MASTER

A SUMMARY OF THE PHASE II - TITLE I ENGINEERING ASSESSMENT OF INACTIVE URANIUM MILL TAILINGS NEW AND OLD RIFLE SITES, RIFLE, COLORADO

OCTOBER 1977

PREPARED FOR

UNITED STATES DEPARTMENT OF ENERGY
GRAND JUNCTION, COLORADO, CONTRACT NO. E(05-1)-1658

BY

Ford, Bacon & Davis Utah Inc.

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NOTICE

This Phase II - Title I Engineering Assessment has been performed under ERDA Contract No. E(05-1)-1658 executed on June 23, 1975 between the U.S. Energy Research and Development Administration and Ford, Bacon & Davis Utah Inc. On October 1, 1977, ERDA was incorporated into the U.S. Department of Energy; hence, this engineering assessment is issued for the DOE, the present responsible agency.

FOREWORD

This report is a summary of a parent report (issued under separate cover) entitled, "Phase II - Title I Engineering Assessment of Inactive Uranium Mill Tailings, Rifle Sites, Rifle, Colorado". Both reports are authorized under the U.S. Energy Research and Development Administration (ERDA) Contract No. E(05-1)-1658. These reports are part of a series of reports on inactive uranium millsites that address the radiological problems and estimated costs of remedial measures that would reduce exposure of the general public. Title I is not a scientific study but an engineering assessment to determine the relative magnitude of the hazards associated with each site, to identify reasonable remedial action options for each site and to estimate the remedial action costs. If additional data that may alter or have an impact on a final remedial action decision for any site is required, it can be obtained during the Title II Engineering Effort.

Ford, Bacon & Davis Utah Inc. (FB&DU) under supplemental authorization currently is investigating uranium mill tailings stabilization techniques. This research could modify some of the estimated costs in this report.

Also, FB&DU acknowledges the excellent cooperation and assistance given in this engineering assessment. Particular recognition is due the ERDA personnel of both the Germantown, MD, and Grand Junction, CO offices and also the Union Carbide Corporation personnel of the Health Physics Division, Oak Ridge National Laboratory, who provided field radiological measurements and radiometric analyses of samples. The preparation of this report could not have been accomplished without the cooperation and assistance of the following:

- (1) The Environmental Protection Agency for consultation, data, and information from prior surveys and studies with notable assistance from the Office of Radiation Programs, Las Vegas, Nevada
- (2) The State of Colorado:

Department of Health, Mr. A. J. Hazle, and Mr. G. A. Franz
- (3) Union Carbide Corporation; Mr. R. G. Beverly, Grand Junction Office and Mr. H. Piper and other plant personnel at Rifle
- (4) Colorado West Area Council of Governments
- (5) Other local government officials from the City of Rifle and Garfield County, and local business personnel in the Rifle area

- (6) EG&G, Las Vegas, Nevada; Mr. Jack Doyle, for aerial photography
- (7) Center for Health and Environmental Studies, Brigham Young University, Provo, Utah; for socioeconomic studies

ABSTRACT

Ford, Bacon & Davis Utah Inc. has performed an engineering assessment of the problems resulting from the existence of radioactive uranium mill tailings at Rifle, Colorado. The Phase II - Title I services include the preparation of topographic maps, the performance of core drillings and radiometric measurements sufficient to determine areas and volumes of tailings and other radium-contaminated materials, the evaluation of resulting radiation exposures of individuals and nearby populations, the investigation of site hydrology and meteorology and the evaluation and costing of alternative corrective actions.

Radon gas release from the 3.1 million tons of tailings at the two Rifle sites, constitutes the most significant environmental impact. Windblown tailings, external gamma radiation and localized contamination of surface waters are other environmental effects. The 15 alternative remedial action options presented range from millsite decontamination and off-site remedial action (Options I and IV), to adding various depths of stabilization cover material (Options II, V, VI and VII), to removal of the tailings to long-term storage sites and decontamination of the present sites (Options III and VIII through XV). Cost estimates for the first 14 options range from \$224,000 to \$20,300,000. Option XV, estimated at \$32,200,000, includes the cost for moving both Rifle tailings piles and the Grand Junction tailings pile to DeBeque for long-term storage and site decontamination after removal of the piles.

Reprocessing of the tailings for uranium appears to be economically attractive at present.

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GLOSSARY

Abbreviations/Terms

Definitions

absorbed dose	Radiation energy absorbed per unit mass.
A-E	Architect-Engineer.
AEC	Atomic Energy Commission.
alpha particle (α)	A positively charged particle emitted from certain radioactive material. It consists of two protons and two neutrons, hence is identical with the nucleus of the helium atom. It is the least penetrating of the common radiation (α , β , γ), hence is not dangerous unless alpha-emitting substances have entered the body.
amenability	The relative ease with which a mineral(s) can be removed from an ore by a particular process.
anomaly (mobile gamma survey)	Any location detected by the mobile gamma survey where the recorded counts per second (c/s) from a large gamma-ray detector exceed the determined background for that area by 50 or more c/s.
aquifer	A water-bearing formation below the surface of the earth; the source of wells. A confined aquifer is overlain by relatively impermeable rock. An unconfined aquifer is one associated with the water table.
atmospheric pressure	Pressure exerted on the earth by the mass of the atmosphere surrounding the earth; expressed in inches of mercury (at sea level and 0°C, standard pressure is 29.921 in. Hg).
background radiation	Naturally occurring low-level radiation to which all life is exposed. Background radiation levels vary from place to place on the earth.
beta particle (β)	A particle emitted from some atoms undergoing radioactive decay. A negatively charged beta particle

	is identical to an electron. A positively charged beta particle is called a positron. Beta radiation can cause skin burns and beta-emitters are harmful if they enter the body.
BEIR	Biological Effects of Ionizing Radiation.
BIA	Bureau of Indian Affairs.
BOM (USBOM)	Bureau of Mines.
CHES	Center for Health and Environmental Studies, Brigham Young University, Provo, Utah.
Ci	Curie (the unit of radioactivity of any nuclide, defined as precisely equal to 3.7×10^{10} disintegrations/second).
daughter product	The nuclide remaining after a radioactive atom (parent) has undergone radioactive decay. A daughter atom may itself be radioactive, producing further daughter products.
diurnal	Daily, cyclic (happening each day or during the day).
dose equivalent	A term used to express the amount of effective radiation when modifying factors have been considered (the numerical product of absorbed dose and quality factor).
EGR	External gamma radiation (gamma radiation emitted from a source(s) external to the body, as opposed to internal gamma radiation emitted from ingested or inhaled sources).
EPA (USEPA)	Environmental Protection Agency.
ERDA (USERDA)	Energy Research and Development Administration.
ERDA-GJO	Energy Research and Development Administration-Grand Junction Office.

erg	The basic unit of work or energy in the centimeter-gram-second system (1 erg is equal to 7.4×10^8 ft-lb).
exposure	Related to electrical charge produced in air by ionizing radiation per unit mass of air.
exhalation	Emission of radon from earth (usually thought of as coming from a uranium tailings pile, but actually from any location).
FB&DU	Ford, Bacon & Davis Utah Inc.
gamma background	Natural gamma ray activity everywhere present, originating from two sources: (1) cosmic radiation, bombarding the earth's atmosphere continually, and (2) terrestrial radiation. Whole body absorbed dose equivalent in the U.S. due to natural gamma background ranges from about 60 to about 125 mrem/yr.
gamma ray	High energy electromagnetic radiation emitted from the nucleus of a radioactive atom, with specific energies for the atoms of different elements and having high penetrating power.
GJO	Grand Junction Office.
ground water	Subsurface water in the zone of full saturation which supplies wells and springs.
health effect	Adverse physiological response from tailings (in this report, one health effect is defined as one case of cancer from exposure to radioactivity).
heap leaching	A process for removing uranium from ore, tailings, or other material wherein the material is placed on an impermeable pad and wetted with appropriate reagents. The uranium solution is collected for further processing.
HEW (USHEW)	Department of Health, Education and Welfare.

