocky Flats are the boiler fans, ventilation system fans, transformers, and heavy machinery located in and around the Plant. As required by ERDA Manual Chapter 0550, in-plant noise is subject to Air Force Standards with a maximum of 84 DBA (decibels, adjusted) for an eight-hour exposure. As a result of insulation provided by the buildings and the distance from the Plant to the site boundaries, the operational noise of the Plant does not impact the surrounding region.

The Rocky Flats Plant is responsible for several off-site air sampling stations at various locations surrounding the plant, which were also considered noise sources. Recently, new designs for these air sampling stations were implemented to mitigate the noise impact and meet current Housing and Urban Development (HUD) standards.

The additional commuter traffic during early morning and evening hours contributes to the increased off-site noise levels in the area. Most of the highways are well-travelled by other than Rocky Flats personnel, and the increase in noise level is not significant.

3.4.6 Technology And Community Activities

The Rocky Flats Plant provides technical knowledge, skills, and advice to local communities, individuals, and to organizations throughout the U.S. and the world. Locally, the Rocky Flats Plant has provided advice on such subjects as fire prevention, training of fire-fighters, effluent monitoring and pollution control, water and sewage treatment, landfill management, radiation dosimetry, and safety programs.

Rocky Flats also has aided other countries with the knowledge and ability to handle and process rare and exotic materials such as plutonium, uranium, and beryllium. Results of Rocky Flats' research in chemistry, metallurgy, machining, gauging, nondestructive testing, safety, fire prevention, health physics, and ecology are disseminated worldwide through scientific literature. Publications concerning Rocky Flats' efforts (as of December 1977) include 52 patents, 330 journal articles, and 711 technical reports. (Unclassified technical reports are available through the National Technical Information Service, Washington, D.C.)

Rocky Flats personnel possess technical skills and experience in the safe handling of actinide and other radioactive materials during such diverse processes as chemical recovery, fabrication, and basic research. These attributes constitute a national resource that would be extremely difficult and costly to duplicate. Employees at Rocky Flats are among the most knowledgeable in the world in the field of plutonium metallurgy and plutonium chemistry.

Plant employees are active in community activities such as Boy Scouts, local government, United Way, church programs, and volunteer fire departments. Plant personnel have been very active in community minority programs. The Plant contractor was recently honored by the League of Latin American Citizens for Plant personnel assistance to the League. Many employees are part-time teachers in local colleges, universities, and trade schools. Since 1972, employees have donated over 3,000 pints of blood at drives held every three months. Employees also participate actively in the purchase of U.S. Savings Bonds. The 1977 drive resulted in 73% of the employees purchasing $40,000 in bonds every month.

There are significant interactions between Plant personnel and community agencies concerned with Plant activities. Open monthly meetings between DOE, the Plant contractor, Colorado Department of Health, Jefferson County Health Department, Boulder City and County Health Department, Environmental Protection Agency, and interested citizens are held to review results of monitoring programs and to discuss topics of interest and concern. News media representatives usually attend these meetings and report highlights to the community.

The contractor has an extensive public contact program in which public tours of the Plant are conducted regularly. Several thousand visitors have toured the Plant in the last two years. These tours include special interest groups concerned about the use of plutonium, in addition to the public at large.

As a result of a recommendation of the Lamm-Wirth Task Force Report, a Citizens Monitoring Committee, comprised of 15 individuals, was appointed by Governor Lamm. This committee monitors Plant operations that committee members think might have an adverse impact on the public or on Plant employees. DOE and contractor officials have worked very closely with this committee for the past two years providing information and briefings about the Plant's operation.

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4. UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

Current and continued operation of the Rocky Flats Plant results in unavoidable environmental impacts in three primary areas: (1) nonradiological, (2) radiological, and (3) socioeconomic. Nonradiological impacts include alterations to the physical environment, the use of natural and energy resources, and biological effects of nonradioactive effluents. Radiological impacts are only those biological effects attributed to the release of radioactive effluents. This differentiation is maintained to provide maximum definition of radiological impacts, which are of primary interest at Rocky Flats, as previously discussed in Chapter 3. Socioeconomic impacts include all other indirect or secondary impacts attributable to Plant operation, as discussed in Section 3.4. This section discusses these impacts and the mitigating measures implemented and planned in each of the three primary areas defined above. Various mitigating measures have been and will continue to be implemented to reduce the adverse impacts attributed to Plant operations.

4.1 NONRADIOLOGICAL EFFECTS

Nonradiological, unavoidable, adverse environmental impacts include alterations to the physical environment, the use of natural resources, and the biological effects from release of nonradioactive materials.

4.1.1 Alterations to the Physical Environment

Disruption of the surficial geological features and hydrologic characteristics, however minor, are impacts that cannot be avoided and that will persist as long as the Plant continues to operate and occupy the present location. Such impacts are characteristic of all construction developments and represent typical impacts attributable to the presence of an industrial facility.

4.1.2 Utilization of Natural Resources

The consumption of natural resources at Rocky Flats constitutes an unavoidable environmental impact. Resources used include fossil fuels (oil and gas), chemicals, metals, and electricity. The consumption can be direct, as in the case of oil and gas; or indirect, as electricity produced by fossil-fueled power plants. Water is used by the Plant and returned to the region as a resource through water vapor from the liquid process wastewater treatment plant and evaporation from cooling towers, solar evaporation ponds, and holding ponds.

4.1.3 Biological Effects of Nonradioactive Effluents

Nonradioactive materials are discharged in small amounts through air and water (see Sections 2.6.6, 2.9.1 and 3.1.1.3). Biological effects resulting from water discharges are discussed in Section 3.1.1.3. With a few exceptions, discharges have been within the applicable State and Federal limits (Sections 2.9.1 and 3.1.1.3).

4.2 RADIOLOGICAL EFFECTS

Normal operation of the Rocky Flats facility results in unavoidable releases of small amounts of radioactivity to the general environment. In addition, there will be continuing dispersal of radioactivity to the general environment from past releases. There is also a small risk of accidental releases from continued operations of the facility. The amounts of material that might be released during future operation of Rocky Flats from both routine and accident conditions have been given in Sections 3.1.2 and 3.2.

The release of any amount of radioactivity implies some potential risk to the general ecosystem and to man. As discussed in Section 3.1.2, however, continued operation of the Rocky Flats facility should contribute only a small, additional amount of radioactivity to that already released by the Plant and already present from natural sources and other man-made sources such as fallout. Ecological studies of the Rocky Flats area to date have indicated no detectable changes in the ecosystem because of existing radiation levels, nor has any concentration mechanism been identified to indicate that significant changes should be expected (Whicker, 1977). (See Appendix A-2.)

Releases of radioactivity to the general environment could result in an increased dose commitment to members of the Denver-area population. Appendix F and Section 3.1.2 contain the calculations and discussion of dose commitment to the population from the presence of Rocky Flats.

Probabilities of accidental releases of radioactivity which could impact residents in the Denver area are listed in Table 3.2.3-1. The potential maximum individual doses from these hypothetical accidents are given in Table 3.2.4-2 and the associated risks are shown in Table 3.2.3-1. The State of Colorado Radiological Emergency Response Plan for Rocky Flats and the Colorado Department of Health Protective Action Guide included in the Plan (State of Colorado, 1978) define doses to members of the population for which protective action would be required (see Section 2.11.4.3). From the data in Section 3.2.3, the probability of occurrence of an accident requiring protective action is approximately four times in 10,000 years. The maximum potential risk to the Denver area population from both routine and accidental releases, given continued operation of the Rocky Flats facility over 70 years, is less than one potential death spread over the population of the Denver area.

4.3 SOCIOECONOMIC EFFECTS

As discussed in Section 3.4, the primary socioeconomic impacts of the Rocky Flats Plant result from additional, Plant-related employment and the associated increase in population in the general vicinity of the Plant. These impacts include increased demand for housing, school facilities, and municipal services (such as water, sanitary waste, police, and fire protection).

Because of the proximity of Rocky Flats to several population centers, the Plant's socioeconomic impacts, although unavoidable, have little adverse effect on the surrounding region. Most of the communities in which employees and their families reside have grown substantially in recent years. These communities have developed adequate housing, schools, and municipal services to meet the needs of this growing populace. The Plant has been in operation since the early 1950s and is expected to remain in operation through at least the year 2000. Therefore, the employment is of a long-term nature, and the socioeconomic impacts of transient populations are minimized.

Other impacts include (1) the loss of agricultural productivity and income from the land comprising the Rocky Flats Plant site, and (2) a change in the tax base. This change results from land being withdrawn from the public tax rolls, and tax revenue being generated instead by income, property, and sales taxes collected from Plant employees. Taxes assessed on agricultural land are based on the productivity of the land. Since land within the Plant boundaries is of low agricultural value, the income and taxes generated by agricultural use were small in comparison with those generated by construction and operation of the Plant. The presence of Rocky Flats also has resulted in Federal impact funds being given to area school districts.

4.4 MITIGATION OF ADVERSE ENVIRONMENTAL EFFECTS

Several areas of endeavor serve to lessen adverse environmental effects from Plant operations. These include an enlarged buffer zone, total water recycle, and actions such as improvements in accident prevention to reduce potentially adverse radioactive and nonradioactive effects on the environment.

4.4.1 Utilization of Natural Resources

In 1975, the U.S. Government purchased approximately 4,000 acres around the original 2,520-acre Rocky Flats Plant site. This acquisition expands the original buffer zone and prevents industrial or residential development too near the Plant. The buffer zone provides a safety margin in the event of an abnormal occurrence at the Plant.

A total water-recycle plan, which eliminates all routine wastewater discharges, is being implemented and is to be completed in 1979. All process and laundry wastewater will be treated and distilled to create a supply of high-purity water. Other wastewater streams, principally sanitary wastes, will be treated in the sanitary waste treatment plant and also will be recycled for industrial use. Treatment at this plant involves a recently completed tertiary step and a planned reverse osmosis process. Completion of these changes will mean that no Plant wastewater will leave the site except by evaporation. This plan will eliminate routine sanitary wastewater discharges to the Great Western Reservoir.

The above described actions mitigate possible adverse impacts on residential development in the vicinity of the Rocky Flats Plant. Alternatives that also could be considered in the mitigation of adverse Plant impacts are discussed in Chapter 5. A discussion of land use in the immediate vicinity of the site is presented in Chapter 7.

4.4.2 Mitigation Of Nonradiological Effects

Unavoidable adverse impacts from nonradiological sources are being mitigated by reducing the quantities of natural resources consumed and by reducing the quantities of nonradioactive material released.

4.4.2.1 Consumption of Energy Resources

The DOE and its operating contractor at Rocky Flats have taken positive actions to reduce the consumption of various fuels and water used by the Plant. Table 4.4.2-1 shows the total consumption of energy, both fossil fuels and electricity, and water for FY 1973 through FY 1977. An energy conservation program was implemented in FY 1974, and year-end figures for that year show total energy consumption was reduced approximately 13% over FY 1973. For FY 1975, a further reduction of approximately 1.5% over FY 1974 was achieved; a 9.4% improvement occurred in FY 1976 and a 2.4% reduction in FY 1977. Thus, a reduction of about 26% was realized in FY 1977 over FY 1973 as a result of the energy conservation program. As almost one-third of the Plant's water usage is for cooling tower operation, which is directly related to energy use, a net reduction of approximately 33% in water consumption was also realized during the same period. The energy conservation program also directly reduces the quantities of (1) Plant effluents associated with the combustion of fossil fuels, and (2) chemicals used in water treatment.

Numerous actions are responsible for reducing the Plant's consumption of energy resources. For example, the Energy Conservation Council was formed to initiate, implement, and monitor energy conservation programs that would reduce energy use without compromising security or employees' health and safety. A complementary action has been managerial-level reviews of energy-related practices. Considerable effort continues to be directed toward impressing employees with the importance of their participation in conserving energy.

Various gasoline-saving efforts involve Government-owned vehicles. Intra-plant bus service has been curtailed except in inclement weather; transportation of mail within the Plant and to off-site post offices has been reduced; and Government automobiles having eight cylinders have been replaced by six-cylinder vehicles. Deliveries of Plant material are consolidated, when possible, for further savings.

TABLE 4.4.2-1

CONSUMPTION OF ENERGY RESOURCES AND WATER
(Fiscal Years)

Resource	1973	1974	1975	1976	1977
Natural Gas (cu ft x 10^3)	726,302	746,456	746,285	568,389	637,224
Number 6 Fuel Oil (gal)	1,619,000	702,100	513,900	940,200	335,000
Gasoline (gal)	112,082	86,571	90,215	97,979	101,390
Diesel (gal)	38,728	36,397	35,852	21,126	19,356
Propane (gal)	58,505	10,180	7,625	12,204	40,876
Electricity (MWhr)	112,348	102,758	105,832	104,820	104,050
Total Btu (x 10^9)	1,372	1,190	1,171	1,061	1,036
Reduction (%)		13	1	9	2
Water (gal)	161,161,000	143,435,000	125,952,000	115,963,000	113,244,000
Reduction (%)		11	12	8	2

Energy has been conserved through turning off lights and electrical equipment not essential to the work being performed or not required for safety. Utility services have been curtailed in areas of reduced activity. Energy conservation has also been further emphasized in the Plant's maintenance programs, in the purchasing of new equipment, and in building design. The Plant has one of the highest percentages of employees who participate in car-pools in the State of Colorado. In addition, the Plant, with the cooperation of DOE and Denver's Regional Transportation District (RTD), has initiated a pilot van-pool program to help decrease air pollution. The Plant also particpates in a paper recycling program.

The consumption of energy by the Plant has declined since 1973. A Plant goal for FY 1978 is not to exceed the energy consumed in FY 1977. New ideas for energy conservation are being sought through an employees' suggestion program.

4.4.2.2 Control of Nonradioactive Material

Several Plant systems and operating practices have been modified to minimize the release of nonradioactive material and thereby minimize the adverse environmental impacts resulting from these releases.

