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HISTORY OF FMPC RADIONUCLIDE DISCHARGES, REVISION OF NLCO-2039 - (USED AS A REFERENCE IN OU2 RI REPORT)

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(Revision to NLCO-2039)
Internal Special

HISTORY OF FMPC RADIONUCLIDE DISCHARGES

By
M. W. Boback, D. A. Fleming, T. A. Dugan,
R. W. Keys and R. B. Grant

November 1986

FEED MATERIALS PRODUCTION CENTER
Westinghouse Materials Company of Ohio
P. O. BOX 398704
CINCINNATI, OHIO 45239

PREPARED FOR THE
U.S. DEPARTMENT OF ENERGY
WEAPONS DIVISION OF OAK RIDGE OPERATIONS
UNDER CONTRACT DE-AC05-860R21600

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HISTORY OF FMPC RADIONUCLIDE DISCHARGES

INTRODUCTION

This report presents information on the discharge of radionuclides from the Feed Materials Production Center. Discharges to both air and water have occurred but airborne releases are emphasized because inhalation is the principal potential exposure route for most offsite residents in the FMPC area.

Information in this report was compiled in response to a DOE request for a history of radionuclide discharges during the 34 years of FMPC operations from 1951 through 1984. DOE desired that best estimates be made when sampling data were not available to provide a complete history. This desire applied most directly to airborne uranium discharges because of the relative importance of the airborne pathway in regard to radiation doses to offsite population groups. Therefore, for those periods when stack emission data were not available, reasonable estimates were made. Most of these estimates were made by extrapolating from periods when emissions were measured or they were derived from measured production - discharge ratios applied to periods for which only production data were available.

SITE OPERATIONS

The FMPC is a uranium production facility owned by the U. S. Department of Energy and managed under a prime contract by Westinghouse Materials Company of Ohio (WMCO). Production facilities occupy 136 acres in the center of the 1050-acre site. Cincinnati, Ohio, is located 16 miles to the southeast and the small communities of Fernald, Shandon, Okeana and Ross are located within several miles of the site. See Figure 1.

Uranium production has been the primary FMPC activity since the first operations began in October, 1951. Uranium isotopes, therefore, have been the principal radionuclides discharged in air and water. Lesser amounts of thorium were also produced in intermittant operations from 1954 to 1975 and small quantities of thorium were emitted.

Most of the uranium received at the FMPC has been through one or more chemical separations at other sites. These separations remove most of the daughter products and ingrowth of new daughters is limited by the long half lives of several of those daughter isotopes. This was not the case when pitchblende ore and uranium concentrates (yellowcake) were processed in the FMPC refinery. In pitchblende, the entire decay chain may be present and the concentrates contained daughter products which passed through the initial milling operation. The most significant daughter product present in both types of feed was radium-226.

Pure uranium metal and uranium compounds are introduced into the FMPC processes at several points. Impure starting materials are dissolved in nitric acid and the uranium is extracted into an organic liquid and then back-extracted into dilute nitric acid to yield a solution of uranyl

nitrate. Evaporation and heating convert the nitrate solution to uranium trioxide (UO_3) powder. This compound is reduced to uranium dioxide (UO_2) with hydrogen and then converted to uranium tetrafluoride (UF_4) by reaction with anhydrous hydrogen fluoride. Uranium metal is produced by reacting UF_4 and magnesium metal in a refractory-lined reduction vessel. This primary uranium metal is then remelted with scrap uranium metal to yield a purified uranium ingot which is shipped offsite for extrusion. Enriched ingots are extruded into billets which are shipped directly from the extrusion plant to the DOE facility near Richland, Washington. Depleted ingots are extruded into long tubes which are returned to the FMPC for sectioning and machining to final dimensions. The finished sections, called "cores," are shipped to the DOE Savannah River site in South Carolina.

AIRBORNE DISCHARGES

Most uranium production operations result in the generation of dust, fume or reaction gasses. These operations are conducted in ventilated enclosures and the air is passed through dust collectors or scrubbers. The filtered or scrubbed air is exhausted to the atmosphere. Over ninety dust collectors have been used at the FMPC and currently fifty-five are in use. Some original collectors have been replaced and others were removed from service as production operations changed. Since the mid-1950's, dust collector discharges have been determined through continuous stack sampling. Each stack has a sampling system which consists of a center-line probe, a pleated filter and a vacuum source. The vacuum is adjusted for isokinetic sampling. Filters are changed regularly and analyzed for uranium.

Stack sampling was originally undertaken not for accountability purposes but to show there was a need for close attention to dust collector operations. Minor problems with sampling rates and sampler vacuum supply did not interfere with this objective but may have affected the accuracy of discharge estimates. These problems have received attention and no longer exist because of changes made over the years. Stack flow rates were determined for the initial adjustment of sampler vacuum but were not rechecked unless there was reason to suspect a significant flow rate change might have occurred. Vacuum lines were occasionally found disconnected or the vacuum pump turned off. In the brief uranium hexafluoride process in plant 7, the centerline probes were occasionally plugged. No adjustment could be made for the plugging and discharges may have been underestimated; in compiling this report, an effort was made to minimize that underestimation. At other production plants, large discharges determined from the stack samplers could not be corroborated by other means. These discharges were, nevertheless, reported despite the lack of corroboration. The effect of this reporting is that discharges in some years would have been overestimated.

Table 1 contains the height and diameter of FMPC dust collector and scrubber stacks as well as the stack exhaust velocity. When originally installed, all stacks had rain caps as shown in Figure 2. There were plans to remove all rain caps so that stack discharge conditions fit the capability of the EPA-mandated computer program for calculations required under National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations. Those plans have been dropped and the rain caps will be retained because of their beneficial effect in reducing the range of particulate dispersion. Table 2 contains data on building dimensions and

roof heights. Figures 3 and 4 show production building locations and other important site features.

Continuous air sampling is carried out at seven locations on the plant boundary. See Figure 3. Air is drawn at one cubic meter per minute through an 8-inch x 10-inch filter which is changed weekly. The filter and its dust load are dissolved and the resulting solution is analyzed for uranium and gross beta radioactivity. The remaining solution is held to provide a long-term composite for the determination of other radionuclides such as thorium isotopes and transuranics. Airborne thorium may be due to resuspension of the residual left from past operations, the thorium stored onsite or the trace that is present as a contaminant in most uranium compounds and metals. Trace concentrations of transuranics are present in the purified uranium received from DOE reprocessing sites. Boundary air sampling results for uranium and the trace radionuclides are reported in an annual FMPC Environmental Monitoring Report (ref.1).

Since 1981, commercial samplers have been used to measure radon at the FMPC boundary air sampling stations and two offsite locations. The devices are left in position for a calendar quarter and then returned to the manufacturer for readout. Results have been consistently well within the DOE standard for radon-222 in ambient air (ref 1). Independent monitoring of radon levels in the FMPC area has been done by the State of Ohio Department of Health (ODOH) and the Monsanto Research Corporation. The same type of commercial track etch device used at the FMPC through 1984 is also now being used by ODOH. Monsanto used a monitor which utilizes a lithium fluoride thermoluminescent dosimeter that is removed

for readout. ODOH (ref. 2,3,4) and Monsanto (ref. 5) have reported boundary radon-222 concentrations that are similar to or lower than those reported in the FMPC annual Environmental Monitoring Report.

The principal source of radon at the FMPC is a pair of concrete silos which contain the radium-bearing residue from the processing of pitchblende ore. An earth embankment surrounds both silos. Total residue weight in both silos is 19.4 million pounds. The estimated total quantity of radium-226 is 1652 curies. The manhole and pipe openings in each silo dome have been gasketed and are bolted shut. Additional silo information starts on page 24 of this report.

WASTEWATER DISCHARGES

Each of the individual production plants has sumps and equipment for the collection and initial treatment of process wastewater. Effluents from the plants are collected at a central facility, called the General Sump, for mixing and additional treatment, if needed. At the present time, the collected wastes are held in large tanks until the solids settle. The clear supernate is tested for uranium and other prinicpal contaminants and, if contaminant levels are acceptable, the supernate is pumped from the General Sump to pit 5. Because of the volume of water in pit 5, this tends to reduce the variation in contaminant concentrations. From pit 5, the water is decanted to a clearwell where it is sampled for laboratory tests. If the water quality is acceptable, the water is pumped from the clearwell and combined with the sewage plant effluent and the water which collects in the storm sewer system. The combined wastewater stream flows 4200 feet through a buried pipeline to the Great Miami River. Settled solids in the General Sump tanks are pumped to filters and after

filtering the solids are drummed for offsite disposal at a DOE facility.

Prior to the current practice of drumming wastewater solids for offsite disposal, the treated waste slurry was sent to pit 5. The solids settled and the clear supernate flowed to the clearwell. The clear supernate was pumped from the clearwell to the discharge line leading to the Great Miami River. Pit 3, the first FMPC settling pit, is clay lined; Pit 5, the second settling pit, is lined with clay plus a synthetic membrane. Neither pit is in active use. Pit 3 is covered with clean fill; Pit 5 remains open but receives only collected precipitation from an adjacent solid waste pit and the General Sump clear supernate.

The FMPC production area is served by a storm sewer system which collects precipitation runoff and routes the flow to a storm sewer lift station. The station's two pumps transfer the water to the main wastewater discharge line which leads to the Great Miami River. If the flow exceeds the station pumping capacity, the excess overflows to the storm sewer outfall ditch, a natural drainage course which leads to Paddy's Run in the southwest corner of the site. Paddy's Run, an intermittent stream, meets the Great Miami River about 1.5 miles south of the FMPC. Water collected in the storm sewer system consists of runoff and groundwater which infiltrates the system's piping, manholes and catch basins. This flow has a low concentration of dissolved uranium (about 1 mg/L) which results from materials deposited around the production plants.

An onsite tertiary treatment plant handles all sewage generated at the FMPC. The system consists of a primary settling basin, a sludge

digestion tank, two trickling filters operated in series, a secondary settling basin and ultraviolet disinfection of the basin effluent.

Daily samples are collected of the individual major wastewater effluents: General Sump, pit clearwell, sewage treatment plant and storm sewer system. In addition, a continuous sample is collected from the discharge line after all streams mix together. Samples are analyzed for uranium, alpha and beta radioactivity and several nonradioactive chemicals. Since 1975, the discharge of wastewater has been governed by a permit issued under the National Pollutant Discharge Elimination System (NPDES) administered by the U. S. Environmental Protection Agency and the Ohio EPA. A summary of NPDES performance is included in the annual FMPC Environmental Monitoring Report (ref. 1).

The discharge of radionuclides has always been within the limits set by the Department of Energy and its predecessor agencies.

Water samples are collected from the Great Miami River upstream and downstream of the FMPC discharge line. Samples are analyzed for uranium, radium, and several non-radioactive chemicals. Results are reported in the annual Environmental Monitoring Report and consistently show that downstream concentrations are well within federal and state water quality standards (ref. 1).

GROUNDWATER

Action by the Illinoian and Wisconsinan ice sheets gave the FMPC area its basic geological features and provided conditions for a bountiful groundwater supply. Outwash from retreating glaciers filled in the wide valley of a large ancient river. Underlying the FMPC is about 50 feet of

clay-rich till which may be a remnant of a large glacial moraine. Beneath the till is about 150 feet of sand and gravel which fills the buried valley of the preglacial river. The sand and gravel layer provides a steady potable water supply. In the FMPC area, the groundwater flows in a southerly direction and water which passes under the site is thought to enter the Great Miami River between New Baltimore and the mouth of Paddy's Run. See Figure 1.

Three production wells were installed on the FMPC site in 1952 and have been tested routinely for uranium and other potential contaminants since that time. A network of test wells has been installed over the years with the first wells placed around the waste storage area. During 1984, there were 12 onsite test wells and the three original production wells which were sampled on a routine basis.

Since 1981, the groundwater sampling program has been expanded and 22 offsite wells were sampled in 1984 (ref. 1). Wells in three offsite locations show above-background concentrations of uranium. One location is a residence where the water supply was used until 1984. The other two locations are small companies which use the wellwater for industrial purposes only. Samples from over 100 offsite wells in the FMPC area have been analyzed by the FMPC and the Ohio Department of Health; no other wells have been found to contain above-background uranium concentrations. No other radionuclides or chemicals associated with FMPC operations have been observed in down-gradient wells.

A year-long study by a consulting firm identified the storm sewer outfall ditch as the primary pathway for uranium-bearing water to reach the upper layer of the aquifer and to migrate to the offsite wells (ref. 6). In

most of the site area, the clay-rich till minimizes the movement of surface water into the sand and gravel aquifer. This retarding cover thins out in the southern part of the site, allowing surface water to percolate into the ground. The storm sewer outfall ditch which carries uranium-bearing overflow from the FMPC storm sewer system passes through this clay-free area. The southern reach of Paddy's Run was identified as a pathway of lesser importance.

DATA COMPILATION: AIR EMISSIONS

Although daughter products, fission products and transuranic nuclides have been emitted, most of the calculated potential dose from FMPC operations is due to uranium. Because of this fact, considerable effort was expended on the compilation of airborne uranium discharges for each dust collector stack on a calendar year basis. Results are reported in Tables 3 - 11.

Plant 1 operations began in December, 1953, and sampling of the plant 1 dust collector stacks began in September, 1955. The actual measured uranium discharges for each dust collector during the last four months of 1955 were tripled to obtain an estimated annual discharges for the entire year. The same discharge amounts were assumed for 1954; plant 1 production data were not available to use to adjust the discharges on the basis of production levels or throughput. One-twelfth of the 1954 discharge was assumed for the one-month of plant 1 operations in 1953. See Table 3.

Operations in plant 2/3 (the FMPC refinery) began in December, 1953. Stack monitoring began in July, 1955, and total dust collector discharges

measured during July through December were doubled to obtain estimated annual discharges for all of 1955. To obtain an estimate of stack discharges in 1954, the 1955 stack totals were multiplied by the ratio of refinery UO_3 output in 1954 and 1955: 642 metric tons of uranium (MTU) in 1954 and 3288 MTU in 1955; ratio, 0.195. One-twelfth of the 1955 discharge was used as the estimated discharge during the one month of operation (December) in 1953. See Table 4.

Plant 4 operations began in October, 1953, and the continuous sampling of individual dust collector stacks began at various times during 1955. The average measured monthly discharge for each plant 4 collector during 1955 was multiplied by 12 to obtain an estimate of the annual discharge. Data from sampling in January, 1954, and November and December, 1953, were not used because of the short sampling period and the lack of specific dust collector identification. Estimates of the 1954 discharges were based on the 1955 totals and the ratio of 1954-1955 production tonnages in plant 4: 1568 MTU of UF_4 produced in 1954 and 3314 MTU produced in 1955; ratio, 0.473. An estimate for 1953 discharges could not be based on tonnages because of the lack of production data for 1953. Therefore, the estimate is based on time; discharges during the three months of operation during 1953 were assumed to be one-fourth of the discharges estimated for the 12 months of 1954. See Table 5.

Operations in plant 5 began in May, 1953, and occasional stack sampling began in November, 1953. However, sampling during 1953 and 1954 was too sporadic to provide an adequate basis for estimating total annual discharges. Continuous sampling of several plant 5 production stacks began in April, 1955; sampling of the remainder began in October, 1955.

Discharges actually measured during part of 1955 were extrapolated on the assumption that all dust collectors operated during the entire year.

Plant 5 discharge estimates for 1953 and 1954 were based on the 1955 estimates and the ratio of production tonnages: 6075 MTU in 1954 and 15352 MTU in 1955; ratio, 0.396. Therefore, the 1955 stack uranium discharges were multiplied by 0.396 to obtain estimates of the 1954 discharges. The same procedure was followed for obtaining estimates for 1953; 135 MTU in 1953 and 15352 MTU in 1955; ratio, 0.00879. See Table 6.

Plant 6 operations began in July, 1952, and stack sampling began in August, 1955. The discharge measured during the last five months of 1955 were extrapolated for the full year. Production tonnage ratios for plant 6 were used to obtain discharge estimates for 1953 and 1954. The 1953/1955 ratio is 0.238; the 1954/1955 ratio is 0.530. One half of the 1953 estimated discharges was assumed for the six months of operation in 1952. See Table 7.

Plant 7 was constructed for the conversion of UF_6 to UF_4 and production operations lasted for only 24 months, from June, 1954, through May, 1956. Continuous sampling of dust collector stacks began in September, 1955, and continued throughout the final nine months of operation. Occasionally, stack sampling vacuum lines became plugged but no adjustments could be made for the unknown length of time that the stack samplers were non-functioning. After new vacuum pumps were installed in January, 1956, line plugging was not a problem. In order to obtain maximum estimates for this historical report, the uncertain monthly results were not included in the averaging if their inclusion caused a

lowering of the average discharge per day. There were four dust collectors in plant 7 and discharge results were reported on a monthly basis for the nine months of sampling. Therefore, there are 36 stack discharge results for the operating lifetime of plant 7. Only five of these results were not used because of their lowering effect on the average discharge per day of sampling.

To obtain plant 7 discharge estimates for 1954, the average daily discharge per day of sampling was multiplied by the total calendar days from June 1 through December 31 (214 days). For the 1955 estimate, the average was multiplied by 365. There was continuous stack sampling during 1956 and the reported discharges were used without any changes. See Table 8.

Operations in plant 8 began in October, 1954, and stack sampling began in July, 1955. The total measured discharges from July through December, 1955, were doubled to provide estimates for the entire year. To obtain an estimate of stack discharges in 1954, the 1955 discharge estimates were multiplied by the ratio of 1954/1955 plant 8 production tonnages: 266 MTU in 1954 and 1160 MTU in 1955; ratio, 0.229. See Table 9.

Uranium production did not begin in plant 9 until 1957. Stack sampling for uranium began at the same time and all data in Table 10 are from measured discharges; no estimates were necessary.

Pilot plant operations began in October, 1951, and continuous stack sampling began in 1955. During 1955, sampling was conducted from September through December. Discharges measured during this four-month

period were tripled to provide estimates for the entire year. See Table 11.

During 1954, sampling of pilot plant stacks was conducted from January through March and the discharge totals were multiplied by four to provide estimates for the entire year.

During 1953, the pilot plant stacks were sampled from June through August and the discharges measured during this period were multiplied by four to provide estimates for the entire year. The same annual totals were used as the estimated discharges in 1952 because no stack sampling was conducted during 1952 and production data are not available to use in estimating discharges. For the three months of operation in 1951, the discharges were assumed to be one-fourth of the 1953 discharges.

A significant pilot plant airborne uranium release was not monitored by a sampling system. On February 14, 1966, a valve was inadvertantly removed from a heated cylinder of uranium hexafluoride (UF_6). An estimated 1195 kg of uranium, as UF_6, vented to the atmosphere before the valve opening could be plugged. The release point was about six feet above the ground. The release started at approximately 8:40 a.m. and lasted for one hour. During the release, the wind was from the north at a speed of about 5 MPH. Weather conditions recorded at the Greater Cincinnati Airport were:

	7:00 a.m.	10:00 a.m.
Air temperature	33 F	35 F
Humidity	96%	89%
Wind from the	NW	N
Wind speed	7 MPH	6 MPH

No precipitation occurred during the hour-long release.

Most FMPC dust collectors have handled several different enrichments and many have handled more than one uranium compound throughout an operating lifetime. Attempting to assign compounds and enrichments to each collector for each year that a discharge occurred would be difficult and inexact. A large part of the assigning would have to depend on the memories of a small group of operating personnel who worked in the production operation since the early and mid 1950's. In some production plants, overall operations have changed little over the years. For example, UO_3 has been the major refinery product; the plant 4 process still begins with UO_3 and ends with the UF_4 product; in the plant 5 reduction area the major dusts are UF_4 and U_3O_8 (in MgF_2); U_3O_8 is the principal uranium dust produced in the plant 5 remelt area, plant 9 and plant 6. Various compounds have been handled in plant 1, plant 8 and the Pilot Plant.

A history is available of the average enrichment in dust collector discharges (See Table 12). The history is on a fiscal year basis and records are not available to convert it to a calendar year record for much of the period covered.

Three plant 1 dust collectors listed in Table 3 were not equipped with stack samplers through 1984: G2-2, G2-6014, G2-6015. Samplers were installed in 1985. In general, these dust collectors served operations that involved dusts with low uranium concentrations. Based on a review of operations and materials handled, it is not likely that discharges from each collector would have exceeded an average of 0.5 kg U per year. Collector G2-2 serves a station where magnesium fluoride slag is unloaded

from drums or hoppers for milling. Uranium content of the slag is low, about 0.2% by weight. Collector G2-6014 serves an operation in which 55-gallon steel drums are cleaned with abrasive grit. Prior to this step, the drums are sent through a drum washer to receive a caustic solution wash and a water rinse. This step removes all but traces of material from the drums and most of the dust collected in G2-6014 consists of rust, paint flakes and grit fragments. Collector G2-6015 also served the abrasive cleaning operation for many years. For the past few years, the collector has ventilated an operation for shredding copper motor windings which contain only traces of uranium.

Table 13 contains information about systems used to incinerate various types of FMPC wastes. The old oil burner and the graphite burner were simple fire boxes with short stacks. High temperatures and the variable exhaust velocity interfered with proper stack sampling of these units; therefore, discharge estimates are based on knowledge of the amount of material burned and available sampling data. Discharge estimates for the old solid waste incinerator are based on data from several stack emission tests. The last years of operation for these three units were: Oil burner, 1979; old solid waste incinerator, 1979, graphite burner, 1984. Estimates of uranium discharged from the new solid waste incinerator are based on compliance stack testing data; estimates for the new liquid organic incinerator are based on performance criteria and the concentration of uranium in the incinerator feed.

Plant 8, the recovery plant, has five wet scrubbers which receive the airborne discharges from furnace and kiln operations. These operations are generally used to prepare uranium residues for the FMPC refinery.

Estimates of uranium discharges are made monthly for each unit; the estimates are based on loss factors established by stack sampling. Discharge records have been kept on a fiscal year basis and no records prior to 1980 are available for conversion to a calendar year basis. Data for individual scrubbers are not available prior to 1980; therefore, information in Table 14 is on a fiscal year basis and is the total uranium discharge for all plant 8 scrubbers.

Table 15 contains information on the concentration of other radionuclides in scrubber solution samples collected in September, 1985. Results are reported in microcuries of radionuclide per kilogram of uranium. For the purpose of this report, it can be assumed that the radionuclide-to-uranium ratio in the stack effluent is the same as in the scrubber solution. No information is available that would permit ratio adjustments for materials processed in earlier years.

Particle size information was obtained on bulk dust collector material and on air stream particulates from collector inlet and outlet ducts. Samples were collected from June through September, 1985. A subcontractor team used an Andersen Mark III in-stack particle fractionating sampler to collect the airstream samples. Because of the low dust loading in outlet ducts, sampling periods of up to 80 hours were required. After sample collection, glass fiber filters from the fractionating sampler were weighed by the subcontractor and returned to the FMPC where they were dissolved for uranium analysis. Because of the small amount of material collected on many sampler stages, the quantity of uranium on each stage as determined by analysis for uranium is a more accurate figure than the weight of total material that might have been

obtained from filter weighings. Following the analyses for total uranium, solutions from all stages of each sample were composited for a determination of isotopic uranium composition.

Inlet and outlet duct samples were collected from 15 dust collectors and analyzed before this report was assembled. Results are given in Tables 16 - 30. Bulk samples have been collected from 21 other dust collectors and analyzed for particle size, percent uranium, and isotopic uranium composition. Results are given in Tables 31 - 51.

As noted earlier, airborne emissions produce the only offsite exposure that most area residents would receive from FMPC operations. In those emissions, uranium is the principal radionuclide and produces most of the dose. Other radionuclides are present in low concentrations and are of lesser interest in determining historical doses. However, because of the low concentrations and resulting stack sampling difficulties, the only analytical data available are from the analyses of annual boundary air sample composites (ref.1). To provide a basis for estimating the emission of other radionuclides, all samples of dust collector bulk dust were analyzed for 14 other nuclides. These nuclides are uranium and thorium daughter products, transuranics and fission products. Results for the 36 bulk samples are given in Tables 52 - 87. It is likely that the transuranic and fission product concentrations were lower in prior years when FMPC starting materials included a high percentage of concentrates.

On several occasions, thorium compounds and thorium metals were produced at the FMPC. These operations were served by dust collectors and

scrubbers and occasional thorium discharges occurred. Table 88 lists all such releases.

From 1953 through 1955, the FMPC refinery processed pitchblende ore from the Belgian Congo. No chemical separation or purification had been performed prior to the receipt of the ore at the FMPC. As a result, all stack discharges of the ore included the daughter products of the uranium decay chains. No archival information exists about the amount of these nuclides discharged or the concentrations in the pitchblende. In order to provide a discharge estimate, a file sample of pitchblende was analyzed in 1985 for several radium and thorium isotopes. The concentrations found were used to calculate emissions based on the amount of uranium discharged. Data for 1953 - 1955 are included in Table 89.

Beginning in 1956, the refinery feed consisted of uranium concentrates from Canada and the U.S.A. In the milling process that produced the yellowcake from ore, most of the uranium daughters had been removed. One important daughter product, radium-226, is carried over in amounts that vary with the type of process; concentrates produced by resin-in-pulp extraction or sulfuric acid leach methods have one-tenth or less Ra-226 than does yellowcake prepared by the carbonate leach process.

As in the case of the pitchblende, there are no archival data regarding concentrate radium levels. Also, identification of the type of concentrates processed is not available. Therefore, an average radium concentration was selected. The reported range of Ra-226 in concentrates, according to one study made by the U. S. Public Health Service, was 26 - 7190 pCi/g of sample (ref. 7). Assuming that concentrates contain 70% uranium, this range converts to 0.037 - 10.3

uCi/gU. However, the maximum reported for Homestake-Sapin concentrate was considerably greater than the concentration found, in 1985, in a file sample of that concentrate; 7190 pCi/g was reported and 1600 pCi/g was found. The reported U. S. Public Health Service results and the 1985 FMPC results are given below:

CONCENTRATE	Radium-226 pCi/g of sample	Radium-226 uCi/kgU
1985 FMPC DATA		
Homestake-Sapin	1600	2.3
Texas Zinc Miner	1500	2.1
Durango	170	0.24

CONCENTRATE	Radium-226 pCi/g of sample	Radium-226 uCi/kgU
U.S. PHS DATA		
Homestake-Sapin	7190	10.3
Homestake-Partners	3490	5.0
Gunnison	35	0.050
Edgemont	150	0.21
Climax	26	0.037

An average of 1.0 uCiRa/kgU was selected for estimating refinery emissions. If additional data are obtained that justify a different average, the estimates can be adjusted.

