RFA 4.12

SUMMARY OF FINDINGS

HISTORICAL PUBLIC EXPOSURES STUDIES ON ROCKY FLATS

August 1999

Colorado Department
of Public Health
and Environment

HISTORICAL PUBLIC EXPOSURES STUDIES ON ROCKY FLATS

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Colorado Department of Public Health and Environment

PROJECT Overview

The Rocky Flats Historical Public Exposures Studies involved nine years of research including identification and assessment of past releases of radioactive materials and chemicals from the former Rocky Flats Nuclear Weapons Plant, located northwest of Denver, Colorado. The studies focused on estimating increased cancer risk to residents living or working in surrounding communities during the plant's operation from 1952 to 1989. The studies addressed only past releases that were carried off-site and led to exposure of the public and did not include possible releases after production ceased in 1989. On-site releases, worker exposure and worker health effects are addressed in other studies.

The Colorado Department of Public Health and Environment administered the Historical Public Exposures Studies. Oversight was provided by a 12-member Health Advisory Panel appointed in 1990 by former Governor Roy Romer.

This independent panel made up of scientists, physicians, health officials, local officials and members of the public was charged with overseeing research that focused on past emissions from Rocky Flats.

The studies were divided into two phases. Phase I of the Historical Public Exposures Studies (1990 to 1994) was conducted by the contractor ChemRisk, a division of McLaren/Hart Environmental Engineering. Radiological Assessments Corporation (RAC) conducted Phase II (1992 to 1999). This booklet summarizes the results of both phases.

KEY Findings

People who lived near the plant and led active, outdoor lifestyles had the highest level of exposure to airborne plutonium.

- Plutonium, a radioactive metal, was the contaminant of primary concern released from Rocky Flats.
- The largest amounts of plutonium released from Rocky Flats into nearby communities came from a fire at the plant in 1957 and from a waste oil storage area in the late 1960s.
- Carbon tetrachloride, a solvent used at Rocky Flats for cleaning and degreasing, was the key chemical of concern released from the plant.
- The individual's location, lifestyle and period of exposure were found to have a greater effect on health risks than gender or age.
- Soil sampling conducted by the Citizens' Environmental Sampling Committee, coordinated by the Health Advisory Panel, confirmed previous soil sampling studies, which showed that the highest off-site plutonium concentrations in soils were predominantly east of the plant.
- The greatest off-site exposure to plutonium and carbon tetrachloride resulted from people breathing contaminants released into the air. Exposures by ingesting water, vegetables and meat, and through skin contact were found to be significantly smaller than exposures from breathing plutonium.
- The main risk of inhaled plutonium is cancer of the lung, liver, bone and bone marrow.
- Carbon tetrachloride exposure may cause liver cancer, but this has only been demonstrated at high doses in experimental animal studies.
- People who lived near the plant and led active, outdoor lifestyles (such as laborers or ranchers) had the highest level of exposure to airborne plutonium. Of these lifestyles and locations modeled, a laborer living or working southeast of Leyden near Indiana Street and 64th Ave. had the highest risk of developing cancer. The majority of this exposure was due to plutonium inhaled from a Rocky Flats fire on September 11 and 12, 1957.
- Health risks due to dioxin and beryllium releases from Rocky Flats were considerably less than risks from plutonium or carbon tetrachloride.
- Health risks due to uranium releases from Rocky Flats were less than risks from plutonium releases.
- The accidental release in water of the radioactive chemical tritium (hydrogen-3) from Rocky Flats in 1973 to Great Western Reservoir was the greatest source of drinking water contamination, but presented a small off-site health risk.

WHAT WAS THE Purpose of the studies?

The studies' three main objectives were to:

- Create a public record of plant operations and accidents that contributed to contaminant releases from Rocky Flats between 1952 and 1989.
- Assess public exposures to contaminants and potential health risks from past releases to communities near Rocky Flats.
- Determine the need for future studies of possible health effects.

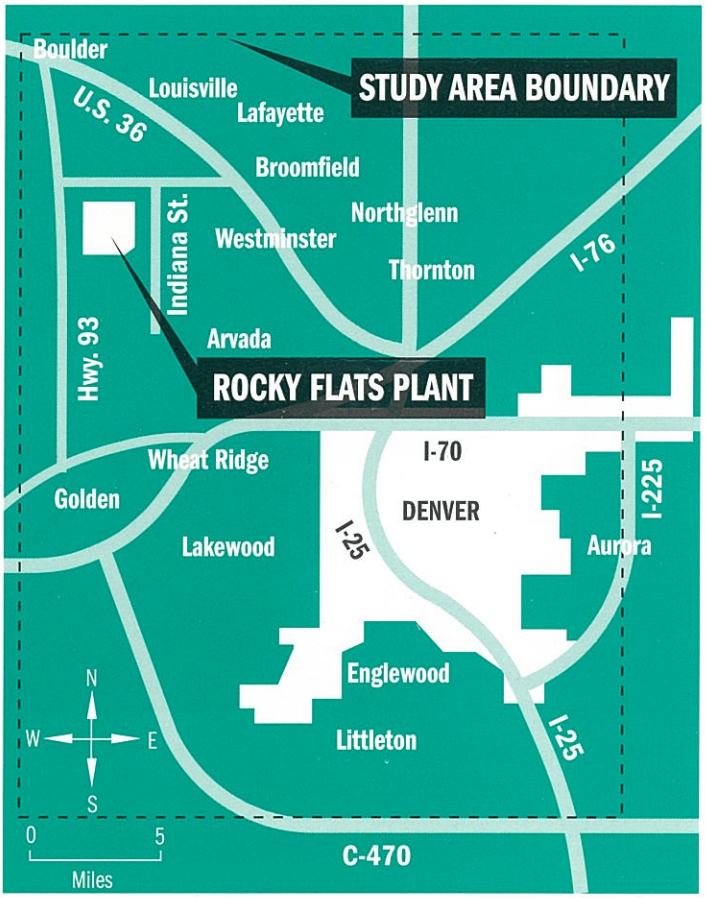
The most important goal of the studies was to inform off-site residents about their possible exposures to materials released from Rocky Flats and the cancer risks from those exposures.

WHAT WERE THE MAJOR Accomplishments of the studies?

The researchers:

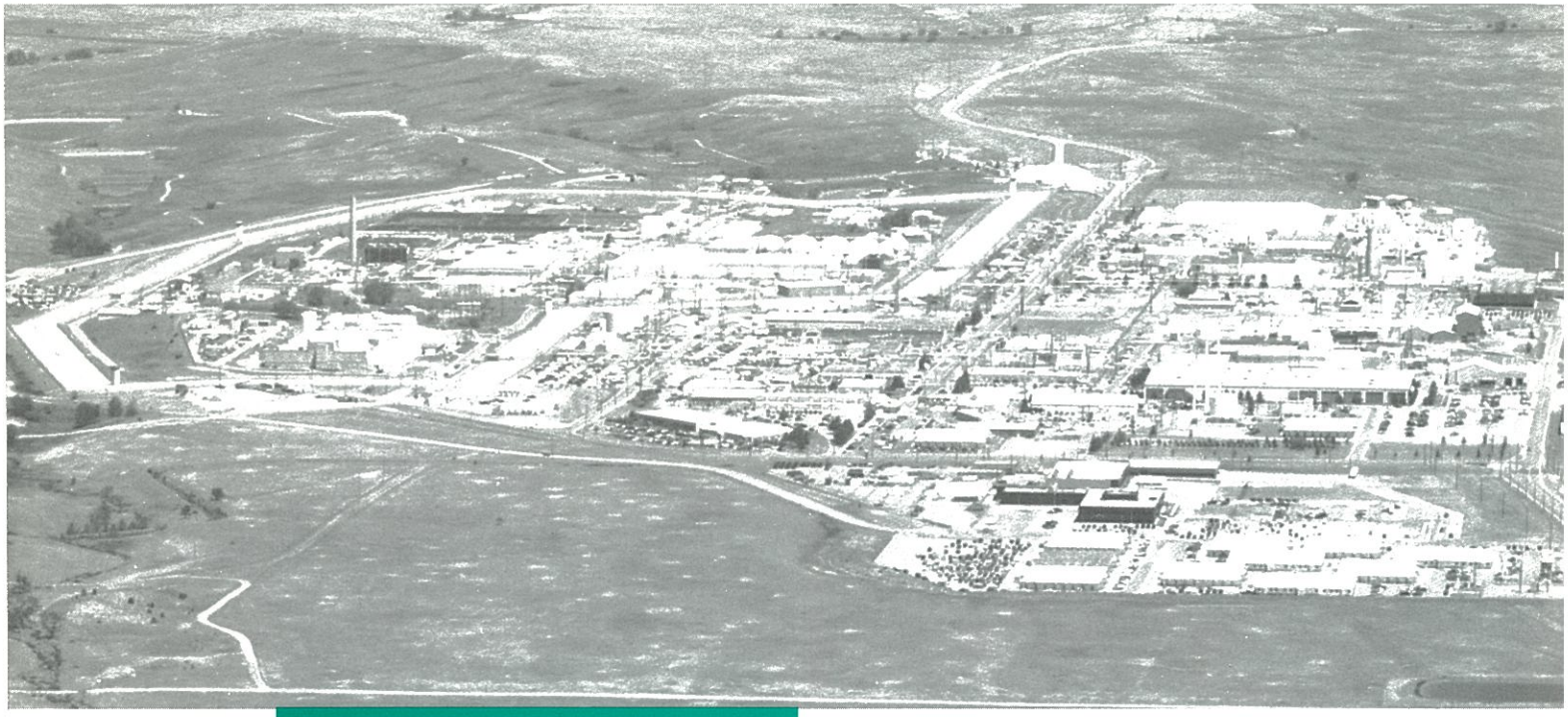
- Developed a comprehensive history of the Rocky Flats Plant including a list of the radioactive materials and chemicals used throughout the plant.
- Determined and researched the main events responsible for contamination released off-site and estimated the amounts released during each event.
- Determined how contaminants moved through the environment and the ways in which people were exposed.
- Estimated the amounts of contaminants to which people living or working near Rocky Flats may have been exposed.
- Estimated the risk of cancer from exposure to releases from the Rocky Flats Plant.