Adverse effects of sewage plant discharge have been mitigated by improved controls. Originally the effluent was discharged directly into South Walnut Creek upstream from a retention pond. It now flows into retention Pond B-1, is then released to Pond B-3, is analyzed and subsequently released to mix with South Walnut Creek at Pond B-4. The South Walnut Creek drainage bypasses Pond B-1, B-2 and B-3 so that it does not disrupt the holding pond system used for sanitary waste effluent. This bypass discharges into Pond B-4. Some storm runoff normally flows to Pond B-4 through the bypass system. Occasionally, during periods of high runoff, the runoff can be diverted to discharge below the B-series ponds into the Walnut Creek Drainage. Figure 2.3.9-3 shows the ponds and storm runoff bypass system.

The tertiary treatment project improved the existing sewage treatment plant by adding a clarifier, filter system, pumphouse, pumps, and instrumentation to the existing sewage treatment plant. The effluent now has less suspended solid material and meets present effluent standards for off-site release (see Sections 2.9.1 and 3.1.1.3). The plant also makes the effluent more compatible with future water-recycle plans.

Water from backflushing the raw-water treatment plant filters contains solids removed during treatment. The water was previously released to Woman Creek and then off site. Settling tanks were provided for this water, which is pumped back to the treatment plant, and the sludge is pumped to drying pits. Dried sludge is trucked to the sanitary landfill.

Cooling tower blowdowns and drains previously were discharged to the ground and allowed to drain into the ground or to follow normal surface runoff. This water contains about 30-ppm sodium silicate for corrosion protection. The water now is piped to sanitary drains for treatment in the sewage plant. This water is part of the future water-recycle project, which will treat and reuse effluent from the sewage plant for nondomestic purposes.

In the past, solar evaporation ponds that hold process waste liquids containing nitrates have leaked. These nitrates built up in the soil around the ponds so that runoff water from springs and rains carried the nitrates to watercourses, and, potentially, off-site. New collection trenches, completed in 1974, collect that water, which is then pumped back to the evaporation ponds, and thus help to prevent contamination of the watercourses. The trenches are shown in Figure 2.9.3-1. If flooding would occur so that the capacity of the trenches is exceeded, the runoff would go to Pond A-3, a nearly dry reservoir for emergency water retention (Figure 2.3.9-3). McKay Ditch, which originally contributed to the drainage that feeds Pond A-3, has been rerouted to decrease the contribution to this pond in the case of a flood.

To ensure that runoff water is stopped before leaching undesirable material from the landfill and carrying it off site, a trench was built around the landfill. Drains were placed outside the landfill, and a barrier was placed between these drains and the landfill to prevent underground water from reaching the landfill. Some water may still drain from the sanitary landfill. For this reason, a small dam and reservoir were built so that the water can be held for sampling and analysis. The water can then be released or it can be pumped to the process waste treatment facility, whichever is deemed proper after analysis. The landfill will thus meet criteria under the proposed EPA rule "Solid Waste Disposal Facilities," 40 CFR 257, February, 1978 (see Section 2.9.4).

Airborne releases of nonradioactive materials are mitigated by (1) use of scrubber systems for stacks that might otherwise emit acid fumes, (2) reduced fuel consumption and the purchase of fuel oil containing no more than 1.25% sulfur, which reduces combustion product effluents (Tables 2.6.6-2 and 2.6.6-3), and (3) improved filtration of beryllium processing buildings (Sections 3.1.1.3 and 2.10.1.1).

4.4.3 Mitigation of Radiological Effects

Rocky Flats uses many different measures to guard against the release of radioactive materials during routine operation. These measures include elaborate systems for the containment of radioactive materials, the filtering of air, and the treatment of water that comes in contact with radioactive materials. The containment and effluent control systems are explained in detail in Sections 2.5.1, 2.7.1, and 2.7.3.2.

4.4.3.1 Control of Radioactivity

Administrative procedures and control equipment are continually being updated and improved to further reduce the quantity of radioactive materials released to the environment. The following paragraphs describe some of the changes that have been or are being made.

Recently instituted administrative controls include (1) a critical review of all procedures affecting health, safety, and the environment, (2) a requirement for written Operational Safety Analyses for all operations, (3) a quality assurance program prescribing the inspection of glove-box gloves, (4) the elimination of all outdoor storage of plutonium-contaminated waste, and (5) a review and administrative sign-off procedure for water discharge from Ponds A-3 and B-3.

All systems filtering air from plutonium operations were upgraded and modified to ensure a minimum of four stages of filtration before glove-box air is discharged to the environment. All filtering systems for uranium operations are being upgraded to minimize leakage. All process-liquid waste lines between Plant buildings are being replaced with inspectable, double-walled lines that will contain any leakage.

The new process wastewater treatment facility will recover water from Plant liquid process wastes for subsequent reuse in steam generation. Upon completion, the waste-treatment facilities will help reduce the release of radioactive materials to the environment (see Section 2.7.3.3) by eliminating the use of open evaporation ponds. An incinerator for low-level solid waste will reduce the volume and weight of LSA waste shipped off site.

A project for removing on-site soil containing plutonium is underway. Further discussion of this program is given in Section 5.2.4.

To prevent its release off site, laundry wastewater is being impounded until the new process waste-treatment facility is completed. Currently, this water bypasses the sewage treatment plant and discharges into the second retention pond (Pond B-2), bypassing B-1. The treated sewage effluent bypasses this pond and dumps from Pond B-1 into Pond B-3. Pond B-2 is not large enough to hold the amount of laundry wastewater that will be generated before the new process waste-treatment facility is completed. Therefore, a line from Pond B-2 is used to transfer this excess of water to a larger pond (A-2) on North Walnut Creek for storage and evaporation (Figure 2.3.9-3). North Walnut Creek is diverted around this pond, thus isolating the pond from normal stream flow.

The sanitary-water recycle system will collect all sanitary liquid effluent, treat it, and reuse it in the Plant cooling towers. This project is scheduled for completion in 1979.

Engineering-Science, Inc., in their report (ES, 1974) on water control and recycle for Rocky Flats, recommended drainage canals and an associated reservoir that would collect all surface runoff water originating in or flowing through the facility area (the area where all Plant buildings are located). A modification of this project, which will utilize three retention reservoirs, has been prepared. The project is scheduled for completion in 1979.

The net effect of the zero water discharge program will be to eliminate the routine discharge of Plant wastewater into Great Western Reservoir. More detail on the zero water discharge program is given in Section 5.2.3.

4.4.3.2 Effluent Monitoring

Elaborate effluent monitoring systems continuously monitor all discharge points to ensure that any release is within an acceptable range. The monitoring systems and requirements are explained in Section 2.10. Administrative controls are also used to ensure that all releases are consistent with the as-low-as-practicable release operating policy (Section 2.7.2). Overall, releases are substantially below applicable DOE guidelines (see Section 2.10).

In addition to on-site monitoring, the contractor conducts routine environmental monitoring of ambient air and water in the general Denver area to ensure that no buildup of radioactive materials occurs in any medium to which the general public might be exposed. In addition, special studies have evaluated the potential impact of Plant operations on the general ecosystem of the area. These studies are discussed in Sections 2.3.10.2 and 3.1.1.3. The environmental monitoring data are used to verify that radioactive effluents have not exceeded any applicable guideline, and that they also are held to within as-low-as-practicable (ALAP) or as-low-as reasonably achievable (ALARA) levels (Section 2.7.2).

4.4.4 Accident Prevention

Plant process and effluent control systems are continually updated to guard against any accidents. In particular, elaborate systems and administrative controls have been designed into facilities (and transportation systems) to prevent any accidental criticality. Extensive systems improvements have been completed toward preventing fires at the Plant. These fire prevention and suppression measures include the following items:

(1) Sprinkler systems in all production buildings.
(2) Heat reduction and fire extinguishing systems in all building-ventilation filter plenums.
(3) Fire doors and fire extinguisher access ports in glove boxes.
(4) Improved fire alarm system.
(5) Inert atmosphere rather than air in many glove boxes, especially in new facilities and processes where it is important to do so.
(6) Eliminating all possible combustible materials from process areas.
(7) Painting combustible shielding with fire-retardant paint.

Fire prevention measures are explained in greater detail in Sections 2.5.1 and 3.2.2.4.

Existing structures are being reviewed to determine the earthquake, wind, tornado and non-tornadic forces they can resist. Buildings constructed after 1974 are designed to meet criteria developed in the following reports: for earthquakes, Blume

(1974); for tornadoes, McDonald and Minor (1972), and USNRC Regulatory Guide 1.76 (1974) (slight modifications on the model tornado have been applied where appropriate); for winds, Surdahl, 1975. All boilers and pressure vessels are designed, installed, and certified according to applicable codes and regulations (USERDA, 1973). Explosive chemicals, or other substances such as natural gas, are controlled both in amount and by location to prevent any explosion from damaging the containment system of buildings handling radioactive materials. Such materials are handled and packaged according to strict standards (USERDA, 1973) to prevent their accidental release or loss.

Extensive monitoring and analysis systems coupled with detailed administrative controls are used at Rocky Flats to ensure that all radioactive materials are properly identified, and unplanned releases are prevented or detected in time for remedial action. A strict double-entry accountability system is utilized to guard against any undetected losses of material, and all special nuclear materials are maintained in special areas under constant system monitoring to prevent their loss. Mitigating measures taken to prevent the loss of special nuclear materials are explained in greater detail in Section 2.12.

In addition to safety systems, monitoring programs, and administrative controls to guard against accidental releases of radioactivity, Rocky Flats maintains an Emergency Preparedness Plan to respond to all credible Plant accidents. The Plan provides for a systematic, orderly handling of emergencies in such a manner as to minimize the impacts. The emergency plan is described in Section 2.11.

4.5 REFERENCES

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5. ALTERNATIVES

Various alternatives have been considered regarding the Rocky Flats Plant, its operations, and its impact on the environment. These alternatives range from making no change in current activities, to complete relocation of the Plant and restoration of the existing site to a near-natural condition. The five alternatives considered are: (1) no change in current activities, (2) completion of changes currently underway, (3) relocation, (4) termination of operations, and (5) other alternatives. The cost that would be incurred and the fraction of the 70-year dose remaining after implementation of the various alternatives are shown in Table 5-1 for different portions of the population within 50 miles of Rocky Flats. Revisions in this section result from the different approach to dose evaluation, Chapter 3. Also the estimated acreage in excess of the State plutonium-in-soil standard has been reduced from the 11,000 acres presented in the DEIS, to 1,000 acres, as a result of new data.

The emission sources from Rocky Flats are: (1) routine airborne releases, (2) airborne releases from resuspension of on-site contaminated soil, (3) routine waterborne releases, (4) accidental airborne releases and (5) accidental water releases. Each alternative being considered can affect any one, or all, of these sources. The effect can range from a partial reduction to complete elimination of emission from that source. Normal waterborne releases and surface runoff sources both ultimately result in increased radionuclide concentration in Great Western Reservoir and Standley Lake. In this Statement, there is no separate modeling of these two pathways; instead, both are accounted for by using measured drinking water concentrations from these reservoirs. Thus, reduction in only one of these two emission sources leads to a dose change that could range from close to zero to almost the entire impact of the two emission sources combined. The fraction of the background doses received by the maximum reference man from routine operations (average intake), as compared with natural background, are 0.00011 for the total body, 0.010 for the liver, 0.020 for the bone, and 0.0043 for the lungs (Section 3.1.2.4).

Estimates of dose are predicted separately for three categories of people: (1) those drinking water supplied from Great Western Reservoir, (2) those drinking water supplied from Standley Lake, and (3) all others living within 50 miles of the Rocky Flats Plant. The change in the dose to these various segments of the population differs because of the differing effects of the various alternatives on these segments, and difference in the maximized source term contributions for the water pathways. To determine the 70-year dose to a given individual following the implementation of one of the alternatives, multiply the fraction from Table 5-1 for the appropriate drinking water supply by that individual's corresponding organ dose found in Table 3.1.2-3.

The last column in Table 5-1 shows the fraction of the accident risk dose remaining following implementation of the various alternatives. Refer to Table 3.2.4-1, for the 70-year risk dose, presented there as organ dose per individual.