IHS	Indian Health Service.
insult	Negative impact on the environment or the health of individuals.
Interim Drinking Water Standards (EPA)	Title No. 40 of the Code of Federal Regulations, Chapter 1, Part 141, dated Dec 24, 1975; scheduled to become effective Jun 24, 1977.
iso-exposure line	A line drawn on a map to connect all points having the same exposure rate.
isotope	One of two or more atoms with the same atomic numbers (the same chemical element) but with different atomic weights. Isotopes usually have very nearly the same chemical properties, but somewhat different physical properties.
JCAE	Joint Committee on Atomic Energy.
knot	A unit of velocity, approximately equal to 1.15 mi/hr.
μ R/hr	Microroentgen per hour.
mR/hr	Milliroentgen per hour.
MeV	Million electron volts.
MPC	Maximum permissible concentration (the highest concentration in air or water of a particular radionuclide permissible for occupational or general exposure without taking steps to reduce exposure).
NAS	National Academy of Sciences.
NIOSH	National Institute for Occupational Safety and Health.
noble gas	One of the gases, such as helium, neon, radon, etc., with completely filled electron shells which is therefore chemically inert.
NRC	Nuclear Regulatory Commission.

nuclide	A general term applicable to all atomic forms of the elements; nuclides comprise all the isotopic forms of all the elements. Nuclides are distinguished by their atomic number, atomic mass, and energy state.
ORNL	Oak Ridge National Laboratory.
ORP-LVF (EPA)	Office of Radiation Programs, Las Vegas Facility (Environmental Protection Agency).
pCi/l	Picocurie per liter.
PHS (USPHS)	Public Health Service.
QF	Quality factor (an assigned factor which denotes the modification of the effectiveness of a given absorbed dose by the linear energy transfer).
R	Roentgen (a unit of exposure to ionizing radiation. It is that amount of gamma or X-rays required to produce ions carrying 1 electrostatic unit of electrical charge, either positive or negative, in 1 cubic centimeter of dry air under standard conditions, numerically equal to 2.58×10^{-4} coulombs/kg).
rad	The basic unit of absorbed dose of ionizing radiation. A dose of 1 rad means the absorption of 100 ergs of radiation energy per gram of absorbing material.
radioactivity	The spontaneous decay or disintegration of an unstable atomic nucleus, usually accompanied by the emission of ionizing radiation.
radioactive decay chain	A succession of nuclides each of which transforms by radioactive disintegration into the next until a stable nuclide results. The first member is called the parent, the intermediate members are called daughters, and the final stable member is called the end product.

radium	A radioactive element, chemically similar to barium, formed as a daughter product of uranium (^{238}U). The most common isotope of radium, ^{226}Ra , has a half-life of 1,620 yr. Radium is present in all uranium-bearing ores. Trace quantities of both uranium and radium are found in all areas, contributing to the gamma background.
radon	A radioactive, chemically inert gas, having a half-life of 3.8 days (^{222}Rn); formed as a daughter product of radium (^{226}Ra).
radon background	Low levels of radon gas found in an area, due to the presence of radium in the soil.
radon concentration	The amount of radon per unit volume. In this assessment, the average value for a 24-hr period of atmospheric radon concentrations, determined by collecting data for each 30 min period of a 24-hr day and averaging these values.
radon daughter	One of several short-lived radioactive daughter products of radon (several of the daughters emit alpha particles).
RDC	Radon daughter concentration (the concentration in air of short-lived radon daughters, expressed usually in pCi/l; also measured in terms of working level (WL)).
radon flux	The quantity of radon emitted from a surface in a unit time per unit area (typical units are in pCi/cm ² -sec).
raffinate	The liquid part remaining after a product has been extracted in a solvent extraction process.
recharge	The processes by which water is absorbed and added to the zone of saturation of an aquifer, either directly into the formation or indirectly by way of another formation.

rem

(Acronym of roentgen equivalent man) The unit of dose of any ionizing radiation which produces the same biological effect as a unit of absorbed dose of ordinary X-rays, numerically equal to the absorbed dose in rads multiplied by the appropriate quality factor for the type of radiation. The rem is the basic recorded unit of accumulated dose to personnel.

residual value

The value of minerals in tailings material.

riprap

An irregular wall of broken rock, placed as a retaining wall, as a protection for dikes, etc.

sands

Relatively coarse-grained materials produced along with the slimes as waste products of ore processing in uranium mills (see tailings). These sands normally contain less radioactive material than the slimes.

scintillometer

A gamma-ray detection instrument normally utilizing a NaI crystal.

slimes

Extremely fine-grained materials, mixed with small amounts of water, produced along with the sands as waste products of ore processing in uranium mills (see tailings). Most of the radioactive material remaining in tailings is found in the slimes.

tailings

The remaining portion of a metal-bearing ore after the metal, such as uranium, has been extracted. Tailings also may contain other minerals or metals not extracted in the process (e.g. radium).

WL

Working level. A unit of radon daughter exposure, equal to any combination of short-lived radon daughters in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy. This level is equivalent to the energy produced in the decay of the daughter products RaA, RaB, RaC, and RaC' that are present under equilibrium conditions in a liter of air containing 100 pCi of Rn-222. It does not include decay of RaD (22 yr half-life) and subsequent daughter products.

WLM

Working level month. One WLM is equal to the exposure received from 170 WL-hours.

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1.1 INTRODUCTION

The U. S. Energy Research and Development Administration (ERDA) has contracted with Ford, Bacon & Davis Utah Inc. (FB&DU) of Salt Lake City, Utah, to provide architect-engineering services in the assessment of the problems resulting from the existence of large quantities of radioactive uranium mill tailings at the sites of inactive mills in eight western states.

A preliminary survey (Phase I) was carried out by ERDA in cooperation with the EPA and the affected states and completed in October 1974. In the Summary Report⁽¹⁾, ERDA identified 17 sites in Arizona, Colorado, Idaho, New Mexico, Utah, and Wyoming for which practical remedial measures are to be evaluated. Subsequently, ERDA added five additional sites (Riverton and Converse County, Wyoming; Lakeview, Oregon; Falls City and Ray Point, Texas) to the list for a total of 22 sites. Most of these mills produced by far the greatest part of their output of uranium under contracts with the U. S. Atomic Energy Commission (AEC) during the period 1947 through 1970. After operations ceased, some companies made no attempt to stabilize the tailings, while others did so with varying degrees of success. Recently, concern has increased about the possible adverse effects to the general public from long-term exposure to low-level sources of radiation from the tailings piles and sites.

To date, the studies of radiation levels on and in the vicinity of these sites have been limited in scope. The data available were insufficient to permit assessment of risk to people with any degree of confidence in the conclusions reached. In addition, information on practicable measures to reduce radiation exposures and estimates of their projected costs are limited. The purpose of this study is to develop the necessary information to provide a basis for decision-making for appropriate remedial actions for each of these sites.

In assessing the significance of the conditions existing at the Rifle sites, evaluations of the following factors were included:

- (a) Exhalation of radon gas from the tailings
- (b) On-site and off-site direct radiation
- (c) Land contamination from windblown tailings

⁽¹⁾ See end of chapter for references.

- (d) Hydrology and contamination by water pathways
- (e) Potential health impact
- (f) Potential for extraction of additional metals from the tailings

Investigation of these and other factors led to the detailed evaluation of nine potential practical alternatives. These may be placed within three main categories:

- (a) Minimum remedial action, which amounts to off-site remedial action
- (b) Stabilization designed for long-term storage of tailings in their current location
- (c) Removal of the tailings to alternative sites suitable for long-term storage and stabilization

The estimated costs of carrying out the remedial work to implement each option depend on such parameters as the degree of decontamination to be achieved, and the degree of stabilization necessary.

