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A SUMMARY OF THE
ENGINEERING ASSESSMENT OF
INACTIVE URANIUM-MILL TAILINGS:

CANONSBURG SITE,
CANONSBURG, PENNSYLVANIA

MASTER

APRIL 1982

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PREPARED FOR
UNITED STATES DEPARTMENT OF ENERGY
ALBUQUERQUE OPERATIONS OFFICE
URANIUM MILL TAILINGS
REMEDIAL ACTIONS PROJECT OFFICE
ALBUQUERQUE, NEW MEXICO
CONTRACT NO. DE-AC04-76GJ01658

BY

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CANONSBURG SITE
CANONSBURG, PENNSYLVANIA

April 1982

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Prepared for
U.S. DEPARTMENT OF ENERGY
ALBUQUERQUE OPERATIONS OFFICE
URANIUM MILL TAILINGS REMEDIAL ACTIONS
PROJECT OFFICE
ALBUQUERQUE, NEW MEXICO

Contract No. DE-AC04-76GJ01658

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NOTICE

This engineering assessment has been performed under DOE Contract No. DE-AC04-76GJ01658 between the U.S. Department of Energy and Ford, Bacon & Davis Utah Inc.

Copies of this report may be obtained from the Uranium Mill Tailings Remedial Action Project Office, U.S. Department of Energy, Albuquerque Operations Office, Albuquerque, New Mexico 87115.

FOREWORD

This report is a summary of a parent report (issued under separate cover), entitled "Engineering Assessment of Inactive Uranium Mill Tailings, Canonsburg Site, Canonsburg, Pennsylvania." Both reports have been authorized by the U.S. Department of Energy (DOE), Albuquerque Operations Office, Uranium Mill Tailings Remedial Action Project Office, Albuquerque, New Mexico, under Contract No. DE-AC04-76GJ01658.

Ford, Bacon & Davis Utah Inc. (FB&DU) has received excellent cooperation and assistance in obtaining new data to prepare these reports. Special recognition is due Richard H. Campbell and Mark Matthews of DOE. Several local, county, and state agencies contributed information, as did many private individuals.

ABSTRACT

Ford, Bacon & Davis Utah Inc. has evaluated the Canonsburg site in order to assess the problems resulting from the existence of radioactive residues at Canonsburg, Pennsylvania. This engineering assessment has included the preparation of topographic maps, radiometric measurements sufficient to determine areas and volumes of tailings and radiation exposures of individuals and nearby populations, the investigations of site hydrology and meteorology, and the evaluation and costing of alternative remedial actions.

Radon gas released from the approximately 300,000 tons of tailings and contaminated soil at the Canonsburg site constitutes the most significant environmental impact, although windblown tailings and external gamma radiation also are factors. The four alternative actions presented in this engineering assessment range from millsite and off-site decontamination with the addition of 3 m of stabilization cover material (Option I), to removal of the tailings and contaminated materials to a remote disposal site and decontamination of the Canonsburg site (Options II through IV). Cost estimates for the four options range from \$23,244,000 for stabilization in-place, to \$27,052,000 for disposal at a distance of about 17 mi.

Three principal alternatives for the reprocessing of the Canonsburg tailings were examined:

- (a) Heap leaching
- (b) Treatment at an existing mill
- (c) Reprocessing at a new conventional mill constructed for tailings reprocessing

As required by Public Law 95-604, under whose auspices this project is conducted, the U.S. Department of Energy has solicited expressions of interest in reprocessing the tailings and residues at the Canonsburg site for uranium recovery. Since no such interest was demonstrated, no effort has been made to estimate the value of the residual uranium resource at the Canonsburg site.

CHAPTER 1

A SUMMARY OF THE ENGINEERING ASSESSMENT OF INACTIVE URANIUM MILL TAILINGS

TABLE OF CONTENTS

<u>Chapter</u>	<u>Title</u>	<u>Page</u>
	Notice.	ii
	Foreword.	iii
	Abstract.	iv
1	A SUMMARY OF THE ENGINEERING ASSESSMENT OF INACTIVE URANIUM MILL TAILINGS	1-1
	1.1 Introduction	1-1
	1.1.1 Background.	1-2
	1.1.2 Scope of Phase II Engineering Assessment.	1-4
	1.2 Site Description	1-6
	1.2.1 Location and Topography	1-6
	1.2.2 Ownership and History of Milling Operations and Processing	1-6
	1.2.3 Present Condition of the Site	1-7
	1.2.4 Tailings and Soil Characteristics	1-8
	1.2.5 Geology, Hydrology, and Meteorology	1-9
	1.3 Radioactivity and Pollutant Impacts on the Environment	1-10
	1.3.1 Radiation Exposure Pathways, Contamination Mechanisms, and Background Levels	1-11
	1.3.1.1 Radon Gas Diffusion and Transport.	1-11
	1.3.1.2 Direct Beta-Gamma Radiation On Site.	1-12
	1.3.1.3 Windblown Contaminants	1-13
	1.3.1.4 Ground and Surface Water Contamination.	1-13
	1.3.1.5 Soil Contamination	1-14
	1.3.2 Remedial Action Criteria.	1-14
	1.3.3 Potential Health Impact	1-16
	1.3.4 Nonradioactive Pollutants	1-18
	1.4 Socioeconomic and Land Use Impacts	1-18
	1.5 Recovery of Residual Values.	1-19
	1.6 Mill Tailings Stabilization.	1-19

TABLE OF CONTENTS (Cont)

<u>Chapter</u>	<u>Title</u>	<u>Page</u>
1.7	Off-Site Remedial Action	1-20
1.8	Disposal Site Selection.	1-21
1.9	Remedial Actions and Cost-Benefit Analyses	1-22
1.9.1	Remedial Action Options	1-22
1.9.2	Cost-Benefit Analyses	1-22
Table 1-1	Summary of Conditions Noted at Time of 1980 Site Visits	1-24
Table 1-2	Summary of Remedial Action Options and Effects	1-26
Chapter 1	References.	1-28
ADDENDUM, FIGURES AND TABLES.		1-30

CHAPTER 1

A SUMMARY OF THE ENGINEERING ASSESSMENT OF INACTIVE URANIUM MILL TAILINGS

1.1 INTRODUCTION

The U.S. Energy Research and Development Administration (ERDA) contracted in 1975 with Ford, Bacon & Davis Utah Inc. (FB&DU) of Salt Lake City, Utah, to provide architect-engineering services and final reports based on the assessment of the problems resulting from the existence of large quantities of radioactive uranium mill tailings at inactive mill sites in eight western states and in Pennsylvania. In 1980, the U.S. Department of Energy (DOE) contracted with FB&DU to produce revised reports of the sites designated in the Uranium Mill Tailings Remedial Action (UMTRA) program in order to reflect the current conditions, new criteria and options, and to estimate current remedial action costs.

A preliminary survey (Phase I) was carried out in 1974 by the U.S. Atomic Energy Commission (AEC) in cooperation with the U.S. Environmental Protection Agency (EPA) and the affected states. In a summary report,⁽¹⁾ ERDA identified 17 sites in Arizona, Colorado, Idaho, New Mexico, Utah, and Wyoming for which practical remedial measures were to be evaluated. Subsequently, ERDA added five additional sites (Riverton and Converse County, Wyoming; Lakeview, Oregon; Falls City and Ray Point, Texas). More recently, DOE has added a site in Canonsburg, Pennsylvania, and two sites in North Dakota (Belfield and Bowman), and deleted Ray Point, Texas, for a total of 24 sites. Most of the mills at these sites produced by far the greatest part of their output of uranium under contracts with the 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.

Prior to 1975, the studies of radiation levels on and in the vicinities of these sites were limited in scope. The data available were insufficient to permit assessment of risk to people with any degree of confidence. In addition, information on practicable measures to reduce radiation exposures and estimates of their projected costs was limited. The purposes of these recent studies performed by FB&DU have been to revise the information necessary to provide a basis for decision making for appropriate remedial actions for each of the 24 sites.

Evaluations of the following factors have been included in this engineering assessment in order to assess the significance of the radiological conditions that exist today at the Canonsburg site:

- (a) Exhalation of radon gas from the residues
- (b) On-site and off-site direct radiation
- (c) Land contamination from windblown residues
- (d) Hydrology and contamination by water pathways
- (e) Potential health impact
- (f) Potential for extraction of additional minerals from the residues

In this report, the remedial action alternatives are generally classified as follows:

- (a) Option I - Stabilization of all residues on site with a 3-m cover
- (b) Option II - Disposal of Canonsburg residues at disposal site in Washington County, 17 mi northwest of Canonsburg; stabilization of Pennsylvania Railroad Landfill tailings in place
- (c) Option III - Stabilization of Canonsburg residues on site; disposal of Pennsylvania Railroad Landfill tailings at disposal site in Washington County, 17 mi northwest of Canonsburg
- (d) Option IV - Disposal of Canonsburg residues and Pennsylvania Railroad Landfill tailings at disposal site in Washington County, 17 mi northwest of Canonsburg

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 an appropriate remedial action to limit the exposure of individuals to radiation from uranium mill tailings.