TABLE 5-1

SUMMARY OF COSTS AND FRACTION OF ORGAN DOSES TO THE INDIVIDUAL REMAINING AT COMPLETION OF ALTERNATIVES

			Fraction of 70-year dose				
			Normal Operations				Accident Risk Dose
Alternative	Cost ($ Million)	Drinking Water Source	Total Body	Liver	Bone	Lung	All Organs
1. No change in current activities			No Change				
2. Completion of changes currently underway							
a. Plutonium recovery facility	190	All	No Change				
b. Waste treatment facility	††	GWR**	1.00	1.00	1.00	1.00	*
		SL***	1.00	1.00	1.00	1.00	1.00
		Other	1.00	1.00	1.00	1.00	1.00
c. Water recycle	3.1	GWR	≥0.16†	≥0.40†	≥0.40†	0.96	1.00
		SL	1.00	1.00	1.00	1.00	1.00
		Other	1.00	1.00	1.00	1.00	1.00
d. Partial removal of on-site plutonium-contaminated soil	0.47	GWR	0.99	0.97	0.97	0.94	1.00
		SL	0.97	0.95	0.95	0.94	1.00
		Other	0.93	0.93	0.93	0.94	1.00
3. Relocation - partial	2000	GWR	0.01	0.02	0.02	0.05	0.00
- complete	2230	SL	0.03	0.04	0.04	0.05	0.00
		Other	0.05	0.05	0.05	0.05	0.00
4. Termination of Operations							
a. Standby	17.8	GWR	0.99	0.99	0.99	0.94	≥0.00†††
		SL	0.97	0.98	0.98	0.94	≥0.00†††
		Other	0.94	0.97	0.97	0.94	≥0.00†††
b. Complete shutdown, total decommissioning, and partial decontamination	332	GWR	0.01	0.02	0.02	0.05	
		SL	0.03	0.04	0.04	0.05	0.00
		Other	0.05	0.05	0.05	0.05	0.00
c. Complete shutdown, total decommissioning, total demolition and site restoration	526	GWR	0.01	0.02	0.02	0.05	0.00
		SL	0.03	0.04	0.04	0.05	0.00
		Other	0.05	0.05	0.05	0.05	0.00
5. Other potential alternatives							
a. Actions regarding plutonium-contaminated soil							
(1) Removal of all soil above State guideline	1500	GWR	0.87	0.64	0.63	0.18	1.00
		SL	0.56	0.36	0.36	0.16	1.00
		Other	0.15	0.13	0.13	0.16	1.00
(2) Soil removal of all soil above 500 d/m/g and plowing remaining soil above State guideline	72.4	GWR	0.89	0.71	0.70	0.33	1.00
		SL	0.64	0.48	0.48	0.31	1.00
		Other	0.31	0.28	0.28	0.31	1.00
(3) Removal of all soil above 500 d/m/g and no plowing	72.3	GWR	0.96	0.89	0.89	0.75	1.00
		SL	0.87	0.81	0.81	0.74	1.00
		Other	0.75	0.74	0.74	0.74	1.00
(4) Plowing of all land above State guideline	0.12	GWR	0.88	0.68	0.67	0.28	1.00
		SL	0.60	0.44	0.43	0.25	1.00
		Other	0.25	0.22	0.22	0.25	1.00
(5) Removal of buried waste	38		No Change				
b. Structural integrity of buildings ††††	–		No Change				
c. Additional land acquisition	5		No Change				
d. Surface water control	2.8	GWR	1.00	1.00	1.00	1.00	*
		SL	1.00	1.00	1.00	1.00	1.00
		Other	1.00	1.00	1.00	1.00	1.00

*breakdown by organ:Total Body = 0.74, Liver = 0.46, Bone = 0.47, Lung = 0.99

**Great Western Reservoir (lives 4 miles from the plant in the ENE direction)

***Standley Lake (lives 2 miles from the plant in the ESE direction)

†could range from this value to 1.00.

††the plutonium recovery and waste treatment facilities are being constructed as one project costing $190 million

†††could range from 0.00 to 1.00, due to uncertainties in normal operation and risk dose associated with Pu recovery operation only

††††cost, radiation dose, and benefit information on this alternative is not yet available

5.1 NO CHANGE IN CURRENT ACTIVITIES

Continuing Plant operations as they exist today represents the simplest of any of the alternatives considered. Actual and potential radioactive and nonradioactive releases, their impact and sources, as described in Chapter 3, would remain unchanged.

If there is no change in current activities, consumption of natural resources, as identified in Chapters 2, 3, and 4 would continue at the present rate as long as external factors, such as loss of natural gas supply, did not precipitate change.

5.2 COMPLETION OF CHANGES CURRENTLY UNDERWAY

Several modifications to operations, as described in Sections 2, 3, and 4, are currently planned or are being implemented as part of a continuing effort to upgrade the Plant, replace obsolete facilities, provide technical improvements for operation, increase protection for the environment, and expand Plant functions. In addition, studies are being conducted and plans developed in several other areas where future actions and modifications to existing operations may be desirable. The following major changes are currently in progress: (1) construction of a new facility for plutonium recovery, (2) construction of a new process waste-treatment facility, (3) total recycle of the Plant's water, and (4) partial removal of on-site soil containing plutonium. Completion of these projects will reduce the 70-year organ dose from Plant sources to person living in the vicinity to the levels indicated in Table 5-1.

5.2.1 Plutonium Recovery Facility

The new plutonium recovery and process waste-treatment facilities will involve essentially independent, self-contained buildings; yet they will be part of a single structure and are being built as a single construction program. Total floor space for these facilities plus a support facility is 335,000 square feet. Completion is expected in 1979.

The present plutonium-recovery system is described in Section 2.7.3. The age of existing facilities guided the AEC (now DOE) in its decision to construct a new facility. The new facility utilizes essentially the same processes as discussed in Chapter 2 for the existing facility; however, it is being constructed to stricter criteria and specifications to ensure that the structure, equipment, and controls provide assurance of continued, safe operation. An environmental impact statement (USAEC, January 1972) was issued on the new facility. Now under construction, the new plutonium recovery facility will result in plutonium-recovery operations being performed in greater safety, with greater operating economy, and with a reduced amount of plutonium waste. The possibility of spreading contaminants by fire or other accidents will be decreased. This new facility is being built to more rigid earthquake, tornado, fire, and other specifications required by the criteria for new plutonium facilities. The facility will recover as much plutonium as possible for return to the manufacturing system, and unrecoverable plutonium residues will be concentrated for transfer to a DOE-approved, waste storage site. The new plutonium recovery building is not expected to result in any change to the organ doses to persons living in the vicinity of the Plant, either from routine releases or from risk of accidents.

5.2.2 Process Waste Treatment Facility

The new waste-treatment plant (Section 2.7.3.3) has been designed to handle the present workload at Rocky Flats, the maximum possible output from the new recovery plant, and any increase in Plant process liquid waste through 1985. This facility will be in a single structure that will be in a single structure that will also house the new plutonium-recovery operations. About 42,700 square feet of this building will be used for waste treatment.

Public concern has been expressed regarding the release of toxic and radioactive material (Lamm-Wirth, 1975). The new waste-treatment facility is an important element of the overall DOE program for achieving as-low-as-practicable releases of effluents. New design features include the following:

a. A capacity to treat all aqueous process wastes generated at Rocky Flats, thus eliminating use of the solar evaporation ponds. This removes the possibility of chemical and low-level radioactive seepage from the ponds into the ground and from carryover by high winds onto the surrounding soil.
b. Capability of drying low-level radioactive sludge to minimize shipping weight and volume.
c. Capability to pelletize salts from the evaporator to reduce dusting and volume, and to afford more economical disposal.

Concentrated salt solutions now stored in the solar evaporation ponds will be evaporated as part of the new facility's start-up program. The solar evaporation practice will then be discontinued. A simplified flowsheet for the new waste treatment facility, Figure 2.7.3-1 depicts the operations.

Typical process solutions from the new plutonium recovery facility will be at plutonium and americium concentrations of 10^{-5} g/l. Further processing of these solutions in the new waste-treatment facility will reduce the plutonium alpha activity to 10×10^{-10} g/l. The disposal of this liquid is discussed in Section 2.7.3.3. Its concentration is considerably below DOE's radioactivity concentration guide (RCG) for plutonium in drinking water, $1{,}667 \times 10^{-9}$ μCi/ml (for an individual in a population in an uncontrolled area). (See Table 2.7.2-2 to make the conversion to comparable units.) A detailed material balance (i.e., an accountability system) calls for less than 10 grams of plutonium in the waste plant at any one time. This avoids any criticality hazard and eliminates requirements for critically safe geometry and for nuclear reaction inhibitors in the operations. This quantity restriction will also limit potential environmental hazards.

The primary benefit to the Denver-area population from the waste treatment facility will be the elimination of any further need for solar evaporation ponds. The risk of an impoundment failure, discussed in Section 3.2.2.3 becomes zero. The contribution of this postulated accident to persons drinking water from Great Western Reservoir is eliminated; reducing the risk dose for the reference man residing at a distance of 4 miles ENE of the Plant to 0.74, 0.46, 0.47, and 0.99 of the values of the total body, liver, bone, and lungs risk doses presented in Table 3.2.4-1, respectively. Risk doses to persons who do not drink water from Great Western Reservoir are not changed.

5.2.3 Water Recycle

Current handling of Rocky Flats' raw, treated, and waste water is discussed in Chapters 2 and 3. Procedures followed at the Plant have resulted in effluents being generally within applicable guidelines. These guidelines have been established as maximum concentrations for most industrial chemicals and radionuclides in air and water.

As described in Section 2.9, suspended solids and biological oxygen demand (BOD) in the Plant's liquid effluent have occasionally exceeded EPA guidelines for short periods of time. These excesses happened from construction of a tertiary water treatment system, changes in operating conditions associated with an upgrading program for the waste-treatment system, and cleaning of the treatment plant. An improvement, such as tertiary treatment, minimizes future problems in meeting NPDES permit requirements.

DOE is working toward the elimination of all routine liquid discharges from the Plant. This will require total recycling of all Plant aqueous wastes. There are two major construction projects designed to attain this goal. The first of these projects is the Water Control and Recycle project, which will provide facilities for the purification and recycling of all sanitary effluent and cooling tower blowdown water. The water will be purified by using the reverse-osmosis process. It will be reused in the existing raw-water system that supplies makeup water to the cooling towers. This project is expected to be operational in 1980 at an estimated cost of $3.1 million.

The second related project is the process waste-treatment portion of the new plutonium recovery and process waste-treatment facilities (Sections 5.2.2 and 2.7.3.3) which will recycle all aqueous process wastes. Together, these two systems will develop a total recycle system. Effluent from the process waste treatment facility, as described in Chapter 2, will be reused on site.

Recycling will reduce the volume of new water required for operations by an average of 6.12-million gallons per month. Of that total, 5.2-million gallons will be sanitary wastewater recycled by means of the reverse osmosis process; 920,000 gallons will be recycled process waste from the new waste-treatment facility. More important, the project will result in zero discharge of liquid effluent off site from the Rocky Flats Plant. Plant effluent water will no longer flow into Great Western Reservoir, which stores raw water for the city of Broomfield. Because of periodic low flow conditions, the drainage between the Plant and Great Western Reservoir does not support a fish population.

As explained in Chapters 2 and 3, alpha radioactivity concentration in the drinking water supply downstream from the sanitary waste discharges is, at this time, consistently less than 1% of the amount permitted by EPA drinking water standards. This does not include releases of natural uranium activity present in water taken into the Plant from off-site sources. Continued release of water from holding ponds used for sanitary waste, however, could result in the release of plutonium that is resuspended from previously contaminated sediments.

The benefit of the water recycling is to remove that fraction of the source term associated with water discharges from the Plant, and attributed to drinking water from Great Western Reservoir. The fraction of the source term may be anywhere between 1.0 and 0, inclusive. The benefit to persons drinking water from Great Western Reservoir, therefore, can range between no change in the organ dose from routine releases to the fractions of the organ doses listed in Table 5-1. For a person drinking water from Great Western Reservoir (residing at 4 miles in the ENE sector), the fractions are greater than or equal to 0.16 of the total body dose, 0.40 of the liver dose, 0.40 of the bone dose, and 0.96 of the lung dose. No benefit by way of a reduction in organ dose occurs to persons who drink water supplied from other water systems.

5.2.4 On-Site Contaminated Soil

At present, plutonium concentrations in soil in the vicinity of the Plant are at levels above statewide background levels. (See Section 2.3.9 for a more complete description of the background plutonium levels in the vicinity of Rocky Flats). This plutonium concentration resulted primarily from drums that leaked plutonium-contaminated oil during the period 1959-1969. The highest levels of plutonium are found in an area just inside the Plant's eastern security fence, about 1.5 miles inside the Plant boundary.

Uncontained on-site soil contaminated above 5,000 d/m/g or 22.5 microcuries per square meter, which involves about 43,000 square feet, has been removed, packaged, and shipped to a DOE-approved storage site. To reduce this level to the background level for field instruments, the top 9 inches of soil, a total of approximately 1,200 cubic yards, has been removed. This project cost was about $470,000.

The effect of the removal of soil for this project is to reduce the annual airborne source term from resuspension of on-site soil by 7.2% and to reduce the organ dose to persons living in the vicinity of the Plant to approximately 93% or more of the present estimated amount (Table 3.1.2-3), depending on their distance of residence from the Plant. An environmental assessment was prepared for the project (Rockwell, 1975). It concluded that the project would not have a significant adverse effect on the environment. Care was taken to minimize any increased dispersion of plutonium during the removal process. Such dispersion would negate any future savings from a reduced plutonium source.

5.3 RELOCATION

Relocation has been considered as an alternative to Rocky Flats' current location. Such an action could be a complete relocation of all functions associated with Rocky Flats, or it could be limited to relocation of only those operations having the highest potential for adverse effects on the environment.

5.3.1 Complete Relocation

All operations currently conducted at Rocky Flats could be transferred to another existing DOE facility or to a new site. A recent study (Rockwell, 1976) indicates a total cost of approximately $2.2 billion for this alternative. This estimate includes the following:

a. Removal of all equipment and systems plus decontamination and demolition of all structures ($240 million).
b. Removal of contaminated soil, which includes the asphalt pad area and sediment from ponds in the A and B series, and restoration of the Plant site to near natural conditions ($42 million).
c. Construction of new process and support facilities at a different site ($776 million).
d. Indirect costs of 15% plus 25% for contingency ($463 million).

These figures bring the total cost of this alternative to about $1.5 billion in 1976 dollars. An undertaking such as this would have to be implemented in several phases to maintain necessary production capabilities while new facilities are constructed and placed in operation. A period of about 10 to 12 years would be required for full implementation at the new site. Escalation at 6% per year through mid-1984 would add $710 million to the cost; thus, a total of $2.2 billion in costs could be expected by the anticipated completion date of 1988. Local expenditures for site demolition and restoration, including indirect, contingency, and escalation costs, would involve about $405 million of this overall total.

If the new location were less populated, a beneficial impact on the total environment would be involvement of fewer people should a potential accident release significant quantities of radioactive material. To the population in the vicinity of the present site, a benefit from complete relocation would be lowering the organ dose to persons living within 50 miles of the Plant. Routine releases from Plant buildings would be eliminated, resuspension of plutonium in on-site contaminated soil would be reduced to 5% of its present estimated value (Section 3.1.2.1), and the risk from the postulated accidents would be eliminated. The organ doses for those persons would be reduced to 5% or less of the corresponding organ doses for current routine operations, as given in Table 3.1.2-3, and organ risk doses from postulated accidents as given in Table 3.2.4-1 would be reduced to zero. Doses to populations at the new site cannot be estimated without knowing the population distributions, the meteorological characteristics and the water pathways in the new location. A comparison of costs and benefits is made in Chapter 9.

