Ref. 1

#19

ACCIDENT INVESTIGATION IN R-120

JULY 6, 1960

TO: Dr. J. F. Eichelberger on July 12, 1960.

Investigation Committee: S. S. Freeman, Chairman - Engineering Division; H. F. Daniels - Production Division; J. Putnam - Security Division.

The accident, discharge of radioactive particulate material into the atmosphere, involved Dr. [redacted], Group Leader, and Mr. [redacted], Research Chemist working under [redacted]'s direction.

Dr. [redacted] is 33 years old and has been with Mound Laboratory for 8 years. [redacted] is 30 years old and has been with Mound Laboratory for 2½ years. He has only worked on and off with the dry air equipment involved in the accident.

The accident occurred at about 3:05 PM on July 6, 1960, during the purging operation of the inert atmosphere dry box in Room R-120.

Purging is usually performed when the dry box is placed in service or whenever it is determined that oxygen may be present. The normal operation of the system is as follows. (See Sketch 1)

The gas, in this instance argon, is circulated through the system by a Roots-Connersville blower to a lectrodryer, thence to the hoods, through a filter, and back to the blower. Equilibrium of pressures is maintained by the two solenoid valves on the vent and inlet. When the pressure upstream of the dry box exceeds -½" of water the sensing element at 'B' causes the venting solenoid to open. When the pressure downstream of the dry box falls below -1½" of water the sensing element at 'A' causes the inlet solenoid to open and admit gas from a cylinder of argon which is connected through a pressure regulating valve.

In addition, two Meltron pressure actuating switches are provided as a safety measure. These switches are set at plus and minus 4" of water so that whenever the pressure of the system exceeds these limits the blower and the venting solenoid (normally closed type valve) are shut down.

The purging procedure, as set up by [redacted], is to crack open the regulating valve on the argon cylinder and hold open the inlet solenoid with a magnet. This continuous bleed of argon causes an increase in pressure which then activates the venting solenoid, allowing the gases to purge.

The accident occurred in the inert atmosphere dry box in Room R-120. This laboratory was initially set up for work by Dr. L. Jones' group but temporarily used by Mr. [redacted]'s group for work on the Special Metallurgical development program. Mr. [redacted] had told Mr. [redacted] about noon that there was indication that oxygen was present in the dry box and to arrange with Dr. Jones' group (who handled the dry air system for this laboratory) for purging the dry box. Mr. [redacted] requested Dr. [redacted] that this be done.

Dr. [redacted] asked Mr. [redacted] to keep an eye on the cylinder of argon that he was using for the purge and to replace it with a full cylinder when empty. A little before 3:00 PM, [redacted] noted that the cylinder was empty. He removed the magnet holding the inlet solenoid valve open and replaced the empty cylinder with a full one. [redacted] opened the argon cylinder valve and cracked open the regulator until the static pressure read 8 psig. He then opened the inlet solenoid, holding it open with the magnet. Within a few minutes [redacted] noticed that the venting solenoid was not clicking, indicating to him that something was wrong. Believing that the argon was bleeding in too fast, he again removed the magnet, closed the regulating valve and reset it at 2 psig. He then placed the magnet on the inlet solenoid valve. Again he did not hear the venting solenoid valve operate so he called Dr. [redacted]. Dr. [redacted] immediately noticed that the Roots-Connersville blower was not running. [redacted] pushed the reset button and started the blower. [redacted] looked at the pressure gauge for the first time and caught a glimpse of the pressure falling to about -2" water pressure. The venting solenoid still did not click and [redacted] wondered if the fluid in the manometer at the hood had blown out. [redacted] went into Room 120 and found the fluid blown clear to the adjoining wall. [redacted] reported this to Dr. [redacted], who suggested putting a stopper on the manometer. [redacted] returned to Room 120 and stoppered the manometer. On returning, Dr. [redacted] exclaimed to [redacted] that the venting solenoid valve must be wide open, indicating a considerable leak, and that [redacted] should go back to check the gloves.

As [redacted] reached the door of Room 120, [redacted] was ushering five (5) visitors out of the laboratory, making the remark, "Who took the glove off the glove port?"

[redacted] volunteered to return to Room 120 to replace the glove. Dr. [redacted] taped him up and [redacted] entered Room 120. He found the glove at the partition separating Room 120 from 120B with the 1/8" "O" ring near by. When he replaced the glove, he noted that the 1/4" "O" ring was still in its groove and when he could not remove it with the help of a pencil, replaced the glove over it, holding the glove on with the 1/8" "O" ring.

According to [redacted], he had entered the laboratory just after 3:00 PM and almost immediately noticed the missing glove. He had the visitors place their hands in their pockets and leave the room.

2. Revise purging procedure to conform with the existing or revised installation and in particular to require stand-by personnel to keep an eye on the equipment and pressures. Procedure should be written up and explained to all personnel involved.

3. Review the air conditioning in the Research building so as to minimize the spread of contamination.

4. Direct all personnel to call Health Physics at the first sign of possible contamination instead of attempting to carry on own investigation.

5. Revise Disaster Plan to include procedure for major contamination disasters.

6. Purchase monitoring equipment with audible alarm for those laboratories subject to heavy contamination.

7. Require covers be placed on glove ports of all hoods while not in use and to use more positive clamping than rubber "O" rings. For the pressures involved these measures would not have helped, but it indicates the possibility of a loss of gloves with even a moderate pressure rise.

S. S. Freeman

H. F. Daniels

J. Putnam

SSF/ras
(mb)

ACCIDENT INVESTIGATION IN R-120

TO: S. Soukup

Make the following changes in the circulating, dry-argon system in R-120 to comply with the safety recommendations made by the investigating committee of July 6, 1960.

1. Install a warning alarm to sound when the gas pump stops.

2. Install a purge line from the argon cylinder to the system with a solenoid valve which can be manually activated but the solenoid will close if the pump should stop.

3. Install a small orifice in the argon line to restrict the argon supply, or procure an argon regulator with a flow meter.

4. Install a mechanical (non-electrical) safety valve which will vent to a filter if the glove-box becomes pressurized.

L. J. Wittenberg
August 31, 1960

TO: Mr. David L. Scott

In general the recommendations of the committee were accepted. B. C. Blanke and L. J. Wittenberg and members of their groups have spent considerable time with S. Soukup, of the Engineering Division, evaluating the recommendations and planning the best methods of putting the recommendations into effect. Putting all the recommendations into effect has been greatly hampered by the contamination from the incident of July 6 and a further spread of activity through these areas by a recent incident in R-116 (Richmond). In the meantime no work has been performed in R-120 and R-159 other than decontamination. However, the recommendations will be put into effect before any major operations are resumed. The following comments are made with respect to the recommendations.

Recommendation 1

a. A mechanical by-pass with a filter to trap radioactivity has been ordered installed in the hood to prevent greater than 1/2" of water overpressure inside the hood in place of the rewiring recommended. It is felt that the recommended change could introduce air into the dryboxes which could be a safety hazard with the materials involved.

ACCIDENT INVESTIGATION IN R-120

b. A Klaxon horn has been ordered.

c. A restrictive orifice has been ordered.

d. The suggested system change has been ordered.

Recommendation 2

Procedures are being written up by Dr. Wittenberg's group. Changing of tanks will be done by two men. Normal operation of the purging equipment will be checked periodically.

Recommendation 3

All hood-enclosed radioactive programs in the "R" Building have been suspended until the Engineering Division completes a rebalance of the air supply and exhaust systems of the building. Drawings of the "R" Building ventilation system are being checked against the installed equipment to insure conformity and to bring them up-to-date.

Recommendation 4

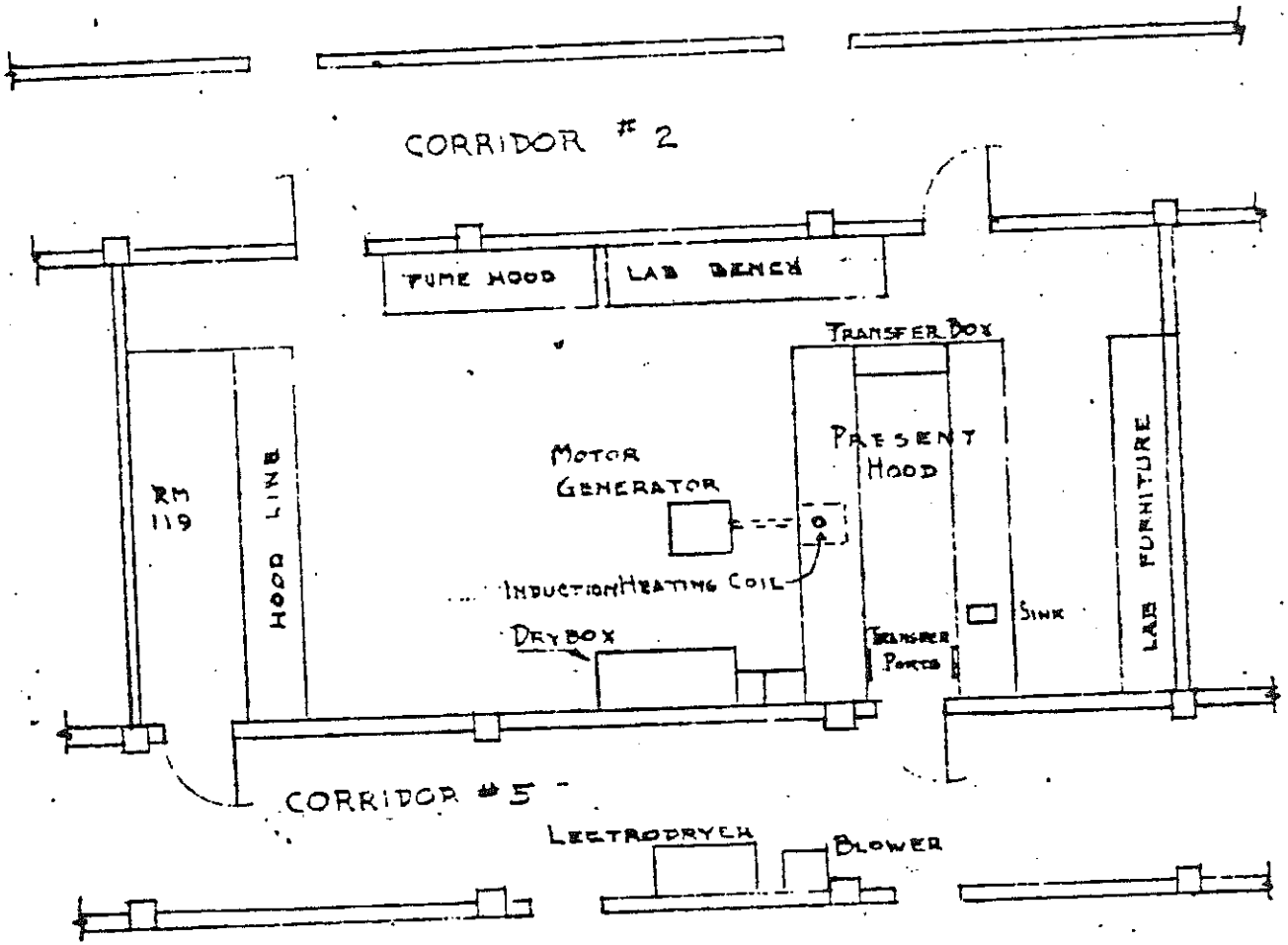
This is supposed to be standard operating procedure.

Recommendation 5

The Mound Laboratory Disaster Plan under II - Assumptions, A., 1., defines "Unexpected Operational Accidents", as those that may result in fires, explosions, release of toxic fumes, acids, or radioactive material, or accidents involving personnel. Therefore in principle, a major contamination disaster should be handled under the existing procedures.

Also under II - Assumptions, B., 1., defines the nature of the emergency as "Limited in Nature". Since a spill usually cannot be evaluated for severity immediately, the "R" Building procedure is to summon both Health Physics and the Building Brigade in case of a spill. The function of the Brigade is to control traffic and the Brigade leader has the additional responsibility to determine whether the emergency is minor, or whether it is major.

If it happens that a general emergency threatens, the Brigade leader will promptly notify the Plant Manager, who will put the Major Disaster Plan into effect.

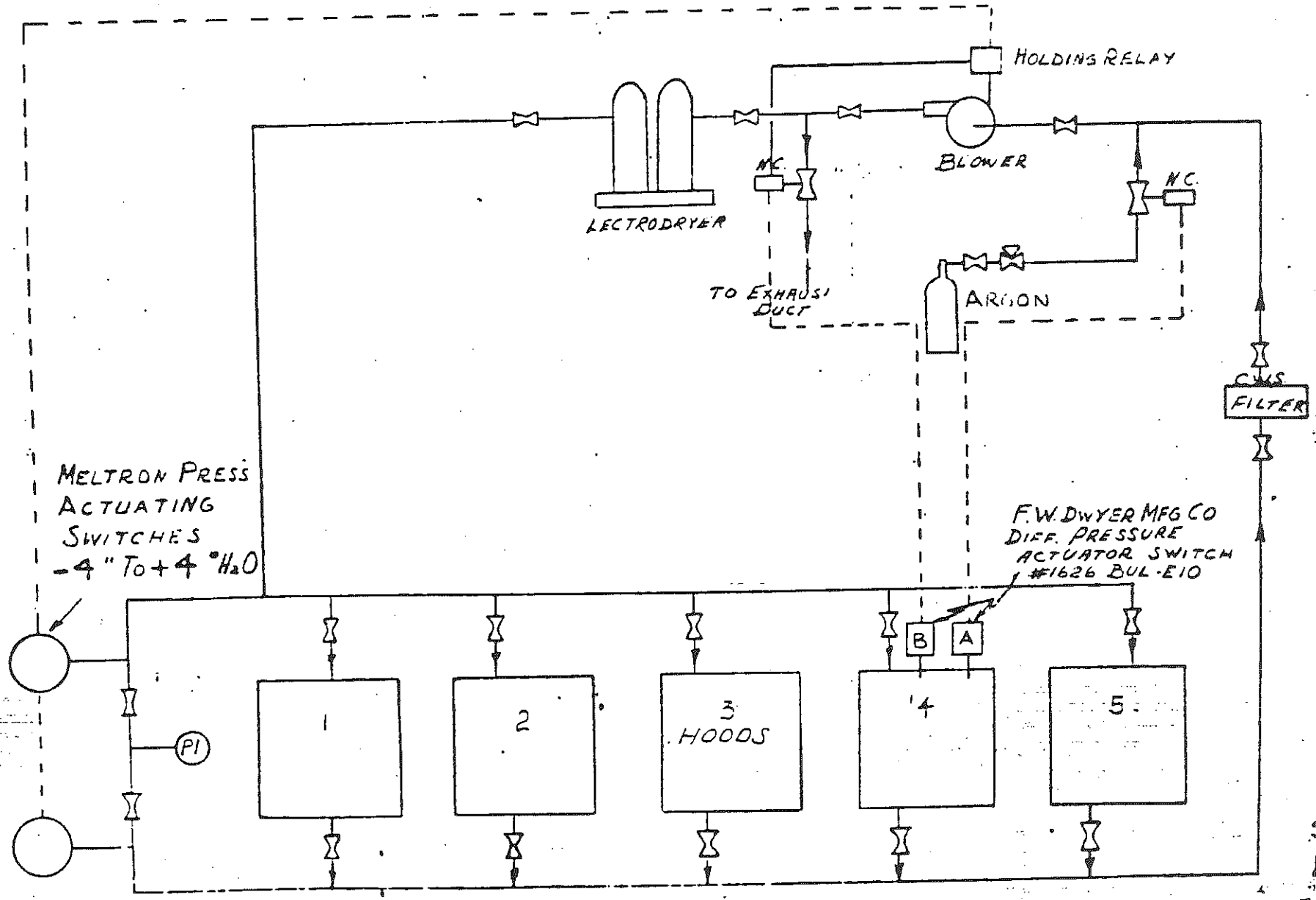


SKETCH NO. 2

R-120 PURIFICATION LAYOUT

H. T. JOHNSON ... 4-1-58.

DRY AIR SYSTEM R-120 PRESSURE CONTROL FOR PROCESS HOODS



SKETC
NO. 1

REV 7-29-59 5-14-58

JOB NO. 1536

ACCIDENT INVESTIGATION IN R-120

Recommendation 6

These monitors (audible alarms) have not been too satisfactory at Mound Laboratory. Depending on such monitors, which were defective, caused personnel to get hot in the spill in R-105 and 106. However, an audible alarm has been ordered as recommended.

Recommendation 7

"O" Rings have been supplemented by hose clamps to hold gloves onto glove ports. Glove ports are supposed to have covers when not in use and metal clamps are supposed to be used.

John F. Eichelberger
September 8, 1960

(mb)

STANDARD FORM NO. 64

Ref. 2

Safety

Office Memorandum • UNITED STATES GOVERNMENT

TO : G. H. Dugger, Director, Health and Safety Division, Albuquerque Operations

DATE: February 6, 1961

FROM : E. A. Walker, Acting Area Manager
Dayton Area Office

SUBJECT: REPORT ON JULY 6, 1960 RADIATION INCIDENT AT MOUND LABORATORY

Symbol: ELJ:DAO

Reference: Memorandum G. H. Dugger to W. B. Creamer dtd January 27, 1961

This memorandum is a recapitulation of the actions taken on the recommendations made by the investigation committee. This listing of actions taken supersedes that listed in copies of Mr. D. L. Scott's letter of December 8, 1960.

Recommendation 1

a. The rewiring of the venting solenoid valve was completed September 1, 1960.

b. The Klaxon horn was installed by September 1, 1960.

c. The installation of the orifice in the argon feed line was completed December 8, 1960.

d. The suggested system change was completed as of September 1, 1960.

Recommendation 2

The procedure was written and posted as of October 7, 1960. It is being complied with in all respects.

Recommendation 3

The Engineering Division completed the air balance revamping as of October 15, 1960.

Recommendation 4

The standard operating procedure is being complied with.

87258

Item 3 September 30, 1960

ESTIMATE OF DIRECT LOSSES TO REACTOR FUELS ACTIVITY
JULY 6, 1960 INCIDENT

The Reactor Fuels Group spent some of their time decontaminating delicate equipment. The program was delayed one month by the necessary decontamination.

Costs for decontamination of Equipment	$ 4,200
Miscellaneous supplies discarded (no salvage)	1,000
2 R.F. Generators discarded (no salvage)	8,000
1 Leak detector discarded (no salvage)	5,000
Total supplies and equipment discarded (relatively new and not depreciated)	$14,000

NOTE: An additional $37,310 worth of equipment was contaminated and could not be cleaned to zero count. It will be used in the present area but could not be relocated to a clean area.

Item 4

ESTIMATE OF LOSSES TO CLOVER DEVELOPMENT ACTIVITY
JULY 6, 1960 INCIDENT

Equipment loss (depreciated - no salvage)	$ 550
Direct salaries (scientists) for equipment decontamination	60
Activity losses (accountable)	0

NOTE: A total of 80 grams of accountable plutonium was in the hood. None of this was lost.

An unknown amount of plutonium oxide was blown out of the hood on dust. The estimated amount is in the milligram range and had already been considered an unrecoverable quantity lost in operations in the hood. The milligrams of plutonium lost have a negligible value and cannot be salvaged.

Recommendation 5

A disaster plan exists which covers major contamination disasters.

Recommendation 6

The history of the action taken on this recommendation is as follows: A work order was written September 30, 1960, and approved November 12, 1960. The purchase order for the selected monitor was placed December 5, 1960, and the monitor received February 2, 1961. Ordering was delayed because of problems in selecting a suitable model. The model decided upon was Model AM-2A Continuous Air Monitor made by Nuclear Measurements Corporation of Indianapolis, Indiana. The monitor is being installed in Rooms 145-147 R-Building as of this date and installation should be completed by February 8, 1961.

Recommendation 7

Hose clamps are on all glove ports to hold gloves and all boxes with controlled dry air are equipped with metal glove port covers.

We trust that this may be considered the final report on this incident inasmuch as all recommendations have been complied with.

Janda:bjw

cc: G. H. Dugger (3)

FOR OFFICIAL USE ONLY
SIC
PREMISE NO

0857 09 1196

STATE OF OHIO

EAST 732 NORTH 4390
ZONE 16

OHIO AIR POLLUTION CONTROL BOARD

JAN 0 3 1973

Ref. 3

United States Atomic Energy Commission

Facility Name Mound Laboratory

Person to Contact J. F. Stevens

Facility Address P. O. Box 66 (Street)
Miamisburg, Ohio 45342 (City, State, Zip)

Mailing Address Mound Laboratory P.O. Box 66 (Street)
Miamisburg, Ohio 45342 (City, State, Zip)

Telephone (AC 513) 866-7444

Normal Operating Schedule 1 Shifts/Day 260 Day/Year Number of Employees 1800

Seasonal Percent Production 25% Winter 25% Spring 25% Summer 25% Fall

FUEL FIRED INDIRECT HEAT EXCHANGES

I. Fuel is Used for the Generation of Steam, Heat or Power in Units Having a Heat Input of 1,000,000 BTU/Hr or Greater:

(X) Yes Number of Units 5

( ) No

PROCESS EQUIPMENT

II. Manufacturing or Process Equipment, as Described Below, is Used at This Facility (except spray booths and storage tanks).

A. Equipment or processes potentially capable of emitting* "particulate matter" to the "ambient air".

B. Equipment or processes, potentially capable of emitting* sulfur compounds to the "ambient air". Such equipment or processes include - but are not limited to - the following: sulfuric acid plants, sulfur recovery plants, primary non-ferrous smelters and sulfite pulp mills.

C. Equipment or processes utilizing "liquid organic materials" and potentially capable of emitting* organic compounds to the "ambient air".

D. Equipment or processes potentially capable of emitting* carbon monoxide to the "ambient air". Such equipment or processes include - but are not limited to - the following: blast furnaces, basic oxygen steel furnaces, grey iron furnaces and petroleum refining equipment.

E. Equipment or processes potentially capable of emitting* nitrogen oxides to the "ambient air". Such equipment or processes include - but are not limited to - nitric acid plants.

F. Equipment or processes using elemental or any compound or combination of: asbestos, beryllium, lead or mercury.

( ) Yes Number of Process Devices _____
Describe Process:

(X) No

SPRAY BOOTHS

III. Paint Spray Booths With a Spraying Capacity of 10 Gallons per Day or Greater are Used at this Facility: (Other coating operations should be indicated in Section II - Process Equipment)

(X) Yes Number of Booths 1 present use 4 gallon/day

( ) No

*"Potentially capable of emitting" means that the equipment or process emits, or would in the absence of air cleaning equipment emit, the particular "air pollutant"; i.e., such equipment or process should be reported whether controlled, uncontrolled or partially controlled.

(insert carbon paper)

STORAGE TANKS

IV. Tanks for the Storage of "Liquid Organic Materials" Having a Capacity of 40,000 Gallons or Greater Are Used at this Facility:

(X) Yes Number of Tanks 1

( ) No

COMBUSTIBLE WASTE DISPOSAL

V. Combustible Waste at this Facility is Disposed of:

(X) On Site By. (Indicate Method) (X) Incineration Number of Incinerators 1
(X) Other Method open burning of explosive waste, landfill

( ) Off Site By: _____ (Hauler) _____ (Address)

( ) No Combustible Waste

AIR POLLUTION CONTROL EQUIPMENT

VI. Air Pollution Control Equipment is Used at this Facility:

(X) Yes Number of Air Pollution Control Devices ~~17~~ 5 (see attachment)

( ) No

STACKS

VII. Stacks (or other egress points) Discharging Emissions to the "Ambient Air" are Used at this Facility:

(X) Yes Number of Stacks ~~23~~ 11 (see attachment)

( ) No

In accordance with the provisions of the Ohio Air Pollution Control Act, Chapter 3704 of the Ohio Revised Code, as amended (December 23, 1971) and the rules and regulations adopted by the Air Pollution Control Board pursuant thereto, registration hereby is made for application(s) for permit(s) to operate, construct, modify, or variance to operate stationary source(s) of air pollution within the State of Ohio. All of the information attached hereto is made a part of this registration.

Signature of Authorized Official (See AP-9-04(b)(1)) _____
Title _____
Address _____

VERIFICATION

_____, being first duly sworn, says that he is the officer or person duly authorized to execute the foregoing registration and that the statements made and information provided therein are true and complete as he verily believes.

Signature of authorized official _____

Sworn to and subsribed in my presence this _____ day of _____, 19 ____, at _____ County of _____ and State of _____.
Signature of Notary Public _____.

(insert carbon paper)

(Seal)

VI. Air Pollution Control Equipment

The seventeen devices listed include the following:

A. Four dust collectors on exhaust air points from "M" Building and Building 33. The sources are three (3) maintenance shops where welding, carpentry and grinding operations are carried out and the machine shop where routine machining is carried out.

B. One scrubber on the General Waste Incinerator.

C. Twelve filter bank facilities to filter radioactive particulates from exhaust air streams. The radioactive particulates originate from the handling of radioactive materials in various buildings on-site.

VII. Stacks

The twenty-three stacks listed include the following:

A. Four discharge points of the dust collectors listed under VI. A.

B. One incinerator stack.

C. Twelve stacks for discharging exhaust air from buildings where radioactive materials are handled.

D. Five stacks from fuel fired indirect heat exchangers.

E. One discharge point from the Paint Spray Booth listed under III.

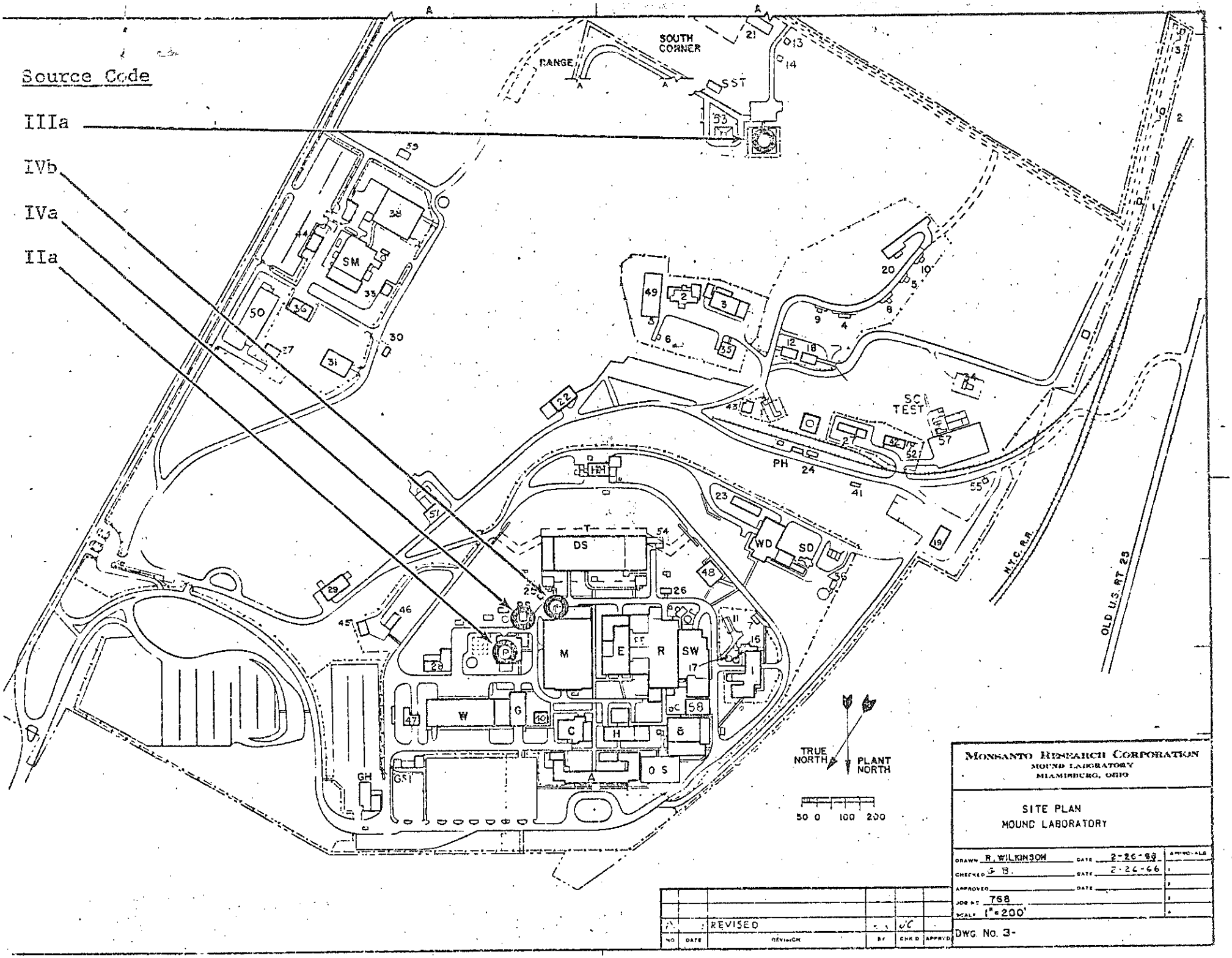
Source Code

IIIa

IVb

IVa

IIa



Ref. 4

UNITED STATES
ATOMIC ENERGY COMMISSION
DAYTON AREA OFFICE
P.O. BOX 66
MIAMISBURG, OHIO 45342

November 8, 1973

Mr. William M. Auberle, Supervisor
Regional Air Pollution Control Agency
451 West Third Street
Dayton, Ohio 45427

SUBJECT: REFUSE INCINERATOR FORMS

Dear Mr. Auberle:

Attached are copies of the incinerator forms which were sent to you on March 13, 1973. Dave Redic has requested an additional copy for his file.

We appreciated the opportunity to meet and talk with Dave on his visit yesterday.

Yours truly,

R. L. Wainwright,
Area Manager

Attachments: 3

Stevens:hw

UNITED STATES
ATOMIC ENERGY COMMISSION
DAYTON AREA OFFICE
P.O. BOX 66
MIAMISBURG, OHIO 45342

November 7, 1973

Mr. William M. Auberle, Supervisor
Regional Air Pollution Control Agency
451 West Third Street
Dayton, Ohio 45427

SUBJECT: REFUSE INCINERATOR FORMS

Dear Mr. Auberle:

Attached are copies of the incinerator forms which were sent to you on March 13, 1973. Dave Redic has requested an additional copy for his file.

We appreciated the opportunity to meet and talk with Dave on his visit yesterday.

Yours truly,

Original Signed By
R. L. Wainwright

R. L. Wainwright,
Area Manager

Attachments: 3

Stevens:hw

FOR OFFICIAL USE ONLY
Premise No. 08 / 57 / 09 / 1196
Source No. N 1001

INCINERATOR

1. Facility Name Mound Laboratory — Person to Contact Jack Stevens

Facility Address Mound Road (Street) — Mailing Address P. O. Box 66 (Street)

Miamisburg (City, Village or Township) Montgomery (County) 45342 (Zip) — Miamisburg, Ohio (City, State) 45342 (Zip)

Telephone 513 (Area Code) 866-7444 (Number)

2. This information is submitted in connection with our operation of:
   - ☒ an existing source
   - ☐ Permit to construct a new source or modify an existing source
   - ☐ Variance from regulation(s) _____ for _____ months
3. Check-list of information attached
   - ☐ Plans and drawings ☐ Emission tests or calculations ☐ Process flow diagram
   - ☐ Compliance time schedule ☐ Construction schedule ☐ Additional information
4. Source of combustible waste:
   - ☐ Hospital, number of beds _____ ☐ Other, describe _____
   - ☐ Apartment, number of units _____
   - ☐ Institution, number of rooms _____
   - ☒ Industrial process, describe _____
5. Incinerator located: ☐ Indoors ☐ Outdoors ☒ Charged indoors, unit outdoors
6. Manufacturer Various Make or model _____
7. Rated capacity 5000 lb./hr. Year installed 1971 Your identification Bldg. #51
8. Type of incinerator ☐ Single chamber ☒ Multiple chamber
9. Method of charging waste: ☐ Chute fed ☐ Flue fed ☒ Direct fed ☐ Other. If other, describe: _____
10. Type of draft: ☒ Forced ☒ Induced ☐ Natural ☐ Starved air ☒ Overfire air jets, capacities _____
11. If liquid incinerator, type of atomization Steam
12. Type of flue damper: ☐ Barometric ☒ Butterfly (vane) ☐ Guillotine ☐ Sliding ☐ None
13. Adjustable air ports: ☐ Yes ☒ No
14. Burner input (BTU/hr.): Primary None Secondary _____
15. Secondary burner ignition: ☐ Manual (timer) ☐ Automatic (charging door switch) N/A
16. Secondary burner temperature control: ☐ Yes Lower limit _____ °F ☒ No
17. Type of refractory: ☒ Firebrick ☐ Castable Pyrometric cone equivalence _____
18. Primary chamber dimensions (inches) Length 222" Width 81" Height 176"
19. Secondary chamber dimensions (inches) Length 61" Width 81" Height 176"
20. Describe provisions for combustion or tempered make-up air Combustion air supplied with forced draft fan under grates and tuyeres.

OPERATING SCHEDULE AND AMOUNT OF WASTE INCINERATED

21. Normal operating schedule: hrs./day 8 days/wk. 1 wks/yr. 52
22. Percent annual incineration by season: Winter 25 Spring 25 Summer 25 Fall 25
23. Quantity of waste burned (lbs./hr): Average 2000 Maximum 5000
24. Type of waste (see instructions) Type I Heat content of waste 5500 BTU/lb.
25. Type of fuels used: ☐ Natural gas ☐ Oil ☐ LP gas ☒ None
26. Amount of fuel used per year None Burner manufacturer/model None
27. Type of charging: ☐ Continuous ☒ Intermittent ☐ Batch
28. Percent projected annual increase in incineration zero

Important Notes: If emissions from this source have been determined by source tests, material balances or emission factors, include such data and supporting calculations

A waste analysis should be included.

A detailed drawing of the incinerator showing all dimensions (inside and out) should be included. Indicate position of charging doors, burners and any auxiliary equipment.

AP-PS-05

FOR OFFICIAL USE ONLY
Premise No. 08 / 57 / 09 / 1196
Source No. C / 005

DATA SHEET
CONTROL EQUIPMENT

Facility Name: Mound Laboratory — Person to Contact: Jack Stevens

Facility Address: Mound Road (Street) — Mailing Address: P. O. Box 66 (Street)

Miamisburg Montgomery 45342 (City, Village or Township; County; Zip) — Miamisburg, Ohio 45342 (City; State; Zip)

Telephone: 513 (Area Code) 866-7444 (Number)

2. Type of gas cleaning equipment (check one):
   ☒ Settling chamber ☐ Cyclone ☐ Multiple cyclone ☐ Electrostatic precipitator ☐ Fabric filter
   ☐ Absorber ☐ Incineration ☒ Wet collector, type flooded tray ☐ Adsorber

A separate "Data Sheet for Control Equipment" must be completed for each control device. Stack data should be shown on form AP-PS-07, "Data Sheet -- Stacks and Other Egress Points".

3. Manufacturer Peabody — Model No. ____ — Year installed 1971
4. Your identification None — Pollutant(s) controlled Flyash
5. Design efficiency ____ — Pressure drop across collector ____ in. H_2O
6. Efficiency (operating - if known) ____ — Controlled pollutant emission rate (if known) ____
7. Total installed capital equipment cost Estimated $50,000

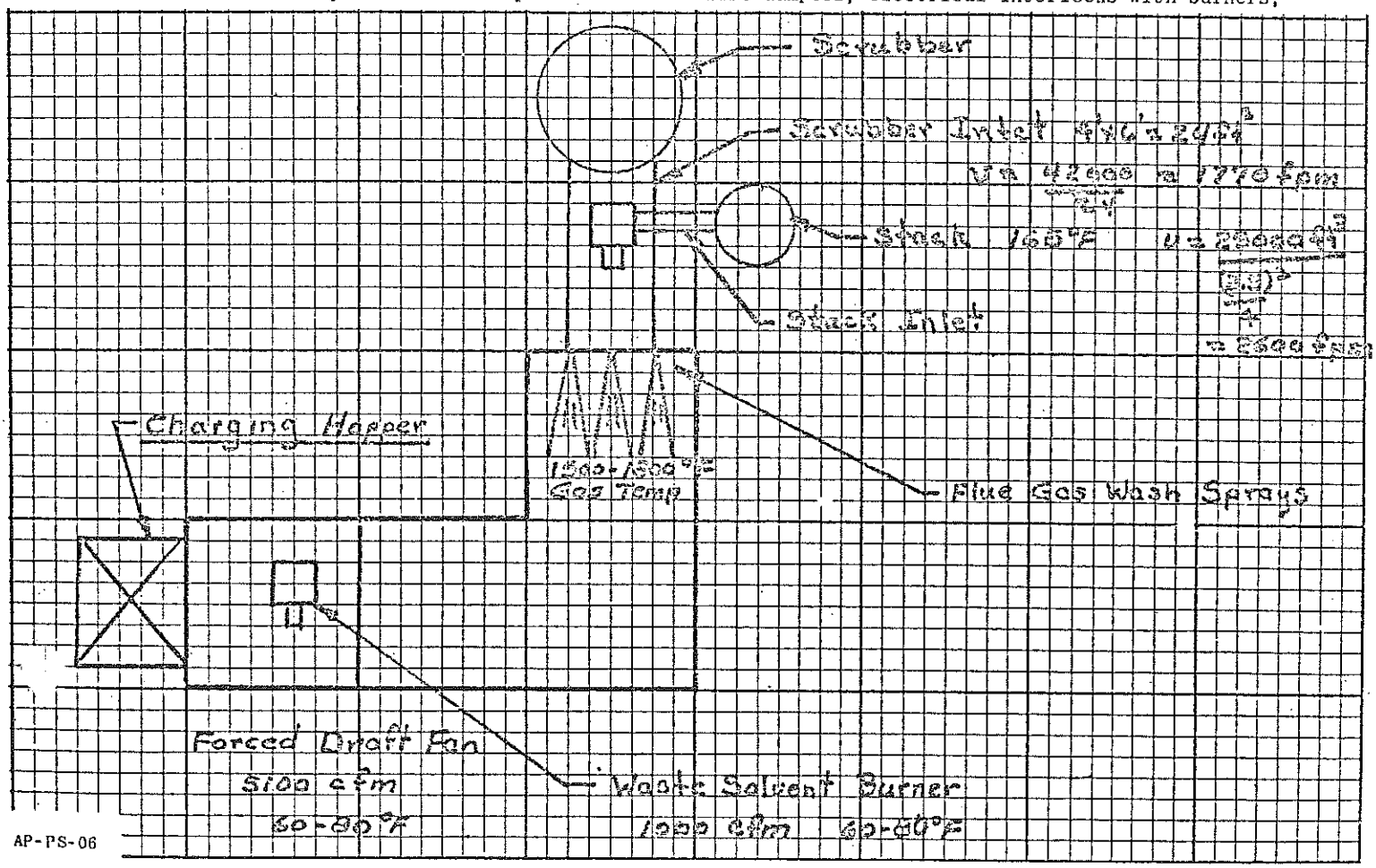
FAN DATA

	RPM	HP	Static pressure
(3)	3300	3	6" H_2O
(2)	1200	15	6" H_2O
(1)	1260	60	10" H_2O

8. Type: ☐ Axial ☐ Centrifugal
9. Volume 25,000 CFM at 165 °F. No. of fans in system 3
   (2) 10,000 60°F
   (3) 2,000 60°F

CAPTURE AND TRANSPORT DATA

10. Ductwork detail: Draw a plan view of the source equipment and air cleaning equipment. Indicate transport velocity in actual feet per minute, total system resistance in inches of water, and gas moisture content and temperature. Include such other pertinent information as: dimensions, elbows, duct material, dampers and cleanouts. When required for fire prevention show fire dampers, electrical interlocks with burners,



AP-PS-06

FOR OFFICIAL USE ONLY
Premise No. 08 / 57 / 09 / 1196
Source No. S 1011

DATA SHEET
STACKS AND OTHER EGRESS POINTS

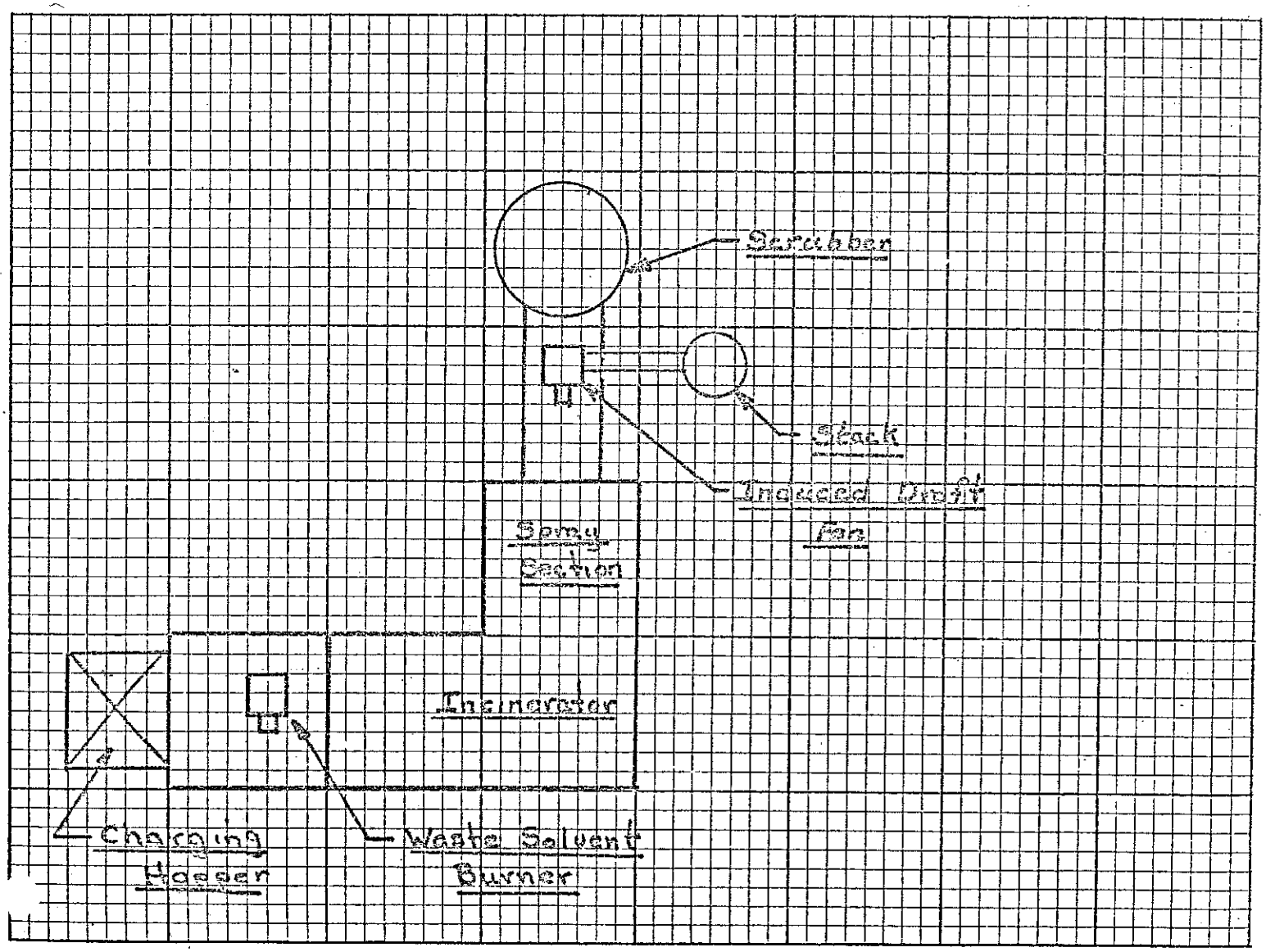
Facility Name: Mound Laboratory
Person to Contact: Jack Stevens

Facility Address: Mound Road (Street)
Mailing Address: P. O. Box 66 (Street)

Miamisburg (City, Village or Township) Montgomery (County) 45342 (Zip)
Miamisburg, Ohio (City, State) 45342 (Zip)

Telephone: 513 (Area Code) 866-7444 (Number)

2. Type: ☒ Round ☐ Rectangular - top inside dimension(s) (L & W or Diam.) 42 in.
3. Height: Above roof 21 ft. Above ground 56 ft.
4. Exit gas: Temp. 165 °F. Volume 25,000 ACFM Velocity 2600 feet per minute
5. Continuous monitoring equipment: ☐ Yes ☒ No. If yes, indicate: Type _____
   Manufacturer _____ Make or model _____ Pollutant _____
6. Draw a flow diagram in plan view of the source equipment, control equipment and stacks. If more than one source or control device discharges into this stack show all connections.



Important Note: If emissions from the above stack have been determined by performance testing or other means, include such data and supporting calculations with this data sheet.

AP-PS-07

Ref. 5

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
NATIONAL ENVIRONMENTAL RESEARCH CENTER
CINCINNATI, OHIO 45268

Office of Radiation Programs

July 16, 1974

Mr. Gary Bramble
State of Ohio Environmental
Protection Agency
Division of Surveillance
7 East Fouth Street
Dayton, Ohio 45402

Dear Mr. Bramble:

The results of plutonium analyses performed by the USEPA Eastern Environmental Radiation Facility on 20 aliquots of core samples are enclosed. These were collected and processed by Mound Laboratory and submitted by you on June 14, 1974. All of the ^{238}Pu values and some of the ^{239}Pu values are higher than fallout levels.

The environmental samples collected on June 19, 1974, are now being analyzed, and results should be available in several weeks.

Sincerely yours,

Bernd Kahn

Bernd Kahn, Director
Radiochemistry & Nuclear Engineering
Facility

cc: G. Gels, R&NEF
M. Conlon, EPA Region V
C. Porter, Director, EERF
D. Oakley, ORP-EPA

enclosure

Plutonium Analyses by USEPA

Eastern Environmental Radiation Facility

July 16, 1974

Mound Laboratory sample designation	Plutonium concentration, pCi/g dried weight	
	^{238}Pu	^{239}Pu
EA1	0.13	< 0.02
EB1	0.13	< 0.02
EC1	4.8	0.07
ED1	1.1	< 0.02
EE1	440.	2.4
EF1	1080.	7.9
EG1	11.	0.18
EH1	26.	0.16
EI1	0.98	0.06
EJ1	1.3	0.06
FA1	20.	0.68
FE1	17.	0.18
GA1	0.48	< 0.02
HA1	5.1	0.07
IA1	2.5	0.06
JA1	0.72	< 0.02
KA1	27.	0.27
LA1	11.	0.30
(BA1)	9.1	0.13
(BE1)	19.	0.20

Notes:

1. All values approximately ± 10%.
2. LA1 also contains ^{242}Pu at a concentration of 4.0 pCi/g.
3. Samples BA1 and BE1 were Ohio EPA sample designations.

Inter-Office Communication

Ohio EPA

to Peter A. Precario, Chief, Litigation Development Section

from Dr. Thomas J. Birch, Chief, Environmental Evaluation TJB

date July 9, 1974

subject: Plutonium 238 Incident in the Area of Mound Laboratory, Miamisburg, Ohio

Jolt Gilligan
Governor
Dr. Ira L. Whitman
Director

In response to your memo requesting information available to me on the plutonium 238 incident in the area of Mound Laboratory at Miamisburg, Ohio, I am attaching to this memo all of the correspondence I have on this matter which summarizes our involvement to date. With reference to your memo, please note that this situation does not appear to have developed from a spill in the sense that the term "spill" is usually used by our staff in the agency. Rather, the plutonium 238 deposits in the sediments appeared to have been the result of discharge of this material over a longer period of time than we would usually associate with a spill. Per your request, I will keep you abreast of all information made available to me on this matter. I hope this information is useful to you.

TJB/may

cc: (memo only)
G. Bramble
J. Dobbins
A. Franks
E. Neal
A. Turner

Attachment

RECEIVED
JUL 12 1974
Ohio Environmental Protection Agency
SOUTHWEST DISTRICT

100% Recycled Paper

Ref. 6

INTER-OFFICE COMMUNICATION

TO Thomas J. Birch, Chief, E. E. Group DATE August 6, 1974

FROM: Ken M. Harsh through G. Bramble, Environmental Evaluation - SWDO

SUBJECT: Mound Laboratory

Approximately one month has passed since our last communication in regards to Plutonium 238 in silt at Mound Laboratory. On July 17, 1974, I attended a meeting at Mound and was given a packet with additional data. On that same date, we also received the sample results from the USEPA, Eastern Environmental Radiation Facility. Those results are from split samples between Mound, USEPA, and OEPA and taken by Mound. The samples results compare fairly well and are the same order of magnitude.