1.1.1 Background

On March 12, 1974, the Subcommittee on Raw Materials of the Joint Committee on Atomic Energy (JCAE), Congress of the United States, held hearings on S. 2566 and H.R. 11378, identical bills submitted by Senator Frank E. Moss and Representative Wayne Owens of Utah. The bills provided for a cooperative arrangement between the AEC and the State of Utah in the area of the Vitro tailings site in Salt Lake City.* The bills also provided for the assessment of and appropriate remedial action to limit the exposure of individuals to radiation from uranium mill tailings.

Dr. William D. Rowe, testifying in behalf of the Environmental Protection Agency (EPA), pointed out that there are other sites with similar problems. He recommended the problem be approached as a generic one, structured to address the most critical problem first.

Dr. James L. Liverman, testifying for the AEC, proposed that a comprehensive study should be made of all such piles, rather

*The proceedings of these hearings and the Summary Report on the Phase I Study were published by the JCAE as Appendix 3 to ERDA Authorizing Legislation for Fiscal Year 1976. Hearings before the Subcommittee on Legislation, JCAE, on Fusion Power, Biomedical and Environmental Research; Operational Safety; Waste Management and Transportation, Feb 18 and 27, 1975, Part 2.

than treating the potential problem on a piece-meal basis. He proposed that the study be a cooperative two-phase undertaking by the states concerned and the appropriate federal agencies, such as the AEC and EPA. Phase I would involve site visits to determine such aspects as their condition, ownership, proximity to populated areas, prospects for increased population near the site, and need for corrective action. A preliminary report then would be prepared which would serve as a basis for determining if a detailed engineering assessment (Phase II) were necessary for each millsite. The Phase II study, if necessary, would include evaluation of the problems, examination of alternative solutions, preparation of cost estimates, and of detailed plans and specifications for alternative remedial action measures. This part of the study would include physical measurements to determine exposure or potential exposure to the public.

The Phase I assessment began in May 1974, with teams consisting of representatives of the AEC, the EPA, and the states involved visiting 21 of the inactive sites. The Phase I report was presented to the JCAE in October 1974. Table 1-1 summarized the conditions at the time of the Phase I visits.⁽¹⁾ Based on the findings presented in the report, the decision was made to proceed with Phase II.

On May 5, 1975, ERDA, the successor to AEC, announced that Ford, Bacon & Davis Utah Inc. of Salt Lake City had been selected to provide the architect-engineering (A-E) services for Phase II. ERDA's Grand Junction, Colorado, office (GJO) was authorized to negotiate and administer the terms of a contract with FB&DU. The contract was effective on June 23, 1975. The Salt Lake City Vitro site was assigned as the initial task, and work began immediately. Work on the Rifle sites began in May 1976.

1.1.2 Scope of Phase II Engineering Assessment

Phase II A-E Services are divided into two stages: Title I and Title II.

Title I services include the engineering assessment of existing conditions and the identification, evaluation and costing of alternative remedial actions for each site. Following the selection and funding of a specific remedial action plan, Title II services will be performed. These services will include the preparation of detailed plans and specifications for implementation of the selected remedial action.

This report is the assessment made for Title I requirements and was prepared by FB&DU. The Oak Ridge National Laboratory (ORNL) at Oak Ridge, Tennessee, under separate agreement with ERDA, provided measurements of the radioactivity concentrations in the soil and water samples and gamma surveys. The EPA staff provided the results of radiation surveys they previously had made at the Rifle sites.

The specific scope requirements of the Title I assessment as given in the contract may include but are not limited to the following:

- (a) Preparation of an engineering assessment report for each site, and preparation of a comprehensive report suitable for submission to the Congress on reasonable remedial action alternatives and their estimated costs.
- (b) Determination of property ownership in order to obtain release of federal government and A-E liability for performance of engineering assessment work at both inactive millsites and privately owned structures.
- (c) Preparation of topographic maps of millsites and other sites to which tailings and other radioactive materials might be moved.
- (d) Performance of core drillings and radiometric measurements ample to determine volumes of tailings and other radium-contaminated materials.
- (e) Performance of radiometric surveys, as required, to determine areas and structures requiring cleanup or decontamination.
- (f) Determination of the adequacy and the environmental suitability of sites to which mill tailings containing radium can be moved for long-term (>50 yr) storage; and once such sites are identified, perform evaluation and estimate the costs involved.
- (g) Performance of engineering assessments of structures where uranium mill tailings have been used in off-site construction to arrive at recommendations and estimated costs of performing remedial action.
- (h) Evaluation of various methods, techniques and materials for stabilizing uranium mill tailings to prevent wind and water erosion, to inhibit or eliminate radon exhalation, and to minimize maintenance and control costs.
- (i) Evaluation of availability of suitable fill and stabilization cover materials that could be used.
- (j) Evaluation of radiation exposures of individuals and nearby populations resulting from the inactive uranium millsite, with specific attention to:
 - (1) Gamma radiation

- (2) Radon
- (3) Radon daughter concentrations
- (4) Radium and other naturally occurring radio-isotopes in the tailings
- (k) Investigation of site hydrology and meteorology.
- (l) Evaluation of recovering residual values, such as uranium and vanadium in the tailings and other residues on the sites.
- (m) Performance of demographic and land use studies. Investigation of community and area planning, and industrial and growth projections.
- (n) Evaluation of the alternative corrective actions for each site in order to arrive at recommendations, estimated costs, and socioeconomic impact based on population and land use projections.
- (o) Preparation of preliminary plans, specifications, and cost estimates for alternative corrective actions for each site.

Not all of these items received attention at this site.

1.2 SITE DESCRIPTION

1.2.1 Location and Topography

There are two sites at Rifle: Old Rifle and New Rifle. The two sites are approximately 2 mi apart. The Old Rifle site is just east of the city limits of Rifle, Garfield County, Colorado. U. S. Highway 6 and 24 runs along the north side of the site and the Denver and Rio Grande Western Railroad tracks are on the south side. The Colorado River is immediately south of the railroad tracks. The New Rifle site is west of Rifle and is bordered on the north by the Denver and Rio Grande Western Railroad tracks and on the south by Interstate 70 and the Colorado River. The valley in which the tailings are located is at an elevation of approximately 5,300 ft. Steep cliffs and mesas up to elevations of 9,300 ft are on the north of the tailings and long sloping mountains on the south rise to the Grand Mesa National Forest and elevations of 10,000 ft. The sites and their relationship to the surrounding area are shown in the aerial photographs of Figures 2-1A and 2-1B, Chapter 2.*

*All figures and tables referenced in this summary are from the parent report and are attached.

1.2.2 Ownership and History of Milling Operations and Processing⁽¹⁾

Both mills were constructed and operated by Union Carbide Corp. or its predecessor the United States Vanadium Corporation, a subsidiary of UCC. Both sites are still under the ownership of Union Carbide Corp.

1.2.2.A Old Rifle Site

The plant operated from 1924 to 1932 for the recovery of vanadium from roscoelite ore. It operated again from 1942 until 1958 during which time processing was altered to allow recovery of uranium as well. 761,000 tons of ore from all over the Uravan Mineral belt as well as the Rifle mine, were fed to the process for uranium and vanadium recovery with an average grade of 0.31% U_3O_8 .

1.2.2.B New Rifle Site

The mill operated from July, 1958 until December 1972, but is still under an active license. It was built as a part of a complex of upgraders including Slick Rock, Colorado and Green River, Utah. A total of 2.7 million tons of ore and upgrader products and tailings from other mills were processed.

1.2.3 Present Condition of the Site

1.2.3.A Old Rifle Site

Figure 2-3A, Chapter 2 is a descriptive map of the 22-acre site as it now exists. The tailings, which cover approximately one-half of the site were stabilized with approximately 6 in. of earth cover and vegetation. This cover has resisted erosion and the pile is now covered with about 85% vegetative cover. The site is fenced with a chainlink fence and is posted. The owner provides security and maintenance.

One structure (the old assay building) remains on the site along with some concrete foundations remaining from the other mill structures.