Dr. William D. Rowe, testifying on behalf of the 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 than treating the potential problem on a piecemeal 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, adapted from Reference 1, summarizes the conditions in 1980. Based on the findings presented in the Phase I 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, Utah, 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.

*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, Bio-medical and Environmental Research; Operational Safety; Waste Management and Transportation, Feb 18 and 27, 1975, Part 2.

On November 8, 1978, the Uranium Mill Tailings Radiation Control Act of 1978 (PL 95-604) became effective. This legislation provides for state participation with the Federal Government in the remedial action for inactive tailings piles. Pursuant to requirements of PL 95-604, the EPA has the responsibility to promulgate remedial action standards for the cleanup of areas contaminated with residual radioactive material and for disposal of tailings. The U.S. Nuclear Regulatory Commission (NRC) has the responsibility for enforcing these standards.

In 1979, DOE established the UMTRA Program Office in Albuquerque, New Mexico. Work on the program has since been directed by personnel in that office.

The Canonsburg site was originally included in the Formerly Utilized MED/AEC Sites Remedial Action Program (FUSRAP) but was transferred to the UMTRA program in 1980. While yet included in the FUSRAP, site survey work was conducted by ORNL and FB&DU personnel in 1977.^(2,3) FB&DU personnel conducted brief supplementary studies in September 1980.

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.

The specific scope requirements of the Title I assessment 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 cost.
- (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 at which mill tailings containing radium could be disposed; and once such sites are identified, perform evaluations 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 radioisotopes in the tailings
- (k) Review of existing information about 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 socio-economic 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 the Canonsburg site.

1.2 SITE DESCRIPTION

1.2.1 Location and Topography

The Canonsburg site, comprising approximately 18.6 acres, is located in north Washington County within the corporate limits of the borough of Canonsburg, Pennsylvania. The property is located on George Street where it intersects with Strabane Avenue; it is bounded by Chartiers Creek, the Pennsylvania Railway right-of-way, the Chemical and Solvents Company, and the Pittsburgh Railroad right-of-way. Figures 2-1, 2-2A, and 2-2B* depict the site and its location relative to its surroundings.

The site is designated as Parcel No. 1 DBU 1162 P. 331, Parcel No. 2 DBU 1162 P. 331, and Parcel No. 3 DBU P. 331, situated in the borough of Canonsburg, county of Washington, state of Pennsylvania.

The site slopes to the east toward Chartiers Creek, from 998 to 968 ft above sea level.

1.2.2 Ownership and History of Milling Operations and Processing

The greater part of the site is presently owned by the Canon Development Company, Inc., and is called the Canon Industrial Park. The rest of the site is owned by Washington County. The various buildings on the site are leased to

*Figures and tables referenced in this summary are extracted from Chapters 2 through 9 of the parent report and are in the addendum.

tenant companies with approximately 75 full-time employees as of 1978. No opportunity was available to update this number during the 1980 field work.

The Standard Chemical Company was the first processor to operate at the site, from 1911 to 1922, extracting radium as bromide and sulfate from carnotite ore. No further operations were conducted until about 1930 when Vitro Manufacturing Company (now the Vitro Corporation of America) acquired the plant. From 1930 to 1942 Vitro extracted radium and uranium salts from on-site residues and carnotite ore. In 1942, operations funded by Federal Government contracts were turned to the recovery of uranium from various ores, concentrates, and scrap materials. Vitro Manufacturing Company records show that in October 1948, approximately 30,000 lb of U_3O_8 per month were being extracted from 300,000 lb of waste received from various AEC installations. Although there is a variety of materials, tailings, and residues at the Canonsburg site, they are referred to as tailings in this report.

By May 1949, Vitro was recovering uranium and other metals from waste material shipped from Mallinckrodt Chemical Works, Hanford Operations, Harshaw Chemical Company, and Electro Metallurgical Company--all AEC contractors.

In September 1956, personnel from the Oak Ridge Operations Office of the AEC approved the removal of approximately 6,000 tons (dry weight) of waste residues containing 0.097% U_3O_8 from the Vitro site.⁽²⁾ The uranium (approximately 6 tons of U_3O_8) was classified as "unrecoverable material--measured". The material was transported to a landfill on Pennsylvania Railroad property in Burrell Township, Pennsylvania. Subsequent estimates of volume suggest that all, or nearly all, of the material mentioned above was indeed moved to that location in 1957.

The last AEC contract with Vitro was terminated in 1957. A "storage only" license was issued in 1961, and the contaminated site was controlled under an AEC source material license until February 14, 1966. Since 1967, the property has been owned by the Canon Development Company; it is leased to tenant companies for light industrial use.

1.2.3 Present Condition of the Site

The site is divided into three areas: Area A (11 acres) is the highest ground of the site where all on-site buildings are located; Area B (4.5 acres) contains no structures and is land upon which dredgings from Chartiers Creek have been placed; and Area C (3.1 acres) is the portion of the site with lowest elevation and where a softball diamond has been constructed over filled ground.

Most of Area A is enclosed by a 6-ft-high chainlink fence topped with three strands of barbed wire. The fence is in fairly good condition. There are a few small trees in the area, most of which are outside the fenceline.

Area B is graded relatively flat and slopes toward Chartiers Creek, which is on its northeastern edge. There are no fences or structures in this area. An overhead powerline crosses the area in a generally north-south direction.

At Area C, with nearly level surface, fencing lines the west and south sides while Chartiers Creek forms the northerly and easterly boundaries. The softball diamond, now inactive, is in the southwest corner of the area.

The existing buildings on the site are numbered 1, 2, 3, 6, 7, 8, 9, 10, 11, 15, 16, 18, and 19. These buildings total approximately 106,000 ft² and have a total volume of approximately 1,490,000 ft³. Pertinent data on each building are summarized in Table 2-1.

The original Vitro-era buildings that remain are generally of the same type of construction: structural steel frames, concrete floors and ceilings on two-story buildings; all have either 8- or 12-in. concrete block exteriors, which are curtain, or nonbearing walls. Structurally, the old buildings are in good condition in spite of their declining exterior appearance. The old block nonbearing walls are in poor condition, with cracks that give the appearance of being near failure.

The newer buildings (since 1967) are in excellent structural condition and generally follow the same type of construction as the original buildings, except that precast concrete roof panels were used on the flat-roofed buildings. However, the concrete roof panels do not appear to be in good condition because of the fit-into-place construction that was used to connect the buildings.

The roofs of the buildings are either flat, near-flat, or pitched (2.5:12 in.). Even though roofs are coated with roll asphalt and tar or with corrugated metal that has been asphalt-coated, in many locations they leak. Flashing placed where a new building was added to an old one has rusted through in several places. Roof gutters and downspouts are generally either rusted beyond use or nonexistent.

1.2.4 Tailings and Soil Characteristics

The site and much of the surrounding area has been classified as "urban land" by the Greene and Washington Counties Soil Survey of the Soil Conservation Service.⁽⁴⁾ The original soils on the site were a mixture of the upland slope and alluvial soils surrounding the site. The original soils have been disturbed by urban development. These soils have been

covered with fill materials or removed completely; consequently, the evaluation of characteristics cannot be made without intense on-site investigations.

The types, volumes, and weights of contaminated materials are summarized in Table 2-2.

1.2.5 Geology, Hydrology, and Meteorology

The unconsolidated materials at the site reflect their relatively recent geologic history of fluvial environments. Underlying these deposits are sedimentary strata of the Pennsylvanian System. They consist of sandstone with a little conglomerate, shale, limestone, clay, and numerous beds of coal. However, only the Pittsburgh coal is of great economic value. The site lies on top of the Conemaugh Formation, which is predominantly shale with abundant sandstone beds and some limestone, clay, and coal. Figure 2-7 is a simplified stratigraphic column showing these rock units.

There are abundant surface waters in the area, including several streams, numerous intermittent drainages, and several reservoirs and ponds. Surface waters in the vicinity of the site include Chartiers Creek and several ditches which carry runoff. At a gauging station in Carnegie, about 12 mi northeast of Canonsburg, the annual average flow of Chartiers Creek was recorded at 287 ft³/sec.⁽⁵⁾ The estimated annual average flow of Chartiers Creek in Canonsburg is between 90 and 130 ft³/sec. During the September 1912 flood, the recorded flow in the Canonsburg-Houston area was 8,500 ft³/sec and 20,000 ft³/sec in the Carnegie area; this level of flooding is estimated to recur about every 52 yr. The extent of flooding is shown in Figure 2-9. Completion of a flood control project⁽⁶⁾ in this area will reduce this frequency to once every 600 yr. If this project is completed, the site would hardly be affected by flooding. However, if the site under present conditions is covered to any extent, there would be some erosion of contaminated soils from the surface.