238 Plutonium Results
(in pCi/g)

SAMPLE NUMBER	USEPA	MOUND LABORATORY
EA1	0.13	0.121
EB1	0.13	0.0883
EC1	4.8	2.97
ED1	1.1	.932
EE1	440	435
EF1	1080	1060
EG1	11	13.6
EH1	26	24.4
EI1	0.98	.94
EJ1	1.3	.431
FA1	20	7.86
FA1 (duplicate)	9.1	
FE1	17	UNK
FE1 (duplicate)	19	
GA1	0.48	0.43
HA1	5.1	4.93

SAMPLE NUMBER	USEPA	MOUND LABORATORY
IA1	2.5	2.08
JA1	0.72	0.67
KA1	27	28.8
LA1	11	9.86

Agreement is really excellent considering the fact that as of yet, there is no "approved" method of ^{238}Pu analysis. Note also that USEPA analyzed for ^{239}Pu. I believe that these results indicate that samples analyzed by Mound Laboratories are accurate. However, this accuracy does not answer or mitigate any effects or confirm sources of the radiation in the silt. You will note that Dr. Kahn indicates that ^{238}Pu are above fallout levels - well normal ^{238}Pu bakcground levels are around .01 pCi/g. The highest level (from the canal near the overflow) was 4,560 pCi/g which is 450,000+ times in excess of background levels. Only the lowest JA5 at .009 pCi/g, approaches normal background levels. Indications were that another meeting would be called in Mid-August and at that time 1/2 - 2/3 of all sample results should be known.

Sometime in September, all results from the preliminary sampling should be known and some sort of report made available.

Since the IOC of July 9, 1974, fish samples have been taken by OEPA, a team from Woods Hole Oceanographic Laboratories has sampled the canal, and sampling of the Great Miami River has been initiated and completed using the services of Bowser-Morner, an independent testing laboratory here in Dayton.

Indications were such at the meeting, that Mound is very concerned with preliminary results. They intend to sample numerous other sites in the area to determine extent and causes of the radiation.

At this time, I do not recommend legal action, but should the cause of this radiation leak be determined or results show real radioactive "hot spots", Pete Precario's memo to you of July 22, 1974, may become very, very important. The levels of ^{238}Pu are too high to permit laxness on the part of the Ohio EPA. While some sites are contaminated at the top - most levels of silt, some others show significant levels even at a 5 foot depth. I will keep you informed as events warrant.

sjg

cc: Peter A. Precario, Chief
Litigation Development Section

Attachments: 1. USEPA Sample Results
2. Labeled (unofficial data) Mound Lab Sample Results

ate of Ohio Environmental Protection Agency, Box 1049, 450 East Town Street, Columbus, 43216 469-3543

September 6, 1974

Re: Mound Laboratory - Plutonium Contamination - Miamisburg, Ohio

Mr. Francis Mayo
Regional Administrator
U. S. Environmental Protection Agency
1 North Wacker Drive
Chicago, Illinois 60606

OhioEPA
RECEIVED
SEP 12 1974
Ohio Environmental Protection Agency
SOUTHWEST DISTRICT

ohn J. Gilligan
iovernor
r. Ira L. Whitman
irector

Dear Mr. Mayo:

It has recently come to our attention that Plutonium 238 has been discovered in certain silt which is deposited in an Ohio waterway near the Mound Laboratory in Miamisburg, Ohio. At the present time Mound Laboratory itself is running a great deal of sampling and monitoring studies concerning this silt and the plutonium. While it is clear that all the data are not presently assembled, it is also clear that the Ohio Environmental Protection Agency and the U.S. Environmental Protection Agency must begin scrutinizing with much more detail that data which is currently available.

Because of the proximity of this plutonium to the people of Miamisburg, it is incumbent upon us to make absolutely certain that this entire matter is under control and is being closely evaluated. I would specifically request that persons from your agency be assigned to work with the Ohio EPA in evaluating both the technical aspects of the cause of this spill, any and all related health problems which may arise as a result of this spill, and appropriate steps which can be commenced to remove any danger or threat to the people of Miamisburg or the waters of the State of Ohio. In the interim I have suggested to the Mayor of Miamisburg that people utilizing the area be notified of potential danger.

I would like you to inform me in the near future what persons from your agency could be made available to assist us in this matter and to work out some formal means of coordination and communication between our agencies. I would also like to have an appropriate person from your agency meet with Mr. Ernest Neal, chief of our Division of Surveillance, to discuss the monitoring and surveillance of this matter and the technical persons and facilities which each of our agencies can make available for the task.

I look forward to working closely with you and your agency so that we can insure that this radiological incident can be resolved in the shortest possible time. Please call me at your earliest convenient time so that we may discuss the handling of this matter.

Very truly yours,

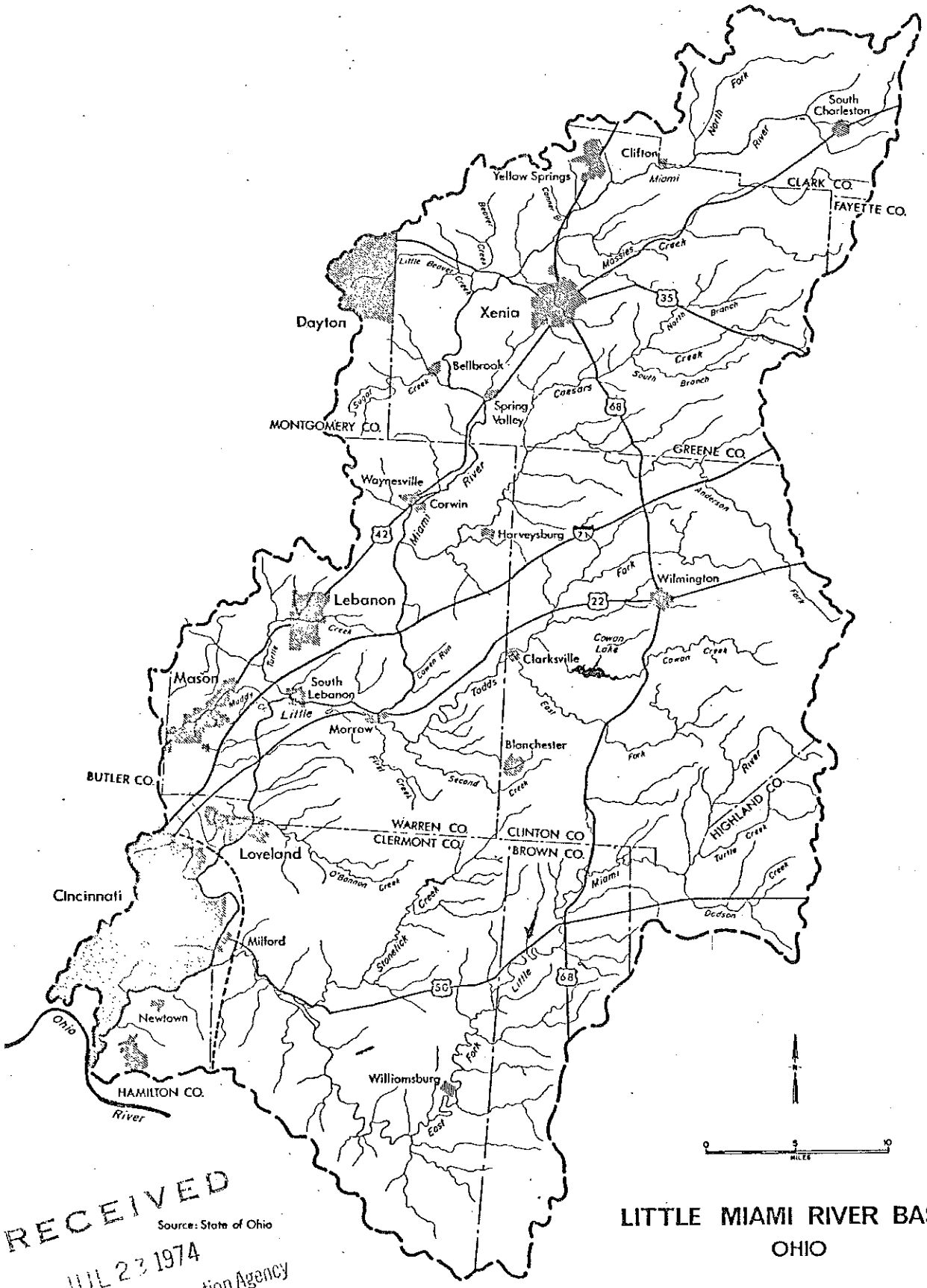
Ira L. Whitman

Ira L. Whitman
Director

ILW/js

cc: Ernest Neal, Chief, Division of Surveillance
Jack Wilson, Chief, Division of Enforcement

Copy: Talsma



Source: State of Ohio

LITTLE MIAMI RIVER BASIN
OHIO

RECEIVED
JUL 23 1974
Ohio Environmental Protection Agency
SOUTHWEST DISTRICT

Ref. 7

Meeting on Plutonium - Attendees
10:00 A.M., September 11, 1974
Conference Room 155

ODH Radiation Advisory Council

Dr. George Callendine
Dr. Frank Woltz
Mr. Herbert Meyer
Mr. Gene Ferraro

OEPA

Dr. Tom Birch
Mr. Jack Wilson
Mr. Ken Harsh

U.S. EPA

Dr. Gordon Burley
Mr. Jerry Gels
Mr. Leon Zelner

Montgomery County Health Department

Mr. Donald Niederkorn

ODH

Dr. John Cashman
Mr. Ray Watts
Mr. James Wynd
Mr. William Betz

Plutonium-238

Half-life

Radiological	86.4 years
Biological	200 years
Effective (biological)	62 years

Percent equilibrium reached in body in 50 years = 43%

Radiations

Alpha	5.46-5.50 MeV
Gamma	very weak - insignificant

Maximum Permissible Concentrations (MPC) - Soluble Form.*

	Occupational	Non-Occupational
Air (40/hr/wk)	$2X10^{-12}$ µCi/cc	----------
Air (168 hr/wk)	$7X10^{-13}$ "	$7X10^{-14}$ µCi/cc
Water (40/hr/wk)	$1X10^{-4}$ "	----------
Water (168/hr/wk)	$5X10^{-5}$ "	$5X10^{-6}$ "

Amount Ingested in One Year of Continuous Exposure to Water @ Non-occup. MPC

$$(2200 \text{ ml})\ (5X10^{-6})\ (365 \text{ days}) = 4\ \mu Ci$$
$$= 4000 \text{ nCi}$$

Approx. Dose From Ingestion of 4000 nCi (soluble) = 0.010 rem/yr.

Amount of Sediment to Yield 4000 nCi @ 5 nCi/g = 800 grams
= 1 3/4 pounds

*From NBS Handbook 69 (NCRP) and A.E.C.'s 10 CFR 20

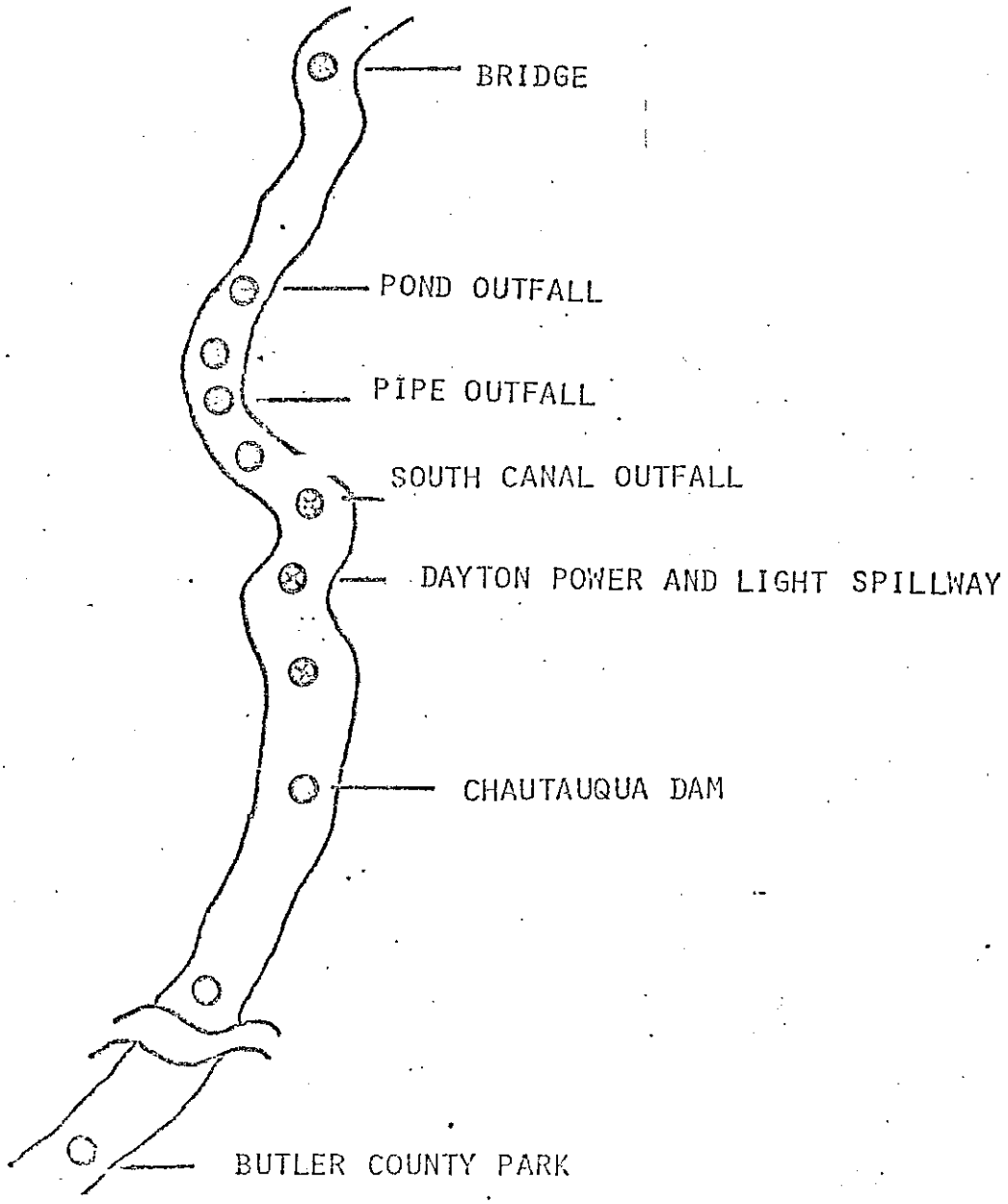
June, 1974

RADIATION ADVISORY COUNCIL

Authority: Ohio Revised Code Section 3701.93
Appointed by: Director with approval of Governor
Term: Five Years

MEMBERS	FIELD	TERM EXPIRES
Dr. Eugene Saenger Radioisotope Laboratory Cincinnati General Hospital Cincinnati, Ohio	Recognized ability in the field of medicine with experience in radiation problems	12/31/74
Mr. Herbert Meyer Head of Health Physics Section Mound Laboratories Miamisburg, Ohio	Experience in radiation protection	12/31/75
Dr. George Callendine, Jr. Radiological Physicist Riverside Hospital Columbus, Ohio	Recognized ability in the field of radiation physics	12/31/76
Dr. Frank Woltz Superintendent of Engineering Development Goodyear Atomic Corporation Piketon, Ohio	Recognized ability in the field of atomic energy	12/31/77
Mr. Eugene R. Ferraro Administrative Assistant to the Vice President of New Product Development Industrial Nucleonics, Inc. Columbus, Ohio	Recognized ability in the field of industrial application of radiation devices	12/31/78

PROPOSED SAMPLE LOCATIONS - GREAT MIAMI RIVER



APPROXIMATELY 10 MI. DOWNSTREAM OF MOUND LABORATORY

TABLE II

ESTIMATED NUMBER OF SAMPLES

	NUMBER OF LOCATIONS	COMPOSITE	PROFILE/ 1' SECTION	SUSPENDED SOLIDS	WATER
DITCH	2	6	6/30	2	2
N. CANAL	4	40	40/200	24	24
S. CANAL	3	30	30/150	18	18
N. POND	3	6	6/30	6	6
S. POND	3	6	6/30	6	6
RUN-OFF HOLLOW	3	6	6/30	6	6
RIVER	11	70	70/350	70	70
RIVER OUTFALL	3	6	6/30	6	6
WATER TABLE	4	-	-	-	4
SURFACE RUN-OFF	5	5	-	-	-
TOTAL	41	175	170/850	138	142

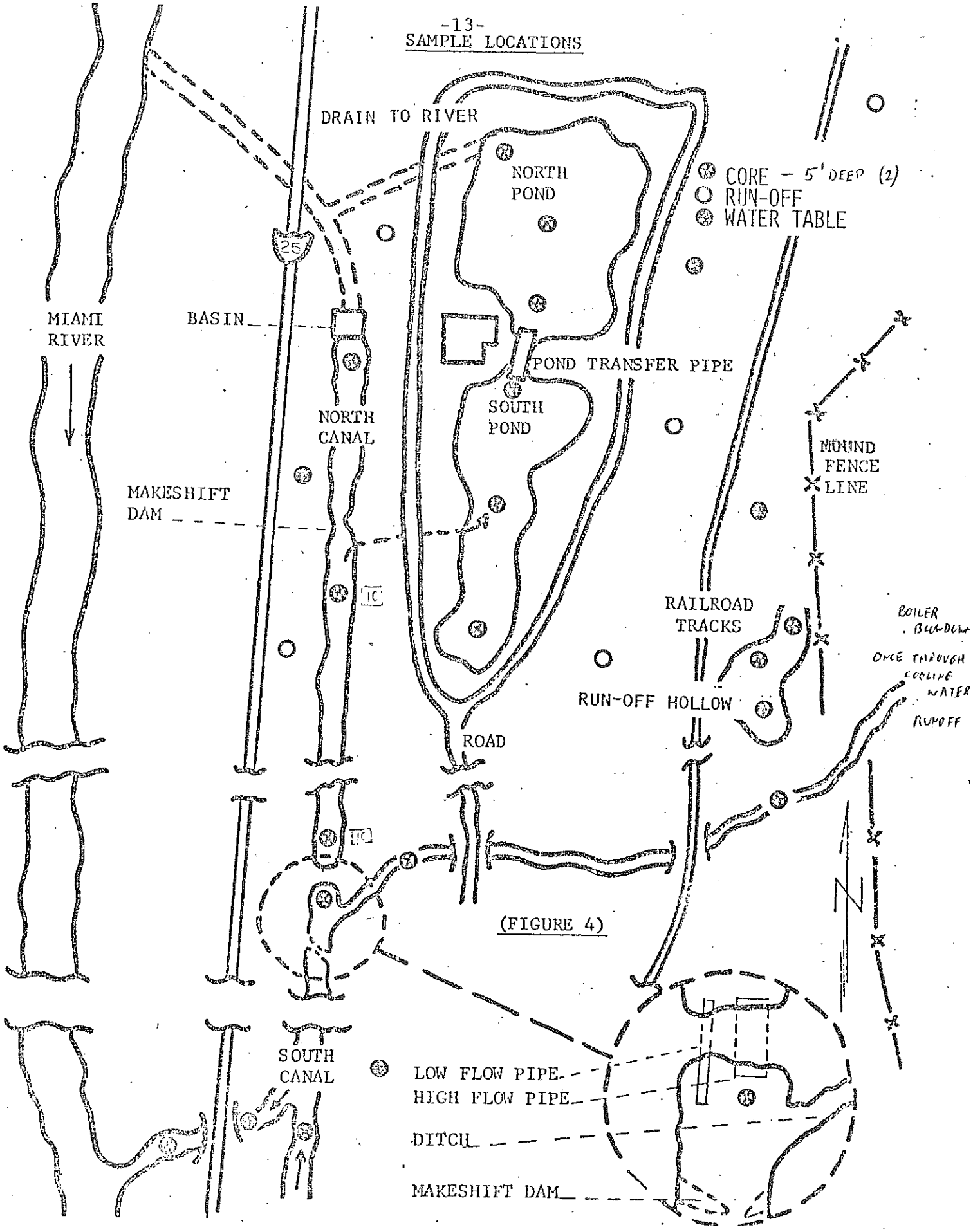
TABLE III

ESTIMATED NUMBER OF ANALYSIS

COMPOSITE	175
PROFILE/1' SECTION	850
WATER	142
SUSPENDED SOLIDS	138
VEGETATION	26
WATER TABLE	4
RUN-OFF	5
TOTAL	1340*

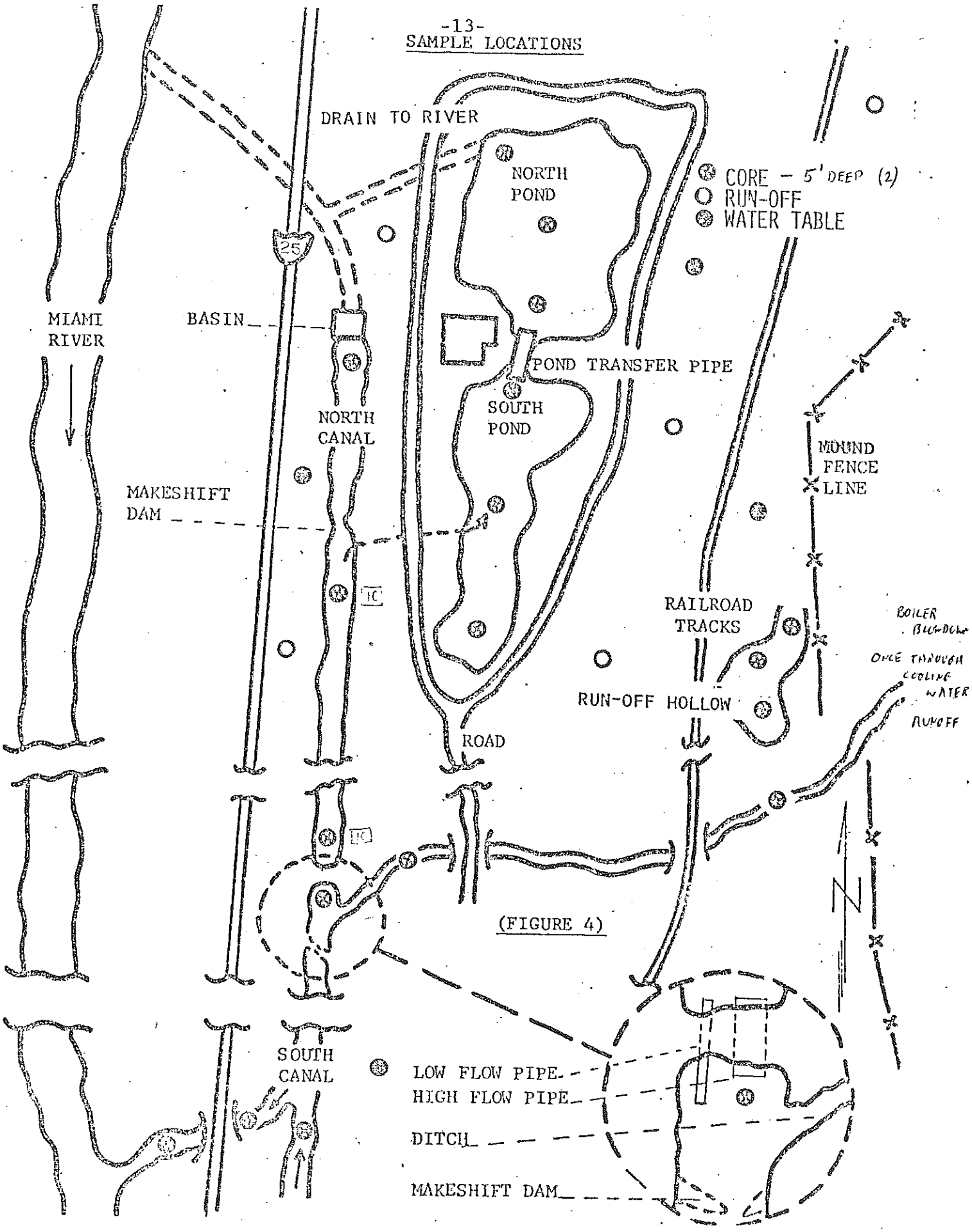
*ADDITIONAL ANALYSIS OF FISH/SMALL ANIMALS FOUND AT SAMPLE LOCATIONS NOT INCLUDED.

SAMPLE LOCATIONS



(FIGURE 4)

SAMPLE LOCATIONS



(FIGURE 4)

Ref. 8

INTER-OFFICE COMMUNICATION

TO Dr. Thomas Birch, Ambient Water Group Chief DATE September 13, 1974

FROM: Ken M. Harsh, through Gary Bramble

SUBJECT: Interpretation of Mound Laboratory Results

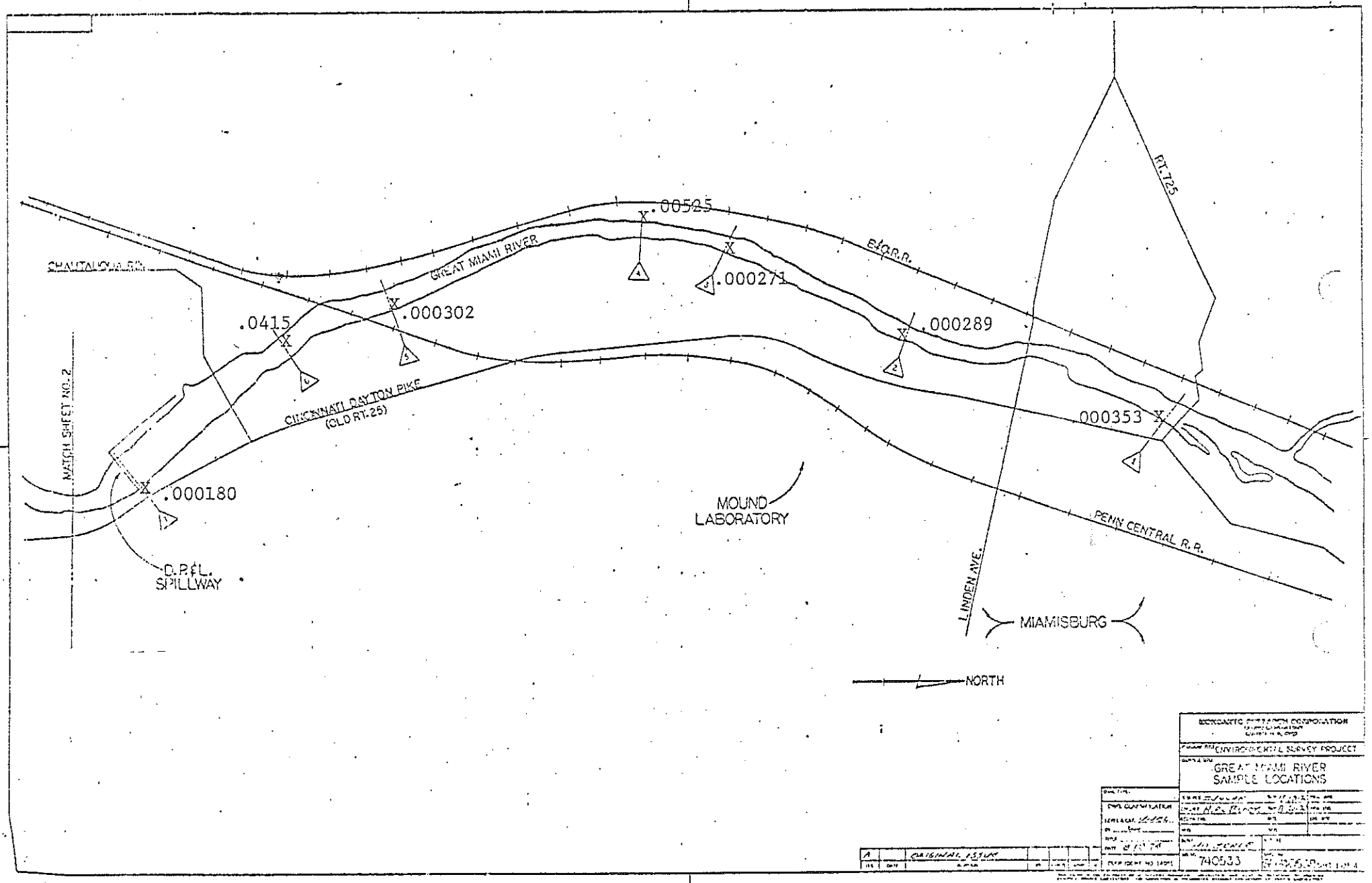
The following seven sheets detail the highest reading (in mannocuries/gram) for each site sampled by Mound Laboratory. Several interesting facts come to light as the results are scrutinized. The highest river sample results are near the Mound outfall and the single highest result is at the confluence of the canal and the river. Levels even at the upstream site at State Route 725 in Miamisburg, Ohio exceed background levels, which may be due to levels in ambient air in that area.

Levels at the rest of the sites are higher than background levels. The highest levels found in the canal are from location E near the north end of the canal; at D the highest spot (4.56 mannocuries/gram); the canal overflow; and two locations on the southern end of the canal. Even more significant is the fact that (and note that where two numbers are listed, the second number is for a silt sample) almost every sample of silt is higher than the highest level of any of the foot long core sections. For example, at site L in the south pond, the highest core sample is .00969 mannocuries/gram and the silt sample gave .208 mannocuries/gram. This would tend to indicate that at least some of the plutonium and maybe the largest amounts, have been deposited fairly recently (within the past year). It becomes apparent that Mound has had several incidents or a continuous incident that is depositing plutonium in the ponds, canal, and Great Miami River as indicated on the area maps.

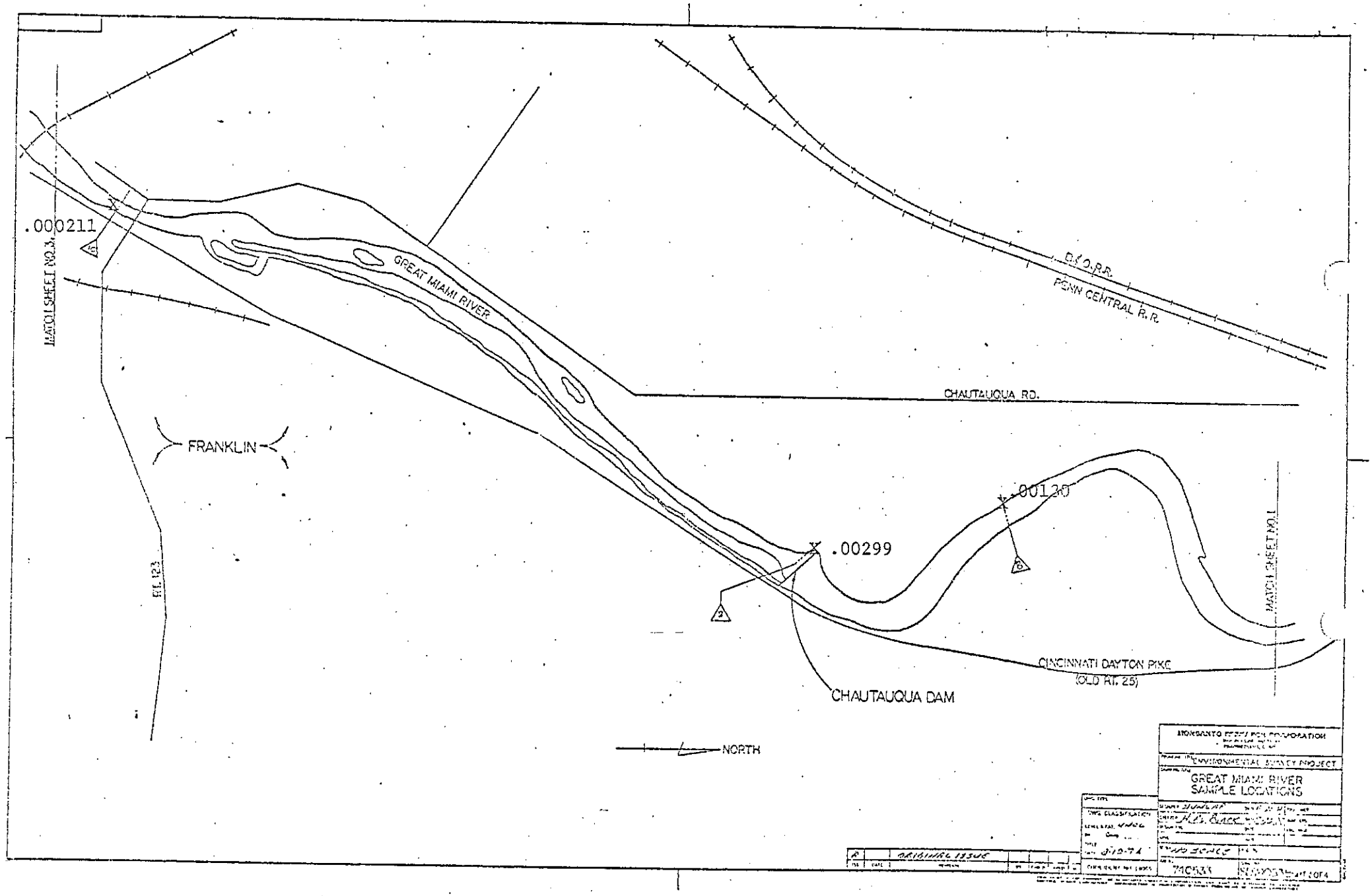
As further data becomes available, I will pass it along to you.

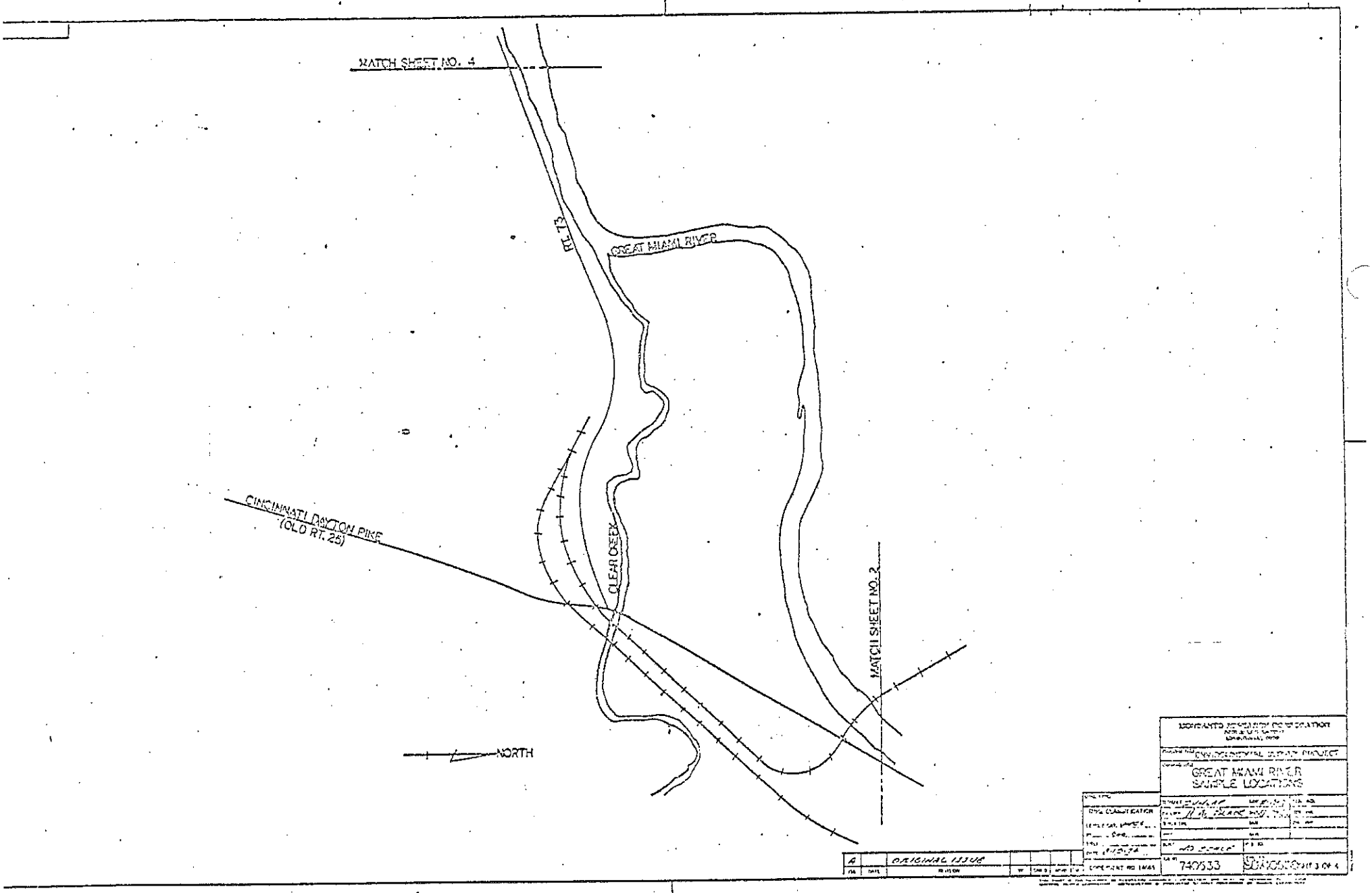
sjg

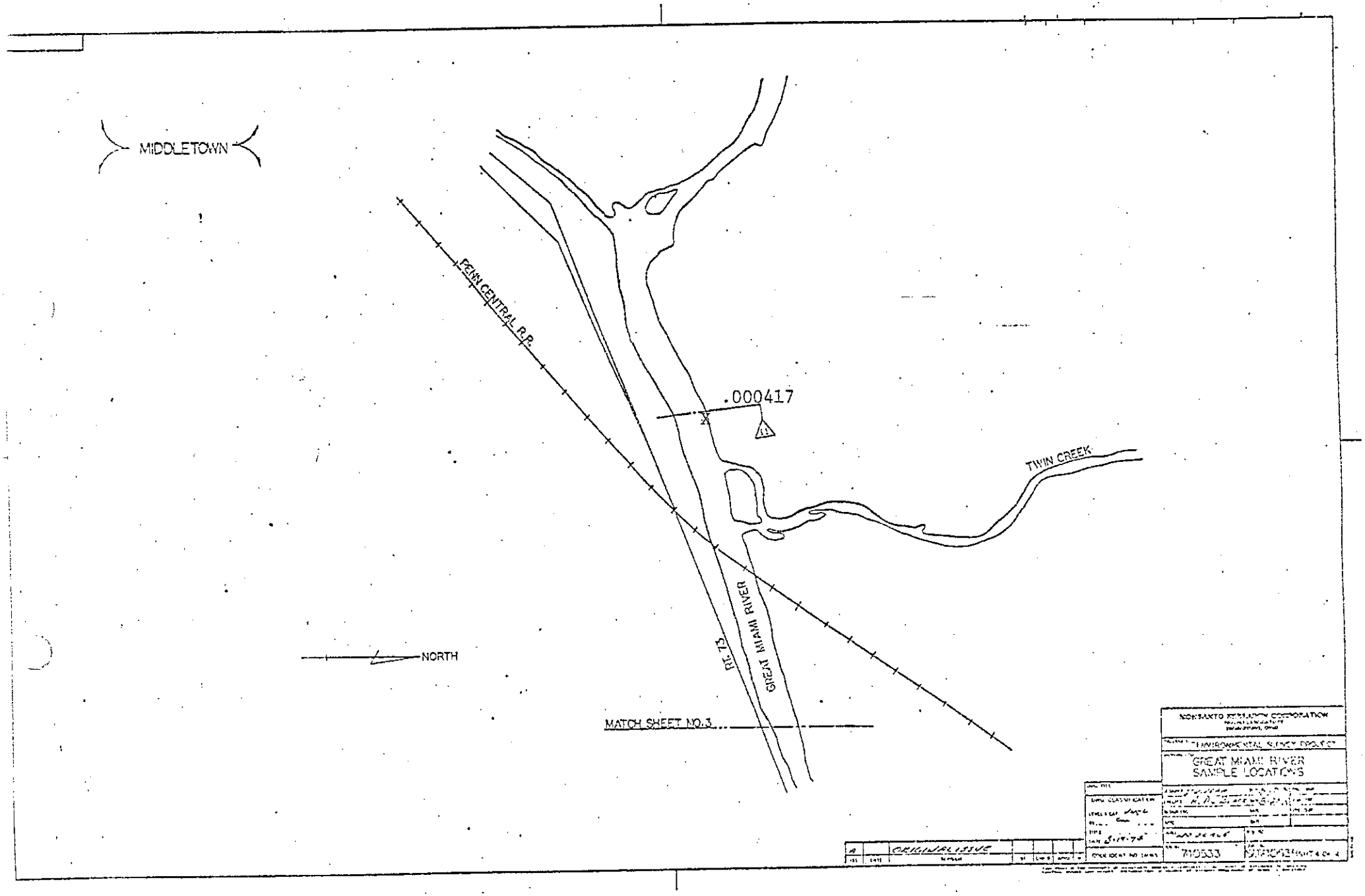
Attachments

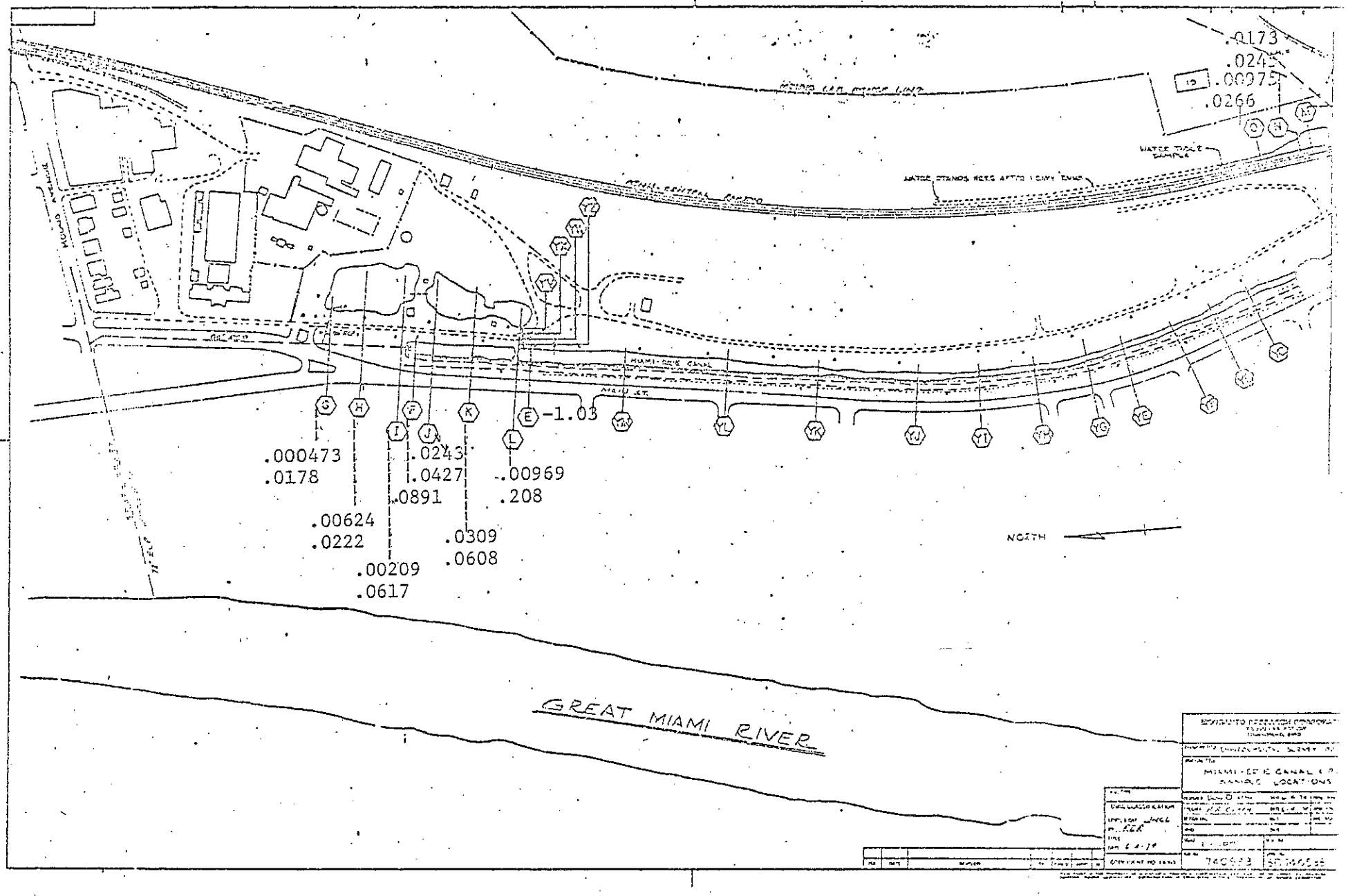


.00525
.000271
.000302
.0415
.000289
.000353
.000180
GREAT MIAMI RIVER
CHAUTAUQUA RD.
CINCINNATI DAYTON PIKE
(OLD RT. 25)
MATCH SHEET NO. 2
D.P.&L.
SPILLWAY
MOUND
LABORATORY
PENN CENTRAL R.R.
LINDEN AVE.
MIAMISBURG
RT. 725
NORTH
MONSANTO RESEARCH CORPORATION
ENVIRONMENTAL SURVEY PROJECT
GREAT MIAMI RIVER
SAMPLE LOCATIONS
740533
ORIGINAL ISSUE


.000211
MATCH SHEET NO. 3
GREAT MIAMI RIVER
D.&O.R.R.
PENN CENTRAL R.R.
CHAUTAUQUA RD.
FRANKLIN
RT. 123
.00299
.00130
MATCH SHEET NO. 1
CINCINNATI DAYTON PIKE
(OLD RT. 25)
CHAUTAUQUA DAM
NORTH
MONSANTO
ENVIRONMENTAL SURVEY PROJECT
GREAT MIAMI RIVER
SAMPLE LOCATIONS
ORIGINAL ISSUE


MATCH SHEET NO. 4
RT. 73
GREAT MIAMI RIVER
CINCINNATI DAYTON PIKE
(OLD RT. 25)
CLEAR CREEK
MATCH SHEET NO. 2
NORTH
GREAT MIAMI RIVER
SAMPLE LOCATIONS
740533
ORIGINAL ISSUE


MIDDLETOWN
PENN CENTRAL R.R.
.000417
TWIN CREEK
RT. 73
GREAT MIAMI RIVER
NORTH
MATCH SHEET NO. 3
MONSANTO RESEARCH CORPORATION
ENVIRONMENTAL SURVEY PROJECT
GREAT MIAMI RIVER
SAMPLE LOCATIONS
ORIGINAL ISSUE
710533



.0173
.0245
.00975
.0266
WATER TABLE SAMPLE
MIAMI-ERIE CANAL
MIAMI ST.
-1.03
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.0178
.00624
.0222
.00209
.0617
.0243
.0427
.0891
.0309
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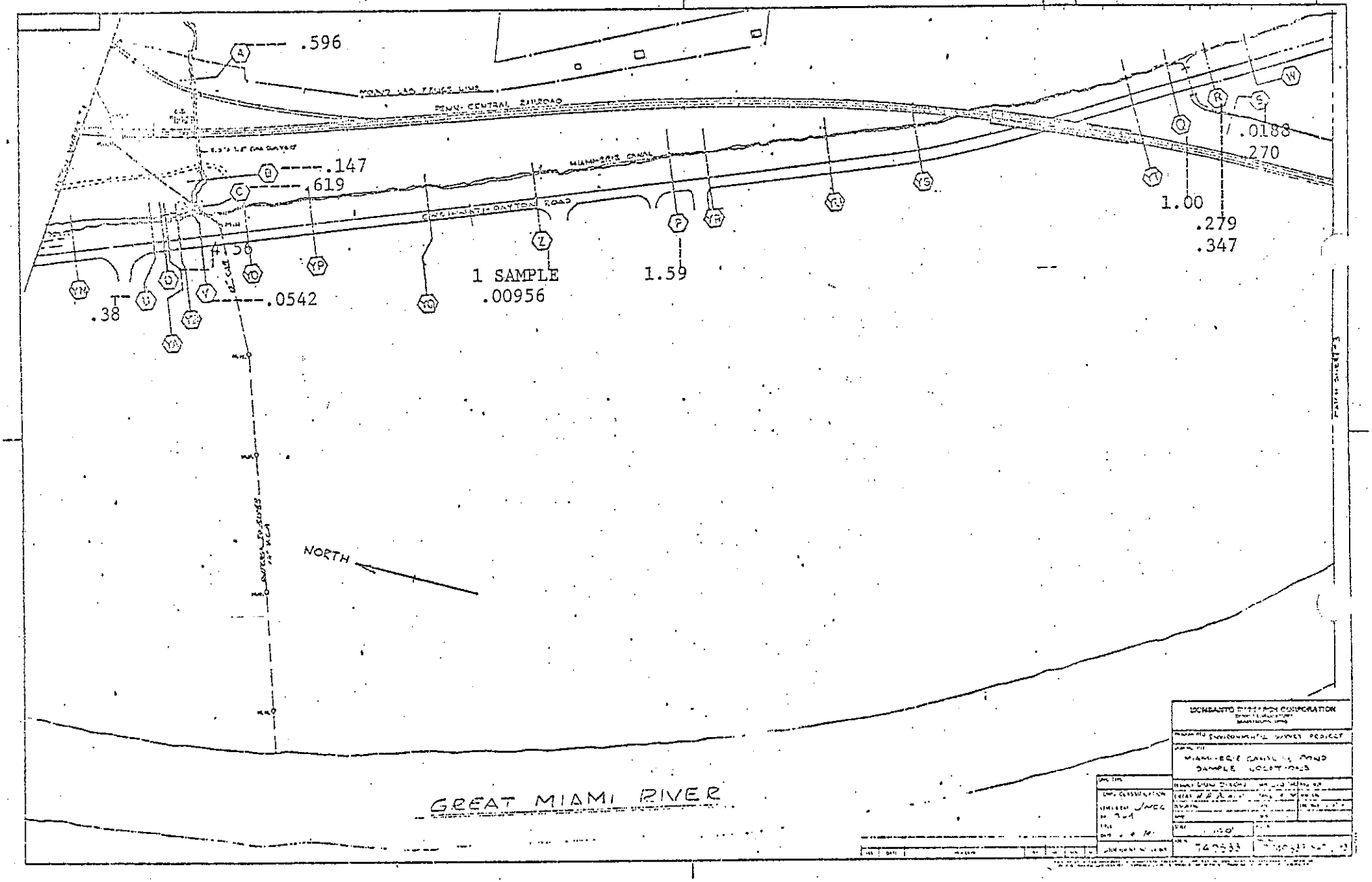
.00969
.208
NORTH
GREAT MIAMI RIVER
MIAMI-ERIE CANAL
SAMPLE LOCATIONS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PENN. CENTRAL RAILROAD
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MIAMI-ERIE CANAL
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1 SAMPLE
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1.59
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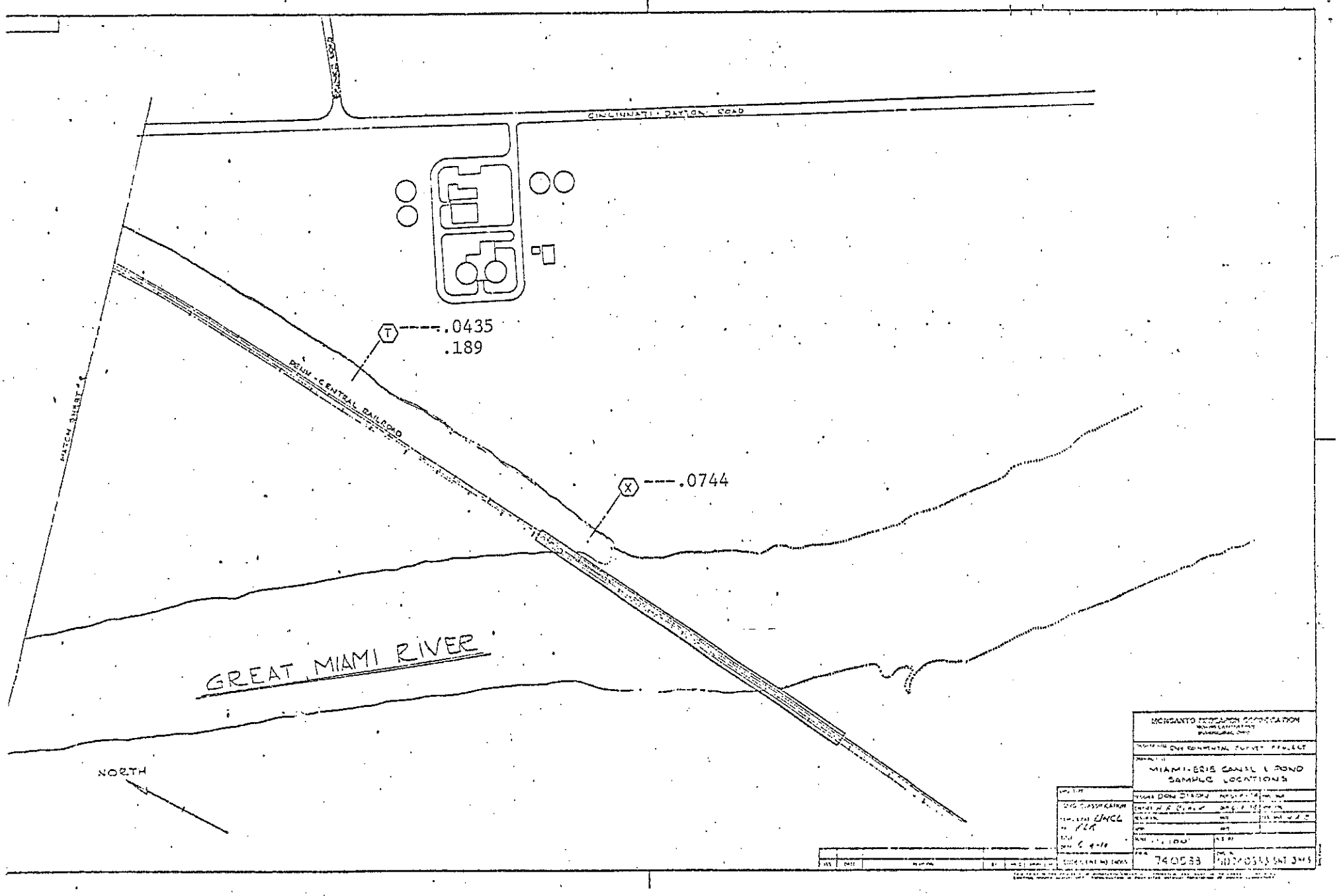
.38
NORTH
GREAT MIAMI RIVER


CINCINNATI - DAYTON ROAD
PENN - CENTRAL RAILROAD
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.0435
.189
X
.0744
GREAT MIAMI RIVER
NORTH
MONSANTO REFINING CORPORATION
MIAMI-ERIE CANAL & POND
SAMPLE LOCATIONS
740588

Ref 9.