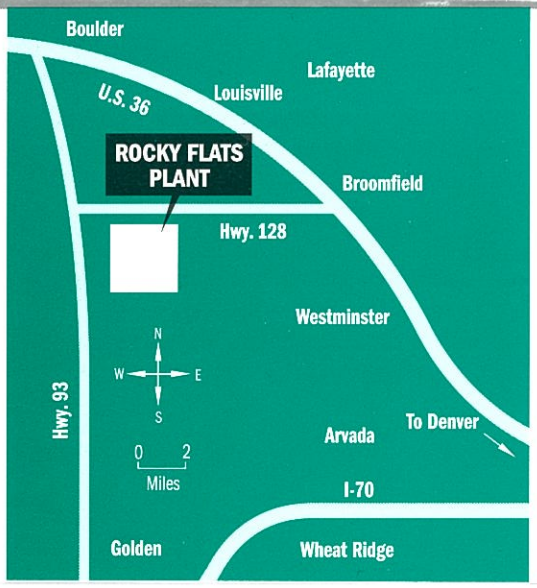
WHAT GEOGRAPHIC Area was studied?



Most of the Denver metropolitan area and the city of Boulder were included in the study area, which encompassed 850 square miles. The study area extended about 17 miles south, 7.5 miles west, 14 miles north and 20 miles east from the Rocky Flats site.

WHAT IS THE History of Rocky Flats?





The Rocky Flats Plant is located 16 miles northwest of downtown Denver in close proximity to Golden, Boulder, Arvada, Westminster and Broomfield. The Rocky Flats site and buffer area around it occupy approximately 11 square miles, and are surrounded by ranchland and encroaching suburbs.

For almost 40 years, nuclear weapons parts were produced at Rocky Flats. The industrial facility used radioactive materials and more than 8,000 chemicals. Rocky Flats stopped weapons production in 1989, and cleanup of contamination at the site began in 1992.

Shown is a 1998 aerial shot of the Rocky Flats Plant.

Workplace accidents, spills, fires, emissions, leaking storage containers and day-to-day operations allowed plutonium and chemicals to be released from the plant site.

The plant produced weapons triggers or "pits" from plutonium buttons, pictured above.

From 1952 to 1989, Rocky Flats workers used plutonium to build nuclear weapons triggers, called "pits." The pits were shipped to Texas to be incorporated into weapons. Plutonium is a man-made radioactive metal that can cause cancer. The metal can spontaneously combust in air, becoming hot enough to ignite nearby materials. The type of plutonium examined in the studies was weapons grade (mainly plutonium-239, -240), which remains in the environment for thousands of years after release.

The plant also used other materials such as uranium and beryllium to make weapons parts. Other chemicals such as carbon tetrachloride, a cleaning solvent, were used in the manufacturing processes.

Precautions were taken to control particulate toxic substances. For example, air was filtered in buildings before it was released to the environment, to reduce the amounts of airborne contaminants. However, minimal effort was made to keep carbon tetrachloride from being released into the atmosphere. Workplace accidents, spills, fires, emissions, leaking storage containers and day-to-day operations allowed plutonium and many chemicals to be released from the plant site.

Why WERE THE HISTORICAL PUBLIC EXPOSURES STUDIES initiated?

Fire Is Reported At Rocky Flats

A fire at the Dow Chemical Co. Rocky Flats plant Sunday released a small amount of radioactive plutonium contamination, a plant spokesman said.

He said the fire broke out in a production building. The cause of the blaze was not known.

Although the plutonium contamination
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man said. h
toring tean
monitoring
tion outside the plant grounds
through the evening.

He explained the plant is a major production facility in the Atomic Energy Commission weapons complex and handles the radioactive plutonium as part of that work.

Rocky Mountain News, May 12, 1969

A 1969 fire at the plant was the first time the public became generally aware of contaminant releases from Rocky Flats. At that time, the fire was considered the most costly industrial accident in United States history.

The FBI and EPA raided Rocky Flats in June 1989 to investigate allegations of environmental crimes.

Federal agents raid Rocky Flats

Illegal storage, disposal of hazardous waste alleged

Early operations at Rocky Flats were cloaked in secrecy to protect national security after World War II. People living nearby were provided little information about the plant or its chemical and radioactive releases.

In 1969, a fire at the plant focused public attention on the potential releases from Rocky Flats for the first time. Independent analyses of soil samples collected near the plant after the fire confirmed that radioactive materials had escaped off-site. As a result, public mistrust and protests over how the plant was managed and operated gained momentum.

On June 6, 1989, agents from the Federal Bureau of Investigation (FBI), the Justice Department and the Environmental Protection Agency (EPA) raided Rocky Flats to investigate allegations of environmental crimes. That same year, Rocky Flats was placed on the EPA's list of Superfund hazardous waste sites slated for cleanup, and the manufacture of plutonium triggers at the plant ceased.

In response to these events, former Colorado Governor Roy Romer signed an Agreement in Principle in 1989 with the Department of Energy to fund state oversight of various Rocky Flats health and environmental studies. The Colorado Department of Public Health and Environment administered the studies.

KEY Questions addressed by the research

Q. What were the most significant contaminants released from the plant?

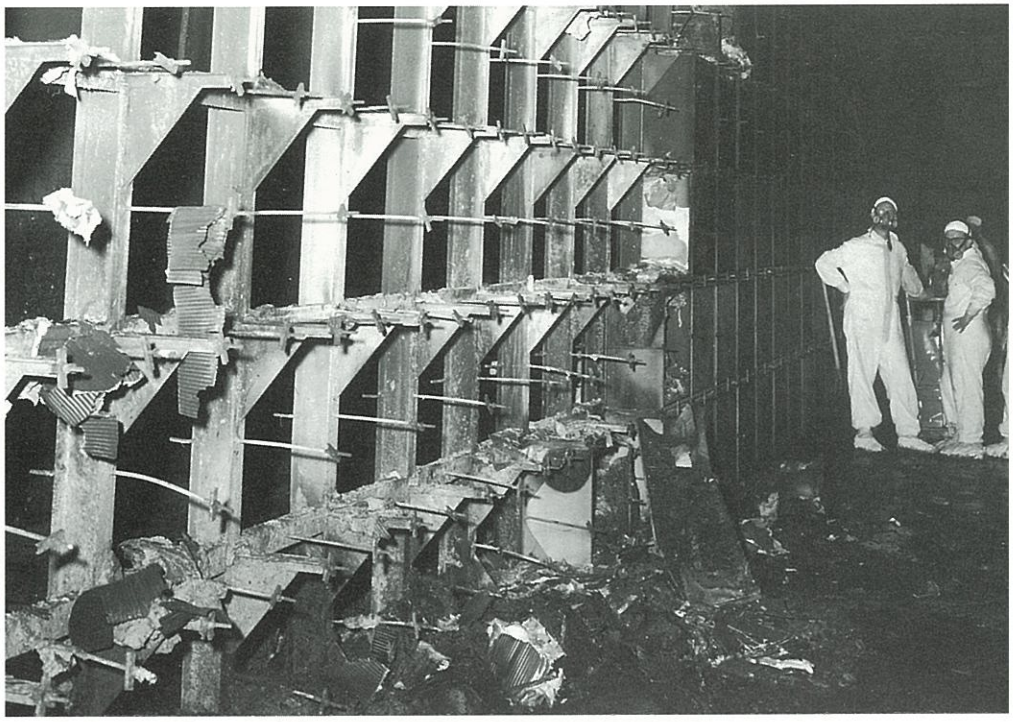
A. Of the more than 8,000 materials used or stored at Rocky Flats, plutonium and carbon tetrachloride were identified as the major contaminants that moved off-site. Radioactive tritium also was released into the creeks on the plant site on several occasions and entered a reservoir downstream. Beryllium, used in weapons production, dioxin, a byproduct from incineration, and uranium also were carefully studied.

Q. When and how were the materials released from the plant?

A. Plutonium was released during routine industrial production from 1953 to 1989. Within the facilities, plutonium operations were conducted in enclosed cabinets, called gloveboxes. The gloveboxes allowed manipulation of the plutonium but kept it separated from the workers. Many minor fires and accidents released plutonium dust inside the gloveboxes. Gloveboxes had filtered ventilation systems that discharged through air exhaust systems or through separate vents. The filtration systems did not collect all the airborne plutonium, and small amounts were released to the environment through building rooftop vents and the tall stack of Building 71. The stack and vents were monitored, and the measured releases reflect the discharges that resulted from routine work.

The researchers identified two major events that caused the largest plutonium releases to areas outside the plant boundaries. These events included a fire that occurred in the plutonium processing building in 1957, and wind-blown releases, mainly during 1968 and 1969, from an outdoor waste oil storage area. A second, larger fire occurred in Building 776 in 1969. Because of multiple effluent filters and the actions of firefighters to maintain building integrity, the release of plutonium to the environment was smaller compared to the two other events. Another major release from Rocky Flats was the chemical carbon tetrachloride. This release occurred over many years.