1.2.3.B New Rifle Site

Figure 2-3B, Chapter 2 is a descriptive map of a portion of the approximately 300-acre site as it now exists. The tailings pile covers approximately 32 acres with very steep side slopes. The top of the pile has two levels each being relatively flat with the highest portion about 65 ft high. The tailings have been covered with mulch, fertilizer, and have been seeded. Union Carbide has done a successful job of stabilizing the tailings without benefit of any earth cover by using the method mentioned above plus the use of wind break devices such as snow fences, etc. and of the use of irrigation during the dry summer months. The

mill buildings remain in a standby condition. The site is fenced and posted. Constant maintenance and surveillance is provided by owner-personnel at the site. The newly constructed Interstate 70 borders the site on the south and the Colorado River is to the east of the site and just south of the freeway.

1.2.4 Tailings and Soil Characteristics

The Old Rifle tailings pile consists of uranium tailings and stabilization cover. The tailings are finely ground sands with a medium clay content and bulk densities of 95 to 106 lb/ft³. The New Rifle tailings pile has no stabilization but does have a mulch cover on portions of the pile. The tailings are sandy in character and have bulk densities of 70 to 73 lb/ft³. The amounts of tailings site materials are presented in Table 2-1, Chapter 2.

Soil beneath the piles is alluvium of the Colorado River consisting of gravel and cobbles.

1.2.5 Geology, Hydrology, and Meteorology

The Rifle tailings piles and millsites are located on river run alluvium of the modern Colorado River flood plain. The river valley is cut into a thick sequence of shales and lenticular sandstones of the Wasatch Formation which dip 5 to 10 deg west-southwest. The Wasatch Formation is hundreds of feet thick beneath the tailings and acts as a barrier to the downward and upward migration of ground waters. A simplified stratigraphic column is shown in Figure 2-5, Chapter 2.

The surface waters adjacent to or near the Old Rifle site consist of the Colorado River, a lined ditch east of the pile, and occasional accumulations of water on the site near the eastern fence and along the southwestern edge of the site. Neither an intermediate regional flood (100-yr flood) nor a more severe standard project flood would top the railroad embankment which separates the tailings pile from the river. The occasional on-site accumulations of water are from storm runoff (southwestern area) and from drainage onto the pile from seepage from a road cut above the site.

The surface waters adjacent to or near the New Rifle pile consist of a raffinate pond; the Colorado River; and ponds west and northwest of the pile; a marshy area northwest of the pile; and irrigation ditches. The base of the tailings pile is approximately at the level of a standard project flood and hence there is little potential for erosion by flood waters. The construction of Interstate 70 immediately south of the site, the dike and riprap to the east of the pile, and roadways on the site all serve to protect the site from floodwaters. However, the artificial channeling of the river and the embankments could result in the collection of flood waters on the millsite should flood waters breach the northern section of the dike.

Contamination of surface waters near the piles could occur by seepage from the piles and from physical transport off the New Rifle site. The potential for water erosion is lessened by the relatively flat terrain. Except for the seepage onto the Old Rifle site, the overland flow onto the piles is limited almost entirely to the precipitation and irrigation water that actually falls on the piles. The average annual precipitation totals about 11 in.

The unconfined aquifers in the Rifle area consist of waters within the valley alluvium. There is a potential for seepage of water through the piles and ground waters flowing through the unconsolidated material could be contaminated by any such seepage. During a standard project flood, the water table would rise into the Old Rifle tailings and would rise into the New Rifle settling pond areas. Records in the State Engineer's Office show no registered wells within 2 mi of the sites at a hydraulically lower gradient than the base of the piles. Unconfined ground waters tend to parallel the flow gradient of surface waters and discharge into the river. Thus, any contaminants would tend to flow parallel to and into the river and eventually become diluted. However, the development of ground water in the immediate vicinity of either pile could induce waters to move toward the withdrawal points. The Wasatch Formation acts as a barrier confining the waters of the aquifers of older sedimentary strata. There is no potential for contamination of confined aquifers.

The tailings are vulnerable to strong winds that are channeled up and down the valley. The steep slopes of the New Rifle pile are difficult to stabilize and tailings have been eroded from some of the more intractable areas of the New Rifle pile. High-intensity rainfall such as thunderstorms could result in physical erosion of these areas of the New Rifle site, and in the ponding of waters and seepage through the Old Rifle pile.

1.3 RADIOACTIVITY AND POLLUTANT IMPACTS ON THE ENVIRONMENT

About 85% of the total radioactivity originally in uranium ore remained in the tailings after removal of the uranium because the radium and thorium, principal contributors to radioactive emissions, were not normally removed from the uranium ores during milling. The principal environmental radiological impact and associated health effects arise from the ^{230}Th , ^{226}Ra , ^{222}Rn , and ^{222}Rn daughters contained in the uranium tailings. Although these radionuclides occur in nature, their concentrations in tailings material are several orders of magnitude greater than their average concentrations in the earth's crust.

1.3.1 Radiation Exposure Pathways, Contamination Mechanisms, and Background Levels

The major potential environmental routes of exposure to man are:

- (a) Inhalation of ^{222}Rn and its daughter products, resulting from the continuous radioactive decay of ^{226}Ra in the tailings. Radon is a gas which diffuses from the piles. The principal exposure results from inhalation of the ^{222}Rn and Rn daughters. This exposure affects the lungs. For this assessment, no criteria have been established for radon concentrations in air. However, the pathway for radon and radon daughters accounts for the major portion of the exposure to the population.
- (b) External whole-body gamma exposure directly from radionuclides in the piles.
- (c) Inhalation and ingestion of windblown tailings. The primary health effect relates to the alpha emitters ^{230}Th and ^{226}Ra , each of which causes exposure to the bones and lungs.
- (d) Ingestion of ground and surface water contaminated with radioactive elements (primarily ^{226}Ra) and other toxic materials.
- (e) Contamination of food through uptake and concentration of radioactive elements by plants and animals is another pathway which can occur; however, this pathway was not considered further in this study.

1.3.1.1 Radon Gas Diffusion and Transport

Short-term radon measurements were performed with ERDA supplied continuous radon monitors at 12 locations in the vicinity of the two Rifle tailings piles. The locations and values of the 24-hr radon concentrations including background are shown in Figure 3-3, Chapter 3. The highest outdoor radon concentration was measured on the Old Rifle pile (180 pCi/l). Background measurements of atmospheric radon at four locations from 0.5 to 2.0 mi from the sites averaged 1.2 pCi/l. Radon above the average background level was detected to 0.8 mi from the site.

1.3.1.2 Direct Gamma Radiation

The range of natural background values in the Rifle area was between 8 and 15 $\mu\text{R/hr}$ averaging 12 $\mu\text{R/hr}$ as measured 3 ft above ground with an energy compensated Geiger Mueller detector.⁽²⁾ Above the surface of the Old Rifle and New Rifle tailings piles, gamma radiation rates ranged to a maximum of 780 $\mu\text{R/hr}$. In the mill and ore storage areas at New Rifle, gamma radiation rates varied from two times background value to 640 $\mu\text{R/hr}$. At the Old Rifle mill and ore storage areas, gamma radiation rates ranged up to 230 $\mu\text{R/hr}$.

1.3.1.3 Windblown Contaminants

Prevailing winds in the area are from the west and east along the valley. Surface soil samples indicate some windblown contamination to the east of the two piles. Limited windblown contamination toward the east is also shown by the iso-exposure lines illustrated in Figures 3-10A and B, Chapter 3, which were obtained by EPA from gamma radiation measurements.

1.3.1.4 Ground and Surface Water Contamination

Twenty-one water samples taken from the Colorado River, standing water, a spring, and a well in the vicinity of the piles ranged in ^{226}Ra content from 0.03 to 13.0 pCi/l. There is evidence of contamination of the surface water adjacent to the Rifle tailings piles, and the hydrologic conditions at the site indicate a potential for groundwater contamination. Monitoring of the Colorado River for several years up- and downstream from the tailings showed radium concentration to be far below the maximum acceptable for the EPA Interim Drinking Water Standards.