ENVIRONMENTAL PROTECTION AGENCY
NATIONAL ENVIRONMENTAL RESEARCH CENTER
Cincinnati, Ohio 45268

October 1, 1974

Office of Radiation Programs

Mr. Gary Bramble
State of Ohio Environmental
Protection Agency
Division of Surveillance
7 East Fourth Street
Dayton, Ohio 45202

Dear Mr. Bramble:

Final results are enclosed of Plutonium analyses performed by the U. S. EPA Eastern Environmental Radiation Facility at the request of the Ohio EPA. The values are summarized in Table 1; these supersede the preliminary data for core samples in my letter to you of July 16, 1974, and include the samples collected by us on June 19, 1974 at the locations shown in Figure 1. Results for samples that were analyzed by both Mound Laboratory and the U. S. EPA are compiled in Table 2. The results are believed to indicate the following:

1. The analyses of ^{238}Pu in the sediment core samples collected by Mound Laboratory show good agreement by the two laboratories. Of 20 sample results, 19 were in agreement. At low ^{238}Pu concentrations, agreement was much better than expected from the large uncertainties reported by Mound Laboratory. The concentrations of these comparison samples cover a reasonable range of values compared to the complete range of 0.006 to 4,560 pCi/g in the Mound Laboratory progress report of August 30, 1974 from which all preliminary unofficial data cited here are taken.

2. The analyses of samples collected in surface waters immediately west of the Laboratory confirm the observations by Mound Laboratory of considerably higher 238Pu levels in this area. The isotopes ^{239}Pu and ^{242}Pu were also found in some samples (see Table 1) at levels attributed to Mound Laboratory effluents. That samples taken from the 1 inch of sediment were not higher in ^{238}Pu content than those taken from the top foot suggests that the contaminating event did not occur very recently.

3. Elevated concentrations of ^{238}Pu in drainage ditches to the east and south, and in surface soil in all directions near the laboratory suggest that the entire vicinity is contaminated although at much lower levels than to the west. The contamination

appears to have resulted from both airborne and liquid discharges. For comparison, background ^{238}Pu values of 0.001 pCi/cm^2 soil and lowest values of 0.005 pCi/g sediment and 0.05 pCi/liter surface water were reported by Mound Laboratory in Rad. Data Repts. 15, 134 (1974).

4. The wellwater used in the nearby municipal swimming pool contained no detectable plutonium. The fish and three of the four vegetables obtained in the immediate vicinity contained very low levels of ^{238}Pu. Background samples will have to be analyzed to determine if these levels are attributable mostly to Mound Laboratory or to atmospheric fallout.

5. The presence of ^{238}Pu in surface water samples at concentrations higher than the lowest values given above suggests either that ^{238}Pu was still being discharged on the date of sampling, or that a fraction of the deposited ^{238}Pu was resuspended.

The observed environmental contamination by ^{238}Pu requires answers to the following questions:

1. What was the population radiation exposure from the release or releases that resulted in the higher plutonium levels to the west of the Laboratory?

2. What is the potential population radiation exposure from the plutonium now in the environment?

3. How can plutonium discharges be minimized in the future:

The investigations of operations and the evaluations of possible exposure pathways that are now being undertaken by Mound Laboratory are expected to provide these answers. It is suggested that consideration of further activities be based on the magnitude of the past, present and future exposures to be indicated by this information. Additional radionuclide measurements may be required if the information is highly uncertain or will not be available for some time.

Sincerely yours,

Bernd Kahn

Bernd Kahn
Director
Radiochemistry & Nuclear Engineering
Facility

Enclosures

Table 1

Plutonium in Samples from the Vicinity of Mound Laboratory

I.D.#	Location	Concentration ^{238}Pu	^{239}Pu	^{242}Pu
	Core sediment samples collected by Mound Laboratory, pCi/g dried weight			
EA-1	North Canal at south end of South Pond	0.13	< 0.02	
		0.09	< 0.02	
EB-1	"	0.13	< 0.02	
		0.11	< 0.02	
EC-1	"	4.8	0.07	
ED-1	"	1.1	< 0.02	
EE-1	"	440	2.3	
EF-1	"	1170	15.4	
		1090	7.9	
EG-1	"	10.8	0.18	
EH-1	"	26	0.16	
EI-1	"	0.98	0.06	
EJ-1	"	0.89	0.05	
		1.30	0.06	
FA-1	North end of North Canal	8.9	0.51	
		7.5	0.44	
		9.1		
FE-1	"	16.9	0.18	
		19.2	0.05	
GA-1	North end of North Pond	0.48	< 0.02	
HA-1	Middle of North Pond	5.1	0.07	
IA-1	South end of North Pond	2.5	0.06	
JA-1	North end of South Pond	0.70	< 0.02	
KA-1	Middle of South Pond	27	0.27	

.ble 1

I.D.#	Location	Concentration ^{238}Pu	^{239}Pu	^{242}Pu
LA-1	South end of South Pond	10.9	0.30	4.0
CE-1	South Canal at west drainage ditch	24	0.46	0.16
QE-1	South Canal where it crosses US 25	920	10.9	
	Sediment samples, top 1 inch, pCi/g dried weight			
EPA-1	South Canal at west drainage ditch	230	3.54	6.03
EPA-20	East drainage ditch, ~200 ft south of Mound Rd culvert	1.9	0.06	
EPA-17	South drainage ditch, 15 ft from junction with South Canal	47	0.84	
EPA-18	South Canal, 10 ft from junction with south drainage ditch	60	0.77	
	Surface soil and mud samples, top 1 inch, pCi/g dried weight			
EPA-2	Railroad cut south of control box	0.12	0.02	
EPA-3	Railroad cut north of control box	0.39	0.13	
EPA-6	Run-off hollow	3.8	0.11	
EPA-7	At shelter house SE of South Pond	0.44	0.07	
EPA-13	NE of Lab, at fence between tennis court and Harmon Field	0.10	< 0.02	
EPA-14	SE of Lab, at SW corner of Mound Park	0.44	0.04	
EPA-15	SW of Lab, at junction of US 25 with South Canal	0.96	0.04	0.19
EPA-12	NW of Lab, at alley south of Mound Rd	0.19 0.17	0.05 0.05	0.60 0.87
	Algae samples, pCi/g dried weight			
EPA-9	Algae from south end of South Pond	79	12.7	
EPA-21	Algae from east drainage ditch, ~200 ft south of Mound Rd culvert	0.88	0.08	

Table 1

I.D.#	Location	Concentration ^{238}Pu	Concentration ^{239}Pu	Concentration ^{242}Pu
	Water samples, 1 liter aliquots, pCi/liter			
EPA-4	Railroad cut north of control box	0.29	< 0.02	
EPA-5	Run-off hollow, east of railroad	0.94	0.09	
EPA-8	South Pond	0.42	< 0.02	
EPA-10	North Canal, near south end of South Pond	0.60	< 0.02	
EPA-11	Well between ponds (swimming pool water)	< 0.02	< 0.02	
EPA-16	South Canal, at junction under US 25	0.60	< 0.02	
EPA-19	East drainage ditch, ~200 ft south of Mound Rd culvert	0.04	< 0.02	

Vegetable and fish samples, pCi/g ash

		% Ash Wet Wt	% Ash Dried Wt	Concentration ^{238}Pu
EPA-24	Green beans, 0.9 mile, 270°	0.9	9.1	0.03
EPA-25	Lettuce, 0.7 mile, 310°	0.7	21	0.16
EPA-26	Lettuce, 0.7 mile, 30°	0.8	21	< 0.02
EPA-27	Peas, 1.2 miles, 150°	1.2	5.2	0.27
EPA-28	Fish from South Pond	1.6	5.4	0.87

Notes:

1. For location of samples with EPA identification numbers see Figure 1; other samples have Mound Laboratory identification numbers.

2. Samples EPA-1 to EPA-21 were collected by USEPA on June 19, 1974; samples EPA-24 to EPA-27 were obtained by Mound Laboratory; sample EPA-28 was collected by Ohio EPA. CE-1 was also designated EPA-22, and QE-1 was EPA-23.

3. The counting error for solids was approximately ± 15% above 0.5 pCi/g and ± 30% below this value. The ^{238}Pu counting error for liquids was approximately ± 0.2 pCi/l except for sample EPA-19 (± 0.02 pCi/liter); the ^{239}Pu counting error

Table 1

for sample EPA-5 was $\pm$ 0.05 pCi/liter.

4. Analyses were by the Eastern Environmental Radiation Facility, ORP-EPA, Montgomery, Alabama.

5. Vegetable and fish samples contained no detectable ^{239}Pu and ^{242}Pu (< 0.02 pCi/g ash).

Table 2

Comparison of ^{238}Pu Results by EPA and Mound Laboratory*

Identification No.	^{238}Pu Concentration, pCi/g EPA	Mound
EA-1	0.13 0.09	0.108 ± 0.095
EB-1	0.13 0.11	0.076 ± 0.074
EC-1	4.8	2.87 ± 1.99
ED-1	1.1	0.909 ± 0.875
EE-1	440	425 ± 36
EF-1	1170 1080	1030 ± 80
EG-1	10.8	9.79 ± 4.0
EH-1	26	23.8 ± 9.1
EI-1	0.98	0.093 ± 0.171
EJ-1	1.30 0.89	0.958 ± 0.909
FA-1	8.9 7.5 9.1	9.43 ± 4.67
FE-1	16.9 19.2	13.8 ± 4.3
GA-1	0.48	0.419 ± 0.503
HA-1	5.1	4.71 ± 2.84
IA-1	2.5	2.03 ± 1.55
JA-1	0.70	0.672 ± 0.705
KA-1	27	30.9 ± 10.9
LA-1	10.9	9.64 ± 4.75
CE-1	24	30.2 ± 10.7
QE-1	920	1000 ± 130

*Preliminary unofficial data, Aug. 30, 1974

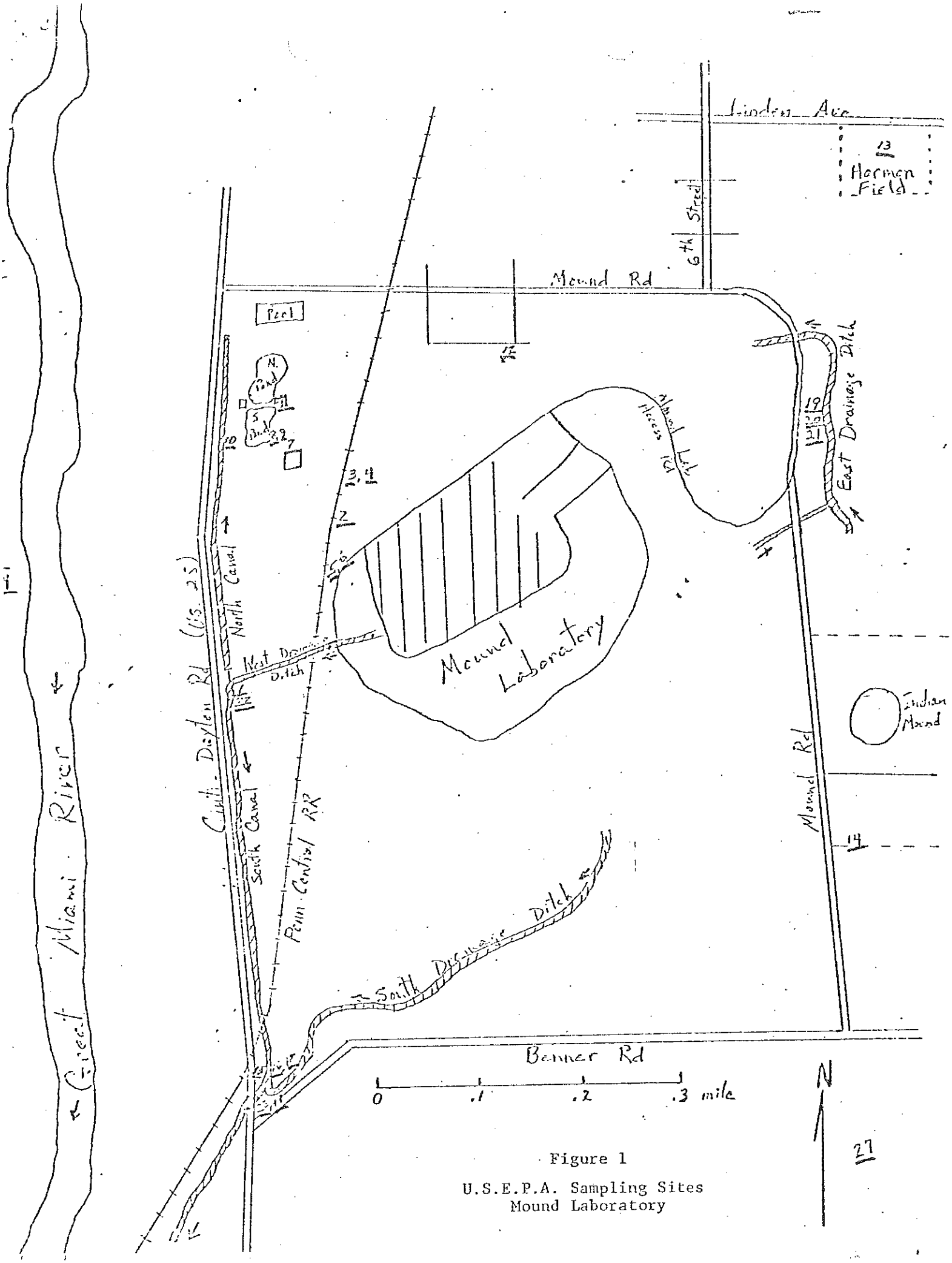


Figure 1

U.S.E.P.A. Sampling Sites
Mound Laboratory

Ref. 10

Auto copy of Slides 10-2-74 Press Release that day

MOUND PLUTONIUM STUDY

MOUND PLUTONIUM STUDY

OBJECTIVES:

1. Evaluating the inventory of plutonium-238 in the environment at Mound Laboratory
2. Determining the source of the plutonium-238
3. Alleviating any potential health hazard to the general public

TOPICS

- Locations of Contamination
- Results of Sampling
- Health and Safety Analysis
- Source of Contamination
- On-Site/Off-Site Actions

MOUND PLUTONIUM STUDY

PROJECT DIRECTOR

Consultant Review Group

Advisory Review Group

Scientific Advisor

Identify cause

Review scientific validity of operations

Recommend sample location changes based on incoming data

Sampling & Analysis

Develop plan for
- Waterways
- Perimeter
- On-site

Manage operations

Engineering Design & Service

Develop plan to eliminate offsite situation

Civil Engineering for entire area

Coordinate all work in Engineering Department and other areas

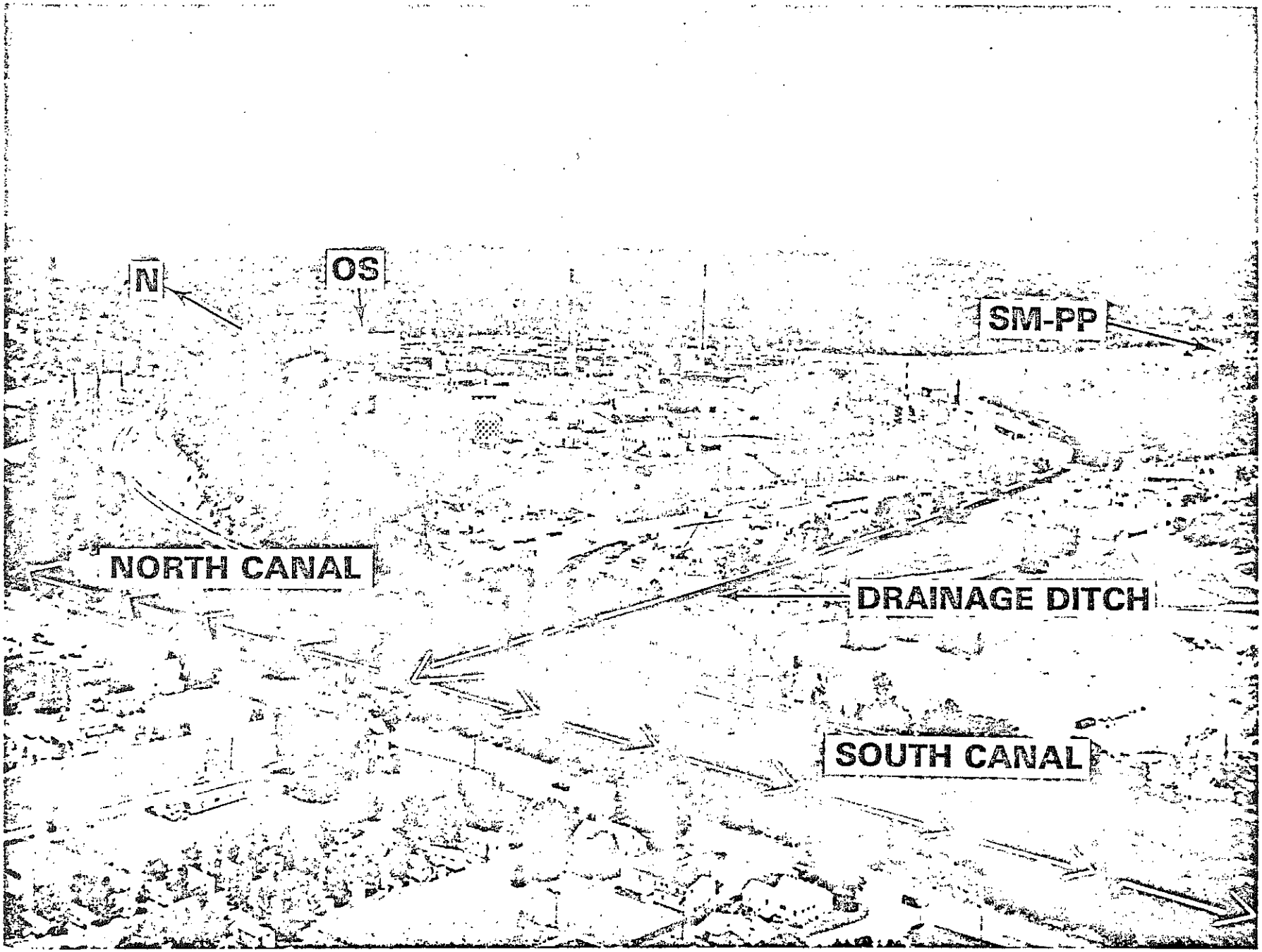
Specialists

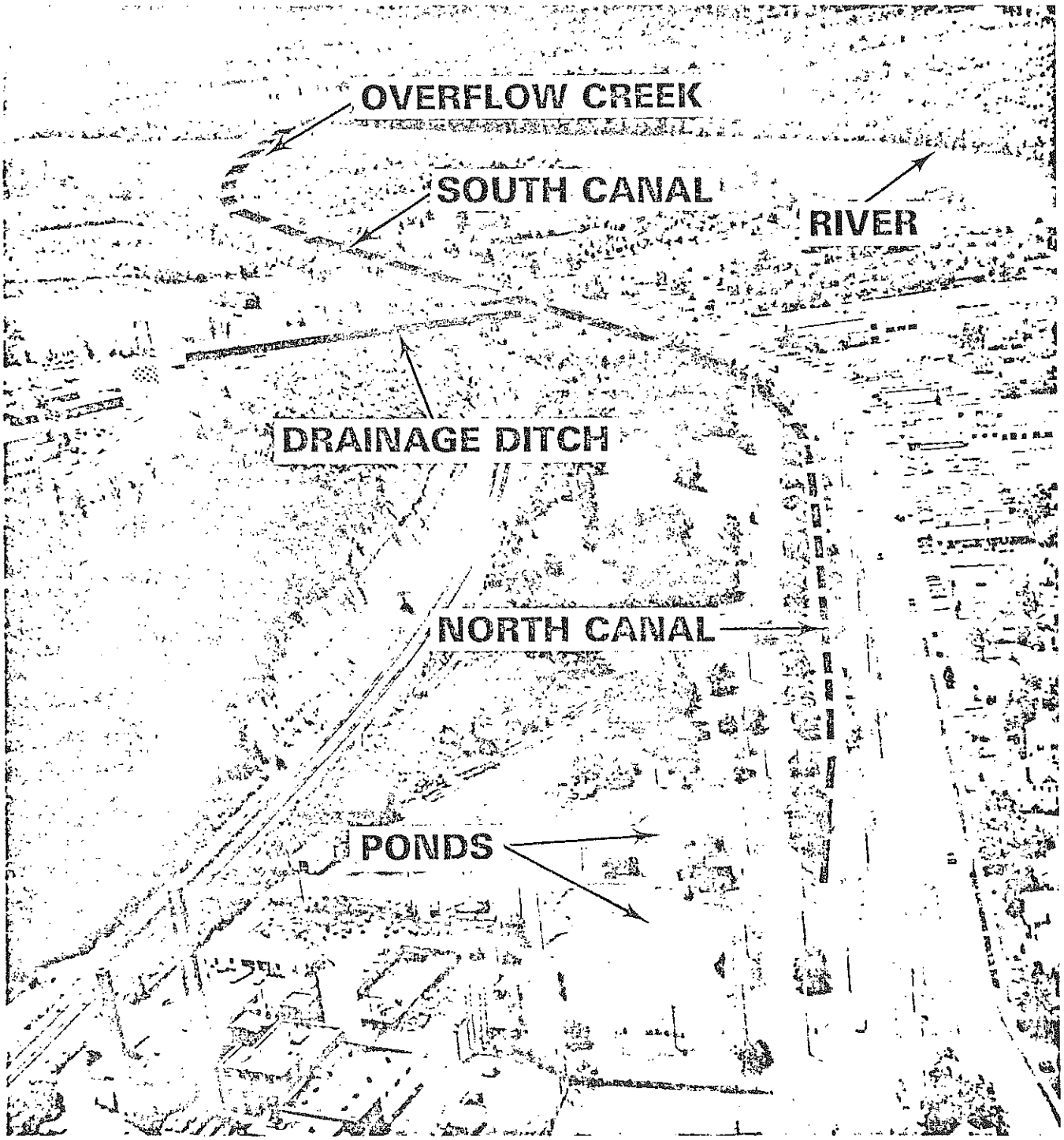
Law - Finance - Communications

Expertise as required

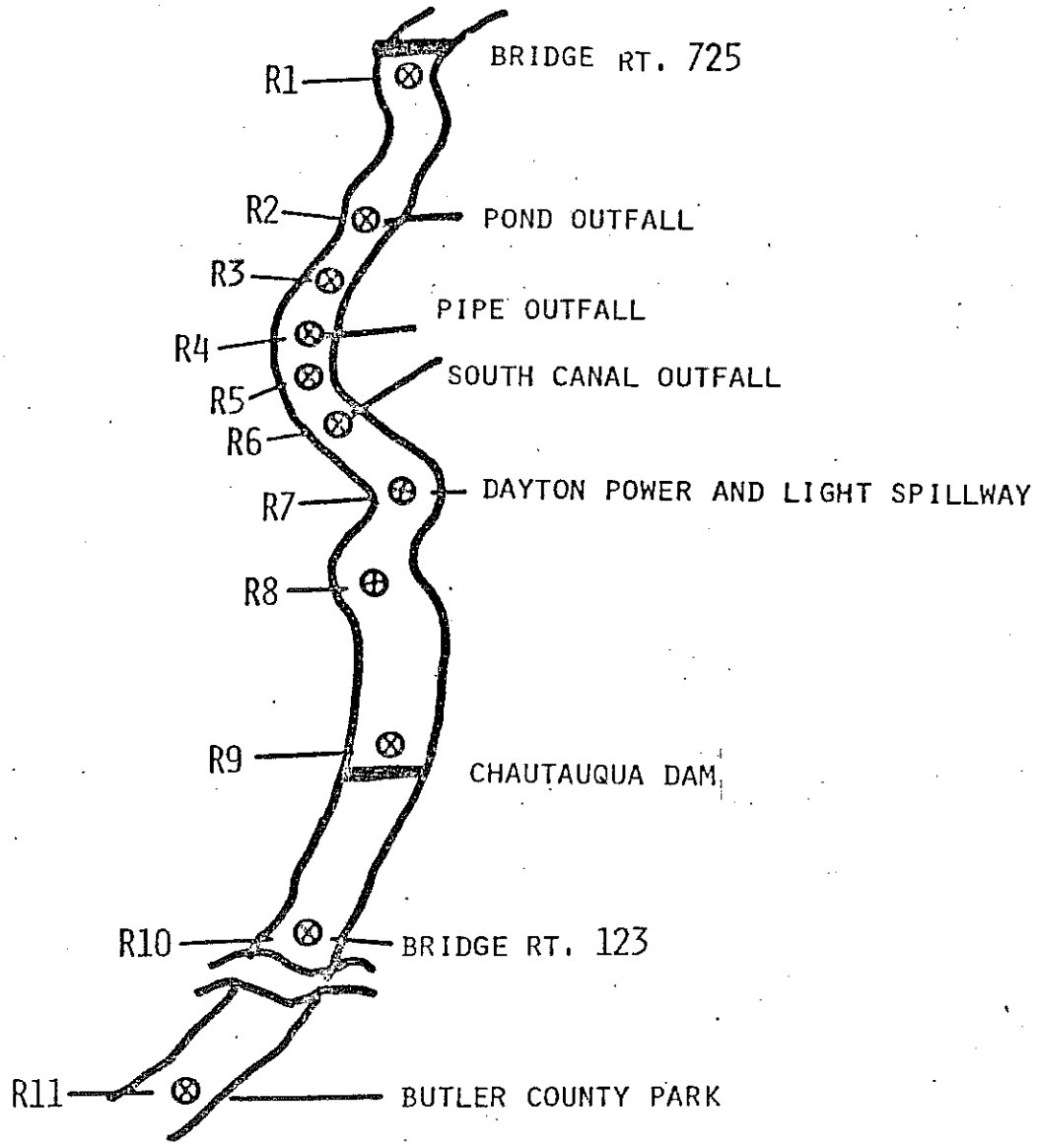
PLANS REVIEWED BY:

- Monsanto
- AEC
- Montgomery County Health Dept.
- Miami Conservancy District
- Ohio Dept. of Health
- Ohio EPA
- U. S. EPA
- Consultants
    - U.S.D.A.
    - Private Companies
    - Universities


N
OS
SM-PP
NORTH CANAL
DRAINAGE DITCH
SOUTH CANAL


OVERFLOW CREEK
SOUTH CANAL
RIVER
DRAINAGE DITCH
NORTH CANAL
PONDS

SAMPLE LOCATIONS
GREAT MIAMI RIVER



APPROXIMATELY 10 MI. DOWNSTREAM OF MOUND LABORATORY

ESTIMATED NUMBER OF ANALYSES

Composite	175
Profile/1' Section	850
Water	142
Suspended Solids	138
Vegetation	26
Water Table	4
Runoff	5
	1340*

*Additional Analysis of Fish/Small Animals Found at Sample Locations not Included.

10-2-74

EVALUATION OF SHORT TERM HAZARD IN AREA NEAR MOUND LAB.

Considerations

- Water & Air Concentrations Below Concentration Guide
- Sediment Under Water, Moist or Overgrown With Vegetation
- The Solubility of Pu-Sediment in Water is Very Low

THERE IS NO SHORT TERM HAZARD

BEHAVIOR OF ^{238}Pu IN MOUND LABORATORY SEDIMENT

- Examination of Sediment (LFE) Shows Very Few Discrete Particles
- Solubility Studies in 8M HNO_3 (ORNL) Indicate That The Nature of The Pu in This Sediment is Not Particulate PuO_2
- Recent Tests Show Pu IS Strongly Sorbed Onto The Soil (Pu is Fixed on Soil)

COMPARISON OF THE CONDITIONS USED
BY HEALY AND BY MOUND LABORATORY

Considerations	Conditions Assumed by Healy	Conditions at Mound Laboratory
Extent of Contamination	Wide Spread ~39 sq miles	Very Small ~0.01 sq miles
Physical Nature of Contamination	PuO_2 Fallout (Not Fixed)	Pu Sorbed on Sediment (Fixed to Sediment)
Nature of Climate and Soil	Arid Western Soil	Moist Fertile Ohio Soil Mostly Clay
Nature of the Area	Wide Open Level Plain	Recessed Canal in River Valley - Lined With Trees
Solubility of Pu	Considered Soluble or Nearly Soluble	Solubility Very Low $\frac{\text{Pu Concentration in Water}}{\text{Pu Concentration in Sediment}} = \frac{1}{100{,}000}$

ON SITE ACTIONS TAKEN/PLANNED

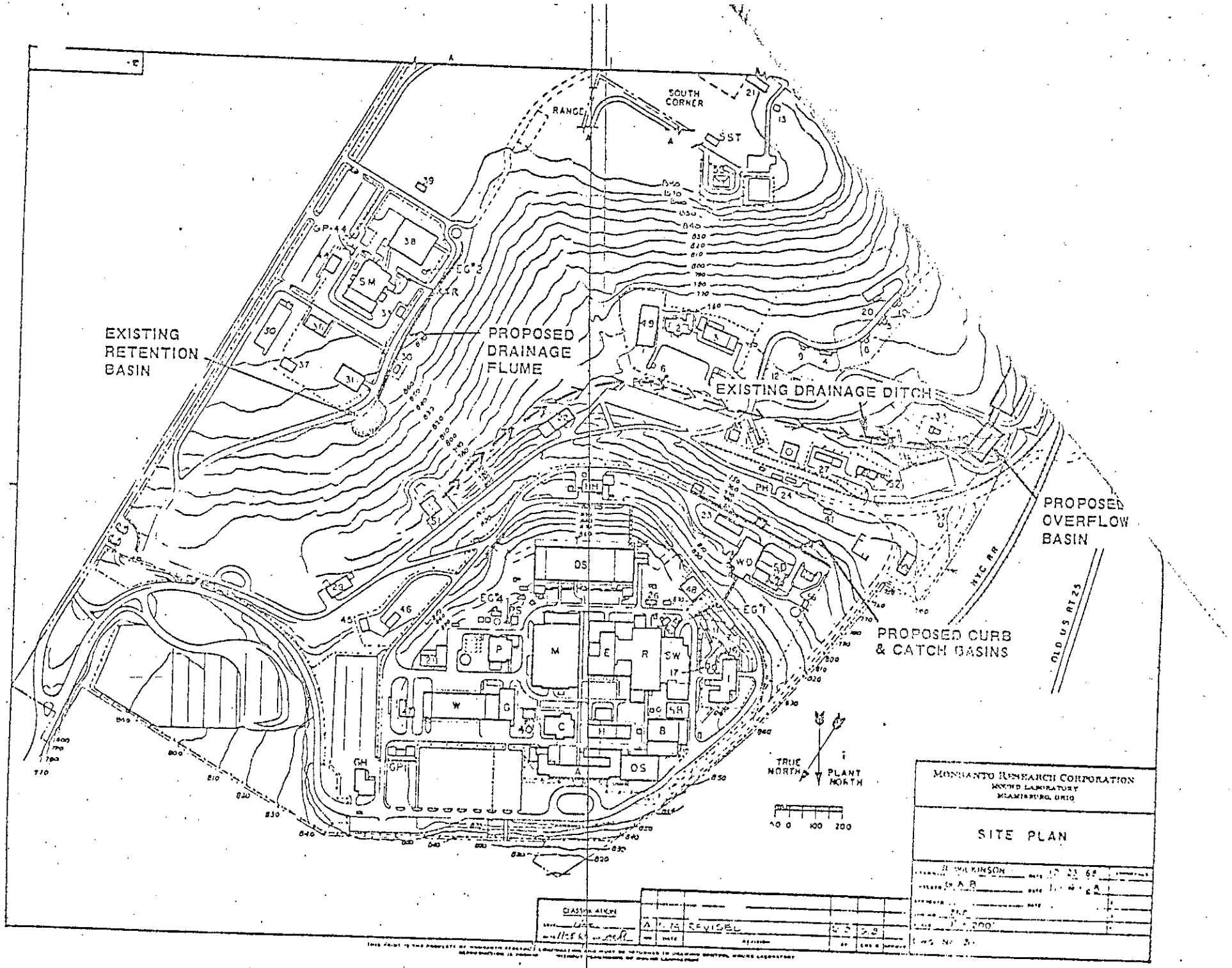
Temporary Dams

Hillside Soil Removal

Hillside Ground Cover

Retention Basins/Drainage Upgrade

Overflow Basin


EXISTING RETENTION BASIN
PROPOSED DRAINAGE FLUME
EXISTING DRAINAGE DITCH
PROPOSED OVERFLOW BASIN
PROPOSED CURB & CATCH BASINS
SOUTH CORNER
RANGE
SST
NYC RR
OLD U.S. RT 25
TRUE NORTH
PLANT NORTH
MONSANTO RESEARCH CORPORATION
MOUND LABORATORY
MIAMISBURG, OHIO
SITE PLAN

...EAM OFF SITE ACTION

CONCLUSION: No Health Hazard

ACTION:

Maintain Surveillance

Long Term Agreement - Site Condition

Analysis Reviewed by Ouside Experts

ALTERNATES:

Buy Land

Remove Selected Areas

Remove All Silt

SUMMARY OF RESULTS

	Low nCi/g	High nCi/g
North Pond	<.0001	0.0022
South Pond	"	0.208
North Canal	"	4.56
Runoff Hollow	"	0.0266
Off Site Ditch	"	0.596
South Canal	"	3.37
Overflow Creek	"	0.189
River	"	0.0367
Background 50 Miles	.0000002	
Blanks	<.0001	
Baseline in Park	.0004	
^{239}Pu Fallout	.000006	

POTENTIAL HAZARDS OF ^{238}Pu TO MAN

- External Radiation – Insignificant
- Internal Radiation – Uptake in Body

NCRP & ICRP STANDARDS FOR AN INDIVIDUAL IN THE GENERAL POPULATION

Body Burden	4 nCi
Lung Burden	1.6 nCi

CALCULATED

SEDIMENT ^{238}Pu "CONCENTRATION" GUIDE BASED ON ABSORPTION

	"Concentration" Guide for Sediment Near Mound Laboratory nCi/g
Absorption Through:	
Skin	590
Wounds	
1% Abrasion	590
10% Abrasion	59
Highest Sediment Concentration in the Canal Area Near Mound Laboratory	4.6

CALCULATED

SEDIMENT ^{238}Pu "CONCENTRATION" GUIDE BASED ON INGESTION AND THE FOOD CHAIN

	"Concentration" Guide for Sediment Near Mound Laboratory nCi/g
Ingestion of:	
Sediment Directly	
Deliberate	52
Casual	520
Combination	460
Water	500
Plants	>1000
Animals	> 84
Fish	84
Highest Sediment Concentration in the Canal Area Near Mound Laboratory	4.6

CALCULATED

SEDIMENT ^{238}Pu "CONCENTRATION" GUIDE BASED ON INHALATION

	"Concentration" Guide for Sediment Near Mound Laboratory nCi/g
CANAL AREA ALLOWED TO DRY	
Inhalation Due to:	
Dust Loading	250
~~Wind Suspension~~	90 - 350
Resuspension Factor:	
Low Mech. Disturbance	190
Mod. Mech. Disturbance	19
Extreme Mech. Disturbance	2
Personal Clothing	300
Home Contamination	300
Highest Sediment Concentration in the Canal Area Near Mound Laboratory	4.6

NCRP AND ICRP CONCENTRATION GUIDES

	Concentration Guides	Concentrations in Canal Area
Water	5×10^{-3} nCi/ml	5×10^{-6} nCi/ml
Air	1×10^{-9} nCi/ml	6×10^{-13} nCi/ml
Soil Baseline	None	4×10^{-4} nCi/g
Sediment	None	4.56 nCi/g

Ref. 11

INTER-OFFICE COMMUNICATION

TO Ernie Neal, Chief, Division of Surveillance DATE October 11, 1974

FROM: KMH Ken Harsh, through Art Talsma, Division of Surveillance - SWDO

SUBJECT: Mound Laboratory - Monsanto Research Corporation - Miamisburg, Ohio

Plutonium Incident

On Thursday, October 3, 1974, a combined press conference and information meeting was held at Mound Laboratory to detail additional sampling data and to pinpoint the source of the radioactive contamination in that area. Art Talsma represented the Ohio EPA at that meeting. At that time, OEPA was also given copies of data analysis furnished by the USEPA radiation laboratories in Montgomery, Alabama. Included in that packet of data were samples of an adjacent well, soil, vegetation, fish, and water samples. Monsanto detailed the events that led to the plutonium incident and theorized that all contamination was due to a 1969 pipeline breakage. Soil in the area of the break is being removed to an appropriate disposal site and that specific area is cordoned off.

Seven of the following sheets detail the highest reading (in nannocuries/gram) for each site sampled by Mound Laboratory. Several interesting facts come to light as the results are scrutinized. The highest river sample results are near the Mound outfall and the single highest result is at the confluence of the canal and the river. Levels even at the upstream site at State Route 725 in Miamisburg, Ohio exceed background levels, which may be due to levels in ambient air in that area.

Levels at the rest of the sites are higher than background levels. The highest levels found in the canal are from location E near the north end of the canal; at D the highest spot (4.56 nannocuries/gram); the canal overflow; and two locations on the southern end of the canal. Even more significant is the fact that (and note that where two numbers are listed, the second number is for a silt sample) almost every sample of silt is higher than the highest level of any of the foot long core sections. For example, at site L in the south pond, the highest core sample is .00969 nannocuries/gram and the silt sample gave .208 nannocuries/gram. This would tend to indicate that at least some of the plutonium and maybe the largest amounts, have been deposited fairly recently (within the past year). It becomes apparent that Mound has had several incidents or a continuous incident that is depositing plutonium in the ponds, canal, and Great Miami River as indicated on the area maps. It may or may not be caused by one pipeline rupture in 1969.

The eight pages following that are information relating to quality control samples split with Ohio EPA and Mound Laboratories, and results of samples independently collected by OEPA and USEPA. Those samples show several things: EPA 11 is a sample of a well located between the two contaminated ponds and has no detectable ^{238}Pu, which is good news. The water samples of USEPA and Mound gave similar results, although USEPA results were slightly higher. None of the water samples to date has exceeded NCRP guidelines. However, all of the samples except for the pool well sample were in excess of background levels.

Perhaps the most interesting aspect of the USEPA-OEPA samples is EPA-9 algae from the South Pond, 79 pCi/g dried weight ^{238}Pu, and EPA 28 - some fish which had .87 pCi/g ash ^{238}Pu. Also interesting is the fact that where it was analyzed for ^{242}Pu was higher than ^{238}Pu in the USEPA samples. The algae sample and the fish sample, in addition to the newspaper article clipped from the Cincinnati Enquirer lead me to believe that there may be some concentration and uptake of Plutonium in the food chain. I am especially worried that some of the plants in the area, like the cattails growing in the canal may contain very high ^{238}Pu concentrations and additional sampling is warranted. If plant contamination is shown, Mound may have to take some additional precautionary measures. I am also not convinced that the pipeline rupture was the source of all the contamination in areas where runoff from that source is unlikely. All of the slides and sheets that Mound has presented have not convinced me that the safety record of Mound is complete.

Also, these facts come to mind: part of the canal dried up this summer and was not moist and/or overgrown. The area of contamination is obviously greater than .01 square miles of area. Most of the safety recommendations are based upon unknown calculations in relation to resuspension factors, sediment level, and dust levels. One of the major problems is that USEPA guidelines for sdeiments and soil samples have not yet been issued. At any rate, I am not overconfident that all of Mound's gentle words and assurances are appropriate.

sjg

Attachment

(3)

Ref. 12

Report of the Ad Hoc Committee to Evaluate the Health and Safety Aspects of ^{238}Pu in the Environment Adjacent to Mound Laboratory

to
The Manager, Albuquerque Operations Office
Energy Research and Development Commission
Albuquerque, New Mexico

February 1976

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REPORT OF AD HOC COMMITTEE TO EVALUATE THE HEALTH AND SAFETY ASPECTS OF THE ^{238}Pu IN THE ENVIRONMENT ADJACENT TO MOUND LABORATORY

In January 1969 a rupture occurred in an underground pipeline at Mound Laboratory in Miamisburg, Ohio. The pipeline carried waste from the Plutonium Processing Facility down a hillside to the Waste Disposal (WD) Facility (Figure 1). As indicated by Table 1, mitigating actions were immediately taken by laboratory personnel, including excavation of contaminated soil, repair of the pipeline, and initiation of a sampling program in 1971 to measure plutonium residuals in the air, soil, and water near the site.

Excavation began at the rupture site on January 24 and soil containing approximately 185 Ci of ^{238}Pu was placed in metal drums. Excavation was completed and the pipeline was repaired on January 26. Beginning on January 28, before the excavated site could be cleaned up, the Miamisburg area and the Mound Laboratory site experienced very heavy rainfall which continued through January 31. Cleanup began on February 1 and from February 7 to 17 soil containing approximately 35 Ci of ^{238}Pu was removed from selected areas on the hillside where the leak had occurred and placed in metal drums. In April of 1969 the excavations were filled with uncontaminated soil.