Underground relocation of the Plant is but a variation of Plant relocation discussed in the previous paragraphs. To make this change would be extremely costly as it would include all costs of complete relocation plus the cost of underground construction. Putting the Plant underground would decrease the risk from accidents as a result of an aircraft crash, high winds, or tornadoes.

5.3.2 Partial Relocation

The partial relocation alternative considers the action and impacts associated with transferring the Plant's radioactive-materials-handling functions to another site, leaving only those functions related to the processing of nonradioactive materials. This alternative would include complete decontamination, demolition, crating, and shipment off site of all contaminated structures and equipment; soil removal; deep plowing; and revegetation of contaminated land on site. New facilities would be required at a new site for all radioactive-material processes and associated administrative and support services.

As discussed in Section 5.3.1, the recent study (Rockwell, 1976) of costs for complete relocation of the Plant provides an adequate basis for estimating partial relocation costs. In this case, the new facilities would cost approximately $751 million. This includes certain stainless steel and beryllium fabrication facilities, at a cost of $202 million, which cannot realistically be separated from plutonium operations. All plutonium fabrication, scrap recovery, process development, research, waste treatment, receiving, packaging, and storage facilities would be included in the new facilities, at a cost of approximately $450 million. New administrative and support facilities would cost approximately $99 million.

Decontamination, demolition, crating, and shipping costs at Rocky Flats for structures and equipment are estimated at $149 million. This includes demolition of older contaminated structures only, as the newer structures can be adequately cleaned by sandblasting all surfaces. Removal of soil, deep plowing, and revegetation plus removal of the A- and B-series pond sediment, is estimated to cost $42 million, bringing the total decontamination costs at the existing site to $191 million in 1976 dollars.

Adding 15% for indirect costs and 25% for contingency, approximately $423 million (in 1976 dollars) would be added for a total of $1.36 billion. Completion of this alternative would require 10 to 12 years; thus, escalating the cost at 6% per year to a midpoint in 1984, with completion expected in 1988, the total cost of this alternative would be $2 billion. Regional expenditures, including indirect, contingency and escalation costs, would amount to about $275 million.

Personnel, supplies, and utilities at Rocky Flats would be required at approximately 37% of the current level. This is based on the continued need for maintenance, support, and administrative services for remaining facilities, additional administrative load resulting from decentralized operations, and the need to coordinate operations with the new facility. This constitutes a reduction of 63% in personnel and utilities. Assuming also a 50% reduction in supplies purchased, the direct annual after-tax revenue loss would be $26 million for the area. Reductions in induced payroll (after taxes) and in Federal impact payments would add another $44.6 million to the regional revenue loss for the partial relocation alternative.

Benefits to the Denver area that are attributable to this alternative would include the elimination of 100% of operational radioactive emissions, the elimination of 95% of future resuspension from on-site soil, elimination of 100% of potential Plant accidents involving radioactive materials, and a reduction in the consumption of natural resources. The organ doses to persons living within 50 miles of the Plant would be reduced to 5% or less of the corresponding organ doses for current routine operations, as given in Table 3.1.2-3, and organ risk doses from postulated accidents would be reduced to zero. Nonradioactive emissions would continue, although at a slightly reduced rate, but with no significant adverse impact on the environment.

5.4 TERMINATE OPERATIONS

Termination of operations at Rocky Flats without provision for equivalent capabilities at another facility or at a new facility would result in discontinuation of the production of certain nuclear weapons components. This alternative is inconsistent with the current national defense policy established by the President and endorsed by Congress through legislation, including appropriation acts. The current national defense policy is beyond the scope of this Environmental Impact Statement for Rocky Flats. The localized effects and direct costs of terminating operations at the Rocky Flats Plant have been evaluated and are presented in this section as three options: (1) Standby, (2) Complete Shutdown, with Total Decommissioning, and Partial Decontamination, and (3) Complete Shutdown, with Total Decommissioning, Complete Decontamination, Total Demolition, and Site Restoration.

5.4.1 Standby

Placing the Rocky Flats Plant on standby would consist of a shutdown of production and research and development activities, mothballing the equipment, and performing some decontamination. Operations to recover plutonium from waste and scrap would continue, as would security, health, safety, environmental, maintenance, fire department, transportation, and other support activities and personnel. A work force of approximately 1,400 people would be required. Based on a cost of $30 per square foot, and assuming approximately 35% of the total Plant floor area of 1.7 million square feet would require decontamination, the cost estimate for standby mode is approximately $17.8 million. In keeping with the definition of standby, this estimate does not include costs for disassembly of equipment and systems, or for decontamination of external surfaces or land areas immediately adjacent to the buildings.

Existing contamination of Plant structures and land would be unchanged, and maintenance, security, health physics, administrative, and management personnel would be required to monitor and maintain the Plant to ensure a continuously safe and secure status for all facilities. Placing the Plant in a standby mode would require approximately two to three years because of the material in process and the time required for decontamination.

The benefit to the environment of placing the Plant on standby would be a reduction in the radioactive and nonradioactive effluents from routine Plant operation. Another benefit would be an avoidance of some potential accidents involving the release and spread of radioactive and nonradioactive materials. Closing the Plant would also mean a reduction in the consumption of natural resources in this area. A standby mode of operation would eliminate essentially all the assumed source term of 100 μCi of plutonium alpha activity emitted annually to the air from routine Plant operations. It would also eliminate the potential 5 Ci of tritium activity;

but it would not affect source term, 4,400 μCi, a maximized estimate of plutonium alpha activity emitted from existing on-site contamination. No change is expected in the drinking water source term for water from Great Western and Standley Lake.

The effect of the standby condition on persons residing within 50 miles of the Plant, for routine, chronic releases, is a reduction of the organ doses to 94% or more of the current operating impact. Organ risk doses for postulated accidents would be reduced, but the reduction has not been quantified.

5.4.2 Complete Shutdown, Total Decommissioning, and Partial Decontamination

Complete shutdown, total decommissioning, and partial decontamination of the Rocky Flats Plant, as postulated in this alternative, would entail shutdown of all activities, decontamination of all structures and equipment, dismantling of all production and process systems and components, and crating them for shipment to DOE-approved storage site. The decontaminated structures would remain, along with their utilities and other service systems. Some contaminated soil within the Plant boundaries probably would remain.

An estimate of costs for this mode of termination was made during a recent study (Rockwell, 1976). In this study, decontamination of structures would include sandblasting of certain walls and floors after general scrubdown and cleaning of all contaminated surfaces. Soil decontamination of certain areas would consist of removal and shipment of approximately 812,000 cubic feet of soil, plus deep plowing and revegetation of approximately 220 acres, including 20 acres associated with the 812,000 cubic feet of soil removed. The asphalt pad, its underlying soil, and pond sediment would also be removed and shipped off site.

Estimated cost for these actions is $278 million in 1976 dollars: $167 million for building-equipment decontamination and disposal and for building restoration, $50 million for building demolition and disposal, and $61 million for decontamination of soil and pond sediment and for site restoration. These figures allow 15% for indirect costs and 25% for contingencies. Escalation at 6% annually to a three-year midpoint would raise the total cost to $331 million, assuming completion of the project in 1982.

The cost of soil and pond decontamination efforts in the above estimates were based on the following criteria:

(1) All areas of the Plant site and buffer zone in which plutonium contamination is above 1,000 d/m/g will be excavated by an environmentally approved method to remove the top 1/8 inch to 1/4 inch of soil. The areas will then be deep plowed and revegetated with natural grasses.

(2) All areas of plutonium contamination on site and in the buffer zone between 100 d/m/g and 1,000 d/m/g will be deep plowed and revegetated.
(3) Soil under the asphalt pad and sediment in the bottom of the A- and B-series ponds will be removed and shipped offsite.

A total annual revenue loss to the region of approximately $44 million in direct expenditures and $70 million in induced payroll would result (Chapter 9).

Benefits from complete shutdown, total decommissioning, and partial decontamination would be the elimination of all radioactive and nonradioactive effluents, accidental release potential, consumption of natural resources, and potential impacts of contaminated soil for the areas decontaminated. The 220 acres that would be decontaminated, including the asphalt pad area and pond sediment, contain about 95% of the on-site soil contaminated with plutonium (refer to Section 2.3.9.1 for detailed discussion of plutonium distribution).

Plant shutdown and partial decontamination would have the same effect on the organ doses to persons living within 50 miles of the Plant as would complete relocation. The organ doses for those persons would be reduced to 5% or less of the corresponding organ doses from current routine operations, and organ risk doses from postulated accidents would be reduced to zero.

5.4.3 Complete Shutdown, Total Decommissioning, Complete Decontamination, Total Demolition, and Site Restoration

The third mode of termination extends the complete decommissioning and partial decontamination discussed in Section 5.4.2 to include demolition of all Plant structures and facilities, crating and shipping them for storage, and complete restoration of the site through plowing and revegetation. Some residual plutonium and americium would remain in the soil and stream sediments, as indicated in Section 5.4.2. The cost for decontamination, demolition, and crating of all remaining structures and equipment, above the $278 million estimated in Section 5.4.2, is estimated to be $139 million. Soil removal, plowing, and revegetation of the area previously occupied by Plant structures would add about $1 million. This would raise the total cost for this alternative, including indirect and contingency costs, to $418 million in 1976 dollars (Rockwell, 1976). Escalation at 6% annually to a four-year midpoint would increase the cost to $528 million, with an estimated completion date of 1984. A total annual revenue loss to the region of approximately $44 million in direct expenditures and $70 million in induced payroll would result (Chapter 9).

The benefits of this alternative would be identical to those described in Section 5.4.2; i.e., site decontamination, elimination of all effluents and accident potential, and elimination of the consumption of natural resources. An additional

30 acres, now occupied by Plant structures, would be returned to range after demolition and removal of all Plant structures. This would increase the site restoration acreage to 250. The reduction in the organ doses to persons living within 50 miles of the Plant is identical to that for the alternative presented in Section 5.4.2.

5.5 OTHER ALTERNATIVES

In contrast to Section 5.2, which discusses changes to Plant operations that have been approved, funded, and currently are in various stages of completion, this section discusses other changes that have been considered. The alternatives included in this section involve (1) actions regarding plutonium-contaminated soil, (2) structural integrity of buildings, (3) additional land acquisition, and (4) surface-water control.

5.5.1 Actions Regarding Plutonium-Contaminated Soil

In addition to the plutonium-contaminated soil that has been removed from the lip area (as discussed in Section 5.2.4), there are areas in which some soil removal has been done or is under consideration. The areas included are adjacent to the solar evaporation ponds, the soil under the asphalt pad, east and southeast of the lip area, and some waste burial sites. A large fraction of the organ dose described as resulting from normal operation is attributable to these source areas.

Possible actions that can be taken with the contaminated soil include one or more of the following:

(1) Separating plutonium from the soil.
(2) Containing the plutonium.
(3) Removing the plutonium with the soil (Section 5.2.4).

Rocky Flats is researching methods to remove plutonium from the soil. The methods are intended for application in the decontamination of soil under the asphalt pad. The research has focused on three basic processes:

(1) Partial concentration by attrition scrubbing, sizing, and screening.
(2) Concentration by one or more physical techniques:
   a. conventional magnetic separation
   b. high-gradient magnetic separation
   c. flotation
   d. density gradient
(3) Chemical leaching of the final concentrate from Step 2.

At present, research indicates 70 to 90% soil decontamination may be obtained by two stages of sizing, screening, and attrition scrubbing, but a third stage process specific to plutonium must be satisfactorily demonstrated. A soil decontamination plant based on these processes is receiving budget consideration for completion by 1982, but will not be built if it is determined that some other option, such as soil removal, is safer and less expensive.

Containment of the plutonium is exemplified by the asphalt pad which covers the area where contaminated oil leaked from steel drums. Containment by the asphalt pad removed about 1.7 Ci of plutonium from possible resuspension. Vegetation presently serves as an effective means of containment in most areas to which the present discussion applies. Containment methods acceptable for long-term control might include deep-plowing the soil to place the plutonium out of availability for surface resuspension. Deep-plowing dilutes the concentration of the radioactivity in the soil, making it less available to plants with shallow root zones and to surface runoff. Deep-plowing would be followed by application of top soil and revegetation.

Five specific actions concerning plutonium-contaminated soil on and off site have been considered. These actions, which follow, are based on the recommendations of Healy (1974) and the guidelines of the Colorado Department of Health (Section 2.3.9.2):

(1) Removal of all soil above the State guideline of 2 d/m/g (0.01 $\mu Ci/m^2$).
(2) Removal of all surface soil above 500 d/m/g and deep-plowing the soil containing plutonium levels above the State guideline.
(3) Removal of all surface soil above 500 d/m/g, but refraining from any other action.
(4) Deep-plowing all surface soil containing plutonium above the State guideline.
(5) Removal of buried waste containing radioactivity above the State guideline.

Costs, impact on organ dose, and benefits associated with these five actions are listed in Table 5-1. Costs for all soil-removal efforts include packaging the soil and shipping it to a DOE-approved storage site.

The most comprehensive soil removal alternative would be to remove all exposed soil with plutonium levels above the State guideline of 2 d/m/g (0.01 $\mu Ci/m^2$). Based on data from DOE contracted studies, this potentially would involve about 1,000 acres of off-site land and about 2,000 acres of on-site land. If these 3,000 acres were excavated at an estimated cost of $11 per square foot, this action would cost about $1.44 billion, not including capital equipment. Removal of the asphalt pad and the soil under it and removal of sediment from the A and B series ponds is estimated at $61 million, including indirect costs and contingency allowance (Rockwell, 1976). The total estimated cost for this alternative is therefore $1,500 million.