Canadian concentrates were used as refinery feed from 1956 through 1960. Each type was analyzed for thorium prior to processing so that extraction conditions could be established. The thorium content of the Canadian material was high enough to require special efforts to ensure that the refinery product, UO_3, was within the thorium specifications of 50 ppm on a uranium basis. In order to meet this specification, blending was done to produce extraction feed solutions which did not exceed 0.5% thorium on a uranium basis. A concentration of 0.5% Th converts to 0.56 uCiTh/kgU and this concentration was used to estimate the thorium discharges reported in Table 89 for 1956 - 1960.

Archival information on the concentration of thorium in two U. S. concentrates was augmented with the FMPC analyses in 1985 of three concentrate file samples:

CONCENTRATE	Thorium-232 uCiTh/kgU
FMPC ARCHIVAL DATA	
Cannonsburg Vitro	3.4×10^{-3}
Colorado Vitro	2.2×10^{-2}
FMPC 1985 ANALYSES	
Durango	2.4×10^{-3}
Homestake-Sapin	2.8×10^{-2}
Texas Zinc Miner	9.2×10^{-2}
AVERAGE	3.0×10^{-2}

The average Th-232 concentration of 0.03 uCi/kgU was used to estimate the refinery thorium discharges for 1961 - 1977 reported in Table 89.

The three concentrate file samples were also analyzed in 1985 for Ra-228, Th-228 and Th-230. Average concentrations were used to calculate the discharge estimates reported in Table 89. Although the file samples were U. S. concentrates, the averages were also used to calculate discharges for 1956 - 1960 when Canadian concentrates were processed. There are no file samples of Canadian concentrates and archival data are not available; it is unlikely that any concentrate samples were analyzed for trace radionuclides when the material was being received and processed at the FMPC.

DATA COMPILATION: WASTEWATER DISCHARGES

Radionuclides in wastewater do not contribute significantly to the population radiation dose because average concentrations are low and the Great Miami River is not used as a potable water supply. For example, an individual who consumed 2 liters per day from a point just below the FMPC effluent outfall during 1984 would have a 50-year committed dose equivalent of 0.14 mrem to the bone surface and 0.005 mrem effective dose equivalent. These doses are well below current regulatory standards and are below the doses received from natural background sources of radiation.

While a record has been maintained of the discharge of uranium in wastewater, other radionuclides at lesser concentrations have been less closely monitored. Starting in 1969, however, estimates were made for

other nuclides based on the analysis of several long-term composite samples each year.

A record of wastewater discharges is given in Tables 90 and 91. Table 90 is a fiscal year record of uranium discharges beginning in 1952. Table 91 is a calendar year record, starting in 1957, for several other radionuclides.

DATA COMPILATION: GROUNDWATER

Offsite wells that are routinely sampled are shown in Figure 5 and 1984 results are given in Table 92. Wells 12, 15 and 17 have above background uranium concentrations which were observed initally in late 1981 when the first offsite samples were analyzed. Well 12 is at a private residence and the well water was used until April, 1985 when a new deep well was installed; water from the deep well contains only background uranium. Wells 15 and 17 are at small industrial sites. At the well 15 site, bottled drinking water has been in use for at least two years. At the well 17 site, bottled drinking water has been used since 1974.

The average uranium concentration found in these three offsite wells during 1984 was used to calculate the 50-year committed dose equivalents, assuming the wells were used as the sole source of drinking water. Maximum committed dose equivalents due to ingestion of water from well 12 are 30 mrem effective dose and 442 mrem to the bone endosteum. For well 15, the doses are 40 mrem and 587 mrem; for well 17, the doses are 7 mrem and 97 mrem. See Table 93.

DATA COMPILATION: RADON-222 SOURCE TERM

Residues from the processing of Belgian Congo pitchblende remained the property of the African Metals Corporation (Afri-Met), an agency of the Belgian Government. By agreement between Afri-Met and the U.S. Atomic Energy Commission, the residues were to be stored for eventual return to the owner. Therefore, when the residues were generated they were not mixed with other site wastes but were placed in the two dedicated silos. In 1983 the lease agreement was ended and DOE assumed full ownership and responsibility for the residues.

Pitchblende residues were first added to the concrete storage silos in 1953. The residues were batch-pumped from the FMPC refinery to the silos as an aqueous slurry. The supernatant liquid was withdrawn and pumped back to the refinery to be reused in the slurrying step. Additions to the silos ended in 1955 when the last pitchblende was processed at the FMPC. Also in 1955, pitchblende residues from another site were added to the silos. Filling and return lines were then removed and all openings except one on each silo were covered with metal plates. The single remaining opening on each silo was a small gooseneck pipe. In 1977, the remaining openings were capped and all cover plates were gasketed and bolted. Core sampling of the silo contents in 1972 showed a dry free-flowing powder at the surface and 40% moisture in samples from the bottom.

The estimated source term for radon-222 flux, for both silos under the present storage conditions, is 60 Curies per year. Dispersion code calculations predict that this flux will add an average of 0.006 pCi/L to

the radon-222 concentrations at the nearest residence. This increase is about 2.5% of the natural background Rn-222 concentration in the Cincinnati area. Appendix 1 is a report which discusses the source term derivation and the concentration and dose calculations. For conservatism in the source term derivation, the amount of Ra-226 in the silos was assumed to be 1760 curies instead of the previously used estimate of 1652 curies.

As noted on pages 5 and 6, radon-222 concentrations measured at the site boundary are within the applicable DOE standard. In addition, concentrations reported by two outside groups are about the same as, or lower than, concentrations reported by the FMPC. Table 94 contains a comparison of FMPC radon results with results reported by Mound Laboratory and the Ohio Department of Health.

POTENTIAL PATHWAYS

As noted in a preceding section, ingestion of river water is not a significant potential source of offsite radiation exposure because of the low concentration of radionuclides in the water and because the river is not used as a source of potable water. In addition, ingestion pathways for substances other than drinking water can be eliminated from consideration when calculating the offsite radiation dose due to FMPC operations. This conclusion is based on a statistical analysis of the radionuclide concentrations in fish, vegetables and milk collected from the FMPC environs (ref. 1). This analysis shows there is no significant difference between radionuclide concentrations in these foodstuffs and in corresponding foodstuffs from distant control locations. There was no statistical difference in the uranium concentrations found in fish

collected from three locations in the Great Miami River: Mouth of Paddy's Run, River Mile (RM) 19.5; FMPC outfall, RM 24.1; Ross, Ohio, RM 27. Average concentrations found in fish collected in 1984 were: RM 19.5, 0.242 pCi/g; RM 24.1, 0.299 pCi/g; RM 27, 0.331 pCi/g. Concentration units used here are picocuries of uranium per gram of fillet ash. Analyses of milk samples from a local dairy and from a location 18 miles away yielded identical results for the uranium concentration. During 1984, five milk samples from each location were analyzed by a commercial laboratory. The uranium concentration for all samples was below the detection limit and all results were reported by the commercial laboratory as less than 1 ug/L.

The possible 70-year committed dose due to soil ingestion by a child as calculated using a uranium concentration of 3.86 pCi/g, the concentration found in soil near the Elda Elementary School in Ross, Ohio. An annual soil intake of 100 grams was assumed. For this special case, a 70-year dose factor was used because the child's life expectancy is greater than 50-years. The calculated dose to the critical organ, bone endosteum, was 6.2×10^{-3} mrem. This is an extremely low dose and most of it is due to uranium naturally present in soil. It is improbable that soil would be consumed in a quantity that would produce a significant dose.

The external dose from the immersion pathway also can be removed from consideration of historical dose estimates because the dose is insignificant in comparison with existing standards and the dose from background radiation and other sources. Beta and gamma emitting radionuclides at the boundary air monitoring stations have not been found in concentrations that would contribute a significant dose. For example,

during the period 10/31/84 to 12/7/84, a series of dust collector upsets occurred at the FMPC. The highest skin dose calculated for this period was 1.36 x 10^{-4} mrem. This indicates the external dose due to air immersion is minimal and can be ignored when estimating the dose to the public due to historical emissions.

For the potential internal dose due to the inhalation pathway, the 50-year committed dose to the lungs, bone endosteum and the effective dose were calculated using the highest 1984 average concentration at the seven boundary air sampling stations. Results are given in Table 95. Thorium-230, Rn-222 and the uranium isotopes account for the major part of the calculated potential organ dose: Lung, 99%; bone endosteum, 84%; effective dose 97%. In addition, Th-232, Th-234 and Pu-239/240 contribute 15% of the calculated potential dose to the bone endosteum. Since these radionuclides produce almost all of the calculated potential dose, it may not be necessary to reconstruct the historical emission record for other nuclides which do not contribute significantly to the potential offsite doses.

Potential doses due to the consumption of water from offsite wells with above-background concentrations of uranium are given in Table 93. This pathway and the inhalation and direct radiation pathways are the only significant routes for potential exposure of offsite residents.

Since 1975, gamma radiation dose rates at the FMPC boundary air sampling stations have been monitored with thermoluminescent dosimeters. The TLD's are hung on the station fences, about five feet above the ground. Dosimeters are changed and processed every three months and data are reported in the FMPC annual Environmental Monitoring Report (ref. 1).

Naturally-occurring dose rates are observed at most boundary locations. Results are similar from year to year and the maximum dose rate occurs along the west side of the site. During 1984, the calculated maximum committed dose equivalent at an offsite residence, due to direct radiation from FMPC operations, was 9.8 mrem or about 10% of the dose received from natural background radiation (ref. 1).

ACCURACY OF HISTORICAL DOSE ESTIMATES

Accuracy of the dose estimates will depend upon two points:

(1) Accuracy and completeness of the discharge estimates.

(2) Accuracy of the computer program used to calculate doses from the discharge data.

The sources of the discharge estimates reported in this document vary from actual measured values to estimates based on production rates, extrapolated data, or consensus judgments. It is fortunate that the dust collector uranium discharges, which have produced the major part of the potential offsite doses, were monitored through continuous stack sampling. The sampler was developed at the FMPC in the early 1950's and experience has indicated that these units have given good data on uranium discharges.

Figure 6 is a diagram of an ideal stack sampler system. Figure 7 shows the disassembled components and Figure 8 shows a unit installed on a FMPC dust collector stack. Before a sampler is installed, a traverse of the stack is made to determine the total air flow and velocity profile. The sampler is installed with the probe in the stack centerline. The filter

holder is attached to a vacuum source which is adjusted to provide an isokinetic sampling rate. A cellulose pleated filter is used to collect particulates; filter diameter is four inches and the effective filtering area is 77 square inches. Until late 1984, new filters were numbered and weighed. After removal from the sampler, they were weighed and an aliquot of the collected dust was removed, weighed and analyzed for uranium. This procedure provided the percent uranium in the dust and the total dust and total uranium on the filter. Knowledge of the probe diameter and duct diameter permitted a calculation to obtain total dust discharged and total uranium. In December, 1984, the analytical procedure was changed; stack filters and the contained dust are dissolved completely in acid and the solution is analyzed for uranium.

Accuracy of the computer program that will be used to calculate radiation dose from stack discharge data is not known. It is, no doubt, a partial function of the accuracy of the input data: Stack physical characteristics; radionuclide emission rate; and meterological information. Although the accuracy of the program cannot be determined, the measured uranium concentration at the boundary sampling stations should provide an indication. In addition to the population doses that are intended to be calculated from data in this report, calculations will be made of expected uranium concentrations at the seven boundary sampling stations. Results will be compared with the concentrations actually measured by analysis of filters from the continuously-operated air samplers.

QUALITY ASSURANCE

Efforts to ensure the reliability of FMPC environmental data existed since the start of site operations. Good laboratory practice was relied upon when operations began in the early 1950's; quality control measures were introduced later; and now quality assurance practices have been added. Time and effort spent on controls and obtaining proof of reliability increased as the use of environmental data progressed from a strictly internal recording to the obligatory submission of data to regulatory agencies to show compliance with the requirements of operating or discharge permits.

The elements of quality assurance which have been applied to effluent stack sampling at the FMPC include the following: Establishing sampler locations in accordance with appropriate ANSI standards and good industrial hygiene practice, with consideration of facility design; establishing and checking of proper isokinetic centerline sampler flowrate by measurement of stack flowrate using standard pitot tube methods and written standard operation procedures; periodic filter change inspection, including inspection of the sampler conducted per standard operating procedure; measurement of sampler airflow with calibrated rotameter and verification of proper sampler flowrate at each inspection; use of individually numbered filters to ensure proper sample identification and delivery of filters to the laboratory; recording of stack sampler inspection data on standard forms with distribution to appropriate production plant supervision; evaluation of airflow data and

analytical data to verify proper sampler operation and appropriateness of analytical result including comparison with past results.

Until December, 1984, filter samples collected to monitor airborne discharges of uranium from dust collectors were analyzed in the Health and Safety Division laboratory facilities. The initial designation of "Analytical Laboratory" for these facilities was subsequently changed to "Bioassay Laboratory." Over the years, improvements were made in the analytical methods and there were an increasing number of quality assurance practices applied to the analyses of stack filter samples for uranium. From 1951 until June, 1960, standard analytical laboratory quality assurance practices were followed such as the use of distilled water and analytical grade reagents. Uranium standards were analyzed and a new calibration curve constructed whenever fresh reagents were prepared or any changes were made which might effect analytical results. Such changes included the replacement of spectrophotometer cells or the installation of new instrument components. Additionally, samples were analyzed in duplicate at various times as a check of analytical performance and to evaluate the precision of the analyses.

A very significant quality assurance practice was initiated prior to 1960 and continued until December, 1984. Whenever the initial analytical result for a filter indicated a uranium discharge of 50 pounds or more had occurred, the sample was subjected to a second analysis. The second analysis was performed in the Technical Division Nuclear Materials Control Laboratory using a well established and reliable oxidation-reduction method which was closely monitored by quality assurance

techniques. In these instances, uranium stack discharges were based on the Technical Division analytical result.

During June, 1960, the analyses of quality control samples on a regular basis were added to the above quality assurance measures for the determination of uranium in stack samples in the Bioassay Laboratory. The control samples were provided by the Quality Assurance Section of the Technical Division Analytical Department. Personnel in the Quality Assurance Section evaluated the control sample results and regularly submitted reports to the Bioassay Laboratory so that corrective actions could be taken if necessary. Since December, 1984, uranium analyses of all stack filter samples have been performed by the Technical Division Analytical Department which has an extensive quality assurance program described later in this report.

The elements of quality assurance which have been applied to water sampling at the FMPC include: Collection of water samples according to current good practice and NPDES requirements, as appropriate, regarding sampling location, container type, proper preservation, and holding times; collection of samples in new containers, uniquely identified, and promptly delivered to the laboratory; maintenance of flow data quality by periodic calibration of instrumentation and by use of standard measurement devices such as the parshall flume; construction and installation of groundwater monitoring wells using current good practice standards to provide representative samples of the aquifer, geologic zone, impoundment, or facility being monitored; collection of groundwater samples using well evacuation and cross-contamination control techniques;

evaluation of analytical results, including comparison with past results for appropriateness.

Much of the particle size and radionuclide data listed in this report relating to airborne discharges are based on analyses performed by the Technical Division Analytical Department. The Analytical Department has been involved in a detailed internal quality assurance program for approximately 30 years. Quality assurance is administered by a section independent of the Department's laboratories. Analytical accuracy and precision are regularly evaluated by analyses of blind standards and recycle samples. The results of these analyses provide prompt indication of any problems and help ensure that the various laboratories are consistently producing reliable results. The Analytical Department also participates in three ongoing, external laboratory testing and evaluation programs. These are: (1) Safeguards Analytical Laboratory Evaluation (SALE), (2) General Analytical Evaluation (GAE), both conducted by the DOE New Brunswick Laboratory, and (3) Uranium Metals Sample Exchange Program, conducted by Los Alamos Scientific Laboratory.

Collector bulk dust samples were analyzed for Sr-90 and Ru-106 by the Analytical Chemistry Division of Oak Ridge National Laboratory which maintains an extensive quality assurance program. Ten percent of the analyses performed are for quality assurance purposes. The laboratory which performed the Sr-90 and Ru-106 analyses participates in the DOE Quality Assessment Program (QAP) administered by DOE's Environmental Measurement Laboratory (EML) and the USEPA-Las Vegas intercomparison analyses program in addition to the ORNL in-house quality assurance programs.

Data in this report on radionuclides discharged in liquid effluents are based on analyses performed in the WMCO Bioassay and Analytical Departments, at ORNL and at a commercial laboratory. The quality assurance programs of the Analytical Department and ORNL described in previous sections regarding airborne discharges would also apply to analyses performed by these laboratories for the purpose of characterizing liquid effluent discharges. Quality assurance practices followed by the Bioassay Laboratory for the analyses of liquid effluent samples include daily measurements or checks of background count rate and detection efficiencies of counting equipment and routine analyses of blanks, standards, and spiked sample aliquots. The values obtained from these analyses have been within the ranges which indicate the analytical systems are under control and the results being obtained are reliable. Uranium control samples provided by the Quality Assurance Section of the Technical Division are analyzed daily as part of the intralaboratory quality assurance activities. The values which have been obtained for these daily control samples show that the procedure used for uranium analyses produces reliable data. The Bioassay Laboratory also participates in DOE's Quality Assessment Program. In this program, laboratories receive samples of various media for analysis. Results are reported to DOE's Environmental Measurements Laboratory (EML) for comparison with established values. Since April, 1977, the Bioassay Laboratory has analyzed 19 soil, 26 water and 31 air filter samples for uranium. The ratio of Bioassay Laboratory results to EML values for these analyses has averaged 1.15 for soil, 1.08 for water and 1.12 for air filter samples.

A limited number of analyses have been performed on liquid effluent samples by a commercial laboratory which has been providing analytical services to the nuclear industry for many years. Relative to environmental monitoring analyses, the laboratory's quality assurance plan meets the requirements of 10CFR50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," and NRC Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment." The quality assurance program also closely corresponds to the "Handbook for Analytical Quality Control in Radioanalytical Laboratories," EPA-60017-77-088, August, 1977.

Thermoluminescent dosimeters used at the FMPC boundary stations have been tested in the annual International Environmental Dosimeter Intercomparison Project sponsored by DOE and the U. S. Nuclear Regulatory Commission. In this project, participating organizations submit dosimeters to be placed in a uniform outdoor radiation field. After exposure, the dosimeters are returned to the organizations for determination of the dose received. Results are reported to the sponsors and the sponsors issue a report that lists the actual dose and the values reported by all participants. FMPC thermoluminiscent dosimeters have performed well; in recent intercomparisons, the differences between the FMPC results and the actual doses received has been 10% or less. This is considered highly acceptable performance for the determination of environmental radiation doses.

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(2) Letter, Ben Wilmoth (Ohio Department of Health) to J. A. Reafsnyder, March 20, 1986.

(3) Private Communication from Ben Wilmoth, Ohio Department of Health, September, 1986.

(4) Letter, Ben Wilmoth, (Ohio Department of Health) to J. A. Reafsnyder, September 23, 1986.

(5) G. R. Hagee, et al., Radon and Radon Flux Measurements at the Feed Materials Production Center, Fernald, Ohio, Monsanto Research Corporation, Report No. MLM-MU-85-68-0001, August 6, 1985.

(6) Department of Energy, Feed Materials Production Center Groundwater Study - Task C Report, prepared by Dames & Moore for NLO, Inc., July, 1985.

(7) Process And Waste Characteristics at Selected Uranium Mills, U. S. Public Health Service, Technical Report W62-17, 1962.

(8) Aas, C. A., D. L. Jones, and R. W. Keys, Feed Materials Production Center Environmental Monitoring Report For 1985, Westinghouse Materials Company of Ohio, Report FMPC-2047 (Special), May 30, 1985.