Routine environmental sampling was begun on and offsite in 1971. Initial 1971 ^{238}Pu analysis of samples of sediment from the offsite canal gave

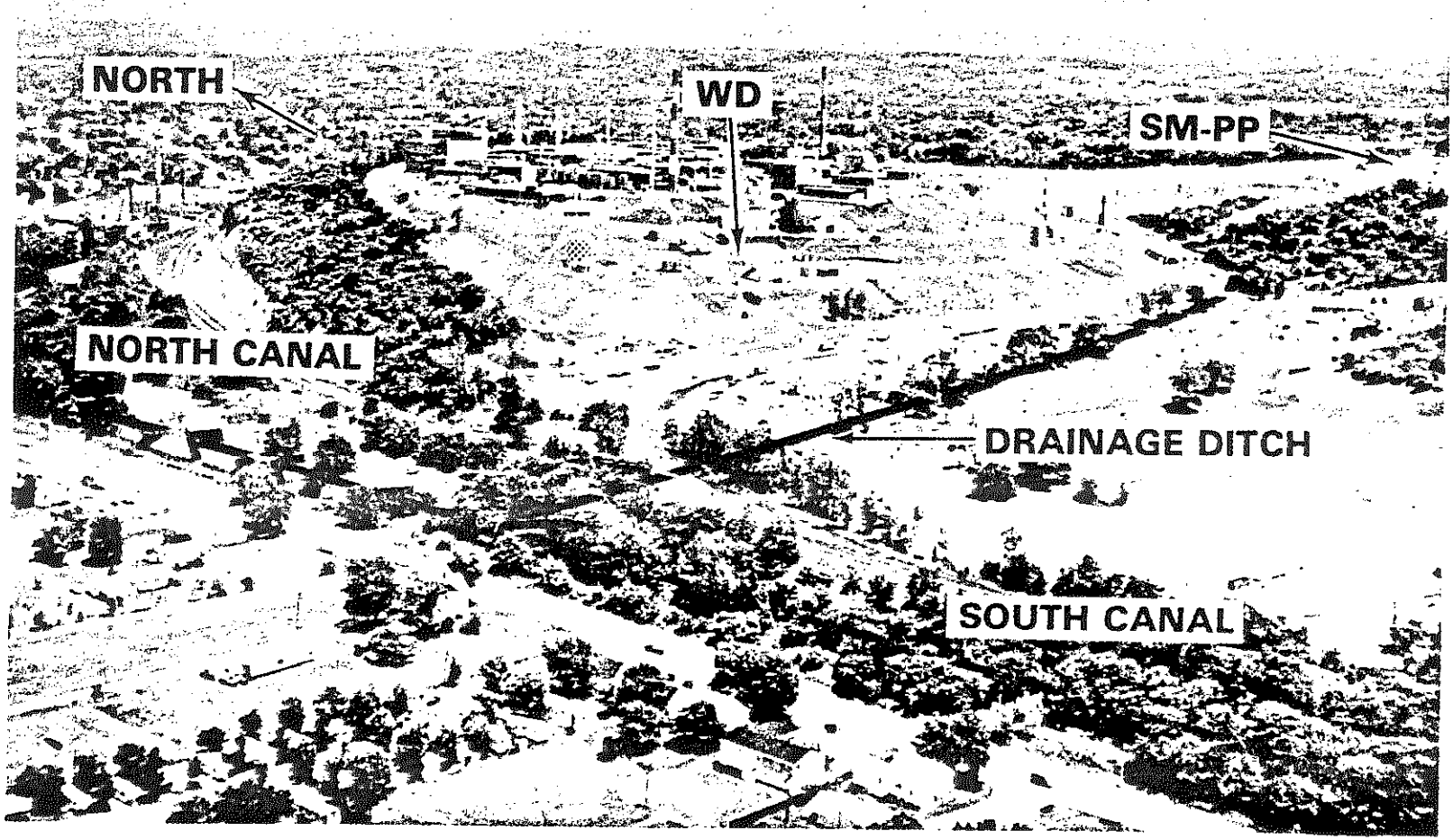

FIGURE 1. Aerial View (From the West) of Mound Laboratory Showing Major Surface Hydrological Arteries

TABLE 1. Chronology of Events Following Pipeline Rupture

1969	(Jan 23)	Process waste pipeline ruptured near Waste Disposal Facility.
	(Jan 24-26)	Excavation and repair at rupture site. Approximately 185 Ci ^{238}Pu/soil drummed and placed on road at end of WD Street.
	(Jan 26)	Pipeline repaired.
	(Jan 28-31)	Intensive rainfall.
	(Feb 1-7)	Area cleanup.
	(Feb 7-17)	Soil removed in selected areas of hillside; approximately 35 Ci ^{238}Pu/soil drummed.
	(Apr)	Excavations filled with uncontaminated soil.
1971		Weir dam and sampling station constructed on main drainage ditch.
1971		Grab sediment samples collected, ^{238}Pu results erratic
1974	(Jan-Feb)	Sediment core samples taken, clear indication of ^{238}Pu.
	(Apr 26)	Mound Laboratory notified AEC.
	(May)	First safety evaluation performed by Mound. Detailed sampling plan devised, reviewed and approved by AEC and others.
	(May 15)	Public announcement of offsite ^{238}Pu deposit.
	(May 25)	^{238}Pu sediment interaction measured.
	(Jun)	Temporary sediment control dams built on drainage ditch. Mound Plutonium Study and health and safety analysis begun.
	(Jul)	Extensive onsite survey and sampling begun.
	(Aug)	WD hillside found to be contaminated; covered with plastic to control erosion.
	(Sep)	35 Ci ^{238}Pu/soil removed from WD hillside and boxed. Results of Mount Plutonium Study and health and safety analysis reported to AEC/DAO, ALO, DMA, DBER, DOS, Commission.
	(Oct 2)	Briefing of federal, state, and local health agencies. Press conference at Mound, briefing of Joint Committee and Congressional Representatives.
1975	(Feb 19-20)	Detailed presentation to scientific review panel.

inconsistent results. In January and February of 1974 core samples of sediment were analyzed and a clear indication of the amount of ^{238}Pu in the canal bed was obtained. In June 1974 temporary dams were built on the drainage ditch which empties into the canal to minimize transport of ^{238}Pu offsite. On the recommendations of consultants, an intensive study of the ^{238}Pu release was begun, including detailed sampling of the environment around Mound Laboratory.

It is estimated that the soil of the hillside still contains about 36 Ci of ^{238}Pu. Sampling results indicate that about 9 Ci were transported offsite via the ditch to the canal. In addition, there was an estimated total release to the environment of about 0.5 Ci by all other air and water routes between 1960 and 1974.

In January 1975, General H. C. Donnelly, Manager of the Albuquerque Operations Office of the Atomic Energy Commission (now Energy Research and Development Administration), appointed an ad hoc Committee to evaluate the health and safety aspects of ^{238}Pu in the environment of Mound Laboratory. The ad hoc Committee was specifically asked to:

1. examine the results of the Mound Laboratory ^{238}Pu study,
2. review the health and safety analyses performed by Mound Laboratory, and
3. determine whether the plutonium deposited in the offsite areas of the canal, ditch, overflow creek, ponds and river constitutes a hazard to the general population, now or in the future.

On February 19 and 20, 1975, at Mound Laboratory, the ad hoc Committee was briefed on the events leading to the discovery of plutonium in the environs of the Laboratory site and on the Mound Laboratory ^{238}Pu study. The Committee also inspected relevant on-plant and off-plant sites and identified the information that would be needed to complete the evaluation. By April 11, 1975, the Mound Laboratory staff had provided this information (Table 2). This, with the material presented at the February briefing, formed the basis for the Committee's review.

TABLE 2. Information Requested for Use in Evaluation

1. Chronology of events
2. Calculation of inventory at rupture site
3. Hydrology and geology of release site
4. Sources of ^{238}Pu which moved offsite
5. Distribution of plutonium at rupture site
6. List of other radioactive effluents including release routes and amounts
7. List of consultants and copies of relevant reports
8. Soil properties at WD site
9. Relationship of Mound Laboratory to Argonne National Laboratory Studies
10. Plans for continued surveillance of release site, canal, and river areas
11. Copies of environmental monitoring reports for 1973 and 1974
12. Plans for control of canal and and adjacent areas
13. Measurements of plutonium in soil along banks of canal
14. Continuous air sampling data from vicinity of canal
15. Examples of publicity
16. Relevant meteorological data
17. Flow sheet of sample analyses

RECOMMENDATIONS

The ad hoc Committee has determined, on the basis of the data submitted by Mound Laboratory, that the ^{238}Pu released to the environment during the 1969 process waste pipeline rupture is not, under present conditions, a health hazard to persons living in the vicinity of Mound Laboratory. However, the Committee recognizes both that there are some deficiencies in the sampling data and that possible future physical modifications to the sites of plutonium deposition in the canal and pond areas could alter the amounts of plutonium available for contamination of the local human population. In the interests of avoiding future health risks, the following recommendations are offered.

AIR SAMPLING

The Committee believes that inhalation of airborne plutonium is the major potential route of contamination for persons who reside in the vicinity of Mound Laboratory. Therefore, we recommend increasing the scope of the air sampling program. In particular, extensive sampling in the vicinity of the pond and canal area is necessary to assure that plutonium presently associated with the pond and canal sediments does not become airborne as a result of geologic, hydrologic or meteorologic forces or human intervention.

PLANS FOR CONTROL OF DRAINAGE WATER

Offsite sampling results indicated that about 9 Ci of ^{238}Pu were transported via the drainage ditch to the canal as a result of the pipeline break. Since that time two dams have been installed in the drainage ditch to form settling ponds. The Committee supports this action, but also recommends improvement of onsite drainage and elimination of the flow of drainage ditch water into the North Canal. In addition, stream gaging and sediment sampling stations should be installed and perforated access tubes should be located on the WD hillside to monitor the translocation of plutonium. Construction of a large-volume retention basin will help prevent further offsite release of plutonium. Finally, the Committee recommends that stabilization of the area of highest plutonium concentration in the North Canal, either by water or other means, be considered.

PARTICLE SIZE ANALYSIS

Limited data indicate that most of the plutonium in the pond and canal is well distributed among the particulate matter in the sediment. However, the presence of some particulate plutonium can be assumed from the star tracks seen in autoradiograms of the sediment samples. Whether the particles are plutonium or clay particles heavily contaminated with plutonium is unknown. The Committee recommends preparing autoradiograms of the air samples collected in this area to determine the form of plutonium which becomes airborne.

ADSORPTION - RESORPTION OF PLUTONIUM ON CLAY PARTICLES

To properly address the question of long-term mobilization of plutonium released to the environment, it is necessary to understand the dynamics of the adsorption of plutonium to clay and other surfaces in the soils and sediments. The Committee recommends that consideration be given to obtaining this information for use in modeling the long-term behavior of plutonium in the environment of Mound Laboratory.

ASSESSMENT OF POTENTIAL HEALTH RISKS

This estimate of possible risks to the population in the Miamisburg area from ^{238}Pu is based on absolute risk estimates for the U.S. population at large taken from the BEIR Report.[1] The BEIR Report uses the linear nonthreshold model, the most conservative model available. The 50-year dose commitments for the Miamisburg population are given in Table 3.

TABLE 3. 50-Year Dose Commitments for Miamisburg Residents in Rem*

	bone	liver	lung
Sum of all ingestion and absorption pathways	.18	.09	--
Inhalation	.025	.012	.0038
Total, ingestion and inhalation	.2	0.1	.004

*See following sections for development of the dose commitment values.

Risk estimates are given for 10^6 persons and for a population of 10,000, or the number of persons who could presumably be exposed over a 50-year period. (This group was selected as representative of the Miamisburg population which in 1970 numbered 14,797.) The risk estimates are based on the following equation:

$$\text{Deaths}/10^6 = \text{risk per } 10^6 \text{ person/year/rem} \times \text{number of years at risk} \times \text{average dose}$$

Table 4 shows the number of cancers of bone, lung and liver (whole body) calculated using this model. In addition, the table gives the population death rate from a natural background of 100 mrem per year for 50 years, or 5 rem, assuming the same model is used for comparison. The last column of Table 4 presents calculations for a population of 10,000 persons, a conservative estimate in view of the number of persons who could be exposed in the Miamisburg area.

Ratios of death rates attributable to ^{238}Pu compared with those from the natural background are 0.04 for bone cancer, 0.0008 for lung cancer, and 0.02 for liver (all other) cancer. The estimated numbers of deaths that could be attributed to ^{238}Pu using a linear nonthreshold hypothesis are thus seen to be negligible in relation to those attributable to the natural background. The Committee has therefore concluded that the ^{238}Pu spill at Mound Laboratory will not contribute significantly to an increase in cancer incidence or cancer death rates in the Miamisburg, Ohio area.

TABLE 4. Calculation of Risks* From ^{238}Pu in Miamisburg, Ohio for 50 Years of Exposure

Page Ref. in Beir	Organ-System	Absolute Risk* Best Estimate Cases or Deaths Per 10^6 Persons/ yr/rem	Absolute Risk* Lower 90%	Absolute Risk* Upper 90%	Years at Risk	50-yr Dose Commitment (rem)	Deaths Per 10^6 Persons in 50 Years Best Estimate	Deaths Per 10^6 Persons in 50 Years Lower 90%	Deaths Per 10^6 Persons in 50 Years Upper 90%	Deaths Per 10^4 - Best Estimate	Deaths/10^6 Persons in 50 Years Due To Background	Deaths For 10^4 Persons Due To Background
p. 129	Bone for ^{226}Ra	0.11	0.087	0.13	50	0.2	1.1	0.87	1.3	0.011	27.5	.275
p. 151	Lung - Uranium Miners	0.53	0.46	0.60	50		0.11	0.09	0.12	0.0011	132.5	1.325
	Lung - Fluorospar Miners	1.6	1.3	1.9	50		0.32	0.26	0.38	0.0032	400	4
p. 152	Lung - Thorotrast Patients	0.53	0.18	1.1	50	0.004	0.11	0.036	0.22	0.0011	132.5	1.325
p. 171	Whole Body - All Other Cancers (e.g., Liver)**	1	-		50	0.1	5			0.05	250	2.5

*These calculations are based on risk estimates taken from the BEIR report.(1) Background is estimated at 100 mrem/year. The 1970 census showed the population of Miamisburg to be 14,797. Risk estimates based on 10^4 persons included for comparison.
**Leukemia is excluded.

EVALUATION OF ENVIRONMENTAL DATA COLLECTING PROCEDURES

CORE SEDIMENT SAMPLING PROCEDURES

In the opinion of the Committee, the core sediment sampling program conducted in the Miami-Erie Canal and adjacent waterways has been adequate to define gross ^{238}Pu contamination[2,3] and to provide an inventory of ^{238}Pu throughout the canal and waterways.

Because the cores were subdivided into depth intervals of 1 foot, refined estimates of depth distribution of ^{238}Pu within the canal were not possible. Disparity in ^{238}Pu concentrations within and among cores probably reflects differences in proportions of reactive sediment components (the natural variability in reactive colloids versus nonreactive, coarser-grained silicates within each sample), real differences in lateral and vertical ^{238}Pu distribution profiles, and confounding due to sampling procedures. It is extremely difficult to extract an uncompressed and undisturbed core that exactly reproduces the natural structure of a canal sediment.

On May 6, 1975, Dr. L. P. Wilding made an onsite examination of sediments in the canal structure and attempted to obtain undisturbed cores. He encountered some sediment attributes that make such sampling difficult: water logged-low bearing capacity sediment conditions, presence of living and dead organic debris throughout the core section, stratified geologic bedding of sediments (ranging from lenses of coarse-grained sands through

organic-rich clays), and presence of foreign debris (tin cans, wood, etc.). In such situations upper sediment zones are compressed to a greater degree than are underlying, more consolidated canal bed-floor materials. Attempts to uniformly partition compression throughout the core generally introduce significant depth-control errors.

To obtain a sediment core with minimum disruption would require a large-diameter coring device (4 to 6 inch diameter) with a razor-sharp, beveled cutting edge. The coring device would be gently pressed into the sediments with a twisting motion so the cutting edge would sever vegetative debris without compressing and compacting underlying sediments. From such a core, a refined vertical depth distribution of ^{238}Pu could be ascertained which would reflect geologic bedding strata or permit arbitrary close-interval (1 to 2-inch) vertical sampling.* The upper 2 or 3 feet would be most informative in this regard.

WATER SAMPLING

During 1974 the concentration of ^{238}Pu was routinely measured in 500 cc water samples from the following locations, shown in Figure 2:[2]

1. The pond-canal area --
   a) North Pond - 249 samples

*Comments to Mound Laboratory from J. Roger McHenry

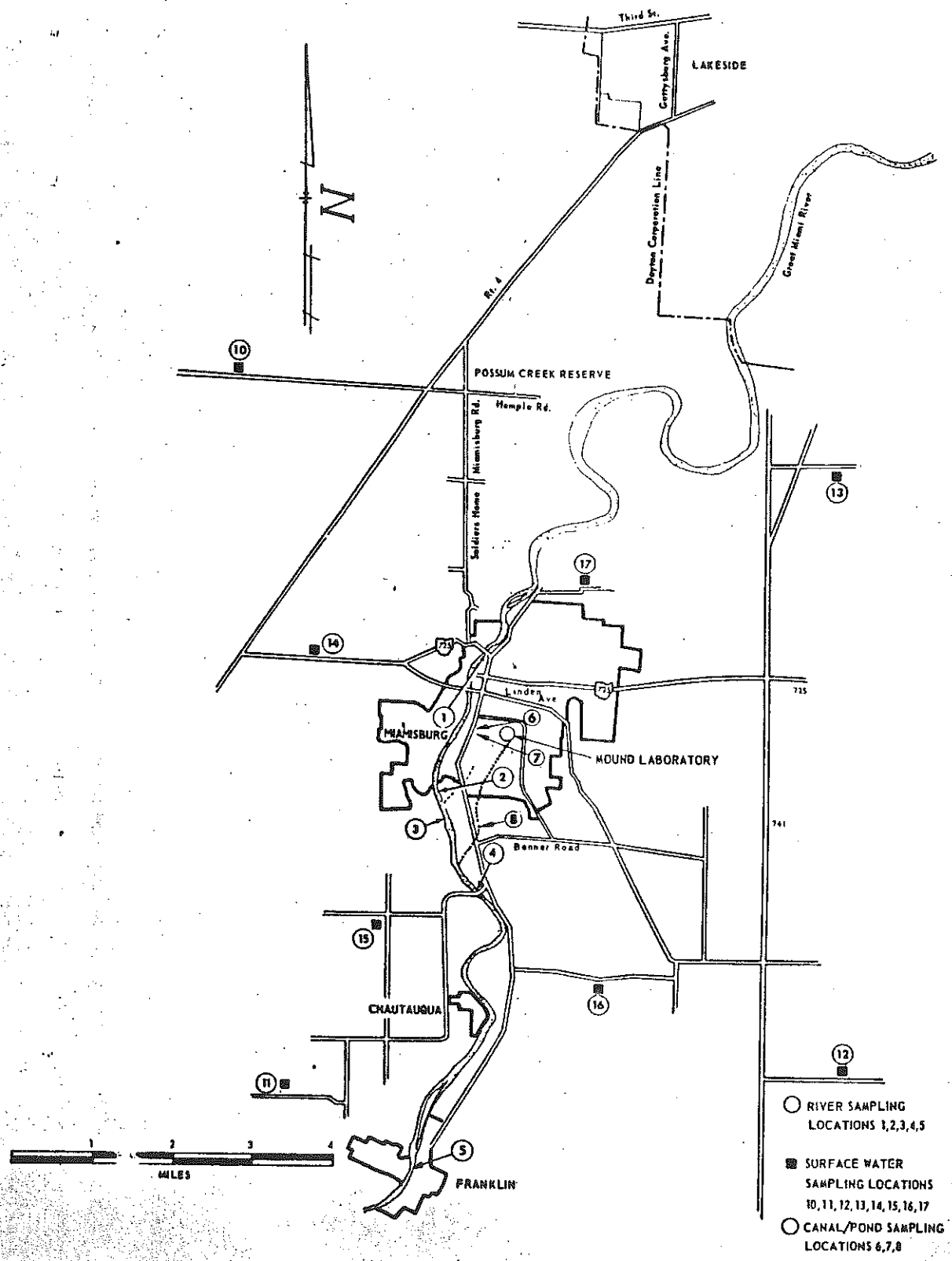

FIGURE 2. Offsite Water Sampling Locations

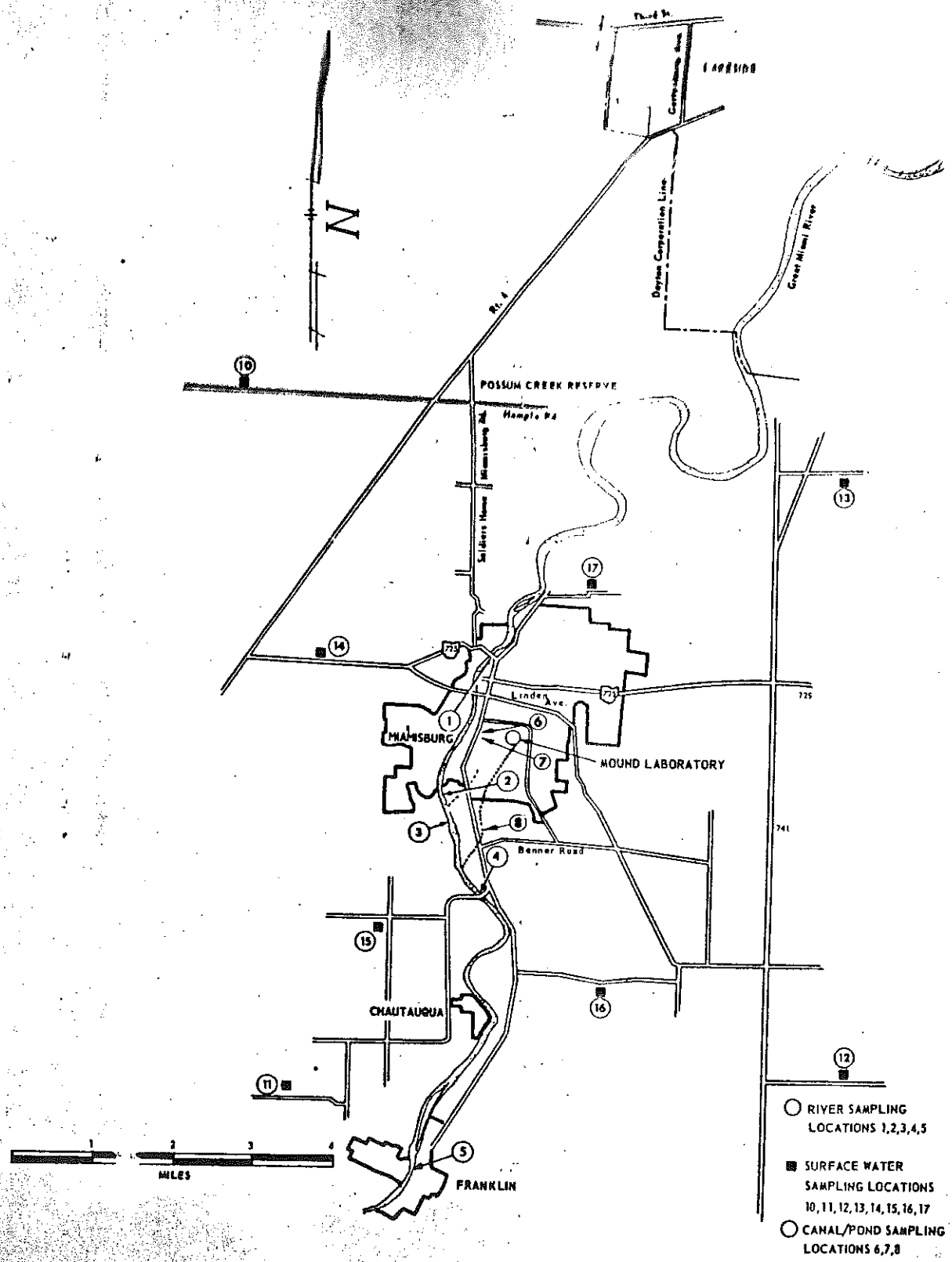

FIGURE 2. Offsite Water Sampling Locations

b) North Canal - 249 samples

c) South Canal - 249 samples

2. The Great Miami River - 249 samples from each of five locations on the river, one above the plant site and four below the plant site.

3. Offsite surface water - four samples from each of eight locations located from about 2-1/2 to 6 miles from the laboratory.

Samples from the pond-canal area and the Great Miami River were collected daily and the ^{238}Pu analyses were performed on a monthly composite of the daily samples. Quarterly samples were obtained at the offsite surface water locations.

In addition, approximately 50 samples of water which accumulated in the sampling (coring) tubes were collected for ^{238}Pu analysis during the detailed sampling in 1974 to ascertain the extent of ^{238}Pu contamination of the waterway leading from the laboratory to the Great Miami River.[2] The water was filtered and the filtrate and particulate matter were analyzed separately.

A periodic water sampler (20 ml/1000 gal) has now been installed at the weir on the main drainage canal near the site boundary. This sampler and one at the sanitary sewer outfall monitor the ^{238}Pu in all discharged water that originates from the WD area. These samplers, however, do not integrate the ^{238}Pu that is associated with the sediments washed offsite.

The Committee considers the water sampling program sufficient to adequately monitor the presence of any ^{238}Pu in the aqueous environment and to detect any ^{238}Pu that is inadvertently discharged from the site. However, we recommend developing a means of integrating sediment-bound ^{238}Pu at the weir, or establishing that with the hold-up basins this mode of transport is not significant.

AIR SAMPLING

The air samples in the vicinity of the canal are taken in insufficient numbers, at only one location, and for very short sampling periods. Samplers should be used to ascertain the ^{238}Pu content in air immediately north, south and west of the canal and pond area.

Prediction of air concentrations solely from a knowledge of surface soil concentrations is at best an approximate procedure, especially where the activity is nonuniformly distributed and some of the soil is under water part of the year. Permanent sampling locations should be established and operated for several years.

Accordingly, air concentrations measured over all seasons of the year are required to establish the airborne ^{238}Pu concentration. Information about particle size distribution in air (for example, determination of respirable fraction with a two stage sampler) is needed on a short-term (i.e., less than one year) basis. Such a research station might be established by the

ERDA Health and Safety Laboratory. In addition, information on mass loading of the filters is desirable and should be collected along with all measurements of ^{238}Pu in air.

^{238}PU SORPTION AND TRANSPORT IN SOIL, WATER AND AIR AT MOUND LABORATORY SITE

At the Mound Laboratory site, the major avenue for transport of plutonium in soil, water or air is by physical processes. Plutonium that enters the soil sorbs strongly to soil colloids and in this particulate phase can be transported by geologic, hydrologic, or meteorologic forces. Likewise, plutonium that enters a waterway tends to quickly and strongly sorb to the sediments, with which it is transported. In the presence of soils or sediments very little plutonium enters the solution phase. A more detailed discussion of transport processes is presented in Appendix A.

TRANSPORT IN SOILS AND SEDIMENTS

On May 6, 1975, Dr. L. P. Wilding conducted on onsite examination of the bedrock and soils in the Mound Laboratory Area. This study is described in Appendix A.

Results of the study indicated that the bedrock of the area (and specifically that in the vicinity of the leak, near the WD building) is not generally conducive to rapid vertical transfer of pollutants, as would be associated with leachate percolating into deeper major groundwater supplies. In addition, reactive surfaces exist for sorption of cationic pollutants.

Soil and landform conditions in the watershed surrounding the leak site make this area highly susceptible to intense erosion. Sediments eroded from the vicinity of the leak site are mixed with other erosion products from the watershed and transported to the Miami-Erie Canal via surface drainage. The only access to the canal from the watershed is through two 5-foot diameter culverts cut through a railroad embankment. The embankment forms a hydrological restricting barrier between the major portion of the watershed and the canal. The railroad embankment and the two outlet culverts control the maximum rate of discharge to the canal.

Hydrologically, this drainage system promotes continued sedimentation of erosion products in the canal. Even with high intensity, low frequency storms it is improbable that significant amounts of sediments in the South Canal structure would be eroded and transported downstream or that they would experience secondary movement by fluvial processes. However, such fluvial processes may disaggregate sand and silt-size clay aggregates, yielding clay colloids for resuspension and secondary transport downstream.

At Mound Laboratory, ^{238}Pu from the leak site was apparently dispersed in the overland flow of soil erosion products. Initially, upon pipe rupture, acid waste containing the plutonium interacted with calcareous soil in the immediate vicinity of the pipe. Channeling and fissuring of the soil probably occurred upon carbonate dissolution and thus some ^{238}Pu would have moved into solution prior to its sorption to the noncarbonate soil complex. However, rapid transfer of soluble ^{238}Pu to underlying soil and bedrock

would have been prevented by the high seasonal soil moisture regime, the impermeable soil conditions, the high soil carbonate levels, and the rapid sorption to soil colloids, even under strongly acid environments. Actual vertical movement of ^{238}Pu immediately below the pipe rupture was to at least 8 feet, or 12 feet below the soil surface.[3] The precise lower limit of vertical dispersion at the leak site is not well documented.

When the site was excavated to repair the ruptured pipe, apparently plutonium-contaminated soil was exposed at the surface and left unprotected. Both at this time and during subsequent periods when contaminated soil was exposed to the elements (before vegetative stabilization), plutonium-contaminated soil materials would have been transported downslope. Sedimentation of these deposits would depend upon the interaction of particle size and fluvial energy. Many natural sediments agglomerate to form sand- and silt-sized aggregates of clay. These coarser separates would retain high plutonium-sorption activity but be sensitive to sedimentation wherever slope gradient, water velocity, and thus fluvial energy decreased. Major points of sedimentation would be near the mouth of the watershed, particularly near the junction with the abandoned Miami-Erie Canal and throughout both sectors of this canal. Finer-grained colloidal sediments would remain in suspension and be transported to points further downstream prior to deposition. Because plutonium is not readily desorbed from the soil, either during transport or after deposition, it moves wherever the particles are physically moved.

Another mechanism that could cause movement of ^{238}Pu to deeper soil or bedrock zones at the leak site is detachment and suspension of contaminated colloids with the downward front of soil leachate. A rapid influx of water into a cracked and fissured soil during periods of soil moisture stress often causes this effect.

A third possible mechanism for redistribution of plutonium within soils would be biological uptake and chemical redistribution within the organism. Such a mechanism has been demonstrated for plutonium translocation from barley shoots to roots after uptake in soils.[4] This could represent a significant internal recycling mechanism for plutonium in the soil environment.

TRANSPORT IN WATER

As indicated by the discussion of ^{238}Pu transport in soils, transport of soluble plutonium in water is of negligible consequence. Rodgers et al.[3] found that the distribution ratio of ^{238}Pu in water to that of sediments in the Miami-Erie Canal was about 1×10^{-5}. In addition, equilibrium stuides in water by Dahlman et al.[5] at ORNL demonstrated that only 0.005% of plutonium added to a Ca-humate (organic matter fraction) was desorbed at pH 6.5; with montmorillonite and kaolinite clays about 2 to 3% was desorbed. Plutonium sorption efficiency was reduced when organic matter and iron oxide coatings were removed from natural clays; upon such treatment 1 to 5% of the added plutonium was found in solution. Even weak citrate solutions

which could form complexes with plutonium were not effective in desorbing it from the humic acid fraction of organic matter; only 0.5% of the added plutonium was found in solution. (See Appendix A for further detail.)

It was concluded that under conditions such as those prevailing at Mound Laboratory, plutonium would not remain in solution but rather would be quickly and strongly sorbed to soil colloids. This would be particularly true for sediments containing high levels of organic matter, such as those in the canal structure. When the energy of the fluvial medium is sufficient to suspend plutonium-contaminated soil separates, the only significant movement of plutonium in water will be by physical means. Thus, the major vehicle for plutonium transport in this environment is by particulate phase, rather than solution phase.

TRANSPORT IN AIR

Wind speed and direction data are not available for Miamisburg but have been summarized for the Dayton area. Although it is probably misleading to extrapolate directly from Dayton to the canal vicinity, the available data can indicate general meteorologic trends in the area.

In Dayton, average morning windspeeds are highest in winter and lowest in summer, while afternoon windspeeds are highest in winter and spring and lowest in summer.

Most of the observed soil contamination is south of the park, so southerly winds are more likely to be sources of exposure from resuspension than northerly or westerly winds. The frequency distributions for spring, summer and autumn (the swimming season for this area) are shown below.

	Frequency Distribution (%)	
	SE to WSW (135°-247°)	S to WSW (180°-247°)
Annual Average	46	35
Spring	41	31
Summer	49	39
Autumn	48	31

Thus, the wind blows from the south or southwest toward the park about 40% of the time.

RESULTS OF 1974 SAMPLING PROGRAM

WATER

The average concentrations of ^{238}Pu measured in the water samples collected daily in 1974 were ≤ 2 pCi/l in the North Pond, 5.0 + 0.4 pCi/l in the North Canal, and 19 $\pm$ 1 pCi/l in the South Canal. This compares to about 1 pCi/l in samples from the Great Miami River and <1 pCi/l in the offsite surface water samples collected at various distances from the laboratory.

The ^{238}Pu concentrations measured in the water associated with the core samples were generally low, varying from about 0.1 to 10 pCi/l.[2] One sample from the North Pond (1A core series), however, was reported to contain ~19,000 pCi/l. This value appears high since the concentration in the associated sediment was not atypically high, 22 pCi/g, nor were concentrations in any other water samples from the pond (0.1-0.4 pCi/l). This value may be due to particles that escaped filtration or, more likely, to cross contamination during analysis. These data indicate a concentration ratio of water/sediment on the order of 10^{-5}, as reported by the laboratory.[3]

The total ^{238}Pu activity discharged during 1974, as measured at the weir and at the sanitary sewer outfall, was 4 mCi (Item 6). If it is assumed that all 4 mCi of ^{238}Pu released were in a soluble form and the average low flow of the Great Miami River is 212 cfs, or 1.9×10^{11} l/yr, the 4 mCi released

would produce a concentration in the river of 0.02 pCi/l, well below the minimum detectable level of about 0.4 pCi/l. This amount would not contribute significantly to the environmental ^{238}Pu level, considering the 9 Ci previously released to the environment as a result of the 1969 waste pipeline rupture near the WD site.

AIR

Air sampling in the vicinity of the canal and ponds has been infrequent and of short duration. Between April 1974 and February 1975, 14 samples were collected, each for about 2 hours, with a high-volume modified Staplex air sampler situated about a foot above the ground. Eleven of these samples were taken in September and October.

Seven samples were taken east of the North Canal near the Monsanto discharge ditch, six east of the North Pond, and one east of the South Canal (Figure 3). With the exception of one sample which averaged 55×10^{-15} μCi/cc, the samples ranged between 0.4 and 7.2×10^{-15} and all averaged 6×10^{-15} μCi/cc. If the high sample is neglected, the average is 2×10^{-15} μCi/cc. The total sampling time was 28 hours.

It is not clear whether these concentrations represent local resuspension phenomena or merely reflect concentrations in air which are characteristic of normal plant operation, as the average of these samples does not differ greatly from the annual average at onsite station #211. The annual

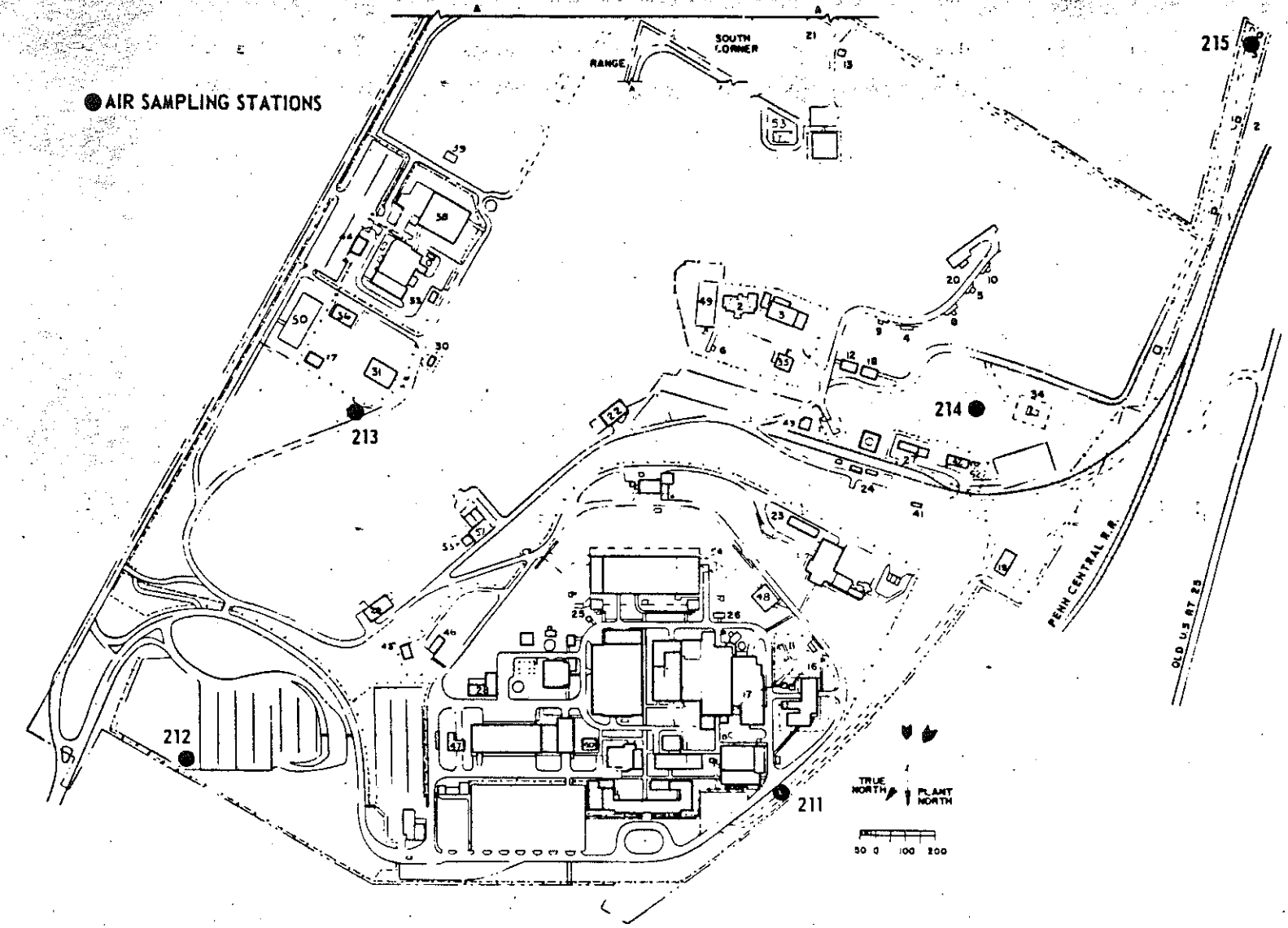

FIGURE 3. Onsite Air Sampling Locations

averages are plotted in Figure 4. They generally exhibit a decreasing concentration in the order of onsite samplers to offsite samplers, with the highest onsite sampler exhibiting concentrations almost an order of magnitude above that in the highest offsite sampler (101). The phenomenon is depicted in Figures 5 and 6, in which monthly concentrations of ^{238}Pu in air for 1974 are plotted.

Finally, mass loading data for Station 101 are plotted in Figure 7, along with ^{238}Pu concentration and specific activity (in pCi/g) in air. The ^{238}Pu concentrations and mass in air do not vary in the same manner, which suggests that the two parameters (^{238}Pu and mass in air) do not have the same source. This conclusion might be interpreted to mean that resuspended ^{238}Pu from soil does not contribute significantly to total ^{238}Pu in air.

A continuous air sample taken during March 1975 at the newly established permanent air sampling location between the ponds showed a concentration of 7×10^{-17} μCi/cc,* a mass loading of 47 μg/m^3, and a specific activity of 1.5 pCi/g. This concentration is within the range of the 1974 average annual concentrations observed at the other permanent stations in the vicinity of Miamisburg. This result is consistent with the postulate that local contamination in and near the canal is making no appreciable contribution to the ambient air levels of ^{238}Pu. For April, the observed concentration was 1.4×10^{-17} μCi/cc.

*Revised value from letter of June 16, 1975 from R. L. Wainwright to W. J. Bair.

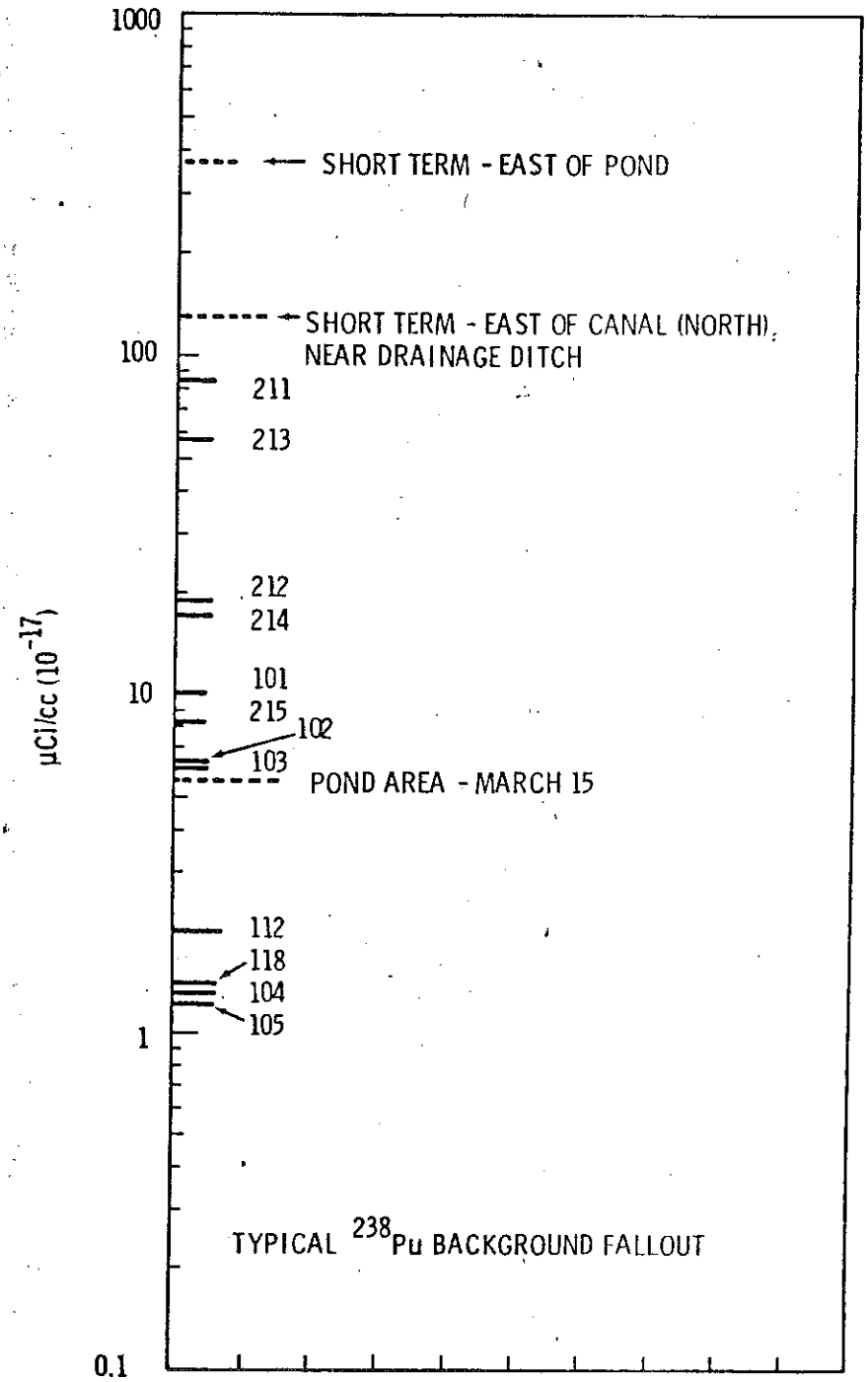

FIGURE 4. Annual Average ^{238}Pu Concentrations in Air at Permanent Fixed Sampling Stations

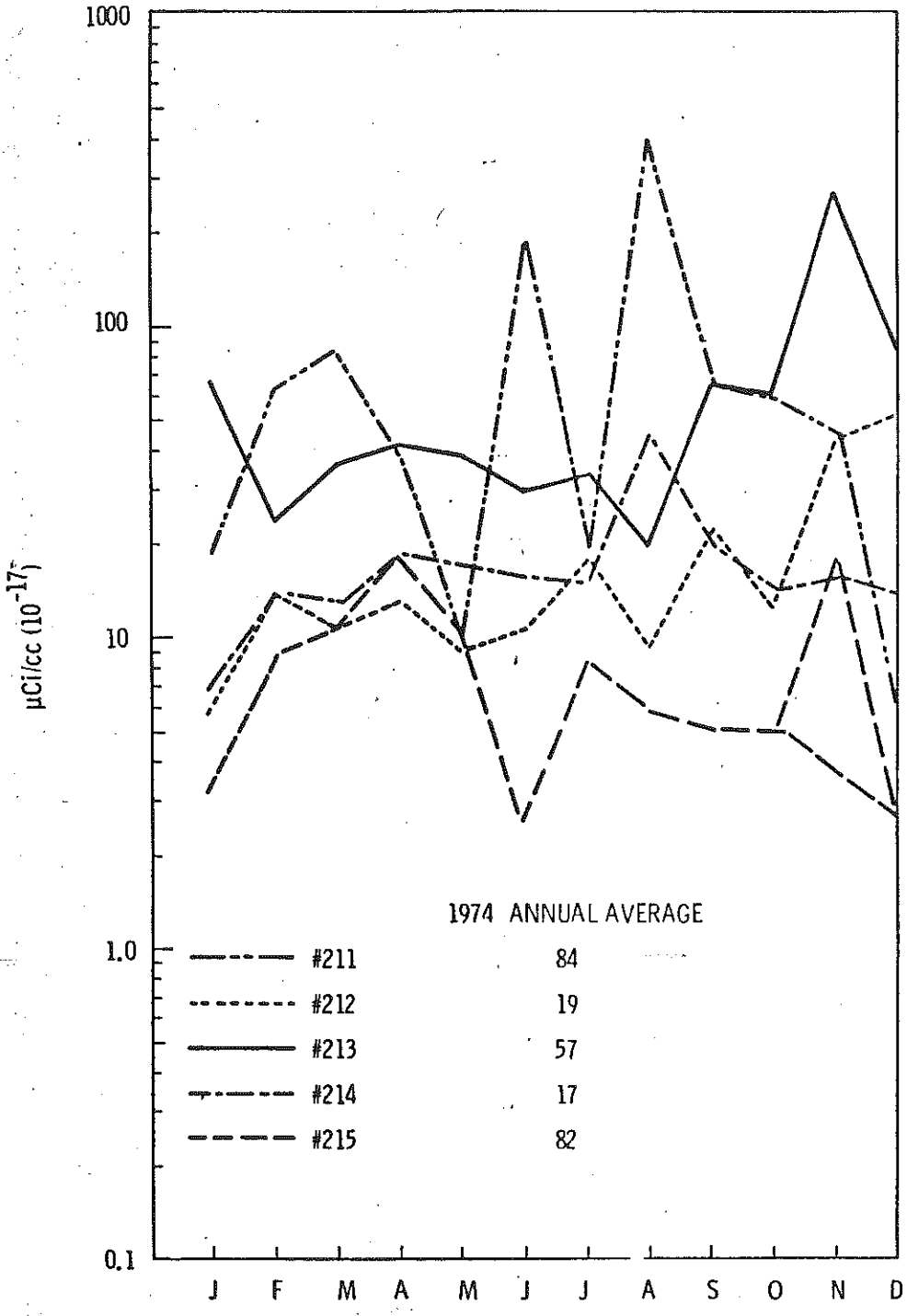

FIGURE 5. Monthly Concentrations of ^{238}Pu in Air, 1974 (onsite sampling stations)

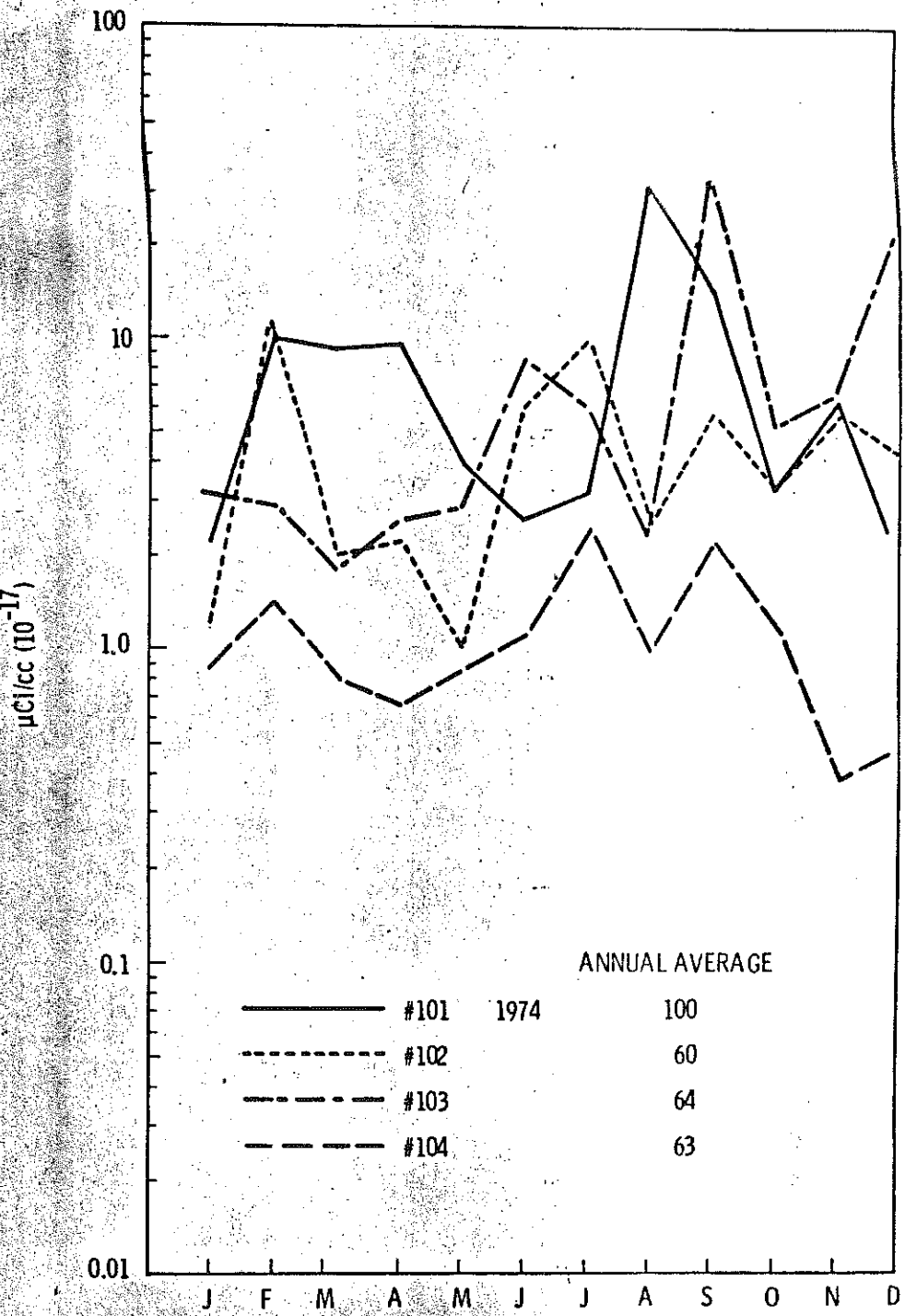

FIGURE 6. Monthly Concentrations of ^{238}Pu in Air, 1974 (offsite sampling stations)

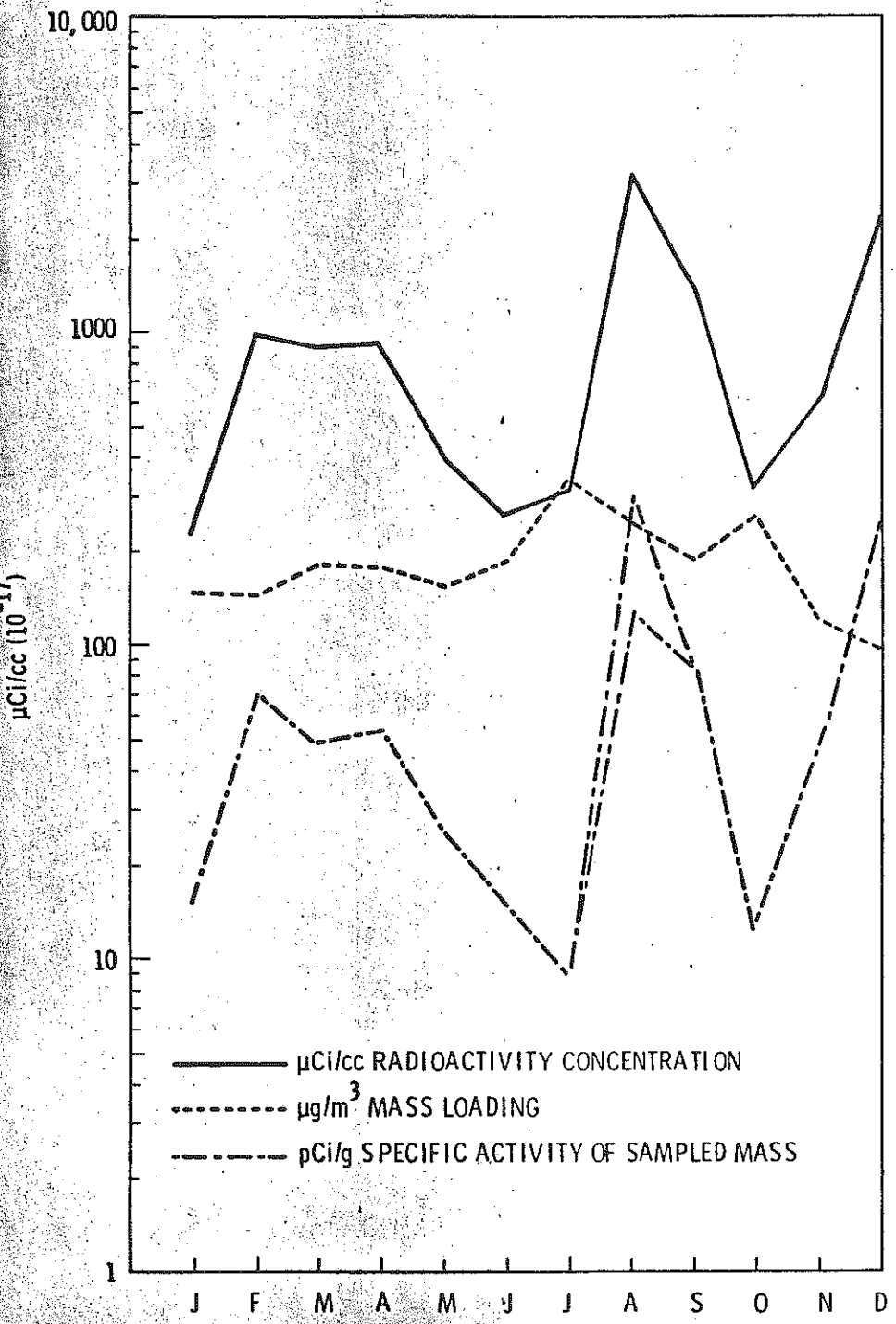

FIGURE 7. Mass Loading Data for Station 101 (offsite)

Data from the 1975 air sampling program are given in Table 5.