The surface contour in the vicinity of the site and to a smaller extent, the system of ditches adjacent to the site precludes flow of off-site surface waters onto the site.

Confined ground-water systems in the Conemaugh Formation under the site occur largely in the sandstone beds with limited quantities in the bedding-plane passages and in joint plains of the shales and limestones. Yields are variable and unpredictable but generally range from small to moderate. A median yield for wells in this aquifer is 5 gal/min. Yields large enough for industrial or municipal purposes are difficult to obtain.

The possibility that the confined ground water at the site is being affected by contamination from the site is very

unlikely due to the fact that the hydraulic gradient probably prevents all but very minimal recharge. In any event, the aquifer is not heavily tapped in this area.

Unconfined ground water at the site is found in fill materials and in alluvial deposits. In Area A, most of the contamination is above the ground water, but in Areas B and C, contaminated soils are saturated. During flood stages the ground water tables would rise and inundate even larger sections of these contaminated areas.

The ground water at the site moves to the north and northeast toward Chartiers Creek. Since it is possible that the shallow ground water at the site is contaminated, Chartiers Creek may be affected; however, water samples from the creek show no elevated radium levels. Measurements of water samples from drill holes indicate only slightly elevated radium levels. These measurements suggest that transport of the contamination has been limited. However, there are no shallow ground water wells downgradient from the site between the site and the creek to allow monitoring and substantiation of this conclusion.

Based on a 97-yr record, average annual precipitation at Pittsburgh is 36.87 in. and for the 50-yr records kept at Washington is 37.07 in. The normal monthly precipitation at Pittsburgh is a maximum of 3.95 in. during June and a minimum of 2.31 in. during February. In Washington, a maximum average of 4.22 in. occurs in June and a minimum average 2.38 in. occurs in November. Summer rains are usually the result of convectional storms of short duration and high intensity. There have been rainfalls of 10 to 12 in. in several hours unofficially recorded in the stream basin north of Canonsburg. Precipitation occurring in the fall, winter, and early spring is more general and more moderate in intensity. Average annual snowfall in Pittsburgh is 33.7 in. and at the Greater Pittsburgh International Airport is 42.2 in. For the period from 1953 to 1968, a maximum of 14.4 in. of snow fell in a single snowstorm. The snow cover is generally not continuous through the winter.

Prevailing winds at Canonsburg are estimated to be from the west or have a westerly component, with a mean speed of about 10 mi/hr. Maximum velocities of about 70 mi/hr have been recorded for short durations. In the past 17 yr, eight tornadoes have occurred in southwestern Pennsylvania. Table 2-3 presents wind data used in this evaluation. Winds are estimated to be from the westerly directions over 45% of the time.

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. 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 and residues. Although these radionuclides occur in nature, their concentrations in tailings and residues 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 ^{222}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 that can occur; however, this pathway was not considered in this study.

1.3.1.1 Radon Gas Diffusion and Transport

Although no direct measurements of ^{222}Rn flux from the contaminated areas have been made, an effort was made to estimate this release of radioactivity, based on average ^{226}Ra content and other characteristics of the contaminated areas. It was estimated that the ^{222}Rn flux from the site is approximately $280 \text{ pCi/m}^2\text{-s}$.

In the radiological survey,⁽²⁾ radon was measured at several locations for a minimum of 10 hr. Radon daughter concentrations were determined from alpha activity collected on a membrane filter through which air was passed for 5 to 10 min. These samples were collected during the morning and afternoon at each radon monitor location. Thus, an average WL concentration was determined during working hours.

There are 12 buildings on site, as shown in Figure 2-3. Radon and radon daughter measurements were made in all of these buildings during this survey. The average radon and radon daughter concentrations found in each building are given in Table 3-2.⁽²⁾

Radon concentrations at several outdoor and indoor locations off the site and at two outdoor locations on the site were measured. The results of these measurements are reported in Figure 3-3. Average (24-hr) radon concentrations as high as 17 pCi/l were measured outdoors on the site. Average concentrations outdoors as high as 2.1 pCi/l were observed off site. Since background radon concentrations are generally less than 1 pCi/l, the radon concentrations measured off site appear to be the result of atmospheric transport of radon from the site. However, elevated ^{226}Ra concentrations were found in soil at some off-site locations. Hence, it is possible that off-site ^{226}Ra contamination is contributing to the elevated radon concentrations measured off the site.⁽²⁾

1.3.1.2 Direct Beta-Gamma Radiation On Site⁽²⁾

The entire site, excluding the area covered by buildings, was divided into 50- x 50-ft survey blocks; at the intersection of perpendicular lines forming the grid system, open- and closed-window readings were taken with a Geiger Mueller detector at the surface and at 1 m above the surface. Several additional external gamma radiation measurements were taken at 1 m above the ground around each building on the site. The results are reported in Table 3-3.

In Area A, beta-gamma dose rates at 1 cm above the ground level exceeded 0.20 mrad/hr at approximately 50% of the grid points. Beta-gamma dose rates on this area are very nonuniform. Beta-gamma dose rates in Area A were as high as 25 mrad/hr and exceeded 0.20 mrad/hr in approximately 90% of the survey blocks in Area A.

A large portion of Area B is covered by 8 to 12 ft of fill dirt which consists, at least in part, of dredgings from Chartiers Creek. Beta-gamma dose rates in Area B exceeded 0.20 mrad/hr in some areas of this fill dirt and on much of the surface not covered by the fill dirt. Beta-gamma dose rates at 1 cm above ground level exceeded 0.20 mrad/hr over a

large section of Area C near Strabane Avenue and were as high as 17 mrad/hr. In the southeast corner of Area C, beta-gamma dose rates were near background levels.

External gamma levels at 1 m above the surface, measured approximately 10 ft from the outer walls of the buildings, are shown in Figure 3-5.

The external gamma radiation (EGR) levels measured on the tailings pile are represented in Figure 3-6. These measurements, which include background, were taken 1 m above ground with calibrated NaI scintillation detectors. The highest gamma radiation rate (1,300 μ R/hr) was measured about 50 ft southwest of the intersection of the railroad spur and George Street.

The mean external gamma radiation level at 1 m above the surface found on the site was 160 μ R/hr, although there are wide variations. This is approximately 10 times greater than the local background gamma radiation level.

Gamma rate measurements away from the tailings pile, taken at 100-ft intervals, without exception reached 2 to 3 times background levels within 300 to 400 ft of the site boundary.

1.3.1.3 Windblown Contaminants

Prevailing winds in the area are from the westerly directions.

Surface soil samples were taken in the area surrounding the site.⁽²⁾ The sample locations and ^{226}Ra concentrations are shown in Figure 3-3. With the exception of contamination apparently due to migration in surface waters or intentional transport, the soil sample with the highest ^{226}Ra content was taken on the south side of the Penn Central railroad, about 200 ft west of Strabane Avenue, and indicated a ^{226}Ra concentration of 22 pCi/g with a ^{238}U concentration of 43 pCi/g.

Fourteen traverses with the scintillometer were conducted across open lands adjacent to the site and were continued until a soil contamination of 5 pCi/g of ^{226}Ra was indicated. These traverses are shown in Figure 3-7 and the location of 5 pCi/g of ^{226}Ra is marked on each traverse. This locus of points is connected to indicate the area surrounding the site contaminated in excess of 5 pCi/g of ^{226}Ra . The resulting boundary is in good agreement with surface soil samples taken in the vicinity.

1.3.1.4 Ground and Surface Water Contamination

Water samples taken from auger holes on site show ^{226}Ra concentrations ranging from 100 to 390 pCi/l and ^{238}U concentrations ranging from 10 to about 2,100 pCi/l,⁽²⁾ as shown in

Table 3-4. There are, however, no positive indications that ground waters or surface waters are significantly affected by the presence of the contaminated material.

1.3.1.5 Soil Contamination⁽²⁾

In most locations on Area A, concentrations of ^{226}Ra and ^{238}U in the surface soil exceed the average background concentrations. The concentration of ^{226}Ra was at least a factor of 10 above background in more than 90% of the surface samples taken in Area A, and 5 samples showed a ^{226}Ra concentration of 1,000 pCi/g or more. The concentration of ^{238}U exceeded 10,000 pCi/g in 3 surface samples from Area A. At one location shown in Figure 3-8, the concentration of ^{238}U measured in a surface soil sample was 51,000 pCi/g. This location was chosen for sampling because of the high beta-gamma dose rate (5 mrad/hr) and the high ratio of beta to gamma radiation at the surface. Elevated concentrations of ^{227}Ac , a daughter of ^{235}U , were found also in several surface samples taken on Area A. The surface contamination in this area appears to be very nonuniform, and much of the elevated external gamma radiation at 1 m on this area appears to be attributable to subsurface contamination.