1.3.1.5 Soil Contamination

The leaching of radium from the tailings into the subsoil at both sites generally extends to about 4 ft before reaching twice the average background concentration of radium concentration in the soil. The average background concentration of ^{226}Ra in soil from western Colorado is 1.5 pCi/g.⁽²⁾ In the ore storage areas there are isolated locations where contamination reaches at least 5 ft deep.

1.3.2 Remedial Action Criteria

Radiological criteria established for this engineering assessment are divided into two general categories:

- (a) Criteria applicable to structures with tailings underneath them or within 10 ft
- (b) Criteria pertaining to the mill tailings site and open land

The criteria utilized for habitable structures are the guidelines published by the Surgeon General of the United States for use in the Grand Junction, Colorado, remedial program. These guidelines recommend graded levels for remedial action in terms of the external gamma radiation (EGR) levels and of the indoor radon daughter concentration (RDC) levels above background found within dwellings constructed on or near uranium mill tailings. (In this usage, the word "external" refers to gamma radiation from sources outside the human body to which an individual may be exposed.)

The recommended graded levels are as follows:

<u>EGR</u>	<u>RDC^a</u>	<u>Recommendations</u>
Greater than 0.1 mR/hr ^b	Greater than 0.05 WL ^c	Remedial action indicated
From 0.05 to 0.1 mR/hr	From 0.01 to 0.05 WL	Remedial action may be suggested
Less than 0.05 mR/hr	Less than 0.01 WL	No remedial action indicated

^aBased upon yearly average values from six air samples of at least 100-hr duration taken at a minimum of 4-wk intervals throughout the year

^bmR/hr = milliroentgen per hour, a measure of gamma radiation,
1 mR/hr = 1,000 μ R/hr

^cWL = working level, a measure of alpha radiation from short-lived radon daughter elements

The criteria for land decontamination have the objective of reducing residual gamma radiation to levels which are as low as practicable. However, topographic and economic considerations frequently preclude complete decontamination. A provisional maximum of 40 μ R/hr above background is used in such circumstances. Average background in the Rifle area was determined in this study to be 12 μ R/hr. As a guideline for the land beyond the site, if residual gamma levels are less than 10 μ R/hr above background, the land may be released for unrestricted use. Where cleanup is necessary the radium content of the soil should be reduced to no more than twice the radium background in the area. If the radioactive tailings material is stabilized in place, the same criteria apply but control of gamma radiation would be by an earth covering. However, the area should be designated a controlled area, be fenced to limit access, and be restricted as to human occupancy. The numerical guidelines provide a basis for the engineering assessment, but are subject to review based on the overall findings of Phase II.

The radium and gross alpha content of ground and surface water should meet applicable state and federal standards.

1.3.3 Potential Health Impact

Radon gas exhalation from the piles and the subsequent inhalation of radon daughters account for most of the total dose to the population from the Rifle site under present conditions. The gamma radiation exposure from the piles is essentially zero since there are very few persons who live or work within 0.2 mi of the piles where gamma radiation is above background.

Gamma radiation can be reduced effectively by shielding with any dense material. However, experience has shown that it is very

difficult to control the movement of radon gas through porous solid materials. Once released from the radium-bearing minerals in the tailings, the gaseous radon diffuses by the path of least resistance to the surface. The radon has a half-life of about 4 days, and its daughter products are solids. Therefore, part of the radon decays en route to the surface and leaves daughter products within the tailings piles. If the diffusion path can be made long enough, then, theoretically, substantially all the radon and its daughter products can be made to decay before escaping to the atmosphere. Calculations using the techniques of Kraner, Schroeder, and Evans⁽³⁾ indicate that 13 ft of earth cover theoretically would be required to reduce the radon diffusion from the Rifle tailings by 95%.

The health significance to man of long-term exposure to radiation is a subject that has been studied extensively for many years. The end results of long-term exposure to low-level radiation is increased susceptibility to diseases such as lung cancer or leukemia, which also are attributable to many other causes. Therefore, the determination of specific cause in any given case becomes very difficult. Therefore, the usual approach to evaluation of the health impact of low-level radiation exposures is to make projections from observed effects of high exposures on the premise that the effects are linear. A considerable amount of information has been accumulated on the high incidence of lung cancer in uranium miners exposed to radon and its daughters in mine air. This provides a basis for calculating the probable health effects of low-level exposure to large populations. (The term "health effect" refers to an incidence of disease; for radon daughter exposure, 1 health effect = 1 case of lung cancer.) This is the basis of the health effects calculations in this report. It should be recognized, however, that there is a large degree of uncertainty in such projections. Among the complicating factors is the combined effect of radon daughters with other carcinogens. As an example, the incidence of lung cancer among uranium miners who smoke is far higher than can be explained on the basis of either smoking or the radiation alone.

The risk estimators used in this report are given in the report of the National Academy of Sciences Advisory Committee on the Biological Effects of Ionizing Radiation (BEIR report).⁽⁴⁾ This report presents risk estimators for lung cancer derived from epidemiological studies of both uranium miners and fluorspar miners. The average of the absolute risk estimator for these two groups is: 6 cancers per year per 10^6 person-WLM exposure. The term WLM means working level month, or an exposure to a concentration of one working level of radon daughter products in air for 170 hr, which is a work-month. A working level (WL) is a unit of measure of radon daughter products which recognizes that the several daughter elements are frequently not in equilibrium with each other nor with the parent radon. Because of the many factors which contribute to natural biological variability, and of the many differences between exposure conditions in mines and residences, this estimator (6 cancer cases per year per 10^6 person-

WLM) is considered to have an uncertainty factor of about 3. The relative risk estimator can be several factors larger than the absolute risk estimator. (5)

For the purpose of the mill tailings assessment, it was assumed that about 50% equilibrium exists inside structures between radon and its daughter elements resulting in the following conversion factors:

$$1 \text{ pCi/l of } ^{222}\text{Rn} = 0.005 \text{ WL}$$

For continuous exposure:

$$0.005 \text{ WL} = 0.25 \text{ WLM/yr}$$

On the basis of measurements of radon concentrations in excess of background values, it is calculated that the average radon-induced lung cancer risk due to the piles in the area within 2.0 mi from the Rifle site is 1.1×10^{-5} per person per year, or about 6% of the average cancer risk due to all causes for Colorado residents (1.8×10^{-4}). (6)

The 25-yr health effects were calculated for three population projections using a present population of 2,300 in the area within 0 to 2.0 mi of both piles. The results for pile-induced Rn and background Rn were as follows:

25-Yr Cumulative Health Effects 0-2.0 Mi from Edge of Piles

<u>Projected Population Growth</u>	<u>Pile-Induced RDC</u>	<u>Background RDC</u>
Static	0.60	3.0
0.8% growth rate	0.66	3.3
10% growth rate ^a	1.43	7.2

^aThis growth rate decreases linearly with time to zero in 25 yr

Pile-induced radon daughter health effects are approximately 20% of the background radon daughter health effects for the 0.8% growth rate. The exposure and consequent risk will continue as long as the radiation source remains in its present location and condition.

1.3.4 Nonradioactive Pollutants

There are other potentially toxic materials in the tailings. Chemical analyses of tailings samples from drill holes on the Rifle tailings piles show arsenic and selenium at about 5 ppm, and lead, chromium and barium content between 10 and 280 ppm. All samples of surface waters in the vicinity of the Rifle tailings

pile contained selenium in concentrations above the EPA Interim Drinking Water Standards. However, the contamination was found upstream as well as down and cannot be definitely ascribed to the tailings pile. While there is no definitive evidence demonstrating the contamination of the surface or unconfined ground water in the vicinity of the tailings, the hydrologic conditions of the site indicate a potential for contamination.