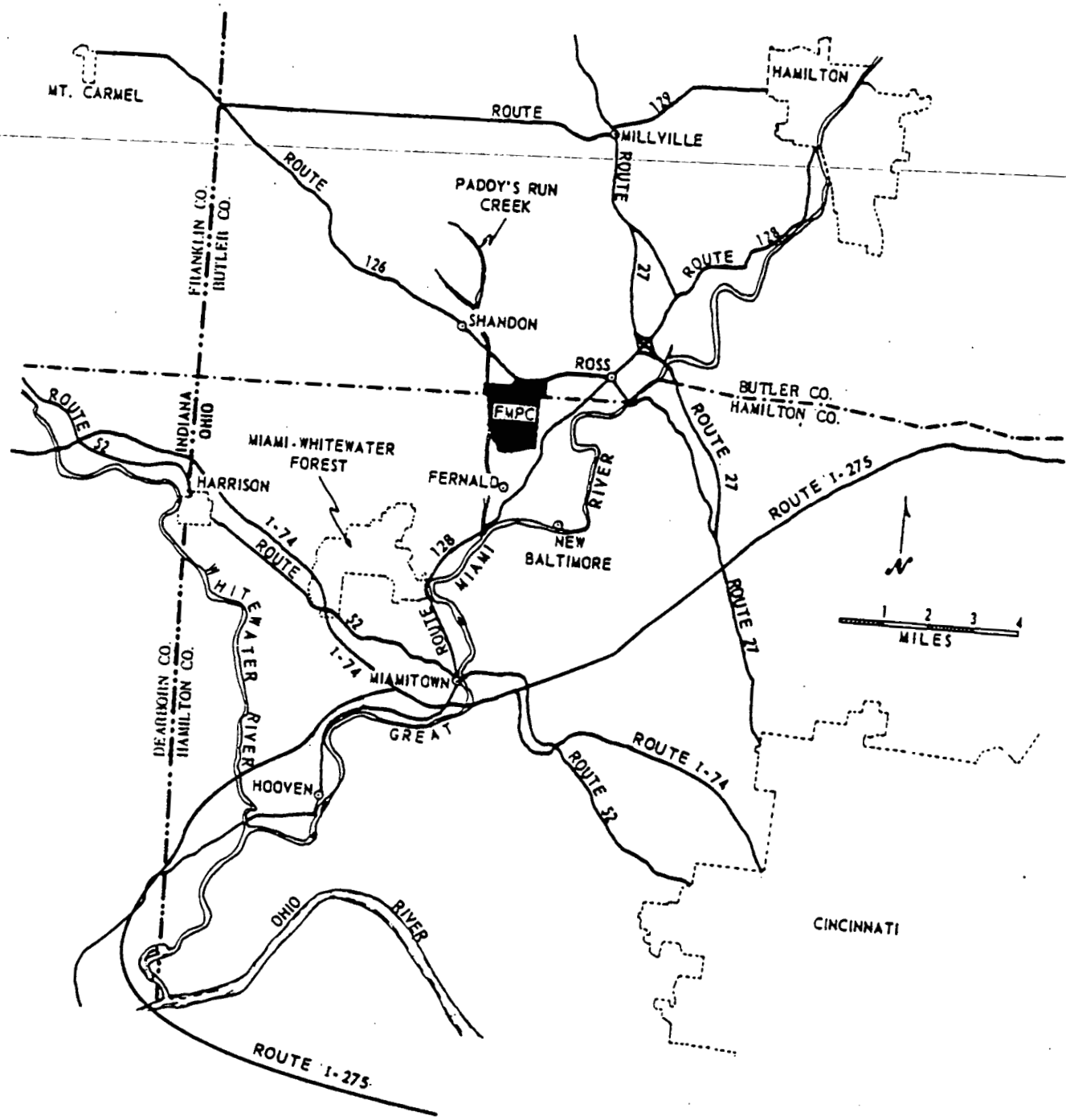


Figure 1. Map of FMPC Area

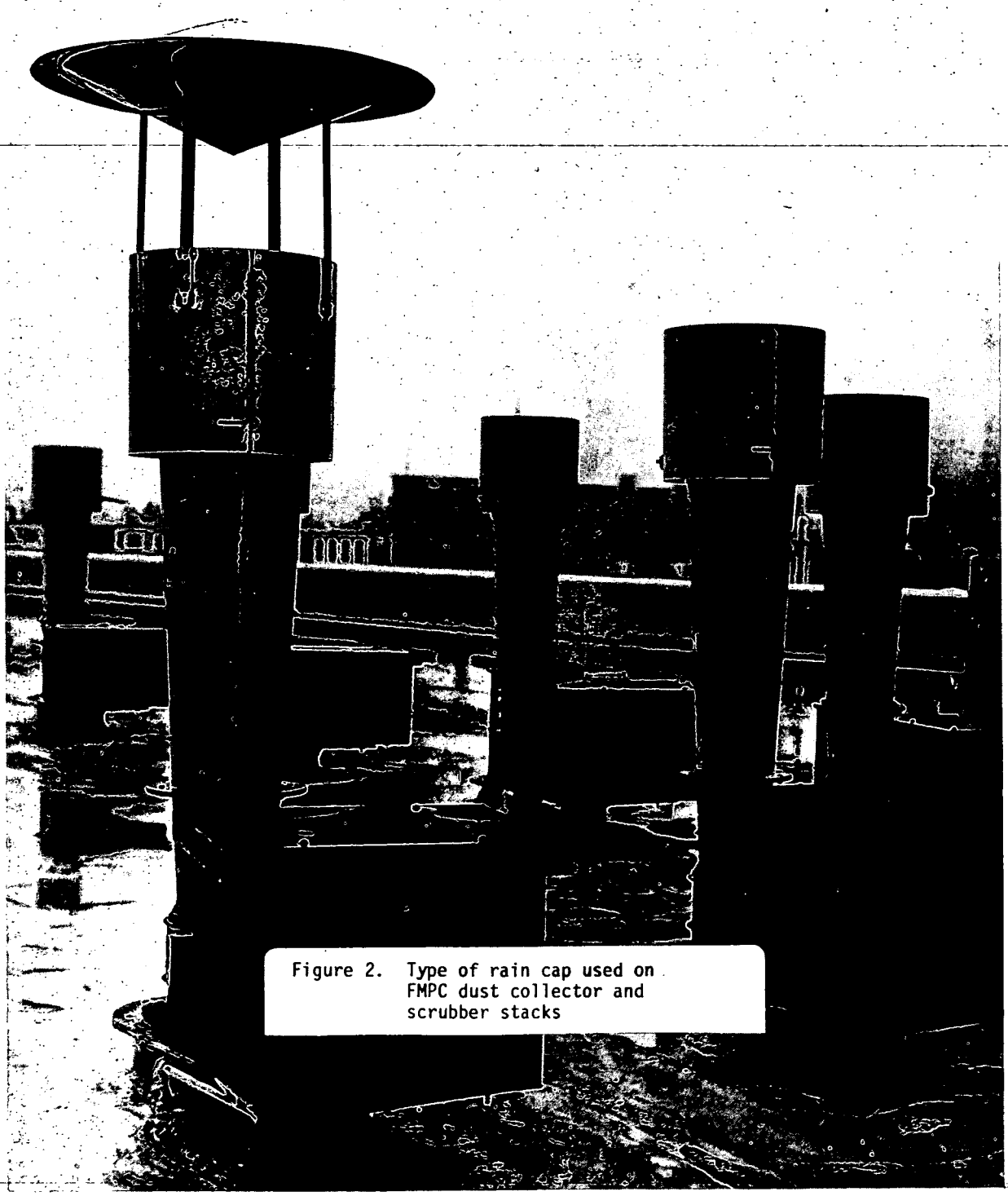


Figure 2. Type of rain cap used on FMPC dust collector and scrubber stacks

FIGURE 3

FEED MATERIALS PRODUCTION CENTER

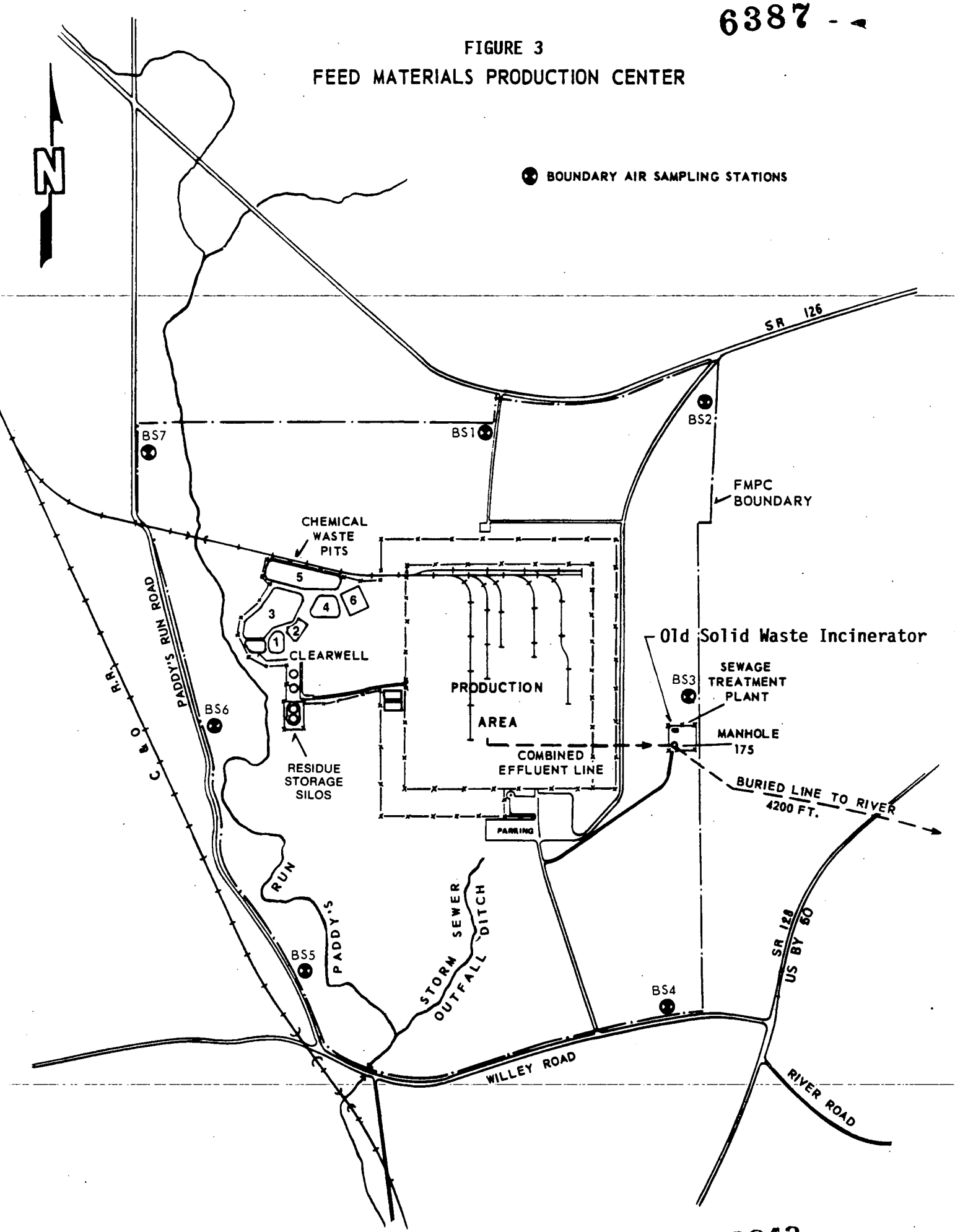
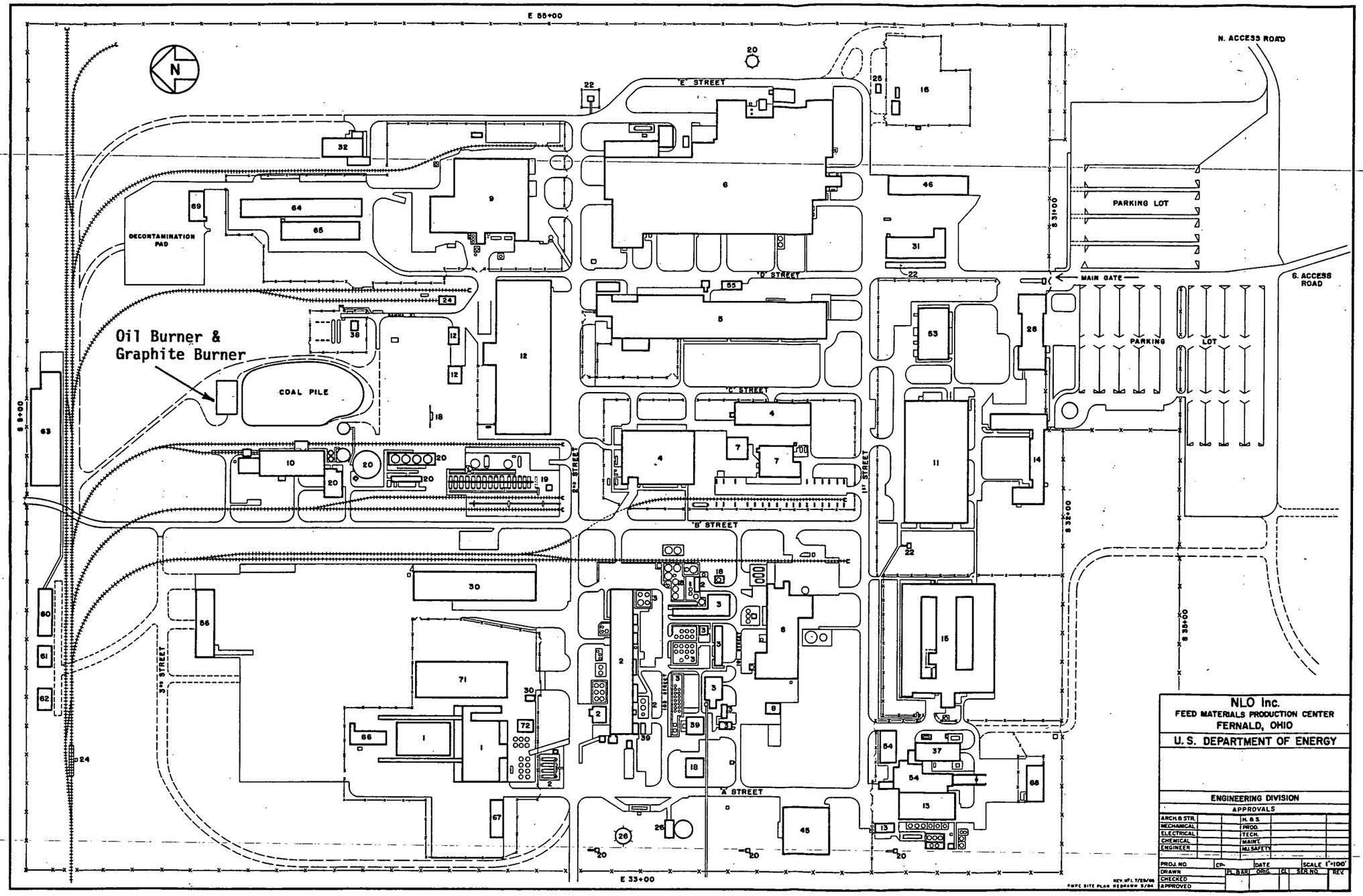


FIGURE 4. FMPC PRODUCTION AND ADMINISTRATIVE AREA



AREA CODE NUMBER	TITLE
1	Preparation Plant
	Silo Storage (South of Sampling Plant)
2	Ore Refinery Plant
3	Nitric Acid Recovery Plant
4	Green Salt Plant
5	Metals Production Plant
6	Metals Fabricating Plant
7	Building 7
8	Recovery Plant
9	Special Products Plant
10	Boiler Plant
11	Service Building
12	Mechanical Shop & Storeroom
13	Pilot Plant (Wet End)
14	Administration Building
15	Laboratories
16	Main Electric Sub-Station
18	Water Pollution Control
	Chemical Feed Building
	General Sump
19	Metal Tank Farm
20	Water Supply System
	Cooling Tower
	Cooling Tower Pump House
	Elevated Storage Tank - East
	Treated Water Storage Tank
	Chlorine Building (For Water Treatment Area)
	Water Wells
	Reactivator
22	Interplant Service & Product Lines
	Gas Meter House
	Lift Station
	Pipe Trestle
	Truck Scale
23	Communication & Alarm System
24	Railroad System
25	Sanitary Sewer System
	Sewage Disposal
	Imhoff Tanks
	Sludge Beds
26	Fire Protection System
	Elevated Water Tower - West
28	Security System - Guard House
30	Chemical Warehouse
31	Engine House - Garage
32	Magnesium Storage
34	K-65 Storage Area
35	Metal Oxide Storage Area
37	Pilot Plant Annex
38	Propane Storage
* 39	Incinerator Plant
40	Waste Management - Solids
44	Temporary Structures
45	Building 45
46	Heavy Equipment Garage
47	Mobile Equipment
51	UF_6 to UF, Reduction Facility II
53	Health, Safety & Production Control Building
54	UF_6 to UF, Reduction Facility I
55	Slag Recycling Plant - East
56	CP Storage Warehouse
60	Quonset Number 1
61	Quonset Number 2
62	Quonset Number 3
63	KC-2 Warehouse
64	Plant 9 Warehouse
65	Plant 5 Warehouse
66	Drum Reconditioning Building
67	Plant 1 Storage Building (No. 1 & No. 2)
68	Pilot Plant Warehouse
69	Decontamination Building
71	General In-Process Storage Warehouse
72	Drum Storage Building
73	Fire Brigade Training Center
74	Paved Area Storage
75	Site Preparation

* Location of new solid waste incinerator and liquid organic waste incinerator.

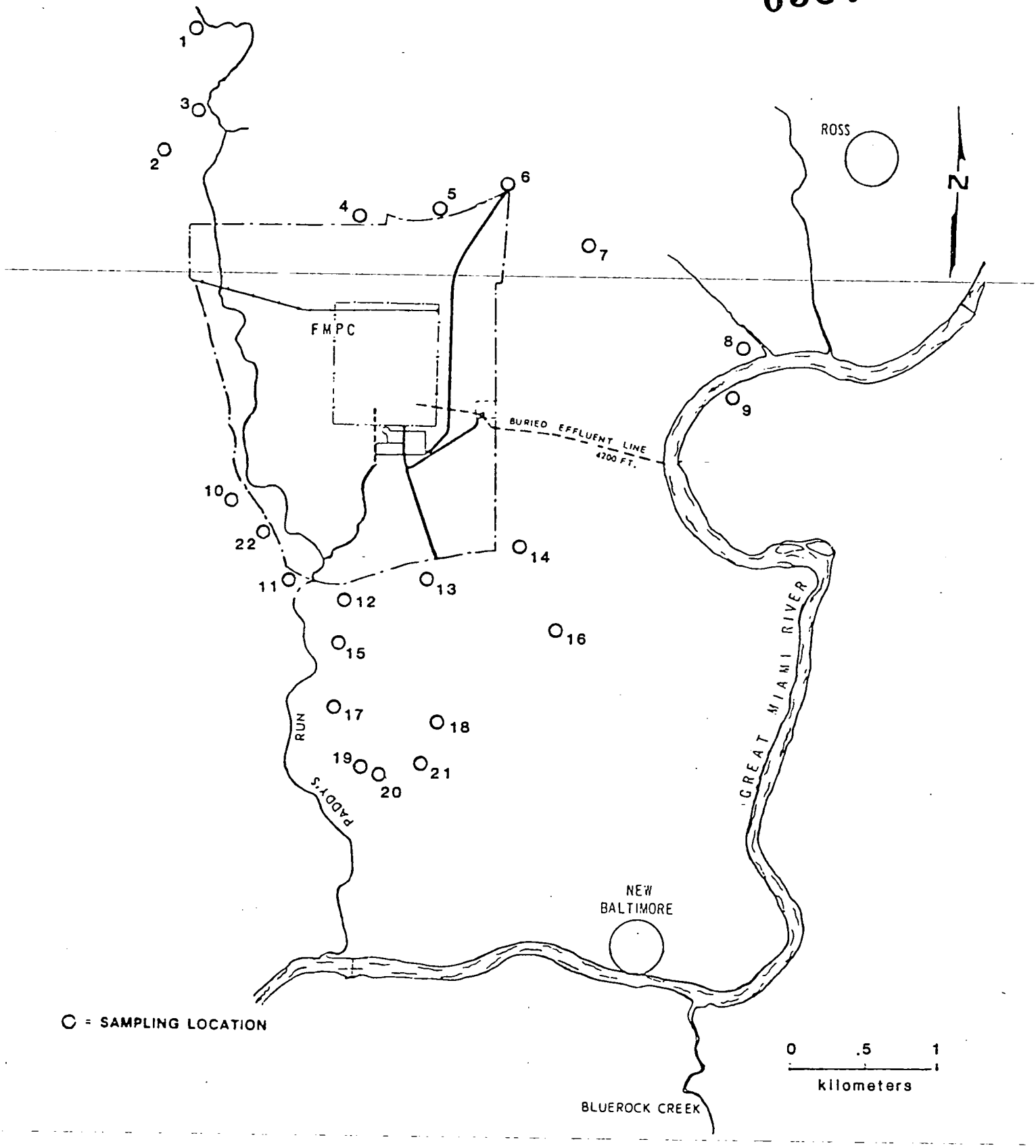


FIGURE 5. OFFSITE MONITORING WELL LOCATIONS

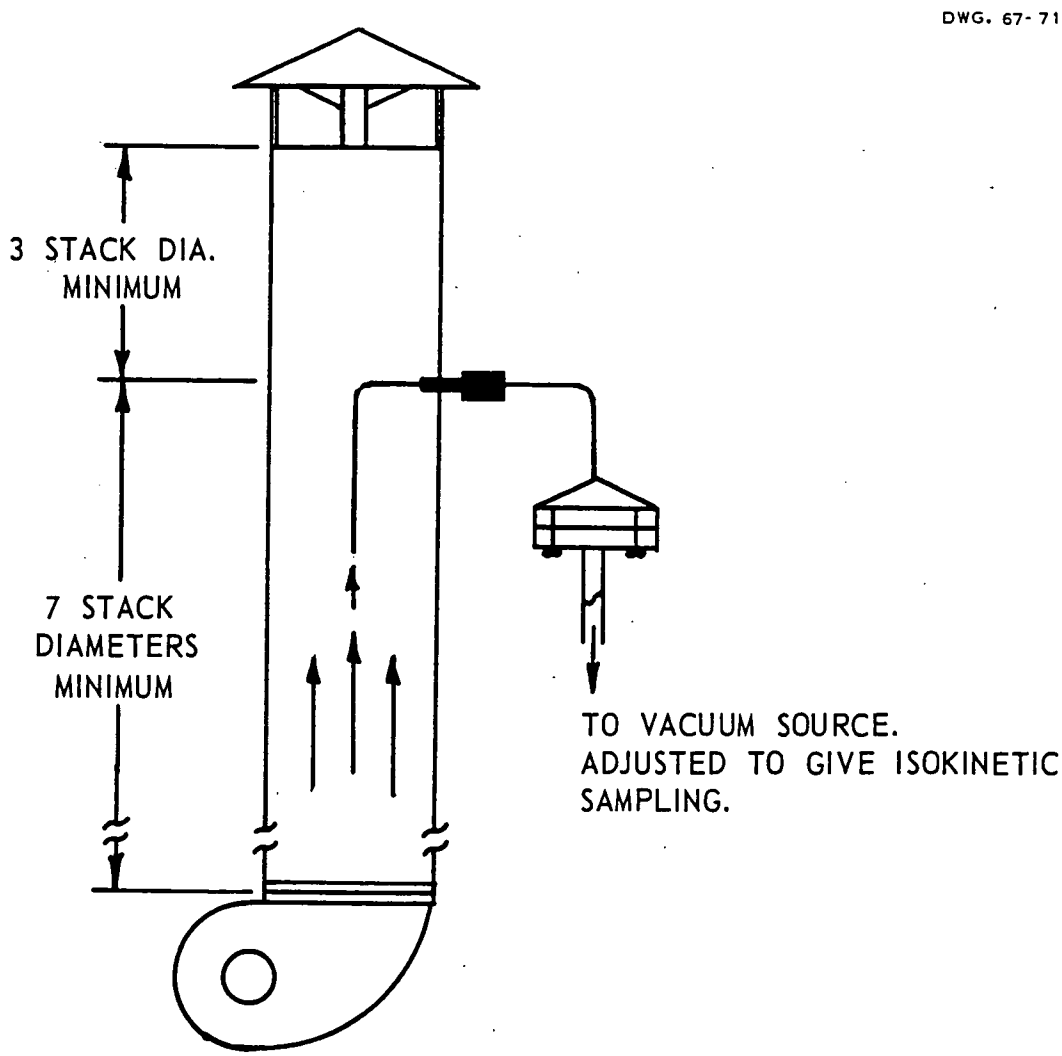


FIGURE 6. DIAGRAM OF IDEAL SAMPLER INSTALLATION

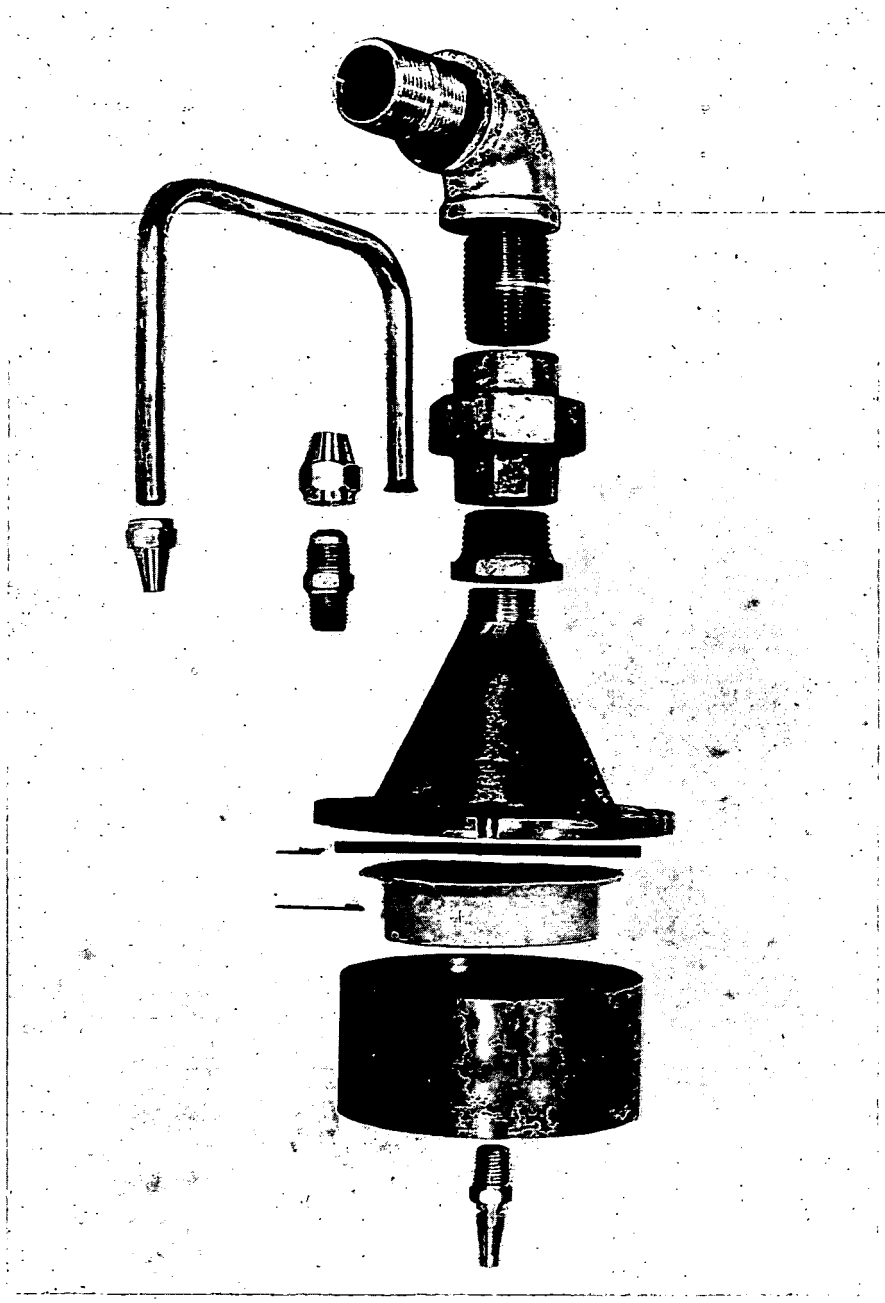


FIGURE 7. DISASSEMBLED STACK SAMPLER

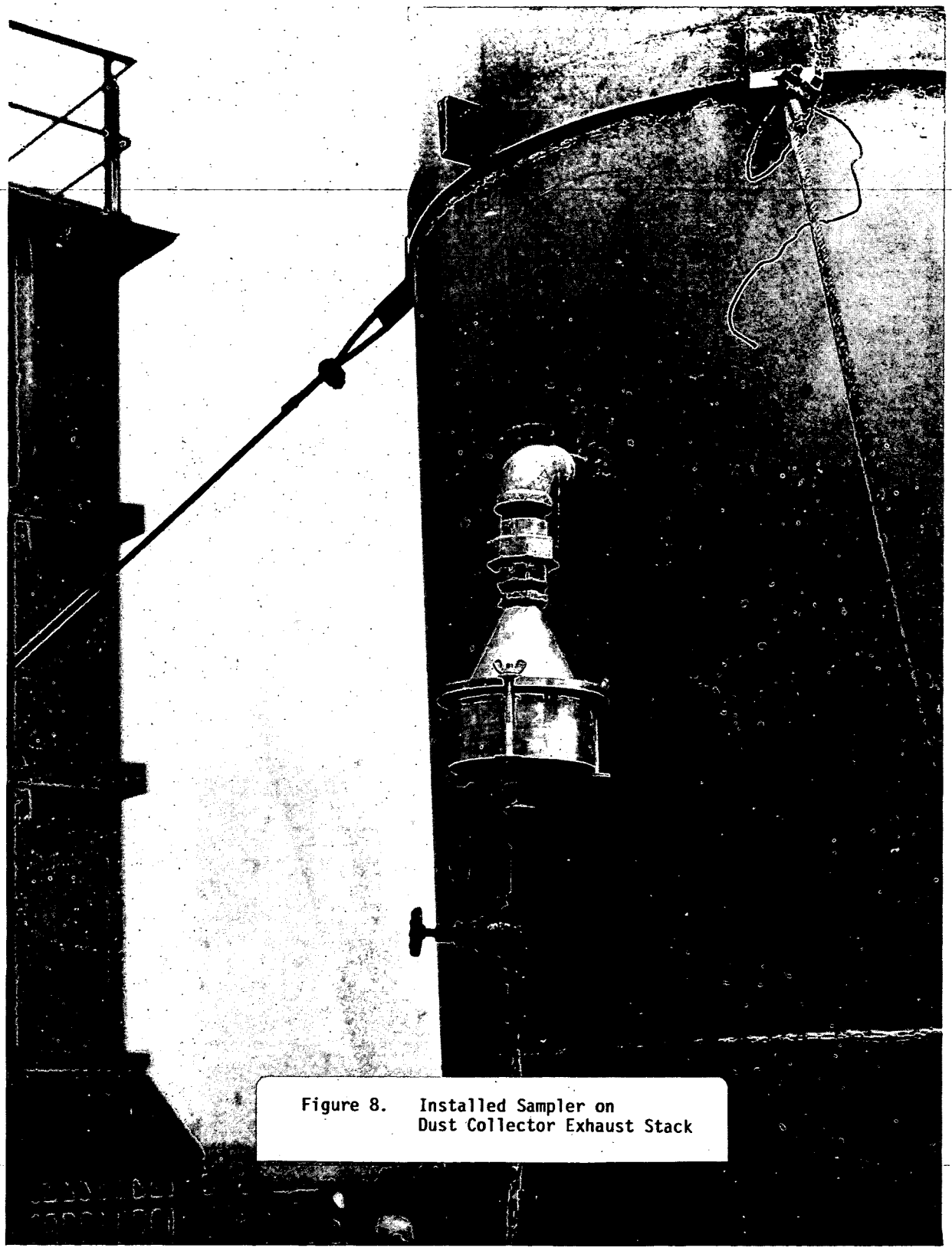


Figure 8. Installed Sampler on Dust Collector Exhaust Stack

TABLE 1. STACK DATA FOR DUST COLLECTORS AND PLANT 8 SCRUBBERS

DUST COLLECTOR	STACK HEIGHT, FT.(1)	STACK DIAMETER, IN.(2)	EXHAUST VELOCITY FT/MIN
PLANT 1			
G2-1	10	8	1600
G2-2	67	14	2651
G2-63	67	24	1910
G2-64	67	24	2448
G2-67	67	24	2610
G2-68	67	18	3221
G2-76	67	24	1308
G2-77	67	18 x 22	1018
G2-171	65	10	4884
G2-172	40	18	2858
G2-174	65	8	5730
G2-235	67	6	1475
G2-6014	25	14 x 15 (3)	2648
G2-6015	25	19 x 15 (3)	4469
G2-6042	67	10	4481
PLANT 2/3			
G1-94	72	16	2078
G1-252	72	23	3118
G1-754	72	17	3938
G1-856	72	17	2855
3-N	72	20	2202
3-S	72	20	2059

TABLE 1. STACK DATA FOR DUST COLLECTORS AND PLANT 8 SCRUBBERS (Continued)

DUST COLLECTOR	STACK HEIGHT, FT.(1)	STACK DIAMETER, IN.(2)	EXHAUST VELOCITY FT/MIN
PLANT 4			
G4-1	97	10	2994
G4-2	97	20	3280
G4-3	97	28	2590
G4-4	97	12	908
G4-5	97	11	2697
G4-7	97	28	935
G4-8	97	21	3100
G4-12	97	12	3470
G4-13	97	8	388
G4-14	105	24	1413
G4-15	97	9	2434
G4-7001	97	11	2380
PLANT 5			
G2-67	48	24	3473
G5-247	57	16	3377
G5-248	57	16	4340
G5-249	57	24	2622
G5-250	57	24	3631
G5-251	57	24	2863
G5-252	57	22	2500
G5-253	57	24	3229
G5-254	57	22	3153
G5-256	57	22	3132
G5-258	57	22	2447
G5-259	57	30	2811
G5-260	57	22	1886
G5-261	57	30	3968
G5-262	57	23	1779
G5A-100	57	30	2654
G5A-101	52	22	2253
Bldg. 55	62	13	4365

TABLE 1. STACK DATA FOR DUST COLLECTORS AND PLANT 8 SCRUBBERS (Continued)

DUST COLLECTOR	STACK HEIGHT, FT.(1)	STACK DIAMETER, IN.(2)	EXHAUST VELOCITY FT/MIN
PLANT 6			
G6-86	53	17	3534
G6-88	53	17	3222
G6-6057	53	47	2053
North ESP	25	47	2500
Mid ESP	25	32	6547
South ESP	25	47	2761
PLANT 7			
G4-2507	120	22	1733
G4-2508	120	22	1733
G4-2509	120	18	2123
G4-2510	120	18	2123
PLANT 8			
G3A-2	55	16	1725
G8-1	53	13	2585
G8-2	53	23	3761
G8-3	53	19	1821
G8-4	53	19	3850
G8-7	45	11	3119
G8N1-1000	53	18	1180
G43-27	45	28	3432
G43-29	45	16	1725
G43-44C	53	14	3600
6018	53	9.5 x 9.5 (3)	
6019	53	9.5 x 9.5 (3)	3350
8002	53	10 x 10	2592
8021	45	10	4700
8024	45	10	4750
8035	45	13	4416
8057	53	12	3685
8083	53	10 x 10 (3)	2592
8102	53	10 x 10 (3)	2592

TABLE 1. STACK DATA FOR DUST COLLECTORS AND PLANT 8 SCRUBBERS (Continued)

DUST COLLECTOR	STACK HEIGHT, FT.(1)	STACK DIAMETER, IN.(2)	EXHAUST VELOCITY FT/MI
PLANT 8 SCRUBBERS			
Rotary Kiln	53	12	2720
No. 1 Oxidation Furnace	53	10	1265
No. 2 Oxidation Furnace	53	12	2796
Box Furnace	53	11.5	1145
Muffle Furnace	53	14	2552
PLANT 9			
G9N1-1039	44	36	3107
G9E2-400	44	46	2140
G42-615	44	30	4085
G42A-100	44	26	3300
PILOT PLANT			
G-1	50	12	2567
G-2	50	12	2675
G2-20	52	20	2350
G6-93A	52	24	3118
G37-5011	52	17	4053
735-13-7041	52	24	1975
735-13-7050	52	34	1098
108843	52	30	2030
Oxidation Furnace	52	12	3118

(1) Stack height is the distance from ground level to stack mouth.