In terms of benefits, removing all soil presently above the Colorado State guideline would dispose of about 90% of the estimated 6.9 Ci of on-site plutonium and 90% of the 2.6 Ci off-site plutonium. This would mean a reduction of the on-site resuspension source term to 0.1 of the value estimated for current operations (Section 3.1.2.1). No reduction in source term would result from removal of the asphalt pad and soil under it, because the plutonium in that location is presently considered to be 100% contained. Likewise, no reduction in waterborne source term beyond that estimated under water recycle (Section 5.2.3) is expected from removal of pond sediments.

The reduction in the organ doses for persons living within 50 miles of the Plant for routine releases are shown in Table 5-1 for this alternative. For the person residing at 4 miles from the Plant in the ENE sector and drinking water supplied from Great Western Reservoir, the 70-year bone dose is reduced to 63% of its present estimated value (Table 3.1.2-3). The 70-year bone dose would be reduced to 36% and 13% for the person residing at 2 miles in the ESE sector and drinking water supplied from Standley Reservoir and for persons drinking water supplied from other sources, respectively.

The removal of off-site soil above the State guideline of 2 d/m/g (0.01 $\mu Ci/m^2$) would reduce the organ doses to hypothetical persons living on that ground. The land is presently uninhabited. See Section 3.2.4.3 and Table 3.2.4-3 for the presentation of these doses. This removal would reduce the contours of 0.05 $\mu Ci/m^2$ and 0.02 $\mu Ci/m^2$ to a value of 0.01 $\mu Ci/m^2$, or possibly less, with a reduction in the organ doses to a hypothetical person living at those locations to 20% and 50% respectively.

Removing soil containing plutonium above 500 d/m/g (a judiciously chosen, but arbitrary guide)* and plowing the remaining land containing plutonium above the State guideline could appreciably reduce the cost as compared with removing all soil above 2 d/m/g. There are an estimated 50 acres on the Plant site that exceed 500 d/m/g. The 50 acres are in four locations, two of which do not involve bare soil. The areas are as follows:

(1) Sediment at the bottom of the B-1 and B-2 holding ponds.
(2) Soil under and adjoining the asphalt pad.
(3) Soil extending southeast of the asphalt pad.
(4) A former waste storage site at the northeast corner of the Plant security area.

Removal of the soil under the asphalt pad and removal of sediments from the A and B series ponds has been estimated at $61 million (Rockwell, 1976), including indirect costs (15%) and contingency (25%). Soil adjoining the pad having plutonium levels above 500 d/m/g are estimated to include 1.02 million square feet (27 acres). At $11 per square foot, the cost of this action would be $11.3 million. The total cost of soil removal would be $72.3 million. At $40 per acre (Rockwell, 1976), plowing and restoring the remaining 2,950 acres of land containing plutonium concentrations between 500 d/m/g and the State guideline of 2 d/m/g would cost an additional $118,000; thus, the total estimated cost for this alternative is $72.4 million.

The effect of these actions is to reduce the source term for routine releases from resuspension of on-site soil to 26% of its present estimated value (Section 3.1.2.1). The effect on the organ doses to persons living within 50 miles of the Plant is given in Table 5.1. For routine operations the doses to the organs will be 28 to 89% of the present estimated amount. This alternative has no effect on the risk dose from postulated accidents. Plowing of off-site soil above the State guidelines of 0.01 $\mu Ci/m^2$ is expected to have the same reduction as for the soil removal discussed for the first alternative in this section.

The third alternative is removing all soil containing plutonium above 500 d/m/g, but doing nothing with the remaining plutonium-contaminated soil. This would involve the removal of pond sediment plus dirt from under and near the asphalt pad. The estimated cost would be $72.3 million. The effect of this action is to reduce the source term for current releases from resuspension of on-site soil to 73% of its present estimated amount. The effect on the organ doses to persons living within 50 miles of the Plant is given in Table 5-1. Doses to the organs will be 74% to 96% of the present estimated amount.

The fourth alternative, plowing and restoring all surface soil containing plutonium above the State guideline of 2 d/m/g, would require plowing approximately 3,000 acres at an estimated cost of $120,000 ($40 per acre). The effect of this action is to reduce the source term for routine releases from resuspension of on-site soil to 20% of its present estimated value. The effect on the organ doses to persons living within 50 miles of the Plant is given in Table 5-1. The doses to the organs are in the range of 22 to 88% of their present estimated values. The effect on off-site soil is the same as for the first two alternatives in this section.

In addition to the surface-contaminated areas, there are certain places on the Plant site that have been used as disposal sites, covered by two to three feet of soil. The soil below the surface in these areas may contain low levels of plutonium, but because of the low mobility of plutonium in soil, there is no evidence from air and well sampling that the plutonium has moved or that any off-site contamination or exposure of the general public has resulted from this subsurface contamination; nor is there any reason to expect any spread of this contamination within the next few decades. Additionally, studies on soil disturbance by burrowing animals (Winsor, 1975) indicate upcast soil comes from around the 10-cm horizon, implying that no disturbance occurs to soils at 100-cm depth. Therefore, there will be no exposure to the Denver-area population in the next 70 years and no benefit, as determined in previous sections, would be gained by decontamination. It is recognized, however, that because plutonium has a long half-life (24,000 years), decontamination could prevent dispersal of plutonium over a very long period and thus prevent any potential hazards from that dispersal.

A fifth alternative considered in dealing with plutonium-contaminated soil is to remove those disposal sites where the existence of plutonium concentrations above background levels are known or suspected. The material involved in these areas (excluding the asphalt pad area) amounts to a total estimated volume of 6.4 million-cubic feet. Available information indicates that most of the radioactivity in these areas is from uranium and other naturally occurring alpha emitters. The average level of plutonium in these disposal sites is about 0.01 nCi (0.00001 μCi) per gram. This level is so low that the soil would not require special packaging for off-site shipment. As a result, removal costs would be reduced to $6 per cubic foot for a total cost estimated at $38 million.

The EPA is currently establishing guidelines (Section 2.3.9.2) for allowable levels of plutonium in soil. These guidelines may have an influence on future Rocky Flats actions concerning contaminated soil. The Environmental Protection Agency (EPA) has proposed a guideline of 0.2 $\mu Ci/m^2$. This value applies to the top 1 cm of soil in uncontrolled areas and is described as a screening level rather than an upper limit. Current data indicate that off-site soil contamination levels do not exceed the federal proposed screening level. On site, a planimetric estimate from HASL isopleths (Krey, and others, 1976) indicates that approximately 300 acres of exposed soil exceeds the proposed screening level. If the presently proposed 0.2 $\mu Ci/m^2$ screening level for the top centimeter of soil is accepted, no off-site land would require remedial action. About 300 acres of on-site land would contain plutonium in excess of the guide for remedial action, excluding areas covered by the asphalt pad and the sediments in the ponds. This land is presently in a controlled-access area, and therefore is not subject to the recommended actions of the proposed guide. Deep-plowing the 300 acres at $40 per acre for plowing and restoration would cost about $12,000.

No dose reduction benefit is expected from this action.

Presently, radioactivity in soil at Rocky Flats is contained and the locations are documented. Close surveillance of all areas having radioactivity is maintained by the Plant's operating contractor and by State and Federal agencies.

5.5.2 Structural Integrity of Plant Buildings

Since the Rocky Flats Plant first became operational in 1952, many changes have occurred at the Plant. Expansion, modification, and renovation have been virtually continuous processes, both to increase capabilities and capacity, and to upgrade existing structures, systems, and equipment so as to improve the handling of radioactive materials and ensure safe operation. Throughout the Plant's history, every new facility has been designed and constructed to meet the most stringent safety requirements in effect at the time of construction. Many of these new criteria originated from research and development at the Plant, and many different design criteria have been implemented at different times in the Plant's history. In general, structures and systems have been subject to more stringent (with greater safety factors) design criteria as time passed. The increased conservatism resulted primarily from consideration of more serious postulated accidents. These considerations resulted in a criterion requiring greater load capacity of structures. This does not mean that existing structures will not withstand the corresponding loads if the postulated conditions were to occur. All engineered facilities have safety margins in excess of the design criteria.

Formal Safety Analysis Reports are being prepared for major Plant structures. As part of this project, a detailed structural analysis is being conducted to determine the structural capability of each major building as it pertains to certain natural phenomena. These analyses will document the structural response in facility Safety Analyses Reports of the major buildings to seismic, tornado, and extreme wind forces. The results will then be used in connection with subsequent decisions on Plant improvements.

5.5.3 Land Acquisition

Congress appropriated $11.4 million for the purchase during 1974 and 1975 of about 4,000 acres of land surrounding the original Rocky Flats Plant site. Prior to the purchase, an Environmental Impact Statement was prepared (USAEC, April 1972). The intent was to provide a 1 to 1.5 mile extension of the buffer zone around the facility. The acquisition was and is intended to minimize the type of problems that often arise when residential communities encroach upon industrial facilities. This buffer zone will also provide an extra margin of public safety in the event of an accident at Rocky Flats.

About 450 acres of the present buffer zone is being developed into a wind energy test facility as described in Section 2.4. Planting of trees and shrubs in the buffer zone could enhance the esthetic value of the area. Such efforts have and will continue to be challenged by unfavorable soil and climatic conditions prevalent in this area. A land management plan has been drafted for the buffer zone area. Implementation of the plan will encourage protection of the existing ecology, archeology, and facilitate research, and operational use where this is appropriate, and revegetation where it is needed.

Air and soil monitoring done at the boundary of the Plant show that land adjacent to it is within the EPA proposed Guidance for Transuranics in the Environment (1977). Although a DEIS commenter has suggested that the air monitoring data are not reliable, this has not been substantiated (see Appendix I).

As stated in this section, plutonium concentration levels above the Colorado State guideline of 2 d/m/g exist in certain areas beyond the new site boundary. Recent measurements, using the Colorado Health Department's soil-sampling technique, indicate that the actual amount of land with soil above the State guideline of 2 d/m/g may be limited to 1.5 square miles (1,000 acres) on the east boundary of the facility. The cost for that 1,000 acres would approximate $5 million; however, DOE plans no additional land acquisitions.

The effect of acquiring the additional land having plutonium concentration levels above the State guidelines of 0.01 $\mu Ci/m^2$ is to prevent persons from living on that land. The acquisition, therefore, eliminates the possibility that persons could receive the organ doses presented in Table 3.2.4-9 for contours greater than 0.01 $\mu Ci/m^2$.

5.5.4 Surface Water Control

Alternatives have been proposed to reduce the impact of plutonium-contaminated soil surrounding the Plant. For example, a study of the Plant's overall water requirements and existing water systems was conducted in 1974 (ESI, 1974) as part of the total water recycle project. This study recommended that a perimeter canal and large reservoir be constructed to collect the surface runoff water originating in or flowing through the control area (inside the security fence) where all Plant buildings are located. Upon completion of the total water recycle project, storm runoff would be the only remaining water discharge from the Plant site that could carry contaminants to downstream water users.

Existing retention ponds on North Walnut Creek, South Walnut Creek, and Woman Creek are not sufficiently large to hold storm runoff water originating inside the Plant security fence during heavy rainfall. Before these ponds fill to capacity, they are bypassed to prevent the release of resuspended pond sediment with the runoff water. The proposed surface water system would contain and control storm runoff. After analytical sampling to ensure that the water quality is within acceptable limits, the water can be released.

The presently planned system, begun in 1978, is described in Section 2.10.2. It will consist of open drainage ditches and three, earthen impoundment dams. The dams will be constructed on North Walnut Creek (Dam A-4), South Walnut Creek (Dam B-5), and Woman Creek (Dam C-2). McKay Ditch, located to the west and north of the security fence, will be enlarged to contain runoff from the 100-year storm. To the west of the controlled area, a flume will be constructed across North Walnut Creek. This flume will divert water to McKay Ditch and thus prevent water flow from the west from entering the controlled area of the Plant Site.

The dam core will be constructed from clay obtained from clay formations in the buffer zone. Other dam-construction soil will be obtained from suitable sites in the buffer zone. All newly exposed soil will be protected from erosion by reseeding or by riprapping.

Almost in line with the midpoint of the controlled area, Woman Creek will be diverted by a bypass ditch around the existing C-1 dam and the new C-2 dam. Drainage from the controlled area will go into a drainage ditch which will be constructed between the security fence and Woman Creek. This ditch will pass through the C-1 and C-2 dams before joining Woman Creek. These dams can contain all runoff water from the 100-year storm; thus, the diversion ditch will prevent storm runoff that passes through the area inside the security fence from entering Woman Creek. This system is to be completed by the end of FY 1979. The estimated cost is $2.8 million.

This surface water control system will minimize the redistribution of radioactive and nonradioactive contaminants that might otherwise occur as a result of a heavy storm, and it also would reduce the threat of excessive erosion of downstream channels and of flooding Great Western Reservoir and Standley Lake if the 100-year storm should occur. This project is expected to result in no change in the organ doses to persons from routine releases. Elimination of accidental waterborne-releases will have the same effect as the waste treatment facility on the risk dose from accidents (Section 5.2.2).

Other alterations of the environment because of this control system will be removal of top soil in the dam construction sites and Woman Creek bypass ditch plus redistribution of the soil elsewhere in the buffer zone. The redistributed soil would be reseeded with local grasses.

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6. RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

This section briefly summarizes the cumulative environmental effects resulting from Rocky Flats' short-term (1951 to present) use of area resources. In addition, possible effects from decommissioning and relocation of the Plant are discussed. A more detailed discussion of these issues is found in Chapters 5 and 9 of this Environmental Impact Statement.

6.1 CUMULATIVE ENVIRONMENTAL EFFECTS

The construction of the Plant and its operation since 1951 have affected the environment, as would the construction and operation of any major industrial plant. The primary cumulative environmental effects to date because of Rocky Flats operations have included the following:

(1) Some chemical and radioactive contamination of soil, water, and air.
(2) Interference with the natural habitat of flora and fauna.
(3) Prevention of agricultural, industrial, and residential development on land within the Plant boundary.
(4) Consumption of natural and energy resources.