1.4 SOCIOECONOMIC AND LAND USE IMPACTS

The area near the Old Rifle site is grazing land, vacant land, or sand and gravel pits. A relatively new housing development and a new hospital are within 2,000 ft northwest of the tailings and virtually all of the town of Rifle lies within a mile of the site. Except for a strip development of homes and commercial units along the highway between Rifle and the New Rifle mill, there are no population concentrations near the New Rifle site.

The Rifle Planning Commission has recommended that no development take place on the site except those industrial uses selected by Union Carbide. At present, there are virtually no pressures to introduce new land uses for either site. The location of the sites between the river and highway, the lack of industrial expansion and the availability of other land, severely reduces pressures for development of the sites for other land uses.

The listed values of land (30% assessed value without improvements) between the railroad and the Colorado River is less than \$1.00/acre. The land north of the railroad near the Old Rifle site ranges in listed value from less than \$1.00/acre to \$100.00/acre. The presence of the tailings at both Rifle sites limits the uses of the sites and their land values but the tailings do not appear to have had an extensive effect on existing land uses and values off the site. Recent land sales have ranged from \$200/acre to \$2,000/acre.

1.5 RECOVERY OF RESIDUAL VALUES

Estimates of the uranium content of the Rifle tailings by the AEC indicate an average U_3O_8 concentration of 0.049% for the Old Rifle tailings and 0.038% for the New Rifle tailings. The average U_3O_8 concentration for the combined tailings is 0.039%. This concentration is in a range where reprocessing is economically viable.

There are five factors that should be employed to evaluate whether reprocessing the Rifle tailings to extract residual uranium and other mineral values would be practicable:

- (a) The amount of tailings present
- (b) Concentrations of residual values
- (c) Projected recovery

(d) Current market price of recovered values

(e) Proximity to processing mills

Based on the aforementioned criteria, reprocessing of either the Old Rifle tailings alone or the combined Old and New Rifle tailings appears to be sufficiently attractive to justify reprocessing in conjunction with each of the options presented.

1.6 MILL TAILINGS STABILIZATION

Present practices and technology of mill tailings stabilization are being examined. This investigation indicates that much research and development remains to be performed before complete and permanent stabilization of radioactive mill tailings can be realized.

Reasonably effective means of wind and water erosion control are available, although they will involve continued maintenance costs. Lining of containment areas or chemical solidification of the tailings are possible methods for control of leaching.

Up to this time, no attempt has been made to contain radon in a tailings pile. Although a thick earth cover is theoretically effective, it has not actually been tried. The observed variability of radon exhalation rates indicates that with better understanding of the mechanism involved, control may be possible.

The existing cover and vegetation on the Old Rifle tailings has been effective in controlling tailings erosion from wind and rainfall and provides partial control over gamma radiation, but little control over radon exhalation. With great effort, a vegetative cover has been established on the New Rifle tailings. Irrigation is continuing to aid the present vegetation and to keep bare tailings areas wet and thus reduce wind erosion.

1.7 OFF-SITE REMEDIAL ACTION

A mobile scanning unit, operated by the AEC under interagency agreement with the EPA, was used to perform a gamma radiation survey of the Rifle, Colorado area in 1971. A subsequent field survey identified 74 off-site locations where tailings-use was suspected or confirmed to be within 10 ft of any structure. The cost of remedial action for these locations has been estimated to be \$952,000. Cleanup of the windblown tailings surrounding the two sites has been estimated to cost a total of \$140,000. The total remedial action cost for off-site structures and for decontamination of off-site open lands has been estimated to be \$1,092,000, exclusive of engineering costs and contingency.

1.8 LONG-TERM STORAGE SITE SELECTION

Eight of the alternative remedial actions options include moving the Rifle tailings to a long-term (greater than 50 yr)

storage site. The sites were selected after consultation with the Colorado State Division of Wildlife, local and federal agencies, concerned individuals, and personnel in industry. Each site was evaluated on the basis of hydrology, meteorology, geology, ecology, economics, and proximity to population centers. The seven sites (two of the options are at the same site) were selected from a total of 15 sites initially considered.

The sites referred to in Table 1-2B under Options VIII through XV are shown on a map in Figure 8-1, Chapter 8. In each of these options, surface material would be removed and stockpiled and a retaining dike and diversion ditches would be constructed if necessary. The tailings would be emplaced, contoured, and covered with 2 ft of cover from the stockpiled material, and fenced. In all options, continuing maintenance would be required to repair fences and erosion of the cover material. These annual maintenance costs have been provided for by a sinking fund in costing each option.

1.9 REMEDIAL ACTIONS AND COST-BENEFIT ANALYSES

1.9.1 Remedial Action Options

The remedial options examined cover a range from: (a) basically leaving the piles as they now are but providing for off-pile and off-site decontamination and remedial actions to (b) stabilizing the piles in place to (c) removal of all radioactive materials to an area for long term storage where they could be isolated from the public.

Options I through III relate to the Old Rifle site, and IV through XV to the New Rifle site.

1.9.1.A Old Rifle Site

The options for which cost estimates were made include off-pile and off-site decontamination, one level of stabilization on the present site and one option for the removal of the tailings to the New Rifle site. The options are summarized in Table 1-2A.

The base case, from which the cost and effectiveness of other remedial alternatives can be judged, is the first option examined. In Option I no work is done to the pile, but the millsite and ore storage areas are decontaminated as well as off-site areas contaminated by windblown tailings. The tailings are completely fenced and maintained. Also a surface drainage problem would be corrected. This option would not reduce direct exposure nor reduce radon gas exhalation from the tailings, and would not increase protection from wind and water erosion.

Option II adds to Option I the cost for more completely stabilizing the pile by the addition of 1.5 ft of cover, making it a total of 2 ft, and the construction of additional dike protection in the form of riprap at the base of the pile. Wind and water ero-

sion of the tailings would be controlled; however, radon exhalation would be reduced at most by 25%. The site still would be unsuitable for most uses. Option III would relocate the tailings to the New Rifle mill and the site would be completely decontaminated, leaving it free from any radiation contamination.

1.9.1.B New Rifle Site

The options for which cost estimates were made include off-site decontamination at structures and lots, three levels of stabilization of the present site, and the removal of both the Old and New Rifle tailings to seven possible locations for long-term storage. The options are summarized in Table 1-2B.

The base case, from which the cost and effectiveness of other remedial alternatives for the New Rifle tailings can be judged, is Option IV. In Option IV the pile is not affected but required off-site remedial action is taken in the form of cleanup of areas where tailings have been taken or have been dispersed by wind. This option would not reduce direct exposure, wind and water erosion, nor reduce radon gas exhalation from the tailings.

Option V assumes the addition of the Old Rifle tailings to the New Rifle pile after reprocessing and adds to Option IV the cost for more completely stabilizing the resulting pile by spreading it over a larger area, decreasing the slope of the pile, and adding 2 ft of cover. Wind and water erosion of the tailings would be controlled; however, radon exhalation would be reduced very little. The site still would be unsuitable for most uses. Option VI involves adding 9 ft of cover to the reshaped pile. Option VII is the same as Option V except that 13 ft of cover would be provided, which would reduce radon exhalation by 95%.

Seven sites involving eight options were evaluated as possible long-term storage sites for the tailings (both the Old and New) including preparation of cost estimates.

The lowest cost alternative site is the one closest to the tailings, which is in Hubbard Gulch on BLM property north of the site, and west of Rifle. Transportation of the tailings could be by off-road haul vehicles, a conveyor system, or by conventional truck-trailer combination vehicles. The Helmer Gulch site is the next closest site, and is in an area formerly used for a land fill dump and is south of the site, across the freeway and the river. It is also on BLM land.

West of Rifle, about 6.3 mi from the tailings, there is a site at the east side of Sharrard Park on the west edge of Webster Mesa. This is in a natural basin on desolate land under private ownership.