(2) Stack diameter is the inside diameter at the stack mouth.

(3) Rectangular stack.

TABLE 2. BUILDING DIMENSIONS

	Dimension, Ft.		Roof Peak
	North-South	East-West	Height, Ft.
Plant 1	100	160	60
Plant 2/3	60	380	67
Plant 4	225	165	94
Plant 5	650	100	52
Plant 6	500	200	39(1)
Plant 7	110	80	114
Plant 8	60	260	48
Plant 9	300	225	40
Pilot Plant	210	235	54
Building 55	60	30	51

(1) Three small dormers along the west side of plant 6 have a roof peak height of 50 feet.

TABLE 3. PLANT 1 DUST COLLECTOR URANIUM DISCHARGES, CY-1953 THROUGH CY-1984
(kg U)

DUST COLLECTOR	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
G2-1	-	-	-	-	-	-	-	-	-	-	-
G2-2(1)	-	-	-	-	-	-	-	-	-	-	-
G2-63	0.2	3	3	2	6	6	-	-	4	1	0.4
G2-64	-	-	-	1	0.4	297	-	-	0.4	-	1
G2-67	-	-	-	5	4	10	-	-	-	-	-
G2-68	-	-	-	1	4	4	13	4	2	1	25
G2-76	-	-	-	4	1	2	-	4	3	10	55
G2-77	3.5	42	42	27	34	88	33	12	32	1	0.4
G2-171	-	-	-	-	-	-	-	-	-	-	-
G2-172	-	-	-	3	-	-	-	-	5	1	0.4
G2-174	0.1	1.2	1.2	-	-	-	-	-	6	-	-
G2-235	-	-	-	-	-	-	-	-	-	-	-
G2-6014(2)	-	-	-	-	-	-	-	-	-	-	-
G2-6015(3)	-	-	-	-	-	-	-	-	-	-	-
G2-6042	-	-	-	0.4	-	0.4	-	-	0.4	-	0.4
Plant Total	3.8	46.2	46.2	43.4	49.4	407.4	46	20	52.8	14	82.6

(1) No stack sampler, 1953 - 1984. It is not likely that the uranium discharge exceeded an average of 0.5 kg U per year.

(2) Dust collector installed 1956. No stack sampler, 1956 - 1984. It is not likely that the uranium discharge exceeded an average of 0.5 kg U per year.

(3) Dust collector installed 1957 or later. No stack sampler, 1957 - 1984. It is not likely that the uranium discharge exceeded an average of 0.5 kg U per year.

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TABLE 3. PLANT 1 DUST COLLECTOR URANIUM DISCHARGES, CY-1953 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
G2-1	-	-	-	-	-	-	-	-	-	-	-
G2-2	-	-	-	-	-	-	-	-	-	-	-
G2-63	-	-	-	-	-	-	-	-	-	-	-
G2-64	6	-	4.1	6.0	0.1	8.0	1.3	2	28	1	-
G2-67	-	-	-	-	-	-	-	-	-	-	-
G2-68	-	-	-	-	-	-	-	-	-	-	-
G2-76	2	-	1.3	1.5	-	2.0	0.3	-	-	-	1
G2-77	-	-	-	-	-	-	-	-	-	-	-
G2-171	-	-	-	-	-	-	-	-	-	-	-
G2-172	6	-	4.1	9.0	0.3	12.2	2.1	6	-	-	-
G2-174	-	-	-	-	-	-	-	-	-	-	-
G2-235	4	4.1	2.7	3.9	0.1	5.0	0.8	1	0.4	-	0.4
G2-6014	-	-	-	-	-	-	-	-	-	-	-
G2-6015	-	-	-	-	-	-	-	-	-	-	-
G2-6042	-	-	-	-	-	-	-	-	-	-	-
Plant Total	18	4.1	12.2	20.4	0.5	27.2	4.5	9	28.4	1	1.4

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TABLE 3. PLANT 1 DUST COLLECTOR URANIUM DISCHARGES, CY-1953 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
G2-1	-	-	-	-	-	-	-	-	-	-
G2-2	-	-	-	-	-	-	-	-	-	-
G2-63	-	-	-	-	-	-	-	-	-	-
G2-64	3.5	2.7	0.6	1.8	0.8	-	-	1.2	1.9	1.2
G2-67	-	-	-	-	-	-	-	-	-	-
G2-68	0.5	-	-	-	-	-	-	-	-	-
G2-76	-	-	-	-	-	5.7	1.3	0.9	2.0	1.9
G2-77	1.6	-	-	-	-	-	-	-	-	-
G2-171	-	-	-	-	-	-	-	-	-	-
G2-172	-	-	-	-	-	6.7	-	-	0.7	0.1
G2-174	-	-	-	-	-	-	-	-	-	-
G2-235	-	-	-	-	-	-	-	-	-	0.1
G2-6014	-	-	-	-	-	-	-	-	-	-
G2-6015	-	-	-	-	-	-	-	-	-	-
G2-6042	-	-	-	-	-	1.0	-	-	1.8	8.8
Plant Total	5.6	2.7	0.6	1.8	0.8	13.4	1.3	2.1	6.4	12.1

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TABLE 4. PLANT 2/3 DUST COLLECTOR URANIUM DISCHARGES, CY-1953 THROUGH CY-1984
(kg U)

DUST COLLECTOR	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	(1) 1963
G1-94	0.8	9	47	156	207	-	13	78	4	36	-
G1-252	-	-	-	-	-	-	-	-	-	-	-
G1-754	5	60	306	54	215	153	-	56	23	29	-
G1-856	0.2	2	10	18	558	67	106	79	40	2	-
3-N	-	-	-	-	-	-	-	-	-	-	-
3-S	-	-	-	-	-	-	-	-	-	-	-
Plant Total	6	71	363	228	980	220	119	213	67	67	0

(1) No operations in plant 2/3 during 1963

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TABLE 4. PLANT 2/3 DUST COLLECTOR URANIUM DISCHARGES, CY-1953 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	(1) 1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
G1-94	-	12.7	29.0	-	-	-	-	-	-	13	3
G1-252	-	-	-	-	-	-	-	-	-	-	3
G1-754	-	-	23.4	-	-	-	-	-	-	-	-
G1-856	-	-	1.6	26.8	9.5	8.2	46.7	26	410	173	9
3-N	-	-	-	-	-	-	-	-	-	-	-
3-S	-	-	-	-	-	-	-	-	-	-	
Plt. Total	0	12.7	54.0	26.8	9.5	8.2	46.7	26	410	186	15

(1) No operations in plant 2/3 during 1964.

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TABLE 4. PLANT 2/3 DUST COLLECTOR URANIUM DISCHARGES, CY-1953 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
G1-94	6.4	-	-	-	-	-	-	-	-	0.2
G1-252	8.4	3.6	-	-	-	-	-	-	-	0.3
G1-754	-	-	-	-	-	-	-	-	-	-
G1-856	-	-	-	-	-	-	-	2.3	-	0.9
3-N	-	-	-	-	-	1.0	-	-	-	1.6
3-S	49.9	5.6	6.2	-	-	1.7	-	-	-	1.3
Plt. Total	64.7	9.2	6.2	0	0	2.7	0	2.3	0	4.3

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TABLE 5. PLANT 4 DUST COLLECTOR URANIUM DISCHARGES, CY-1953 THROUGH CY-1984
(kg U)

DUST COLLECTOR	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
G4-1	-	-	-	-	-	-	-	-	-	-	72
G4-2	251	1004	2122	782	380	71	79	89	49	117	77
G4-3	868	3473	7341	4088	78	44	700	43	134	207	526
G4-4	34	134	283	4	76	8	136	2	4	9	14
G4-5	9	36	76	242	175	166	343	1	7	30	51
G4-7	311	1244	2628	28	94	292	161	49	22	202	224
G4-8	-	-	-	-	-	-	-	24	34	130	500
G4-12	-	-	-	-	-	-	-	-	-	-	5
G4-13	-	-	-	-	-	-	-	-	-	-	-
G4-14	-	-	-	-	-	-	-	-	-	-	-
G4-15	-	-	-	-	-	-	-	-	-	-	-
G4-7001	-	-	-	1	11	80	9	4	12	8	-
Plt. Total	812	5890	12450	5145	814	661	1428	212	262	703	1469

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TABLE 5. PLANT 4 DUST COLLECTOR URANIUM DISCHARGES, CY-1953 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
G4-1	1	-	0.4	0.6	0.5	0.1	-	-	-	-	-
G4-2	1	-	0.4	0.6	0.5	0.1	-	-	9	-	8
G4-3	152	19.1	63.5	78.1	74.6	13.8	8.4	-	-	-	-
G4-4	49	1.5	20.5	25.2	24.0	4.4	2.7	-	-	-	-
G4-5	29	4.4	12.1	14.8	14.2	2.6	1.6	-	-	-	0.4
G4-7	234	292.2	97.7	120.0	114.7	21.3	12.9	-	-	-	-
G4-8	31	14.6	13.0	16.0	15.2	2.8	1.7	-	-	-	-
G4-12	48	2.9	20.1	24.6	23.5	4.3	2.6	-	-	-	-
G4-13	-	-	-	-	-	-	-	-	-	-	-
G4-14	-	-	-	-	-	-	-	-	-	57	16
G4-15	-	-	-	-	-	-	-	-	-	-	-
G4-7001	-	-	-	-	-	-	-	-	-	-	-
Plt. Total	545	334.7	227.7	279.9	267.2	49.4	29.9	0	9	57	24.4

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TABLE 5. PLANT 4 DUST COLLECTOR URANIUM DISCHARGES, CY-1953 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
G4-1	-	-	-	-	-	6.2	1.8	0.2	-	0.2
G4-2	24.6	-	-	-	-	53.2	238.0	3.2	18.5	30.3
G4-3	5.9	-	-	-	-	-	-	1.9	-	-
G4-4	29.3	15.8	-	-	-	-	-	-	-	-
G4-5	6.1	3.0	-	-	-	50.1	11.5	1.5	20.9	4.2
G4-7	-	-	-	-	-	-	6.0	5.6	2.5	0.7
G4-8	-	-	-	-	-	-	-	-	-	-
G4-12	-	-	11.8	11.9	5.5	18.5	4.0	1.3	0.9	0.1
G4-13	-	-	-	-	-	-	-	-	-	0.5
G4-14	53.9	7.3	-	-	40.8	5.8	170.8	7.3	0.1	3.6
G4-15	-	-	-	-	-	-	-	-	-	-
G4-7001	-	-	-	-	-	-	-	-	-	-
Plt. Total	119.8	26.1	11.8	11.9	46.3	133.8	432.1	21	42.9	39.6

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TABLE 6. PLANT 5 DUST COLLECTOR URANIUM DISCHARGES, CY 1953 THROUGH CY-1984
(kg U)

DUST COLLECTOR	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
G2-67	-	-	-	-	-	-	-	-	-	-	-
G5-247	-	-	-	-	7	-	-	-	-	-	-
G5-248	-	-	-	-	7	2	11	1	-	8	14
G5-249	-	9	22	4	-	2	0.4	0.4	0.4	3	-
G5-250	-	5	13	10	-	1	11	5	-	-	-
G5-251	-	2	5	5	0.4	-	16	10	0.4	-	2
G5-252	-	3	7	6	-	-	-	-	-	-	2
G5-253	-	9	22	136	442	30	32	0.4	0.4	3	4
G5-254	0.4	58	147	43	52	18	29	3	1	20	7
G5-256	-	13	33	73	6	20	28	29	7	12	24
G5-258	0.4	60	152	144	57	46	75	8	11	10	48
G5-259	24	2774	7010	1446	2341	260	138	44	4	116	411
G5-260	3	325	822	1086	463	98	28	60	34	29	3
G5-261	8	861	2177	548	270	189	93	38	15	143	247
G5-262(1)	-	-	-	-	-	-	-	-	-	-	-
G5A-100	-	-	-	-	-	-	-	-	-	-	1
G5A-101	-	-	-	-	-	-	-	-	-	-	-
Bldg. 55	-	-	-	-	19	49	17	4	3	12	20
Plt. Total	35.8	3909	10410	3501	3664.4	715	478.4	202.8	76.2	356	783

(1) G5-262 serves the graphite machine shop where only clean, new graphite is machined. No uranium discharges are expected; a stack sampler was not installed until after 1984.

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TABLE 6. PLANT 5 DUST COLLECTOR URANIUM DISCHARGES, CY 1953 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
G2-67	-	-	-	-	-	-	-	-	-	3	1
G5-247	-	-	-	-	-	-	-	-	-	1	-
G5-248	-	-	-	-	-	-	-	-	-	1	-
G5-249	-	-	-	-	-	-	-	-	-	-	-
G5-250	1	-	0.2	0.4	0.3	0.4	0.2	-	-	-	-
G5-251	-	-	-	-	-	-	-	-	-	-	-
G5-252	8	-	1.8	3.5	2.1	2.9	1.3	-	-	-	-
G5-253	54	-	12.5	24.1	14.3	19.4	8.7	-	-	-	-
G5-254	23	7	5.3	10.3	6.1	8.4	3.7	-	-	3	1
G5-256	4	7	0.9	1.8	1.0	1.4	0.6	-	-	3	-
G5-258	70	7	16.3	31.5	18.7	25.3	11.2	-	-	-	-
G5-259	94	126	21.9	42.1	25.1	34.0	15.2	-	-	21	-
G5-260	9	-	2.1	4.0	2.4	3.2	1.4	-	8	-	-
G5-261	58	56	13.5	26.1	15.5	21.0	9.4	-	-	41	34
G5-262	-	-	-	-	-	-	-	-	-	-	-
G5A-100	4	-	0.9	1.8	1.1	1.4	0.6	-	24	5	2
G5A-101	0.4	-	-	0.1	0.1	0.1	-	-	-	-	-
Bldg. 55	5	23.5	1.2	2.2	1.3	1.8	0.8	-	1	1	2
Plt. Total	330.4	226.5	76.7	147.9	88	119.3	53.1	0	33	79	40

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TABLE 6. PLANT 5 DUST COLLECTOR URANIUM DISCHARGES, CY 1953 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
G2-67	-	-	-	-	-	-	-	0.7	2.4	2.1
G5-247	-	-	2.6	-	-	0.6	0.8	0.8	0.3	0.3
G5-248	2.6	2.1	4.3	3.1	4.2	5.1	4.1	1.6	-	0.4
G5-249	-	-	-	-	-	-	25.8	-	0.9	0.2
G5-250	-	-	-	-	-	-	-	-	-	1.4
G5-251	-	-	-	-	-	-	-	-	-	5.0
G5-252	-	-	-	-	-	-	-	-	-	-
G5-253	-	-	-	-	-	-	-	1.3	0.8	0.8
G5-254	0.5	-	-	2.7	-	2.5	5.1	5.7	2.6	3.0
G5-256	-	7.3	-	-	3.0	2.0	3.8	2.0	5.3	1.3
G5-258	-	-	-	-	-	-	-	-	-	0.2
G5-259	10.9	-	-	-	-	-	-	3.1	-	15.0
G5-260	2.6	-	-	3.1	-	13.6	27.9	38.6	4.4	8.4
G5-261	-	-	40.1	-	-	41.8	63.5	52.8	16.1	29.5
G5-262	-	-	-	-	-	-	-	-	-	-
G5A-100	1.8	-	4.6	-	-	3.0	2.7	-	-	0.4
G5A-101	-	-	-	10.6	-	2.3	1.0	1.1	2.9	0.4
Bldg. 55	0.6	4.3	1.7	9.6	5.1	18.6	0.9	14.1	5.7	15.5
Plt. Total	19	13.7	53.3	29.1	12.3	89.5	135.6	121.8	41.4	83.9

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TABLE 7. PLANT 6 DUST COLLECTOR URANIUM DISCHARGES, CY 1952 THROUGH CY-1984
(kg U)

DUST COLLECTOR	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
G6-86	-	-	-	-	-	-	-	-	1	-	18	-
G6-88	-	-	-	-	-	-	-		-	2	-	84
G6-6057	-	-	-	-	-	-	-	38	38	116	58	9
North ESP	-	-	-	-	-	-	59	-	-	-	-	-
Mid ESP	5	10	23	43	22	28	-	-	-	-	-	12
South ESP	1	2	5	10	5	7	102	89	230	-	1	58
Plt. Total	6	12	28	53	27	35	161	127	268	119	59	181

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TABLE 7. PLANT 6 DUST COLLECTOR URANIUM DISCHARGES, CY 1952 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
G6-86	5	-	1.7	0.4	4.5	0.4	-	-	-	-	-
G6-88	14	8.2	4.7	1.1	12.5	1.1	-	-	-	-	-
G6-6057	4	-	1.3	0.3	3.6	0.3	-	-	-	-	-
North ESP	-	-	-	-	-	-	-	-	-	-	-
Mid ESP	-	22.9	-	-	-	-	-	-	-	-	-
South ESP	11	11.5	3.6	0.9	9.8	0.9	-	-	-	-	-
Plt. Total	34	42.6	11.3	2.7	30.4	2.7	0	0	0	0	0

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TABLE 7. PLANT 6 DUST COLLECTOR URANIUM DISCHARGES, CY 1952 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
G6-86	-	-	-	-	-	-	-	-	-	-
G6-88	-	-	-	-	-	-	-	-	-	-
G6-6057	-	-	-	-	-	-	-	-	-	0.8
North ESP	-	-	-	-	-	-	-	-	-	-
Mid ESP	-	-	-	-	-	-	-	-	-	-
South ESP	-	2.4	-	-	-	-	-	0.5	-	0.2
Plt. Total	0	2.4	0	0	0	0	0	0.5	0	1.0

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TABLE 8. PLANT 7 DUST COLLECTOR URANIUM DISCHARGES, CY 1954 THROUGH CY-1956
(kg U)

DUST COLLECTOR	1954	1955	1956
G4-2507	2087	3560	458
G4-2508	942	1606	402
G4-2509	980	1672	834
G4-2510	252	430	49
Plt. Total	4261	7268	1743

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TABLE 9. PLANT 8 DUST COLLECTOR URANIUM DISCHARGES, CY 1954 THROUGH CY-1984
(kg U)

DUST COLLECTOR	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
G3A-2	-	-	-	-	-	-	-	-	-	70
G8-1	-	-	-	-	-	-	-	-	35	231
G8-2	-	-	-	-	-	-	-	-	-	-
G8-3	-	-	-	-	-	-	-	-	-	-
G8-4	-	-	-	-	-	-	-	-	-	-
G8-7	-	-	-	-	-	-	-	-	-	-
G8N1-1000	-	-	4	-	-	-	-	-	-	35
G43-27	191	1838	920	538	574	92	102	19	119	152
G43-29	10	94	5	57	26	17	1	2	15	93
G43-44C	-	-	-	-	-	-	-	-	-	14
6018	-	-	-	13	12	7	24	13	17	36
6019	-	-	150	49	6	3	-	-	-	-
8002	-	-	-	-	-	-	-	-	-	41
8021	-	-	4	6	-	-	16	37	23	2
8024	-	-	83	24	50	98	11	69	29	248
8035	-	-	28	80	194	21	36	8	344	43
8057	-	-	118	22	5	5	7	14	6	25
8083	-	-	4	2	-	3	-	5	10	4
8102	-	-	-	-	8	14	101	42	20	-
Plt. Total	201	1932	1316	791	875	260	298	209	618	994

000070

6387

TABLE 9. PLANT 8 DUST COLLECTOR URANIUM DISCHARGES, CY 1954 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
G3A-2	-	-	-	-	-	-	-	-	-	-	-
G8-1	87	59.4	27.1	31.8	68.7	32.3	43.3	-	-	-	-
G8-2	315	27.4	99.1	118.1	255.2	120	161.5	8	4	-	-
G8-3	5	32	1.6	20.9	45.2	21.3	28.5	52	1	-	-
G8-4	-	9.1	-	3.7	8.0	3.8	5.0	10	-	-	-
G8-7	-	-	-	-	-	-	-	-	-	-	-
G8N1-1000	189	27.4	58.8	68.9	148.9	70.1	94	-	-	-	-
G43-27	301	27.4	94.6	116.0	250.7	118	158.7	17	-	7	-
G43-29	15	1.8	3.7	5.5	11.9	5.6	7.4	-	-	7	-
G43-44C	4	-	1.2	1.5	3.4	1.5	2.0	-	-	-	-
6018	13	109.6	4.0	4.7	10.1	4.8	6.3	-	-	-	-
6019	-	-	-	-	-	-	-	-	-	-	-
8002	3	-	0.9	1.1	2.3	1.1	1.5	-	-	-	-
8021	12	-	3.7	4.3	9.2	4.3	5.7	-	-	-	-
8024	105	13.7	32.7	39.7	85.8	40.4	54.1	4	-	-	11
8035	1	82.2	0.3	0.4	0.8	0.4	0.5	-	-	-	-
8057	1	-	0.3	0.4	0.8	0.4	0.5	-	-	-	-
8083	-	-	-	-	-	-	-	-	-	-	-
8102	-	-	-	-	-	-	-	-	-	-	-
Plt. Total	1051	390	327	417	901	424	569	91	5	14	11

000071

6387

TABLE 9. PLANT 8 DUST COLLECTOR URANIUM DISCHARGES, CY 1954 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
G3A-2	-	-	-	-	-	-	-	-	-	-
G8-1	-	-	-	-	-	-	-	-	-	-
G8-2	-	-	-	-	-	-	-	-	-	-
G8-3	-	-	-	-	-	-	-	-	-	-
G8-4	-	-	-	-	-	-	-	-	-	-
G8-7	-	-	-	-	-	-	-	-	-	-
G8N1-1000	-	-	-	-	-	-	-	-	-	-
G43-27	-	6.3	4.6	-	-	-	-	80.1	10.3	1.3
G43-29	-	-	-	-	-	5.1	-	0.7	-	0.5
G43-44C	-	-	-	-	-	-	-	-	-	-
6018	-	-	-	-	-	-	-	-	-	-
6019	-	-	-	-	-	-	-	-	-	-
8002	-	-	-	-	-	-	-	-	-	-
8021	1.3	-	-	-	-	-	-	-	-	-
8024	2.2	0.6	-	-	-	-	-	-	14.4	2.7
8035	-	-	-	-	-	-	-	0.4	-	3.6
8057	-	0.3	-	-	-	-	-	-	-	-
8083	-	-	-	-	-	-	-	-	-	-
8102	-	-	-	-	-	-	-	-	-	-
Plt. Total	3.5	7.2	4.6	0	0	5.1	0	81.2	24.7	8.1

000072

6387

TABLE 10. PLANT 9 DUST COLLECTOR URANIUM DISCHARGES, CY 1954 THROUGH CY-1984
(kg U)

DUST COLLECTOR	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
G9N1-1039	-	-	-	-	-	-	-	-	-	12
G9E2-400	-	-	-	-	-	-	-	-	-	12
G42-615	-	-	-	0.4	679	382	185	40	59	73
G42A-100	-	-	-	-	-	35	34	27.4	76	62
Plt. Total	0	0	0	0.4	679	417	219	67.4	135	159

000023

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TABLE 10. PLANT 9 DUST COLLECTOR URANIUM DISCHARGES, CY 1954 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
G9N1-1039	112	58.3	21.6	33.9	53.7	5.6	6.0	-	24	15	38
G9E2-400	10	-	1.9	3.0	4.8	0.5	0.5	-	-	-	-
G42-615	130	-	25	39.3	62.5	6.6	7.1	-	-	-	-
G42A-100	-	9.7	-	-	-	-	-	-	-	-	-
Plt. Total	252	68	48.5	76.2	121.0	12.7	13.6	0	24	15	38

000074

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TABLE 10. PLANT 9 DUST COLLECTOR URANIUM DISCHARGES, CY 1954 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
G9N1-1039	-	2.8	-	72	2.3	-	-	5.1	-	108
G9E2-400	-	-	-	-	-	-	-	-	-	1.2
G42-615	-	-	-	-	-	-	-	-	-	61.7
G42A-100	-	-	-	-	-	-	-	-	-	-
Plt. Total	0	2.8	0	72	2.3	0	0	5.1	0	170.9

000075

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TABLE 11. PILOT PLANT DUST COLLECTOR URANIUM DISCHARGES, CY 1951 THROUGH CY-1984
(kg U)

DUST COLLECTOR	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
G-1	-	-	-	-	-	-	-	-	-	-	-	-	-
G-2	-	-	-	-	-	-	-	-	-	-	-	-	-
G2-20	106	423	423	14	442	26	10	25	34	716	170	147	47
G6-93A	-	-	-	-	-	-	-	-	-	-	-	-	-
G37-5011	0.1	0.4	0.4	4	1	6	8	2	-	2	-	-	0.4
735-13-7041	-	-	-	-	-	-	-	-	-	-	-	-	1
735-13-7050	-	-	-	-	-	-	-	-	-	-	4	-	3
108843	-	-	-	-	-	-	-	-	-	-	-	27	0.4
Oxidn. Fce	-	-	-	-	-	-	-	-	-	-	-	-	-
Burnout(1)	6	25	25	253	-	-	-	-	-	-	-	-	-
Hoffman(1)	0.1	0.4	0.4	-	-	-	-	-	-	-	-	-	-
Boildown(1)	-	0.2	0.2	-	-	-	-	-	-	-	-	-	-
Chip Furnace(1)	11	44	44	-	-	-	-	-	-	-	-	-	-
Plt. Total	123	493	493	271	443	32	18	27	34	718	174	174	51.8

(1) Specific collectors were not identified in discharge reports. These designations were not used after 1954.