Off-site soil containing plutonium from Rocky Flats presents no known danger to human health (CDH, 1971). Soil contamination is discussed in detail in Sections 2.3.9.1 through 2.3.9.3. The radioactivity and chemicals in water and air leaving the Plant are below Federal and State standards established to protect human health. Minor exceptions have occurred with chemicals in water. These exceptions are discussed in Section 2.9.1.2. Future dissemination in the environs of radioactive and non-radioactive effluents from Rocky Flats will be reduced even further when a new waste-processing facility and a total water-recycle program become operational. Additionally, the need for raw water will be reduced by about 40% when the water recycle program is operational.

If Plant operations continue as at present, access to the Rocky Flats site will be limited, and use of land within the site boundary will remain restricted to activities having minimal environmental impact. Additional land surrounding the Plant was purchased in 1975 to enlarge the buffer zone (see Section 5.5.3) and is considered in the Rocky Flats Land Management Plan. The Plan is directed toward maintaining the area surrounding the Plant in as natural a state as possible and toward minimizing any adverse impact of Rocky Flats on the environment. Recent environmental improvement programs have involved top soil rehabilitation, reseeding of natural grasses, tree planting, as discussed in Section 2.3.10.4. These programs make beneficial contributions to the area ecology.

The presence of the Plant may have prevented some industrial and residential development, and has resulted in a small loss of grazing land for livestock and grain production. That loss, however, will be offset by the probable recovery of overgrazed land, with a concurrent increase in wildlife. Restricted land use, planting of trees and natural grasses, and controlling of surface waters will minimize erosion and will promote the growth of natural vegetation and wildlife. The uses to which the site can be put will continue being limited as long as the Plant operates with its present mission. If alternate uses are chosen for the Plant, the long-term effect on the environment will depend on the use.

6.2 DECOMMISSIONING

The Rocky Flats Plant will continue producing components for nuclear weapons as long as required for national defense or until the operation is moved to another location (an alternative discussed in Section 5). When no longer needed, the Plant could be decommissioned and possibly used for some other purpose such as research. The land also could be made available for an alternate use such as commercial development, residential development, or agriculture. Future uses differing from current Plant activities might require soil decontamination, depending on the level of radioactivity in soil as allowed by recognized standards existing at the time. Soil decontamination, if needed, will require considerable time, money, and a suitable technology.

Consideration of moving Rocky Flats operations to another location would raise fundamental issues of practicality and economy. These issues include the acceptability of another location to perform the unique Rocky Flats mission, the time needed to build or modify another facility, and the substantial costs associated with relocation. The acceptability of another location would depend on a number of factors, such as the availability of a skilled work force and other resources comparable to those in the Denver area. A conservative estimate of costs associated with relocating the current Rocky Flats operation elsewhere and leaving the site in a condition suitable for other types of work is approximately $2 billion. This cost estimate was derived on the basis that conversion of the site would be initiated in the near future; it does not include costs that would be incurred in converting the existing, highly specialized structures to non-nuclear work. The estimated time required for relocation is about 10 years. Decontamination and decommissioning are discussed in greater detail in Sections 5.3, 5.4, and 5.5.

6.3 REFERENCES

CDH. USAEC Rocky Flats Plant, 1971 Environmental Surveillance Summary Report. Colorado Department of Health, Division of Occupational and Radiological Health. 1971.

7. RELATIONSHIP TO LAND-USE PLANS

The Rocky Flats Plant, like most industrial facilities, has some impact on the surrounding areas. To assess this impact, land-use plans in the vicinity of the Plant site were identified, and possible Plant influences on these plans were evaluated. This section briefly covers land-use plans for areas within 10 miles of the Plant and mentions possible conflicts with these plans. The existing land-use of this area is described in Section 2.3.2.

7.1 LAND-USE PLANS

Land-use plans and zoning maps were acquired for Adams, Boulder, and Jefferson Counties, and for the cities of Arvada, Boulder, Broomfield, Lafayette, Louisville, Superior, Westminster and Wheat Ridge. The general area of interest was reviewed, and a composite land-use planning map was developed from the above sources. This map is shown in Figure 7.1-1.

7.1.1 State Land-Use Plans

The most recent edition available of the State land-use map was published in 1973. For the vicinity of the Rocky Flats Plant, the most detailed information was acquired from counties and municipalities; this information is, however, generally consistent with the objectives of the State planning.

7.1.2 County Land-Use Plans

The area within 10 miles of the Rocky Flats Plant is located in three counties: Adams, Boulder, and Jefferson.

Adams County, east of the Plant, includes portions of Arvada, Broomfield, and Westminster. Most of this area is under the jurisdiction of the cities and is discussed in Section 7.1.3.

The Rocky Flats site and most of the area within 10 miles to the east, south, and west is located in Jefferson County. Future land use in Jefferson County is covered by two documents: (1) the Golden/Ralston Plan, adopted by the Jefferson County Planning Commission in 1973 and amended September 1974; and (2) the land use zoning maps published December 15, 1977, in an information booklet issued by Jefferson County Planning Department. As shown in Figure 7.1-1, the land west of the Plant is planned primarily for agriculture or open space, except for a narrow strip adjacent to the western Plant boundary. That strip is planned for industrial use.

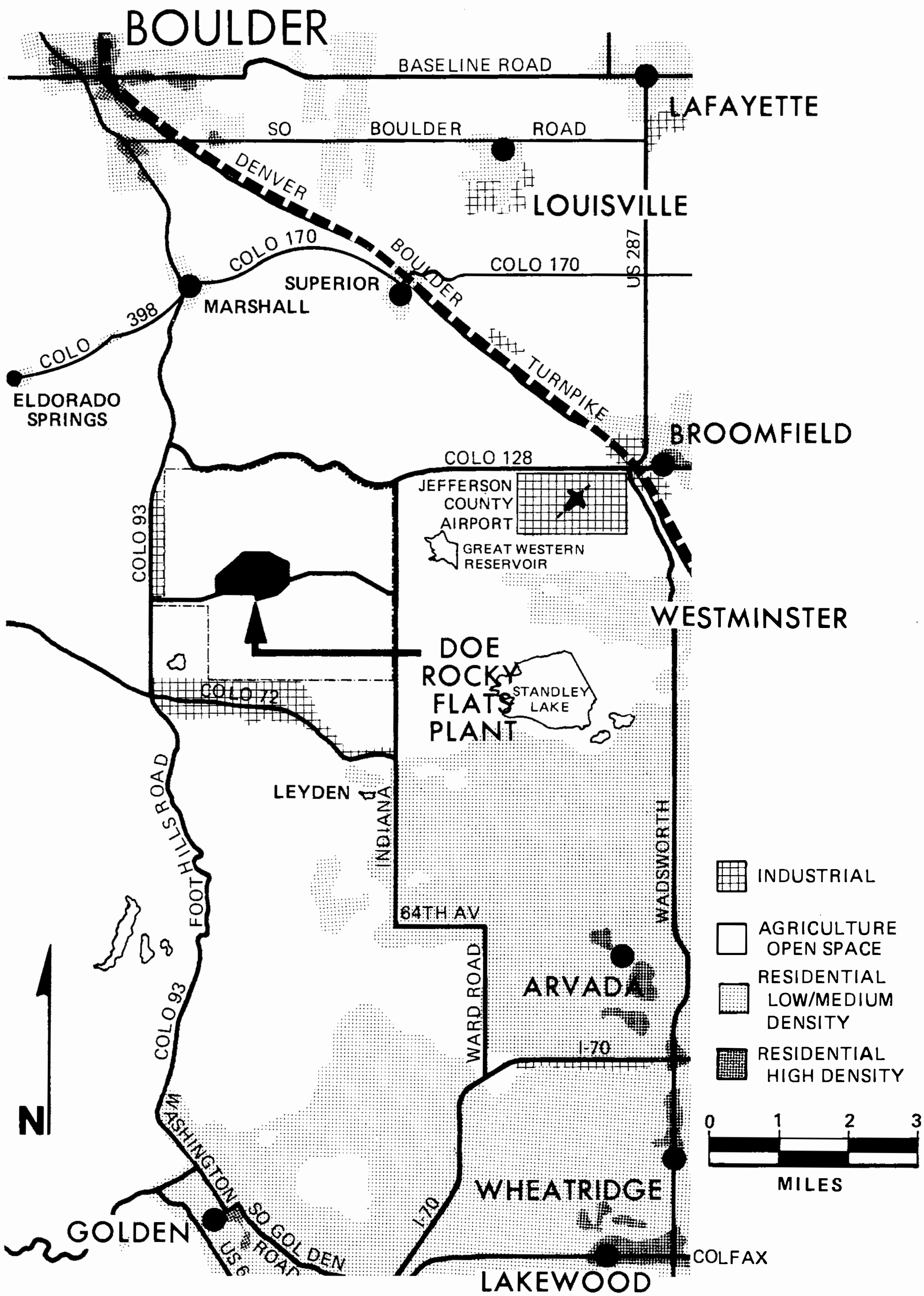

Figure 7.1-1 Land-Use Map

Land adjacent to the Plant's southern boundary is planned for industrial expansion, with some low density residential development.

East of the Plant, an area adjacent to the Jeffco Airport is planned for industrial expansion, with most of the remaining land planned for low (zero-to-three units per acre) residential expansion. The area immediately adjacent to Standley Lake, southeast of the Plant, is planned for open space, which will limit residential expansion in that area.

The area north of the Plant is in Boulder County; it is covered primarily by the Boulder Valley Comprehensive Plan. The Boulder County Plan generally projects limited residential expansion into the unincorporated areas during the next few decades. The Plan does not, however, project residential expansion within three to four miles of Rocky Flats' northern boundary.

7.1.3 City Land-Use Plans

Evaluation of comprehensive land-use plans and zoning maps for population centers surrounding the Rocky Flats Plant included the cities of Arvada, Boulder, Broomfield, Golden, Lafayette, Louisville, Superior, Westminster, and Wheat Ridge. Plans were acquired from these cities except for Golden, Arvada, Westminster, and Wheat Ridge which currently do not have adopted land-use plans. Information from these plans was incorporated into Figure 7.1-1 and was compared with the county land-use plans for consistency.

General urbanization of the areas east and southeast of the Plant is shown on various plans and zoning maps particularly those of Arvada and Westminster. The closest residential area, 4.5 miles distant from the Plant, is approved for a PUD (Planned Unit Development) and will have an average housing density of less than 3.5 units/acre.

North of the Plant, the cities of Boulder, Lafayette, Louisville, and Superior have comprehensive land-use plans covering the area within their respective city limits; these cities are distant enough from the Plant boundaries, however, that they do not affect the area in the Plant vicinity. To the south is the city of Golden, which is also located far enough from the Plant that growth will not affect the Rocky Flats area.

7.2 PLANT INFLUENCE ON LAND USE

After the various comprehensive land-use plans and zoning maps in the vicinity of the Rocky Flats Plant were reviewed, an evaluation was made of the influence the

Plant might have on these plans. The only area of potential land-use conflict is near the eastern boundary of the Plant. Land-use in this area, generally under the jurisdiction of Jefferson County, is affected by the residential expansions of Arvada and Westminster.

In 1972 the Colorado Department of Health defined an "Area of Concern." In 1975, after additional soil sampling, the area was reduced in size, to having a northern and western boundary of Colorado 128 and Colorado 93, respectively, with a southern boundary of 80th Avenue extended to Colorado 72 and an eastern boundary of Simms Street extended through Standley Lake. Special construction techniques, such as plowing, may be required by the State Health Department on soil containing plutonium in excess of 2.0 d/m/g or 0.01 $\mu Ci/m^2$ (see Section 2.3.9.2).

In May 1975, zoning for a residential development immediately southeast of Rocky Flats was denied by Jefferson County Commissioners because of concern over possible plutonium contamination. Subsequently three lawsuits were filed by the owners of the land adjacent to the Plant against the United States, The Dow Chemical Company, and Rockwell International Corporation. These landowners allege that operation of the Plant has damaged their property. The defendants have denied the allegations and are defending the suits. Resolution of this litigation may determine whether any changes in existing land-use plans will be required.

8. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

8.1 NATURAL AND ENERGY RESOURCES

Most energy resources consumed for utilities and transportation in daily operations of the Rocky Flats Plant are irretrievable. The quantity of resources consumed is based primarily on operational needs of Plant facilities. These needs are influenced by the work load, and, with few exceptions, are unrelated to the number of people employed at Rocky Flats.

The following figures for FY 1977 indicate the levels at which these resources are being expended: 104,050 megawatt hours of electricity; 637 million cubic feet of natural gas; 101,396 gallons of gasoline (excluding employees' personal transportation); 335,000 gallons of residual fuel oil; 19,353 gallons of diesel fuel; 40,876 gallons of propane, and 113.2 million gallons of water. In FY 1977, the sewage treatment plant returned 56.8 million gallons of the water used by Rocky Flats directly back to the environs. The remaining water was also returned to the environs--mostly by evaporation. Chemical usage for the Plant is summarized in Table 2.8-1. Fuel systems are discussed in Section 2.6.6.

Plant requirements for resources other than water are expected to increase modestly in the future, but efforts are being directed toward utilizing the resources as efficiently as possible. Examples of these actions are reduced lighting in various areas of the Plant, reducing utilities during off-duty hours, conservation of gasoline by reducing bus and mail service, and encouragement of employee carpools. Construction is also underway on facilities for a total water-recycle program, as described in Section 5.2, and for recovering and recycling nitric acid in the new plutonium recovery facility.

The use of the land is not considered an irreversible and irretrievable commitment of resources. Future options for an appropriate renovation program are discussed in Section 5.4.

8.2 MANPOWER RESOURCES

One consideration in evaluating the irreversible and irretrievable commitments of resources is that of the manpower necessary for Plant operation. Although usually considered a benefit, the employment required for Plant operation is a commitment of area manpower and, therefore, is an irretrievable resource in that man-hours expended at Rocky Flats cannot be recovered or used elsewhere.