Auger holes were drilled at the 88 locations shown in Figure 3-9 to determine subsurface soil contamination. Concentrations of ^{238}U and ^{227}Ac in soil samples taken from the auger holes are reported also in Table 3-6.

Holes were drilled with motorized drilling rigs through the concrete floor in Buildings 2A, 10, and 18 and soil samples were taken from depths of 6.5 ft or less beneath the floor using a split-spoon sampler. All samples were analyzed for ^{226}Ra and ^{238}U ; the results are given in Table 3-7.

1.3.2 Remedial Action Criteria

For the purpose of conducting the original engineering assessments,⁽⁷⁾ provisional criteria provided by the EPA were used. The criteria were in two categories, and applied either to structures with tailings present or to land areas to be decontaminated. For structures, the indoor radiation level below which no remedial action was indicated was considered to be an external gamma radiation level of less than 0.05 mR/hr above background and a radon daughter concentration of less than 0.01 WL above background. Land could be released for unrestricted use if the external gamma radiation levels were less than 10 $\mu\text{R/hr}$ above background. When cleanup was necessary, residual radium content of the soil after remedial action should not exceed twice background in the area.

Since enactment of the Uranium Mill Tailings Radiation Control Act of 1978 (PL 95-604), which was effective November 8, 1978, the EPA has published interim (45 FR 27366) and proposed

(45 FR 27370) standards for structures and open lands. These standards establish the indoor radon daughter concentration, including background, below which no remedial action is indicated at 0.015 WL. The indoor gamma radiation limit is 0.02 mR/hr above background.

For open land, remedial action must provide reasonable assurance that the average concentration of ^{226}Ra attributable to residual radioactive material from any designated processing site in any 5-cm thickness of soils or other materials within 1 ft of the surface, or in any 15-cm thickness below 1 ft, shall not exceed 5 pCi/g.

Environmental standards have been proposed by the EPA (46 FR 2556) for the disposal of residual radioactive materials from inactive uranium processing sites. These standards require that disposal of residual radioactive materials be conducted in a way which provides a reasonable assurance that for at least 1,000 yr following disposal:

- (a) The average annual release of ^{222}Rn from the disposal site to the atmosphere by residual radioactive materials will not exceed 2 pCi/m²-s.
- (b) Substances released from residual radioactive materials after disposal will not cause:
 - (1) the concentrations of those substances in any underground source of drinking water to exceed the level specified below,* or
 - (2) an increase in the concentrations of those substances in any underground source of drinking water where the concentrations of those substances prior to remedial action exceed the levels specified below for causes other than residual radioactive materials.*

<u>Substance</u>	<u>mg/l</u>
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium	0.05
Lead	0.05

*These requirements apply to the dissolved portion of any substance listed above at any distance greater than 1.0 km from a disposal site that is part of an inactive processing site, or greater than 0.1 km if the disposal site is a depository site.

<u>Substance</u>	<u>mg/l</u>
Mercury	0.002
Molybdenum	0.05
Nitrogen (in nitrate)	10.0
Selenium	0.01
Silver	0.05
	<u>pCi/l</u>
Combined ^{226}Ra and ^{228}Ra	5.0
Gross alpha particle activity (including ^{226}Ra but excluding radon and uranium).	15.0
Uranium	10.0

- (c) Substances released from the disposal site after disposal will not cause the concentration of any harmful dissolved substance in any surface waters to increase above the level that would otherwise prevail.

Since the passage of PL 95-604, the NRC has published final regulations for uranium mill tailings licensing in the Federal Register (45 FR 65521). They include the requirement that the stabilization method must include an earth cover of at least a 3-m thickness and sufficient to reduce the radon emanation rate from the tailings to 2 pCi/m²-s above background. In addition, seepage of materials into ground water should be reduced by design to the maximum extent reasonably achievable.

While these standards may undergo further revisions, the interim and proposed standards as indicated above form the basis for determining required remedial actions and their associated costs.

1.3.3 Potential Health Impact

Only the potential health effects from the inhalation of radon daughters are estimated quantitatively in this assessment because this pathway produces the most significant exposure. Furthermore, the uncertainty in the estimates of the potential health effects from this pathway far exceeds the magnitude of the health effects from the other pathways.

It is extremely difficult to predict with any assurance that a specific health effect will be observed within a given time after chronic exposure to low doses of toxic material. 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 basis that the effects are linear, using the conservative assumption of no threshold for the effects. The resulting risk estimators also have

associated uncertainties due to biological variability among individuals and to unknown contributions from other biological insults which may be present simultaneously with the insult of interest. No synergistic effects are considered explicitly in this analysis. For the purpose of this engineering study, lung cancer is the potential health effect considered for RDC. The health effects were estimated using the absolute risk model.

Since radiation exposure from ^{222}Rn progeny is expressed in terms of working levels (WL) and working level months (WLM), total population exposures as well as health risk estimates are based upon these units; i.e., person-WLM. Exposures and resulting health effects are often expressed in terms of rems; however, estimates of the WLM-to-rem conversion factor for internal lung exposure to alpha particles from ^{222}Rn progeny are observed to vary by over an order of magnitude.⁽⁸⁾ Presently, there are significant differences of opinion related to the choice of an appropriate conversion factor. Consequently, disagreements of calculated health effects from RDC occur when these effects are based on the rem.

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-III report).⁽⁹⁾ This report presents risk estimators for lung cancer derived from epidemiological studies of both uranium miners and fluorspar miners. The average of the age-dependent absolute risk estimator for these two groups as applied to the population at large is 150 cancers per year per 10^6 person-WLM of continuous exposure, assuming a lifetime plateau to age 75. The term WLM means working level months, 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 or with the parent radon. Because of the many factors that contribute to natural biological variability and of the many differences between exposure conditions in mines and residences, this estimator (150 cancer cases per year per 10^6 person-WLM of continuous exposure) is considered to have an uncertainty factor of about 3. Another means of expressing risk is the relative risk estimator, which yields risk as a percentage increase in health effects per 10^6 person-WLM of continuous exposure. However, this method has been shown to be invalid⁽¹⁰⁾ and is not considered in this assessment.

For the purpose of this engineering 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 predictions of radon concentrations in excess of the background value under present conditions, it was calculated that the average lung cancer risk attributable to radon released from the site in the area within 3 mi of the Canonsburg site is about 1.7×10^{-6} per person per year, or less than 1% of the average lung cancer risk due to all causes for residents (3.6×10^4).

The 25-yr health effects were calculated for three population projections using the present population of about 20,200 in the 0- to 3-mi area. The results for induced radon and background radon for this area were as follows:

25-Year Cumulative Health Effects within 3 Miles of Edge

<u>Projected Population Growth</u>	<u>Pile-Induced RDC</u>	<u>Background RDC</u>
Constant 0.3% growth rate	0.87	9.8
Constant 1.1% growth rate	0.98	11
3% declining growth rate*	1.1	12

Pile-induced radon daughter health effects are approximately 9% of the background radon daughter health effects for the 0- to 3-mi area. 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

No measurements were made, nor samples taken, to determine the presence of nonradioactive pollutants in soil or water samples. However, frequently it has been observed at uranium mill tailings piles that concentrations of such pollutants as selenium, molybdenum, and arsenic are unusually high.(11)

1.4 SOCIOECONOMIC AND LAND USE IMPACTS

Populations in Canonsburg and Houston have been declining for the past 20 yr, but as a result of recent flood control measures and urban renewal programs, this trend may reverse.

The land use pattern in the area near the Canonsburg site is a mixture of industrial, commercial, public, and residential. The commercial and industrial businesses are located largely along Chartiers Creek, the railroads, and

*Declines linearly from its initial value to zero in 25 yr and remains constant at zero thereafter.

Pike Street. The land use plan for Canonsburg calls for the development of a homogeneous, light-industrial area north and west of the site.

The Department of Housing and Urban Development (HUD) suspended funding of eight middle-income housing projects in the Canonsburg area early in 1980, pending the results of a DOE-sanctioned gamma survey. When notification by DOE of normal radiation readings at these sites was received, the ban was lifted by HUD (August 1980).

The proximity of the railroad and fairly convenient freeway access, coupled with nearby housing areas and a small-town flavor, make the site land ideal for development. However, because of the contamination within the buildings, their current market value would be difficult to assess. The buildings and site have deteriorated and show lack of maintenance. Areas B and C may also be considered prime areas for development if the contamination were removed and backfill were provided.