000076

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TABLE 11. PILOT PLANT DUST COLLECTOR URANIUM DISCHARGES, CY 1951 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1964	1965	1966(1)	1967	1968	1969	1970	1971	1972	1973	1974
G-1	-	-	-	-	-	-	-	-	-	-	-
G-2	-	-	-	-	-	-	-	-	-	-	-
G2-20	10	-	13.9	9.1	2.8	2.8	-	-	-	-	-
G6-93A	-	-	-	-	-	-	-	-	-	-	-
G37-5011	-	1	-	-	-	-	-	-	-	-	-
735-13-7041	3	4	4.2	2.7	0.8	0.8	-	-	-	-	-
735-13-7050	-	5	-	-	-	-	-	-	-	-	-
108843	-	-	-	-	-	-	-	-	-	-	-
Oxidn. Fce	-	-	-	-	-	-	-	-	-	-	-
Plt. Total	13	10.	18.1	11.8	3.6	3.6	0	0	0	0	0

(1) See page 14 for information regarding a 1966 Pilot Plant release of gaseous uranium hexafluoride not discharged through a dust collector.

000027

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TABLE 11. PILOT PLANT DUST COLLECTOR URANIUM DISCHARGES, CY 1951 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
G-1	-	-	-	-	-	-	-	-	-	0.7
G-2	-	-	-	-	-	-	-	-	-	0.4
G2-20	-	-	-	-	-	-	-	-	-	-
G6-93A	-	-	-	-	-	-	-	-	-	-
G37-5011	-	-	-	-	-	2.6	-	-	-	-
735-13-7041	-	-	-	-	-	-	-	-	-	1.2
735-13-7050	-	-	0.1	-	-	-	-	-	-	0.4
108843	0.4	-	10.3	0.5	-	-	-	-	-	-
Oxidn. Fce	-	-	-	1.7	-	0.7	-	-	-	0.1
Plt. Total	0.4	0	10.4	2.2	0	3.3	0	0	0	2.8

000078

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TABLE 12. % U-235 IN DUST COLLECTOR STACK DISCHARGES

FISCAL YEAR	WEIGHTED % U-235
1984	0.81
1983	0.85
1982	0.41
1981	0.32
1980	0.42
1979	0.29
1978	0.91
1977	0.56
1976A(1)	0.20
1976	0.54
1975	0.53
1974	0.56
1973	0.68
1972	0.74
1971	0.71
1970	0.78
1969	0.86
1968	0.90
1967	0.84
1966	1.68
1965	0.82
1964	0.75
1963	0.85
1962	0.75
1961	0.86

TABLE 12. % U-235 IN DUST COLLECTOR STACK DISCHARGES (continued)

FISCAL YEAR	WEIGHTED % U-235
1960	0.73
1959	0.77
1958	0.72
1957	0.71
1956	0.52
1955	0.71
1954	0.63
1953	0.14
1952	-

(1) FY-1976A is the period of time from July 1, 1976 to September 30, 1976.

TABLE 13. NON-PRODUCTION SOURCES OF AIRBORNE URANIUM DISCHARGES

Graphite Burner

(1) Operating period: 11/1/65 to 9/14/84

(2) Estimated uranium discharge:

1965	1.2 kg
1966-1982	7 kg/yr
1983	2.4 kg
1984	6.4 kg

(3) U-235 content: 0.92%

Oil Burner

(1) Operating period: 3/31/62 to 6/15/79

(2) Estimated uranium discharge:

1962	20 kg
1963-1978	27 kg/yr
1979	15 kg

(3) U-235 content: 0.75%

Old Solid Waste Incinerator

(1) Operating period: 11/16/54 to 12/31/79

(2) Estimated uranium discharge:

1954	15 kg
1955-1968	118 kg/yr
1969	94 kg
1970-1979	71 kg/yr

(3) U-235 content: approximately 0.7%

TABLE 13. NON-PRODUCTION SOURCES OF AIRBORNE URANIUM DISCHARGES (continued)

New Solid Waste Incinerator

(1) Operating period: 1/2/80 to present

(2) Estimated uranium discharge:

1980	0.7 kg
1981	1.2 kg
1982	1.8 kg
1983	2.4 kg
1984	6.4 kg

(3) U-235 content: approximately 0.7

Liquid Organic Waste Incinerator

(1) Operating period: 4/1/83 to present

(2) Estimated uranium discharge:

1983	3 kg
1984	4 kg

(3) U-235 content: approximately 0.7%

TABLE 14. DISCHARGE OF URANIUM FROM FMPC WET SCRUBBERS

FISCAL[1] YEAR	URANIUM DISCHARGE kg	WEIGHTED % U-235
1984	38	0.91
1983	58	0.98
1982	37	0.95
1981	10	1.02
1980	11	0.95
1979	-	-
1978	-	-
1977	-	-
1976	-	-
1975	-	-
1974	-	-
1973	39	1.09
1972	-	-
1971	541	0.77
1970	666	0.88
1969	3123	0.90
1968	3082	0.83
1967	1790	0.83
1966	926	0.83

TABLE 14. DISCHARGE OF URANIUM FROM FMPC WET SCRUBBERS (continued)

FISCAL[1] YEAR	URANIUM DISCHARGE kg	WEIGHTED % U-235
1965	5810	0.82
1964	2865	0.79
1963	2171	0.86
1962	2304	0.75
1961	2371	0.87
1960	2604	0.75
1959	2100	0.76
1958	1650	0.72
1957	1575	0.71
1956	1442	0.71
1955	948	0.71
1954	217	0.71

(1) Scrubber uranium discharges on a calendar year basis could be obtained for only five years:

CALENDAR YEAR	URANIUM DISCHARGE kg	WEIGHTED % U-235
1984	38	0.90
1983	49	1.00
1982	39	0.95
1981	22	0.95
1980	20	0.98

TABLE 15. RADIONUCLIDES IN PLANT 8 SCRUBBER LIQUIDS.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g Sample	uCi/kg U
BOX FURNACE SCRUBBER		
Pu-239+240	1.2×10^{-5}	7.1×10^{1}
Pu-238	1.6×10^{-6}	9.5×10^{-1}
Np-237	2.5×10^{-6}	1.5
Th-234(1)	5.4×10^{-4}	3.2×10^{2}
Pa-234	3.0×10^{-7}	1.8×10^{-1}
Th-232	3.9×10^{-5}	2.3×10^{1}
Th-230	5.1×10^{-5}	3.0×10^{1}
Th-228	3.8×10^{-5}	2.3×10^{1}
Ra-228	8.9×10^{-7}	5.3×10^{-1}
Ra-226	1.8×10^{-6}	1.1
Cs-137	2.2×10^{-5}	1.3×10^{1}
Ru-106	$<1.0 \times 10^{-6}$	$<5.9 \times 10^{-1}$
Tc-99	1.2×10^{-4}	7.1×10^{1}
Sr-90	$<1.0 \times 10^{-5}$	<5.0

Scrubber liquid density: 1.0024
Uranium concentration: 1.69 g/L
Isotopic composition, % by weight:

U-233	<0.001
U-234	<0.01
U-235	0.63
U-236	0.03
U-238	99.34

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 15. RADIONUCLIDES IN PLANT 8 SCRUBBER LIQUIDS. (continued)

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g Sample	uCi/kg U
ROTARY KILN SCRUBBER		
Pu-239+240	2.0×10^{-5}	3.0
Pu-238	2.2×10^{-6}	3.3×10^{-1}
Np-237	4.7×10^{-6}	7.0×10^{-1}
Th-234(1)	4.1×10^{-3}	6.1×10^{2}
Pa-234	1.4×10^{-6}	2.1×10^{-1}
Th-232	5.2×10^{-5}	7.7
Th-230	5.2×10^{-4}	7.7×10^{1}
Th-228	4.2×10^{-5}	6.2
Ra-228	1.5×10^{-6}	2.2×10^{-1}
Ra-226	8.3×10^{-7}	1.2×10^{-1}
Cs-137	4.4×10^{-6}	6.5×10^{-1}
Ru-106	$<9.8 \times 10^{-7}$	$<1.5 \times 10^{-1}$
Tc-99	2.6×10^{-4}	3.9×10^{1}
Sr-90	2.3×10^{-5}	3.4

Scrubber liquid density: 1.0226
Uranium concentration: 6.9 g/L
Isotopic composition, % by weight:

U-233	<0.001
U-234	<0.01
U-235	0.92
U-236	0.05
U-238	99.03

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 15. RADIONUCLIDES IN PLANT 8 SCRUBER LIQUIDS. (continued)

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g Sample	uCi/kg U
NO. 1 OXIDATION FURNACE		
Pu-239+240	1.3×10^{-6}	3.6×10^{-2}
Pu-238	4.4×10^{-7}	1.2×10^{-2}
Np-237	1.3×10^{-6}	3.6×10^{-2}
Th-234(1)	3.4×10^{-3}	9.4×10^{1}
Pa-234	1.3×10^{-6}	3.6×10^{-2}
Th-232	3.7×10^{-5}	1.0
Th-230	4.2×10^{-5}	1.2
Th-228	1.3×10^{-4}	3.6
Ra-228	5.5×10^{-6}	1.5×10^{-1}
Ra-226	5.8×10^{-7}	1.6×10^{-2}
Cs-137	4.6×10^{-5}	1.3
Ru-106	$<9.8 \times 10^{-7}$	$<2.7 \times 10^{-2}$
Tc-99	2.1×10^{-4}	5.8
Sr-90	9.8×10^{-6}	2.7×10^{-1}

Scrubber liquid density: 1.0188
Uranium concentration: 36.8 g/L
Isotopic composition, % by weight:

U-233	<0.001
U-234	<0.01
U-235	0.22
U-236	<0.01
U-238	99.77

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 16-A. URANIUM PARTICLE DATA. PLANT 4 DUST COLLECTOR G4-2. INLET DUCT.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
11.0	30.7
6.5	53.4
4.2	79.8
2.9	94.0
1.8	98.8
0.92	99.6
0.58	99.7
0.37	99.8

B. AMAD [2]: 7.5 ± 2.0 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.84%
U-236	0.07%
U-238	99.09%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 16-B. URANIUM PARTICLE DATA. PLANT 4 DUST COLLECTOR G4-2. EMISSION STACK.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
12.0	35.1
7.8	61.0
5.1	80.1
3.4	89.6
2.2	93.6
1.15	95.7
0.67	97.0
0.45	98.6

B. AMAD [2]: 9.8 ± 2.3 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.82%
U-236	0.06%
U-238	99.11%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 16-C. TOTAL PARTICULATE DATA. PLANT 4 DUST COLLECTOR G4-2. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	27.3
20	54.2
10	81.8
7	86.2
5	88.7
4	91.3
3	93.5
2	95.6
1	97.1
0.6	97.5
0.4	97.8

B. MEDIAN SPHERICAL DIAMETER: 22.5 ± 2.8 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 75.9% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.84%
U-236	0.07%
U-238	99.09%

(1) Equivalent spherical diameter.

TABLE 17-A. URANIUM PARTICLE DATA. PLANT 4 DUST COLLECTOR G4-5. INLET DUCT.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
11.0	27.8
6.9	35.4
4.5	44.9
3.1	71.0
1.9	88.5
1.0	96.3
0.51	98.2
0.40	99.6

B. AMAD [2]: 4.4 ± 1.9 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.88%
U-236	0.05%
U-238	99.06%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 17-B. URANIUM PARTICLE DATA. PLANT 4 DUST COLLECTOR G4-5. EMISSION STACK.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
12.0	30.3
7.1	45.4
4.9	58.2
3.3	68.7
2.1	78.0
1.1	89.1
0.65	93.5
0.43	96.6

B. AMAD [2]: 6.2 ± 4.4 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight[3]

U-233	<0.0010%
U-234	<0.01%
U-235	0.80%
U-236	0.05%
U-238	99.14%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.
(3) Insufficient uranium on impactor filters to run isotopic analysis. Isotopic composition given there is for a sample of collector bulk dust obtained during the sampling of the emission stack.

TABLE 17-C. TOTAL PARTICULATE DATA. PLANT 4 DUST COLLECTOR G4-5. COLLECTOR BULK DUST.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
44	2.0
20	22.6
15	37.8
10	59.8
7	78.0
5	86.1
4	89.7
3	92.7
2	96.3
1	98.8
0.6	99.6

B. MEDIAN SPHERICAL DIAMETER: 11.5 ± 2.2 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 71.1% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.80%
U-236	0.05%
U-238	99.14%

(1) Equivalent spherical diameter.

TABLE 18-A. URANIUM PARTICLE DATA. PLANT 4 DUST COLLECTOR G4-7. INLET DUCT.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
9	6.0
5.9	13.2
3.9	19.1
2.6	30.4
1.7	60.7
0.91	84.9
0.5	94.8
0.32	98.4

B. AMAD (2): 1.9 ± 3.8 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.88%
U-236	0.06%
U-238	99.05%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 18-B. URANIUM PARTICLE DATA. PLANT 4 DUST COLLECTOR G4-7. EMISSION STACK.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
20	24.6
12.5	38.4
8.8	50.7
5.9	60.7
3.2	73.0
1.7	83.0
1.1	91.4
0.70	96.3

B. AMAD [2]: 9.0 ± 5.6 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.93%
U-236	0.04%
U-238	99.02%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 18-C. TOTAL PARTICULATE DATA. PLANT 4 DUST COLLECTOR G4-7. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	10.0
20	38.1
15	53.2
10	66.5
7	73.5
5	77.9
4	81.5
3	86.5
2	91.0
1	98.0
0.6	99.1
0.4	99.6

B. MEDIAN SPHERICAL DIAMETER: 16.0 ± 4.7 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 50.8% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	1.11%
U-236	0.05%
U-238	98.82%

(1) Equivalent spherical diameter.

TABLE 19-A. URANIUM PARTICLE DATA. PLANT 4 DUST COLLECTOR G4-12. INLET DUCT.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
11.0	38.8
6.9	74.7
4.5	90.7
3.0	96.0
1.9	98.2
0.97	99.0
0.59	99.4
0.39	99.6

B. AMAD (2): 10.5 ± 2.3 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	1.76%
U-236	<0.01%
U-238	98.22%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 19-B. URANIUM PARTICLE DATA. PLANT 4 DUST COLLECTOR G4-12. EMISSION STACK.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
11.2	28.7
7.1	59.6
4.9	81.5
3.2	93.5
2.1	96.5
1.1	98.0
0.60	98.8
0.42	99.2

B. AMAD [2]: 8.0 ± 1.9 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.0010%
U-234	<0.01%
U-235	1.70%
U-236	0.03%
U-238	98.27%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 19-C. TOTAL PARTICULATE DATA. PLANT 4 DUST COLLECTOR G4-12 COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	<0.1
20	13.2
15	23.8
10	40.0
7	54.0
5	68.2
4	77.6
3	86.0
2	93.8
1	97.4
0.6	98.8
0.4	99.6

B. MEDIAN SPHERICAL DIAMETER: 7.8 ± 2.4 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 75.1% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.0010%
U-234	<0.01%
U-235	1.78%
U-236	<0.01%
U-238	98.20%

(1) Equivalent spherical diameter.

TABLE 20-A. URANIUM PARTICLE DATA. PLANT 4 DUST COLLECTOR G4-14. INLET DUCT.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
11.5	63.0
7.2	89.1
4.9	97.8
3.3	99.4
2.2	98.8
1.1	99.9
0.66	99.95
0.44	99.95

B. AMAD [2] [3]: 14 ± 2.1 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.20%
U-236	<0.01%
U-238	99.80%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.
(3) Estimated.

TABLE 20-B. URANIUM PARTICLE DATA. PLANT 4 DUST COLLECTOR G4-14. EMISSION STACK.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
16	21
9.9	45
6.8	64.3
4.6	76.7
2.9	87.5
1.45	92.5
0.90	94.5
0.67	96.5

B. AMAD [2]: 9.0 ± 3.0 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.32%
U-236	0.01%
U-238	99.67%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 20-C. TOTAL PARTICULATE DATA. PLANT 4 DUST COLLECTOR G4-14. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	26.1
20	39.4
10	75.6
7	89.3
5	94.1
4	96.3
3	97.8
2	98.5
1	99.3

B. MEDIAN SPHERICAL DIAMETER: 14.7 ± 1.8 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 75.9% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.20%
U-236	<0.01%
U-238	99.80%

(1) Equivalent spherical diameter.

TABLE 21-A. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-249. INLET DUCT.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
12.0	40.4
7.0	70.2
4.8	86.8
3.2	94.6
2.0	97.1
1.0	98.2
0.61	98.9
0.42	99.4

B. AMAD [2]: 10.3 ± 2.2 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	1.43%
U-236	0.02%
U-238	99.85%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 21-B. URANIUM PARTICLE DATA. PLANT 5 G5-249 DUST COLLECTOR. EMISSION STACK.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
12.0	24.2
7.8	46.6
5.2	62.0
3.4	70.5
2.1	76.0
1.01	78.0
0.65	80.0
0.44	81.0

B. AMAD [2]: 6.7 ± 2.2 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.85%
U-236	0.05%
U-238	99.09%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 21-C. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5-249. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	7.9
20	13.0
10	76.1
7	85.7
5	90.3
4	94.0
3	96.3
2	98.2
1	98.2
0.6	99.1
0.4	99.1

B. MEDIAN SPHERICAL DIAMETER: 13.5 ± 1.4 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 46.6% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.22%
U-236	<0.01%
U-238	99.77%

(1) Equivalent spherical diameter.

TABLE 22-A. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-250. INLET DUCT.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
13.0	62.7
7.9	86.6
5.2	96.2
3.6	98.8
2.3	99.6
1.2	99.8
0.70	99.8
0.47	99.8

B. AMAD [2]: 16.3 ± 2.0 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.32%
U-236	<0.01%
U-238	99.79%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 22-B. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-250. EMISSION STACK.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
11.0	37.5
6.6	57.9
4.5	73.6
2.9	81.5
1.9	89.4
0.95	93.3
0.59	94.8
0.38	97.2

B. AMAD [2]: 8.3 ± 3.1 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight[3]

U-233	<0.001%
U-234	<0.01%
U-235	0.20%
U-236	<0.01%
U-238	99.85%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.
(3) Insufficient uranium on impactor filters to run isotopic analysis. Isotopic composition given there is for a sample of collector bulk dust obtained during the sampling of the emission stack.

TABLE 22-C. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5-250. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	15.8
20	23.4
10	74.7
7	84.4
5	89.9
4	93.7
3	96.2
2	97.9
1	98.3
0.6	98.3
0.4	98.7

B. MEDIAN SPHERICAL DIAMETER: 14 ± 2 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 34.4% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.20%
U-236	0.01%
U-238	99.79%

(1) Equivalent spherical diameter.

TABLE 23-A. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-251. INLET DUCT.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
12.0	1.9
7.1	3.8
4.8	5.9
3.2	7.5
2.1	9.8
1.1	17.7
0.62	37.7
0.48	62.0

B. AMAD [2]: 0.48 ± 8.8 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.27%
U-236	<0.01%
U-238	99.73%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 23-B. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-251. EMISSION STACK.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
12.0	15.0
7.0	60.0
4.75	69.8
3.25	76.9
2.1	81.4
1.05	87.3
0.63	92.4
0.42	94.7

B. AMAD [2]: 7.8 ± 5.2 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight[3]

U-233	<0.001%
U-234	<0.01%
U-235	0.43%
U-236	0.01%
U-238	99.55%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.
(3) Insufficient uranium on impactor filters to run isotopic analysis. Isotopic composition given there is for a sample of collector bulk dust obtained during the sampling of the emission stack.

TABLE 23-C. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5-251. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	2.0
20	4.9
10	19.6
9	73.5
7	94.1
5	94.2
2	95.1
1	96.1
0.5	96.5

B. MEDIAN SPHERICAL DIAMETER: 9.4 ± 1.1 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 3.7% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.43%
U-236	0.01%
U-238	99.55%

(1) Equivalent spherical diameter.

TABLE 24-A. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-253. INLET DUCT.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
11.0	32.8
7.0	72.5
4.8	77.3
3.2	81.9
2.0	90.3
1.0	94.6
0.62	97.5
0.42	98.7

B. AMAD [2]: 9.0 ± 2.6 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.80%
U-236	0.06%
U-238	99.14%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 24-B. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-253. EMISSION STACK.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
12.0	1.3
7.0	3.3
4.8	5.9
3.3	12.2
2.0	18.3
1.0	35.2
0.63	60.4
0.42	97.9

B. AMAD (2): 0.72 ± 1.5 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.21%
U-236	<0.01%
U-238	99.79%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 24-C. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5-253. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	52.6
25	59.2
20	64.0
15	73.9
10	85.8
7	92.3
5	95.8
3	98.3
2	99.5
1	99.8

B. MEDIAN SPHERICAL DIAMETER: >44 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 1.6% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.39%
U-236	<0.01%
U-238	99.60%

(1) Equivalent spherical diameter.

TABLE 25-A. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-254. INLET DUCT.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
10.0	37.0
6.1	59.8
4.1	76.2
2.8	87.4
1.7	95.1
0.89	99.2
0.55	99.8
0.37	99.9

B. AMAD [2]: 7.6 ± 2.5 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.0010%
U-234	<0.01%
U-235	0.87%
U-236	0.05%
U-238	99.07%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 25-B. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-254. EMISSION STACK.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
11.0	14.2
6.8	34.9
4.5	58.4
3.0	71.7
1.9	81.3
0.98	89.7
0.59	95.3
0.40	98.5

B. AMAD (2): 5.2 ± 3.0 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.44%
U-236	0.02%
U-238	99.54%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 25-C. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5-254. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	34.7
25	38.0
20	47.1
18	66.7
15	94.8
10	99.3
5	99.3
1	>99.3

B. MEDIAN SPHERICAL DIAMETER: 19.5 ± 3.7 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 2.2% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.28%
U-236	0.01%
U-238	99.71%

(1) Equivalent spherical diameter.

TABLE 26-A. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-256. INLET DUCT.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
11.0	27.9
7.1	55.0
4.8	75.3
3.2	85.5
2.1	90.7
1.0	93.7
0.63	95.4
0.42	97.3

B. AMAD [2] [3]: 7.8 ± 2.2 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight[3]

U-233	<0.001%
U-234	<0.01%
U-235	0.27%
U-236	0.01%
U-238	99.72%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.
(3) Insufficient uranium on impactor filters to run isotopic analysis. Isotopic composition given here is for a sample of collector bulk dust obtained during the sampling of the emission stack.

TABLE 26-B. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-256. EMISSION STACK.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
11.0	15.3
6.9	48.1
4.2	56.3
2.9	61.8
1.8	71.1
0.91	83.7
0.59	93.5
0.38	97.3

B. AMAD (2): 6.5 ± 1.7 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.51%
U-236	0.02%
U-238	99.46%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 26-C. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5-256. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	20.3
25	29.1
20	76.1
18	82.5
15	88.0
10	93.6
5	94.4
1	98.0
0.5	99.2

B. MEDIAN SPHERICAL DIAMETER: 23 ± 1.4 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 2.5% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.27%
U-236	0.01%
U-238	99.72%

(1) Equivalent spherical diameter.

TABLE 27-A. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-260. INLET DUCT.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
11	24.2
6.6	53.1
4.4	73
2.9	85
1.9	92.8
0.95	98
0.58	98.7
0.38	98.8

B. AMAD (2): 7.0 ± 2.3 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.26%
U-236	<0.01%
U-238	99.73%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 27-B. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-260. EMISSION STACK.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
14.0	5.0
8.9	9.5
6.0	13.4
4.1	15.9
2.6	16.9
1.3	46.3
0.80	68.1
0.55	91.0

B. AMAD [2]: 1.1 ± 1.8 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight[3]

U-233	<0.001%
U-234	<0.01%
U-235	0.20%
U-236	<0.01%
U-238	99.80%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.
(3) Insufficient uranium on impactor filters to run isotopic analysis. Isotopic composition given there is for a sample of collector bulk dust obtained during the sampling of the emission stack.