Two of the sites are north of Rifle. One is west of Rifle Gap and the other is on the west side of a gravelled road which leads to Hubbard Mesa. These sites have the advantage of isola-

tion, but the disadvantage of the necessity for hauling the tailings through populated areas of the city. Both are on BLM property.

The Dry Creek area site is southeast of Rifle and the airport which serves the community. It is in an area currently being used as a dump by Garfield County. Tailings stored here could be located upslope from the landfill operations, or in an adjacent basin just west of the area. The tailings would be well sheltered from winds and truck traffic would be through less populated areas.

The site at DeBeque has the advantage of being of sufficient size to handle the Rifle tailings and the tailings from the pile located at Grand Junction, Colorado. Rail transport is proposed for this location which is approximately midway between Rifle and Grand Junction. The same railroad line borders both sites and is near the disposal site which is at the head of a rugged canyon 1.5 mi northeast of the community of DeBeque, Mesa County, Colorado.

1.9.2 Cost-Benefit Analyses

As summarized in Tables 1-2A and 1-2B, the total costs for the three remedial action options at Old Rifle vary from \$224,000 to \$410,000 and the 11 remedial action options at New Rifle vary from \$1,800,000 to \$20,300,000 (not counting the option which considers joint storage with the Grand Junction tailings). Each of these costs would yield a distinct health and monetary benefit. The number of cancer cases avoided per million dollars expended for each option is given in Figure 9-3, Chapter 9. The option numbers are identified as follows:

<u>Option</u>	<u>Description</u>
<u>Old Rifle:</u>	
I	Decontamination, drainage modifications
II	Stabilization in place with 2-ft cover
III	Removal of tailings to New Rifle for reprocessing, site and area decontamination
<u>New Rifle:</u>	
IV	Decontamination of off-site structures and lots, dike raising
V	Stabilization in place with 2-ft cover

VI	Stabilization in place with 9-ft cover
VII	Stabilization in place with 13-ft cover
IX	Removal to Hubbard Gulch
X	Removal to Helmer Gulch
XI	Removal to Rifle Gap area
XII	Removal to Hubbard Mesa area
XIII	Removal to Dry Creek area
XIV	Removal to DeBeque area (stored alone)
XV	Removal to DeBeque area (stored with the Grand Junction tailings)

The curves in Figure 9-3, Chapter 9, indicate an increase in the health benefit/cost ratio with time due to the increasing number of health effects avoided. The potential cancer cases avoided for each option and the cost per potential cancer case avoided are given in Table 9-2, Chapter 9.

TABLE 1-1
SUMMARY OF CONDITIONS NOTED AT TIME OF PHASE I SITE VISITS^a

	Cond. of Tailings	Cond. of Structures on Site	Mill Housing	Adequate Fencing, Posting, Security	Property Close by River or Stream	Houses- Industry w/in 1/2 Mile	Evidence of Wind Water Erosion	Possible Water Contami- nation	Tailings Removed for Pri- vate Use	Other Hazards On-site
<u>ARIZONA</u>										
Monument	U	R	N	No	No	Yes	No	No	No	No
Tuba City	U	PR-UO	E-O	No	No	Yes	Yes	No	No	Yes
<u>COLORADO</u>										
Durango	P	PR-UO	N	Yes	Yes	Yes	Yes	No	Yes	Yes
Grand Junction	S	PR-O	N	Yes	Yes	Yes	No	No	Yes	No
Gunnison	S	B-O	N	Yes	No	Yes	No	Yes	No	No
Maybell	S	R	N	Yes	No	No	No	No	No	No
Naturita	S	PR-O	E-P	Yes	Yes	No	Yes	Yes	No	No
New Rifle	P	M-O	N	Yes	Yes	Yes	Yes	Yes	No	No
Old Rifle	S	PR-UO	N	Yes	Yes	Yes	No	Yes	Yes	No
Slick Rock (NC)	S	R	N	No	Yes	Yes	Yes	No	No	No
Slick Rock (UCC)	S	R	E-P	Yes	Yes	Yes	No	No	No	No
<u>IDAHO</u>										
Lowman	U	R	N	No	Yes	Yes	No	No	Yes	No
<u>NEW MEXICO</u>										
Ambrosia Lake	U	PR-O	N	Yes	No	No	Yes	No	No	No
Shiprock	P	PR-O	E-O	Yes	Yes	Yes	No	No	Yes	Yes
<u>OREGON</u>										
Lakeview	U	M-UO	N	Yes	No	Yes	Yes	No	No	No
<u>TEXAS</u>										
Falls City	P	M-UO	N	Yes	No	No	No	No	No	No
Ray Point	P	M-UO	N	Yes	No	No	No	No	No	No

TABLE 1-1 (Cont)

	Cond. of Tailings	Cond. of Structures on Site	Mill Housing	Adequate Fencing, Posting, Security	Property Close by River or Stream	Houses- Industry w/in 1/2 Mile	Evidence of Wind Water Erosion	Possible Water Contami- nation	Tailings Removed for Pri- vate Use	Other Hazards On-site
<u>UTAH</u>										
Green River	S	B-O	N	Yes	No	Yes	Yes	Yes	No	No
Mexican Hat	U	B-O	E-O	No	No	Yes	Yes	Yes	No	No
Salt Lake City	U	R	N	No	Yes	Yes	Yes	Yes	Yes	Yes
<u>WYOMING</u>										
Converse County	U	R	N	No	No	No	No	No	No	No

(1) S - Stabilized but requires improvement

P - Partially stabilized

U - Unstabilized.

(2) M - Mill intact

B - Building(s) intact

R - Mill and/or buildings removed

PR- Mill and/or buildings
partially removed

O - Occupied or used

UO- Unoccupied or unused.

(3) N - None

E - Existing

O - Occupied

P - Part occupied.

^aThis table does not necessarily represent conditions at the present time.

TABLE 1-2A

SUMMARY OF REMEDIAL ACTION OPTIONS AND EFFECTS, OLD RIFLE SITE

<u>Option Number</u>	<u>Cost (\$000)</u>	<u>Description of Remedial Action</u>	<u>Benefits</u>	<u>Adverse Effects</u>
I	224	On-site contaminated soil would be cleaned up as would off-site windblown tailings. Modification to upslope drainage is included.	A B	V X W Y Z
II	402	In addition to Option I actions, the pile would be stabilized with the addition of 1.5 ft of local earth cover, and natural vegetation would be established. The area between the pile and the railroad would be strengthened with the addition of riprap.	A C D E F	V W X
III	410	The tailings, contaminated soil and rubble would be removed from the site and taken to the New Rifle plant where the tailings would be reprocessed. The contaminated soil and material would be moved to the tailings pile. Cleanup and decontamination would be as in Option I.	A H I	

Definition of Benefits

- A. On-site windblown tailings cleaned up
- B. Wind and water erosion controlled, moderately
- C. Wind and water erosion controlled
- D. Site not used for tailings available for limited other uses
- E. Less likelihood of Colorado River flood washing away tailings
- F. Radon exhalation reduced by 25%
- H. The source of gamma radiation and radon gas removed from site
- I. Total tailings site available for unrestricted usage

TABLE 1-2A (Cont)

Definition of Adverse Effects

- V. Some security and maintenance required
- W. Tailings remain in the center of a growing area
- X. Restricted use of tailings site
- Y. No decrease in radon exhalation
- Z. No decrease in gamma radiation

Costs are in 1977 thousands of dollars

TABLE 1-2B

SUMMARY OF REMEDIAL ACTION OPTIONS AND EFFECTS, NEW RIFLE SITE

<u>Option Number</u>	<u>Cost (\$000)</u>		<u>Benefits</u>	<u>Adverse Effects</u>
IV	1,800	Off-site contaminated soil would be cleaned up and off-site remedial action would be taken at lots and structures.	A B	W Y X Z
V	2,400	The pile would be re-contoured and stabilized with 2 ft of local earth cover, and natural vegetation would be established. On-site contaminated soil would be cleaned up.	A B C D E	V X
VI	3,200	The scope of the work would be the same as for Option V except that 9 ft of earth cover would be placed on the pile.	A D B F C	V X
VII	3,500	The scope of work would be the same as for Option V except that 13 ft of earth cover would be placed on the pile.	A G B H C	V X
VIII	11,200	The tailings, contaminated soil and rubble would be removed from the site to a long-term storage area in Hubbard Gulch where the tailings would be buried and stabilized. Native vegetation would be reestablished both on the site and at the long-term storage site. Cleanup and decontamination would be as in Option IV.	A B C J	V