TABLE 5. Plutonium-238 Concentrations in Air at Mound Laboratory Site, 1974-1975

	Units of 10^{-17} μCi/cc
RCG (continuous occupancy)	7000
Maximum observed short-term air concentrations (2 hours)	5500
Average observed short-term air concentrations	600
Lowest observed short-term air concentrations	40
March 1975 average air concentration at new pond station*	7
April 1975 average air concentration at new pond station*	1.4
Annual 1974 average air concentration at Station 101	10
Annual 1974 average air concentration at Station 104	1.3

*Based on total monthly air sample

ESTIMATES OF RADIATION DOSES TO RESIDENTS OF MOUND LABORATORY AREA

The radiation dose calculations are based on the maximum "very surface" concentration in soils and sediments, 0.4 nCi ^{238}Pu/gm, and the average of 249 water samples collected from the South Canal during 1974, 0.019 nCi/l. The average concentration in surface soil from the canal area is 0.035 nCi/gm, or 0.1 times that used in the calculations, while use of water concentrations from the North Canal and North Pond would result in doses 0.26 and 0.11 times less, respectively. Other assumptions used in the calculations are listed in Appendix B.

CALCULATION OF RADIATION DOSES

To convert intakes into radiation doses, information and models from several ICRP publications were used.[6,7,8] The Medical Research Council (MRC) in Great Britain recently summarized the dose calculations for ^{239}Pu utilizing the new metabolic model for man:[9] to convert ^{238}Pu body burdens to skeletal dose, 4 nCi will deliver 3.0 rem/yr and 1 pCi = 0.75 mrem/yr.

The average dose equivalents to bone and liver from ingestion and to bone, liver, and lung from inhalation are shown in Table 6 for soluble (Class W) and insoluble (Class Y) compounds.

TABLE 6. Estimates of Dose Commitment Per Microcurie Intake

Mode of Intake	Organ of Reference	50 Year Dose Commitment (rem/μCi)
Ingestion:		
Soluble, Class W	bone	0.4
	liver	0.2
Insoluble, Class Y	gut	0.1
Inhalation:		
Soluble, Class W	bone	2000
	liver	1000
	lung	30
Insoluble, Class Y	bone	700
	liver	400
	lung	300

Average dose to each identified organ is calculated using a quality factor of 10 for alpha particles and a dose modifying factor of one for lung and liver and five for bone. The validity of these factors and the various ICRP models has been reviewed by the MRC.[9] They concluded that the recent models derive reasonable estimates of risk.

Although this evaluation is concerned only with ^{238}Pu, the alpha energy of ^{238}Pu differs only slightly from that of ^{239}Pu, so no significant dosimetric error will occur if the calculations for ^{239}Pu are used.

For the metabolic model described in ICRP-19,[8] it was assumed that Class W (soluble) compounds have an uptake across the GI tract of 3×10^{-5} and Class Y compounds (insoluble) of 10^{-6}. Average dose equivalent (rem) is calculated in bone, liver and lung. Distribution factors of five for bone and one for liver and lung are used; a quality factor of 10 is used for the alpha emissions.

Once plutonium enters the blood stream it is apportioned among bone (45%), liver (45%), and soft tissue (10%). Inhalation doses were calculated for typical aerosols of 1 μm activity median aerodynamic diameter (AMAD). Class Y compounds are retained in the lung with a 500-day half life.

To calculate dose, the constants summarized in Table 6 are multiplied by the appropriate intakes (see Appendix B). The most reliable air samples taken in the vicinity of the laboratory are those for which the monthly averages in March and April were 7 and 1.4×10^{-17} μCi/cc respectively. Since only two months' data are available, this calculation uses the higher value for the month of March as an annual average.

Table 7 shows the 50-year dose commitment to a standard man from inhalation during one whole year. (The dose commitment to a child, woman, or man of another size would probably not be severely under-represented by this analysis.) An estimate of dose for longer exposure periods must take into account years of exposure and the annual (50-year) dose commitment. For very long exposure periods (50 years or more) the dose commitment will

approach 1/2 the product of the annual 50-year dose commitment and the years of exposure (assuming the exposure rate remains constant).

TABLE 7. Fifty-Year Dose Commitment (rem) from Inhalation for One Year at 7×10^{-17} μCi/cc

Organ	Soluble (Class W)	Insoluble (Class Y)
Bone	10^{-3}	3.5×10^{-4}
Liver	0.5×10^{-3}	2×10^{-4}
Lung	1.5×10^{-5}	1.5×10^{-4}

Accordingly, the dose delivered over a 50-year period for continuous exposure at 7×10^{-17} μCi/cc would be 25 times (50/2) that shown in Table 7. Table 8 summarizes the estimates of dose (rem) which would be delivered during an exposure period of 50 years to individuals with the living habits and characteristics described in the assumptions.

TABLE 8. Summary Estimates of Fifty-Year Doses from Fifty-Year Exposure (Constant Intake Rates Specified in Appendix B)

Pathway	Fifty-Year Dose Commitment (rem)		
	Bone	Liver	Lung
Water → man	0.14	0.070	--
Water → fish → man	0.0012	0.0006	--
Soil → vegetables → man	0.0058	0.0029	--
Soil and water → beef → man	0.012	0.0058	--
Soil → man	0.0064	0.0032	--
Inhalation	0.025	0.012	0.0038*
Absorption through skin	0.0008	0.0004	--
Absorption through wounds	0.001	0.0005	--

*Class Y (insoluble); others are soluble (Class W) to maximize the dose estimate.

Table 8 may be simplified by combining all the ingestion and absorption pathway estimates (i.e., assuming an individual is simultaneously exposed to all these pathways). The dose commitments then become as indicated in Table 9.

TABLE 9. Dose Commitment for Exposure for Fifty Years (rem)

	Bone	Liver	Lung
Sum of all ingestion and absorption pathways	0.17	0.09	--
Inhalation	0.025	0.012	0.0038
Total: Ingestion and Inhalation	0.2	0.1	0.004

This describes the dose to an individual with all the habits and characteristics listed in the assumptions, Appendix B. Most of the dose would be due to ingestion, primarily of water and soil. The Committee believes that these doses are probably overestimated and related to extreme, rather than probable, cases.

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APPENDIX A

CONSIDERATIONS IN EVALUATING GROUND TRANSPORT OF ^{238}PU

The bedrock underlying the Mound Laboratory site is composed predominantly of calcareous Ordivician interbedded shale and limestone. Onsite examination of the bedrock exposure along the railroad tracks west of Mound Laboratory was conducted by Dr. L. P. Wilding on May 6, 1975. He found most of the bedrock to be calcareous, dark gray, fissile shale with interbedded fossiliferous limestone strata about 1 to 2 inches thick spaced vertically every 10 to 18 inches. It was estimated that 15 to 20% of the total exposure is limestone. All of the bedrock strata are flat-lying. Horizontal seep planes were observed between shale beds at interfaces with limestone beds, but no evidence of vertical fissuring or fracturing was evident. However, permeability tests conducted by Dames and Moore do indicate that vertical fissures occasionally occur in this bedrock, particularly in the more weathered upper section.

The nature of the bedrock and its orientation would not favor rapid liquid transfer through most of these materials. Water moving laterally through the glacial till or fill materials above would be intercepted by the shale-rich bedrock. Because of the low vertical permeability and transmissibility of the bedrock, most of the water moves along bedding planes until they are intercepted by the surface topography of the area. At such intersections,

seepage zones occur at the land surface. Soil and geologic shale materials upslope from the seepage zones are subject to land slippage during periods of moisture surplus, particularly those that occur on steep gradients.

In summary, the bedrock of this area (and specifically that in the vicinity of the leak, near the WD building) is not generally conducive to rapid vertical transfer of pollutants, as would be associated with leachate percolating into deeper major groundwater supplies. Although the shale components have less surface area and sorption capacity than finer-grained clay components derived from weathered shale deposits, they still contain reactive surfaces for sorption of cationic pollutants. These comments are particularly relevant to the movement of ^{238}Pu after rupture of the pipe leading to the WD building.

SOILS, SEDIMENTS AND HYDROLOGY IN MOUND LABORATORY AREA

The following standard definitions for soil, silt, and sediment follow concepts presented in the Glossary of Terms, Soil Sci. Soc. Amer. Proc. (SSSAP)[A-1] and Glossary of Geology and Related Sciences:[A-2]

Soil - "The unconsolidated mineral matter on the surface of the earth that has been subjected to and influenced by genetic and environmental factors of: parent material, climate (including moisture and temperature effects), macro- and microorganisms, and topography, all acting over a period of time and producing a product - soil - that differs from the material from which

it is derived in many physical, chemical, biological and morphological properties and characteristics."[A-1] In the case of Mound Laboratory, the soil can be considered the natural three-dimensional landscape bodies that have developed from geologic materials and are in situ in the present landscape.

Sediment - "Solid material, both organic and inorganic, that is in suspension, that is being transported or has been moved from its site of origin by air, water, or ice and has come to rest on the earth's surface either above or below sea level."[A-2]

Silt - "A soil separate consisting of particles between 0.05 and 0.002 mm in equivalent diameter."[A-1]

In upland, steeply sloping segments near Mound Laboratory, the soils have the following characteristics, as shown in Figure A-1: they are well drained, shallow to moderately shallow over bedrock (usually less than 40 in.), moderate to slowly permeable when wet (0.2 to 0.63 in./hr), fine-textured (30 to 50% clay content); they have a moderately high shrink-swell capacity (volume change of 6 to 8% over moisture range of air dry to 1/3 atm. moisture tension, and are moderately to strongly eroded (less than 50% of original surface soil remaining).

The soils have developed primarily in clay-rich till materials superimposed on Ordovician limestone (soils 644/B-1 and 644/D-3, Figure A-1). Soils associated with till deposits greater than 40 in. also occur in this area and are designated 604/B-2, 604/D-3, 604/C-θ, 604/B-θ, and 606/F-2 in Figure A-1. The B, C, D, E and F symbols signify slope ranges of 2-6, 6-12, 12-18, 18-25, and greater than 25%, respectively. The numerals (1, 2, and 3) following the slope classes signify slight, moderate, and severely eroded soil conditions, respectively, and θ represents areas where the natural soil has been disturbed by construction activities.

On May 6, 1975, Dr. L. P. Wilding also conducted an onsite investigation of the soil conditions at the leak site (see attached logs of auger borings). Information furnished by Mound Laboratory indicated the bedrock to be about 20 feet below the surface at this site, while the soils map suggested bedrock within 2 to 3 feet of the surface. Because shallow bedrock conditions could have an important bearing on initial and subsequent movement of ^{238}Pu from the leak source, an onsite evaluation was conducted. It was concluded on the basis of this examination that bedrock at the leak site is at least 10 feet below the present land surface, or about 5 to 7 feet below the pipe rupture.

Throughout this zone the soil materials consist of calcareous, dense glacial till that is nearly structureless, clay-rich, plastic and of low porosity. The till is low in organic matter (organic carbon) and strongly influenced by underlying shale-rich bedrock. Many flat limestone rocks occur in the upper 5 feet of the till "fill" materials. When the soil is

FIGURE A-1. Soil Types of Montgomery County, Ohio

saturated or sufficiently moist to be fully swelled, permeability is very low and transfer of fluids markedly restricted. Likewise, when these materials are saturated they are subject to land slip and slumping, particularly on steep slopes such as the one immediately east of the leak site. Seepage zones observed at the base of this slope likely reflect water transfer along bedded shale which has subsequently been intercepted by the present surface.

During summer periods of moisture stress, the soil at the leak site is highly susceptible to shrinkage and cracking. Rainfall during this period will result in rapid influx of water through desiccation cracks until the soil swells (in several days to several months) to close these fissures. Suspended colloids are detached from the conducting walls upon rapid wetting. They move with the percolating leachate until they are either physically filtered (as water is absorbed by the soil) or chemically precipitated. This process represents the major avenue for movement of ^{238}Pu to greater depths in the soil or bedrock once sorption to soil colloids has occurred.

Since the dispersion of ^{238}Pu from the ruptured pipe at the leak site occurred during a period of high seasonal soil moisture content, soil conditions would not favor rapid transfer of soluble ^{238}Pu into the underlying soil and bedrock prior to its sorption by soil colloids. This would be a decided concern in shallow soils over fissured bedrock, particularly during periods of soil moisture stress when soils are cracked and most of the flow is along these voids with little soil content or time for adsorption equilibrium.

Dr. Wilding collected samples of soil materials at the leak site and sediments at the southern tip of the North Canal during the site visit. Table A-1 gives the clay mineralogy (as determined by X-ray diffraction), carbonate mineralogy, and organic carbon status of these samples as determined by X-ray diffractograms (Figures A-2 through A-5).

TABLE A-1. Soil Characteristics at Leak Site and in Canal

	Soil at Leak Site	
	0-74"	100-134"
Clay Mineralogy*	Mica, Vermiculite, Kaolinite	Mica, Vermiculite, Kaolinite and Chlorite
Total Carbonates (%)	27.0	19.0
Calcite (%)	25.5	14.5
Dolomite (%)	1.5	4.5
Organic Carbon (%)	.36	Not Analyzed
	Canal Sediments	
	0-1"	2-6"
Clay Mineralogy	Mica, Expandables,** Vermiculite, Kaolinite	Same
Total Carbonates (%)	20.0	22.5
Calcite (%)	6.0	12.0
Dolomite (%)	14.0	18.5
Organic Carbon (%)	2.20	2.85

*Layer structure clays in decreasing order of relative abundance.
**Minerals which expand beyond 14.5 A upon glycolation (including montmorillonite and interstratified montmorillonite-vermiculite-mica assemblages)

It is clear from these data that there are substantial differences between the properties of soils at the leak site and sediments in the canal. The carbonates in the soil are primarily calcitic, while those in the canal structure are dolomitic. Canal sediments contain appreciable expandable minerals not present at the leak site. Another major difference is the

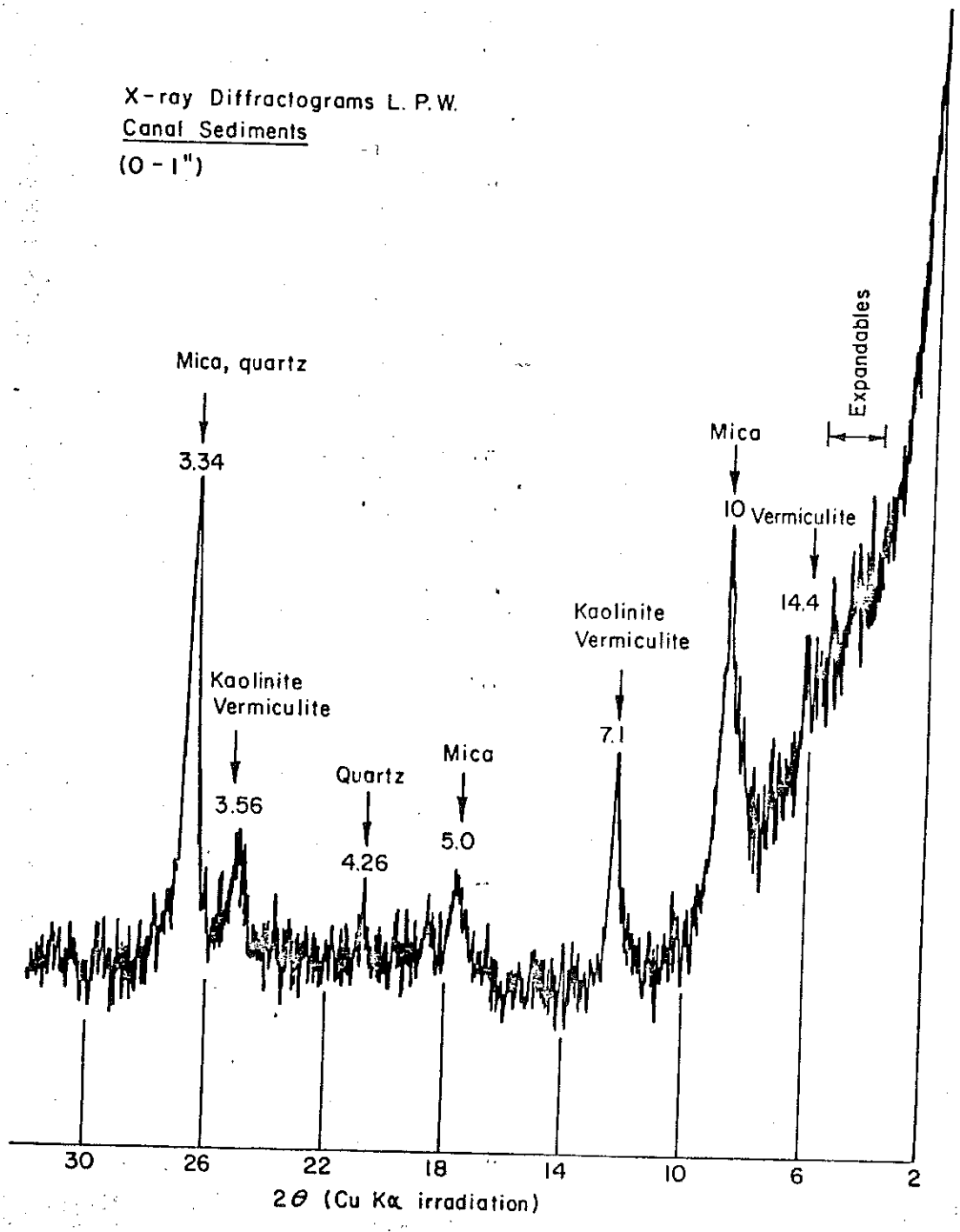

FIGURE A-2. X-Ray Diffractogram of Leak Site Samples, 0"-74"

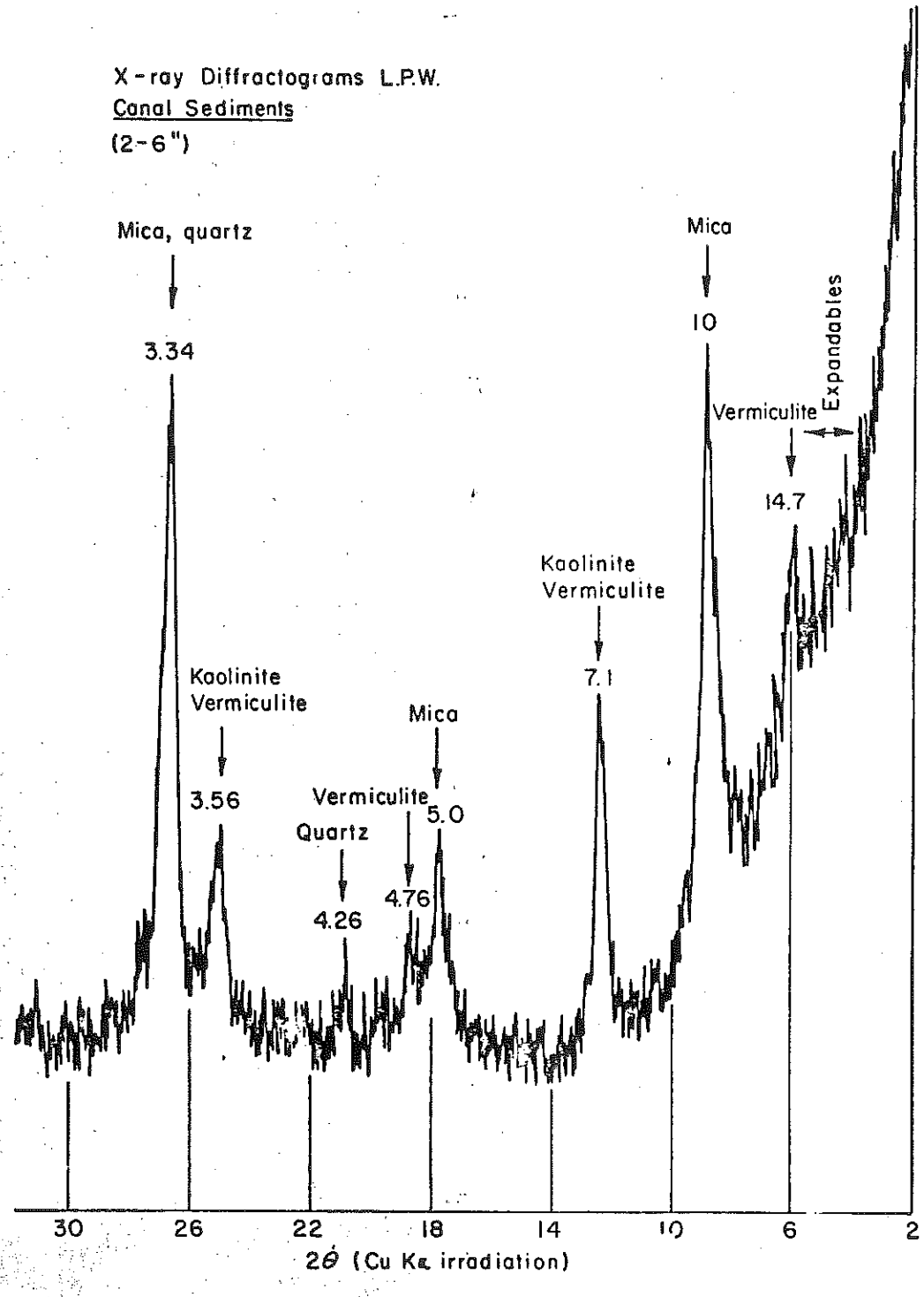

FIGURE A-3. X-Ray Diffractogram of Leak Site Samples, 100"-134"

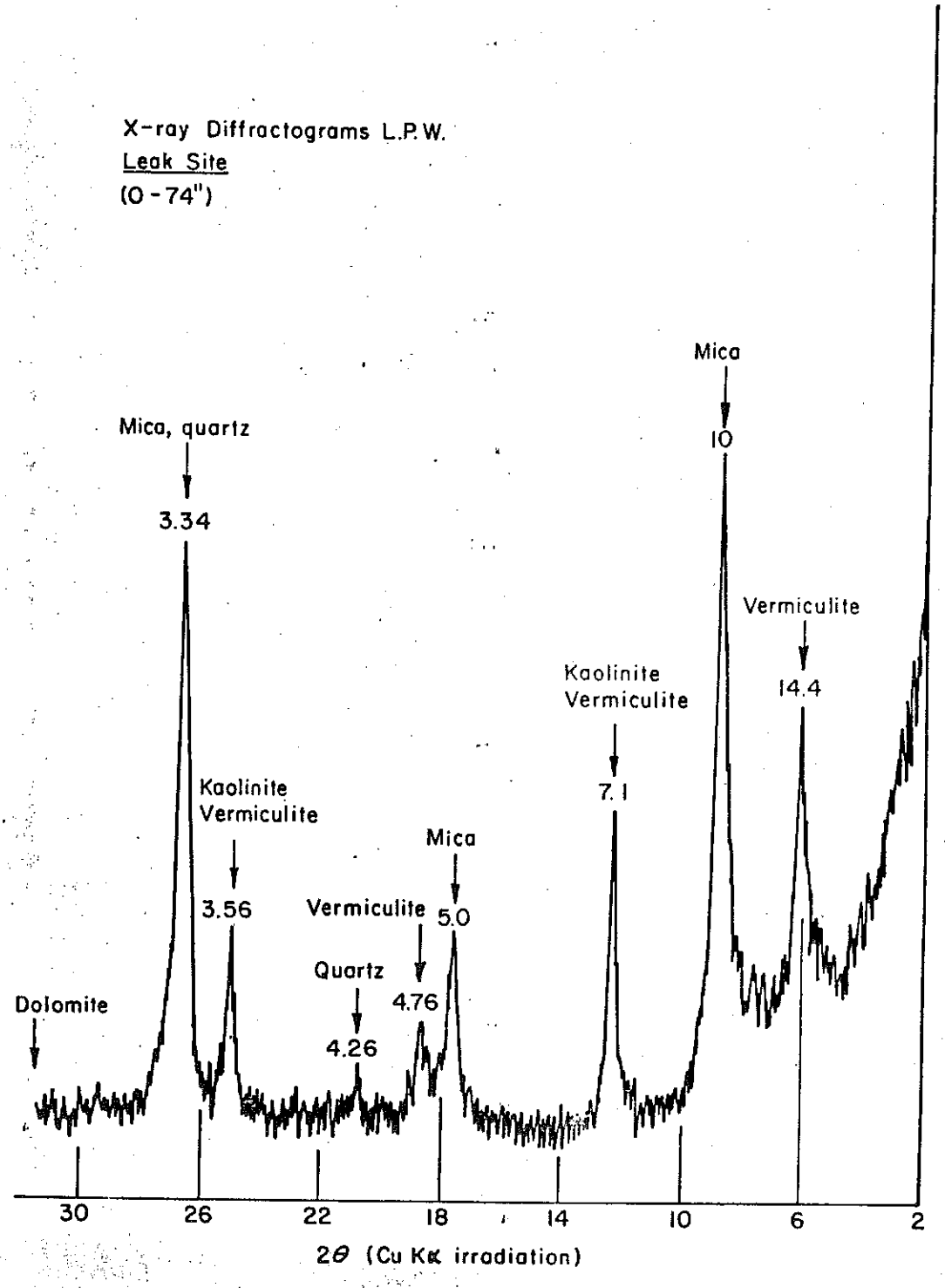

FIGURE A-4. X-Ray Diffractograms of Canal Sediments, 0"-1"

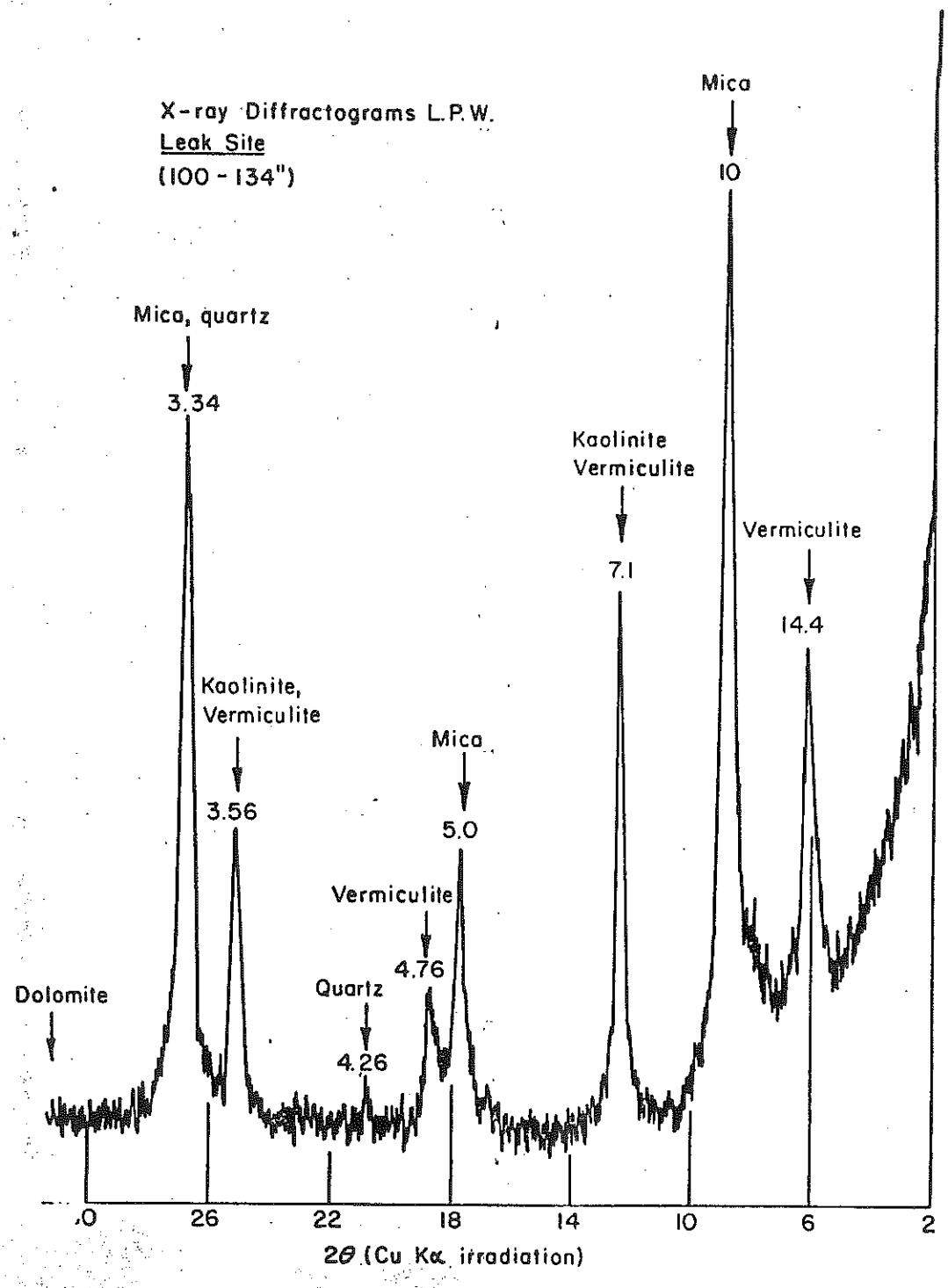

FIGURE A-5. X-Ray Diffractograms of Canal Sediments, 2"-6"

substantial organic carbon content of canal sediments, as contrasted with the negligible organic levels in leak site soils. Such differences in material composition, particularly organic carbon levels and clay mineralogy, would be expected to have a majro impact on sorption-desorption ^{238}Pu reactions.

The sediments in the canal structure are texturally quite variable, ranging from sand (in interbedded lenses) to clay. In the North Canal section the sediments are waterlogged and under reducing conditions for major periods of the year. In the South Canal section the sediments cycle from anaerobic to aerobic conditions according to the intensity of runoff events and seasonal moisture conditions.

PLUTONIUM-238 SORPTION AND TRANSPORT BY SOILS

The precise mechanisms governing plutonium sorption-desorption equilibria in soil systems are not well documented. However, sufficient evidence is available from previous studies to confirm that plutonium is rapidly and strongly bonded to soil colloids.[A-3 - A-9] The chemical behavior of plutonium, its modes of movement and rates of cycling in the natural environment would likely be determined by soil composition, soil weathering processes, and biological activities. These conditions vary markedly not only within a limited geographical region but from one climatic region to another. Thus, laboratory studies should be extrapolated to field conditions with caution and only after careful consideration of comparable soil and environmental variables.

At Mound Laboratory, ^{238}Pu was dispersed into the environment at the leak site in the Pu (IV) state as $Pu(NO_3)_4$ in nitric acid (~1 M). In dilute neutral solutions that do not contain strong oxidizing or reducing agents plutonium tends to remain in the IV valence state. Pu (IV) is further stabilized by hydrolysis and complex formation.[A-3 - A-5] The hydrolytic behavior of plutonium is important because the resulting cationic species does not apparently react as a simple multicharged cation. On the basis of plutonium chemistry, ionic size, and valence states, plutonium in soil environments would be expected to be (a) hydrolyzed to a greater degree, (b) precipitated by more anions, and (c) more strongly adsorbed onto soil colloids than other multivalent cations such as Zr (IV), Th (IV), Fe (III), Ce (III), or U (II); therefore, plutonium would be generally less soluble and less mobile in soil leachates than the above species.[A-5] Long-term behavior of plutonium in soils is believed to be chemically analogous to that of FE (III) and Zr (IV).

Equilibrium studies with ^{238}Pu (or ^{239}Pu) added to natural soils, clay extracts, organic matter extracts (Ca-humates) or reference clays attest to the strong affinity of plutonium for soil colloids. In natural soils most of the plutonium sorption is associated with the clay (<2 μm) fraction, according to Mound Laboratory data. The plutonium sorption is rapid and quite high; Bondietti[A-4] found that in a 3-week period montmorillonite and kaolinite removed similar amounts of plutonium (about 95%) while calcium humate removed 99.9 + %. Miner et al.[A-6] in studying 13 soils found that 59% of the time the equilibrium sorption was >99%, while only 5% of the

time it was less than 90%. With canal sediments from Mound Laboratory, Rodgers et al.[A-8] found distribution ratios in natural water and dilute acid of 1×10^{-5}, respectively. Sorption of plutonium to sediments can take place at low pH; equilibrium studies by Bondietti[A-4] were at pH 2 and Rodgers et al.[A-8] noted well over 50% sorption at pH = 0.

The type of bonding involved between plutonium and soil colloids is not clear, but present evidence suggests it is a complex formation with functional groups of organic matter and inorganic clay surfaces (perhaps iron oxide coatings on clay surfaces), rather than simple ion exchange. Similar amounts of sorption of plutonium to kaolinite and montmorillonite clay surfaces which have strikingly different cation exchange capacities would argue against a cation exchange mechanism. Less sorption of plutonium in the presence of organic complexers (citrate, DTPA and fulvate) and greater desorption of plutonium from soils by extracts containing organic complexers further support the theory of a complex bonding mechanism.[A-3,A-4,A-8] On the basis of previous work, soils and sediments containing higher levels of organic matter would be expected to adsorb and retain plutonium more effectively than inorganic clay, which has a low organic matter content. Carbonates do not appear to be effective complexers of Pu[A-9] and thus are ineffective carriers of soluble plutonium.

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APPENDIX B

RADIATION DOSE ESTIMATION

GENERAL ASSUMPTIONS USED TO ESTIMATE POTENTIAL ^{238}Pu BODY BURDENS AND DOSES

1. Concentration of ^{238}Pu in soil and sediments is 0.4 nCi/g (see p. 33).

2. Concentration of ^{238}Pu in water is 0.019 nCi/l (see p. 24).

3. Daily ingestion of water = 1 liter

4. Fraction of Pu absorbed through gut = 3×10^{-5} (B-1) (Note: This assumption applies to the following calculations but will not appear in the equation because it has been included in the dose commitment factors presented in Table 6.)

6. Daily intake of fish is 25 g of which 10% is from the canal (2.5 g/d)

7. CF (fish muscle/water) = 3.5 (B-2)

8. A child will consume 4 g soil per year for 10 years

9. Ingestion of vegetables = 73 kg/yr ≃ 200 g/day (canned vegetables for winter; 50%, or 100 g/day, grown in another area)

10. Ratio of Pu in plant/soil = 2×10^{-5} (B-3)

11. 79 kg of beef consumed per year, 10% from canal area ≃ 200 g/day x 0.1 20 g/day

12. Soil-to-muscle concentration of cow grazing = 2×10^{-4} (B-3)

13. Cow consumes 40 liters of H_2O/day

14. Fraction of Pu through cow gut = 2×10^{-5}

15. Cow grazes 6 months/year (182 d/yr)

16. A cow is 20% muscle and weighs 1000 lb: muscle wt. = 1000 lb x 454 g/lb x 0.2 = 9.0×10^4 g

17. Amount of sediment (soil) per unit of skin area = 0.1 g/m^2

18. Surface area of standard man = 1.85 m^2 (surface area of child is smaller)

19. Fraction of Pu in soluble form = 0.1

20. Fraction of soluble Pu absorbed through skin = 0.0025 in 10-day period (B-4)

21. Fraction of skin wounded = 0.001

22. All soil on wound absorbed through the wound irrespective of Pu solubility

23. All calculations assume no loss of Pu (decay or excretion) during exposure period

24. Maximum permissible body burden = 4 nCi

SPECIFIC ASSUMPTIONS

1. Ingestion of water (2-5)*

   Total intake over 50 yr = $19 \times 10^{-6} \frac{\mu Ci}{l} \times \frac{1 \text{ liter}}{\text{day}} \times 365 \text{ d/y} \times 50 \text{ y} =$ .347 μCi.

2. Ingestion of fish caught in Canal (2,4-7)

   Total intake during 50 yr = $19 \times 10^{-6} \frac{\mu Ci}{l} \times 2.5 \frac{g}{d} \times 3.5 \times 10^{-3} \frac{\ell}{kg} \times$ 365 d/y x 50 y = .0030 μCi.

3. Ingestion of sediment (1,4,8)

   Total intake during 50 yr = $0.4 \times 10^{-3} \frac{\mu Ci}{g} \times \frac{4g}{yr} \times 10 \text{ yr} = 0.016 \mu Ci$.

* Refers to numbered assumptions in preceding list.

4. Ingestion of vegetation grown in Canal area (1,4,5,9,10)

Total intake during 50 yr = $0.4 \times 10^{-3} \frac{\mu Ci}{g} \times 2 \times 10^{-5} \times 100 \frac{g}{d} \times 365 \frac{d}{y} \times 50\ y = 0.0146\ \mu Ci$.

5. Ingestion of beef grazing on grass in Canal area and drinking Canal water (1,2,12-16)

Concentration of beef muscle after 5 yr = $\overbrace{0.4 \frac{nCi}{g} \times 2 \times 10^{-4}}^{\text{grazing}} +$

$\overbrace{40 \frac{l}{day} \times .019 \frac{nCi}{l} \times 2 \times 10^{-5} \times 182 \frac{d}{yr} \times 5\ yr \times \frac{1}{9 \times 10^4\ g}}^{\text{water}}$

Beef muscle concentratation = $8 \times 10^{-5} + 1.5 \times 10^{-7} = 8 \times 10^{-5}$ nCi/gm (4,5,11)

Total intake during 50 yr = $8 \times 10^{-8} \frac{\mu Ci}{g} \times \frac{20\ g}{d} \times 365 \frac{d}{y} \times 50\ y = 2.9 \times 10^{-2}\ \mu Ci$.

6. Absorption of Pu through the skin (1, 17-20)

Assumes child will play in area 200 d/yr and that children older than 15 yr will not play in area.

The dose commitments for items 1 through 5 are given by: uptake (μCi)x dose commitment/μCi intake where the dose commitment/μCi is taken from Table 5.

Body burden after 15 yr = $\frac{0.1\ g}{m^2} \times 1.85\ m^2 \times \frac{0.4\ nCi}{g} \times \frac{.0025}{10\text{-day}} \times$

$200\ \frac{d}{yr} \times 15\ y \times 10^{-4} = 6 \times 10^{-5}\ nCi = 6 \times 10^{-8}\ \mu Ci$

7. Absorption of Pu through wounds (1,17,18,21,22)

Body burden = $\frac{0.4\ nCi}{g} \times \frac{0.1\ g}{m^2} \times 1.85\ m^2 \times 0.001 = 7.4 \times 10^{-5}\ nCi =$

$7.4 \times 10^{-8}\ \mu Ci$.

The dose commitments for items 6 and 7 are given by:

$$\frac{(\text{uptake, } \mu Ci, \times \text{ dose commitment}/\mu Ci \text{ intake})}{3 \times 10^{-5}}$$

where the dose commitment/μCi is taken from Table 5.

8. Intake by inhalation will be estimated by assuming a "standard man" intake of 20 m^3/day of air,[B-5] which on an annual basis is 7300 m^3. The annual intake by inhalation is then the annual inhalation of air times the average air concentration of ^{238}Pu.

Ref. 14

State of Ohio Environmental Protection Agency
James A. Rhodes, Governor
Ned E. Williams, Director

02

Permit to Operate an Air Contaminant Source
Terms and Conditions

Date of Issuance 05/06/77 Application Number 08570911968001

Effective Date 06/20/77 Permit Fee $000

This document constitutes issuance to: MOUND LABORATORY
MOUND RD.
MIAMISBURG OHIO 45342

of a permit to operate:
92.5 MMBTUH OIL-GAS FIRED BOILER
155871

The following terms and conditions are hereby expressly incorporated into this permit to operate:

Condition 1

The above described air contaminant source is now operating, and over the period covered by the permit will be operated, in full compliance with all applicable state and federal laws and regulations.

Condition 2

Prior to any physical change in, or change in the method of operation of, this air contaminant source which increases the amount of any air pollutant emitted, or results in the emission of any air pollutant not previously emitted, a permit to install must be granted by the Ohio Environmental Protection Agency (See ~~Chapter EP-30~~ OAC 3745-31 of the regulations).

Condition 3

The Director of the Ohio Environmental Protection Agency, or his authorized representative, may enter upon the premises of the source operation at any reasonable time and subject to safety requirements of the person in control of the premises for the purpose of making inspections, conducting tests, examining records or reports pertaining to any emission of air contaminants and determining compliance with all applicable State and Federal air pollution laws and regulations and the terms and conditions of this permit.

Condition 4 (This condition applicable if checked: ☐)

Upon declaration of an Air Pollution Alert, Warning or Emergency Episode this air contaminant source will follow those emission reduction procedures enumerated in the Emergency Action Plan approved by the Director for this source.

Condition 5

This permit to operate shall be effective until 06/19/80. You will be contacted approximately four months prior to this date regarding the renewal of this permit. If you are not contacted, please write to this agency.

Condition 6

A permit fee in the amount specified above must be remitted within fifteen (15) days of the effective date of this permit.

Condition 7

The Director must be notified in writing prior to any transfer of a permit to operate. Such transfer shall not take place without the written permission of the Director.

Condition 8 (This condition is applicable if checked: ☐)

This permit is subject to the supplementary conditions attached.

OHIO ENVIRONMENTAL PROTECTION AGENCY

Ned E. Williams
Director

4671

AP-PS-202

Request for Non-Registration Status (under 25TPY source)

Application No. 0857091196 B001

Facility Name Mound Laboratory

Equipment Description: Oil-Gas Fired Boiler

Company I.D.: 155871

Current Status: Registration (T) _____
Permit to Operate X

Recommended Status: P.T.O. X
Variance _____
Denial _____

OEPA Use Only

OEPA Status: P.T.O. X
Variance _____
Denial _____
Registration (T) _____

Reasons for Recommended Status:

It is desirable to keep an eye on fuel consumption at this facility considering the size. Potential SO_2 emissions at full capacity and 230 days/yr is 98.4 tons/yr for this boiler. (Note: Federal Facility - so this permit would primarily serve as a reminder to this LAA.)

Engineer (DO/LAA) — 3/23/77 Date — OEPA/OAPC — 4-11-77 Date

Note: If required, a recommendation for a Permit to Operate must be accompanied by any Special Terms and Conditions; a variance recommendation by a compliance schedule and, if required, Special Terms and Conditions; a denial recommendation by Supporting Data: Reasons for Denial. See Procedure 14.

APRS/OAPC use only

Return to APRS by APR 11 1977

AP-PS-2005
01/28/76

Ref. 15

NOTICE OF REGISTRATION

TO:
MOUND LABORATORY
MOUND RD.
MIAMISBURG OHIO 45342

FOR:

APPLICATION NO	0857091196 P004
EQUIPMENT DESCRIPTION	FABRICATION & REPAIR EQUIPMENT
COMPANY ID	CARPENTRY SHOP-M BLDG.
ISSUE DATE	05/20/77
EFFECTIVE DATE	07/04/77

(SEE ENCLOSED LETTER FOR EXPLANATION)

This source has moved to W bldg. & is vented inside.

DG-L
1/16/86

NED E. WILLIAMS, P.E.
DIRECTOR

Ohio Environmental Protection Agency

Information Concerning Operation of

an Air Contaminant Source

Mound Laboratory	Jack Stevens
Facility Name	Person to Contact
Mound Road	P. O. Box 66
Facility Address	Mailing Address
Miamisburg Montgomery 45342	Miamisburg, Ohio 45342
City County Zip	City State Zip
0857091196P004	(513) 866-7444
Source No. (see attached Notice)	Telephone Area Number

1. Complete and attach one of the following appendices most appropriate to the air contaminant source. Only one appendix may accompany this application.

   (Check one)
   - ____Appendix A, Process
   - ____Appendix B, Fuel-Burning Equipment
   - ____Appendix C, Incinerator
   - ____Appendix D, Surface Coating or Printing Operation
   - ____Appendix E, Storage Tank or Loading Facility

2. Description of Source (same as used on appendix): Fabrication and Repair Equipment

3. Your Identification for Source (same as used on appendix): Carpentry Shop - M Bldg.

I, being the individual specified in Chapter EP-32 of the regulations of the Ohio Environmental Protection Agency, hereby provide this information concerning operation of the air contaminant source described herein.