1957 Fire



The fire burned through air filters in the ventilation system, leaving the metal framework.

A major release of plutonium from Rocky Flats occurred on September 11 and 12, 1957, as a result of spontaneous combustion of plutonium stored inside gloveboxes in Room 180 of Rocky Flats Building 71. Plastic in the gloveboxes caught fire and burned. The fire spread from the gloveboxes through the ventilation system to banks of flammable filters. While the fire in the room was extinguished in less than an hour, the fire in the large main filter bank burned vigorously for three to four hours. Most of the release occurred during this period, although smoldering continued for another nine hours.

The exact amount of plutonium released from the 1957 fire is impossible to determine accurately for several reasons. After 40 years, first-hand information is limited about when the fire started and how it progressed. However, despite such limitations, scientists found new data and information to develop better estimates. Scientists were able to reconstruct a plausible fire scenario and to calculate the amount of plutonium released. They estimated that between 40 and 500 grams (or 2.9 and 36 Ci) of plutonium-239, -240 were released into the air and carried off-site. The median value was 300 grams (or 20 Ci).

903 AREA

Additional major releases occurred at the 903 Area, located directly east of the main buildings at the Rocky Flats Plant. The 903 Area contained about 5,000 30- and 50-gallon steel barrels filled with waste oil and solvents that were contaminated with plutonium and uranium. Acids created in these waste barrels caused extensive corrosion. An estimated 5,000 gallons of plutonium-contaminated waste oil leaked from the corroded drums onto the soil.

The leaking barrels were moved in 1967 and 1968; however, contaminated soil was disturbed during the clean-up effort and left exposed for months. Researchers estimated that between 20 and 200 grams (or 1.4 and 15 Ci) of plutonium-239, -240 had leaked onto the 903 Area soil.

When Rocky Flats staff monitored and mapped the area in July 1968, they found soil contamination covering 261,000 square feet (six acres), with the highest plutonium concentrations in the top inch of soil. Windstorms in late 1968 and early 1969 blew plutonium-contaminated soil particles on- and off-site, affecting a much larger area.

Subsequent soil sampling east of the 903 Area indicated that this wind-blown soil was a major contributor to off-site contamination. The amount of plutonium-239, -240 estimated to have been released to the off-site environment from the 903 Area was between 25 and 200 grams (or 1.8 and 15 Ci), with a median value of 52 grams (or 3.7 Ci).

An asphalt covering (commonly called the 903 Pad) was placed over part of the 903 Area in mid-1969 to control windblown contamination. However, winds continued to transport smaller quantities of plutonium from areas not covered by asphalt. Gravel was later placed in the 903 Area east to the interior fence line to reduce subsequent wind-driven suspension of plutonium-contaminated dust.

Barrels corroded and leaked plutonium-contaminated oil onto soil. Weeds grew through the badly corroded bottoms of these barrels.

1969 Fire

On May 11, 1969, a plutonium fire broke out in the processing section of Building 776, creating what was then considered to be the most costly industrial accident in United States history. As a result of independent measurements of soil contamination after the fire, the public learned about earlier plutonium releases from the 903 Area and the 1957 fire.

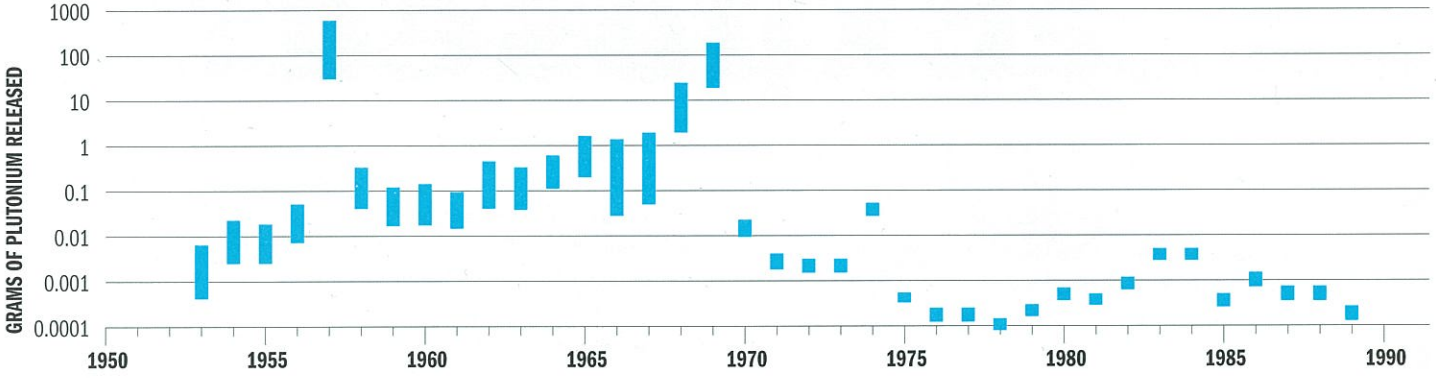
The fire started when plutonium, stored in an open can, began to smolder. The can was one of many located inside a plastic storage chest in the glovebox. The heat from the slowly burning plutonium caused the plastic to catch fire, igniting large quantities of other materials. During the fire, plutonium was discharged from the booster fan system into the environment. It traveled onto the roof and into the air. It was estimated that between 0.14 and 0.9 gram (or 10 and 60 mCi) of plutonium-239, -240 was released and carried off-site. The median value was 0.3 gram (or 20 mCi).

Shown are remains of gloveboxes that burned during the May 11, 1969 fire.

Carbon Tetrachloride

Carbon tetrachloride, a commonly used cleaning solvent, was another major contaminant released off-site through routine, day-to-day operations. Carbon tetrachloride releases were found to be the most significant of the plant's chemical releases in terms of potential off-site impact to humans. It is estimated that 1,100 to 5,400 tons were released from the plant between 1953 and 1989. Carbon tetrachloride was released to surface water, but likely evaporated before it reached public water supplies.

RELEASES OF PLUTONIUM TO THE ATMOSPHERE



OTHER Releases

Plutonium Routine Releases

Many smaller fires and other incidents on-site also were examined. Researchers concluded that releases of plutonium from these events and consequent off-site exposure to the public were considerably less than those from the three major release events. Releases from the smaller fires and incidents are included in results on the amount of plutonium from "routine" releases from the stack and building vents. The total amount of plutonium-239, -240 released from 1953 to 1989 was between 1.2 and 3.4 grams (or 0.086 to 0.24 Ci), with the median value at 1.7 grams (or 0.13 Ci).

Tritium

Tritium, a radioactive chemical, was accidentally released during a weapons recycling operation in 1973. Tritium was released into Walnut Creek, which flowed into Great Western Reservoir, a drinking water source for Broomfield at the time. Researchers concluded that potential adverse health effects were considerably less than those from the three major releases of plutonium or from releases of carbon tetrachloride.

Beryllium

Beryllium is a light, hard, grayish non-radioactive metal used to make nuclear weapons components. Beryllium dust was formed during the machining of beryllium, a process that involves cutting and polishing the metal into shapes for weapons use. The dust particles were released through vents and stacks at the plant. Beryllium is a cancer-causing agent. Researchers studied these releases to the air and determined that the cancer risks were much less than those for exposure to plutonium. Beryllium also can cause a serious illness called chronic beryllium disease in people who become sensitized (i.e., show an allergic response) to beryllium. The studies estimated that off-site beryllium air concentrations were well below acceptable levels established by the EPA.

Uranium

Large quantities of both depleted uranium and highly enriched uranium were processed at Rocky Flats, especially during its first 10 to 20 years of operation. In general, researchers found the releases of uranium were not monitored or controlled as well as plutonium. Depleted uranium was poorly monitored. As a result, relatively large, off-site releases of depleted uranium cannot be excluded.

During the studies, researchers located new information about uranium releases. However, significant gaps remain in their knowledge of depleted uranium releases. Researchers concluded that the overall risks from historical releases of depleted uranium and highly enriched uranium are smaller than the overall risk from plutonium releases. However, more uncertainty surrounds these releases.

HOW WERE PEOPLE Exposed?

Contaminants from Rocky Flats moved off the site through the air and water. The studies determined that breathing radioactive materials or chemicals was the primary way in which people living or working near the plant were exposed to these substances. The lung is the primary organ affected. Because plutonium moves from the lung to the liver and bone, these organs and bone marrow also can be affected. Researchers focused on determining the increased risk of developing cancer in these organs.

WHAT WERE THE POTENTIAL Cancer risks

from exposure to these substances?

Because it is not feasible to determine the risk to each individual, researchers developed "exposure scenarios" representing people who may have lived or worked near the plant and who would have been exposed to releases from Rocky Flats. These "exposure scenarios" considered:

- **Lifestyle (the amount of time the individual spent outdoors working or playing);**
- **When and how long the person lived near the facility during the key release events in 1957 and the late 1960s, or in the 1970s and later when there were fewer releases;**
- **Age and gender of the person; and,**
- **Where the person lived and worked in relationship to the plant.**

Each scenario represents one individual. The scenarios were not designed to include all conceivable lifestyles of residents who lived in this area during the time of the Rocky Flats Plant operations. Rather, the scenarios serve as profiles of people who lived or worked in the area.

EXPOSURE Scenarios

The individuals in the scenarios were organized according to occupational and non-occupational activities. Occupational activities include work, school and activities away from home. Non-occupational activities include time spent at home doing chores inside and outside, sleeping and leisure activities.