The Rocky Flats Plant directly employed approximately 2,800 people, excluding construction workers, during 1977. This direct employment has declined over recent years, from a maximum of 3,750 people in 1972, because of budgetary limitations and reduced production schedules. Employment projections through 1985 range from 2,600 to 3,400 people. Projection of future workloads and funding that will be authorized by Congress have limited the DOE's employment estimates at Rocky Flats to the year 1985.

There has been and will be the need for additional facilities that require construction labor. Historically, an average of 300 construction workers has been employed each year, and this requirement is expected to continue for several more years.

Because of the proximity of the Rocky Flats Plant to metropolitan Denver, these commitments of manpower do not place a significant burden on the available labor pool.

8.3 FINANCIAL RESOURCES

Operation of the Rocky Flats Plant causes the expenditure of considerable sums of Federal money. In addition, initial construction costs of the facilities and the periodic modifications to them have also caused large financial expenditures.

The direct operating cost of the Plant was about $70 million in FY 1977, which includes the payroll plus expenditures for equipment, goods, services, and utilities. This operating cost varies from year to year, depending on production and budgetary limitations. Total construction cost for the Rocky Flats Plant from 1951 to date is approximately $250 million. The cost of additional facilities currently being constructed will raise the total figure to more than $400 million.

The financial resources that have been committed in the past for construction and operation of the Plant are from Federal funds that support the national defense program. If this funding had not been committed to the Rocky Flats Plant, it probably would have been committed to an equivalent facility located elsewhere in the United States.

9. ENVIRONMENTAL TRADE-OFF ANALYSIS

This section analyzes the environmental and economic costs (including potential risks) and benefits associated with (1) operation of the Rocky Flats Plant as it exists today and (2) alternatives to current Plant operations as postulated in Chapter 5. A complete assessment of the national defense program is beyond the scope of this Environmental Impact Statement and was not performed. A summary of the benefits of current Plant operations and of the various alternatives is shown in Table 9-1. A summary of the costs and fraction of organ doses to an individual is shown in Table 5-1.

In reviewing Plant activities and various alternatives to current operations, costs are considered as expenditures for construction and for Plant operations and as negative social and environmental impacts of Rocky Flats on the area. Benefits refer to Rocky Flats contributions to local and national interests and to local expenditures (in dollars). Risks are expressed here in terms of radiation exposure to individuals or to the Denver-area population as a result of normal Plant operations or potential Plant accidents. In identifying costs and benefits associated with the Plant, the facility has been viewed both from the national viewpoint and from that of the Denver area.

From the national viewpoint, all public expenditures, such as those required to operate the Plant, result in a cost (taxes). These costs achieve the primary benefit of the Plant (national defense), a secondary benefit being the development of technology related to the nuclear and energy industries. From the local viewpoint, these costs provide employment, provide a market for goods and services, and contribute to the State and local tax revenues.

9.1 NO CHANGE IN CURRENT ACTIVITIES

The "No Change" alternative, as described in Section 5.1, constitutes the existing Plant operation that creates costs and potential risks while providing associated benefits on national, state, and local levels. This section discusses the impact on cost, benefits, and potential risks of continuing, without change, existing operations at the Rocky Flats Plant.

9.1.1 Costs

Operation of the Rocky Flats Plant involves the direct expenditure of considerable sums of Federal monies. In addition, at the local level, there are external or indirect social and economic costs borne by the communities and residents of the surrounding area.

TABLE 9-1

BENEFITS FROM ALTERNATIVES

Alternative	Employment Direct	Employment Induced	Total Disposable Income to Denver Area ($ million)	Other Local Expenditures from Operations† ($ million)	Short-Term Income to Region from Action ($ million)
1. No Change in Current Activities	2800	6500	100	14.8	NA*
2. Completion of Changes Currently Underway					
a. Plutonium recovery facility	3100**	7200	110	14.8	95
b. Waste treatment facility	3100**	7200	110	14.8	(included in plutonium recovery facility)
c. Water recycle	3100**	7200	110	14.8	3.1
d. Partial removal of on-site plutonium-contaminated soil	2800	6500	100	14.8	0.15
e. Wind energy test facility	2800	6500	100	14.8	
3. Relocation					
a. Complete relocation	0	0	0	0	405
b. Partial relocation	1036	2404	40	6.8	275
4. Termination of Operations					
a. Standby	1400	3220	50	3.4	17.8
b. Complete shutdown, total decommissioning, and partial decontamination	0	0	0	0	332
c. Complete shutdown, total decommissioning, complete decontamination, total demolition, and site restoration	0	0	0	0	526
5. Other Potential Alternatives					
a. Actions regarding plutonium-contaminated soil					
(1) Removal of all exposed soil above State guideline	2850	6555	121	14.8	1800
(2) Soil removal of all soil above 500 d/m/g and plowing remaining soil above State guidelines	2850	6555	121	14.8	12.27
(3) Removal of all soil above 500 d/m/g and no plowing	2850	6555	121	14.8	12
(4) Soil containment (plowing) of all land above State guideline	2800	6500	100	14.8	0.275
(5) Removal of buried waste	2800	6500	100	14.8	26
b. Structural integrity of buildings	2800	6500	100	14.8	0
c. Additional land acqusition	2800	6500	100	14.8	42
d. Termination of plutonium air shipments	2800	6500	100	14.8	negligible
e. Surface water control	2800	6500	100	14.8	2.5

* Not applicable
** Includes 300 construction workers
† Excludes expenditures related to implementation of the alternative actions.

The cost of operating the Rocky Flats Plant is nearly $70 million yearly, including the payroll and direct expenditures for goods, services, and utilities. Additional expenditures are made periodically for new and replacement facilities required to provide safe and efficient operations. Several of the additions currently constructed or planned are discussed in Chapter 5.

Plant operation does affect nearby communities. Most of these effects are associated with such requirements as housing, schools, and municipal services for employees and their families. The population contribution of Rocky Flats employees and their families to the Denver area is approximately 7,900. This population is widely distributed, however, throughout various population centers in the area, and no significant impacts are placed on any one population center. In addition, the population in the metropolitan area has been growing rapidly in recent years. Continued operation of the Plant will not impose any significant, new requirements for area schools, housing, or municipal services since adjustments have already occurred to accommodate families of Rocky Flats employees. Over the life of the Plant, the number of employees has varied. The Plant employed approximately 2,800 full-time employees during 1977 and 300 construction workers. Peak employment occurred in 1972 at 3,750 employees, and the decline in recent years has further mitigated community demands attributable to Plant employees and their families.

9.1.2 Benefits

The primary benefits associated with existing Plant operation are of a national defense, technological, social, and economic nature. On a national level, the principal benefit is Rocky Flats' contribution to national defense. Portions of the Plant, particularly those involved in fabricating plutonium parts for nuclear weapons, contain very specilized capabilities. The scientific capabilities and the knowledge gained through pursuit of the Plant's mission are shared with others, thus enhancing the technology of this nation and much of the world. The only restriction on sharing information is that dissemination not be detrimental to this country's national interest. Scientific information, technical knowledge, and advice are provided to individuals, businesses, and governmental organizations throughout the United States and the world on a variety of subjects. Among these subjects are chemistry, metallurgy, machining, nondestructive testing, safety, fire prevention, and health physics. This information and knowledge relate to such programs as plutonium recycling, radioactive waste management, nuclear materials safeguards, laser fusion, and wind energy.

The wind energy test facility or Small Wind Energy Conversion Systems (SWECS) project, is aimed at evaluating the operational characteristics of low power (one to one hundred kilowatts), commercially available, wind turbine generators. The goal is to promote wind power for agricultural and rural use. The information collected and the program conclusions will be disseminated among potential rural residential and agricultural users and to manufacturers of small wind-generating systems. It is difficult to place a monetary value on the scientific achievements and knowledge attributable to the Rocky Flats Plant.

Local benefits include direct employment of operating personnel and construction workers, induced employment to serve the needs of employees and their families, economic effects of increased disposable income in the region, and direct expenditures for goods and services necessary for Plant operations. Additional benefits are derived from employee participation in community activities such as government, education, charitable programs, youth programs, church, and community-improvement organizations.

Another benefit on the local level is the $80,000 provided to the Colorado Department of Health for the purchase of laboratory analytical and environmental monitoring equipment. An additional $50,000 a year for three years will also go to the Colorado Department of Health as support for their monitoring program.

As discussed in Chapter 3, Rocky Flats directly employed approximately 2,800 people during 1977, which in turn induced an estimated 6,500 more jobs in surrounding communities. This induced employment develops mainly in service-oriented occupations such as retail goods and services, professional services, transportation, and recreational activities. Since the Rocky Flats Plant is one of the largest industrial employers in the Denver area, it has been and will continue to be important to the continued economic, social, and cultural growth of the area.

The Plant generates an annual payroll in excess of $40 million, which, after taxes and deductions, is spent throughout the region by employees and their families. This disposable income, as described in Section 3.4.3, amounts to over $30 million annually for those directly employed at the Rocky Flats Plant plus an additional $70 million for induced employment in the area. When compared with the disposable income of $5.8 billion for the Denver metropolitan area, the $100 million disposable income associated with the operation of Rocky Flats is about 2% of the total.

Plant employees also pay approximately $2 million annually in property taxes and $600,000 in state and local sales taxes. In addition, the Federal government pays the local school districts an estimated $800,000 annually as Federal impact funds. Other input into the area economy involves Plant operations that require spending $28 million each year for the purchase of materials and services plus $5 million for utilities and other costs. Approximately 29% of the purchases for materials and services are within Colorado, primarily in the Denver area. All utilities, including electricity, water, and fuels are purchased locally. Therefore a total of $13.7 million are contributed locally for materials, services, utilities and Federal impact funds.

9.1.3 Risks

The total impact on persons living within 50 miles of the Rocky Flats Plant is the sum of impacts from emissions from routine, normal operations (Table 3.1.2-3) and from risk of emissions from on-site accidents (Table 3.2.4-1). There is also an impact on persons who live on soil contaminated by past releases (Table 3.2.4-9). This impact is limited to the area immediately east of the Plant (see Figure 2.3.9-1). If the Plant were to continue existing operations, with no changes, over a 70-year period, the sum of the 70-year dose and the 70-year risk dose would be 1/5700 or less of background dose for the total body, 1/78 or less for the liver, 1/39 or less for the bone and 1/170 or less for the lungs (Table 3.1.2-6).

For persons downwind from the Plant during the occurrence of an accidental release, the impact may be somewhat greater than for routine, chronic releases. The impacts of postulated maximum credible accidents are summarized in Table 3.2.4-2 in terms of the 70-year dose commitment as a function of downwind distance and in Table 3.2.4-7 in terms of the risk of cancer mortality and genetic defects over 70 years to the maximum individual. For a release from an aircraft impact, the maximum of the postulated maximum credible accidents, the 70-year bone dose commitment is 58 times the 70-year background bone dose for the maximum individual, a value which decreases to one-half the background dose for a person 40 miles downwind. The corresponding values for other organs are less than these values for the bone. If no protective actions are taken following the accident, the risk of cancer mortality plus genetic defects over 70 years for the maximum individual is about 1/3 of the risk of death from common accidents over 70 years (Table 3.2.4-8) and about 1/300 of common accident risk for a person 40 miles downwind. The impact of the other types of postulated maximum credible accidents is even less than that summarized here for the aircraft impact, an accident which might occur about once in 7.7 million years.

9.2 COMPLETION OF CHANGES CURRENTLY UNDERWAY

Several changes to existing Plant systems and operations are currently being implemented. These include (1) the construction of a new facility for plutonium recovery, (2) construction of a new facility for treating liquid process waste, (3) total recycle of the Plant's water, and (4) partial removal of on-site, plutonium-contaminated soil. Frequently the plutonium recovery and waste treatment facilities are considered as a single project. In the following sections, each of the four plans is discussed in terms of its impact on costs, benefits, and potential risks.

9.2.1 Impact on Costs

Considering the new plutonium recovery facility and the new waste treatment facility as one undertaking, costs of the projects are as follows:

(1) and (2) - New plutonium recovery and waste treatment facilities - $190 million.
(3) Water recycling - $3.1 million.
(4) Removal of about 43,000 sq ft of on-site, plutonium-contaminated soil - $470,000.

These funds will be expended over a period of several years. The projects are not expected to cause any significant change in the costs to local communities because of Plant employees and their families, or to the Federal funding requirement of about $70 million annually for Plant operation.

9.2.2 Impact on Benefits

The primary, national benefit, which is Rocky Flats' contribution to national defense, will not be altered by any of the projects. Local benefits of increased expenditures and of increases in direct and induced employment will be affected, however. New construction resulting from these improvements requires more labor, increased payroll, and additional induced employment and revenues above that for normal Plant operations. Since 1971, contractors have employed an average of 300 construction workers on site for various projects, and these workers are considered full-time residents of the area. Direct after-tax revenues to the area from this construction-related employment is approximately $3.2 million. Induced employment provides about 690 jobs and $7.5 million in revenues to the area. For the new plutonium recovery and waste treatment project, millions of additional dollars are spent, much of this locally, for special plutonium processing equipment.

In general, these Plant projects will have little impact on local expenditures for utilities and supplies. The new facilities should be somewhat more efficient; thus, some savings may be realized. The total water-recycle system, for example, although using more energy than current water-treatment operations, will reduce water consumption by an average of over 6 million gallons per month. While this savings in consumption means a benefit of more water being available to the region, it also means a reduction in local revenues of approximately $30,000 annually, based on the present cost of purchasing water for Plant use. This amount will be partially offset by the cost of energy required to recycle the water.

9.2.3 Impact on Risks

Of the projects currently underway, three will result either in a reduction in the dose resulting from normal Plant operation, or in a reduction in the accident risk to the population.

The new plutonium recovery facility is not expected to change either the amount of emissions from routine operations or accident probabilities. As a result, there is no change in organ doses or risk of accidents.