G. A. Chacon

Signature of Officer or Owner*

Area Manager

Title

February 22, 1977

Date

* As per Ohio EPA Regulation EP-32-02(B)(1) (Permit to Operate)
See Directions On Other Side

AP-PS-1101
02/12/76

NOTICE OF REGISTRATION Ref. 16

TO:
MOUND LABORATORY
MOUND RD.
MIAMISBURG OHIO 45342

FOR:

APPLICATION NO	0857091196 P002
EQUIPMENT DESCRIPTION	MACHINING EQUIPMENT
COMPANY ID	MAINTENANCE SHOP-M BLDG.
ISSUE DATE	05/21/76
EFFECTIVE DATE	07/05/76

(SEE ENCLOSED LETTER FOR EXPLANATION)

This source has moved to W bldg. ~~it is~~ vented inside

PG-L
~~1/16/86~~

NED E. WILLIAMS, P.E.
DIRECTOR

FOR OFFICIAL USE ONLY
Premise No. 08/57/09/1196
Source No. P/002

PROCESS

1. Facility Name Mound Laboratory — Person to Contact Jack Stevens
   Facility Address Mound Road (Street) — Mailing Address P. O. Box 66 (Street)
   Miamisburg (City, Village or Township) Montgomery (County) 45342 (Zip) — Miamisburg, Ohio (City, State) 45342 (Zip)
   Telephone 513 (Area Code) 866-7444 (Number)
2. This information is submitted in connection with our operation of:
   ☒ an existing source
   ☐ Permit to construct a new source or modify an existing source
   ☐ Variance from regulation(s) _____ for _____ months
3. Check-list of information to accompany this application:
   ☐ Plans and drawings ☐ Emission tests or calculations ☐ Process flow diagram
   ☐ Compliance time schedule ☐ Construction schedule ☐ Additional information
4. Name of process Maintenance Shop-M Bldg. Year installed _____
5. Product of this process Maintenance Fabrication & Repair of Equipment
6. Process equipment Machining Equipment Your identification _____
7. Manufacturer _____ Make or model _____
8. Capacities (lbs/hr): Rated _____ Maximum _____

OPERATING INFORMATION

9. Normal operating schedule: hrs/day 8 days/wk 5 wks/yr 52
10. Percent annual production (finished units) by season: Winter 25 Spring 25 Summer 25 Fall 25
11. Hourly production rates (lbs): Average varies Maximum _____
12. Annual production (indicate units) varies
13. Projected percent annual increase in production 0
14. Method of exhaust ventilation: ☒ Stack ☐ Window fan ☐ Roof vent ☐ Other, describe _____
15. Type of process: ☒ Continuous ☐ Batch
16. If batch, minutes per cycle _____ minutes between cycles _____
17. Does process involve any of the following (check all applicable)? ☐ Lead ☐ Asbestos ☐ Beryllium ☐ Mercury
18. Materials used in process (include organic materials)

List of Raw Materials	Principal Use	Amount (lbs./hr.)
Steel	Maintenance Repair	Varies
Aluminum	" "	"
Brass	" "	"
Stainless Steel	" "	"
		"

19. This information should include a detailed process flow diagram. Show entry and exit points of all raw materials, intermediate products, by-products and finished products. Label all materials including airborne contaminants and other waste materials.

Important Note: If emissions from this source have been determined by source tests, material balances or emission factors, include such data and supporting calculations

FOR OFFICIAL USE ONLY
Premise No. ____/____/____/____
Source No. C/002

DATA SHEET
CONTROL EQUIPMENT

1. Facility Name Mound Laboratory Person to Contact Jack Stevens

Facility Address Mound Road (Street)
Miamisburg (City, Village or Township) Montgomery (County) 45342 (Zip)

Mailing Address P.O. Box 66 (Street)
Miamisburg, Ohio (City, State) 45342 (Zip)

Telephone 513 (Area Code) 866-7444 (Number)

2. Type of gas cleaning equipment (check one):
☐ Settling chamber ☒ Cyclone ☐ Multiple cyclone ☐ Electrostatic precipitator ☐ Fabric filter
☐ Absorber ☐ Incineration ☐ Wet collector, type ____ ☐ Adsorber

A separate "Data Sheet for Control Equipment" must be completed for each control device. Stack data should be shown on form AP-PS-07, "Data Sheet -- Stacks and Other Egress Points".

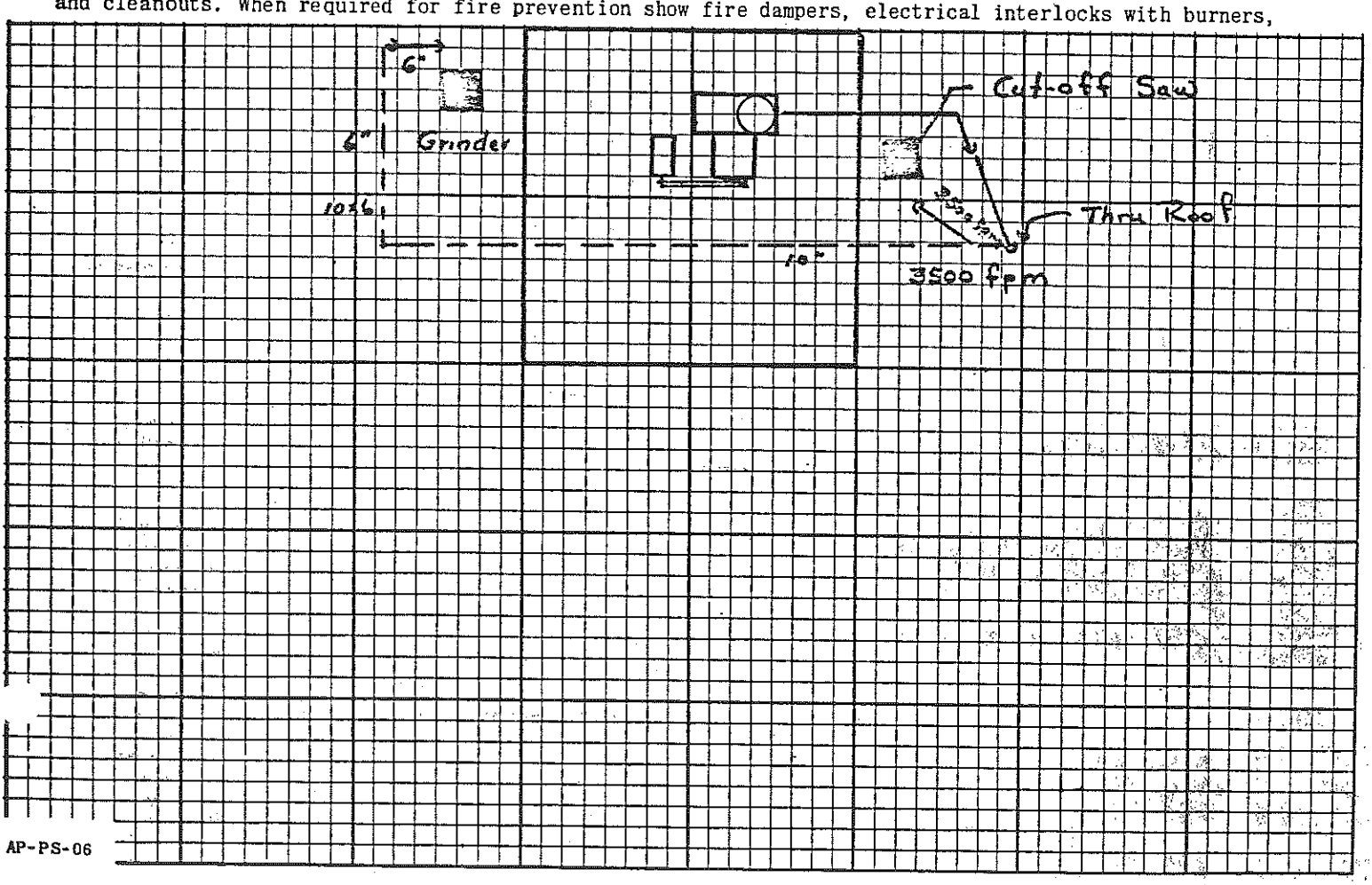
3. Manufacturer Amer.Air Filter Model No. Type D Size 10 Rotoclone Year installed 1967
4. Your identification AEC 56894 Pollutant(s) controlled Dust
5. Design efficiency ____ Pressure drop across collector 4.2 in. H_2O
6. Efficiency (operating - if known) ____ Controlled pollutant emission rate (if known) ____
7. Total installed capital equipment cost ____

FAN DATA

8. Type: ☐ Axial ☒ Centrifugal RPM 1735 HP 5 Static pressure ____
9. Volume 5720 ACFM at 60 °F. No. of fans in system 1

CAPTURE AND TRANSPORT DATA

10. Ductwork detail: Draw a plan view of the source equipment and air cleaning equipment. Indicate transport velocity in actual feet per minute, total system resistance in inches of water, and gas moisture content and temperature. Include such other pertinent information as: dimensions, elbows, duct material, dampers and cleanouts. When required for fire prevention show fire dampers, electrical interlocks with burners,



AP-PS-06

MAINTENANCE SHOP - M BLDG

FOR OFFICIAL USE ONLY
Premise No. 08/57/09/1196
Source No. 5/008

DATA SHEET
STACKS AND OTHER EGRESS POINTS

Facility Name Mound Laboratory Person to Contact Jack Stevens

Facility Address Mound Road (Street) Mailing Address P. O. Box 66 (Street)

Miamisburg (City, Village or Township) Montgomery (County) 45342 (Zip) Miamisburg, (City) Ohio (State) 45342 (Zip)

Telephone 513 (Area Code) 866-7444 (Number)

2. Type: ☒ Round ☐ Rectangular - top inside dimension(s) (L & W or Diam.) 12"

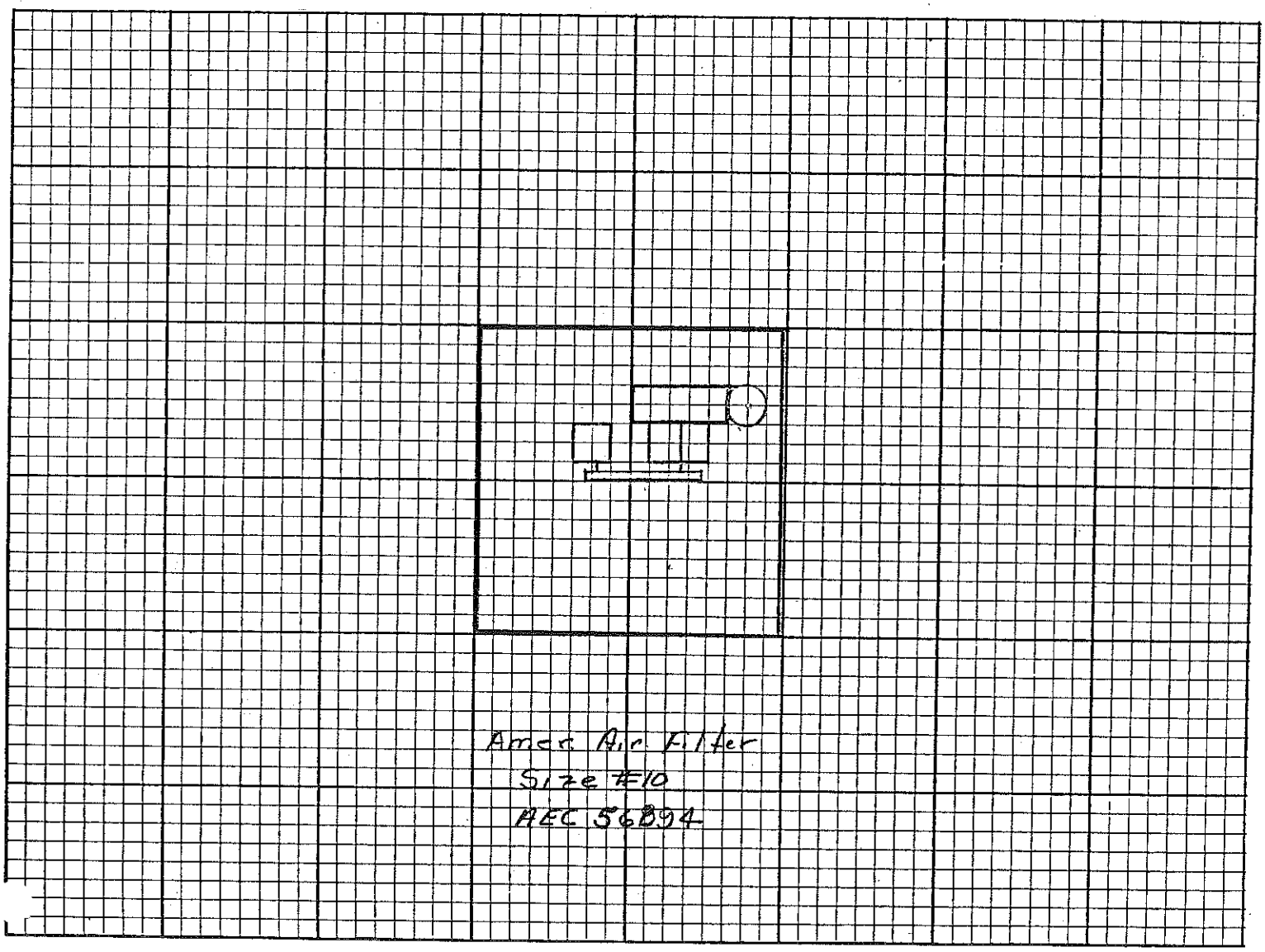
3. Height: Above roof 10.2 ft. Above ground 24.7 ft.

4. Exit gas: Temp. 60 °F. Volume 1700 ACFM Velocity 2166 feet per minute

5. Continuous monitoring equipment: ☐ Yes ☒ No. If yes, indicate: Type _____

Manufacturer _____ Make or model _____ Pollutant _____

6. Draw a flow diagram in plan view of the source equipment, control equipment and stacks. If more than one source or control device discharges into this stack show all connections.



Important Note: If emissions from the above stack have been determined by performance testing or other means, include such data and supporting calculations with this data sheet.

AP-PS-07

NOTICE OF REGISTRATION Ref. 17

TO:
MOUND LABORATORY
MOUND RD.
MIAMISBURG OHIO 45342

FOR:

APPLICATION NO	0857091196 P001
EQUIPMENT DESCRIPTION	MISCELLANEOUS GRINDING EQUIPMENT
COMPANY ID	PRECISION GRINDING SHOP
ISSUE DATE	05/21/76
EFFECTIVE DATE	07/05/76

(SEE ENCLOSED LETTER FOR EXPLANATION)

NED E. WILLIAMS, P.E.
DIRECTOR

FOR OFFICIAL USE ONLY
Premise No. 08/57/09/1196
Source No. P/001

PROCESS

Facility Name Mound Laboratory Person to Contact Jack Stevens

Facility Address Mound Road (Street) Mailing Address P.O. Box 66 (Street)

Miamisburg (City, Village or Township) Montgomery (County) 45342 (Zip) Miamisburg, Ohio (City, State) 45342 (Zip)

Telephone 513 (Area Code) 866-7444 (Number)

2. This information is submitted in connection with our operation of:
   - ☒ an existing source
   - ☐ Permit to construct a new source or modify an existing source
   - ☐ Variance from regulation(s) _____ for _____ months
3. Check-list of information to accompany this application:
   - ☒ Plans and drawings ☐ Emission tests or calculations ☐ Process flow diagram
   - ☐ Compliance time schedule ☐ Construction schedule ☐ Additional information
4. Name of process Precision Grinding Shop - M Bldg. Year installed _____
5. Product of this process Job Shop Items
6. Process equipment Grinders Your identification _____
7. Manufacturer Various Make or model _____
8. Capacities (lbs/hr): Rated _____ Maximum _____

OPERATING INFORMATION

9. Normal operating schedule: hrs/day 8 days/wk 5 wks/yr 52
10. Percent annual production (finished units) by season: Winter 25 Spring 25 Summer 25 Fall 25
11. Hourly production rates (lbs): Average Varies Maximum _____
12. Annual production (indicate units) Varies
13. Projected percent annual increase in production 0
14. Method of exhaust ventilation: ☐ Stack ☐ Window fan ☐ Roof vent ☒ Other, describe Exhausts to Filter Unit
15. Type of process: ☐ Continuous ☐ Batch Intermittent
16. If batch, minutes per cycle _____ minutes between cycles _____
17. Does process involve any of the following (check all applicable)? ☐ Lead ☐ Asbestos ☐ Beryllium ☐ Mercury
18. Materials used in process (include organic materials)

List of Raw Materials	Principal Use	Amount (lbs./hr.)
Steel	Precision Grinding	Varies

19. This information should include a detailed process flow diagram. Show entry and exit points of all raw materials, intermediate products, by-products and finished products. Label all materials including airborne contaminants and other waste materials.

Important Note: If emissions from this source have been determined by source tests, material balances or emission factors, include such data and supporting calculations

FOR OFFICIAL USE ONLY
Premise No. ____/____/____/____
Source No. C/001

DATA SHEET
CONTROL EQUIPMENT

Facility Name Mound Laboratory Person to Contact Jack Stevens

Facility Address Mound Road (Street) Mailing Address P.O. Box 66 (Street)

Miamisburg Montgomery 45342 (City, Village or Township / County / Zip) Miamisburg, Ohio 45342 (City / State / Zip)

Telephone 513 866-7444 (Area Code / Number)

2. Type of gas cleaning equipment (check one):
   ☒ Settling chamber ☐ Cyclone ☐ Multiple cyclone ☐ Electrostatic precipitator ☒ Fabric filter
   ☐ Absorber ☐ Incineration ☐ Wet collector, type ____ ☐ Adsorber

A separate "Data Sheet for Control Equipment" must be completed for each control device. Stack data should be shown on form AP-PS-07, "Data Sheet -- Stacks and Other Egress Points".

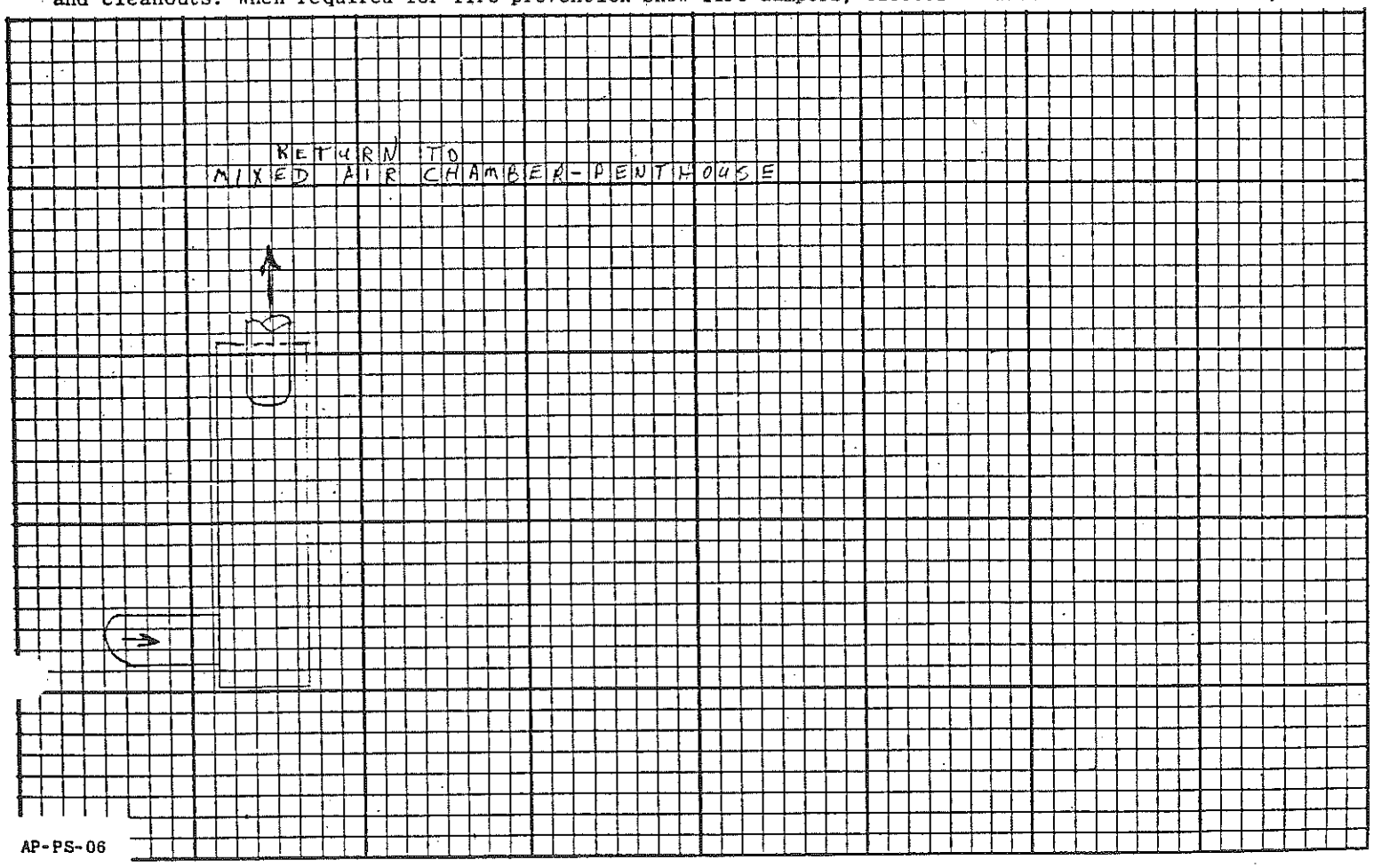
3. Manufacturer Torit Corp. Model No. 1235H Year installed 1966
4. Your identification AEC 52385 Pollutant(s) controlled Dust
5. Design efficiency 80% Pressure drop across collector ____ in. H_2O
6. Efficiency (operating - if known) ____ Controlled pollutant emission rate (if known) ____
7. Total installed capital equipment cost NA

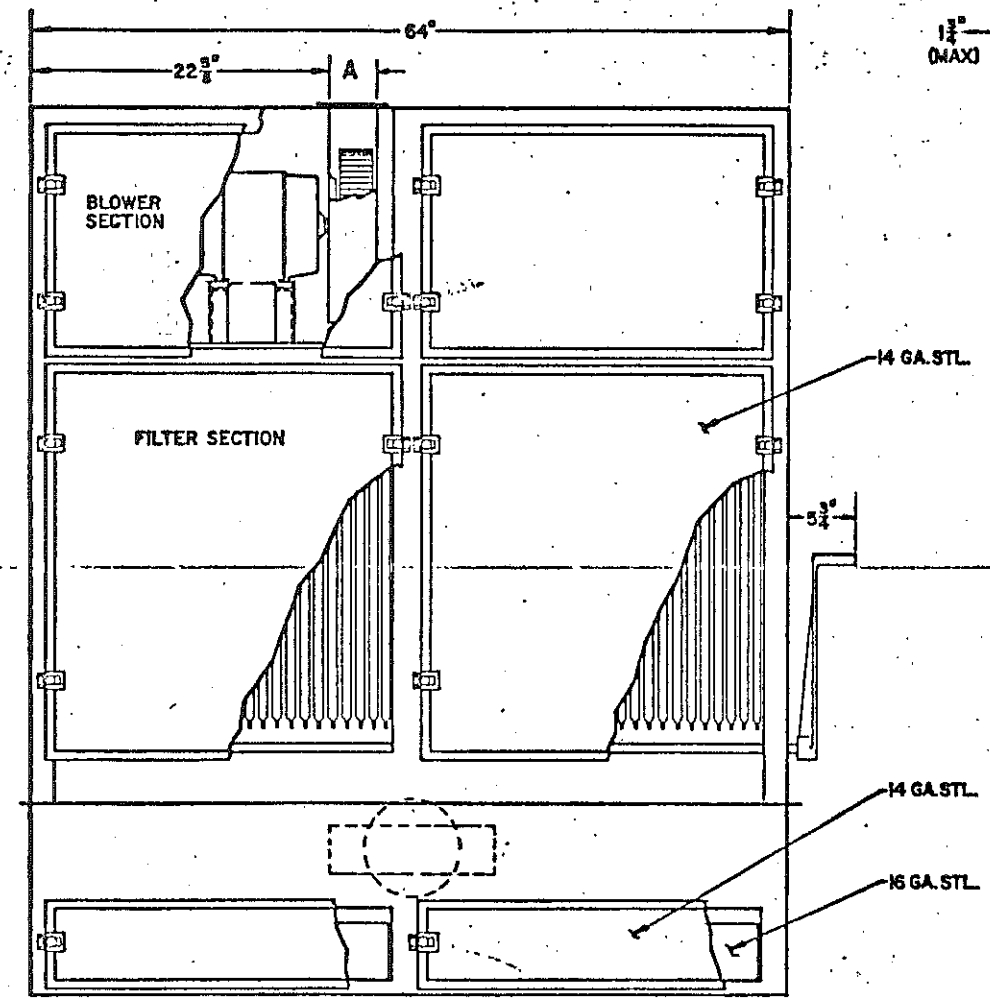
FAN DATA

8. Type: ☐ Axial ☒ Centrifugal RPM 3600 HP 5 Static pressure 5.85"/H_2O (max.)
9. Volume 2163 ACFM at 60 °F. No. of fans in system 1

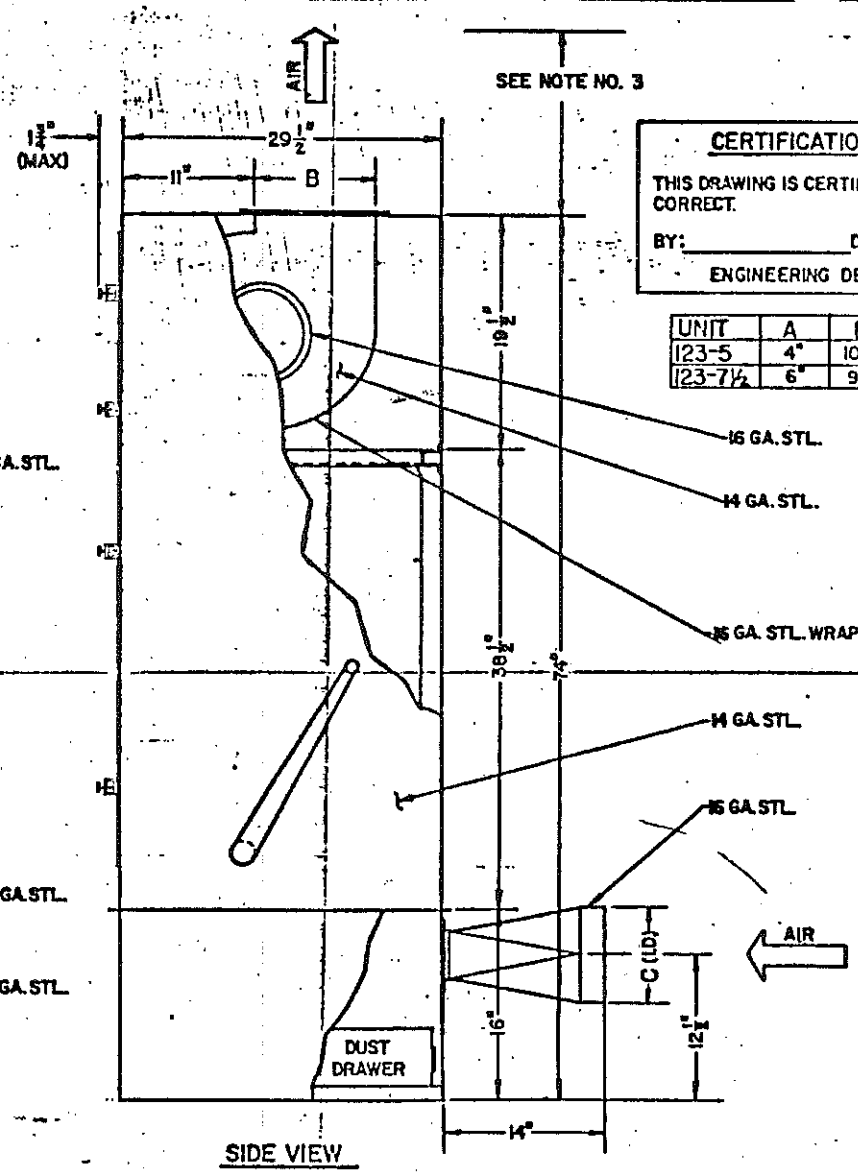
CAPTURE AND TRANSPORT DATA

10. Ductwork detail: Draw a plan view of the source equipment and air cleaning equipment. Indicate transport velocity in actual feet per minute, total system resistance in inches of water, and gas moisture content and temperature. Include such other pertinent information as: dimensions, elbows, duct material, dampers and cleanouts. When required for fire prevention show fire dampers, electrical interlocks with burners,





FRONT VIEW



SIDE VIEW

CERTIFICATION
THIS DRAWING IS CERTIFIED TO BE CORRECT.
BY: _____ DATE: _____
ENGINEERING DEPT.

UNIT	A	B	C
123-5	4"	10½"	8"
123-7½	6"	9¼"	10"

123-5 ···· MULTIPLE RATING TABLES ···· 123-7½

C.F.M.	F.P.M.	EXT. S.P.	C.F.M.	F.P.M.	EXT. S.P.
2100	6050	5.70"	2800	4960	4.45
1800	5150	7.20"	2400	4410	5.85
1500	4280	8.50"	2100	3860	6.90
1200	3420	9.20"	1800	3300	8.30

SPECIFICATIONS

1. MOTOR SHALL BE 5 HP ON NO. 123-5 & 7½ HP ON NO. 123-7½, 3600 RPM, 230-460/60/3.
2. DUST STORAGE CAPACITY SHALL BE 4.4 CU. FT.
3. FILTER AREA SHALL BE 300 SQ. FT. (30 FILTERS 30" x 24" EACH.)
4. NET WT. 900 SHIPPING WT. 1200

NOTES

1. THIS DRAWING IS FOR A 123-5 & 123-7½ DUST COLLECTOR. ANY DEPARTURE FROM THIS DESIGN SHALL REQUIRE SPECIAL FABRICATION AND AN INCREASE IN COST.
2. THIS DRAWING IS NOT CERTIFIED FOR CONSTRUCTION PURPOSES UNLESS PROPERLY SIGNED BY TORIT.
3. ALLOW A MIN. OF 12" CLEARANCE ABOVE FAN OUTLET.

TORIT

THE TORIT CORPORATION ST. PAUL, MINN. 55116

SPECIFICATION CONTROL DRAWING

NO. 123-5 & 123-7½ DUST COLLECTOR

DRAWN: T.S.H.

DRWG. NO. 123-000

FOR OFFICIAL USE ONLY
Premise No. 08/57/09/1196
Source No. 5/007

DATA SHEET
STACKS AND OTHER EGRESS POINTS

1. Facility Name Mound Laboratory — Person to Contact Jack Stevens

   Facility Address Mound Road (Street) — Mailing Address P. O. Box 66 (Street)

   Miamisburg (City, Village or Township) Montgomery (County) 45342 (Zip) — Miamisburg, (City) Ohio (State) 45342 (Zip)

   Telephone 513 (Area Code) 866-7444 (Number)

2. Type: ☐ Round ☐ Rectangular - top inside dimension(s) (L & W or Diam.) N/A

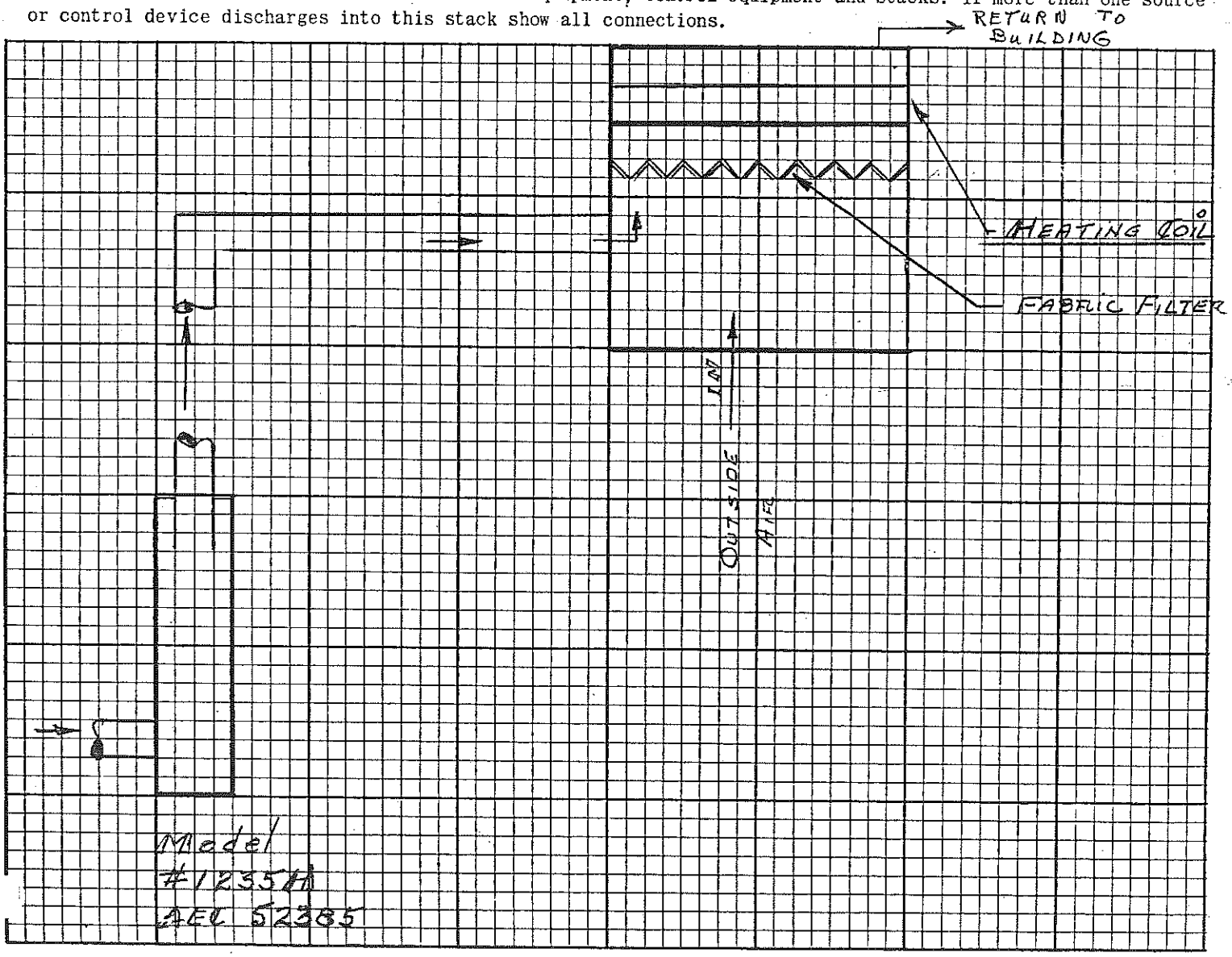
3. Height: Above roof _____ ft. Above ground _____ ft. N/A

4. Exit gas: Temp. _____°F. Volume _____ ACFM Velocity _____ feet per minute N/A

5. Continuous monitoring equipment: ☐ Yes ☐ No. If yes, indicate: Type N/A

   Manufacturer _____ Make or model _____ Pollutant N/A

6. Draw a flow diagram in plan view of the source equipment, control equipment and stacks. If more than one source or control device discharges into this stack show all connections.



Important Note: If emissions from the above stack have been determined by performance testing or other means, include such data and supporting calculations with this data sheet.

AP-PS-07

12-1-22

SUMMARY OF MOUND LABORATORY DOCUMENTS

DATE	INCIDENT	WORKERS EXPOSED/ CONTAMINATION	CAUSE/ DEFICIENCIES	AREA(S) OF CONTAMINATION	RESPONSE
7-6-60	release of radioactive particles (plutonium and unspecified other) from defective glovebox	11 workers (including 5 visitors) 3 day urine for plutonium: #1-0.25; #2-0.30; #3-2.31; #4-0.46; #5-0.58; #6-0.60 (c/m/24 hr)	Malfunctioning equipment allowed pressure build-up in a glovebox, blowing off glove and releasing material	Visitors left with some contaminated clothing still on, spreading outside of compound. Shoe-shine boy contaminated as a result.	Medical treatment, follow-up not discussed. Shoe shine boy not further investigated for fear of "stirring up a hornet's nest"
8-19-60	explosion of steel can containing 80 g. plutonium	1 worker with inhalation and some skin exposure. 2 day urine: 2.1 d/m/24 hr. 3 day feces: 900,000+ d/m. Est. lung burden: 0.0074 uc. Est. body burden: 0.002 uc	Defective packaging of plutonium in steel can by McCullough Tool Co, allowing pressure build-up. ?Worker not wearing full protective gear (i.e. respirator)	Limited to closed-system room	Medical treatment, follow-up not discussed.
11-11-60	leak of polonium from a neutron source while welding	3 workers with skin exposure and inhalation. Urine "excessive" in 1/3, values not reported. Report denies body contam. even though not wearing respirators.	Wall of neutron source weakened from poor welds. Workers not wearing proper gear (e.g. gloves, respirators) for full protection. Absence of safety equip. on glovebox (shields)	Limited to closed-system room	Medical treatment, follow-up not discussed.

Ref. 16

DATE	INCIDENT	WORKERS EXPOSED/ CONTAMINATION	CAUSE/ DEFICIENCIES	AREA(S) OF CONTAMINATION	RESPONSE
2-20-60	Release of polonium from broken ampules of material in storage area	3 workers contaminated. No exposure data given	Inadequate storage of material allowed pressure build-up in vials, causing them to rupture. Inadequate worker protection causing contam. during inspection.	Limited to closed-system room	Medical treatment, follow-up not discussed.
5-11-61	Release of plutonium from "scrubber" system of glovebox	3 workers contaminated. Day-1 urine: #1-127; #2-3.3; #3-3.0 d/m/24 hr. Day-3 feces: #1-10,162; #2-400; #3-272 d/m/24 hr. Tot. body burden: #1-0.082; #2-0.0023; #3-0.0009 uc	Malfunctioning equipment; unavailability of repirators causing inhalation	Limited to closed-system room	No medical treatment beyond natural disipation of radioactivity discussed.
0-20-61	Release of polonium from glass lab equipment when it was dropped	1 worker contaminated above allowable limit. Day-3 urine: 661; Day-4 urine: 832 d/m/24hr. Est. total body burden: "1.43X allowable"	Someone bumped into a decontamination worker carring waste, causing him to drop glass containing polonium. Not wearing protective equip.	Limited to closed-system.	Medical treatment, follow-up not discussed

DATE	INCIDENT
2-2-64	Workers doin with "consid able radioac contam. pote Plutonium-co inated acid dripped out pipe being s in half and on worker.
5-11-64	Radioactive (polonium) o flowed tank side of hood ran out into working room
-27-64	Explosion of chemicals st inside hood, causing rupt of gloves an release of plutonium

DATE	INCIDENT	WORKERS EXPOSED/ CONTAMINATION	CAUSE/ DEFICIENCIES	AREA(S) OF CONTAMINATION
2-20-60	Release of polonium from broken ampules of material in storage area	3 workers contaminated. No exposure data given	Inadequate storage of material allowed pressure build-up in vials, causing them to rupture. Inadequate worker protection causing contam. during inspection.	Limited to closed-system room
5-11-61	Release of plutonium from "scrubber" system of glovebox	3 workers contaminated. Day-1 urine: #1-127; #2-3.3; #3-3.0 d/m/24 hr. Day-3 feces: #1-10,162; #2-400; #3-272 d/m/24 hr. Tot. body burden: #1-0.082; #2-0.0023; #3-0.0009 uc	Malfunctioning equipment; unavailability of repirators causing inhalation	Limited to closed-system room
0-20-61	Release of polonium from glass lab equipment when it was dropped	1 worker contaminated above allowable limit. Day-3 urine: 661; Day-4 urine: 832 d/m/24hr. Est. total body burden: "1.43X allowable"	Someone bumped into a decontamination worker carring waste, causing him to drop glass containing polonium. Not wearing protective equip.	Limited to closed-system.

DATE	INCIDENT	WORKERS EXPOSED/ CONTAMINATION	CAUSE/ DEFICIENCIES	AREA(S) OF CONTAMINATION	RESPONSE
7-26-62	Plutonium sprayed around room when container opened by worker.	6 workers "significantly" contaminated. Day-1 urine: #1-202; #2-62; #3-96; #4-9.4; #5-33; #6-13.3 (Day 6-42) c/m/24hr. Day-1 feces: #1-122,375; #2-242,013; #3-30,688; #4-2,913; #5-74,057; #6-59,050. No body burdens computed.	Pressure build-up in plutonium-containing can, released when lid removed. Regulations not followed for storage. Unavailability of repirators for all workers.	Limited to closed system.	DPTA (attached document says kidney function should always be evaluated beforehand - no mention of such evaluation done). Report says this is first time DTPA used with Pu-238.
12-21-63	Release of radiation from leaking pipes which contain radioactive material. (type not specified, but "large particle size")	At least 2 workers "significantly" contaminated, 5 in all. Urine: day-1-#1-17.5; day 2-#2-0.04; #3-1.56; #4-0.72; day 5-#5-0.38. Feces: day 2- #1-15,986; day 3- #2-10,112. "No significant tot. body burdens" but no computations (d/m/24 hr.)	Old, brittle plastic bag wrapped around site of pipe where radioactive material had been leaking was accidentally burst by workers. Not wearing proper protection.	Limited to closed system.	Medical treatment, follow-up not discussed.

DATE	INCIDENT	WORKERS EXPOSED/ CONTAMINATION	CAUSE/ DEFICIENCIES	AREA(S) OF CONTAMINATION	RESPONSE
3-29-65	Further discussion of 10-27-64 case of high radiation exposure for one worker.	Tot. exposure for April 1965: 3.85 Rem. 1958-1964: 26.7 Rem. 1964: 10.7 Rem	--	--	--
4/5-65	High accumulated neutron and gamma exposure of several workers over 2 month period.	9 workers discussed, all with quarterly cummuative neutron and gamma doses of 1085-4.828 Rem	"The present facility is inadequately shielded..." "No attempt was made to pre-determine or anticipate exposures to be received by personnel...Radiation levels were not measured" (even following a spill in one of the rooms) There is a history of personnel who have been "burned out"... without evidence of corrective action being taken."	--	--
8-27-65	Explosion of plutonium-containing anion-exchange resin.	No workers in room at time, none contaminated. A "near miss" accident. "Its seriousness should not be underestimated"	Temperature control failed on oven which was heating resin mixture, and mixture reached ignition temperature.	Hood glass protection blown apart by explosion, releasing plutonium into room. Aparantly limited to room.	--

DATE	INCIDENT
8-65	Accumulation of excessive radiation by worker over a quarter year.
5-2-66	Alpha contamination of workers from contaminated glovebox; air monitors did not warn workers
10-21-66	Explosion of a pile of waste material containing an unknown quantity of plutonium

DATE	INCIDENT	WORKERS EXPOSED/ CONTAMINATION	CAUSE/ DEFICIENCIES	AREA(S) OF CONTAMINATION
3-29-65	Further discussion of 10-27-64 case of high radiation exposure for one worker.	Tot. exposure for April 1965: 3.85 Rem. 1958-1964: 26.7 Rem. 1964: 10.7 Rem	--	--
4/5-65	High accumulated neutron and gamma exposure of several workers over 2 month period.	9 workers discussed, all with quarterly cummuative neutron and gamma doses of 1085-4.828 Rem	"The present facility is inadequately shielded..." "No attempt was made to pre-determine or anticipate exposures to be received by personnel...Radiation levels were not measured" (even following a spill in one of the rooms) There is a history of personnel who have been "burned out"... without evidence of corrective action being taken."	--
8-27-65	Explosion of plutonium-containing anion-exchange resin.	No workers in room at time, none contaminated. A "near miss" accident. "Its seriousness should not be underestimated"	Temperature control failed on oven which was heating resin mixture, and mixture reached ignition temperature.	Hood glass protection blown apart by explosi releasing plutonium into room. Aparantly limite to room.

DATE	INCIDENT	WORKERS EXPOSED/ CONTAMINATION	CAUSE/ DEFICIENCIES	AREA(S) OF CONTAMINATION	RESPONSE
4-16-67	Leakage of liquid plutonium solution out of glovebox, and subsequent worker contamination.	3 workers contaminated on skin, clothing, and evidence of inhalation. No bioassay data reported.	Improper storage of plutonium solution inside of glovebox allowed overflow outside of glovebox.	Apparently limited to closed-system room.	No medical treatment or follow-up discussed.
4-3-68	Glovebox explosion, causing release of plutonium.	Respirators of workers knocked off by exposion, causing signif. inhalation. 3 were internally contaminated. Day 1 urine: #1: 34,000; #2: 2500; #3: 4400 d/m (spot?). Day 1 feces: #1-2,4 $x10^8$; #2-$8x10^6$; #3-$7.8x10^6$ d/m Day 4 blood: #1-3.31; #2-2.22; #3-0.60 d/m/cc Lung burdens: #1-4.8-21.6 times "allowed" burden; #2-4.1-16.0 times; #3-3.8-13.5 times	Failure of oven control in glovebox allowed overheating of glovebox contents to critical flashpoint of plutonium, causing explosion.	Limited to closed-system room.	DTPA given.

TE	INCIDENT	WORKERS EXPOSED/ CONTAMINATION	CAUSE/ DEFICIENCIES	AREA(S) OF CONTAMINATION	RESPONSE
22-68	Worker exposure to polonium-contaminated lab equipment	4 workers with skin and inhalation exposure. Urine day 3: #1-6,325 d/m/24. Tot. body burden: #1-2.1uci (10 X allowed); #2-0.02 uci; #3-0.008 uci; #4-<0.0007 uci	Contamination of equipment through bad lab technique; broken glovebox exhaust allowing spread of material; poor respirator fit allowing inhalation; poor airflow in lab allowing buildup of contamination in the air; poor work planning by health physics.	Apparantly limited to closed-system room.	"No standard medical treatment is advised or available for minor polonium internal exposures at this time" but DTPA treatment apparently started arfyway.
3-69	Release of plutonium-contaminated argon gas into room during repair operation on gas line.	Apparently 7 workers contaminated. 5 with probable inhalation. Day 1 urine: #1-10.7; #2-5.6; #3-4.6 d/m/16hrs. Tot. body burdens: #1-0.057 ci; #2-0.008 ci; #3-0.002 ci. One worker "above allowable limits"	Failures of proper procedures during repair of gas line. No protective respiratory equip. issued or presence of health physics personnel, "a routine requirement". Routine repair methods ignored.	Apparently limited to closed-system room.	Medical treatment and follow-up not discussed.
10-71	Spontaneous fire of solvents and plutonium.	No one in room at time of fire. 4 firefighters with probable inhalation; data not reported. Body burdens believed to	Improper storage of materials resulting in spontaneous fire.	Release of 49.9 uCi of plutonium through stack into environment. "62.4% of RCG" limit.	Medical treatment and follow-up not discussed.

DATE	INCIDENT	WORKERS EXPOSED/ CONTAMINATION	CAUSE/ DEFICIENCIES	AREA(S) OF CONTAMINATION	RESPONSE
9-28-71	Excessive inhalation of plutonium by health physics surveyor in area of building where high plutonium levels were known to exist due to maintenance work.	One worker with excessive gamma/ neutron exposure and plutonium inhalation. Day 1 urine: 0.6; Day 30 urine: 144; Day 60 urine: 49.9. Day 1 fecal: 4,300 d/m (spot urines?). Lung burden: "22 Rem lung burden"; no tot. body burden reported.	Given inadequate repiratory protection for high-plutonium atmosphere (doesn't work above 100 RCG level; room level was 3000X RCG). Respirator also improperly fitted; "no emphasis in his training on selection of proper respiratory protection." "The recommended use ranges (of respirators) were deleted (from the worker's training manual) to eliminate specific numbers which might later be judged legally binding..." The worker's respirator had previously been found to leak, but was never fixed.	Apparently limited to closed-system room.	"We have determined that it is not always practical to have monitoring capability (for worker exposure) in all zones" DTPA treatments given.
1-17-72	Plutonium-contaminated water line ruptured on cold night, allowing water to run out into room and then outside of building onto grounds.	Apparently several clean-up workers with skin and inhalation exposure. Bioassay data not reported. "It is estimated that no lung exp. >6 nCi occured.	Workers used contaminated air supplies while cleaning spill. Clean-up procedures not followed, causing contamination. Many oversights of procedures.	Off-site air and water contamination. 40 X increase in plutonium in offsite water over previous year. Report says below RCG limits.	Medical treatment and follow-up not discussed.

DATE	INCIDENT	WORKERS EXPOSED/ CONTAMINATION	CAUSE/ DEFICIENCIES	AREA(S) OF CONTAMINATION	RESPONSE
3-13-73	Worker contaminated with Tritium during repair of pipes containing tritium.	One worker with skin absorbtion of tritium. Bioassay data censored from report. Contradictory data on whole body exposure: 17 Rem in one report; 39.5 Rem in another	Worker instructed to use gloves during repair work which were inadequate, allowing leakage.	Stack filters could not trap excessively high levels of tritium; 163 curies released into environment, 2.8 X RCG limit at "fence line". No "significant" increases in off-site sampling of tritium, but no data reported.	Worker given "forced fluid" program consisting of beer, coffee, and water (ave. of 12 cans beer per day)--

Dayton News coverage of incident: Worker: "officials assured me that in no way at all would the exposure to tritium ever affect me or hurt me.". Company rep: "A broken limb is much, much more serious....(This exposure) is equivalent to someone cutting his finger.... The last time that we had something of this type was in April 1968.... We have the best safety record in the AEC."