The age of the individual and years during which exposure occurred were considered when calculating contaminant exposures and potential health risks. Each exposure scenario was divided into three types of activities: sleeping, non-occupational activity and occupational activity. For each activity, time spent at four different exercise levels was assigned. The exercise levels were resting, sitting (sedentary), light exercise and heavy exercise.

The scenarios are independent of location, which means that a particular scenario can be moved to different locations in the study area. As a result, the effect of location on the individual risk can be assessed. Cancer risks for the following representative individuals were estimated in the project.

Cancer risks for the major releases (the 1957 and 1969 fires, redistribution of plutonium from the 903 Area, releases of carbon tetrachloride) were calculated for each exposure scenario. These risk figures are available in the studies' technical reports. The following information describes the combined or cumulative cancer risk to a laborer living or working off-site from the major Rocky Flats releases included in these studies.

Laborer

Lived and worked outdoors in communities around the site.

Rancher

Spent most of the time outdoors, was physically active and lived in the area near Rocky Flats during its entire operational history.

Office Worker

Lived and worked in a sedentary job in communities near the site.

Housewife

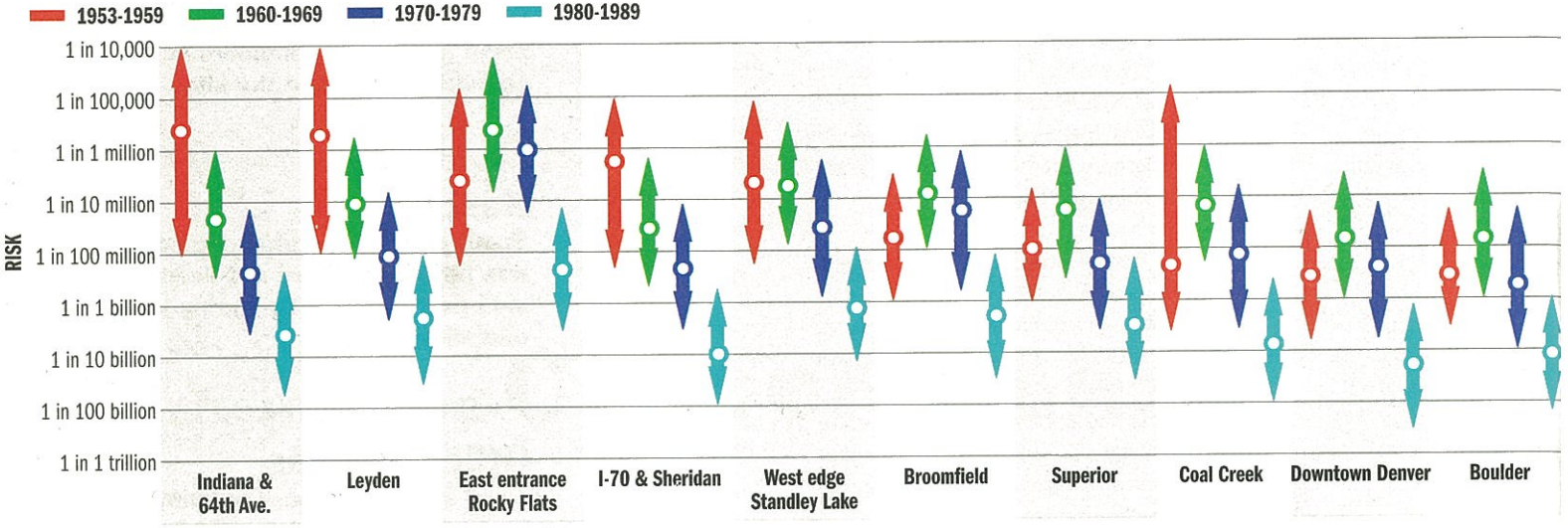
Lived in communities near the plant.

Child

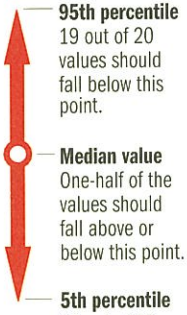
Grew up in communities near the plant.

Risk ESTIMATES

CANCER RISK TO LABORER FROM ALL ROCKY FLATS PLUTONIUM RELEASES



WHAT DO THE RISK MEDIAN VALUE AND RANGE MEAN?



95th percentile
19 out of 20 values should fall below this point.

Median value
One-half of the values should fall above or below this point.

5th percentile
19 out of 20 values should fall above this point.

Highest Risk

Based upon the high-end (95th percentile) estimate for those locations modeled, the laborer living and working southeast of Leyden near Indiana Street and 64th Ave. from 1953 to 1989 had the highest risk of developing cancer from Rocky Flats operations. The laborer's estimated risk of developing cancer was between about 1 in ten thousand and 4 in one hundred million. Researchers are 90 percent confident that the predicted risks fall within this range. This individual's median risk was about 2.5 in one million.

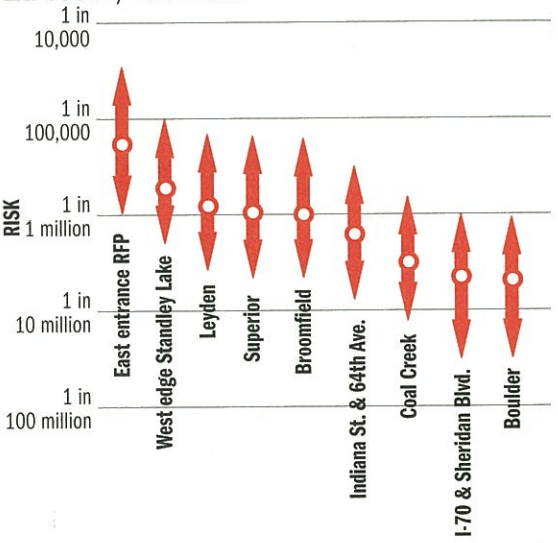
Lower Risk

The laborer working or living in Boulder from 1953 to 1989 had a much lower risk of developing cancer from Rocky Flats releases. The Boulder laborer's risk was between 3 in ten million and 2 in one billion.

Carbon Tetrachloride

The estimated carbon tetrachloride cancer risk for the laborer living and working at the west edge of Standley Lake from 1953 to 1989 was between 1 in one hundred thousand and 6 in ten million. This individual's median risk was about 2.5 in one million.

LABORER CANCER RISK, CARBON TETRACHLORIDE EXPOSURE, 1953-1989



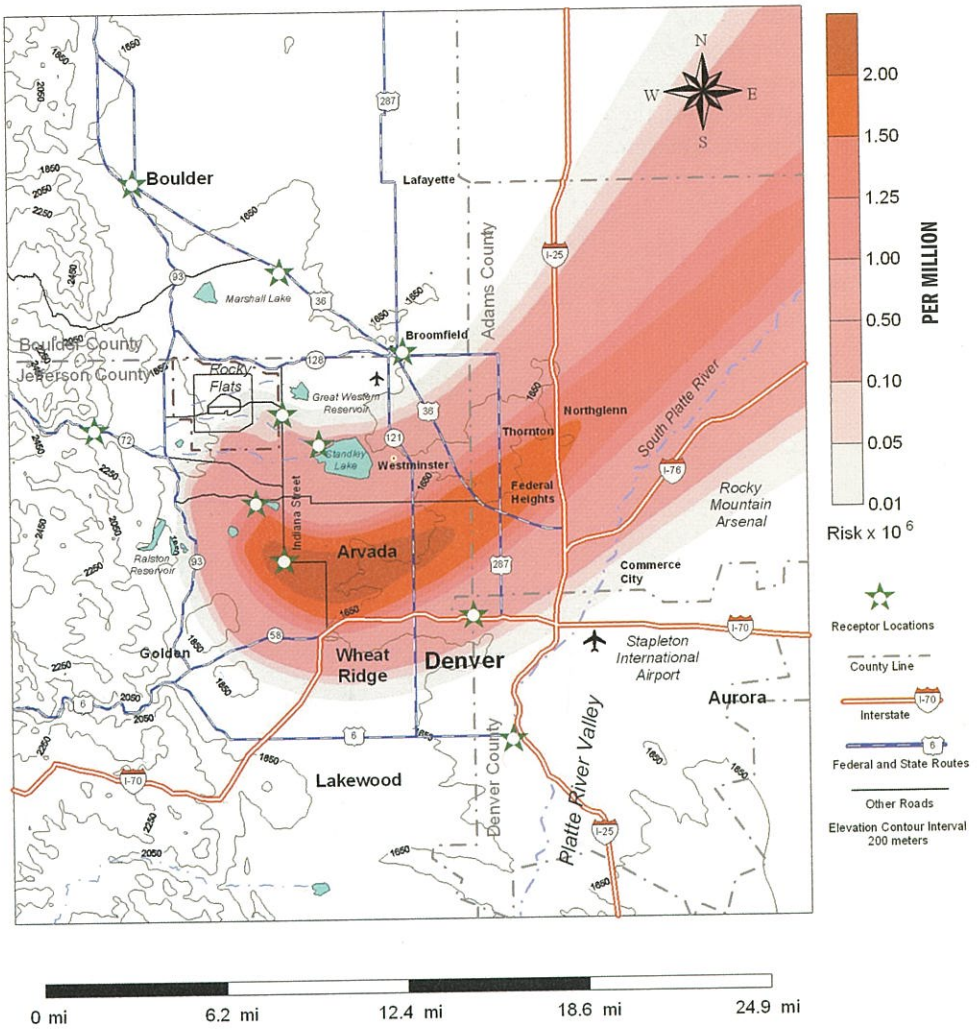
KEY Findings

related to health risks

People who lived near Rocky Flats between 1952 and 1970 were exposed to higher concentrations of plutonium than those people who moved to the area later.