TABLE 27-C. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5-260. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	27.2
20	37.4
10	57.0
7	62.9
5	69.8
4	76.8
3	83.3
2	91.1
1	98.9
0.6	99.4
0.4	99.6

B. MEDIAN SPHERICAL DIAMETER: 12.3 ± 4.4 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 49.5% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.20%
U-236	<0.01%
U-238	99.80%

(1) Equivalent spherical diameter.

TABLE 28-A. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-261. INLET DUCT.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
12	44.5
7.2	73
5.1	87
3.5	92.5
2.2	96.5
1.2	99
0.68	99
0.46	99.5

B. AMAD [2]: 10.8 ± 1.4 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.21%
U-236	<0.01%
U-238	99.78%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 28-B. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-261. EMISSION STACK.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
11	21.5
6.8	55.5
4.4	67.5
3.1	87
2.0	88.5
1.0	96
0.6	97
0.4	98.5

B. AMAD [2]: 6.6 ± 1.2 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.25%
U-236	<0.01%
U-238	99.74%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 28-C. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5-261. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	0.1
20	2
10	2
7	2.5
5	9
4	22.5
3	41
2	67
1	90
0.6	95.5
0.4	97.5

B. MEDIAN SPHERICAL DIAMETER: 2.5 ± 1.8 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 75.12% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.21%
U-236	<0.01%
U-238	99.79%

(1) Equivalent spherical diameter.

TABLE 29-A. URANIUM PARTICLE DATA. PLANT 8 DUST COLLECTOR G43-27. INLET DUCT.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
13	23.6
7.2	48.8
5.2	68.2
3.5	78.5
2.2	88.0
1.1	94.9
0.68	97.2
0.45	98.4

B. AMAD (2): 7.4 ± 3.1 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.86%
U-236	0.05%
U-238	99.09%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 29-B. URANIUM PARTICLE DATA. PLANT 8 DUST COLLECTOR G43-27. EMISSION STACK.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
13.0	20.0
7.8	55.0
5.1	76.6
3.5	86.6
2.2	93.4
1.2	98.5
0.70	99.6
0.48	99.8

B. AMAD [2]: 8.8 ± 2.3 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.87%
U-236	0.05%
U-238	99.08%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 29-C. TOTAL PARTICULATE DATA. PLANT 8 DUST COLLECTOR G43-27. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	25.2
20	29.7
10	49.9
8	57.5
6	67.4
5	73.4
4	80.3
3	86.5
2	93.6
1	99.3
0.6	99.7

B. MEDIAN SPHERICAL DIAMETER: 9.8 ± 2.8 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 10.9% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.93%
U-236	0.05%
U-238	99.01%

(1) Equivalent spherical diameter.

TABLE 30-A. URANIUM PARTICLE DATA. PLANT 9 DUST COLLECTOR G9N1-1039. INLET DUCT.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
10.5	6.3
6.5	36.8
4.3	59.3
2.9	82.1
1.8	90.3
0.92	94.9
0.56	98.5
0.38	99.7

B. AMAD [2]: 5.0 ± 2.0 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.95%
U-236	0.05%
U-238	98.99%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 30-B. URANIUM PARTICLE DATA. PLANT 9 DUST COLLECTOR G9N1-1039 EMISSION STACK.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
11	9.3
6.4	20.6
4.5	31.9
2.9	41.2
1.8	48
0.95	56.8
0.56	77.8
0.39	91.5

B. AMAD (2): 1.3 ± 2.7 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight(3)

U-233	<0.001%
U-234	<0.01%
U-235	0.93%
U-236	0.05%
U-238	99.01%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.
(3) Insufficient uranium on impactor filters to run isotopic analysis. Isotopic composition given here is for a sample of collector bulk dust obtained immediately after sampling of the emission stack.

TABLE 30-C. TOTAL PARTICULATE DATA. PLANT 9 DUST COLLECTOR G9N1-1039. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	16.2
20	33.4
15	43.9
10	56.8
7	64.8
5	71.9
4	77.4
3	84.4
2	91.6
1	97.9
0.5	99.2

B. MEDIAN SPHERICAL DIAMETER: 12.0 ± 4.1 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 55.84% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.93%
U-236	0.05%
U-238	99.01%

(1) Equivalent spherical diameter.

TABLE 31. TOTAL PARTICULATE DATA. PLANT 1 DUST COLLECTOR G2-1. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	30.4
25	39.4
20	45.0
15	52.7
10	68.9
8	79.8
6	93.0
4	96.8
2	99.3
1	99.6
0.6	99.8

B. MEDIAN SPHERICAL DIAMETER: 16.8 ± 2.3 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 70.76% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.95%
U-236	0.01%
U-238	99.03%

(1) Equivalent spherical diameter.

TABLE 32. TOTAL PARTICULATE DATA. PLANT 1 DUST COLLECTOR G2-64. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	15.8
25	18.4
15	26.8
10	43.0
8	51.6
6	63.4
4	77.2
3	85.6
2	93.8
1	99.2
0.6	99.4

B. MEDIAN SPHERICAL DIAMETER: 8.2 ± 2.6 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 16.01% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.71%
U-236	0.01%
U-238	99.27%

(1) Equivalent spherical diameter.

TABLE 33. TOTAL PARTICULATE DATA. PLANT 1 DUST COLLECTOR G2-76. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	35.7
30	42.2
25	48.0
20	60.8
15	66.2
10	86.8
8	91.6
6	96.0
4	98.6
2	99.4
1	99.6
0.6	99.8

B. MEDIAN SPHERICAL DIAMETER: 24.0 ± 2.2 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 2.77% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.84%
U-236	0.02%
U-238	99.13%

(1) Equivalent spherical diameter.

TABLE 34. TOTAL PARTICULATE DATA. PLANT 1 DUST COLLECTOR G2-172. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	26.4
25	36.0
20	44.8
15	58.0
10	77.8
8	85.2
6	90.6
4	95.4
2	99.2
1	99.6
0.6	99.8

B. MEDIAN SPHERICAL DIAMETER: 18.0 ± 2.2 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 23.84% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.67%
U-236	0.02%
U-238	99.30%

(1) Equivalent spherical diameter.

TABLE 35. TOTAL PARTICULATE DATA. PLANT 1 DUST COLLECTOR G2-235. COLLECTOR BULK DUST.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
>44	12.4
25	23.3
20	31.2
15	43.9
10	57.5
8	62.8
6	70.2
4	79.9
2	93.4
1	99.4
0.6	99.6

B. MEDIAN SPHERICAL DIAMETER: 12.6 ± 3.9 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 62.56% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	0.02%
U-235	3.43%
U-236	0.04%
U-238	96.51%

(1) Equivalent spherical diameter.

TABLE 36. TOTAL PARTICULATE DATA. PLANT 4 DUST COLLECTOR G4-1. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	7.7
25	14.4
20	21.7
15	38.2
10	64.6
8	70.6
6	77.8
4	89.0
2	97.5
1	99.0
0.6	99.6

B. MEDIAN SPHERICAL DIAMETER: 13.0 ± 2.8 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 73.43% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.83%
U-236	0.06%
U-238	99.10%

(1) Equivalent spherical diameter.

TABLE 37. TOTAL PARTICULATE DATA. PLANT 4 DUST COLLECTOR G4-4. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	0.3
20	25.0
15	37.2
10	53.6
8	58.4
6	63.4
4	75.0
3	79.2
2	88.6
1	98.6
0.6	99.2

B. MEDIAN SPHERICAL DIAMETER: 11.0 ± 4.4 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 74.60% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.51%
U-236	0.02%
U-238	99.46%

(1) Equivalent spherical diameter.

TABLE 38. TOTAL PARTICULATE DATA. PLANT 4 DUST COLLECTOR G4-13. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	6.0
25	13.0
20	19.2
15	30.4
10	44.8
8	49.6
6	56.6
4	70.8
3	78.6
2	89.0
1	98.6
0.6	99.5

B. MEDIAN SPHERICAL DIAMETER: 7.9 ± 3.3 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 81.72% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.90%
U-236	0.02%
U-238	99.07%

(1) Equivalent spherical diameter.

TABLE 39. TOTAL PARTICULATE DATA. PLANT 4 DUST COLLECTOR G4-15. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	1.8
20	4.0
15	5.0
10	12.2
8	22.4
6	50.6
4	79.4
3	88.0
2	93.4
1	97.0
0.6	99.2

B. MEDIAN SPHERICAL DIAMETER: 6.1 ± 1.7 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 73.51% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.84%
U-236	0.07%
U-238	99.08%

(1) Equivalent spherical diameter.

TABLE 40. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G2-67. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	31.0
35	32.6
30	40.0
25	67.5
20	89.6
15	95.4
10	95.4
8	95.4
6	96.6
5	96.6
4	98.0
3	98.5
2	99.2
1	99.8

B. MEDIAN SPHERICAL DIAMETER: 28.4 ± 1.4 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 2.32% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.81%
U-236	0.05%
U-238	99.13%

(1) Equivalent spherical diameter.

TABLE 41. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5-247. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	43.8
30	48.0
25	57.3
20	82.0
15	96.7
8	98.0
6	98.4
4	98.8
2	99.5
1	99.8

B. MEDIAN SPHERICAL DIAMETER: 29.0 ± 1.5 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 1.39% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.78%
U-236	0.05%
U-238	99.17%

(1) Equivalent spherical diameter.

TABLE 42. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5-248. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	33.8
30	36.6
25	39.6
20	49.8
15	80.2
12	93.4
6	94.8
4	96.0
2	98.0
1	99.4
0.8	99.8

B. MEDIAN SPHERICAL DIAMETER: 19.8 ± 1.4 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 1.47% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.21%
U-236	<0.01%
U-238	99.79%

(1) Equivalent spherical diameter.

TABLE 43. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5-262. COLLECTOR BULK DUST.

A.

PARTICLE SIZE(1) (2) (MICRONS)	% GREATER THAN STATED SIZE
>44	88.2

B. MEDIAN SPHERICAL DIAMETER: >44 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 0.11% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.25%
U-236	<0.01%
U-238	99.74%

(1) Equivalent spherical diameter.

(2) Difficulties encountered in analysis. Dust collector G2-262 serves a shop in which clean graphite is machined. The pure graphite particles are transparent to X-rays.

TABLE 44. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5A-100. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	29.8
25	38.4
20	47.0
15	59.6
10	72.4
8	76.0
6	79.6
4	87.4
2	96.0
1	99.3
0.6	99.8

B. MEDIAN SPHERICAL DIAMETER: 18.8 ± 4.1 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 5.15% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.31%
U-236	0.01%
U-238	99.68%

(1) Equivalent spherical diameter.

TABLE 45. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5A-101. COLLECTOR BULK DUST.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
>44	6.0
25	7.0
20	17.3
15	87.3
10	93.9
8	94.2
5	94.8
4	97.4
2	99.6
1	99.8

B. MEDIAN SPHERICAL DIAMETER: 18.5 ± 1.2 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 6.19% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.22%
U-236	<0.01%
U-238	99.77%

(1) Equivalent spherical diameter.

TABLE 46. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR BLDG. 55. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	19.2
30	22.0
25	25.7
20	39.4
15	85.5
10	96.0
8	96.2
6	96.4
4	96.6
2	98.6
1	99.6
0.6	99.8

B. MEDIAN SPHERICAL DIAMETER: 28.8 ± 1.2 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 2.08% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.21%
U-236	<0.01%
U-238	99.78%

(1) Equivalent spherical diameter.

TABLE 47. TOTAL PARTICULATE DATA. PLANT 8 DUST COLLECTOR G43-29. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	1.8
20	7.0
15	16.8
10	32.8
8	42.4
6	55.2
4	75.6
3	86.0
2	96.4
1	99.6
0.6	99.8

B. MEDIAN SPHERICAL DIAMETER: 6.7 ± 2.2 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 68.87% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.91%
U-236	0.05%
U-238	99.03%

(1) Equivalent spherical diameter.

TABLE 48. TOTAL PARTICULATE DATA. PLANT 8 DUST COLLECTOR 8035. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	15.0
25	18.4
20	22.2
15	28.4
10	41.6
8	49.0
6	60.5
4	77.6
3	86.6
2	92.5
1	97.8
0.6	99.0
0.4	99.6

B. MEDIAN SPHERICAL DIAMETER: 7.9 ± 2.5 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 53.83% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.42%
U-236	0.02%
U-238	99.56%

(1) Equivalent spherical diameter.

TABLE 49. TOTAL PARTICULATE DATA. PILOT PLANT DUST COLLECTOR G-1. COLLECTOR BULK DUST.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
>44	0.4
20	6.0
15	19.6
10	50.0
8	67.4
6	82.4
4	93.0
3	95.8
2	97.6
1	99.6
0.6	99.8

B. MEDIAN SPHERICAL DIAMETER: 10.0 ± 1.9 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 75.24% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.78%
U-236	<0.01%
U-238	99.27%

(1) Equivalent spherical diameter.

TABLE 50. TOTAL PARTICULATE DATA. PILOT PLANT DUST COLLECTOR G-2. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	0.2
20	3.4
15	11.6
10	39.5
8	56.4
6	65.6
4	89.6
3	93.0
2	95.4
1	97.0
0.6	97.6
0.4	98.6

B. MEDIAN SPHERICAL DIAMETER: 8.7 ± 1.9 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 75.06% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.74%
U-236	<0.01%
U-238	99.25%

(1) Equivalent spherical diameter.

TABLE 51. TOTAL PARTICULATE DATA. PILOT PLANT DUST COLLECTOR 735-13-7050. COLLECTOR BULK DUST.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
>44	72.4
30	76.3
25	80.7
20	86.2
15	91.7
10	94.8
8	95.2
6	95.3
4	96.7
2	98.6
1	99.6
0.6	99.8

B. MEDIAN SPHERICAL DIAMETER: >44 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 2.43% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.62%
U-236	<0.01%
U-238	99.37%

(1) Equivalent spherical diameter.

TABLE 52. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 1 DUST COLLECTOR G2-1.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	7.3×10^{-5}	1.0×10^{-1}
Pu-238	7.8×10^{-6}	1.1×10^{-2}
Np-237	3.6×10^{-5}	5.1×10^{-2}
Th-234(1)	3.1×10^{-1}	4.4×10^{2}
Pa-234m	2.7×10^{-1}	3.8×10^{2}
Th-232	8.7×10^{-5}	1.2×10^{-2}
Th-230	1.6×10^{-4}	2.3×10^{-1}
Th-228	5.6×10^{-5}	7.9×10^{-2}
Ra-228	8.7×10^{-6}	1.2×10^{-2}
Ra-226	6.2×10^{-6}	8.8×10^{-3}
Cs-137	2.1×10^{-5}	3.0×10^{-2}
Ru-106	$<2.0 \times 10^{-4}$	$<2.8 \times 10^{-1}$
Tc-99	7.8×10^{-4}	1.1
Sr-90	$<4.0 \times 10^{-6}$	$<5.7 \times 10^{-3}$

Uranium in bulk dust, weight %, sample basis: 70.76

Uranium compound: UF_4 (1984), U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 53. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 1 DUST COLLECTOR G2-64.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	3.5×10^{-2}	2.2×10^{2}
Pu-238	1.4×10^{-3}	8.7
Np-237	1.9×10^{-3}	1.2×10^{1}
Th-234(1)	6.1×10^{-2}	3.8×10^{2}
Pa-234m	5.3×10^{-2}	3.3×10^{2}
Th-232	3.1×10^{-3}	1.9×10^{1}
Th-230	5.9×10^{-1}	3.6×10^{3}
Th-228	1.4×10^{-3}	8.7
Ra-228	1.7×10^{-3}	1.1×10^{1}
Ra-226	6.3×10^{-3}	3.9×10^{1}
Cs-137	2.0×10^{-3}	1.2×10^{1}
Ru-106	$<6.0 \times 10^{-4}$	<3.7
Tc-99	8.9×10^{-3}	5.6×10^{1}
Sr-90	3.7×10^{-4}	2.3

Uranium in bulk dust, weight %, sample basis: 16.01

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 54. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 1 DUST COLLECTOR G2-76.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	1.7×10^{-4}	6.1
Pu-238	1.6×10^{-5}	5.8×10^{-1}
Np-237	2.2×10^{-5}	7.9×10^{-1}
Th-234(1)	2.7×10^{-2}	9.7×10^{2}
Pa-234m	1.7×10^{-2}	6.1×10^{2}
Th-232	3.9×10^{-5}	1.4
Th-230	8.2×10^{-4}	3.0×10^{1}
Th-228	4.9×10^{-5}	1.8
Ra-228	2.2×10^{-5}	7.9
Ra-226	5.5×10^{-5}	2.0
Cs-137	8.3×10^{-4}	3.0×10^{1}
Ru-106	$<2.0 \times 10^{-4}$	<7.2
Tc-99	2.2×10^{-4}	7.9
Sr-90	6.6×10^{-4}	2.4×10^{1}

Uranium in bulk dust, weight %, sample basis: 2.77

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 55. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 1 DUST COLLECTOR G2-172.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	3.8×10^{-4}	1.6
Pu-238	6.9×10^{-5}	2.9×10^{-1}
Np-237	7.9×10^{-5}	3.3×10^{-1}
Th-234(1)	1.5×10^{-1}	6.3×10^{2}
Pa-234m	9.8×10^{-2}	4.1×10^{2}
Th-232	2.1×10^{-3}	8.8
Th-230	6.3×10^{-3}	2.6×10^{1}
Th-228	1.3×10^{-3}	5.5
Ra-228	1.3×10^{-3}	5.5
Ra-226	8.4×10^{-4}	3.5
Cs-137	7.4×10^{-6}	3.1×10^{-2}
Ru-106	$<3.0 \times 10^{-4}$	<1.3
Tc-99	1.2×10^{-1}	5.0×10^{2}
Sr-90	$<1.0 \times 10^{-5}$	$<4.2 \times 10^{-2}$

Uranium in bulk dust, weight %, sample basis: 23.84

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 56. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 1 DUST COLLECTOR G2-235.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	1.1×10^{-4}	1.8×10^{-1}
Pu-238	6.7×10^{-5}	1.1×10^{-1}
Np-237	4.8×10^{-5}	7.6×10^{-2}
Th-234(1)	3.1×10^{-1}	5.0×10^{2}
Pa-234m	2.2×10^{-1}	3.5×10^{2}
Th-232	2.0×10^{-4}	3.2×10^{-1}
Th-230	5.8×10^{-3}	9.3×10^{1}
Th-228	8.3×10^{-4}	1.3×10^{1}
Ra-228	7.8×10^{-5}	1.2×10^{-1}
Ra-226	3.1×10^{-4}	5.0×10^{-1}
Cs-137	1.4×10^{-4}	2.2×10^{-1}
Ru-106	$<5.0 \times 10^{-4}$	$<8.0 \times 10^{-1}$
Tc-99	3.4×10^{-3}	5.4×10^{1}
Sr-90	1.9×10^{-4}	3.0×10^{-1}

Uranium in bulk dust, weight %, sample basis: 62.56

Uranium compound: UO_2, U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 57. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 1 DUST COLLECTOR G4-1.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	2.2×10^{-4}	3.0×10^{-1}
Pu-238	2.1×10^{-5}	2.8×10^{-2}
Np-237	1.6×10^{-4}	2.2×10^{-1}
Th-234(1)	5.3×10^{-1}	7.2×10^{2}
Pa-234m	3.2×10^{-1}	4.4×10^{2}
Th-232	7.2×10^{-5}	9.8×10^{-2}
Th-230	2.2×10^{-4}	3.0×10^{-1}
Th-228	2.0×10^{-4}	2.7×10^{-1}
Ra-228	1.3×10^{-5}	1.8×10^{-2}
Ra-226	1.2×10^{-4}	1.6×10^{-1}
Cs-137	1.2×10^{-3}	1.6×10^{1}
Ru-106	$<2.0 \times 10^{-4}$	$<2.7 \times 10^{-1}$
Tc-99	4.3×10^{-2}	5.8×10^{1}
Sr-90	9.0×10^{-4}	1.2

Uranium in bulk dust, weight %, sample basis: 73.43

Uranium compound: UO_3

(1) Corrected to 12 noon on the day of sample collection.

TABLE 58. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 4 DUST COLLECTOR G4-2.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	4.1×10^{-5}	5.4×10^{-2}
Pu-238	4.8×10^{-6}	6.3×10^{-3}
Np-237	7.8×10^{-5}	1.0×10^{-1}
Th-234(1)	2.1×10^{-1}	2.8×10^{2}
Pa-234m	2.0×10^{-1}	2.6×10^{2}
Th-232	4.6×10^{-5}	6.1×10^{-2}
Th-230	6.8×10^{-5}	9.0×10^{-2}
Th-228	4.0×10^{-5}	5.3×10^{-2}
Ra-228	2.0×10^{-6}	2.6×10^{-3}
Ra-226	2.8×10^{-6}	3.7×10^{-3}
Cs-137	2.0×10^{-5}	2.6×10^{-2}
Ru-106(2)	6.4×10^{-5}	8.4×10^{-2}
Tc-99	6.2×10^{-2}	8.2×10^{1}
Sr-90	5.3×10^{-5}	7.0×10^{-2}

Uranium in bulk dust, weight %, sample basis: 75.86

Uranium compound: UF_4

(1) Corrected to 12 noon on the day of sample collection.

(2) Ru-106 determined by radiochemical analyses; all other radionuclides determined by gamma spectroscopy.

TABLE 59. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 4 DUST COLLECTOR G4-4.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	1.4×10^{-4}	1.9×10^{-1}
Pu-238	1.3×10^{-5}	1.7×10^{-2}
Np-237	4.8×10^{-5}	6.4×10^{-2}
Th-234(1)	4.0×10^{-1}	5.4×10^{2}
Pa-234m	2.7×10^{-1}	3.6×10^{2}
Th-232	1.77×10^{-1}	3.6×10^{2}
Th-230	3.1×10^{-4}	4.2×10^{-1}
Th-228	1.9×10^{-4}	2.5×10^{-1}
Ra-228	5.4×10^{-6}	7.2×10^{-3}
Ra-226	3.8×10^{-6}	5.1×10^{-3}
Cs-137	2.4×10^{-5}	3.2×10^{-2}
Ru-106	$<4.0 \times 10^{-4}$	$<5.4 \times 10^{-1}$
Tc-99	3.9×10^{-2}	5.2×10^{1}
Sr-90	3.3×10^{-5}	4.4×10^{-2}

Uranium in bulk dust, weight %, sample basis: 74.60

Uranium compound: UF_4

(1) Corrected to 12 noon on the day of sample collection.

TABLE 60. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 4 DUST COLLECTOR G4-5.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	7.5×10^{-5}	1.1×10^{-1}
Pu-238	1.3×10^{-5}	1.8×10^{-2}
Np-237	1.0×10^{-4}	1.4×10^{-1}
Th-234(1)	4.3×10^{-1}	6.0×10^{2}
Pa-234m	2.9×10^{-1}	4.1×10^{2}
Th-232	5.5×10^{-5}	7.7×10^{-2}
Th-230	2.3×10^{-4}	3.2×10^{-1}
Th-228	2.1×10^{-4}	3.0×10^{-1}
Ra-228	1.1×10^{-5}	1.5×10^{-2}
Ra-226	5.9×10^{-6}	8.2×10^{-3}
Cs-137	2.0×10^{-4}	2.8×10^{-1}
Ru-106	$<2.0 \times 10^{-4}$	$<2.8 \times 10^{-1}$
Tc-99	6.9×10^{-2}	9.7×10^{1}
Sr-90	1.4×10^{-4}	2.0×10^{-1}

Uranium in bulk dust, weight %, sample basis: 71.10

Uranium compound: UF_4

(1) Corrected to 12 noon on the day of sample collection.

TABLE 61. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 4 DUST COLLECTOR G4-7.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	3.2×10^{-4}	6.3×10^{-1}
Pu-238	2.4×10^{-5}	4.7×10^{-2}
Np-237	7.7×10^{-5}	1.5×10^{-1}
Th-234(1)	3.1×10^{-1}	6.1×10^{2}
Pa-234m	2.1×10^{-1}	4.1×10^{2}
Th-232	8.5×10^{-5}	1.7×10^{-1}
Th-230	1.4×10^{-4}	2.8×10^{-1}
Th-228	1.6×10^{-4}	3.2×10^{-1}
Ra-228	2.1×10^{-6}	4.1×10^{-3}
Ra-226	2.4×10^{-6}	4.7×10^{-3}
Cs-137	3.4×10^{-5}	6.7×10^{-2}
Ru-106	$<6.0 \times 10^{-4}$	<1.2
Tc-99	5.4×10^{-2}	1.1×10^{2}
Sr-90	1.4×10^{-5}	2.8×10^{-2}

Uranium in bulk dust, weight %, sample basis: 50.83

Uranium compound: UO_2

(1) Corrected to 12 noon on the day of sample collection.

TABLE 62. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 4 DUST COLLECTOR G4-12.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	1.0×10^{-5}	1.3×10^{-2}
Pu-238	1.7×10^{-6}	2.3×10^{-3}
Np-237	2.6×10^{-6}	3.5×10^{-3}
Th-234(1)	2.2×10^{-1}	2.9×10^{2}
Pa-234m	1.9×10^{-1}	2.5×10^{2}
Th-232	2.6×10^{-5}	3.5×10^{-2}
Th-230	3.9×10^{-5}	5.2×10^{-2}
Th-228	3.7×10^{-5}	4.9×10^{-2}
Ra-228	2.0×10^{-6}	2.7×10^{-3}
Ra-226	9.1×10^{-7}	1.2×10^{-3}
Cs-137	7.3×10^{-5}	9.7×10^{-2}
Ru-106	$<1.0 \times 10^{-4}$	$<1.3 \times 10^{-1}$
Tc-99	1.6×10^{-3}	2.1
Sr-90	$<5.0 \times 10^{-6}$	6.7×10^{-3}

Uranium in bulk dust, weight %, sample basis: 75.12

Uranium compound: UF_4

(1) Corrected to 12 noon on the day of sample collection.