6-18-73	Plutonium released into air during glovebox operation.	2 workers exposed, 1 reported to have absorbed plutonium. Bioassay data not reported. Total lung burden of worker app. 20 nc. Added to 9.0 nc exposure from previous accident = 30 nc (time period?).	Glovebox and room venting system not properly adjusted, allowing escape of plutonium into the air. Also "(air monitors) were not placed at the optimum location for early warning.... It is possible that...an air sampler nearer the release could have reduced his uptake"	864 uCi released into room (closed system?)	DTPA given. No plans on improving air monitor system which is "limited by economics"

DATE	INCIDENT	WORKERS EXPOSED/ CONTAMINATION	CAUSE/ DEFICIENCIES	AREA(S) OF CONTAMINATION	RESPONSE
12-1-77	Ruptured trash bag released plutonium	One worker's clothing contaminated, then inhalation when respirator removed before decontamination over. Health physics workers contaminated when he removed worker's clothing by hand. Bioassay data censored. Tot. est. lung burden 24.5 nc ("1.6X ave. allowed exp)	improper decontamination procedures followed. Issued improper respirator; seal not tested; mask had defective exhaust valve. Too few men for job.	Apparently limited to closed-system room.	DTPA given.

Dayton News coverage of incident: Company rep: "the affected employee will absorb as much as an extensive series of diagnostic X-rays". "In the case of exposure to the lung, radiation levels of 10-100 times higher would be necessary to present a health hazard."

#1

MOUND LABORATORY DOCUMENTS

Title of Report:	Radiation Incident in R-120, Glovebox -July 6, 1960
Date of Reports:	July 12, 1960
Date of Incident:	July 6, 1960
Documents Included:	Accident Investigation Report and Health Physics Report

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Brief Description

Release of radioactive particles including plutonium from defective glovebox resulted in contamination of 11 workers, including five visitors. Visitors allowed to leave wearing contaminated clothing. A shoeshine boy was contaminated as a result, but further investigation of shoeshine boy called unnecessary for fear of "stirring up a hornet's nest." Medical treatment, follow-up not discussed.

Narrative Summary

The accident involved a leak of plutonium-contaminated particulate on July 6, 1960 in Room R-120. The accident was caused by an equipment malfunction on a glovebox which resulted in the build-up of pressure leading to an explosion which blew the gloves off of their ports.

Five visitors were present in the room when the accident occurred. An alpha check by the chemist revealed that everyone present was "quite hot." Another chemist noticed that the alpha meter in an adjacent room was off-scale. Eleven people were found to be contaminated. Contamination spread to seven rooms and a corridor. Adjacent rooms were measured as high as 100,000 c/m (counts per minute) per 40 square inches.

Contamination to the extent of 1,000 c/m to 5,000 c/m per 100 sq. cm. was detected on the visitor's hair and clothing. Those exposed were decontaminated and the visitor's personal items such as combs and wallets were monitored "during a lot of confusion" and "in a hurry because the visitors were anxious to leave." All outer clothing was found to be contaminated. Shoes were scrubbed off and checked while still damp - - a mistake, according to the report since accurate readings are impossible with wet items. All visitors except one were allowed to keep their shoes and most other personal items. Eyeglasses were simply washed and not

checked. Body contamination of the visitors ranged from 5,000 c/m to 100 c/m.

One of the contaminated visitors from Dow Company subsequently left the site and had his shoes shined in Kettering, Ohio, a community close to the plant. He then flew to the Rocky Flats Plant in Colorado the next day where health physicists discovered that his shoes were contaminated with counts as high as 5,000 c/m. Rocky Flats personnel consfiscated his shoes, and notified Monsanto of the contamination and the fact that the visitor had had his shoes shined by a local shoeshine boy. The report stated that Monsanto did not follow up on checking the shoe shine boy because all that would have been accomplished "would have been to stir up a hornet's nest."

The accident investigation report recommended that Klaxon horns be installed to warn of high level pressure build-ups in gloveboxes; review the air conditioning in the Research Building so as to minimize the spread of contamination; revise the Disaster Plan to include procedures for major contamination disasters; and purchase monitoring alarms for labs subject to heavy contamination.

Comments

Apparently, this is the first time that Monsanto had thought of installing radiation detection alarms in their labs -- standard operating procedure for most professional labs even in 1960. Monsanto had not even prepared a disaster plan to deal with major contamination disasters at that point. The cavalier attitude that management had towards contamination of their workers and visitors is reflected in the language of the report, and especially in the decision made by Monsanto not to attempt to locate the shoe shine boy for obviously political reasons. Tracking plutonium all across the country as the Dow vistor did appears to require some back-checking for contamination. One wonders what other contamination incidents were never investigated for fear of "stirring up a hornet's nest."

#2

MOUND LABORATOORY DOCUMENTS

Title of Report: Explosion of Neutron Source, August 19, 1960

Date of Reports: September 4, 1960 thru January 20, 1961

Date of Incident: August 19, 1960

Documents Included: Interim Investigation Report, September 4, 1960; Bio-assay Data Report, September 3, 1960; Letter, Monsanto to AEC, October 4, 1960; Report of Accident Investigation, Explosion of Neutron Source, January 13, 1961; Supplement to Report of Accident Investigation, January 20, 1961.

Brief Description

Explosion of a steel can containing 80 grams of plutonium resulted in one worker with internal contamination (inhalation) and some skin exposure. The accident resulted from defective packaging of plutonium in steel can allowing pressure build-up. Can exploded after hacksawing attempted. Worker was not wearing full protective gear. Medical treatment, follow-up not discussed.

Narrative Summary

On August 19, 1960 an operating chemist received a memo stating that the McCullough Tool Company had contacted the lab to inform them that there was a broken screw in the cap of a neutron source M-316 steel container that needed replacing. The chemist found a source marked M-218 and assumed that McCullough had mislabeled the source and that the M-218 source was the one in need of repair. The chemist could find no correspondence regarding M-218 so he called his group leader for guidance. The groupleader suggested that the chemist begin the replacement procedures for the stainless steel can of M-218 while he continued looking for information on the source.

The chemist put the M-218 source - - which contained 80 grams of plutonium-239 (or 5 curies) - - on a lathe and began to use a hacksaw to cut through the can. The wall of the can had been nearly penetrated when the source exploded. The internal can was propelled with some force from the steel container, projecting into and denting a welding machine twelve feet away. Luckily, the chemist was leaning away from the lathe at the time of the

#3

MOUND LABORATORY DOCUMENTS

Title of Report:	Radiation Incident, November 11, 1960
Date of Reports:	November 21, 1960 to March 17, 1961
Date of Incident:	November 11, 1960
Documents Included:	Accident Investigation Report, November 11, 1960; Report of Internal Radiation Exposure Incident, November 30, 1960; Status Memo, December 2, 1960; March 17, 1961.

Brief Description

Leak of polonium from a neutron source while welding resulted in contamination of three workers. Workers not wearing protective gear. One worker exposed in excess of permissible body burden. Medical treatment, follow-up not discussed.

Narrative Summary

At 9:45 a.m. on November 11, 1960 an incident involving polonium contamination occurred in Room 279 of the T-Building. Three workers were contaminated as a result. The leak occurred during repair operations on polonium-beryllium neutron source with a 12 curie level. During welding, a worker punched through the metal and created a small hole in the source. The radiation alarms immediately sounded, and the alpha meters went off-scale. Two other workers in the room left, and the welder stayed behind to spot weld the hole when he noticed that both sources were punctured. All three workers were decontaminated as much as possible, and within a twenty-four hour period, it was determined that the welder had received a dose above the maximum permissible body burden.

The health physics report dated November 30, 1960 revealed that "significant" amounts of polonium-210 were released into the laboratory during the accident. The permissible whole body content of polonium was reported to be 0.2 microcuries. 580 d/m (disintergrations per minute) in a 24-hour urine specimen is indicative of the maximum permissible body content. In a 50 ml spot sample, a result of 20 d/m is indicative of the maximum permissible level. The welder's levels in urine samples were reported as 4,841 d/m in a 24-hour period on the first day after the accident; 5,434 on the second day; 5,405 on the third day; and 5,834 on the fourth day. Spot samples during the same period ranged in the area of 112, 152, 184 and 174 d/m. The report

estimated that the worker was over-exposed by approximately 10.06 times the maximum permissible body burden.

The dosage for the welder was so high partially due to the poor judgment exercised by him in spot welding the hole shut. This action of welding on a polonium contaminated surface "volatilized the polonium producing a condensed vapor of a particle size too small to be stopped by the filters in the respirators and masks in use."

Comments

What, if any medical treatment given this individual is not discussed. (Insert comparison with rem dosage for worker.)

#3a

MOUND LABORATORY DOCUMENTS

Title of Report:	Radiation Incident, December 16, 1960
Date of Report:	December 20, 1960
Date of Incident:	December 16, 1960
Documents Included:	Investigation of Radioactive Contamination in ""T" Bldg., Room 310A

Brief Description

Release of polonium from broken ampules of material in storage area contaminated three workers within unreported levels of radiation. Cause of the accident attributed to inadequate storage of material allowing pressure to build-up in vials, causing them to rupture. Inadequate worker protection caused contamination during inspection.

Narrative Summary

This short and inadequate report simply describes that workers heard a report like that of .22 pistol or light bulb breaking. Two workers investigated in the vault at which time they heard a second report. They opened the vault door and discovered glass fragments and a brass identification tag for radioactive materials on the floor and shelf.

It was discovered that two ampules containing polonium exploded due to a pressure build-up caused by a complex chemical and nuclear reaction. Three workers were reported contaminated, although no health physics report was included, nor were levels for exposure given. No medical treatment or followup was discussed. A Health Physics supervisor was reported to have a high hand count because he used cotton glove liners for wipes which is "inadequate for emergency action", in the words of the report.

Counts as high as 125,000 d/m (disintegrations per minute) per 100 square centimeters were measured in the vault, which is "quite high."

Comments

With levels as high as that in the room, I find it curious that no health physics report was included with this report. I suspect that the workers received "quite high" doses. I also wonder why there were no radiation meters or alarms in an area where high level radioactive material is stored. That kind of device could have forewarned the workers from entering the room and getting contaminated. It seems elemental that such a device should have been in place.

#5

MOUND LABORATORY DOCUMENTS

Title of Report: Final Report of Radioactive Contamination Incident in Room 145 - "R" Building - May 11, 1961.

Date of Report: June 21, 1961

Date of Incident: May 11, 1961

Documents Included: See Appendix

Brief Description

Incident involved release of plutonium from "scrubber" system of glovebox. 3 workers were contaminated due to malfunctioning equipment. The unavailability of respirators resulted in inhalation. The contamination was limited to a closed-system room. Workers received no medical treatment beyond natural dissipation of radioactivity discussed.

Narrative Summary

On May 11, 1961 shortly after 10:00 a.m. an accidental release of Plutonium 238 occurred in Room 145 of the Research Building. At the time of the release three workers were present in the room and were contaminated. One worker received 2.05 times the maximum permissible body burden allowable in a single continuous exposure. The following series of events surrounds the incident: The three chemists were working in the "low-risk" room when they heard a hissing noise. The noise seemed to be coming from underneath dryboxes 3 and 15A. One worker looked over to the dryboxes and saw brown gas fumes from the vicinity of dryboxes 2 and 3. Another worker checked dryboxes 6 and 7 and did not find any evidence of ruptured lines. The other worker shut down the nitrogen gas supply and stopped the vacuum pump at drybox 2. Then all three workers went to the door of corridor 5 at which time the air monitor's red light started to flash. In the corridor one worker closed the supply valve for nitrogen by the HF coffin while another worker checked to see if the red light was still flashing red (it was). The three men moved towards the change room R-152 and were met at the air lock by the Health Physics Surveyor. They informed him of the incident and the surveyor fastened his respirator to his face and started towards the area. The workers suggested that he not enter the room due to the contamination. He took their advice and went back to the air lock adjacent to room R-152.

The workers' clothing was tested and found to be contaminated with levels as high as 10,000 to 40,000 c/m / 60 cm2. Their clothing was bagged by the Health Physics personnel. External

readings showed contamination on the worker's hair as high as 40,000 c/m. They showered, and after 2 showers their external bodies were found to be free of contamination. Nose wipes also indicated contamination in two workers. Levels ranged from 1,470 c/m to 33,183 c/m in the workers' nostrils. Feces analysis on one worker read up to 10,162 d/m. This worker's body burden was estimated to be .082 micro-curie (2.05 times the maximum permissible). Health Physics Staff then taped off the air lock doors and put up "Do Not Enter" signs. Painters who were working in adjacent rooms were tested and found to be slightly contaminated. Other workers in the area were tested and found to be free of contamination.

At 11:00 a.m. two men entered room R-145 in bubble suits to determine the extent of contamination, to shut down any valves or electrical equipment left in operation, and to determine the cause of the incident, which was not immediately apparent. Decontamination took two days. An investigative committee found that the area below drybox 2 was still very "hot" making it impossible to conduct a thorough investigation. No leaks or breaks in the line were apparent.

On May 26, 1961 the AEC Dayton Area Office was notified that lab analysis had indicated that one worker had been exposed to 2.05 times the maximum permissible body burden, making the event a special reportable incident. A preliminary report had been issued on May 22, 1961, but at that time no further investigation was done due to fear that they would release more contamination in the investigatory process which would delay work on a high priority program in the same room. Also, they had not received the analysis of the extent of the workers' contamination. On May 29, 1961 a meeting of the investigating committee was held under the new AEC Chair and more formal investigations began.

The incident was linked to a series of conditions and circumstances which led to the spread of airborne Pu-238 when a leak developed in the scrubber system. These conditions included 1) loss of vacuum in the closed scrubber system, 2) the general weakening of the upper section of the caustic scrubber due to mechnical vibration or pressure fluctuation, 3) the wooden box enclosing the Nash pump and the caustic scrubber was not liquid or gas tight, and 4) the closed valve back of the filter box.

Tests done on the feces of one worker on May 21 showed 10,162 disintegrations/minute and a urine sample collected May 11-17th showed 126.6 disintegrations/minute. The two workers who did not receive more than the maximum permissible body burden were allowed to resume their previous work assignments. The worker who was severely contaminated was restricted from working with radioactive materials indefinitely and was transferred to doing "cold" work. (insert standards)

Comments

It is interesting to note that the radioactive release was only

noticed due to the fact that workers heard a hissing noise. Apparently there was no warning system prior to that point which could have prevented contamination of the workers.

#6

MOUND LABORATORY DOCUMENTS

Title of Report: U.S. Govt. Memorandum "Report of Radioactive Contamination Incident in Corridor 20B of "T" Building Operations Floor.

Date of Report: November 8, 1961

Date of Incident: October 20, 1961

Documents Included: U.S. Govt. Memo "Management Action Taken on October 20, 1961 Incident"; U.S. Govt. Memo "Investigation Report - October 20, 1961 Incident"

Brief Description

Incident involved the release of polonium from glass lab equipment when it was dropped. One worker was contaminated above the allowable limit. The incident occurred when someone bumped into a decontamination worker carrying waste, causing him to drop glass containing polonium. The worker was not wearing protective equipment. The incident was limited to a closed-system. The medical treatment or follow-up of the worker was not discussed.

Narrative Summary

On October 20, 1961 at about 9:00 a.m. an incident occurred in the "T" Building, Operations Floor, corridor 20B, in which radioactive material (Polonium 210) was released through the accidental breakage of contaminated glass laboratory equipment which was being carried by a worker from the decontamination area to the neutron source group area. The accident occurred as follows: As a result of experimentation, a piece of laboratory equipment was contaminated. A decontamination worker was instructed by a Health Physics Surveyor to take the equipment to the decontamination room and clean it. No further instructions were given as to procedures, and permission was not obtained from the supervisory personnel of the neutron source group to remove the equipment from the experimentation room to the decontamination room.

The worker moved the contaminated equipment to the decontamination area and placed it on an open bench. The worker took no precaution as to bagging or containing the apparatus when moving it, and it was not tagged or identified in any manner. He only wore cotton glove liners when cleaning and stated that when they became contaminated he threw them away. The usual decontamination techniques were followed, however the worker failed to decontaminate the inside of a glass tube which was part of the apparatus.

After finishing the next day the worker simply hand carried the equipment back up to the neutron source group area. When exiting from an elevator into corridor 20B, he was bumped into by two men coming around the corner. The worker dropped the apparatus and the glass tube, the inside of which was contaminated, broke on the floor. After picking up the glass with his hands the worker went to the Health Physics office to check his hands which were found to be "hot". Although he took three showers and changed clothes, his hands still showed a count. In the meantime, the two men in the hall put on respirators and called the Health Physics office to notify them of the accident. Unfortunately about five minutes elapsed before the office was notified and due to heavy foot traffic in this particular hall the contamination was spread by tracking and transfer. It took 2/3rds of a day to clean the hall; equipment which was moved through the area immediately prior to the clean-up was found contaminated.

Numerous failures of the persons involved to act in a cautious and responsible manner as well as a failure on the part of the company to to adequately advise the workers on established procedures caused this incident. Also, poor traffic visibility at the elevators was a contributing factor.

Tests results showed that the worker recieved a body burden in excess of the maximum permissible continuous concentration (832 d/m in urine of polonium-210). However, the report makes no mention of any treatment given to the worker, but only that he was transferred to a "low-risk" area and was not allowed contact with Polonium for an "appropriate period of time".

Comments

None.

#7

MOUND LABORATORY DOCUMENTS

Title of Report: Investigation of Accident in SM-10

Date of Report: August, 17, 1962

Date of Incident: July 26, 1962

Documents Included: See Appendix

Brief Description

Pressure build-up in plutonium-containing can resulted in plutonium release when the can was opened by a worker. Six workers were significantly contaminated. Contamination occurred in Room 10 and adjacent rooms and corridors. Regulations for the proper storage of plutonium were not followed. Respirators were not available and internal contamination was found in all workers.

Narrative Summary

At about 9:18 a.m., July 26, 1962, in Room 10 of the SM Building of the Mound Laboratory, a calorimeter can ruptured during opening, discharging PU oxide into the room. There was localized high levels of surface contamination and airborne alpha contamination of adjacent areas.

The PU oxide involved was processed in a similar manner to previous batches with the exception of packaging. Previous batches had been handled in "o" ring sealed containers with enough volume to reduce the probability of high pressure buildup. Cans were always opened in a dry box, further reducing the probability of a detectable pressure release upon opening.

The changing of calorimeters necessitated the use of a smaller container. A specially designed can had been ordered but was not available for use with this batch. Small aluminum "button" containers available from other operations were used.

At the time of the incident, the material was removed from the calorimeter, carried to room 10 and placed on top of a work bench for unloading. A Health Physics Surveyor was present to check for radioactivity when the can was opened. Unable to remove the can lid by hand, a worker inserted the blade of a screw driver into a hole in the can lid and succeeded in aligning it for removal. At that moment the lid blew off to a height of 2 feet, dispersing PU oxide into the room. Six workers were in the room within a distance of 12 feet of the can. All were wearing the required protective clothing and two were wearing respirators. Those handling the can announced an evacuation. Four minutes after the incident all were outside in the corridor. Survey

meters with a maximum scale reading of 200,000 c/m ran off the scale in surveying the clothing of those involved. All were instructed to change clothes and shower. At 9:22 a.m. the entire building was evacuated.

Nose wipe counts were made on all personnel present on the low risk side of the SM building. Those showing a count greater than 2000 dis/min (six individuals) were transferred to the Medical Department to begin treatment with DTPA. Counts were as follows: nosewipe counts in d/m for six workers: 445,000 d/m, 95,000 d/m, 45,000 d/m, 39,000 d/m, 32,000 d/m, 24,000 d/m.

Monitoring in Room SM-10 indicated a high level of airborne and surface alpha activity. Building monitors showed a rise in airborne and surface contamination in adjacent rooms and corridors. These areas were decontaminated by July 30, 1962. Decontamination of Room 10 was completed by August 3, 1962. The material remaining in the batch after the incident was further processed and used without first resubmitting to calorimeter assay for accurate determination of loss.

Comments

The incident resulted in an investigation and a series of recommendations, including developing and publishing standard operating procedures describing containers to be used and procedures to be followed in transferring PU oxide outside of a dry box, as well as requirements that containers of radioactive material be opened only in a dry box or fume hood. Apparently written procedures for handling PU oxide in the above detailed process did not exist until after the above described incident.

#8

MOUND LABORATORY DOCUMENTS

Title of Report: Contamination Incident, Special Metallurgical Facility, 2/21/1963

Date of Report: January 7, 1964

Date of Incident: December 21, 1963

Documents Included: January 7 report by David L. Scott, January 13 Report by John E. Bradley, January 17 Report by W.B. Creamer

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Brief Description

Radiation was released from an abandoned vacuum system in the ceiling crawl space of the SM building. An old plastic bag wrapped around pipe ends was accidentally burst by workers installing other piping in the area. The workers were not wearing proper protection resulting in at least two workers being significantly contaminated. Radioactive material of large particle size spread throughout the building.

Narrative Summary

All service lines to the Special Metallurgical Facility (SM building) are carried in an overhead crawl space throughout the building. This service area is hidden from view by suspended "T" bars holding removable panels. Access to the crawl space is by removal of the appropriate panels.

One of the service systems is a stainless steel pipe vacuum transfer system which transferred radioactive solutions from one lab to another. The system presented problems in the past because of minute pinhole leaks at the welded joints, so use of the system was recently discontinued. this.

Complete removal of the system was planned but had not been accomplished when production operations in Room 21 required the removal of a section of the vacuum system. In April 1963, a cut-off point was chosen so that the unnecessary section could be removed. After cutting the pipe, the two pipe ends were closed with plastic electrical tape and plastic bags placed over them. This was not intended to be the permanent method of closure, but was to serve until the system was completely removed.

It appears that liquid seeped through the tape on the end of one of the pipes and into the plastic bag cover. The aging of the plastic, the alpha radiation, and chemical reaction on the plastic caused it to become brittle. At 10:30 a.m. on December

21, 1963 three workers were involved in threading copper tubing through the crawl space in Room 21 when portable air monitor alarms went off. Personnel throughout the low risk side of the facility were evacuated in a rushed and confusing fashion. Subsequent investigation revealed that the copper tubing had jostled the deteriorated plastic bag sealing the vacuum system, and that the bag had disintegrated. The poor ceiling panels and the ventilating conditions existing in the building allowed the spread of radioactive particles (type of radiation not identified) through Rooms 21 10,38,39,17,18 and 9 as well as Corridor 40. The two workers in room 21 involved in laying the copper tubing were found to have abnormally high nose counts and were required to submit urine and feces samples to Health Physics. Nose counts up to 59,662 c/m and 16,155 c/m. Feces analysis indicated levels of 15,986 d/m and 10,112 d/m. Another worker sustained a bruised knee during the building evacuation. Counts in Room 21, in the immediate vicinity of the leakage were well over 2 million.

An investigation of the incident was completed and a series of recommendations were made. These included insitution of a proper evacuation procedure during an emergency. Also, the remainder of the unused vacuum system was to be removed and other pipes in the crawl space that had to be cut and sealed were to be tagged and removed as soon as possible. Finally, a permanent maintenance crew, familiar with the conditions in the building should be stationed there.

Comments

A permanent maintenance crew recommended for the SM building was not installed due to cost considerations. It was stated that temporary help would continue to be used during periods of heavy need. Better supervision and instruction of temporary help would be implemented, however. It is interesting to note that staff in the low risk section of the SM building were endangered by more than one system of improperly sealed pipes that had carried radioactive materials. These systems were present over their heads in a crawl space, shielded only by removable ceiling tile.

#9

MOUND LABORATORY DOCUMENTS

Title of Report: Investigation of Incident in Which XXXXX Received Contaminated Acid Burns

Date of Report: February 13, 1964

Date of Incident: February 2, 1964

Documents Included: Bioassay Information, 10/1/64; Monsanto Final Report, 12/31/64.

Brief Description

Incident involved a pipefitter who received an acid burn on his cheek and thereby plutonium contamination. The incident occurred when a drop of nitric acid containing 0.34 milligrams of plutonium 238 per milliliter of solution fell from a crimped stainless steel pipe being hoisted into position in the vacuum header.

Narrative Summary

On February 2, 1964 at approximately 10:00 a.m. an incident occurred in the SM Building, Room 2, in which a drop of highly contaminated nitric acid (0.34 milligram of plutonium 238 per milliliter of solution) fell from a section of crimped stainless steel pipe, containing approximately 600 milliliters of solution, onto the cheek of a pipefitter standing below the pipe. The accident occurred as follows: The piping system of a vacuum in the SM Building had been abandoned for over a year because of trouble with leaks and radioactive contamination. Most of the open ends were capped and the piping was left in a crawl space. An accident in December of 1963 involving the rupture of a temporary capping on the abandoned system resulted in a significant spread of dry powder contamination.

It was believed that future incidents could be avoided by crimping the pipe ends. It was recognized that the system was extremely contaminated and that plutonium solution could be puddled at various places, but no plans were made to deal with this situation. At least two of the pipefitters, including the foreman, were not even wearing safety glasses when the accident occurred. The workers made two cuts in the piping system without incident. On the third cut they encountered a puddle of contaminated solution which caused the accident to occur. Later testing showed that the pipe was approximately 3/4 full of liquid

when crimped and cut.

The pipefitter victim rushed to a drinking fountain in the low risk corridor and began rinsing his face with water. The wound was scraped alternatively with soap and versene and flushed with water for approximately 15 minutes. The victim was taken to the plant dispensary for treatment. Early urinalysis indicated that the victim received a significant internal deposition of plutonium 238 (13,004 counts/minute for a 24 hour period ending February 5, 1964). The victim was placed on medical treatment with DTPA, a chemical which accelerates elimination of plutonium. The victim had urine concentrations of up to 5.19 counts per minute as late as September of 1964. Computer analysis of 16 urine samples taken since the accident showed that the victim's body burden as of October 8, 1964 was approximately 0.058 microcuries. The maximum permissible body burden is 0.04 microcuries.

The investigation committee recommended that the contaminated piping still left in the SM Building's crawl space be removed as soon as possible and further that the following safety precautions be taken before any work began: workers should wear full face masks; flushing of the system should be attempted; future cutting should be under sealed conditions; emergency washing stations should be placed in the low risk corridor.

Comments

This incident could have been completely avoided with proper planning and consideration of worker safety. One need only envision the victim attempting to flush the wound in a water fountain to understand just how serious and potentially tragic the management's lack of proper planning was in this incident.

#10

MOUND LABORATORY DOCUMENTS

Title of Report: Investigation Report - Internal Radiation Exposure to Po-210, May 11, 1964

Date of Report: May 23, 1964

Date of Incident: May 11, 1964 (date exposure indicated)

Documents Included: Supplement to Investigation Report, and two letters from Monsanto to AEC

Brief Description

Two incidents are involved in this report either of which may have been responsible for the contamination of a particular worker found to be contaminated on May 13, 1964. One incident occurred on April 28th and the other on May 6th. The medical treatment and follow-up of the worker was not discussed.

Narrative Summary

On May 13, 1964 a urine sample for a worker showed 60 counts/minute for polonium-210 which clearly indicates excessive contamination. Since two incidents occurred in the time between the worker's last test on April 27, 1964(which showed 0.6 counts/minute) it is not known which event caused the contamination or how much each incident may have contributed.

On April 28, 1964 two workers in Room T-270 were using the hoods to perform their job duties. One employee turned on the main water header valve for coolant. Water is often used to wash down the walls of the hood. The wash water had been collected in a plastic tank under a center drain hole in the hood. As water flowed into the hood and down the drain it gradually overflowed the plastic tank and ran onto the floor beneath. One of the employees noticed the liquid coming from beneath the hood. Immediately thereafter the alarm sounded twice, and the worker took a wipe at the edge of the growing puddle, which showed contamination. Then a smaller puddle was noticed coming from another hood.

A Health Surveyor came into the room at this point, noticed the air monitor shooting up and ordered respirators to be worn. Rather than leave the room the men took successive wipes, checked the equipment, and began to mop up the puddles. When it was discovered that the puddles were still growing and could not be mopped up, they finally left the room. All the men except the worker concerned in the report were determined to be generally contaminated with direct readings of up to 50,000 counts/minute on an area of 11.2 square inches. The whereabouts of the worker

in question after the room was evacuated are not known, but he doesn't recall taking a shower that day.

The second incident that occurred involving this particular employee was on May 6, 1964. On that date, this worker entered the high-risk area behind the polonium process lines to clean out several hoods. He had been instructed on the proper dressing technique. He spent about 2 hours behind the lines. Although according to the report such entries were not generally eventful from a contamination viewpoint, the worker reported that he usually became slightly contaminated around his neck and chest area while in this area. He also reported that that day he smelled acid fumes somewhat stronger than usual, but had no difficulty decontaminating himself after leaving.

Comments

It is apparent that either of these two incidents could have caused the severe contamination discovered on this particular worker. The first incident seems more likely since no one knows when he left the contaminated room, where he went thereafter, or whether he was decontaminated in any fashion. It is essential that Health Physics contact any worker involved in an accident immediately thereafter to check for contamination. However, the Health Physics Department neglected to do so on this occasion. The estimated dose of 0.8 microcuries of polonium-210 from this accident averaged our for aa yearly exposure of 0.12 microcuries, or 3 times the maximum permissible body burden.

#11

MOUND LABORATORY DOCUMENTS

Title of Report: Investigation of Incident in Room No. 35, Special Metallurgical Building

Date of Report: October 30, 1964

Date of Incident: October 27, 1964

Documents Included: Monsanto letter to AEC, 10/28/64; Investigation Supplement, 10/30/64; Action Taken on Recommendations, 11/30/64.

Brief Description

Incident involved the release of plutonium and contamination of three workers due to an explosion in air hoods of methanol fumes.

Narrative Summary

On October 27, 1964 an accident occurred in Room 35 of the SM Building, in which plutonium oxide was released due to an explosion in Airhoods #16 and 17. The accident occurred as follows: A beaker containing waste contaminated methanol was being evaporated as a means of disposal in Hood #16. Workers added to this beaker until approximately 6:45 p.m. at which time the device controlling evaporation was turned off. The beaker was not removed from the hot plate. At approximately 7:00 p.m. all air supply and exhaust to the system was shut down to effect a filter change. The system remained off until 8:00 p.m. The variacs were not turned on until 9:00 p.m. At that time the workers began second hot plate evaporation with methanol containing 17 grams of plutonium. An explosion occurred at 11:25 p.m. Six gloves on the hoods ruptured and air currents in the building distributed radioactivity throughout the low risks sides of the SM Building.

All six workers in the area were wearing full respirators. Five of the workers went to the nearest changing room. The sixth worker exited via a crash door into an uncompleted section of the SM building and made his way to the outside of the building. The crash doors sealing system had been altered by the security staff and failed to close. As a result of the explosion and the escape of the employee to the outside of the building, contamination was spread throughout the operating areas of the SM Building and to the uncompleted addition, the outside walkways and other non-operating parts of the building. Contamination in the work areas ranged from 10,000 to 100,000 counts per minute.

Three of the six workers were decontaminated by normal showering procedure. The other three workers suffered inhalation exposure to the plutonium oxide. Bioassay data showed that two the workers suffered a body burden of less than 10% of the total permissible at that time. The remaining contaminated worker suffered a body burden of 50-70% of the total permissible burden. External contamination ranged from 4,000 c/m (on his face) to 80,000 c/m (lower rib cage) of plutonium-238. Feces sampling iinducted internal exposures of 850 d/m to 3,800 d/m for one worker; as high as 40,140 d/m for another. All 3 were subjected to DTPA treatment.

The Investigation Committee determined that the explosion was caused by the build-up of methanol vapors inside the hood area to a concentration at which the flash point was reached. An undetermined spark from any of the equipment present set off the explosion. The flow of air to the hoods was not sufficient to remove the vapors of flammable organic solvents at the rate necessary to prevent the build-up of an explosive mixture.

Decontamination of the building took 26 days of intensive work and forced interruption of normal production operation. The costs of the clean-up were approximately $34,000.

Comments

This incident demonstrates the devastating impact of management's poor supervision of procedure: The evaporation system used was wholly inadequate; the technique of disposal through evaporation was inherently dangerous and subsequently abandoned; the evacuation route of one worker caused the spread of contamination to the outside of the building; security had tampered with the crash doors; and most importantly, the air supply system was shut down at a critical point in the evaporation process.

#12

MOUND LABORATORY DOCUMENTS

Title of Report: Monsanto Letter: "Investigation of the Whole Body External Radiation Dosage of XXXXXXX, Which is in Excess of 3 Rem During One Calendar Quarter"

Date of Report: May 11, 1965

Date of Incident: Between March 29th and April 30, 1965

Documents Included: Supplement to Report on the Investigation... (see above)...Quarter; External Radiation Exposure Incident, dated May 25, 1965

Brief Description

This report explains the nature of the work done by a particular employee of Monsanto whose accumulated radiation dosage, consisting principally of exposure to gamma rays and neutrons, was estimated to be 3.85 from the period from March 29th to April 30, 1965. The report includes explanation of the exposure and recommendations for preventative measures, but not does address the health of the worker or why he was allowed to remain in Room 39 despite general knowledge of the dangerous nature of the tasks he was performing.

Narrative Summary

During the month that this employee accumulated the estimated 3.85 Rem dosage he was engaged in the reactivation of and production in the process line in Room 39 of the Special Metallurgical (SM) Building (where plutonium 238 nitrate is converted to plutonium metal). This was his first time to work in Room 39 where reactivation of the process line included repairing and replacing part of the equipment in hoods 1 and 2.

On April 28th the worker, along with two others, began to remove trash accumulated from the repair work and to clean the hoods themselves. This process was very involved and included putting the trash into metal cans or taping the bulky pieces and putting the trash thereafter into plastic bags. Preparation of the trash required this worker and another who was assisting to remain near the front of hood 1 most of the morning.

During the trash preparation and removal operations, a 120 gram batch of material was being fluorinated in hood 2. It is not known for what length of time, if any, the movable neutron shield in hood 1 was positioned at the opening between hoods 1 and 2. Also, during the entire trash removal operation about 400 g of

plutonium oxide, possible partially fluorinated, was located in hood 2. This would constitute a neutron source of unknown magnitude. The extent to which these two sources of neutrons contributed to the external radiation in front of hood 1 during the trash preparation and removal is not known.

The worker in question also spent time behind hood 2 with the large neutron shield removed. An indication of the high level of radiation at this point was demonstrated by a 1 Rem/hour neutron survey made while the investigating committee was in Room 39. The condition inside of hood 2 at this time was not ascertained, but even without a batch of fluorinated material in this hood, the radiation level is very high.

It was discovered that the worker had received 3.85 Rems on April 29 by testing the film badge that he was wearing during the period. Interestingly Table 1 of the report shows the incremental increase of radiation received by this worker for each week beginning with the week ending April 4, 1965.

Comments

It is difficult to understand why this worker was not pulled from this area sooner when it was obvious that his exposure was increasing weekly. Indeed, the Supplement to the Report states "The reported radiation intensities near hoods 1 and 2...are such that it is reasonable to expect that an employee, spending a large amount of his time in this area, could accumulate the dosage reported for..." this worker. This worker's yearly accumulated exposure for 1964 was 10.680 rems. Much of the exposure (at least half) was to neutron radiation.

#13

MOUND LABORATORY DOCUMENTS

Title of Report: External Radiation Exposure of XXXXX, an Employee of Monsanto Research Corp.

Date of Report: June 3, 1965

Date of Incident: March 29th to May 10, 1965

Documents Included: Investigation Report, May 20, 1965; Supplement Report, May 20, 1965; and Recommendation Report, June 1, 1965.

Brief Description

This is a report of an over-exposure of a worker to 4.828 Rems of neutron and gamma radiation in a quarter...a "Type B" reportable incident pursuant to AEC regulations. Nine worker exposures were reported for comparison in the same period (March through May 1965) who worked in the same area.

Narrative Summary

While working in the SM Building, one worker received in excess of 3 Rems (4.828) from March 29, 1965 until May 10, 1965, a Type B reportable occurrence. A review of 8 other workers working in the same area showed higher exposures as well.

The causes of the over-exposures were traced to inoperable pieces of equipment and the following of "non-routine procedures" by workers. It was found that "the present facility is inadequately shielded for quantities of material being handled..." and that "Radiation intensities in some locations are higher than the design criteria for routine operations." Futhermore, the procedures manual was 5 years old and failed to cover non-routine events or equipment breakdowns.

The report further stated "(t)here is a history of personnel who have been 'burned out' from the SM-39 operation this calender quarter without evidence of correction or positive action being taken to reduce the radiation levels or to control radiation exposures." Finally, radiation levels were not measured, even after a spill of plutonium tetrafluoride occurred on May 4, 1965. Radiation doses of nine workers were listed ranging from 1.085 to 4.828 Rem in the calender quarter.

Comments

Unmitigated negligence on the part of Monsanto, not the workers, resulted in significant worker over-exposure and neutron and gamma radiation. Apparently, a production push resulted in the sacrifice of worker safety standards to meet deadlines. No yearly accumulated dosages were reported.

#14

MOUND LABORATORY DOCUMENTS

Title of Report: SM Building Room 38 Fire on August 27, 1965

Date of Report: September 7, 1965

Date of Incident: August 27, 1965

Documents Included: None

Brief Description

This incident involving the explosion of plutonium containing anion exchange resin occurred on August 27, 1965. No workers were in the room at the time and none were contaminated. It was a near miss accident. It occurred when the temperature control failed on an oven which was heating resin mixture, and the mixture reached ignition temperature. A hood glass protection was blown apart by the explosion releasing plutonium into the room.

Narrative Summary

On August 27, 1965 a Monsanto chemist had just left Room 38 after sifting the resin determining that it was free-flowing when an explosion occurred in the hood protection. Several employees in the hall heard the explosion and one, upon glancing in the door window to room 38 instructed the workers to get out. On their way out they hit the fire alarm box in the corridor. After evacuation the operating chemist and another worker donned Scott air packs and prepared to re-enter the building. In the meantime other workers met in the garage and drove to the SM building in the firetruck.

First, efforts were made to put out the fire with a carbon dioxide extinguisher. This was not successful so they took the fire hose into the room and sprayed water into the hood box apparently extinguishing the fire. The two workers then left to replenish their air packs, but upon return noticed that the fire was still burning. They then tore a hole in the lower left hand glove, played the nozzle around inside the box, and finally extinguished the fire.

It is only luck that prevented the chemist from not being seriously injured. The plexiglass window of the box was warped, charred and blistered. The stainless steel surfaces were blackened; polypropylene tubes and ducts were burned away; an exhaust duct filter was blown off; and nylon valve handles were melted. The ceiling above the box was charred black.

It seems that this type of accident is not at all unusual when working with this type of resin as accidents have also occurred in Rocky Flats and Fonteny-aux-Roxes which were even more serious than this one. Apparently, a paper about such problems with resins was due to be released a few weeks after this incident occurred.

Comments

In light of the fact that serious accidents similar to this one had occurred due to the unstable nature of the resin and that a paper was known to be due in 3 weeks which might lead to elimination of the problem, one can only wonder why such processes were not postponed until safety measures could be adopted.

#15

MOUND LABORATORY DOCUMENTS

Title of Report: Investigation of Incident in SM-59 on May 2, 1966

Date of Report: May 6, 1966

Date of Incident: May 2, 1966

Documents Included: None

Brief Description

This incident involved the alpha contamination of workers from a contaminated glovebox when air monitors did not warn workers. Apparently many workers were radiated, but the number was not reported nor any bioassay data. A failure of equipment caused alpha leakage from a glovebox due to improper servicing. The air monitor was incorrectly set for warning the workers. Safety regulations were not followed. The incident was limited to a closed-system room.

Narrative Summary

On May 2, 1966 three workers were assigned to Room 59 of the SM building to conduct operations related to recovery. During the afternoon they were ready to begin an ion exchange run which would require the use of argon. There was difficulty in getting the argon to flow from the main supply. The situation was remedied by striking the check valve which caused the argon to flow albeit at an intermittent rate. Around 3:00 p.m. one worker decided to check the argon availability by opening the valve on one of the jets in the fumehood. A yellowish-brown liquid along with the gas was expelled. He then tested another valve under the fumehood and the same thing happened. He then used paper towels and glove liners to clean up the floor of the fumehood and then discarded both. He also rinsed plastic tubing.

The workers went to the change room and checked their hands and found them to be contaminated. After several unsuccessful attempts to clean their hands, they called the Health Surveyor for assistance. Counts of over 5,000 c/m alpha were detected in nosewipies. Bioassay data was not included in this report.

A solution from the plastic tubing that was taken after it was rinsed contained 0.00041 milligrams of isotope per milliliter. This of course was a diluted sample due to previous rinsings. A small leak was also found in the argon line.

"The seriousness of the incident was expanded by lack of awareness of personal health physics responsibilities of the personnel involved; specifically, failure to recognize the health physics hazard of any unusual occurrence and failure to follow prescribed health physics procedures."

Comments

Management had not trained workers in the most elemental procedural precautions. No health physics data included.

#16

MOUND LABORATORY DOCUMENTS

Title of Report: Investigation of Incident in Room 21, Special Metallurgical Building on October 21, 1966

Date of Report: November 10, 1966

Date of Incident: October 21, 1966

Documents Included: Contamination Incident, SM-21, Oct. 21, 1966, November 30, 1966; Supplementary Report to Investigation of Incident in Room 21, December 5, 1966; Contamination Incident, December 14, 1966; Supplement to Contamination Incident, March 17, 1967.

Brief Description

Incident involved the explosion of a pile of waste material containing an unknown quantity of plutonium. No workers were near the site of explosion; however, a few clean-up workers were contaminated on their skin. The waste pile was believed to contain unstable resin material which reacted to heat and exploded. No medical treatment or follow up of workers is discussed.

Narrative Summary

On October 21, 1966, at 2:45 p.m., a laboratory technician was working in Room 59 of the SM Bldg. with non-combustible drybox waste material separating the coarse wastes and fine wastes. He was emptying the finer matter into a primary vessel preparing it for calorimetry. The technician testified that it was not "hot" at that time, and he followed the procedures for bagging and canning the waste. After he was finished he took the cans up to Room 21 where the calorimetry instrument was located. He left the cans on top of a file safe next to the calorimetry instrument and went back to Room 59 to retrieve the calorimetry vessels. Ten minutes later, while he was away, the cans exploded violently, spreading plutonium waste throughout the room. The emergency alarm was immediately sounded and the building was evacuated except for the personnel immediately involved in the incident.

A Health Physics Surveyor put on his respirator and entered the room to assess the incident and to make sure that no one was in the room. He observed a bluish-white smoke spread over the south end of the room. He exited into Corridor 40 and removed his shoes because he suspected a high level of contamination. He went to the change room and was found to be contaminated with

alpha levels of 2,000,000 c/m on the bottom of his feet and top of his head. His protective clothing was contaminated up to 20,000 c/m, and hand contamination was 200,000,000 c/m. After several showers, the body contamination was removed.

Several other health physics surveyors entered in full protective clothing including plastic oversuits and full face masks to take test wipes and to begin clean-up. The cost of clean-up came to $19,100.

The investigation committee concluded that the cause of the incident was a spontaneous reaction and not a gradual pressure build-up in the can. The can was found to contain nitrated resin which was the only matter in the SM Building with explosive properties.

Comments

This was the second accidental explosion due to resin. On both occasions workers had just left the scene of the explosion. Clearly the problems with working with resin had not been resolved since the prior explosion.

#17

MOUND LABORATORY DOCUMENTS

Title of Report: Investigation of Incident Involving Release of Radioactive material in Room 35B of the SM Building

Date of Report: March 14, 1967

Date of Incident: February 16, 1967

Documents Included: Supplement of Investigation of Incident in Room 35B, SM Building, March 17, 1967; Contamination Incident Room 35 SM Facility, March 14, 1967; Comments on Recommendations of Investigation Committee, April 10, 1967

Brief Description

Incident involved the leakage of liquid plutonium solution out of a glovebox. 3 workers were contaminated on skin, clothing, and evidence of inhalation. The cause of the incident was improper storage of plutonium solution inside the glovebox, allowing overflow outside of glovebox. No medical treatment or follow-up of workers was discussed.

Narrative Summary

At about 7:30 a.m. of February 16, 1967, the alpha air monitor in Room 35B sounded an alarm indicating a slight rise in air radioactivity. The room was surveyed and no cause could be found. So, work continued until 8:30 a.m. when the alarm again sounded. This time a survey showed contamination around glove boxes 2 and 3. One glove was changed and the air radioactivity levels stopped increasing. Upon resurvey no "significant" contamination was found, but the area was posted as a "respirator and double shoe cover area". Interestingly, the investigation committee found no relation between the incident at issue and these two alarms.

At about 10:00 a.m., a chemist transferred nitric acid from a storage vessel in Room 27 to a storage vessel in the box in Room 35B. At 10:30 a.m. while 2 men were in Room 35B the air monitor alarmed. One worker smelled nitric fumes near box 1 and noted that the atmosphere inside the storage box was brownish-yellow. They left the room and called Health Physics; all three men were found to be free of contamination. Three men then re-entered the room and noticed that the air monitor was off scale; further, all could detect nitric vapors. A puddle of dark liquid was then seen on the floor in the back of the 35B storage hood and in the doorway to Room 27. The puddle was covered with wet rags to prevent the further spread of contamination. The men who were

involved in the clean-up which followed were contaminated and had to shower. No significant internal contaminatino was detected.

The cause of contamination was a leak of Plutonium-238 nitrate solution from its storage vessel into the well on the storage glove box and from the box to the floor of Room 35B (Rooms 35A, 35B, and 27 were generally highly contaminated). The cause of the leak was probably corrosion of the stainless steel vessel or perhaps weld failure because of heat related stress.

Comments

Equipment simply should not be allowed to corrode or to leak radioactive matter at the risk of workers' health.

#18

MOUND LABORATORY DOCUMENTS

Title of Report: Part I of Investigation of Explosion in Room 35A, SM Building, April 3, 1968

Date of Report: April 29, 1968

Date of Incident: April 3, 1968

Documents Included: Part II of Investigation of Explosion in Room 35A, April 29, 1968; SM-35 Incident Report - Health Physics, April 26, 1968.

Brief Description

Incident involved the explosion of a glovebox causing the release of plutonium. The respirators of workers were knocked off by explosion causing significant inhalation. 3 were internally contaminated. The failure of an oven control in a glovebox allowed overheating of glovebox contents to the critical flashpoint of plutonium. Incident limited to a closed-system room. The workers were given DTPA.

Narrative Summary

On April 3, 1968 at 2:00p.m. an explosion occurred within the glove box line where non-burnable wastes are processed in Room 35A of the SM Bldg. As a result of the explosion airborne contamination was spread to all parts of Rooms 35A and B, through the ceiling to other rooms and corridors. Some corridors were also contaminated through tracking.

At the time of the explosion 5 men were in the room. Three of these men were standing near the glovebox which exploded and were hit by flying debris with such force that their respirators were displaced causing them to breath the contaminated air in the room. One man was knocked to the floor. Another was trapped beneath the dislodged shielding and needed assistance to get out of the room. One man recieved first degree burns on his face which was found thereby to be extremely contaminated with more than 4 million alpha d/m. The three injured men were removed from further work with plutonium. Since they could not be decontaminated before returning home, they were given head covering and sheets so as not to contaminate their bedding. The other two men in the room who were not near the explosion did not recieve injuries, but one was contaminated. Conotamination was severe. Lung burdens for plutonium ranged from a minimum of 4.8 to 2.6 maximum permissible lung burden, for one worker; 4.1 to 16.0 maximum permissible lung burden to another; 3.8 to 13.5 maximum permissible lung burden for another. Nosewipes indicated

exposures of up to 166,000 d/m for one worker, 59,000 d/m for another; and 1,960 for the third. All wipes were taken after showering.

Feces analysis also indicated very high leels of contamination, with levels as high as 56,000,000 d/m in the first day; 240,000,000 d/m on the second, etc. Resulting in the determinationo that a total of 144 microcuries was eliminated from this worker's body via feces for 11 days after the exposure. One lung burden equals 0.016 microcuries of plutonium-238.

The area involved was immediately sealed off to prevent further spread of the contamination. The investigating committee determined that the basic cause of the incident was the sticking of the points of the drying oven controller, which permitted the oven temperature to rise rapidly with no high-temperature power cut-off. When the gloves reached a temperature of 250-260 degrees celsius they decomposed, emitted flammable vapors which expanded and blew open the oven door. The vapor-air mixture was then ignited by exposed heating elements or possibly sparks from the residue in the glovebox. Thus, the reason for the explosion was the malfunction of equipment due to poor design.

Comments

Although extensive testing was done on the 3 injured workers, it seems somewhat farcical that they were sent home with "bedding" so that they wouldn't contaminate their beds. What about their wives and children? Why weren't they hospitalized? This is another mishap with a glovebox. There have been explosions and leaks due to poor glovebox design.