1.5 RECOVERY OF RESIDUAL VALUES

As required by Public Law 95-604, under whose auspices this project is conducted, DOE has solicited expressions of interest in reprocessing tailings and residues at the Canonsburg site for uranium recovery. Since no such interest was demonstrated, no effort has been made to estimate the value of the residual uranium resource at the Canonsburg site.

1.6 MILL TAILINGS STABILIZATION

Investigations of methods of stabilizing uranium mill tailings piles from wind and water erosion have indicated a variety of deficiencies among the methods. Chemical stabilization (treatment of the tailings surface) has been successful only for temporary applications and is thus viewed as inadequate for currently proposed disposal criteria. Volumetric chemical stabilization (solidifying the bulk of the tailings) techniques appear to be costly and of questionable permanence. Physical stabilization (emplacement of covers over the tailings) methods using soil, clay, or gravel have been demonstrated on a laboratory scale to be effective in stabilizing tailings. Artificial cover materials are attractive but have the disadvantage of being subject to degradation by natural and artificial forces. Vegetative stabilization (establishment of plant growth) methods are effective in limiting erosion.

Migration of contaminants into ground water systems must be limited under the NRC and EPA criteria. Control of water percolating through the tailings can be accomplished by stabilizing chemically, by physically compacting the cover material, and by contouring the drainage area and tailings cover surface. Isolation of the tailings from underlying ground water

systems can be accomplished by lining a proposed disposal site with natural or artificial impermeable membranes.

Several materials have been identified which sufficiently retard radon migration so that the radon flux is substantially reduced, on a laboratory scale. Unfortunately, no large-scale application has been undertaken which would demonstrate that these materials satisfy all of the technical criteria in the EPA-proposed standards and the NRC regulations for licensing of uranium mills. However, extensive investigations of these questions continue in the Technology Development program of the Uranium Mill Tailings Remedial Actions Project Office in Albuquerque, New Mexico.

In view of findings from stabilization research, it appears that physical stabilization of tailings with 3 m of well-engineered cover material may be sufficient to appropriately stabilize tailings at their disposal site to meet NRC regulations.

1.7 OFF-SITE REMEDIAL ACTION

During the summers of 1978 and 1980, ORNL performed radiological surveys of off-site properties adjacent to the Canonsburg site.⁽²⁾ Results of the ORNL survey combined with investigations by the DOE indicate that about 110 properties may be contaminated with residual radioactivity from the site. Thirty-two of these sites have been designated for remedial action.⁽¹²⁾

One of the 110 off-site locations is the Pennsylvania Railroad Landfill Site, Burrell Township. The site is located approximately 1 mi east of the town of Blairsville, Indiana County, as shown in Figure 7-1. The Pennsylvania Railroad owned the property when approximately 6,000 tons (dry weight) of tailings were dumped at the site.⁽²⁾ Ownership of the site passed to the Penn-Central Transportation Company Properties Division (now ConRail); however, the name "Pennsylvania Railroad Landfill" has been retained in this document.⁽¹³⁾ The site is presently owned by the James Burrows Co. of Pittsburgh, Pennsylvania.

The site was originally designated in 1974 by the Federal Government under the "Formerly Utilized MED/AEC Sites Remedial Action Program" or FUSRAP. The objects of FUSRAP include work to determine the radiological conditions of former MED/AEC sites, to identify options for remedial actions that could be undertaken, along with their respective costs, and to analyze the environmental impacts of these actions. Various studies and reports have been published on the landfill under the FUSRAP program.⁽¹⁴⁾

In the recent past the landfill has been reclassified as an off-site property of the Vitro Rare Metals Plant Site, Canonsburg, in the UMRAP program.

1.8 DISPOSAL SITE SELECTION

In this report, three of the alternative remedial action options include moving either the Canonsburg residues or the Pennsylvania Railroad Landfill materials, or both, to a disposal site. The disposal site is presently being considered by the State of Pennsylvania and the Department of Energy. The site was evaluated on the bases of hydrology, meteorology, geology, ecology, economics, and proximity to population centers, among others.⁽¹⁵⁾

Of the numerous sites studied, the State concluded that an area 3 mi northwest of Burgettstown, Washington County, is best suited for long-term disposal. The general area located 3 mi west-northwest of Burgettstown (and about 17 mi northwest from the Canonsburg site) was extensively strip-mined from the 1940's through the mid- to late-1960's. The present topography reflects this activity; there are numerous hills composed of overburden, mine spoils, etc., and valleys of stripped-out areas. The area has been reclaimed and/or stabilized with varying degrees of success.

The long history of mining is reflected in the quality of many of the area's streams. Contamination by acid mine drainage is evident throughout the area in streams and assorted seeps.

Many roads pass through the area and are in fairly good condition, needing only minimal upgrading in order to be suitable for heavy truck use. Railroad facilities for coal transportation once existed in the area. However, there are no rails or ties on the track bed at present. The bed itself is in poor condition with small trees growing on it and numerous erosion washouts undermining its stability.

The area is uninhabited and there are no mining activities going on at present. There are no endangered species, critical habitats, or unique ecological areas.

The general area has low potential for subsidence due to the way in which it was mined. Although the area has been deep-mined, subsequent strip-mining operations eliminated the mine openings. Seismic risk in the area is low.

In Options II through IV, surface material would be removed, as appropriate, from the disposal area and stock-piled. The tailings would be emplaced underground if possible, contoured, and covered with 3 m of soil. The surface would be covered with 0.3 m of riprap or vegetation for erosion control and the entire site appropriately secured.

1.9 REMEDIAL ACTIONS AND COST-BENEFIT ANALYSES

1.9.1 Remedial Action Options

The remedial action options examined include stabilization of the residues in their present locations, and removal of all radioactive materials to an area where these materials could be isolated from the public. The options for which cost estimates were made include stabilization on the present site with 3 m of cover material and the removal of tailings to a possible disposal site location. The options are summarized in Table 1-2. The basis for comparison, from which the cost effectiveness of remedial alternatives can be judged, is the present condition of the site with no remedial action.

Option I represents remedial action activities to stabilize the residues more completely with the addition of 3 m of cover. This option is presented primarily for comparison with costs at Western tailings sites. Radon exhalation would be reduced to not more than 2 pCi/m²-s above background. The site would have limited future use.

In all remedial action options, radon flux, external gamma radiation levels, soil concentrations, and radon daughter concentrations will satisfy proposed and interim cleanup and disposal standards. For Options I through IV, the Canonsburg and Pennsylvania Railroad Landfill sites would be stabilized in place or disposed of at the site described in the previous section as follows:

<u>Option</u>	<u>Canonsburg</u>	<u>Pennsylvania Railroad Landfill Site</u>
I	in-place	in-place
II	disposed	in-place
III	in-place	disposed
IV	disposed	disposed

1.9.2 Cost-Benefit Analyses

As summarized in Table 9-1, the total estimated costs for the four remedial action options vary from \$23,244,000 to \$27,052,000. Each of these options would have associated health and monetary benefits. The options are identified by number in Paragraph 1.1.

The number of cancer cases avoided per million dollars expended for each option is given in Figure 9-2. The curves in Figure 9-2 indicate an increase in health benefit-cost ratio

with time due to the greater reduction in population exposure over longer periods of time as a result of remedial action. The potential cancer cases avoided for each option and the cost per potential cancer case avoided are given in Table 9-2.