People who were in the path of the airborne releases from the fire on September 11 and 12, 1957 were subject to the highest risks from plutonium associated with all Rocky Flats Plant operations. The adjacent graphic shows the risks estimated to be associated with that single event.

LIFETIME CANCER RISK FOR THE LABORER FROM THE 1957 FIRE

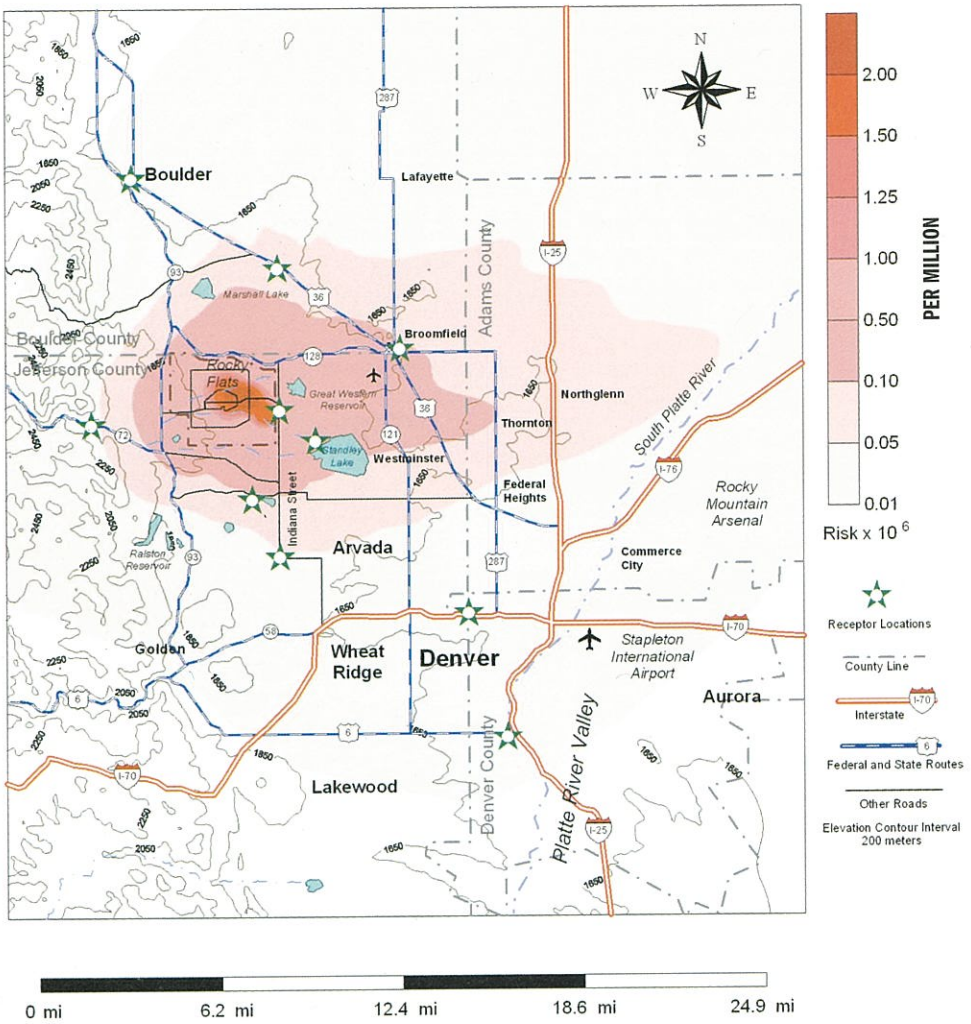


KEY Findings

related to health risks

Other than those individuals exposed the night of the 1957 fire, the highest plutonium exposure and resulting cancer risk were to the east and southeast of the plant. The adjacent graphic shows the risks estimated to be associated with the 903 Area, the 1969 fire and routine releases of plutonium.

LIFETIME CANCER RISK FOR THE LABORER, ALL EVENTS EXCEPT 1957 FIRE

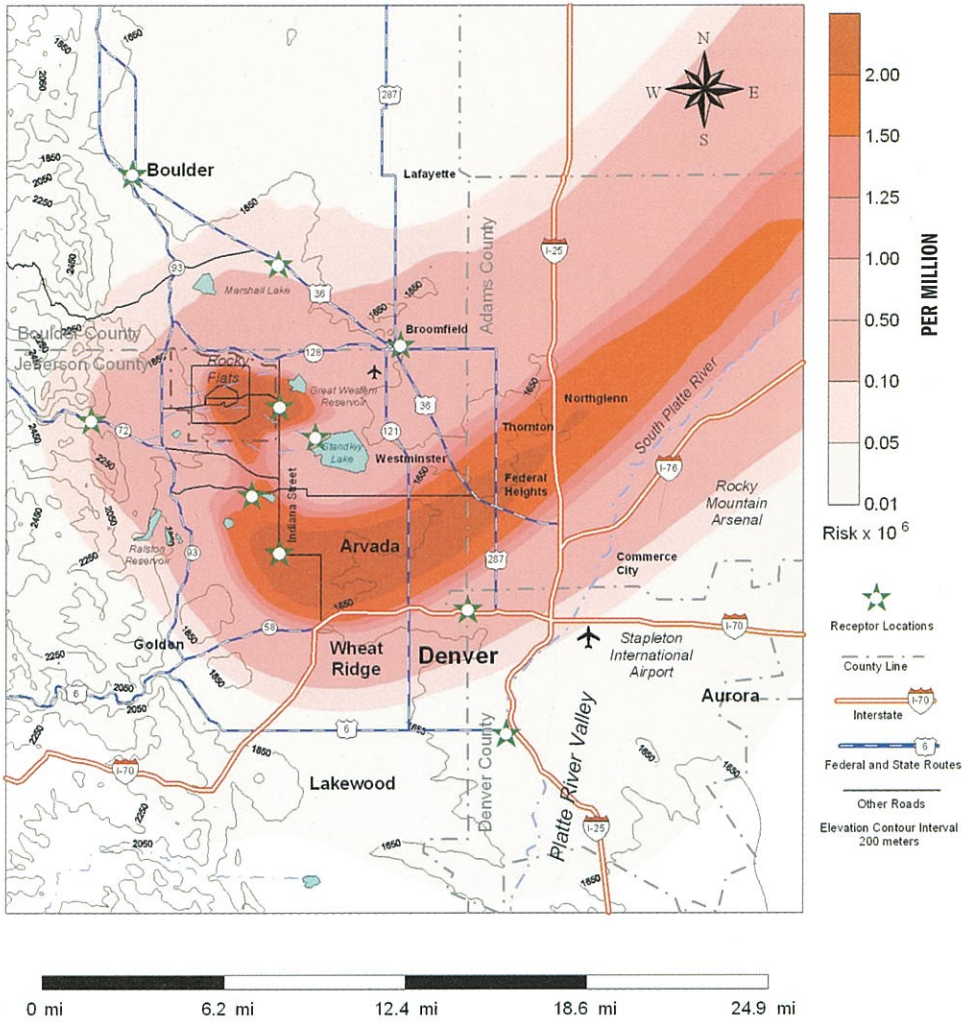


KEY Findings

related to health risks

The adjacent graphic shows the risk of all of the previous releases, assuming laborers were present in the area surrounding Rocky Flats during the entire 1953-1989 operational period of the plant.