TABLE 63. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 4 DUST COLLECTOR G4-13.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	3.9×10^{-5}	4.8×10^{-2}
Pu-238	7.0×10^{-6}	8.6×10^{-3}
Np-237	1.4×10^{-4}	1.7×10^{-1}
Th-234(1)	6.4×10^{-1}	7.8×10^{2}
Pa-234m	6.5×10^{-1}	8.0×10^{2}
Th-232	1.8×10^{-4}	2.2×10^{-1}
Th-230	2.5×10^{-4}	3.1×10^{-1}
Th-228	2.7×10^{-4}	3.3×10^{-1}
Ra-228	4.3×10^{-6}	5.3×10^{-3}
Ra-226	1.1×10^{-5}	1.3×10^{-2}
Cs-137	5.1×10^{-5}	6.2×10^{-2}
Ru-106	$<7.0 \times 10^{-4}$	$<8.6 \times 10^{-1}$
Tc-99	7.6×10^{-2}	9.3×10^{1}
Sr-90	2.6×10^{-5}	3.2×10^{-2}

Uranium in bulk dust, weight %, sample basis: 81.72

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 64. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 4 DUST COLLECTOR G4-14.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	7.6×10^{-7}	1.0×10^{-3}
Pu-238	2.7×10^{-6}	3.6×10^{-3}
Np-237	5.3×10^{-6}	7.0×10^{-3}
Th-234(1)	5.5×10^{-1}	7.3×10^{2}
Pa-234m	2.9×10^{-1}	3.8×10^{2}
Th-232	5.8×10^{-5}	7.7×10^{-2}
Th-230	1.0×10^{-4}	1.3×10^{-1}
Th-228	2.5×10^{-5}	3.3×10^{-2}
Ra-228	3.3×10^{-6}	4.4×10^{-3}
Ra-226	2.1×10^{-6}	2.8×10^{-3}
Cs-137	2.9×10^{-5}	3.8×10^{-2}
Ru-106	$<2.0 \times 10^{-4}$	$<2.6 \times 10^{-1}$
Tc-99	3.5×10^{-5}	4.6×10^{-2}
Sr-90	$<1.0 \times 10^{-5}$	1.3×10^{-2}

Uranium in bulk dust, weight %, sample basis: 75.76

Uranium compound: UF_4

(1) Corrected to 12 noon on the day of sample collection.

TABLE 65. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 4 DUST COLLECTOR G4-15.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	3.4×10^{-4}	4.6×10^{-1}
Pu-238	2.9×10^{-5}	3.9×10^{-2}
Np-237	6.5×10^{-5}	8.8×10^{-2}
Th-234(1)	5.3×10^{-1}	7.2×10^{2}
Pa-234m	2.8×10^{-1}	3.8×10^{2}
Th-232	1.2×10^{-4}	1.6×10^{-1}
Th-230	4.0×10^{-4}	5.4×10^{-1}
Th-228	1.6×10^{-4}	2.2×10^{-1}
Ra-228	3.7×10^{-6}	5.0×10^{-3}
Ra-226	1.1×10^{-5}	1.5×10^{-2}
Cs-137	1.5×10^{-5}	2.0×10^{-2}
Ru-106	$<3.0 \times 10^{-4}$	$<4.1 \times 10^{-1}$
Tc-99	3.9×10^{-3}	5.3×10^{1}
Sr-90	$<1.0 \times 10^{-5}$	$<1.4 \times 10^{-2}$

Uranium in bulk dust, weight %, sample basis: 73.51

Uranium compound: UF_4

(1) Corrected to 12 noon on the day of sample collection.

TABLE 66. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G2-67.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	1.2×10^{-4}	5.2
Pu-238	1.1×10^{-5}	4.7×10^{-1}
Np-237	3.4×10^{-5}	1.5
Th-234(1)	4.6×10^{-2}	2.0×10^{3}
Pa-234m	2.6×10^{-2}	1.1×10^{3}
Th-232	8.3×10^{-5}	3.6
Th-230	2.5×10^{-4}	1.1×10^{1}
Th-228	2.2×10^{-4}	9.5
Ra-228	4.2×10^{-5}	1.8
Ra-226	4.8×10^{-6}	2.1×10^{-1}
Cs-137	2.9×10^{-4}	1.2×10^{1}
Ru-106	$<3.0 \times 10^{-4}$	$<1.7 \times 10^{1}$
Tc-99	8.0×10^{-4}	3.4×10^{1}
Sr-90	1.8×10^{-3}	7.8×10^{1}

Uranium in bulk dust, weight %, sample basis: 2.32

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 67. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5-247.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	4.3×10^{-5}	3.1
Pu-238	7.2×10^{-6}	5.2×10^{-1}
Np-237	1.9×10^{-5}	1.4
Th-234(1)	1.7×10^{-2}	1.2×10^{3}
Pa-234m	9.0×10^{-3}	6.5×10^{2}
Th-232	2.2×10^{-5}	1.6
Th-230	8.7×10^{-5}	6.3
Th-228	2.1×10^{-4}	1.5×10^{1}
Ra-228	2.7×10^{-5}	1.9
Ra-226	7.7×10^{-6}	5.5×10^{-1}
Cs-137	1.5×10^{-4}	1.1×10^{1}
Ru-106	$<2.0 \times 10^{-4}$	$<1.4 \times 10^{1}$
Tc-99	2.5×10^{-4}	1.8×10^{1}
Sr-90	1.3×10^{-3}	9.4×10^{1}

Uranium in bulk dust, weight %, sample basis: 1.39

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 68. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5-248.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	5.9×10^{-6}	4.0×10^{-1}
Pu-238	1.5×10^{-6}	1.0×10^{-1}
Np-237	3.7×10^{-6}	2.5×10^{-1}
Th-234(1)	4.8×10^{-1}	3.3×10^{4}
Pa-234m	1.4×10^{-1}	9.5×10^{3}
Th-232	1.7×10^{-5}	1.2
Th-230	1.7×10^{-5}	1.2
Th-228	9.2×10^{-5}	6.3
Ra-228	2.2×10^{-6}	1.5×10^{-1}
Ra-226	2.0×10^{-6}	1.4×10^{-1}
Cs-137	8.2×10^{-5}	5.6
Ru-106	$<4.0 \times 10^{-4}$	$<2.7 \times 10^{1}$
Tc-99	3.4×10^{-5}	2.3
Sr-90	1.6×10^{-5}	1.1

Uranium in bulk dust, weight %, sample basis: 1.47

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 69. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5-249.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	6.8×10^{-6}	1.5×10^{-2}
Pu-238	1.4×10^{-6}	3.0×10^{-3}
Np-237	7.0×10^{-6}	1.5×10^{-2}
Th-234(1)	4.1×10^{-1}	8.8×10^{2}
Pa-234m	2.5×10^{-1}	5.4×10^{2}
Th-232	3.4×10^{-5}	7.3×10^{-2}
Th-230	7.7×10^{-5}	1.7×10^{-1}
Th-228	3.3×10^{-5}	7.1×10^{-2}
Ra-228	3.3×10^{-6}	7.1×10^{-3}
Ra-226	2.4×10^{-6}	5.2×10^{-3}
Cs-137	2.5×10^{-5}	5.4×10^{-2}
Ru-106	$<3.3 \times 10^{-4}$	$<7.1 \times 10^{-1}$
Tc-99	2.1×10^{-4}	4.5×10^{-1}
Sr-90	5.5×10^{-4}	1.2

Uranium in bulk dust, weight %, sample basis: 46.59

Uranium compound: UF_4

(1) Corrected to 12 noon on the day of sample collection.

TABLE 70. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5-250.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	3.2×10^{-6}	9.3×10^{-3}
Pu-238	9.7×10^{-7}	2.8×10^{-3}
Np-237	6.2×10^{-6}	1.8×10^{-2}
Th-234(1)	4.0×10^{-1}	1.2×10^{3}
Pa-234m	2.3×10^{-1}	6.7×10^{2}
Th-232	3.6×10^{-5}	1.0×10^{-1}
Th-230	1.2×10^{-4}	3.5×10^{-1}
Th-228	7.2×10^{-5}	2.1×10^{-1}
Ra-228	2.0×10^{-6}	5.8×10^{-3}
Ra-226	4.9×10^{-6}	1.4×10^{-2}
Cs-137	1.4×10^{-5}	4.1×10^{-2}
Ru-106	$<2.0 \times 10^{-4}$	$<5.8 \times 10^{-1}$
Tc-99	5.7×10^{-5}	1.7×10^{-1}
Sr-90	1.3×10^{-4}	3.8×10^{-1}

Uranium in bulk dust, weight %, sample basis: 34.43

Uranium compound: UF_4

(1) Corrected to 12 noon on the day of sample collection.

TABLE 71. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5-251.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	3.3×10^{-5}	9.0×10^{-1}
Pu-238	3.1×10^{-6}	8.4×10^{-2}
Np-237	2.2×10^{-5}	6.0×10^{-1}
Th-234(1)	8.8×10^{-1}	2.4×10^{4}
Pa-234m	1.7×10^{-1}	4.6×10^{3}
Th-232	1.1×10^{-5}	3.0×10^{-1}
Th-230	2.2×10^{-4}	6.0
Th-228	5.1×10^{-5}	1.4
Ra-228	4.9×10^{-6}	1.3×10^{-1}
Ra-226	4.6×10^{-6}	1.3×10^{-1}
Cs-137	1.8×10^{-4}	4.9
Ru-106	$<4.0 \times 10^{-4}$	$<1.1 \times 10^{1}$
Tc-99	3.2×10^{-4}	8.7
Sr-90	1.5×10^{-4}	4.1

Uranium in bulk dust, weight %, sample basis: 3.68

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 72. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5-253.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	8.9×10^{-6}	5.7×10^{-1}
Pu-238	9.5×10^{-7}	6.1×10^{-2}
Np-237	3.5×10^{-6}	2.2×10^{-1}
Th-234(1)	4.0×10^{-1}	2.5×10^{4}
Pa-234m	1.2×10^{-1}	7.6×10^{3}
Th-232	9.5×10^{-6}	6.1×10^{-1}
Th-230	3.6×10^{-5}	2.3
Th-228	4.2×10^{-6}	2.7×10^{-1}
Ra-228	2.8×10^{-6}	1.8×10^{-1}
Ra-226	1.8×10^{-6}	1.1×10^{-1}
Cs-137	1.6×10^{-4}	1.0×10^{1}
Ru-106	$<3.0 \times 10^{-4}$	$<1.9 \times 10^{1}$
Tc-99	2.0×10^{-5}	1.3
Sr-90	1.2×10^{-3}	7.6×10^{1}

Uranium in bulk dust, weight %, sample basis: 1.57

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 73. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5-254.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	1.4×10^{-5}	6.5×10^{-1}
Pu-238	2.0×10^{-6}	9.3×10^{-2}
Np-237	7.2×10^{-6}	3.3×10^{-1}
Th-234(1)	4.1×10^{-1}	1.9×10^{4}
Pa-234m	2.0×10^{-1}	9.3×10^{3}
Th-232	1.7×10^{-5}	7.9×10^{-1}
Th-230	2.4×10^{-5}	1.1
Th-228	2.0×10^{-5}	9.3×10^{-1}
Ra-228	4.2×10^{-6}	1.9×10^{-1}
Ra-226	1.5×10^{-6}	6.9×10^{-2}
Cs-137	3.9×10^{-4}	1.8×10^{1}
Ru-106	$<3.0 \times 10^{-4}$	$<1.4 \times 10^{1}$
Tc-99	6.4×10^{-5}	3.0
Sr-90	1.7×10^{-3}	7.9×10^{1}

Uranium in bulk dust, weight %, sample basis: 2.16

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 74. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5-256.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	3.2×10^{-5}	1.3
Pu-238	3.3×10^{-6}	1.3×10^{-1}
Np-237	1.3×10^{-5}	5.3×10^{-1}
Th-234(1)	4.2×10^{-1}	1.7×10^{4}
Pa-234m	1.9×10^{-1}	7.7×10^{3}
Th-232	2.4×10^{-5}	9.7×10^{-1}
Th-230	4.7×10^{-5}	1.9
Th-228	2.8×10^{-5}	1.1
Ra-228	5.1×10^{-6}	2.1×10^{-1}
Ra-226	3.2×10^{-6}	1.3×10^{-1}
Cs-137	5.2×10^{-4}	2.1×10^{1}
Ru-106	$<2.0 \times 10^{-4}$	<8.1
Tc-99	1.2×10^{-4}	4.9
Sr-90	1.1×10^{-4}	4.5

Uranium in bulk dust, weight %, sample basis: 2.47

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 75. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5-260.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	1.5×10^{-5}	3.0×10^{-2}
Pu-238	5.3×10^{-6}	1.1×10^{-2}
Np-237	1.1×10^{-5}	1.5×10^{-2}
Th-234(1)	1.7×10^{1}	3.4×10^{4}
Pa-234m	6.7	1.4×10^{4}
Th-232	1.0×10^{-5}	2.0×10^{-2}
Th-230	1.3×10^{-4}	2.6×10^{-1}
Th-228	6.0×10^{-5}	1.2×10^{-1}
Ra-228	2.7×10^{-6}	5.4×10^{-3}
Ra-226	1.7×10^{-6}	3.4×10^{-3}
Cs-137	1.2×10^{-5}	2.4×10^{-2}
Ru-106	$<3.0 \times 10^{-3}$	<6.1
Tc-99	1.4×10^{-4}	2.8×10^{-1}
Sr-90	$<1.0 \times 10^{-5}$	$<2.0 \times 10^{-2}$

Uranium in bulk dust, weight %, sample basis: 49.47

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 76. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5-261.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	2.5×10^{-5}	3.3×10^{-2}
Pu-238	2.8×10^{-6}	3.7×10^{-3}
Np-237	1.1×10^{-5}	1.5×10^{-2}
Th-234(1)	6.9	9.2×10^{3}
Pa-234m	2.8	3.7×10^{3}
Th-232	3.5×10^{-6}	4.7×10^{-3}
Th-230	5.2×10^{-5}	6.9×10^{-2}
Th-228	4.5×10^{-5}	6.0×10^{-2}
Ra-228	3.1×10^{-6}	4.1×10^{-3}
Ra-226	3.1×10^{-6}	4.1×10^{-3}
Cs-137	1.3×10^{-5}	1.7×10^{-2}
Ru-106(2)	$<2.0 \times 10^{-5}$	$<2.7 \times 10^{-2}$
Tc-99	2.1×10^{-4}	2.8×10^{-1}
Sr-90	1.0×10^{-5}	1.3×10^{-3}

Uranium in bulk dust, weight %, sample basis: 75.12

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

(2) Ru-106 determined by radiochemical analyses; all other radionuclides determined by gamma spectroscopy.

TABLE 77. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5-262.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	1.1×10^{-6}	1.0
Pu-238	1.1×10^{-6}	1.0
Np-237	4.3×10^{-6}	3.9
Th-234(1)	5.2×10^{-3}	4.7×10^{3}
Pa-234m	1.6×10^{-3}	1.5×10^{3}
Th-232	7.5×10^{-5}	6.8×10^{1}
Th-230	5.0×10^{-5}	4.5×10^{1}
Th-228	1.5×10^{-4}	1.4×10^{2}
Ra-228	1.8×10^{-6}	1.6
Ra-226	9.9×10^{-7}	9.0×10^{-1}
Cs-137	7.3×10^{-5}	6.6×10^{1}
Ru-106	$<3.0 \times 10^{-4}$	$<2.7 \times 10^{2}$
Tc-99	3.7×10^{-5}	3.4×10^{-1}
Sr-90	$<1.0 \times 10^{-5}$	<9.1

Uranium in bulk dust, weight %, sample basis: 0.11

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 78. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5A-100.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	8.9×10^{-6}	1.7×10^{-1}
Pu-238	3.2×10^{-6}	6.2×10^{-2}
Np-237	1.7×10^{-5}	3.3×10^{-1}
Th-234(1)	1.5×10^{-1}	2.9×10^{3}
Pa-234m	6.7×10^{-2}	1.3×10^{3}
Th-232	1.2×10^{-4}	2.3
Th-230	1.4×10^{-4}	2.7
Th-228	4.8×10^{-4}	9.3
Ra-228	6.2×10^{-6}	1.2×10^{-1}
Ra-226	3.0×10^{-6}	5.8×10^{-2}
Cs-137	1.6×10^{-4}	3.1
Ru-106	$<2.0 \times 10^{-4}$	<3.9
Tc-99	8.8×10^{-4}	1.7×10^{1}
Sr-90	$<1.0 \times 10^{-5}$	$<1.9 \times 10^{-1}$

Uranium in bulk dust, weight %, sample basis: 5.15

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 79. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5A-101.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	2.0×10^{-5}	3.2×10^{-1}
Pu-238	4.6×10^{-6}	7.4×10^{-2}
Np-237	1.5×10^{-5}	2.4×10^{-1}
Th-234(1)	1.5	2.4×10^{4}
Pa-234m	5.8×10^{-1}	9.4×10^{3}
Th-232	1.2×10^{-4}	1.9
Th-230	1.1×10^{-4}	1.8
Th-228	4.0×10^{-4}	6.5
Ra-228	7.1×10^{-6}	1.1×10^{-1}
Ra-226	3.3×10^{-6}	5.3×10^{-2}
Cs-137	2.6×10^{-4}	4.2
Ru-106	$<1.0 \times 10^{-3}$	$<1.6 \times 10^{1}$
Tc-99	8.0×10^{-5}	1.3
Sr-90	2.4×10^{-4}	3.9

Uranium in bulk dust, weight %, sample basis: 6.19

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 80. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR BLDG. 55.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	3.7×10^{-6}	1.8×10^{-1}
Pu-238	6.1×10^{-7}	2.9×10^{-2}
Np-237	5.3×10^{-6}	2.5×10^{-1}
Th-234(1)	4.9×10^{-1}	2.4×10^{4}
Pa-234m	1.9×10^{-1}	9.1×10^{3}
Th-232	5.7×10^{-5}	2.7
Th-230	8.4×10^{-5}	4.0
Th-228	1.1×10^{-4}	5.3
Ra-228	1.6×10^{-6}	7.7×10^{-2}
Ra-226	3.2×10^{-6}	1.5×10^{-1}
Cs-137	6.8×10^{-5}	3.3
Ru-106	$<2.0 \times 10^{-4}$	<9.6
Tc-99	1.0×10^{-4}	4.8
Sr-90	2.5×10^{-5}	1.2

Uranium in bulk dust, weight %, sample basis: 2.08

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 81. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 8 DUST COLLECTOR G43-27.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	5.1×10^{-4}	4.7
Pu-238	2.6×10^{-5}	2.4×10^{-1}
Np-237	7.0×10^{-5}	6.4×10^{-1}
Th-234(1)	2.8×10^{-2}	2.6×10^{2}
Pa-234m	2.6×10^{-2}	2.4×10^{2}
Th-232	1.2×10^{-4}	1.1
Th-230	1.1×10^{-2}	1.0×10^{2}
Th-228	1.8×10^{-4}	1.7
Ra-228	2.7×10^{-5}	2.5×10^{-1}
Ra-226	2.0×10^{-5}	1.8×10^{-1}
Cs-137	1.5×10^{-5}	1.4×10^{-1}
Ru-106	$<2.0 \times 10^{-4}$	<1.8
Tc-99	3.9×10^{-3}	3.6×10^{1}
Sr-90	2.8×10^{-5}	2.6×10^{-1}

Uranium in bulk dust, weight %, sample basis: 10.9

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 82. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 8 DUST COLLECTOR G43-29.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	4.4×10^{-4}	6.4×10^{-1}
Pu-238	5.7×10^{-5}	8.3×10^{-2}
Np-237	2.5×10^{-4}	3.6×10^{-1}
Th-234(1)	2.6×10^{-2}	3.8×10^{2}
Pa-234m	2.5×10^{-1}	3.6×10^{2}
Th-232	1.6×10^{-4}	2.3×10^{-1}
Th-230	1.3×10^{-3}	1.9
Th-228	5.6×10^{-4}	8.1×10^{-1}
Ra-228	2.4×10^{-5}	3.5×10^{-2}
Ra-226	2.5×10^{-5}	3.6×10^{-2}
Cs-137	1.5×10^{-4}	2.2×10^{-1}
Ru-106	$<2.0 \times 10^{-4}$	$<2.9 \times 10^{-1}$
Tc-99	2.2×10^{-2}	3.2×10^{1}
Sr-90	2.8×10^{-5}	4.1×10^{-2}

Uranium in bulk dust, weight %, sample basis: 68.87

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 83. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 8 DUST COLLECTOR 8035.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	8.6×10^{-5}	1.6×10^{-1}
Pu-238	2.0×10^{-5}	3.7×10^{-2}
Np-237	3.6×10^{-5}	6.7×10^{-2}
Th-234(1)	2.2×10^{-1}	4.1×10^{2}
Pa-234m	2.1×10^{-1}	3.9×10^{2}
Th-232	1.5×10^{-4}	2.8×10^{-1}
Th-230	3.2×10^{-4}	5.9×10^{-1}
Th-228	1.6×10^{-4}	3.0×10^{-1}
Ra-228	3.1×10^{-5}	5.8×10^{-2}
Ra-226	3.2×10^{-6}	5.9×10^{-3}
Cs-137	1.4×10^{-4}	2.6×10^{-1}
Ru-106	$<6.0 \times 10^{-4}$	<1.1
Tc-99	6.8×10^{-3}	1.3×10^{1}
Sr-90	1.5×10^{-5}	2.8×10^{-2}

Uranium in bulk dust, weight %, sample basis: 53.83

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 84. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 9 DUST COLLECTOR G9N1-1039.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	9.3×10^{-4}	1.7
Pu-238	7.3×10^{-5}	1.3×10^{-1}
Np-237	2.5×10^{-4}	4.5×10^{-1}
Th-234(1)	7.6	1.4×10^{4}
Pa-234m	4.0×10^{-1}	7.2×10^{2}
Th-232	3.3×10^{-5}	5.9×10^{-2}
Th-230	1.5×10^{-4}	2.7×10^{-1}
Th-228	1.0×10^{-3}	1.8
Ra-228	7.0×10^{-6}	1.3×10^{-2}
Ra-226	2.4×10^{-4}	4.3×10^{-1}
Cs-137	4.0×10^{-4}	7.2×10^{-1}
Ru-106	$<5.0 \times 10^{-4}$	9.0×10^{-1}
Tc-99	3.8×10^{-2}	6.8×10^{1}
Sr-90	1.2×10^{-4}	2.1×10^{-1}

Uranium in bulk dust, weight %, sample basis: 54.84

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 85. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT P.P. DUST COLLECTOR G-1.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	1.7×10^{-6}	2.3×10^{-3}
Pu-238	1.7×10^{-6}	2.3×10^{-3}
Np-237	3.6×10^{-6}	4.8×10^{-3}
Th-234(1)	6.1×10^{-2}	8.1×10^{1}
Pa-234m	1.6×10^{-1}	2.1×10^{2}
Th-232	5.5×10^{-5}	7.3×10^{-2}
Th-230	2.6×10^{-4}	3.5×10^{-1}
Th-228	9.7×10^{-5}	1.3×10^{-1}
Ra-228	1.7×10^{-6}	2.3×10^{-3}
Ra-226	2.7×10^{-6}	3.6×10^{-3}
Cs-137	1.5×10^{-4}	2.0×10^{-1}
Ru-106	$<2.0 \times 10^{-4}$	$<2.7 \times 10^{-1}$
Tc-99	7.2×10^{-5}	9.6×10^{-2}
Sr-90	$<5.0 \times 10^{-6}$	$<6.6 \times 10^{-3}$

Uranium in bulk dust, weight %, sample basis: 75.24

Uranium compound: UF_4

(1) Corrected to 12 noon on the day of sample collection.

TABLE 86. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT P.P. DUST COLLECTOR G-2.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	1.3×10^{-6}	1.7×10^{-3}
Pu-238	2.6×10^{-6}	3.5×10^{-3}
Np-237	7.4×10^{-6}	9.9×10^{-3}
Th-234(1)	9.2×10^{-2}	1.2×10^{2}
Pa-234m	1.8×10^{-1}	2.4×10^{2}
Th-232	8.5×10^{-5}	1.1×10^{-1}
Th-230	1.4×10^{-4}	1.9×10^{-1}
Th-228	1.0×10^{-4}	1.3×10^{-1}
Ra-228	2.1×10^{-6}	2.8×10^{-3}
Ra-226	1.4×10^{-6}	1.9×10^{-3}
Cs-137	1.6×10^{-4}	2.1×10^{-1}
Ru-106	$<1.0 \times 10^{-4}$	$<1.3 \times 10^{-1}$
Tc-99	1.3×10^{-4}	1.7×10^{-1}
Sr-90	$<4.0 \times 10^{-6}$	$<5.3 \times 10^{-3}$

Uranium in bulk dust, weight %, sample basis: 75.06

Uranium compound: UF_4

(1) Corrected to 12 noon on the day of sample collection.

TABLE 87. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT P.P. DUST COLLECTOR 735-13-7050.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	1.5×10^{-5}	6.2×10^{-1}
Pu-238	1.2×10^{-4}	4.9
Np-237	4.3×10^{-6}	1.8×10^{-1}
Th-234(1)	1.9×10^{-2}	7.8×10^{2}
Pa-234m	9.9×10^{-3}	4.1×10^{2}
Th-232	2.7×10^{-4}	1.1×10^{1}
Th-230	2.2×10^{-4}	9.1
Th-228	2.1×10^{-4}	8.6
Ra-228	1.6×10^{-4}	6.6
Ra-226	1.1×10^{-5}	4.5×10^{-1}
Cs-137	1.5×10^{-4}	6.17
Ru-106	$<2.0 \times 10^{-4}$	<8.2
Tc-99	5.0×10^{-5}	2.1
Sr-90	$<1.0 \times 10^{-5}$	4.1×10^{-1}

Uranium in bulk dust, weight %, sample basis: 2.43

Uranium compound: UO_3, U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 88. STACK AND SCRUBBER THORIUM DISCHARGES

Calendar Year	Discharge	Thorium Discharged kg
1955	Plant 9, dust collector(1)	159
1956	Plant 9, dust collector G42-615	10
1968	Plant 8, dust collector(1)	54
1968	Plant 8, scrubbers	141
1969	Plant 8, dust collector(1)	273
1970	Pilot Plant, dust collector(1)	26
1970	Plant 8, scrubbers	4
1973	Pilot Plant, dust collector(1)	10
	Total:	677 kg

(1) Records do not identify the specific dust collectors.