The process waste treatment facility, being built in conjunction with the plutonium recovery facility, reduces the risk of accidental waterborne release by impoundment failure of solar evaporation ponds. The probability of these releases is expected to drop to near zero. Only that portion of the population drinking water supplied by Great Western Reservoir will be affected. Lung risk dose will show little change. Risk doses for total body, liver, and bone will decrease to 74%, 46%, and 47% of the current risk doses, respectively (Table 3.2.4-1).

Total recycle of the Plant's water will be accomplished primarily by construction of the process waste treatment facility, discussed above, and the sanitary-water recycle project. The latter will provide facilities for the total recycle of all sanitary effluent and cooling tower blowdown water. The impact of this change to Great Western Reservoir cannot be exactly predicted because of the additional impact on surface runoff. The organ doses from normal operation following implementation could vary from no decrease to a value of 16% of that received by the population at the present (see Table 5-1).

Removal of the on-site contaminated soil that is presently underway will result in a reduction in organ dose of 7% or less.

9.3 RELOCATION

The complete relocation alternative, as postulated in Section 5.3.1, includes transferring all operations from the existing Rocky Flats Plant location to a new site or sites, total demolition and decontamination of all on-site facilities and contaminated land areas, and restoration of the site to near natural conditions by deep-plowing and revegetation.

The partial relocation alternative proposed in Section 5.3.2 includes transferring to another site all operations that involve processing and handling radioactive materials and the decontamination of the Rocky Flats Plant and site. Only those functions for processing nonradioactive materials would remain at the Plant.

9.3.1 Impact on Costs

Total escalated cost of the complete relocation alternative would be approximately $2.2 billion by 1988, the assumed date for completing the project. This cost would have to come from Federal monies, with about $405 million incurred at the existing site and the remaining $1.8 billion incurred for new facilities at a new site or sites. When relocation actions are complete, local community costs for Rocky Flats employees and their families would be eliminated. Payroll and other operating costs amounting to $70 million per year for Rocky Flats would be transferred to the new site or sites. Costs for the partial relocation alternative include the expenditure of approximately $275 million for existing site decontamination and $1.7 billion for new facilities at the new site for a total escalated cost of about $2 billion dollars. Additional costs would be incurred because of both facilities operating simultaneously during transition of the operation.

9.3.2 Impact on Benefits

National benefits would not be altered by complete relocation of Plant operations, as national defense functions currently performed at Rocky Flats would continue at the new site. At the local level, however, complete relocation of all Plant operations would eliminate all social and economic benefits currently attributable to the Plant. This includes the direct employment of approximately 2,800 people, induced employment of approximately 6,500 people, and direct and induced annual disposable income of approximately $100 million. A large portion of the direct and induced annual tax revenue of $33 million would be lost at the local level as would the spending locally of approximately $5 million per year for utilities and services. In addition, the purchase of supplies and materials at a cost of about $28 million ($9 million locally) would cease. The increased local availability of these utilities, services, and materials because of decreased consumption would provide some benefit to the local area.

Relocation of only those Plant activities involving radioactivity would reduce the direct Plant employment to approximately 1,000 and the induced employment to 2,400. The direct and induced annual disposable income due to the Plant would be reduced to $40 million and local expenditures for supplies and utilities would be reduced to $6.8 million.

Short-term benefits of relocation for the local area would result from the expenditure of approximately $405 million for complete relocation, Plant demolition, and site restoration or $275 million for partial relocation. The expenditure for either alternative would occur over a period of approximately 10 to 12 years; thus, the impact on local benefits would also be spread over this period. The expenditure would increase local socioeconomic benefits; however, the total escalated costs of complete or partial relocation would not cause a proportional increase in benefits because of the effects of inflation and other non-beneficial factors. Benefits to the national defense would not be altered by partial relocation, nor would there be a change in knowledge gained from Plant operations; however, some transfer of manpower resources to another area would occur. Annual operating expenses would be reduced for the remaining Plant; consequently, social and economic benefits would decrease in proportion to a total direct and induced regional revenue reduction of approximately $70 million. A reduction in the consumption of natural resources would provide some benefit to the area. Overall net benefits would be reduced, however, because of increased transportation requirements and the loss of economies that would occur with decentralized operations. Some economic benefits might be experienced at the new site, but these cannot be evaluated without an assessment of the particular site selected. Short-term benefits for the Denver area would occur from the expenditure of approximately $27 million required to decontaminate the existing Plant site.

9.3.3 Impact on Risks

Complete relocation of the facilities would have little net risk reduction for the environment on a nation-wide basis since the new site also would be subject to potential risks from the operation. The accident risk potential would be eliminated for the Denver area, and a reduction in dose from normal emissions and soil contamination would occur. The organ dose to the persons in the vicinity of the Rocky Flats Plant would be reduced to 5% or less of the dose to any of the organs from present normal operations. This can be put in perspective by noting that normal operational releases give a dose to an individual in the population of about 2% or less of natural organ background for the worst case organ (see Tables 3.1.2-5 and 3.1.2-6). The accident risk dose would be eliminated.

Partial relocation would eliminate all Plant radioactive emissions, postulated Plant accidents, and potential exposure of people in the Plant area to radioactivity above background levels. Dose risk reduction to the population surrounding the Rocky Flats Plant, would be equivalent to the complete relocation alternative described above. The net benefit would be small, however, as some dose would result from operations at the new site, although at a reduced level. The impact of risk described above assumes no risk to the public due to resuspension or accidental releases during decommission, decontamination, or reconstruction at the Plant site. The overall dose savings would probably be slightly less. The risk involved is left to the analysis of a specific detailed proposal to implement any of the alternatives described and cannot be qualified without detailed information on particular sites.

9.4 TERMINATION OF OPERATIONS

Termination of Plant operations is not consistent with current national defense policies since the Rocky Flats Plant contains very specilized capabilities. An analysis of various, postulated modes of termination have been conducted, however, to provide a complete assessment of the Plant and alternatives. As presented in Section 5.4, the termination alternatives consist of (1) Standby; (2) Complete

Shutdown, Total Decommissioning, and Partial Decontamination; and (3) Complete Shutdown, Total Decommissioning, Complete Decontamination, Total Demolition, and Site Restoration.

9.4.1 Impact on Costs

Short-term costs for the various termination modes vary from $17.8 million for the standby mode to $526 million for the complete shutdown and site restoration mode. Annual operating costs of $28 million would still be incurred for the standby mode, while for complete shutdown, all operating costs would be eliminated. In addition, all future costs for Plant modifications would be eliminated by all three termination alternatives. Costs to local communities for employees and their families would be reduced by approximately 50% for the standby mode, while all such costs would be eliminated by complete shutdown. Unemployment costs could be incurred, however, to cope with the reduction in direct and indirect employment. If the standby mode were implemented at Rocky Flats, the number of people potentially without work could be as many as 4,600 (1,600 Plant employees and 3,200 in secondary jobs). Should a total shutdown occur, 9,300 people could be without work (2,800 Plant jobs and 6,500 induced jobs).

9.4.2 Impact on Benefits

In all termination modes, benefits associated with Plant operations would be partially or completely lost. In the standby mode approximately half of the permanent work force would be released, with a resultant after-tax revenue loss of $15 million to the region. Benefits from induced employment and income would also be reduced by approximately 3,220 jobs and $35 million, respectively. Local expenditures for goods and services would be reduced to $900,000 from the current $8.7 million, and utility expenses would drop to approximately $2.5 million. This expenditure over a period of several years, plus the local labor and materials that would be required, would produce some short-term benefits in increased direct and induced revenues for the region.

Complete shutdown, decommissioning, and partial decontamination, as described in Section 5.4.2, would result in total loss of all benefits. Direct and induced employment, totalling approximately 9,300 jobs and a disposable income of $100 million annually, would cease. Regional expenditures of $13.7 million annually for goods, services, utilities, and Federal impact payments would also cease. Total decommissioning of the Plant, and decontamination of certain site areas followed by deep-plowing and revegetation, would require the expenditure of approximately $332 million over a period of several years. This would provide some short-term economic benefit, as would the cessation of the consumption of all natural resources by the Plant.

Complete shutdown and decommissioning, followed by complete decontamination, total demolition of all Plant structures, and restoration of the site to near natural conditions also would eliminate all long-term benefits to the same extent as the complete shutdown, partial decontamination alternative just described. Short-term benefits would result from the expenditure of $526 million required to accomplish the shutdown and site restoration work. Benefits from the elimination of Plant consumption of natural resources would also apply.

9.4.3 Impact on Risks

Each of the termination alternatives would reduce potential exposure risk for the population surrounding the Plant. The standby mode would reduce emissions from buildings and reduce risks of accidents. It would not, however, affect existing plutonium concentrations in soil and plutonium and alpha activity emitted annually to the air from this source. In terms of chronic dose, the standby mode would result in organ doses of 94% to 99% of the present level. Some accident risk dose would be expected.

Complete shutdown, decommissioning, and partial decontamination would result in a cessation of all Plant emissions and the elimination of postulated accidents and most on-site soil contamination. These actions would also result in a reduction of the organ dose for all portions of the population surrounding the Plant to 5% or less of the dose received from normal operations. Reduced risks from decommissioning, complete decontamination, demolition, and site restoration would be equivalent to that achieved by complete shutdown, decommissioning, and partial decontamination.

9.5 OTHER ALTERNATIVES

Other possible alternatives exist that would influence Plant operations and Plant impact on the environment. Among these alternatives are several that already have been considered to varying extents. These are (1) actions regarding plutonium-contaminated soil, (2) improvements to the structural integrity of Plant buildings, (3) enlargement of the buffer zone surrounding the Plant, and (4) construction of reservoirs to collect and hold any surface runoff that may be considered hazardous to the environment.

9.5.1 Impact on Costs

With respect to possible actions concerning plutonium in soil, several alternatives exist. These include (Section 5.5.1):

(1) Removal of all soil containing plutonium in excess of 2 d/m/g, including on-site and off-site lands, the asphalt pad and the soil under it, and the sediments in the ponds - $1,500 million.

(2) Removal of all soil containing plutonium in excess of 500 d/m/g, including the asphalt pad and the soil under it, and the sediments in the ponds, and deep-plowing and restoring all lands, on site and off site, containing plutonium in excess of 2 d/m/g - $72.4 million.

(3) Removal of all soil containing plutonium in excess of 500 d/m/g, including the asphalt pad and the soil under it, and the sediments in the ponds, but no action for lands containing plutonium in concentrations less than 500 d/m/g - $72.3 million.

(4) Deep plowing and restoration of all exposed land containing plutonium in excess of 2 d/m/g - $0.12 million.

An analysis of the structural adequacy of Plant buildings is in progress but has not yet been completed; therefore, a cost analysis cannot be made at this time.

By January 1975, the original Plant boundary was extended to increase the buffer zone around the Plant by about 4,000 acres. Further increase to the size of the buffer zone by purchasing additional land containing plutonium levels above the State guideline of 2 d/m/g would involve about 1,000 acres based upon recent measurements. The cost for that acreage would be about $5 million.

The surface-water control project was begun in the first quarter of FY 1978 and is to be completed in the third quarter of FY 1979. It has an estimated cost of $2.8 million. The system would consist of earthen impoundment dams and canals to collect all surface runoff water originating in or flowing through the area where all Plant buildings are located.

9.5.2 Impact on Benefits

Removal of all soil containing plutonium in excess of 2 d/m/g requires expenditures comparable to those of relocating the Plant. The latter cost included deep-plowing large areas, rather than soil removal, a more costly technique. Removal of 500 d/m/g soil, combined with deep-plowing above 2 d/m/g can be accomplished at 4% of the cost of total soil removal, with a reduction of 1/2 of the comparable lung dose. The incremental cost (less than 1% of the cost of removal of 500 d/m/g soil) provides approximately equal reductions in lung dose. Some economic benefits will result from local expenditures for labor and material associated with soil removal and deep-plowing. Deep-plowing all soil above 2 d/m/g is the more cost effective approach. This alternative, as presented, does not include restoration of the pad area and the pond sediments, for which no dose reductions are achieved.

The proposed reservoirs for surface water would involve spending approximately $2.8 million over a two-year period. Most of this would be for labor and materials from local sources. Benefits from the employment and expenditures would be attributable to this alternative.

9.5.3 Impact on Risks

Reduced risks from decontaminating soil in the Rocky Flats area to either 500 d/m/g or 2 d/m/g, as discussed previously, would involve the removal or covering of soil which is contributing airborne plutonium. This would mean a reduction in the organ dose to between 13% and 87% of the organ dose received by various segments of the surrounding population under normal operating conditions. Subsurface soil containing radioactive material because of on-site burials do not result in any exposure to the public. It is recognized that plutonium contamination is long-lived, and decontamination could prevent dispersal of plutonium over a long period. All evidence to date indicates no translocation has occurred and no health or safety hazard to the employees of Rocky Flats or to the public exists from these burial areas.

With regards to the structural adequacy of Plant buildings, an analysis currently being conducted will establish actual structural capability for the Plant buildings. This material will be presented in the Safety Analysis Reports.

If all land suspected of having radioactivity above the State guideline were purchased, and if the development of that land were prohibited, a reduction in the dose to the hypothetical people in the area above this concentration would be calculated (Table 3.2.4-9). In reality, no residences exist on land containing plutonium concentrations above the State guideline, and construction and landscaping on the land would be expected to reduce existing plutonium concentrations to background levels.

The proposed surface-water control project, to cost approximately $2.8 million, would collect and store all storm surface-water runoff or accidentally released water within the security-fenced area of the Plant. The water collected then could be analyzed before being released downstream. The project would reduce the risk of radioactive and nonradioactive contaminants being redistributed as the result of a heavy storm. This undertaking would also serve to reduce the threat of excessive erosion of downstream channels and of Great Western Reservoir and Standley Lake flooding should the 100-year, maximum-postulated storm occur. The probability of accidental waterborne releases (e.g., impoundment failure) goes to nearly zero in this case. The organ risk dose for persons drinking water supplied from Great Western Reservoir would be 46% to 74% of the present level except for the lung risk dose which would be 99% of the present level. Doses from normal operational release, however, would not change.

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