LIFETIME CANCER RISK FOR THE LABORER, ALL EVENTS

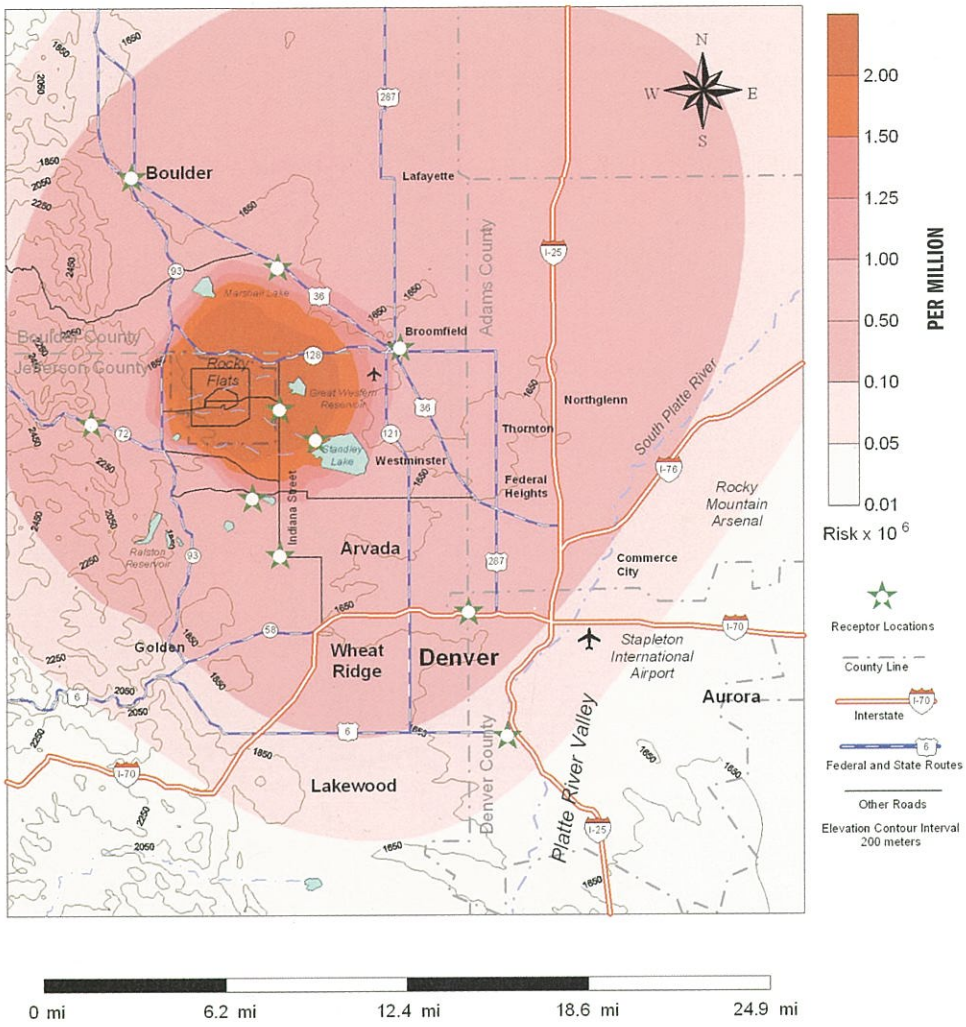


KEY Findings

related to health risks

Large amounts of carbon tetrachloride were released from the plant, and the estimated cancer risk was comparable to that of plutonium. The adjacent graphic shows the effect of carbon tetrachloride releases from 1953 to 1989.

LIFETIME CANCER RISK FOR THE LABORER, CARBON TETRACHLORIDE RELEASES



PUTTING RISK IN Perspective

Risk is defined as the likelihood that negative effects will result from a specific activity. We tend to ignore everyday risks like driving to the grocery store or riding a bike. Risks imposed upon us are less acceptable.

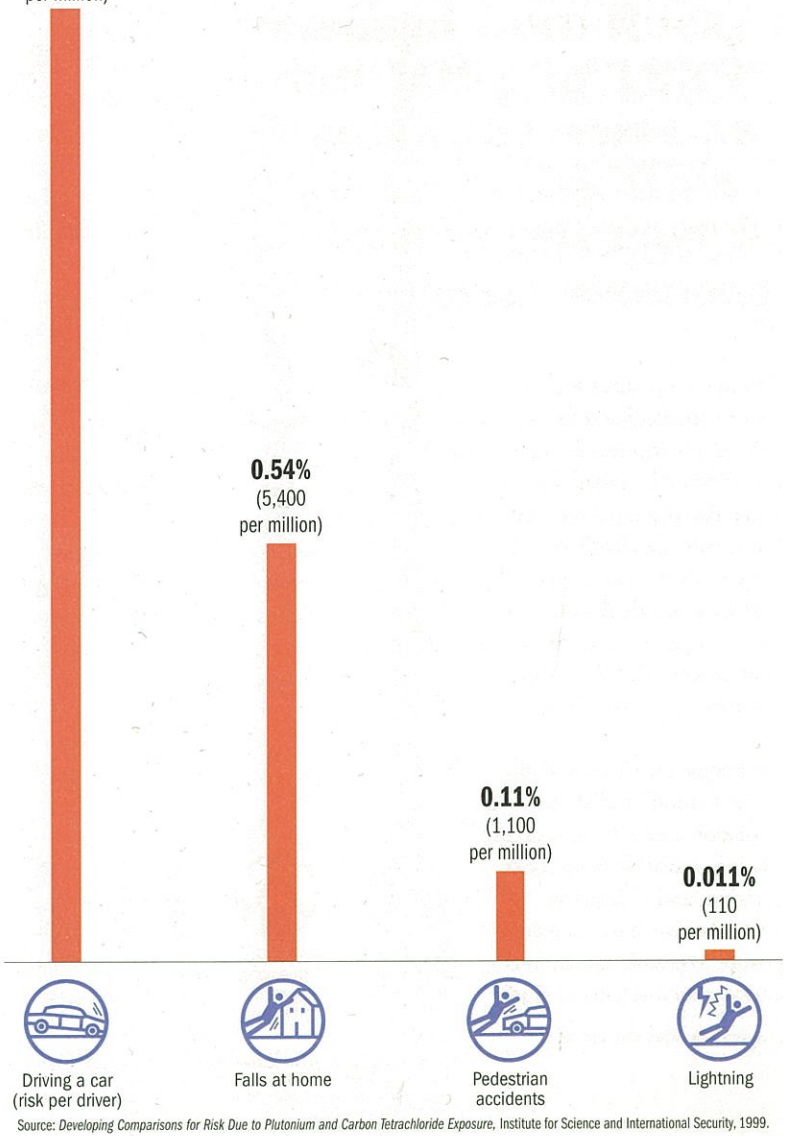
The chart at right lists the risks for several types of accidental deaths in Colorado.

Statistics compiled on the numbers and causes of deaths and risks are calculated from these data. For example, the probability of dying in a car accident is calculated by comparing the number of motor vehicle deaths in a year to the total number of drivers. This number is the annual risk of driving a car. The annual risk can then be multiplied by the estimated duration of the risk, to find the lifetime risk of death.

This same approach is used to evaluate the risk of getting cancer. However, cancer risks are less straightforward for several reasons. First, there can be multiple causes of the same type of cancer that cannot always be sorted out from each other and individually assessed. Second, cancer can appear decades after the initial exposure.

ACCIDENTAL DEATHS IN COLORADO

Lifetime risk of death as percentages, 1997 figures



Source: *Developing Comparisons for Risk Due to Plutonium and Carbon Tetrachloride Exposure*, Institute for Science and International Security, 1999.

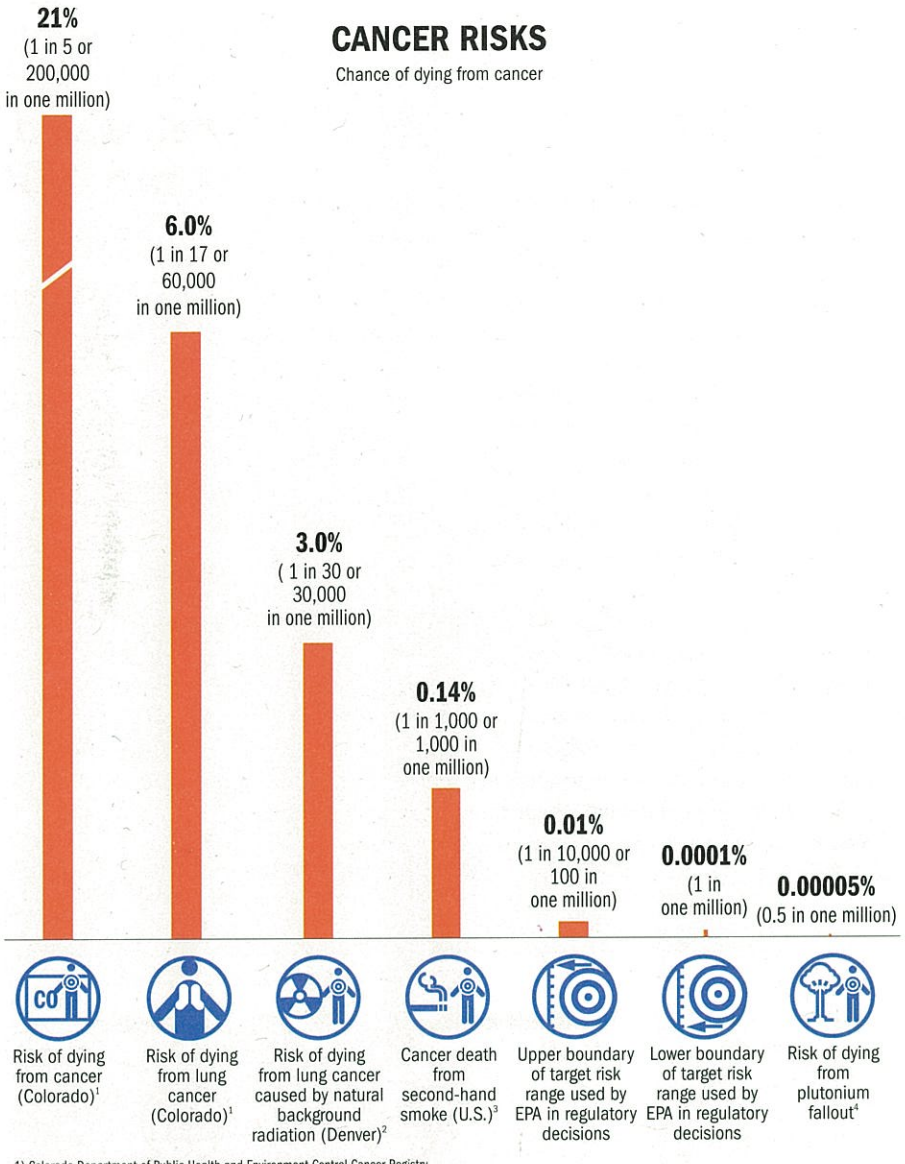
PUTTING RISK IN Perspective

Cancer may be the result of many different causes. The Historical Public Exposures Studies were designed to evaluate the additional risk of developing cancer, above the average cancer rate. The Colorado Central Cancer Registry's statistics indicate that 46 percent of the people in Colorado (about 1 in 2) will develop cancer in their lifetimes.[1] Twenty-one percent of the population (1 in 5) will die from cancer (see the chart at right). The risk to off-site residents of developing cancer from Rocky Flats contaminant releases is small when compared to the cancer risk from all other causes.