TABLE 89. THORIUM AND RADIUM ISOTOPES IN REFINERY (PLANT 2/3) STACK DISCHARGES

CALENDAR YEAR	REFINERY FEED	MICROCURIES DISCHARGED				
		Th-232	Ra-228	Th-228	Th-230	Ra-226
1953	Pitchblende	0.16	0.90	22	5.5×10^3	4.2×10^3
1954	Pitchblende	1.9	10.8	265	6.6×10^4	5.0×10^4
1955	Pitchblende	1.9	10.8	265	6.6×10^4	5.0×10^4
1956	Canadian conc.	128	8.2	570	2.7×10^4	228
1957	Canadian conc.	549	35.3	2450	1.1×10^5	980
1958	Canadian conc.	123	7.9	550	2.6×10^4	220
1959	Canadian conc.	67	4.3	298	1.4×10^4	119
1960	Canadian conc.	119	7.7	532	2.5×10^4	213
1961	U.S. concentrates	2.0	2.4	168	7.8×10^3	67
1962	U.S. concentrates	2.0	2.4	168	7.8×10^3	67
1963	No operations	0	0	0	0	0
1964	No operations	0	0	0	0	0
1965	U.S. concentrates	0.38	0.46	32	1.5×10^3	13
1966	U.S. concentrates	1.6	1.9	135	6.3×10^3	54
1967	U.S. concentrates	0.80	0.96	67	3.1×10^3	27
1968	U.S. concentrates	0.28	0.34	24	1.1×10^3	9.5
1969	U.S. concentrates	0.25	0.30	20	9.6×10^2	8.2
1970	U.S. concentrates	1.4	1.7	117	5.5×10^3	47
1971	U.S. concentrates	0.78	0.94	65	3.0×10^3	26
1972	U.S. concentrates	12	14.8	1025	4.8×10^4	410
1973	U.S. concentrates	5.6	6.7	465	2.2×10^4	186
1974	U.S. concentrates	0.45	0.54	38	1.8×10^3	15
1975	U.S. concentrates	0.28	0.33	23	1.1×10^3	9.2
1976	U.S. concentrates	0.28	0.33	23	1.1×10^3	9.2
1977	U.S. concentrates	0.19	0.22	16	7.2×10^2	6.2

TABLE 90. FISCAL YEAR RECORD OF URANIUM IN WASTEWATER DISCHARGED TO THE GREAT MIAMI RIVER

FISCAL YEAR[1]	WASTEWATER DISCHARGE Kg U
1984	1054
1983	564
1982	755
1981	576
1980	685
1979	1175
1978	880
1977	965
1976A	179
1976	875
1975	1852
1974	1066
1973	1126
1972	1140
1971	1637
1970	1914
1969	2290
1968	1855
1967	2305
1966	3740
1965	3730
1964	10504
1963	4566
1962	3543
1961	5486
1960	4445
1959	6488
1958	3712
1957	2595
1956	1485
1955	657
1954	347
1953	106
1952	11
	74,308

(1) 1952 through 1976, the fiscal year is from July 1 through June 31 of the next year. 1976A is a three month transition period, July 1, 1976 through September 30, 1976. From 1977 to the present time, the fiscal year is from October 1 through September 30 of the next year.

TABLE 91. RADIONUCLIDES IN WASTEWATER DISCHARGES

CALENDAR YEAR	THORIUM kg	CURIES DISCHARGED								
		Sr-90	Tc-99	Ru-106	Cs-137	Ra-226	Ra-228	Np-237	Pu-238	Pu-239/240
1957	- (1)	-	-	-	0.5	-	-	-	-	
1958	-	-	-	-	-	0.5	-	-	-	-
1959	-	-	-	-	-	0.5	-	-	-	-
1960	-	-	-	-	-	0.5	-	-	-	-
1961	-	-	-	-	-	0.5	-	-	-	-
1962	-	-	-	-	-	0.5	-	-	-	-
1963	-	-	-	-	-	0.5	-	-	-	-
1964	-	-	-	-	-	0.5	-	-	-	-
1965	-	-	-	-	-	0.5	-	-	-	-
1966	-	-	-	-	-	0.5	-	-	-	-
1967	27	-	-	-	-	0.5	-	-	-	-
1968	128	-	-	-	-	0.5	1.1	-	-	-
1969	63	-	5.0	-	-	0.2	1.6	-	-	-
1970	29	-	2	-	-	0.2	0.5	-	-	-
1971	30	-	20	-	-	0.1	4×10^{-2}	-	-	-
1972	18	-	7.2	-	-	5.5×10^{-2}	1.5×10^{-2}	-	-	-
1973	9	-	6.2	-	-	2.4×10^{-2}	6×10^{-3}	-	-	-
1974	18	-	(2)	-	-	8×10^{-3}	6×10^{-3}	-	-	-
1975	6.4	-	(2)	-	-	1.3×10^{-2}	1.6×10^{-2}	-	-	-
1976	5.5	-	9	3×10^{-3}	2×10^{-2}	7×10^{-3}	8×10^{-3}	2×10^{-7}	4×10^{-7}	2×10^{-7}
1977	5.1	7.5×10^{-2}	0.1	8.2×10^{-3}	8.4×10^{-2}	7.2×10^{-3}	6.9×10^{-2}	$<5 \times 10^{-4}$	$<2.5 \times 10^{-5}$	$<5.6 \times 10^{-5}$
1978	5.5	6.9×10^{-3}	0.1	1.1×10^{-2}	1.5×10^{-2}	3.2×10^{-3}	4.3×10^{-3}	3.2×10^{-5}	$<2.4 \times 10^{-5}$	$<3.3 \times 10^{-5}$
1979	7.0	3.2×10^{-3}	3.4	1.8×10^{-3}	6.1×10^{-3}	7.8×10^{-4}	9.3×10^{-3}	1.9×10^{-4}	1.0×10^{-5}	2.9×10^{-5}
1980	2.1	2.6×10^{-3}	0.9	8.9×10^{-4}	1×10^{-2}	3.5×10^{-4}	3.3×10^{-3}	$<1 \times 10^{-4}$	3.8×10^{-6}	1.4×10^{-3}
1981	3.0	2.5×10^{-3}	4.2	6.7×10^{-4}	2.3×10^{-3}	1.1×10^{-2}	7×10^{-3}	$<1.4 \times 10^{-4}$	5.1×10^{-6}	2.9×10^{-5}
1982	3.8	3.2×10^{-3}	9.8	3.4×10^{-5}	2.8×10^{-3}	2.9×10^{-3}	1.2×10^{-2}	3×10^{-4}	4.9×10^{-6}	1.5×10^{-5}
1983	2.1	6.0×10^{-3}	21	3×10^{-4}	5.6×10^{-3}	1×10^{-3}	6×10^{-3}	$<2 \times 10^{-4}$	5×10^{-6}	8×10^{-5}
1984	4.5	1.2×10^{-2}	19	5×10^{-4}	1.7×10^{-2}	$<1.7 \times 10^{-2}$	$<1.4 \times 10^{-2}$	2×10^{-4}	3×10^{-5}	5×10^{-5}

(1) A dash indicates data were not collected

(2) Data were collected but could not be retreived.

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TABLE 92. URANIUM IN OFF-SITE WELL WATER, 1984

WELL LOCATION (1)	NUMBER OF SAMPLES	AVERAGE CONCENTRATION pCi/L	% OF STANDARD (2)
1	12	0.34	0.03
2	9	0.27	0.02
3	10	0.34	0.03
4	10	1.29	0.11
5	11	1.42	0.12
6	12	1.29	0.11
7	11	0.95	0.08
8	12	0.54	0.05
9	12	0.81	0.07
10	12	0.34	0.03
11	7	0.68	0.06
12	11	165.19	13.77
13	12	0.41	0.03
14	12	0.74	0.06
15	12	219.35	18.28
16	11	0.41	0.03
17	11	36.29	3.02
18	11	0.34	0.03
19	12	0.20	0.02
20	10	0.20	0.02
21	12	0.27	0.02
22	9	0.74	0.06

(1) See Figure 5

(2) 1200 pCi/L, DOE Order 5480.1A, Attachment X1-1, Table II

TABLE 93. RADIATION DOSE FROM OFF-SITE WELL WATER USAGE[1]

OFFSITE WELL	TARGET ORGAN	CALCULATED DOSE, MILLIREM
No. 12	Bone Endosteum	442
	Effective Dose	30
No. 15	Bone Endosteum	587
	Effective Dose	40
No. 17	Bone Endosteum	97
	Effective Dose	7

(1) 50-year committed dose equivalents from a year-long intake of 2 liters of water per day.

TABLE 94. RADON-222 CONCENTRATIONS, pCi/L, AT THE FMPC BOUNDARY

BOUNDARY STATION NO.	FMPC RESULTS 1984 (1)	FMPC RESULTS 1985 (2)	MOUND LAB RESULTS(3)	OHIO DEPT. OF HEALTH RESULTS (4)	(5)	(6)
1	0.92	0.81	-	0.47	0.15	0.23
2	0.80	0.82	0.24	0.17	0.21	0.82
3	0.84	0.28	0.29	0.63	0.26	0.26
4	0.59	0.56	0.24	-	-	-
5	0.97	0.80	-	0.79	0.59	1.19
6	0.58	0.96(7)	0.46	1.89	0.35	0.47
7	0.72	1.31	-	0.55	0.31	0.66

(1) Average found during 1984 (ref.1)
(2) Averages found during 1985 (ref. 8)
(3) Averages found from September 20, 1984, to February 5, 1985 (ref.5)
(4) Averages found from June 6, 1985, to January 14, 1986 (ref.2)
(5) Averages found from January 14, 1986, to April 29, 1986 (ref.3)
(6) Averages found from April 29, 1986, to August 12, 1986 (ref.4)
(7) An average of duplicate samples, 1.42 and 0.50 pCi/L

Note: References given in the footnotes are listed on page 36 of this report.

TABLE 95. POTENTIAL BOUNDARY DOSES FROM INHALATION PATHWAY

Radionuclide	Max. Avg. Concentration uCi/L(1)	50-Year Committed Dose, Rem		
		Lung	Bone Endosteum	Effective
Cs-137	9.00E-14	1.23E-08	3.83E-08	3.47E-08
Np-237	1.07E-14	6.78E-05	4.78E-04	3.39E-05
Pa-234	3.19E-11	1.34E-06	2.41E-08	2.61E-07
Pu-238	3.95E-15	2.58E-05	1.37E-04	1.44E-05
Pu-239,240	5.54E-14	3.58E-04	2.38E-03	2.34E-04
Ra-226	1.70E-13	1.61E-05	6.28E-06	2.32E-06
Ra-228	9.69E-15	1.01E-07	2.18E-07	2.80E-08
Rn-222(2)	6.70E-07	1.24E-02	5.38E-05	1.51E-03
Ru-106	1.00E-12	2.70E-05	6.42E-08	3.34E-06
Tc-99	8.70E-12	5.59E-05	1.89E-08	5.03E-07
Th-228	5.06E-14	3.26E-04	3.17E-04	5.12E-05
Th-230	7.46E-13	4.38E-03	3.09E-02	1.70E-03
Th-232	2.77E-14	1.44E-04	1.29E-03	6.67E-05
Th-234	3.19E-11	6.05E-05	1.50E-03	8.91E-06
U-234	6.64E-12	3.99E-02	2.56E-04	4.77E-03
U-235	2.18E-13	1.18E-03	7.04E-06	1.42E-04
U-236	4.49E-13	2.55E-03	1.59E-05	2.94E-04
U-238	6.30E-12	3.37E-02	2.01E-04	4.08E-03
Total dose from all radionuclides		9.51E-02	3.76E-02	1.29E-02
Percent of total dose:				
Uranium isotopes		81.3%	1.3%	72.0%
U, Th-230, Rn-222		99.0	83.5	96.9
U, Th-230, Rn-222, Th-232, Th-234, Pu-239/240		99.5	97.3	99.2

(1) Maximum average at the seven boundary sampling stations.
(2) Natural background of 3.0E-07 uCi/L has been subtracted.

Calculation of Radon Emission, Dispersion and Dosimetry from K65 Storage Tanks at the Feed Materials Production Center

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October 1985

Introduction

Two tanks containing residues principally resulting from the processing of pitchblend ore are located on the site of the Feed Materials Production Center near Fernald, Ohio. The residues contain high concentration of ^{226}Ra which produce copius amounts of the nobel gas ^{222}Rn. Release of this gas from the tanks is responsible for elevated concentration of ^{222}Rn in the atmosphere in the vicinity of the plant.

The objective of this study is to characterize the emission of radon from the tanks. This provides a source term which when coupled with meteorological data can be used to compute concentration of radon using an atmospheric dispersion model. The results of this model were used to assess population exposures and suggest ways for reducing concentration to values that are as low as reasonably achievable.

Materials and Methods

The emission of radon from tailings was computed using steady state diffusion equations. The effects of barometric pressure, wind speed and temperature were not included in the source term calculations.

The one dimensional steady state equations describing the diffusion of gases through porous media are (Co81)

$$\frac{D}{\varepsilon}\frac{d^2C}{dz^2} - \lambda C + \phi = 0$$

$$J = -D\frac{dC}{dz}$$

where;

C = Concentration of ^{222}Rn in pore system of the media

J = Current density (FLUX)

D = Effective diffusion coefficient in porous medium

ε = Porosity of medium = ratio of pore volume to bulk volume

λ = Decay constant of ^{222}Rn

ϕ = Production source term of ^{222}Rn in pores

$$= \frac{[Ra] * EF * \rho * \lambda}{\varepsilon} \qquad (pCi/cm^3)$$

[Ra] = Concentration of radium in medium (pCi/g)

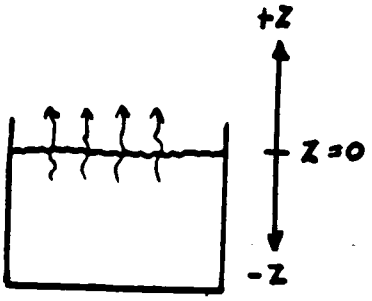
EF = Emanation fraction

ρ = Bulk density of medium

ℓ = Diffusion length = $\sqrt{D/\varepsilon\lambda}$

Solutions for these equations for special cases relating to the K65 tanks are as follows:

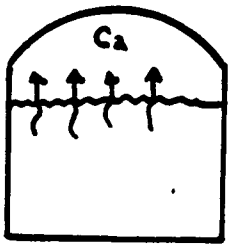
CASE I Open Tank



$$C(z) = \frac{\phi}{\lambda}\left(1-e^{z/\ell}\right)$$

$$J = \frac{\phi}{\lambda\ell} = \phi\varepsilon\ell$$

CASE II Closed Tank



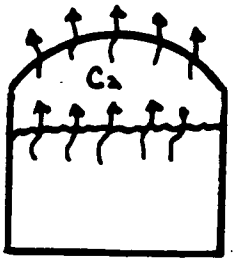
$$Ca = \frac{\phi}{\lambda}\left(\frac{\varepsilon\ell}{\varepsilon\ell+h}\right)$$

$\frac{\phi}{\lambda}$ = Radium Concentration in Pore Space

$\frac{\varepsilon\ell}{\varepsilon\ell+h}$ = Ratio of the value of air voids in the tailings to a depth of one diffusion length compared to the sum of this volume and the air space above tailings

h = Effective height of air volume above tailings

CASE III Diffusion from Tank Cover

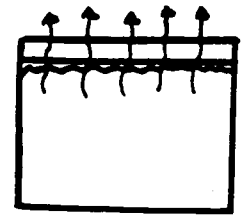


$$J = \varepsilon\lambda\ell\left\{\frac{Ca}{\sinh(L/\ell)}\right\}$$

Ca = Concentration of ^{222}Rn in Tank

L = Thickness of Concrete Cover

CASE IV Diffusion from Concrete Slab Directly Over Tailings



$$J_c = \phi \varepsilon_c \ell_c \left[\cosh\left(\frac{L}{\ell_c}\right) + \left(\frac{\varepsilon_t}{\varepsilon_c}\right)\left(\frac{\ell_t}{\ell_c}\right) \sinh\left(\frac{L}{\ell_c}\right)\right]^{-1}$$

Note: $\frac{J_c}{\phi \varepsilon \ell} = \frac{J_c}{J_o}$ = Ratio of Flux through Concrete Slab to Flux from Bare Tailings

The steady state emission rate can be obtained by multiplying the flux, J, by the surface area of the tanks. Since each tank is surrounded by an earthen beam, the radon was assumed to emerge from two flat surfaces having a diameter of 80′.

The dispersion of radon from the tanks was determined using the computer code UDAD (MO79). This code was developed at Argonne National Laboratory for the Generic Environmental Impact Statement on Uranium Milling. It is particularly well suited for the dispersion of radon originating from mill tailings.

UDAD requires meteorological data including a stability wind rose which describes the relative frequency of occurrence for each wind direction, wind speed class and stability category. Unfortunately, this information does not exist specifically for the FMPC site near Fernald. However, data from the greater Cincinnati airport in Covington KY was available. Seasonal and annual wind distributions by Pasquill stability classes for the period 1/70 - 12/74 were obtained from the U. S. Department of Commerce, National Climatic Center (USDC81). This is the same meteorological data set that was used for the preparation of the Environmental Impact Statement for the FMPC.

The UDAD code provides the annual average concentration of radon gas (PCi/ℓ) and potential alpha energy from radon daughters (Working Level, WL). The principle risk from radon gas comes from the ingrowth and inhalation of radon daughters inside buildings. Thus, the dose conversion factor for population exposures was obtained using the following assumptions:

a) Outdoor radon eventually migrates indoors

b) Radon daughters reach an equilibrium ratio of 50%

c) People are resident in buildings for an average of 16 hours per day

d) The weighted dose equivalent conversion factor for inhalation of radon daughters in houses is 0.55 rem/WLM (OECD83)

This combination of assumptions yields a conversion factor of

$$0.1 \frac{\text{mrem/yr}}{\text{pCi/m}^3}$$

Population densities as a function of distance and direction from the site were obtained from the staff at FMPC.

Results

Source Term

The following parameters were used for modeling the K-65 tanks:

[Ra] = 200 mCi/tonne = $2 * 10^5$ pCi/g

EF = 0.2

$\rho = 1.94 * 10^6$ lbs / $1.95 * 10^5$ f^3 = 1.6 g/cm^3

$\lambda = 2.1 * 10^6$ s^{-1}

ε tailings = 0.3

ε concrete = 0.3

ℓ concrete = 12 cm

ℓ tailings = 150 cm

Area of Tanks = $934m^2$

NLO Case 1: Radon Flux from open tank

$$J_o = \phi \varepsilon \ell$$

$$= 20 \ (pCi/cm^2 \cdot s)$$

$$J_o = 2 * 10^5 \ (pCi/m^2 \cdot s)$$

NLO Case II: Concentration of radon above the tailings in a closed tank

The dome is simulated by a right circular cone of height 8' and diameter of 40'. The volume of a cone is $1/3 \pi b^2 h$. Thus, the effective height of the dome is 8'/3 = 2.6'. The total effective height above the tailings is thus 10' = 300 cm.

$$Ca = 3 * 10^4 \ pCi/cm^3$$

$$= 3 * 10^7 \ pCi/\ell$$

NLO Case III: Radon Flux from Tank Covered with 4" (10 cm) of Concrete

$$J = 0.24 \ pCi/cm^2 \cdot s$$

$$= 2400 \ pCi/m^3 \cdot s$$

NLO Case IV: Radon Flux From 4" Concrete Slab Directly Above Tailings

$$J_c = J_o * 0.105$$

$$= 2 * 10^4 \ pCi/m^2 \cdot s$$

The flux calculated from the model assuming a 4" concrete cover over the tanks is 2400 $pCi/m^2 \cdot s$. Measurements made by Monsanto Research Corporation ranged from 13 to $2.8 * 10^7$ $pCi/m^2 \cdot s$ (Ha85). The extremely large values were reported to be from cracks in the concrete dome. Using an average estimate of 2000 $pCi/m^2 \cdot s$ the annual emission rate is 60 Ci/yr. This source term was used as input for the dispersion code UDAD. Figure 1 shows the computed annual average contribution to the atmospheric radon from the K65 tanks. The data is presented as isopleths of 100, 10, 1 pCi/m^3.

The annual average background level near Cincinnati, Ohio has been estimated to be about 250 pCi/m^3 (Ge83). Measurements made by Monsanto Resesarch Corporation yield values similar to this at the fence line.

Conclusions

The dispersion model predicts that radon concentrations due to emissions from the K65 tanks fall to below background levels at distances less than 500 meters. The 100 pCi/m^3 isopleth lies entirely within the boundry of the FMPC facility. Fence line values are generally less than 5% of natural background.

The closest residence in the NNW direction (22.5°) is about 1.3 Km from the tanks. This corresponds to an excess radon concentration of 6 pCi/m^3 which yields an annual weighted dose equivalent of 0.6 mrem/year. The

closest residences at 90° and 180° would receive an annual weighted dose equivalent of 0.2 mrem/y and 0.3 mrem/y respectively.

An estimation of the population commitment is meaningless since the values predicted by the model are less than normal variation due to fluctuations in natural background and individual lifestyles.

The shape of the isopleths in this study do not conform to those presented in the Monsanto study (Ha85). This should not be surprising since the code cannot model the turbulence and shadowing due to structures very close to the source term and measurements were made only during a few months spanning late autumn and winter. This illustrates the considerable uncertainty in such modeling exercises.

In order to validate the conclusions of this study a comprehensive monitoring program should continue for at least one calendar year. A continuous radon monitor based on a flow through scintillation flask would provide information at daily intervals which could be integrated to yield an annual average. The daily variations could be compared to wind speed and direction to improve the predictive capabilities of the model.

Outdoor measurements of working levels are difficult because of the plate-out characteristics of radon daughters. Since the risk is related to ingrowth and inhalation of daughters indoors it is suggested to make continuous measurements in a small building or trailer. Commercial continuous working level monitors adequately measure radon daughters under these conditions.

A monitoring station containing a continuous radon and working level monitor should be located in a northeast direction about 500 meters from the tank and at the fence line. Background measurements in a general upwind

direction could be made with integrating devices if another set of continuous monitor is not available.

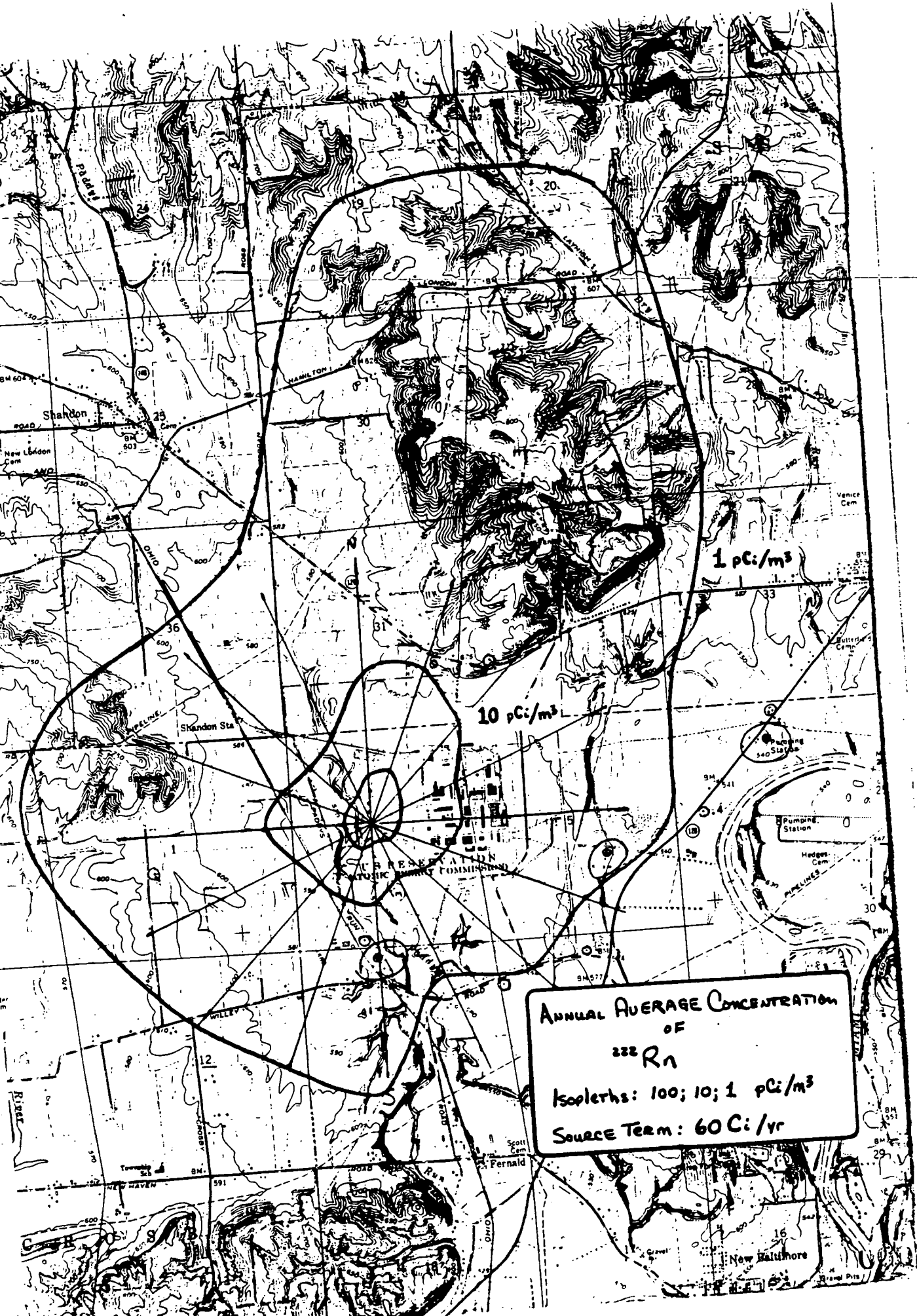
Several continuous monitors are available at Argonne National Laboratory. Since FMPC is a DOE facility a loan arrangement could be negotiated for the duration of the experiment.

If measurements indicate radon concentrations larger than predicted by the model several steps could be taken to reduce emissions from the tank. These are as follows:

a) Seal the apparent cracks in the dome. This is useful but could turn out to be a never ending exercise.

b) Increase the thickness of the concrete cover. This would certainly help but an additional 4" of concrete would only reduce the average flux by 60%.

c) Keep the tailings covered with water. This is an extremely efficient barrier since 2 cm of water is equivalent to 12 cm of concrete. However, caution should be exercised to prevent leaching and migration of Ra into underground aquafers.


1 pCi/m³
10 pCi/m³
Shandon
Shandon Sta
Pumping Station
Pernald
New Baltimore
Annual Average Concentration
of
222 Rn
Isopleths: 100; 10; 1 pCi/m³
Source Term: 60 Ci/yr

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