TABLE 1-1
SUMMARY OF CONDITIONS NOTED AT TIME OF 1980 SITE VISITS

	Condition of Tailings ^a	Condition of Structures On Site ^b	Mill Housing ^c	Adequate Fencing, Posting, Security	Property Close to River or Stream	Houses or Industry within 0.5 Mi	Evidence of Wind or Water Erosion	Possible Water Contam- ination	Tailings Removed for Private Use	Other Hazards On Site
<u>ARIZONA</u>										
Monument Valley	U	R	N	No	No	Yes	Yes	No	Yes	No
Tuba City	U	PR-UO	E-P	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	Yes	Yes	Yes	No
Gunnison	S	B-O	N	No	Yes	Yes	No	Yes	No	No
Maybell	S	R	N	Yes	No	No	Yes	No	No	No
Naturita	RMS	PR-O	N	Yes	Yes	Yes	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	Yes	Yes	Yes	Yes	Yes	No	No
Slick Rock (UCC)	S	R	E-P	Yes	Yes	Yes	No	Yes	No	No
<u>IDAHO</u>										
Lowman	U	R	N	No	Yes	Yes	Yes	Yes	Yes	No
<u>NEW MEXICO</u>										
Ambrosia Lake	U	PR-O	N	No	No	No	Yes	No	No	No
Shiprock	S	PR-O	N	Yes	Yes	Yes	No	Yes	Yes	No
<u>NORTH DAKOTA</u>										
Belfield	R	PR-O	N	No	No	Yes	No	No	No	No
Bowman	R	R	N	No	No	No	No	No	No	No
<u>OREGON</u>										
Lakeview	S	B-O	N	Yes	No	Yes	Yes	No	No	No

TABLE 1-1 (Cont)

	Condition of Tailings ^a	Condition of Structures On Site ^b	Mill Housing ^c	Adequate Fencing, Posting, Security	Property Close to River or Stream	Houses or Industry within 0.5 Mi	Evidence of Wind or Water Erosion	Possible Water Contam- ination	Tailings Removed for Private Use	Other Hazards On Site
<u>PENNSYLVANIA</u>										
Canonsburg	P	B-O	N	Yes	Yes	Yes	No	Yes	Yes	Yes
<u>TEXAS</u>										
Falls City	P	B-O	N	Yes	No	No	Yes	No	No	No
<u>UTAH</u>										
Green River	S	B-Y	N	Yes	Yes	Yes	Yes	Yes	No	No
Mexican Hat	U	PR-UO	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	Yes	No	No	No	No	No	No
Riverton	S	PR-O	N	No	No	Yes	No	No	No	No

^aS - Stabilized but requires improvement
P - Partially stabilized
U - Unstabilized
RMS - Reprocessed, moved and stabilized - contamination remaining
R - Removed - contamination remaining

^bM - 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

^cN - None
E - Existing
O - Occupied
P - Partially occupied

TABLE 1-2

SUMMARY OF REMEDIAL ACTION OPTIONS AND EFFECTS

<u>Option Number</u>	<u>Site Specific Cost (\$000)</u>	<u>Description of Remedial Action</u>	<u>Benefits</u>	<u>Adverse Effects</u>
I	18,900	The Canonsburg and Pennsylvania Railroad Landfill residues and other contaminated materials would be stabilized in place with 3 m of local earth cover. Natural vegetation would be established or a riprap cover provided. On-site contaminated soil would be cleaned up. Off-site properties would be decontaminated.	A,B,C, D,G	X,Y,Z
II	21,500	The Canonsburg residues, contaminated soil, and rubble would be removed by truck to a disposal site, located about 17 mi from the Canonsburg site. The Canonsburg site would be decontaminated as in Option I and released for unlimited use. The Pennsylvania Railroad Landfill site would be stabilized in place as in Option I.	A-G	X,Y,Z
III	20,400	The Canonsburg site would be stabilized in place as in Option I. The Pennsylvania Railroad Landfill residues, contaminated soil, and rubble would be removed by truck to a disposal site located about 17 mi from Canonsburg. The Pennsylvania Railroad Landfill site would be decontaminated as in Option I and released for unlimited use.	A-G	X,Y,Z

TABLE 1-2 (Cont)

<u>Option Number</u>	<u>Site Specific Cost (\$000)</u>	<u>Description of Remedial Action</u>	<u>Benefits</u>	<u>Adverse Effects</u>
IV	23,100	The Canonsburg and Pennsylvania Railroad Landfill residues, contaminated soil, and rubble would be removed by truck to a disposal site about 17 mi from Canonsburg. The Canonsburg and Pennsylvania Railroad Landfill sites would be decontaminated as in Option I and released for unlimited use.	A-C,E-G	X

Definition of Benefits

- A. On-site windblown residues cleaned up
- B. Wind and water erosion controlled
- C. Portions of the site not used for residues available for other use
- D. Less likelihood of Conemaugh River flood washing away residues
- E. The source of gamma radiation and radon gas removed from the site
- F. Total site available for unrestricted use
- G. Radon exhalation flux reduced to less than 2 pCi/m²-s

Definition of Adverse Effects

- X. Some security and maintenance required
- Y. Residues remain in the center of a populated area
- Z. Restricted use of site

CHAPTER 1 REFERENCES

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ADDENDUM

FIGURES AND TABLES

(The figures and tables contained on the following pages have been extracted from Chapters 2 through 9 of the parent report.)

LIST OF FIGURES

<u>Number</u>	<u>Title</u>	<u>Page</u>
2-1	Aerial Photograph of Site	2-11
2-2A	Site Location Map	2-12
2-2B	Site Location	2-13
2-3	Topographic Map of Site	2-14
2-7	Simplified Stratigraphic Column	2-18
2-9	Flood Plain	2-20
3-3	Off-Site Radium and Uranium Concentrations and Results of Radon Measurements	3-21
3-5	External Gamma Measurements at 1 Meter Above Surface	3-23
3-6	Gamma Levels in Vicinity 1 Meter Above Ground.	3-24
3-7	Windblown Contamination Survey.	3-25
3-8	Surface Soil Samples.	3-26
3-9	Auger Hole and Soil Sample Locations On and Near Site.	3-27
7-1	Location Map to Blairsville Off-Site Property . .	7-3
9-2	Potential Cancer Cases Avoided Per Million Dollars Expended.	9-9

FIGURE 2-1. AERIAL PHOTOGRAPH OF SITE

360-20 12/81

FIGURE 2-2A. SITE LOCATION MAP

360-20 12/80

FIGURE 2-2B. SITE LOCATION

360-20 12/80

FIGURE 2-3. TOPOGRAPHIC MAP OF SITE

System or Stage	Group or Formation	Thickness (ft)	Lithologic Character	Hydrologic Character
Quaternary Holocene and Pleistocene	Alluvium	0-63	Well to poorly sorted deposits of clay, sand gravel, and cobbles	Yields generally large, depending upon degree of sorting by grain size.
	Carmichaels Formation	0-30	High terrace sand, silt, clay, and deeply decayed partly rounded pebbles of local deviation	Yields generally large, depending upon degree of sorting by grain size.
Permian-Pennsylvanian	Washington Formation	36-304	Alternating layers of shale and fine-grained sandstone, thin-bedded limestone, and several coal beds	Sandstone members are best producers. Rest of formation is a poor producer.
Pennsylvanian	Monongahela Group	48-397	Limestone beds of variable thickness, discontinuous sandstone beds, and several coal beds	Limestone beds yield moderate water supplies from joints and bedding planes. Sandstone beds are less productive. Not water-bearing beneath thick cover.
	Conemaugh Group	44-438	Gray, green, and red shale with discontinuous sandstone beds, some thin limestone beds and coal; all members variable in thickness	Water-yielding capacity ranges greatly from place to place. Sandstones are best producing beds.
	Allegheny Group	30-400	Composed of shale, sandstone of variable thickness, discontinuous limestone, and coal beds	Large yields are difficult to obtain. Not often tapped because of its depth.
	Pottsville Group	100-150	Predominately sandstone and conglomerate, and thin shale beds	Higher yields are obtained from the deeper wells, and also water of poor quality. Not often tapped because of its depth.

FIGURE 2-7. SIMPLIFIED STRATIGRAPHIC COLUMN

FIGURE 2-9. FLOOD PLAIN

360-20 12/80

FIGURE 3-3. OFF-SITE RADIUM AND URANIUM CONCENTRATIONS AND RESULTS OF RADON MEASUREMENTS

360-20 REV 9/81

FIGURE 3-5. EXTERNAL GAMMA MEASUREMENTS AT 1 METER ABOVE SURFACE

FIGURE 3-6. GAMMA LEVELS IN VICINITY 1 METER ABOVE GROUND

FIGURE 3-8. SURFACE SOIL SAMPLES

360-20 12/80

FIGURE 3-9. AUGER HOLE AND SOIL SAMPLE LOCATIONS ON AND NEAR SITE

FIGURE 7-1. LOCATION MAP TO BLAIRSVILLE OFF-SITE PROPERTY

360-20 12/80

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FIGURE 9-2. POTENTIAL CANCER CASES AVOIDED
PER MILLION DOLLARS EXPENDED

360-20 REV 9/81

LIST OF TABLES

<u>Number</u>	<u>Title</u>	<u>Page</u>
2-1	Summarization of Structures On Site	2-21
2-2	Tailings Site Materials	2-24
2-3	Frequency Distribution for Winds at Canonsburg, Pennsylvania.	2-25
3-2	Radon and Radon Daughter Concentration in On-Site Buildings.	3-31
3-3	Beta-Gamma and Gamma Dose Rates Outdoors On Site	3-32
3-4	Analyses of Water Samples Taken from Auger Holes	3-33
3-6	Contamination in Subsurface Soil.	3-35
3-7	Concentrations of ^{226}Ra , ^{238}U , and ^{227}Ac from Soil Core Samples Drilled Inside Buildings	3-38
9-1	Summary of Stabilization and Disposal Costs	9-10
9-2	Potential Cancer Cases Avoided and Cost Per Potential Case Avoided.	9-11