TABLE 1-2B (Cont)

<u>Option Number</u>	<u>Cost (\$000)</u>	<u>Description of Remedial Action</u>	<u>Benefits</u>		<u>Adverse Effects</u>
IX	13,100	Same as Option VIII except the tailings would be removed to a location in the Helmer Gulch area.	A B	C J	V
X	14,500	Same as Option VIII except tailings would be removed to a location in the Sharrard Park area.	A B	C J	V
XI	14,700	Same as Option VIII except tailings would be removed to the Rifle Gap area storage site.	A B	C J	V
XII	15,500	Same as Option VIII except tailings would be removed to a site in the Hubbard Mesa area.	A B	C J	V
XIII	15,700	Same as Option VIII except tailings would be removed to a site southeast of Rifle in the Dry Creek area.	A B	C J	V
XIV	20,300	Same as Option VIII except tailings would be removed by rail to the DeBeque area.	A B	C J	V
XV	32,200	Same as Option VIII except tailings would be stored at the DeBeque site with the Grand Junction tailings. Cost given is total cost for storing Rifle and Grand Junction tailings.	A B C	I J	V

Notes

1. All New Rifle options include all of the off-site remedial actions and tailings cleanup in the area generally west of the tailings.
2. For Options VIII through XV, costs include removal of 4 ft of contaminated earth below the tailings, but not for backfill to bring the area up to a previous natural grade.

TABLE 1-2B (Cont)

Notes (Cont)

3. Costs are in 1977 thousands of dollars.

Definition of Benefits

- A. Off-site tailings cleaned up
- B. On-site windblown tailings cleaned up west of pile
- C. Wind and water erosion controlled
- D. Site not used for tailings available for limited other uses
- E. Less likelihood of Colorado River flood washing away tailings
- E. Radon exhalation reduced by 25%
- F. Radon exhalation reduced by 80%
- G. Radon exhalation reduced by 95%
- H. Site area not occupied by tailings or mill facilities available for other uses
- I. Shared costs with Grand Junction removal results in cost savings
- J. Unrestricted use of the site after decontamination or removal of mill facilities

Definition of Adverse Effects

- V. Some security and maintenance required indefinitely
 - W. Extensive maintenance required indefinitely
 - X. Restricted use of tailings site
 - Y. No decrease in radon exhalation
 - Z. No decrease in gamma radiation
-
-

CHAPTER 1 REFERENCES

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4. "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation"; Report of Advisory Committee on Biological Effects of Ionizing Radiation; NAS, National Research Council; Nov 1972.
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6. Vital Statistics of the U. S.; Vol II; Mortality; National Center for Health Statistics; HEW; 1968.

ADDENDUM

FIGURES AND TABLES

(The figures and tables contained on the following pages have been extracted from chapters of the parent report.)

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FIGURE 2-1A. AERIAL PHOTOGRAPH OF OLD RIFLE SITE

FIGURE 2-1B, AERIAL PHOTOGRAPH OF NEW RIFLE SITE

FIGURE 2-3A. DESCRIPTIVE MAP, OLD RIFLE

SYSTEM	FORMATION	THICK- NESS (FT)	CHARACTER	POSITION OF THE TAILINGS
TERTIARY	GREEN RIVER FORMATION	500 - 4,500	WHITISH GRAY WEATHERED SILTSTONES AND SAND- STONES WITH OIL SHALE, NAHCOLITE, AND HALITE DEPOSITS; CAPS MESAS; AN AQUIFER AT SOME LOCALITIES	RIFLE TAILINGS PILES ←
	WASATCH FORMATION	1,000 - 5,500	BRIGHTLY COLORED SHALE BEDS, OCCASIONAL SANDSTONES, CONGLOMERATES, AND LIMESTONES; FORMS VALLEYS AND SLOPES; AQUICLUDE ALTHOUGH SANDSTONES COULD YIELD SOME WATER	
	OHIO CREEK FORMATION	50 - 150	SERIES OF MASSIVE, LIGHT COLORED COARSE SANDSTONES, AND COARSE TO VERY COARSE CON- GLOMERATES; POTENTIAL LOW QUALITY AQUIFER	
CRETACEOUS	MESAVERDE FORMATION	1,000- 5,600	FINE TO COARSE-GRAINED SANDSTONE WITH INTER- BEDDED SHALES, SANDY SHALES AND OCCASIONAL COAL BEDS; FORMS PROMINENT BENCHES, RIDGES, AND CLIFFS; AQUIFER	
	MANCOS SHALES	2,000 - 5,000	GRAY SHALE; FORMS VALLEYS AND SLOPES; AQUICLUDE	
OLDER SEDIMENTARY ROCKS				

FIGURE 2-5. SIMPLIFIED STRATIGRAPHIC COLUMN

130-09

FIGURE 3-3. RADON CONCENTRATION IN VICINITY OF PILES

NOTE:
 REFERENCE: TECHNICAL NOTE
 ORP/LV-75-5, GAMMA RADIATION
 SURVEYS AT INACTIVE URANIUM
 MILLSITES, USEPA, LAS VEGAS,
 NEVADA, AUGUST 1975, FIGURE 8
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FIGURE 3-10A. EPA GAMMA SURVEY SURROUNDING OLD RIFLE MILLSITE

130-09

NOTE:

REFERENCE: TECHNICAL NOTE
ORP/LV-75-5 GAMMA RADIATION
SURVEYS AT INACTIVE URANIUM
MILLSITES, USEPA, LAS VEGAS,
NEVADA, AUG 1975, FIGURE 9
PAGE 53

FIGURE 3-10B. EPA GAMMA SURVEY SURROUNDING NEW RIFLE MILLSITE

FIGURE 8-1. LOCATION OF PROPOSED STORAGE SITES

FIGURE 9-3. POTENTIAL CANCER CASES AVOIDED PER MILLION DOLLARS EXPENDED

130-09

TABLE 2-1
TAILINGS SITE MATERIALS

<u>Site</u>	<u>Material</u>	<u>Volume (yd³)</u>	<u>Weight* (tons)</u>
NEW RIFLE			
	Tailings	2,000,000	2,700,000
	Fertilizer and Mulch	<u>1,000</u>	<u>1,000</u>
	Rounded Total	2,000,000	2,700,000
OLD RIFLE			
	Tailings	259,000	350,000
	Stabilization Cover	6,000	10,250
	Rubble	<u>150</u>	<u>300</u>
	Rounded Total	266,000	360,000
* Weight based on average existing field densities which includes moisture			

TABLE 9-2

POTENTIAL CANCER CASES AVOIDED AND COST
PER POTENTIAL CANCER CASE AVOIDED
FOR OLD RIFLE PILE

A. NUMBER OF POTENTIAL CANCER CASES AVOIDED			
Options:	I	II	III
Option Costs (in million \$)	0.22	0.40	0.39
Years After Remedial Action			
25	0	0.1	0.3
50	0	0.2	0.6
75	0	0.3	0.9
100	0	0.5	1.4
Potential Cancer Cases After 100 yr	3.6	3.1	2.2
B. COST PER POTENTIAL CANCER CASE AVOIDED (Million \$)			
Options:	I	II	III
Option Costs (in million \$)	0.22	0.40	0.39
Years After Remedial Action			
25	--	4.4	1.6
50	--	2.0	0.7
75	--	1.2	0.4
100	--	0.8	0.3