For the Historical Public Exposures Studies on Rocky Flats, risks were calculated for developing lung and other cancers. The lung is the primary organ affected by inhaled plutonium. Scientists calculated the risks associated with past releases from Rocky Flats based on the incidence rate or chance of *developing* cancer. Most available data on cancer are presented as mortality rates or the chance of *dying* from cancer. The chart shows various cancer risks that Coloradans face.

One cancer risk that people face is from daily exposure to natural background radiation. This background radiation comes from sources such as cosmic radiation, radiation from rocks and soils including radon, and radioactive materials within our bodies, such as potassium-40. A person's exposure to cosmic radiation is greater at higher altitudes so residents of cities

[1] Rate includes melanoma, but not other skin cancers.



1) Colorado Department of Public Health and Environment Central Cancer Registry.
2) *Developing Comparisons for Risk Due to Plutonium and Carbon Tetrachloride Exposure*, Institute for Science and International Security, 1999.
3) U.S. Environmental Protection Agency, *Respiratory Health Effects of Passive Smoking: Lung Cancer and Disorders*. Report EPA/600/6-90/006F, USEPA Office of Research and Development, 1993.
4) Calculated based on Radiological Assessments Corporation Task 4 Report, Rope et al. 1994 and Plutonium Risk Report, Sinclair, Grogan and Voilleque, 1999.

like Denver receive twice the cosmic radiation compared to people who live at sea level. Due to local geology, Colorado also has higher-than-average levels of indoor radon and radiation from rocks and soils.

Another source of radiation dose comes from man-made materials. This radiation includes exposure primarily from diagnostic x-rays and nuclear medicine procedures. Secondary sources include various consumer products. Of all these sources of background radiation, radon is estimated to contribute the greatest amount, about 55 percent of people's average radiation dose.

One way to look at risks is to divide them into two distinct types: voluntary and involuntary. Voluntary risks are undertaken with knowledge of the possible consequences. Before participating in such activities (flying across the country or scuba diving), people are aware of the chance of injury or death and accept the risk. In contrast, involuntary risks are those that are unwittingly taken or are outside the public's control. Examples of involuntary risk are exposure to air pollution or lightning strikes. Plutonium exposure from Rocky Flats has been an involuntary risk.

The Health Advisory Panel discussed at length the appropriate risks to compare to plutonium exposure from Rocky Flats. Exposure to plutonium from past nuclear weapons testing was determined to be a useful comparison, because it involves exposure to the same type of radiation, and exposure from nuclear weapons testing is an involuntary risk.

The risk to the laborer from plutonium released from Rocky Flats from 1953 to 1989 is about the same as a person's risk from plutonium released from past nuclear weapons testing.

Of all the scenarios modeled, the laborer was selected for comparison because this individual had the highest estimated levels of exposure to Rocky Flats plutonium releases. The overall risk to the laborer from plutonium released from Rocky Flats between 1953 and 1989 is about the same as a person's risk from plutonium released during past nuclear weapons testing.

WHAT ABOUT THE RISKS TO PEOPLE LIVING NEAR ROCKY FLATS Today?

The focus of the Historical Public Exposures Studies has been on past releases and risks, and it is clear from the results that people living in the Denver region during the 1957 fire, or during the late 1960s, were put at higher risk than those who moved into the area in the 1970s. There is still Rocky Flats plutonium in the soil off-site, but movement of the settled and revegetated soil by the wind occurs at a very low rate, even during windstorms.

HOW Certain ARE THE RESULTS?

Because there is no way to be certain how much contamination someone was exposed to, there is a level of uncertainty associated with the studies' results. It is common practice for scientists to provide an estimate of the level of confidence they have in their results. Determining the uncertainties associated with the quantities of materials released and the estimated cancer risks has been an important part of the studies.

Scientists calculated the quantity of contaminants released and the possible cancer risks using many different assumptions. These calculations produced a distribution of possible results. Scientists often describe these distributions using three values: the 5th, 50th and 95th percentiles of the distribution. The median or 50th percentile is the number in the middle of the distribution. Half the estimates are higher than that value, and half are lower. The 5th and 95th percentile values are used to indicate the spread of the estimates. Only 5 percent of the estimates lie below or above those values. Scientists say they have high confidence (90%) that the estimated risk lies between the 5th and 95th percentile values.

The panel has worked to ensure that the methods used to calculate risks associated with uncertainties are comprehensive and reliable. There also has been extensive peer review of the research by internationally recognized experts and members of various public interest groups.

HOW DID Researchers gather information for these studies?

Dose reconstruction is the term used to describe the process of collecting and analyzing the information needed to assess the consequences of past contaminant releases. This research method analyzes the plant's past operations, the contaminants released from the plant into the environment, movement of contaminants in the air, water and soil and likely exposures to people.

In order to estimate how much contamination the public was exposed to, researchers reviewed original records, historical monitoring data, classified reports, meteorological charts from Rocky Flats and similar information from independent sources. Researchers substantiated and verified information by using multiple sources. More than 100 Rocky Flats employees, retirees and others were interviewed about the plant's activities. Computer modeling provided valuable information about where contaminants would travel given different weather patterns.

HOW WAS THE Public INVOLVED IN THE STUDIES?

Throughout both phases of the studies, public input was solicited and incorporated into the research process. Interested citizens were invited to public meetings and technical work sessions over the nine-year study period. Information also was reported through quarterly newsletters, fact sheets and technical topic papers. Panel members gave more than 50 presentations to more than 1,500 citizens in communities near Rocky Flats.

Information also is available through a web site. The staff at the Colorado Department of Public Health and Environment answered questions for many concerned citizens and provided them with reports and information about the studies.

In addition, the Citizens' Environmental Sampling Committee was formed in 1992 to conduct an independent study of plutonium levels found in soil around Rocky Flats. Made up of homeowners, public interest groups, local health departments, interested citizens and Health Advisory Panel members, the committee arranged for sampling and analysis of soil near the plant to measure the amount of plutonium and other radioactive materials present. Some sediment samples from nearby Standley Lake also were analyzed. The results were largely consistent with the concentrations and distribution of radioactive materials found by other soil studies of the area.

WHAT IS THE Value of these studies to the public?

For years, the public lacked information about what went on at the nation's nuclear weapons facilities. The Rocky Flats Historical Public Exposures Studies have provided communities with information about the types and quantities of Rocky Flats contaminants that moved off-site and also have developed cancer risk estimates for those releases.

These studies are the most comprehensive risk assessments ever performed for Rocky Flats. While the project does not answer all questions, it attempts to answer those felt to be most important. The Health Advisory Panel believes that the lessons learned from these studies may help prevent similar problems at the facility in the future.

Problems at Rocky Flats led to unnecessary plutonium releases in the past, particularly from plutonium fires and from uncontrolled releases of disturbed, contaminated soil during windstorms. These past problems make it imperative that dismantling and clean-up activities be planned with a careful eye toward the prevention of similar events in the future. It is clear that the potential for increased release rates will exist during the dismantling and cleanup of Rocky Flats. More specifically, contaminated building rubble and freshly disturbed, contaminated soil present the clear potential to create new risks of plutonium releases during future windstorms and flooding events. The Health Advisory Panel strongly recommends that Rocky Flats staff, the Department of Energy, the Colorado Department of Public Health and Environment and the various citizens' oversight committees actively and jointly evaluate and monitor all clean-up operations to prevent such off-site exposures.

HOW CAN I GET MORE

Information

about the studies?

The detailed findings of Phase I and Phase II of the Historical Public Exposures Studies on Rocky Flats are available in more than 30 technical reports. These reports, citizen summaries of the technical reports, technical topic papers on scientific concepts and additional information are available through the organizations listed here.

For a complete overview of the Historical Public Exposures Studies call the Colorado Department of Public Health and Environment at **303-692-2700** or visit the web site **www.cdphe.state.co.us/rf** or any of these libraries or Rocky Flats Reading Rooms.

Colorado Department of Public Health and Environment

Information Center, Building A
First Floor
4300 Cherry Creek Drive South
Denver, CO 80246-1530
Phone: 303-692-2037

Citizens Advisory Board

9035 N. Wadsworth Pkwy.
Suite 2250
Westminster, CO 80021
Phone: 303-420-7855

Front Range Community College

DOE Rocky Flats Reading Room
College Hill Library
33705 W. 112th Ave.
Room L169
Westminster, CO 80030
Phone: 303-469-4435

University of Colorado at Boulder

Government Publications Library
Campus Box 184
3rd Floor, Norlin Library
Boulder, CO 80309
Phone: 303-492-8834

HEALTH Advisory Panel

Ellen Mangione, M.D., M.P.H.

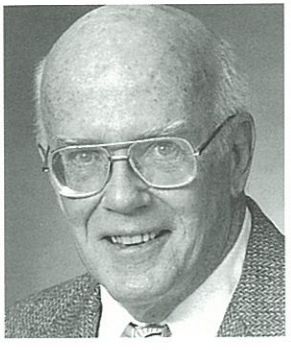
Panel chair and director of the Disease Control and Environmental Epidemiology Division of the Colorado Department of Public Health and Environment, Dr. Mangione is board-certified in internal medicine, infectious diseases and public health/preventive medicine. She is assistant clinical professor at the University of Colorado Health Sciences Center and has served on the Office of Technology Assessment Advisory Panel on Nuclear Weapons Waste, the Health Issues Subcommittee of the Rocky Flats Environmental Monitoring Council, and the Environmental Health Committee of the Colorado Medical Society. She is a member of the Environmental Protection Agency's Science Advisory Board and serves on its Radiation Advisory Committee. Dr. Mangione has extensive experience in epidemiology and has worked on several risk assessment studies at Colorado hazardous waste and mining sites.