TABLE 2-1

SUMMARIZATION OF STRUCTURES ON SITE

<u>Bldg No.</u>	<u>Exterior Dimensions</u>	<u>Area (ft²)</u>	<u>Volume (ft³)</u>	<u>No. of Employees</u>	<u>Year Built</u>	<u>Type of Construction</u>
1	92'4"x31'10"	5,880 (2 stories)	60,800	15	1951	Structural steel frame, concrete floors and ceilings, concrete block exterior walls.
2	92' x 38'	3,496	54,800	4	1951	Structural steel frame, concrete block exterior, corrugated metal roof over steel frame.
2-A	92' x 29'6"	2,714	28,500	0	1967+	Structural steel columns supporting 18-in.-deep open-web steel joists, concrete block exteriors, asphalt-impregnated corrugated metal roofing.
3	92' x 38'	3,496	40,200	6	1920?	Appears to be 2 buildings: one of frame walls and wood joists with block added-on side; the other of block walls with open-web steel truss, purlins, and corrugated metal roofing.
6	18' x 16'	288	2,600	0	1951	Same as Building No. 1.
7	54' x 123'	6,642	94,900	6	1950	Concrete block walls, steel trusses at 20-ft-center purlins and corrugated metal roof.

TABLE 2-1 (Cont)

<u>Bldg No.</u>	<u>Exterior Dimensions</u>	<u>Area (ft²)</u>	<u>Volume (ft³)</u>	<u>No. of Employees</u>	<u>Year Built</u>	<u>Type of Construction</u>
8	18' x 16'	288	2,600	0	1951	Concrete block walls, no roof, metal-grating concrete floor.
9-A	43' x 40'7" plus	3,853	52,500	5	1958	Steel beams, tapered, on block walls, added-on corrugated metal roofing.
9-B	31' x 68'				1951	Concrete block, open-steel truss, corrugated metal roofing.
10	14' x 175'	49,700 (2 stories)	521,800	13	1951	Same as Building No. 1, steel frame, concrete floors and roof.
11	40' x 90'	3,600	80,200	7	1956	Open-web steel trusses with purlins and corrugated metal roof, concrete block walls, concrete floors.
15	24' x 55'	1,320	34,300	1	1958	Rigid steel frame with metal purlins and corrugated metal roof and siding, concrete floor.
16	57' x 127'	7,239	159,300	9	1968	Steel frame with precast concrete roof sections (flat), corrugated asbestos siding, concrete floor.

TABLE 2-1 (Cont)

<u>Bldg No.</u>	<u>Exterior Dimensions</u>	<u>Area (ft²)</u>	<u>Volume (ft³)</u>	<u>No. of Employees</u>	<u>Year Built</u>	<u>Type of Construction</u>
18 (south)	44' x 55'	4,840 (2 stories)	54,500	2	1952	Steel frame concrete floor and 2nd floor; open-truss roof, gable-shaped with purlins and corrugated metal roof, concrete block walls.
18 (central)	55' x 68'	3,740	48,600	2	1968	Open-webbed, tapered-steel joists on concrete block walls, metal purlins, corrugated metal roof, concrete floor, loading dock on each side.
18 (north)	55' x 42'	2,310	41,600	2	1968	Same as Building 18 central section but without loading dock.
19	50' x 130'	6,500	209,000	2	1974	Tapered-steel frame columns supporting open-webbed steel trusses, metal purlins, corrugated iron roofing, and siding.
TOTALS		105,906	1,486,200	74

TABLE 2-2
TAILINGS SITE MATERIALS

<u>Material</u>	<u>Volume (yd³)</u>	<u>Weight (tons)</u>
Tailings and contaminated soil to 5-pCi/g limit	243,000	295,000
Demolished buildings (rubble)	7,200	13,600
Yard rubble (fencing, debris, tanks, concrete, railroad tracks, utilities, etc.)	680	1,000
Yard paving (base rock)	1,800	3,300
Paved public streets adjacent to site	750	1,400
Off-site windblown	15,000	20,000
Off-site other than windblown*	95,000	121,000
Total	363,430	455,300

*Includes an estimated 93,000 yd³ and 119,300 tons at the Pennsylvania Railroad Landfill Site, Burrell Township, Pennsylvania.

360-20 10/81

TABLE 2-3

FREQUENCY DISTRIBUTION FOR WINDS AT CANONSBURG, PENNSYLVANIA*

<u>Direction</u>	<u>Frequency (%)</u>	<u>Direction</u>	<u>Frequency (%)</u>
N	5.4	S	1.8
NNE	3.6	SSW	2.7
NE	3.6	SW	4.5
ENE	3.6	WSW	10.8
E	1.8	W	19.8
ESE	0.9	WNW	15.3
SE	0.9	NW	8.1
SSE	0.9	NNW	6.3

Calms at 0.5 m/s prevail 10% of the time.

Average non-calm wind speed--2 m/s.

Pasquill Stability Class D.

*Based on data from Reference 16.

360-20 10/81

TABLE 3-2

RADON AND RADON DAUGHTER CONCENTRATION
IN ON-SITE BUILDINGS*

<u>Building No.</u>	<u>Average Radon Concentration (pCi/l)</u>	<u>Average Radon Daughter Concentration (WL)</u>
1 First Level	39	0.16
1 Second Level	28	0.12
2	17	0.07
2A	17	0.07
3	106	0.43
7	34	0.14
9	51	0.21
10	38	0.15
11	51	0.21
15	15	0.06
16	38	0.16
19	19	0.08
18 First Level	3	0.01
18 Second Level	31	0.12

*See Reference 1

360-20 10/81

TABLE 3-3

BETA-GAMMA AND GAMMA DOSE RATES
OUTDOORS ON SITE*

Area	Beta-gamma at 1 cm above surface (mrad/hr)			Gamma at 1 m above surface (mrad/hr)		
	Avg	Stand. Dev.	Range	Avg	Stand. Dev.	Range
A	0.46	0.46	0.04-5.00	0.23	0.18	0.04-1.60
B	0.15	0.16	0.03-1.05	0.12	0.10	0.04-0.73
C	0.12	0.18	0.02-1.25	0.11	0.11	0.02-0.78

*See Reference 1

360-20 10/81

TABLE 3-4

ANALYSES OF WATER SAMPLES TAKEN FROM AUGER HOLES*

Location (See Figure 3-10)	^{238}U (pCi/l)	^{226}Ra (pCi/l)
1	10	< 100
5	920	140
9	340	< 100
18	380	< 100
20	10	240
27	1,080	< 100
28	820	190
30	620	< 100
33	120	< 100
34	10	100
37	230	200
39	2,060	< 100
53	650	< 100
55	40	< 100
59	< 10	< 100
60	20	390
64	< 10	< 100
65	40	< 100
69	10	< 100
71	740	220
73	20	< 100
75	280	< 100
78	50	< 100
80	80	< 100
82	30	< 100
84	< 10	< 100
85	< 10	< 100
86	< 10	< 100
87	30	120
88	110	< 100
Radioactive Concentration Guide in Water (RCG_w) (Soluble)	40	0.03
*See Reference 1		
360-20 10/81

TABLE 3-6

CONTAMINATION IN SUBSURFACE SOIL^a

Sample Hole No. (See Figure 3-9)	Depth of Contamina- tion (ft)	Maximum Contamina- tion (ft)	Maximum ²²⁶ Ra (pCi/g)	Average ^b ²²⁶ Ra (pCi/g)	²³⁸ U (pCi/g)	²²⁷ Ac (pCi/g)
1	0 - 2	1.5	82	40	95	10
2	0 - 2	1.5	8	6	42	1
3	0.5 - 1.5	1.0	45	25	34	N D
4	0 - 2	1.0	32	20	142	N D
5	0 - 8	1.5	2,900	No est.	2,600	N D
6	0 - 1.5	1.0	71	45	120	N D
7	0 - 1	0.5	10 ^b	5	--	--
8	0 - 2	1.0	24	15	133	3
9	0 - 2	1.0	420	250	210	N D
10	0.5 - 2.5	1.5	160	95	340	27
11	0.5 - 2.5	1.5	130	100	360	43
12	1 - 4	3.0	140 ^b	90	--	--
13	0 - 1	0.5	300	200	300	30
14	0.5 - 1	0.5	4 ^b	4	--	--
15	0 - 2.5	0.5	300	180	580	87
16	--	--	--	--	--	--
17	0 - 2.5	2.0	80	55	200	N D
18	0 - 3.5	3.0	21	20	43	2
19	0 - 3	2.0	720	370	520	61
20	1 - 3.5	2.5	280	130	24	109
21	1 - 4	1.5	99	50	116	160
22	1 - 2.5	1.5	320	200	92	N D
23	0 - 3.5	2.0	96	40	81	N D
24	1 - 3	2.0	360	200	1,800	48
25	0 - 3.5	2.0	5,700	3,300	N D	420
26	0 - 5	3.0	170 ^b	110	--	--
27	0 - 6	0.5	76	26	66	29
28	0 - 5	3.0	900 ^b	490	--	--
29	0 - 3	1.5	57	40	104	11
30	0 - 2	1.0	220	150	330	51
31	0 - 2.5	1.5	410	220	5,200	N D
32	0 - 3	1.5	18	10	68	11
33	0 - 6	5.0	250 ^b	120	--	--
34	0 - 2	1.0	38 ^b	28	--	--
35	0 - 2	1.5	110	72	29	N D
36	0 - 3	Surface	67	43	71	4
37	0 - 4	1.0	120	57	110	N D
38	0 - 4	3.0	900 ^b	360	--	--
39	0 - 12	4.0	900 ^b	320	--	--
40	0 - 4	2.0	150 ^b	100	--	--

TABLE 3-6 (Cont)

Sample Hole No. (See Figure 3-9)	Depth of Contamina- tion (ft)	Maximum Contamina- tion (ft)	Maximum 226Ra (pCi/g)	Average ^b 226Ra (pCi/g)	238U (pCi/g)	227Ac (pCi/g)
41	0 - 3	2.0	2,100	1,000	908	140
42	No log	--	--	--	--	--
43	0 - 3.5	2.0	170 ^b	95	--	--
44	0 - 2.5	2.0	19 ^b	14	--	--
45	0 - 5	4.0	24 ^b	16	--	--
46	0 - 2	1.5	280 ^b	200	--	--
47	0 - 3	1.5	800 ^b	420	--	--
48	0 - 2	1.0	750	330	37	71
49	0 - 2	1.0	1,700	920	81	130
50	1 - 3	2.5	28 ^b	22	--	--
51	0 - 3.5	2.5	420 ^b	170	--	--
52	0 - 3	1.0	850	450	85	350
53	0 - 5	0.5	110	56	56	53
54	0 - 7	3.0	600 ^b	330	--	--
55	0 - 0.5	Surface	92 ^b	88	--	--
56	None	--	--	--	--	--
57	0 - 2	0.5	7,000 ^b	4,500	--	--
58	None	--	--	--	--	--
59	0 - 3	2.0	160 ^b	96	--	--
60	0 - 1.5	1.0	28 ^b	18	--	--
61	No log	--	--	--	--	--
62	0 - 1.5	0.5	34 ^b	25	--	--
63	0 - 1.5	1.0	8 ^b	7	--	--
64	0 - 3	2.5	8 ^b	7	--	--
65	0 - 5	4.5	180 ^b	100	--	--
66	0.5 - 2.5	1.5	480	290	170	69
67	0.3 - 1.0	0.5	18 ^b	13	--	--
68	0 - 0.5	Surface	160 ^b	160	--	--
69	0 - 2	0.5	240 ^b	740	--	--
70	4 - 18	8.0	1,050 ^b	550	240	16
71	8 - 14	10.0	154 ^b	69	--	--
72	7 - 12	11.0	10 ^b	6	--	--
73	9 - 10.5	10.0	26 ^b	14	--	--
74	9.5 - 12	11.0	250 ^b	110	15	N D
75	8.5 - 12	11.0	450 ^b	250	88	290
76	9 - 11	10.5	180 ^b	140	48	91
77	0 - 16	4.0	15,000	No est.	600	1,700
78	0 - 2	0.5	60 ^b	44	--	--
79	0 - 2	1.0	80 ^b	45	--	--
80	0 - 2	1.0	18 ^b	14	--	--

TABLE 3-6 (Cont)

Sample Hole No. (See Figure 3-9)	Depth of Contamina- tion (ft)	Maximum Contamina- tion (ft)	Maximum 226Ra (pCi/g)	Average ^b 226Ra (pCi/g)	238U (pCi/g)	227Ac (pCi/g)
81	3 - 18	8.0	17,000	No est.	--	--
82	6 - 10	8.0	2,000 ^b	860	--	--
83	0 - 9	8.0	340 ^b	82	66	8
84	None	--	--	--	--	--
85	4 - 6.5	6.0	6 ^b	5	7	N D
86	2.5 - 5	3.5	18 ^b	12	76	2
87	0 - 6	0.5	7 ^b	4	1	N D
88	5 - 7.5	7.0	12 ^b	9	--	--

^aSee Reference 1

^bEstimated value

360-20 10/81

TABLE 3-7
CONCENTRATIONS OF ^{226}Ra , ^{238}U , AND ^{227}Ac
FROM SOIL CORE SAMPLES DRILLED INSIDE BUILDINGS^a

Location Shown in Figure 3-9	Depth (ft)	^{226}Ra (pCi/g)	^{238}U (pCi/g)	^{227}Ac (pCi/g)
B - 1	0.5 - 1.0	60	30	ND ^b
	1.0 - 2.0	480	450	ND
	2.0 - 2.8	380	600	ND
	2.8 - 3.3	350	820	ND
	3.3 - 4.0	520	200	ND
	4.0 - 6.0	2.4	15	ND
	6.0 - 7.5	5.7	15	ND
B - 2	0.5 - 1.0	36	67	ND
	1.0 - 2.0	3,200	300	410
	2.0 - 3.5	3,800	210	540
	3.5 - 4.5	6.4	17	ND
	4.5 - 5.0	10	43	2.1
B - 3	0.5 - 1.0	34	61	7.1
	1.0 - 2.0	6.2	28	1.2
	2.0 - 3.5	33	140	ND
	3.5 - 5.0	34	410	12
B - 4	0.4 - 1.0	220	150	135
B - 5	0.5 - 0.8	63	60	ND

^aSee Reference 1

^bND = Concentration not determined

360-20 10/81

TABLE 9-1

SUMMARY OF STABILIZATION AND DISPOSAL COSTS^a

		Option							
		I		II		III		IV	
		A ^b	B ^b	A	B	A	B	A	B
1.	Tailings Site	8,993	(1,640)	7,627	(1,640)	8,993	(644)	7,627	(644)
2.	Off-Site Other Than Windblown	3,000	--	3,000	--	3,000	--	3,000	--
3.	Off-Site Windblown	121	--	121	--	121	--	121	--
4.	Transportation								
	Tailings a. Capital Costs	--	--	55	--	--	75	--	(75)
	b. Haul Costs	--	--	1,663	--	--	1,253	1,663	(1,253)
	Disposal a. Capital Costs	--	--	45	--	--	--	45	--
	Site b. Haul Costs	--	--	725	--	--	787	725	(787)
5.	Disposal Site	--	--	782	--	--	251	782	(251)
6.	Total Cleanup ^b (sum of lines 1 through 5)	12,114	(1,640)	14,018	(1,640)	12,114	(3,011)	14,018	(3,011)
7.	Engineering Design and Construction Management (30% of line 6, less haul costs)	3,634	(492)	3,489	(492)	3,634	(291)	3,489	(291)
8.	Total ^b (sum of lines 6 and 7)	15,748	(2,132)	17,507	(2,132)	15,748	(3,302)	17,507	(3,302)
9.	Contingency (30% of line 8)	4,724	(640)	5,252	(640)	4,724	(991)	5,252	(991)
10.	GRAND TOTAL ^b (sum of lines 8 and 9)	20,472	(2,772)	22,759	(2,772)	20,472	(4,293)	22,759	(4,293)
		* 23,244 *		* 25,531 *		* 24,765 *		* 27,052 *	

^aCosts are in thousands of year 1980 dollars.^bColumn A represents Canonsburg site; Column B represents Pennsylvania Railroad Landfill site.^cTotals may differ from the sum of component costs because of round-off.

TABLE 9-2

POTENTIAL CANCER CASES AVOIDED
AND COST PER POTENTIAL CASE AVOIDED

A. Number of Potential Cancer Cases Avoided				
Options:	I	II	III	IV
Option Cost (million \$)	23.2	25.5	24.8	27.1
Years After Remedial Action				
25	< 0.98	0.98	0.98	0.98
50	< 2.2	2.2	2.2	2.2
75	< 3.5	3.5	3.5	3.5
100	< 4.7	4.7	4.7	4.7
B. Cost Per Potential Cancer Case Avoided (Million \$)				
Options:	I	II	III	IV
Option Cost (million \$)	23.2	25.5	24.8	27.1
Years After Remedial Action				
25	>24	26	25	28
50	>11	12	11	12
75	> 6.6	7.3	7.1	7.7
100	> 4.9	5.4	5.3	4.7
360-20 9/81				