Eugenia "Bini" Abbott

For more than 38 years, Ms. Abbott has lived on the west shore of Standley Lake, one and a half miles from Rocky Flats. She volunteers with The Horse Protection League, taking in starved and abused horses. In 1992, she was recognized as "Arvada Woman of the Year" by the Northwest Metro Chamber of Commerce for her community and environmental activities, including her leadership in preserving the Two Ponds wetlands area as an outdoor classroom and National Wildlife Refuge. A former elementary school teacher, Ms. Abbott describes herself as an advocate for open space conservation and environmental protection.

David Albright, M.S.

Mr. Albright is president of the Institute for Science and International Security (ISIS) in Washington, D.C. He investigates and develops public information about science and policy issues affecting national and international security, such as production of nuclear weapons in foreign countries and reduction of military arsenals. He earned a 1992 Olive Branch Award from New York University for co-authoring a series of articles on the Iraqi nuclear weapons program for the *Bulletin of Atomic Scientists.* In the mid-1990s he was a nuclear inspector in Iraq for the International Atomic Energy Agency. Mr. Albright also co-authored *World Inventory of Plutonium and Highly Enriched Uranium,* 1996 (Oxford University Press), a comprehensive country-by-country assessment of the amounts of these materials in military and civilian programs. He serves on the Secretary of Energy's Openness Advisory Panel.

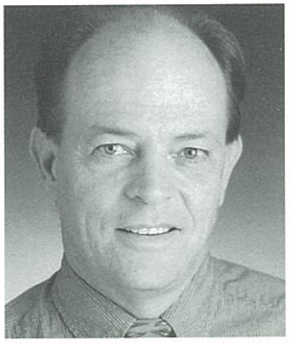


Franklin Gifford, Ph.D.

Dr. Gifford, who is from Oak Ridge, Tennessee, is an internationally recognized meteorologist and consultant on atmospheric diffusion. His clients have included the International Atomic Energy Agency, National Oceanic and Atmospheric Administration, National Academy of Engineering and the National Council on Radiation Protection. Dr. Gifford has authored more than 140 publications in the areas of atmospheric turbulence and diffusion, air pollution and planetary meteorology, and was the former director of the National Oceanic and Atmospheric Administration's Atmospheric Transport and Diffusion Laboratory in Oak Ridge.

Thomas Kirchner, Ph.D.

Dr. Kirchner is senior scientist, Informatics and Modeling, for the Carlsbad Environmental Monitoring and Research Center in New Mexico. An expert in risk assessment and uncertainty analysis, he earned his Ph.D. in zoology and entomology from Colorado State University in 1980 and worked as a senior research scientist there until 1986, at which time he joined New Mexico State University. Dr. Kirchner has been involved in research to estimate the dose received by populations surrounding the Nevada Test Site due to tests of nuclear devices at the facility.



James LaVelle, Ph.D.

Dr. LaVelle is a toxicologist with the Denver consulting firm Camp Dresser & McKee Inc. He was formerly assistant and associate professor of toxicology at the University of Connecticut and toxicologist in the Superfund program in the U.S. Environmental Protection Agency, Region VIII. Dr. LaVelle is an expert in the toxicology of metals and the assessment of risk from metals and chemical exposures. He served for two years on the EPA National Lead Work Group and has provided expert testimony on toxicology and risk for litigation involving environmental risks. He served on a special panel for the Colorado Legislature that provided recommendations on the use of Risk-Cost Benefit Analysis in rule-making for the Air Quality Control Commission.

HEALTH Advisory Panel

Kenneth Lichtenstein, M.D.

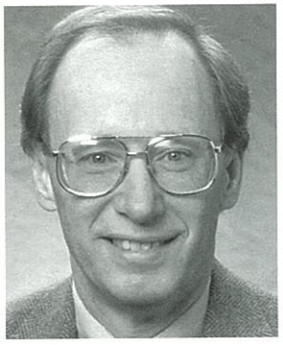
Dr. Lichtenstein is a practicing physician specializing in diagnosis and treatment of infectious diseases and the former national president of Physicians for Social Responsibility (PSR). Dr. Lichtenstein received the Community Service Award at the University of Colorado Health Sciences Center. He shared in the 1985 Nobel Peace Prize awarded to PSR and the International Physicians for the Prevention of Nuclear War. He serves on the board of directors for the Denver Medical Society, is the chief of infectious diseases at Rose Medical Center and clinical professor of medicine at the University of Colorado Health Sciences Center.

Robert Quillin, M.S.P.H., M.S.

Director of the Laboratory and Radiation Services Division of the Colorado Department of Public Health and Environment, Mr. Quillin specializes in radiological health and is certified by the American Board of Health Physics. The division focuses on a wide range of activities and services that include regulating and licensing users of radioactive materials. The division also performs environmental monitoring around Rocky Flats. In 1997, Mr. Quillin was named "Manager of the Year" for the State of Colorado. Before coming to Colorado, Mr. Quillin was radiological health program administrator for the Ohio Department of Health.

Niels Schonbeck, Ph.D.

Dr. Schonbeck is a biochemistry professor in the Department of Chemistry at Metropolitan State College in Denver. He teaches Science and Public Policy, a class focusing on nuclear dilemmas. He is a board member of the Colorado Coalition for the Prevention of Nuclear War and serves as a visiting scientist at the National Center for Atmospheric Research. In 1988 he was appointed to the Rocky Flats Environmental Monitoring Council where he served as chair of the Health Issues Subcommittee. In 1997 he was appointed to the Radionuclide Soil Action Level Oversight Panel.



James Smith, Ph.D.

Dr. Smith is chief of the Radiation Studies Branch of the Centers for Disease Control and Prevention (CDC) in Atlanta, Georgia, where he directs CDC's program for performing radiation health studies and historical dose reconstruction studies at nuclear facilities. He served on the Hanford Health Effects Review Panel in Washington state and currently is a member of the Oak Ridge Health Agreement Steering Panel. Dr. Smith has served on the editorial board of the *Health Physics Journal* and is adjunct associate professor at Emory University's School of Public Health.

Heather Stockwell, Sc.D.

Director of the Office of Epidemiologic Studies at the Department of Energy (DOE), Dr. Stockwell directs DOE's intramural and extramural epidemiologic health studies programs. She coordinates programs of external health studies through state health departments, the Centers for Disease Control and Prevention, and the Agency for Toxic Substances and Disease Registry. Dr. Stockwell also manages an internal epidemiology program of health surveillance for DOE workers. Before joining DOE, Dr. Stockwell was associate professor of epidemiology in the College of Public Health at the University of South Florida, where she served as chair of the Epidemiology Section of the Florida Public Health Association and the steering panel of the Pinellas Plant Feasibility Study. Dr. Stockwell's research interests include radiation health effects, cancer in women, diet and cancer, and occupational and environmental causes of cancer.

Henry Stovall

Mr. Stovall is a councilman for the city of Broomfield and has served on the Boulder County Planning Commission. Retired from AT&T, he is an engineer with training in physics and experience in environmental health. Mr. Stovall served on Congressman David Skaggs' committee for review of technical issues at Rocky Flats and chaired the Rocky Flats Local Impacts Initiative to determine the economic impacts of downsizing the Rocky Flats work force. In 1997 he organized the Radionuclide Soil Action Level Oversight Panel and currently serves as the group's co-vice-chair.

Former & Alternate

HEALTH ADVISORY PANEL MEMBERS

Robert Goldsmith, Ph.D.

Dr. Goldsmith was founder and former director of DOE's Office of Epidemiology and Health Surveillance. He is now special assistant for medical and health surveillance in the Office of Site Operations in the DOE Office of Environmental Management, helping to ensure worker health and safety during cleanup operations at selected closeout sites. He is also involved in expediting site closure at several DOE facilities across the country and facilitates the implementation of integrated safety management across the DOE complex.

F. Owen Hoffman, Ph.D.

Dr. Hoffman is president and director of the Center for Risk Analysis, SENES Oak Ridge Inc. in Tennessee. For several years, Dr. Hoffman was an environmental scientist at the Oak Ridge National Laboratory. He pioneered research on uncertainty in risk analysis, including the use of data from the Chernobyl accident to test predictions about radioactivity in the environment. For six years Dr. Hoffman was a member of the U.S. EPA's Radiation Advisory Committee of the Science Advisory Board and chaired its recent report on uncertainty and radiogenic cancer risk. Dr. Hoffman is a member of the National Council on Radiation Protection and Measurements.

Barbara Brooks, M.S.

Ms. Brooks joined the Office of Epidemiologic Studies in DOE's Office of Health in late 1990 with more than 20 years of federal experience. In addition to serving as DOE's representative on several state advisory panels for health studies, her responsibilities also include program management for a university project concerning the measurement of biokinetics of the actinides in humans and management oversight of DOE's new Comprehensive Epidemiologic Data Resource (CEDR). She has a master's degree in health physics from the University of Tennessee and a bachelor's degree in physics from Southern Illinois University.

Summary of Findings

Prepared by the Health Advisory Panel and
The Colorado Department of Public Health and Environment

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of Public Health
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