#19a

MOUND LABORATORY DOCUMENTS

Title of Report: Part I of Investigation of Inhalation Incident in T Building, Room 277-A on July 22, 1968

Date of Report: August 14, 1968

Date of Incident: July 22, 1968

Documents Included: Part II of Investigation of Inhalation Incident in "T" Building, Room 277-A on July 22, 1968, October 11, 1968; Inhalation Exposure - Health Physics, August 14, 1968

Brief Description

Incident were worker was exposed to polonium contaminated lab equipment. 4 workers suffered skin and inhalation exposure. The equipment was contaminated through bad lab technique, a broken glovebox exhaust allowed spread of material, poor respirator fit allowed inhalation, poor airflow in lab allowed build-up of contamination in the air, and poor work planning by health physics. Although "no standard medical treatment is advised or available for minor polonium internal exposures at this time", DTPA treatment started anyway.

Narrative Summary

On July 22, 1968 two chemists of the Polonium Process Development Group attempted to collect about 1 gram of polonium in a vessel by distillation. After the process was completed the equipment was left to cool. An hour and fifteen minutes later the chemists returned to transfer the product to a calorimeter can to measure the efficiency of the distillation process. This can was capped with a screw cap and gasket and removed from the block. At this point a bluish ionization glow appeared inside the cooling block tubes indicating that some polonium had "boiled over" and escaped the product can. The chemists put on their respirators and prepared to move the can from the pass box to a secondary container. This process complete, the chemists took a wipe of the outside of the secondary can to check for alpha contamination. The wipe reading was off scale--and the chemists presumed that the meter was out of order. One minute later the alpha air monitor sounded its alarm. Upon hearing the alarm a decontamination man entered the room; he found another alpha survey meter and found that it too registered the wipe off-scale.

Wipes of the area and clothing continued to read off scale. The Health Physics Surveyor changed the air monitor filters several times but the alarms continued. Finally, the workers left through an adjacent lab. The workers had remained in the room for 30 minutes after the pass box transfer had taken place. Urine samples of one worker was high--about 800d/m/100cc. One worker was thereafter removed from all radiation areas until further evaluations could be made.

Comments

It is extremely questionable that these workers did no leave the room until 30 minutes after air monitors showed contamination. What reason exists for this?

#20

MOUND LABORATORY DOCUMENTS

Title of Report: Part I of Investigation of Radiation Exposure Incident in Corridor #16, PP Building on January 8, 1969

Date of Report: April 17, 1969

Date of Incident: January 8, 1969

Documents Included: none

Brief Description

Incident involved the release of plutonium contaminated argon gas into a room during repair operation on the gas line. Apparently 7 workers were contaminated, 5 with probable inhalation. The cause of the incident was a failure to follow proper procedures during repair of gas line. No protective respiratoy equipment was issued nor was a health physics surveyor present, a routine requirement. Routine repair methods were ignored. Medical treatment and follow-up of the workers was not discussed.

Narrative Summary

At about 3:30 p.m. on January 8, 1969 a radioactive "spill" occurred within the hydrogen fluoride (HF) gas coffin located in corridor #16 of the Plutonium Processing Building. The spill resulted in a spread of airborne contamintion within the general area where the HF coffin was located. The incident occured when a couple of workers in the hall noticed that there was excessive pressure in the lines. Efforts were made to alleviate the pressure build-up. Several people were involved and during the confusion one worker failed to close a argon purge valve, as instructed. When one of the chemist removed a teflon line from the HF valve the argon pressure carrying radioactive contamination was released. The line was immediately replaced and all personnel exited through the air lock. The workers were excessively contaminated; one worker showed 2 million c/m on his hand. The other workers showed contamination levels of similarly high amounts. Nosewipes indicated internal counts of 13,360 c/m; 5,831 c/m; and 9,524 c/m. Lung burden of 0.042 microcuries measured, above the maximum permissible lung burden.

Thus, the main cause of the incident was the fact that the argon purge valve was left open. This caused pressure from the HF line at the coffin to the fluorinator. So, when the worker disconnected the HF line the argon gas rushed out carrying the

contamination present in the lines.

Comments

This was an obvious example of lack of control or direction by supervisors. The reason that the argon line was not shut down was that a worker "got engaged in conversation and failed to close the valves." Such lack of training and education about the serious nature of work at Mound is the reason for such behavior.

#21

MOUND LABORATORY DOCUMENTS

Title of Report: Accident Investigation Report No. 71-5

Date of Report: February 24, 1971

Date of Incident: February 10, 1971

Documents Included: Accident Investigation Report 371-5, August 19, 1971

Brief Description

Incident involved a spontaneous fire of solvents and plutonium. No one was in the room at the time of the fire. 4 firefighters had probable inhalation, but no data was reported because the body burdens believed to be below reportable levels. The improper storage of materials resulted in spontaneous fire. 49uCi of plutonium was released through a stack into the environment. Medical treatment and follow-up was not discussed.

Narrative Summary

At 12:50 a.m. on February 10, 1971 the fire alarm signaled for Zone 3 of the SM Bldg. Three firefighters arrived on the scene momentarily. The Miamisburg Fire Dept. was also called for help when it was determined that it was a working fire. The 3 firefighters put on Scott Air Paks and entered room 35 where the the corner glovebox was on fire. The flames in room 27 were mostly inside the glovebox in that room, but some may have been on the outside as well. The fires were put out by 1:45 a.m. Substantial damage was done to the gloveboxes as well as the surrounding area.

At the time of the fire Monsanto was attempting to recover plutonium from tanks in the SM Building, before they terminated the work there. The investigation committee concluded that the "point of ignition of the fire was the lower well area either inside or outside of the storage glove box in the southwest corner of Room 35, and the fire was propagated through an open pass box to the adjacent glove box number 3 in Room 27." The source of ignition was either spontaneous combustion of "a combination of oxidizing agent (HNO_3), heat and radioactivity (pu-238) and organics (polyethylene beads, et al.) in the well or from another external source unknown to the investigators. It was determined that 49.9 microcuries was released to the environment as a result of the fire.

#22

MOUND LABORATORY DOCUMENTS

Title of Report: Investigation of Plutonium-238 Inhalation Incident at Mound Laboratory on September 28, 1971, Section I

Date of Report: December 17, 1971

Date of Incident: September 28, 1971

Documents Included: Investigation of Plutonium-238 Inhalation Incident, Section II, December 17, 1971; U.S. AEC "Serious Accidents", Sept. 6, 1972

Brief Description

Incident involved the excessive inhalation of plutonium by health physics surveyor in an area of the building where high plutonium levels were known to exist due to maintenance work. One worker had excessive gamma/neutron exposure and plutonium inhalation. The worker was given inadequate respiratory protection for high-plutonium atmosphere. The respirator was also improperly fitted; there was "no emphasis in his training on selection of proper respiratory protection." The worker's respirator had previously been found to leak, but was never fixed. The investigation committee determined "that it is not always practical to have monitoring capability (for worker exposure) in all zones." The worker received DTPA treatment.

Narrative Summary

On September 28, 1971 an outside surveyor (O.S.) was assisting with a maintenance job. He was dressed in full-face respirator and plastic clothing, His job was to check air levels and surface contamination and he also helped to operate the vacuum system. At other times he passed items to the inside surveyors doing maintenance. At 10:30 a.m. they took a break. The O.S. noticed that air sampler filter paper readings had increased from 50,000-200,000 counts per minute to 300,000 c/m. The O.S. also found that his respirator was contaminated at about 3,500 c/m and his hands and face 200-400 c/m. He showered and monitored himself again and went to lunch.

The working personnel reentered the area at 12:30 p.m. and air sample and surface contamination levels had not changed. But, by 1:30 p.m. the air sampler readings had increased to 2,000,000 c/m which was the maximum instrument capability. At 2:30 p.m. when the air readings still exceeded 2,000,000 c/m, the workers left the area.

This time the O.S. found 5,000 c/m on his respirator filter, 4,500 on his mask, and 2,500 on his face. He took his mask to the decontamination lab, left a nosewipe and showered until he was sure he was decontaminated. His nosewipe read 2,800 d/m but his mask was cleaned rather than monitored.

On October 28, 1971 the PS 6 EC Section of Monsanto determined that his internal exposure to plutonium 238 could result in a dose greater than one lung burden. On November 1, 1971 two lung counts indicated a dose commitment of less than one lung burden.

The investigation team determined that the contamination of the O.S. worker was due to inadequate respiratory protection. When the O.S. entered the work area air samplers indicated the plutonium-238 concentration of at least 3,000 times RCG and it rose to levels of 10,000 RCG (Recommended Concentration Guides). However, full-face respiratory protection is adequate only to 100 RCG. At the time of the occurrence surveyors were not given any specific guidance as to at what levels the respirators provided protection. In fact, guidance was deleted from the Health Physics Precautions Manual "to eliminate specific numbers which might later be judged legally binding instead the guides they were intended to be."

This O.S. had 6 1/2 years of experience and had participated in the Surveyor Training Course within five years of the incident. However, he was never advised on selecting proper respiratory equipment. He had used the customary protective equipment.

Comments

Obviously, this is a blatant example of the lack of concern for worker safety exhibited at Mound. Workers were no advised of proper respiratory equipment because Monsanto did not want to be held legally liable for its own guidelines. In my opinion, such practices as deleting safe exposure numbers from health manuals and failing to train workers who are liable to receive exposures are nothing short of criminal negligence.

#23

MOUND LABORATORY DOCUMENTS

Title of Report: Potential Type "B" Occurrence at Mound Laboratory, January 17-27, 1972, Section I

Date of Report: March 22, 1972

Date of Incident: January 17-27, 1972

Documents Included: Section II of Report; Investigation Report, June 8, 1972.

Brief Description

Incident involved the rupture of a plutonium contaminated water line on a cold night allowing water to run out into a room and then outside of the building onto the grounds. Apparently several clean-up workers had skin and inhalation exposure. Bioassay data was not reported, although "It is estimated that no lung exposure greater than 6nCi occurred. The workers used contaminated air supplies while cleaning the spill. There were many oversights in the clean-up procedures causing contamination. There was a 40 time increase in plutonium in offsite water than over the previous year. The report says it was below RCG limits. Medical treatment and follow-up of workers not discussed.

Narrative Summary

Early in the morning January 17, 1972 a water pipe for the sprinkler system burst in the SM Addition "Penthouse". The -40.0 degree F wind-chill factor was a record-breaking low and although the sprinkler line had been modified the previous winter due to perenial freezing problems, the pipe still could not withstand such temperatures. A minimum of 3,000 gallons of water rushed from the pipe until the Fire Department shut off the supply valve. The water, contaminated with Plutonium 238 went the following route: First, throught an exhaust duct and onto and into gloveboxes located in Rooms 58, 59 and 60. Second, through the penthouse, over the dock roof, onto the blacktop and possibly through the grass to a storm sewer. Third, into the building crawl space and through ceiling penetrations in Rooms 58-61A, then through the 58A airlock and onto the dock and adjoining blacktop.

Most of the water froze on the dock and blacktop, but some did drain down a ditch and into the storm sewer which dumps into the Great Miami River. The monitor in the sewer reported plutonium levels "substantially below RCG levels." The floor drains in the penthouse also carried some water away, but they were unable to handle such an enormous capacity.

Health Physics surveyors arrived at 5:25 a.m. and initiated decontamination at 7:30 a.m. They placed salt on the contaminated ice as well as "Auto-dri" which is an absorbant to soak-up the water. The saturated "Auto-dri" was then placed in drums for burial and a blacktop sealer was applied to the pavement.

During the period when this incident occurred the SM Building and the SM Addition were being abandonned and "termination" work was in process. This basically involved the decontaminatiion of the entire building, salvaging plutonium from gloveboxes or other equipment, and crating equipment and gloveboxes for burial. Thus, some of the workers contaminated were decontamination workers cleaning up from this incident and others were termination workers preparing to abandon the SM Addition.

On January 21st two employees, dressed in bubble suits were removing sprinkler line water from gloveboxes in Room 58. Although the air monitor alarmed, the workers did not contact Health Physics. At around 5:00p.m. that day another worker was in Room 58 picking up trash and again the air monitor alarmed. This worker had to pound on the door to get someones attention to have them notify Health Physics--the phones in the room had been cut off. The worker continued to work although the air monitors were off scale. He was not wearing a bubble suit although it was required in the room.

On January 24th two other workers were in Room 58 working without bubble suits when they noticed that the air monitor alarm light was flashing. The alarm was not sounding because it had been turned off on the 21st. On January 25th another worker was in Room 58 to package trash and only wore white clothing and plastics instead of a bubble suit. During the January 21-25th time period the door on Room 58 only had a "Respirator Required" sign posted, but not a buble suit sign. The requirement of a bubble suit had only been circulated to Health Physics Surveyors.

On January 24th a surveyor found that both airlocks reading 2 million counts/minute (the highest that the monitor can read). He did not record the level of contamination or report it to supervision. That evening a surveyor took two workers half dressed in bubble suits to airlock 58A via the outside of the building. The freezing weather stiffened their suits and so they had to stand in the airlock 10 minutes until the plastic hoods were supple enough to pull over their heads. They were not wearing respirators. On the 27th the airlock was decontaminated. Wipes indicated contamination levels of 120,000 to 260,000 d/m. Aircounts taken on January 28 showed 8 x RCG for a 30 minute sample.

On January 26, 1972 the Health Physics Supervisor in the SM Building noted that two employees had significantly higher nose wipe counts than other employees. Whole body counts done the next day indicated a quantity of contamination exceeding that

specified as a Type B Occurrence. The Supervisor then ordered whole body counts on other employees in the building and discovered 5 more persons with potential internal deposition, three of which were Type B Occurrences. On January 28th termination operations were halted until there was an assessment of the problem. Further testing was done on all 8 employees that were working in termination operations. Each individual had encountered Plutonium 238 contamination doing either decontamination or termination work after the accidental pipe burst.

Comments

None.

#24

MOUND LABORATORIES

Title of Report: Tritium Uptake in SW Building

Date of Report: April 13, 1973

Date of Incident: March 13, 1973

Documents Included: Investigation Report, 4/13/73; U.S. AEC Memorandum, November 13, 1973

Brief Description

During repair of pipes, one worker was severely contaminated with tritium, with whole body exposure as high as 39.5 Rem. Worker was instructed to use gloves during repair work which were inadequate, allowing leakage and exposure. 163 curies of tritium released into environment as a result of leak through stack, 2.8 times the Radioactivity Concentration Guide at the fenceline. Worker's medical treatment involved a ""forced fluid" program consisting of an average of 12 cans of beer a day.

Narrative Summary

At 12:40 p.m. on March 13, 1973 a pipefitter started a routine valve replacement in a tritium effluent recovery system in Room 8 of the SW Building. The pipefitter, suited in a forced air bubble suit, began the repair job by unbolting a valve, which required some force to remove. When the valve broke free, some fluid spilled out into a plastic bag that had been placed under the valve in case of such a leak. A portion of the highly radioactive fluid spilled onto the pipefitter's gloves.

Within seconds of the fuid release, the stack alarm went off, and shortly thereafter, the room monitor alarms sounded. The pipefitter finished the job and proceeded to leave the area and unsuit with the assistance of a Health Physics surveyor. Wipes ewere taken of the pipefitter's hands and face, and he proceeded to the showers. The counting results of the initial wipes from the pipefitter's hands and face were unusually high. Wipes after showering indicated the presence of high level skin contamination. Urinalysis tests confirmed that internal tritium uptake had occurred, with an excess dosage of 5 rems.

It was determined that 132 curies of tritium were released from the stack as the result of the accident. The report noted that the tritium was in an oxide form, which is a form readily introduced into the body by both respiration and skin absorption. The total released for that day from that stack was 163 curies. This amount is in excess of the Radioactivity Concentration Guides by 2.8 times as defined by the AEC at the time.

It was decided that the high tritium uptake was due to the liquid on the glove. Upon examination of the gloves at a later time after the accident, a small hole was found in one set of gloves. The report revealed that heavy duty, impermeable "orange" gloves were available for use, but not in the SW Building. It is very possible that the uptake could have been avoided had the heavier gloves been used. The report also revealed that proper procedure for hand protection had been ignored. Proper procedure also called for stopping work at the first sign of any liquid in such a repair operation. This was not done.

One document pegged the pipefitter's exposure at 17 rems whole body exposure. Another health physics report indicated that the pipefitter's exposure was 39.5 rems. It is difficult to determine which one is correct since all exposure data in specifics is deleted from the report.

The pipefitter's medical treatment consisted of a "forced fluid" program that involved drinking 12 cans of beer per day, on the advice of the company doctor.

News accounts of the accident quoted the pipefitter as saying that AEC and Monsanto officials had assured the pipefitter that his exposure "in no way at all will ever affect or hurt me." A Monsanto official characterized the exposure by saying that a broken limb "is much, much more serious." The accident was likened to a "cut finger" by the same official.

Comments

The company seems to have bent over backwards here to avoid liability for this accident. Likening exposure to 17-39.5 rems of radiation to a "cut finger" seems highly irresponsible and misleading. The treatment prescribed by the company doctor also seems highly questionable. Forced fluids seems O.K., but water or soda seems to be a more appropriate liquid, not 12 cans of beer daily. I wonder if it was to keep the worker too drunk to realize what had happened to him or act in his own best interest?

#25

MOUND LABORATORY DOCUMENTS

Title of Report: Plutonium Uptake in R Building

Date of Report: July 13, 1973

Date of Incident: June 18, 1973

Documents Included: Investigation Report, 7/13/73; Various memos and status reports too numerous to list

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Brief Description

Plutonium released into air during a glovebox operation resulting in two contaminated workers. Accident attributed to improper adjustments of glovebox and room ventilation allowing escape of plutonium into air. Complicated by the fact that the room air monitors were improperly placed for maximum early warning. 864 microcuries of plutonium released into room.

Narrative Summary

At about 12:30 p.m. on June 18, 1973 a technician packaged a plutonium oxide capsule in Room 145 of the R-Building to transfer it to Room 120 for examination. The technician wore protective clothing and a half-face respirator during the operations. A survey of the package revealed no contamination prior to the transfer. The package was hand-carried to Room 120.

In Room 120, the technician placed the package in a passbox for transfer into a glovebox. Once in the glovebox, the sample was sliced lengthwise with a diamond saw, the sample placed into a capped metal container and the technician then withdrew his hands from the glovebox gloves. He struck up a conversation with another worker in the room when contamination alarms went off. The worker donned his respirator and left the room. The technician turned off and reset the alarm, which promptly went off again. He then put on his respirator and left the room.

Surveys indicated no significant surface contamination of the workers. However, nose wipes indicated that the two might have received an uptake of plutonium. Both men were sent to the Whole Body Counter for in vivo lung surveys. The technician was determined to have received a significant uptake, the other worker had not. The technician who was exposed received a total lung burden of 30 nanocuries, which was in addition to a previous lung burden between 8.5 and 9 nanocuries. Lifetime body burden

for a nuclear worker is 40 nanocuries. This was a "Type B" reportable nuclear occurrence, which requires that a company report all exposures to employees in excess of 3 rems per quarter.

Comments

The technician in question received 2/3 of the permissible lifetime body burden for plutonium inhalation.

#26

MOUND LABORATORY DOCUMENTS

Title of Report: Plutonium-238 Inhalation

Date of Report: January, 1978

Date of Incident: December 1, 1977

Documents Included: Investigation Report, 1/78; Various News Releases, Memos and Recommendations

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Brief Description of Incident

A ruptured trash bag resulted in the release of plutonium, resulting in contamination of a worker through inhalation. A Health physics worker was contaminated in turn when he removed the workers clothing by hand. Total estimated lung burden was 24.5 nanocuries. Accident caused by improper decontamination procedures, issuing improper respirator with untested seal; mask had a defective exhaust valve.

Narrative Summary

At approximately 2:00 p.m. on December 1, 1977, a chemist ruptured a plastic package of waste incinerator ash in Building 38 he was preparing for disposal, resulting in a release of plutonium-238. The bag was torn inadvertenly by the chemist as he applied too much pressure to force the bag into a can. The release occurred in the corridor. The alarms sounded at that time and the chemist left the area after finishing taping the bag shut. In the process of exiting the work area and conducting personal monitoring, the chemist inhaled an internal lung deposition of 1.6 lung burdens (24.6 nanocuries). The chemist had a nosewipe count of 14,421 disintegrations per minute (d/m).

After leaving the work area, the chemist began to monitor himself, and found significant contamination on his clothing, which he removed. He then proceeded to another room and rechecked himself, this time finding contamination on his shirt front. A health surveyor arrived and found levels as high as 25,000 counts per minute (c/m) on the shirt. The surveyor removed the shirt, contaminating himself in the process. A nose wipe on the chemist at that time revealed contamination as high as 14,421 d/m. Subsequently, levels as high as 2,000 c/m were found on his cheek and 500 c/m on his mustache. At this point, the chemist showered and submitted to a Whole Body in vivo count

which revealed an internal deposition that averaged 1.6 lung burdens.

The investigation committee determined that the chemist was wearing the wrong kind of mask for the job he was performing. In addition, the recycled respirator that the chemist was using was defective. The chemist, due to his ignorance of operational Health Physics guidelines, did not follow procedures to ascertain the proper mask and testing of equipment that procedures required. Additionally, the investigating team determined that one man was performing a two man operation. However, the team concluded that the contamination was spread through brushing a contaminated area on his shirt, and not due to defective equipment (?) The reason that the bag ripped in the first place is that the chemist applied excessive force to the bag to squeeze it into the can. The can top was blocked by a defective O - Ring.

The committee recommended better training of personnel as to Health Physics procedures, that two men should perform waste removal operations, that workers should not survey themselves, but wait for a health physicist, that respirators should be inspected by the company before use and that other procedures should be developed and followed. Finally, it was determined that the Health Physics Manual was out of date, and that periodic reviews should occur to keep the requirements up to date.

Newspaper accounts of the accident were included. A Monsanto official was quoted as saying that "the affected employee wil absorb as much as an extensive series of diagnostic X-rays. In the case of the lung, radiation levels of 10-100 higher would be necessary to present a health hazard." Plant officials showcased the accident as evidence that all the facility's elaborate safety systems had all worked properly following the accident. The news releases mentioned nothing about the lack of training, the issuance of the wrong mask, the defective valve in the respirator, and the ignoring of relevant procedures.

Comments

The exposed chemist with over 20 years of experience had not been given adequate health physics training for a procedure that he was expected to perform periodically. Secondly, he was issued a defective respirator which the company should have inspected before issuance. Thirdly, he was issued the wrong respirator design in the first place. Too few men performed the job and a supervisor instructed the chemist to monitor himself, which exacerbated the seriousness and extent of the exposure. Only health physics personnel should do such monitoring. Finally, the appropriaate Health Physics Manuals were found to be out of date. So much for the "elaborate safety systems."

Ref. 19

1/12/70

POTABLE WATER STANDARDS PROJECT

MOUND LABORATORY

FOR

MONSANTO RESEARCH CORPORATION

CONTINUATION OF DATA ANALYSES (EFFECTS OF PUMPING)

January 12, 1978

Monsanto Research Corporation
Mound Laboratory
Miamisburg, OH 45342

Attention: Mr. Herb Meyer

Gentlemen:

Report: Potable Water Standards Project
Mound Laboratories
Continuation of Data Analyses
(effects of pumping) for
Monsanto Research Corporation

INTRODUCTION AND BACKGROUND

Our proposal of September 27, 1977 described the purpose of our present studies as two-fold:

1. To determine the significance of tritium rainout at Mound Laboratories.

2. To evaluate the effect of pumping MRC Well No. 1 and Miamisburg Well No. 2, including rebound effects.

Item 1 will be discussed in a separate and subsequent report and Item 2 has been modified in that it was decided to continue pumping and to determine the rebound effects at a later time. Because the pumping period was extended, we have included data collected through November 30, 1977 in our analyses.

Our report "Evaluation of the Buried Valley Aquifer Adjacent to Mound Laboratory" of December 20, 1976, described the effects of pumping Miamisburg Well No. 2 for a relatively short duration during September 1976 and again for approximately one month during October and November

of 1976. In summary, we concluded that pumping Miamisburg Well No. 2 appeared to be of value in reducing tritium levels in the aquifer and we recommended that the pumping should be continued.

Subsequent to our December 20, 1976 report, several significant events have occurred and are summarized herein.

- Miamisburg Well No. 2 has been pumping intermittently during 1977
- MRC Well 71-1 has been pumping intermittently and its discharge is piped to the drainage canal
- MRC Well 71-2 was used for Mound's water supply during the repair of Well 76-1
- New domestic wells were installed at Bud's house, Bud's rental house and Jim's
- Two wiers were installed in the drainage canal for the purpose of evaluating the infiltration from the canal

DATA PRESENTATION AND ANALYSES

The concentration of tritium in the aquifer has been measured by means of sampling from wells which are located both within and beyond Mound Laboratory property. Figure 1 shows the location of the key observation wells and water supply wells which are referred to in this report. Our previous reports contain the details of the construction, operation, and ownership of these wells.

In the Appendix to this report are charts for 20 key wells which graph four parameters in relation to time for a period from June 1976 through December 31, 1977. The four parameters are:

- Pump operation time for Wells 71-1, 71-2, 76-1 and Miamisburg No. 2.
- Tritium concentration in nanocuries per liter (nCi/l).
- Precipitation recorded at Mound Laboratory in inches
- Water level elevation shown in relation to mean sea level or on a relative basis where the actual elevation was not available

We feel that the graphs of these 20 wells demonstrate the effects of pumping on both water level and tritium concentrations in different areas of the aquifer. Figure 1, in addition to showing location, shows recent tritium concentrations which were measured during November 1977.

CONCLUSIONS

The data show that during the pumping of MB-2 and 71-1, the tritium concentrations as measured in the majority of observation wells have decreased. We conclude that the decrease is due in large part to the pumping, although there might be a slight decrease without pumping. In general, the aquifer tritium concentration is below or close to the EPA standard of 20 nanocuries per liter, except in an area outlined by wells OW-1A, OW-4, OW-5, Bud's-1 and Jim's. Our specific conclusions are as follows:

1. The data show that tritium concentrations in MRC Wells 71-1, 71-2, and 76-1 are below the EPA standard of 20 nCi/l. Also, these wells show a continuing downward trend.

2. Tritium concentrations in Miamisburg Well No. 2 are only slightly above 20 nCi/l and there has been a drastic decrease since the pumping of MB-2 and 71-1 commenced in mid-May. (The concentration was over 40 nCi/l). The tritium concentration in MB-3 has remained below 20 nCi/l, and in the past three months has shown a gradual downward trend, although we do not necessarily attribute this to the pumping.

3. The tritium concentrations in Bud's-2 and Bud's-3 are slightly above 20 nCi/l and both wells show a slightly downward trend. Bud's-1 and Jim's remain at concentrations near 40 nCi/l and neither well shows indications of a downward trend at this time. However, it is noteworthy that Bud's-1 had concentrations of 60 nCi/l in December 1976.

4. The tritium concentrations in OW-1A, OW-3, and OW-5 are all nearly 40± nCi/l. The concentrations in OW-3 have been very sporadic, ranging from 20 nCi/l to 150 nCi/l. Since OW-3 is close to the valley wall and has been dry on occasions, we do not consider it a reliable barometer. Concentrations in OW-1A have dropped from 60 nCi/l to 40 nCi/l since mid-May 1977, and have remained nearly constant at 40 nCi/l since August 1977.

The concentrations in OW-4 have remained nearly constant since June 1977, but in the past two months have shown a slight trend downward. The concentrations in OW-5 were showing a marked downward trend from August through October. The November data may not be representative.

5. The tritium concentrations in Wells OW-2, OW-6A, OW-7 and OW-8A have decreased during the pumping and all but OW-2 are below 20 nCi/l.

6. We do not observe any relationship between the precipitation data and the change in tritium concentrations. However, the precipitation data may be more relevant in conjunction with the analyses of infiltration through the drainage canal, which will be presented in a later report.

7. We expect that there was a relatively large body of tritium in the area near Bud's-1 and Jim's, which was most likely part of a larger plume which extended from the intersection of the drainage ditch and the Miami-Erie Canal southwest toward the river. By pumping from MB-2 we are pulling water from the main axis of the original plume, and are also pulling water from the north. It appears that the area to the north, as represented by OW-2, had lower tritium concentrations. The area to the south, as represented by OW-1A had higher concentrations and has probably stabilized at the higher value.

DISCUSSION AND RECOMMENDATIONS

The recommendations presented herein are based upon the data collected and analyzed to date. We realize that the relatively short pumping durations may not have produced lasting effects. One of the difficulties in assessing the long-term affects of pumping is the fact that we do not know how much tritium may be being added to the aquifer from several sources. We have discussed possible input sources in our previous reports, but they are worth repeating:

- Infiltration from the drainage canal, including new process discharge and storm runoff, as well as release of existing tritium in the soil below the canal

- Leakage from the WD effluent pipeline

- Infiltration from the dump area in the vicinity of Well 55-5

Despite the fact that we have not attempted to quantify tritium input from these and perhaps other sources, it does appear that the total tritium output resulting from natural recharge and pumping exceeds the tritium input. The overall effect to date has been to bring the MRC wells within compliance and to maintain the Miamisburg wells, except for MB-2, within compliance.

The following recommendations could be implemented either wholly or in part, and in some cases will depend upon a study of the economic costs:

- Continue the existing pumping program as is to further evaluate the effects on those areas of the aquifer, realizing that it may require years to bring the area near Bud's-1 and Jim's within compliance

- Accelerate the pumping program by installing a high capacity well southwest of MB-2, to more effectively influence that area of the aquifer

- Install additional observation wells at various depths within the aquifer to monitor the possible stratification of tritium concentrations

- Abbreviate the pumping program by intermittently pumping from 71-1 and MB-2 in order to reduce costs and still maintain portions of the aquifer within compliance

- Continue the well monitoring program, but reduce the sampling frequency in specific wells which have been within compliance for several months

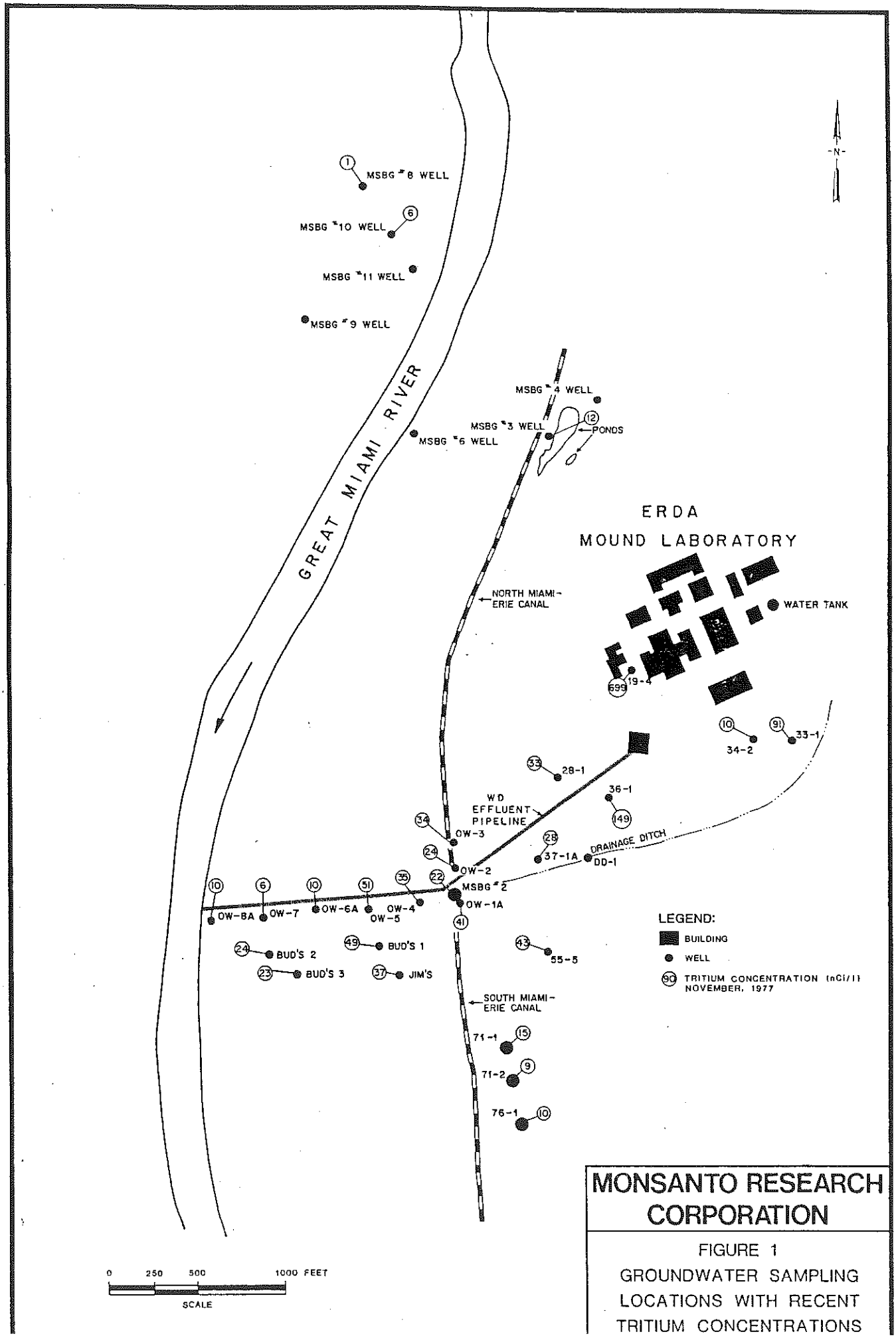
Appendix 1, attached, is a part of this report. Should you have any questions concerning the information presented in this report, do not hesitate to call.

Yours very truly,

DAMES & MOORE

T. Alan Gleason
Associate

TAG:MS



MONSANTO RESEARCH CORPORATION

FIGURE 1
GROUNDWATER SAMPLING LOCATIONS WITH RECENT TRITIUM CONCENTRATIONS

Ref. 20

TRITIUM RAINOUT PROJECT

Prepared for

MOUND FACILITY

MONSANTO RESEARCH CORPORATION

by

DAMES & MOORE

March 6, 1978
Job No. 05627-023-17

SUMMARY

Precipitation samples were collected in various sites around Monsanto Research Corporation's Mound Facility and analyzed for tritium. In addition, on several occasions, rain water runoff was collected and analyzed.

The total 1977 rainfall was 34.88 inches, with an average tritium concentration of 4 nCi/L. A calculated total of 10.94 Ci rained out over an area of 1 km radius around Mound Facility during the year, of which an estimated 2.8 Ci infiltrated the aquifer. This is only 7 percent of the total amount withdrawn from the aquifer. Because a large portion of the total collected tritium rained out during periods of heavy rain, with a resultant increased runoff, the total contribution to the aquifer could be much lower than 2.8 Ci.

Runoff water exhibited an average tritium concentration of 5 nCi/L and never exceeded 10 nCi/L. This concentration is well below the U.S. EPA standard for potable water and is similar to the measured average tritium concentration in rain water.

< .06%

Ref. 21

MLM-2495
UC-11

Mound Laboratory Tritium Environmental Study: 1976-1977

Carl J. Kershner and T. Ben Rhinehammer

Issued: April 10, 1978

MOUND FACILITY
Miamisburg, Ohio 45342

operated by
MONSANTO RESEARCH CORPORATION
a subsidiary of Monsanto Company

for the
U. S. DEPARTMENT OF ENERGY

Contract No. EY-76-C-04-0053

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Abstract

In the course of an extensive investigation of tritium in the aquifer underlying the Mound Facility site, an unusual behavior was noted for a beta-emitting radionuclide contaminant present in the environs of the abandoned Miami-Erie Canal adjacent to the laboratory site. The soil contaminant was determined to be tritium, of which 90% was in the form of a relatively stable or "bound" species that was not readily exchangeable with the "free" water in the soil. (Bound-to-exchangeable transfer half-time was found to be approximately 3 yr.) The contamination was found to be concentrated within two feet of the surface in the center of the canal channel and near the Facility site drainage ditch and canal confluence.

In order to characterize the contaminant and to assess its potential for reaching the aquifer, an analysis program and study were initiated in September 1976. The results and findings from the first phase of this work which was completed in February 1977 are the subject of this report.

A tritium inventory of approximately 200 Ci (0.02 g) as of December 1976 was estimated for the 5200-ft stretch of the canal adjacent to the Facility. However, its significance as a source term to the aquifer to which it contributes was calculated to be only 30 Ci in the next year, since 90% of the contaminant was determined to be in the "bound" form.

On the basis of data obtained in the study of tritium concentrations in the aquifer over the past 5 yr and a postulated three-compartment model for the canal/aquifer interactions, it was concluded that the time of maximum influence by the canal tritium has passed and the aquifer recharge dominates. Moreover, a modest pumping rate of 500 gal/min should produce an aquifer recharge that more than offsets the source terms from the canal.

Introduction

Mound Facility is a research, development, and production facility operated by Monsanto Research Corporation for the Department of Energy (DOE). The site consists of 180 acres of land situated within the southern boundary of Miamisburg, Ohio, on an upland plateau overlooking the old Miami-Erie Canal and the Great Miami River, as shown in Figure 1.

Since operations began in 1949, many radionuclides have been handled at the site. At the present, tritium and plutonium-238 are of primary importance for the work supporting DOE weapons and radioisotopic heat source programs, respectively.

To ensure the safety of the operating personnel and the public, the Facility maintains an active control and monitoring program for all radionuclides being handled [1]. In the course of such an investigation for tritium in ground water at and near Mound Facility, soil sample borings were taken in the abandoned Miami-Erie Canal area adjacent to the site. This canal area receives surface runoff water from a drainage ditch which flows through the onsite valley and was the subject of a previous plutonium-238 environmental study in which its topographical and hydrological features are thoroughly discussed [2]. Analyses performed by the Mound Facility Environmental Assessment and Planning Group showed tritium concentrations in the soil water distillates from these samples reached 186 μCi/liter. In addition to being some three orders of magnitude higher in concentration than for ground water at other onsite and offsite locations, the tritium concentration in the canal soil distillates appeared to depend upon the temperature used for extraction. Distillate fractions taken above approximately 300°C exhibited the highest tritium concentration. These distillations were performed in flowing argon and exhibited considerable tar and heavy oil formation, especially for those soil samples containing relatively high organic (humus) content.

In order to more thoroughly investigate these findings and to determine if the tritium in the soil in the canal is or has the potential of contributing to the aquifer below it, a tritium environmental study was initiated in late September 1976. It is the purpose of this report to present the findings and conclusions from this study.

Soil analysis and sampling

In October 1976, Dames & Moore, of Cincinnati, Ohio, an environmental and applied earth sciences consultants firm, was contracted to obtain soil boring samples from 12 locations in the section of the Miami-Erie Canal adjacent to the Mound Facility site and two background sample borings, one in the Miami-Erie Canal north of Dayton, Ohio, and one in a heavily reeded pond in Hamilton County, Ohio.[3] In most cases the corings were taken to a depth of 60 in. in 6-in. increments. Of the 12 canal sample locations, two cross sections consisting of three corings each were taken in both the north and south sections of the canal. The boring locations at each of the canal cross section positions consisted of one center location with two other locations near the bank on either side. The sample locations along the length of the canal and their estimated cross section distributions are shown in Figure 2. Sample

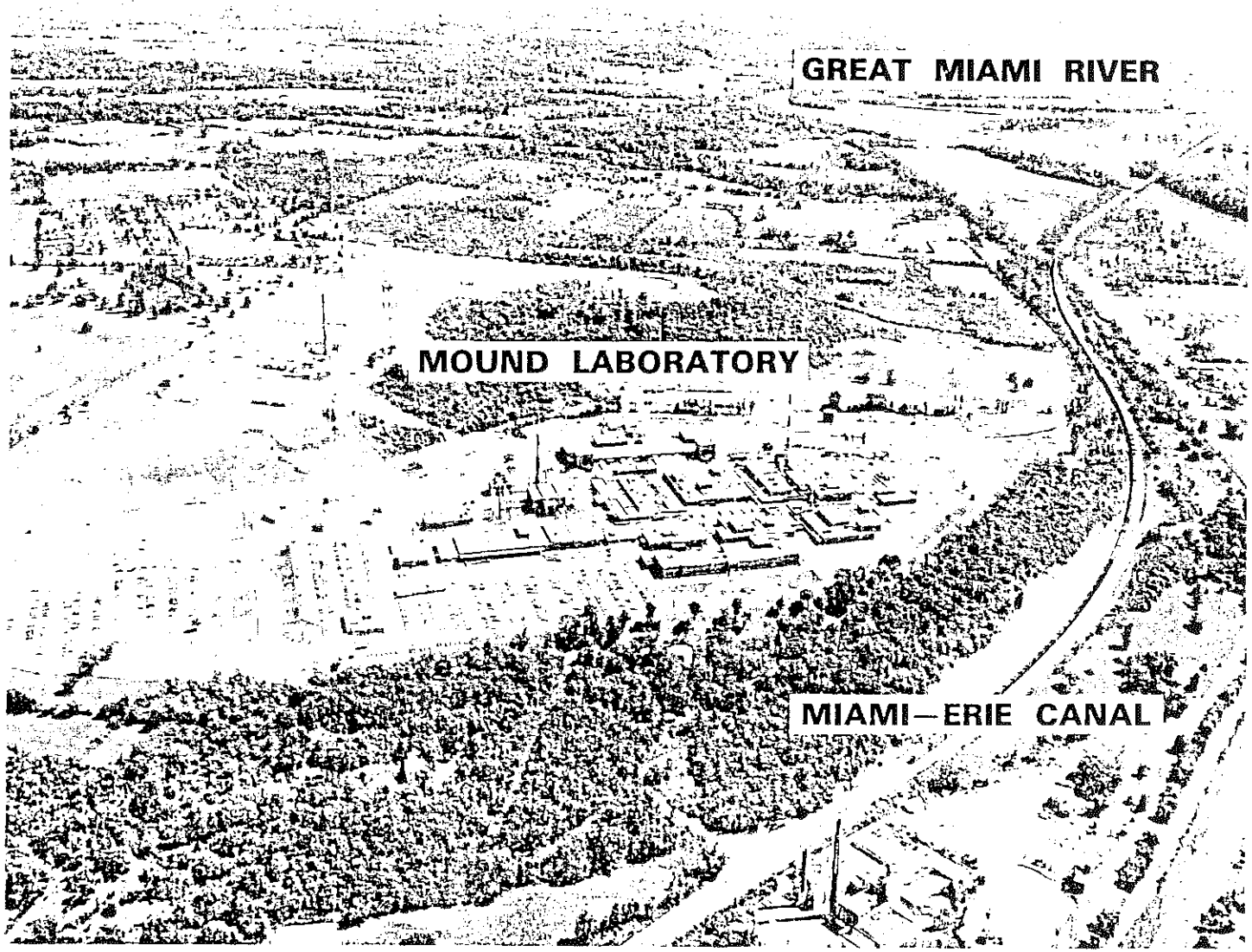

FIGURE 1 - Aerial view of Mound Facility.

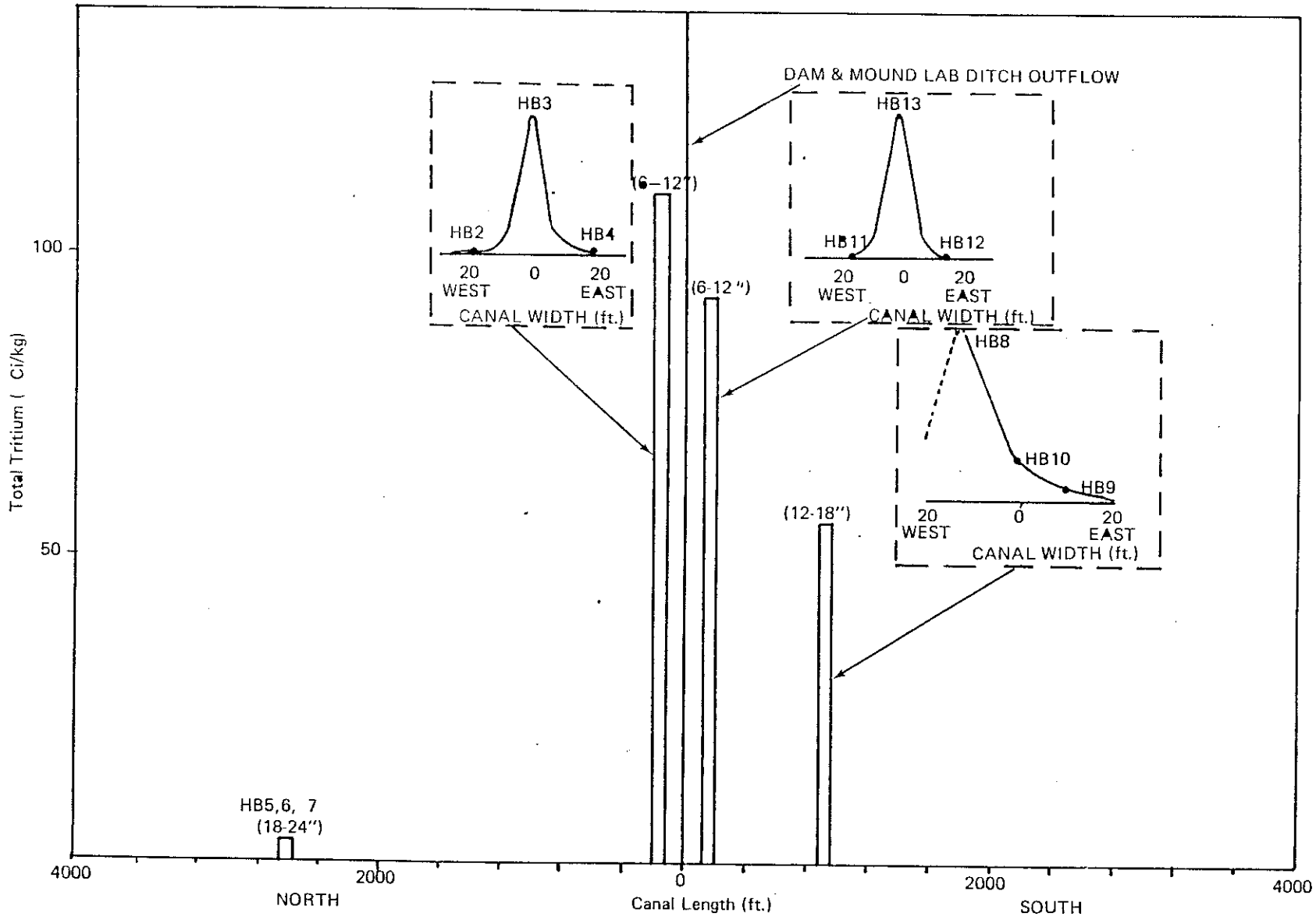

FIGURE 2 - Maximum total tritium concentration at any depth along the Miami-Erie Canal . (Numbers in parentheses indicate depth at which maximum occurred.)

The procedure developed to analyze these soil samples for tritium content was based on a pragmatic approach of determining the tritium content available and unavailable to migrate with the soil water. A water extraction technique was found to be applicable for separating the water-exchangeable portion (labile tritium) from the "bound". It was found that the tritium concentration in equal weight portions of soil and water would come to equilibrium within an hour and remain essentially constant for days. Based on these findings, the HB series of soil samples were analyzed by extracting the exchangeable tritium with a series of water leachings. Tritium concentrations were determined by standard liquid scintillation counting techniques. The total exchangeable tritium in the soil, which could include the "free" water, the adsorbed water, and most of the crystalline water, was determined in this way. After the water extraction, the soil samples were oven dried at 110°C. It was found that once the exchangeable tritium was removed from the sample, essentially no tritium was lost from the soil samples at 110°C. After oven drying, the samples were completely pyrolyzed at 900°C in a flowing oxygen atmosphere in order to convert all the bound tritium, organic or inorganic, to water. The resulting distillate was collected by condensation. Ethylene glycol bubblers were used to trap any water vapor escaping from the condenser. Tritium contents for both the condensate and glycol bubbler were determined by standard liquid scintillation counting techniques. The quantities of tritium found in the exchangeable and bound fractions were referenced to the oven-dried soil weight for comparison purposes.

The results of the HB series analyses have been plotted on bar graphs and are included in the Appendix of this report. The distribution summaries of these data are given in Figure 2. Profiles of HB3 and 13 plotted on a linear grid are shown in Figures 3 and 4, respectively. The most salient features of these results are the very sharply peaked distribution profiles with respect to both the depth below the surface and the distance across the width of the canal. The highest concentration, found to be 110 μCi/kg of soil, was for the 6-12 in. increment of HB3. In Figure 5 this is shown to be the area immediately north of where the drainage ditch enters the canal.

Several soil sample lots taken from the historical inventory maintained from the 1974 Plutonium Environmental Study were analyzed for tritium [2]. Total tritium levels as high as 700 μCi/kg have been found with depth distribution profiles resembling those of the plutonium-238 contamination. Because these soil samples were not taken in the same locations in the canal as the present HB series, they cannot be used directly for comparison of bound-to-exchangeable half-time estimates. The results do, however, indicate that there was tritium present in the canal in 1974 in concentrations that appear to be considerably higher than at present.

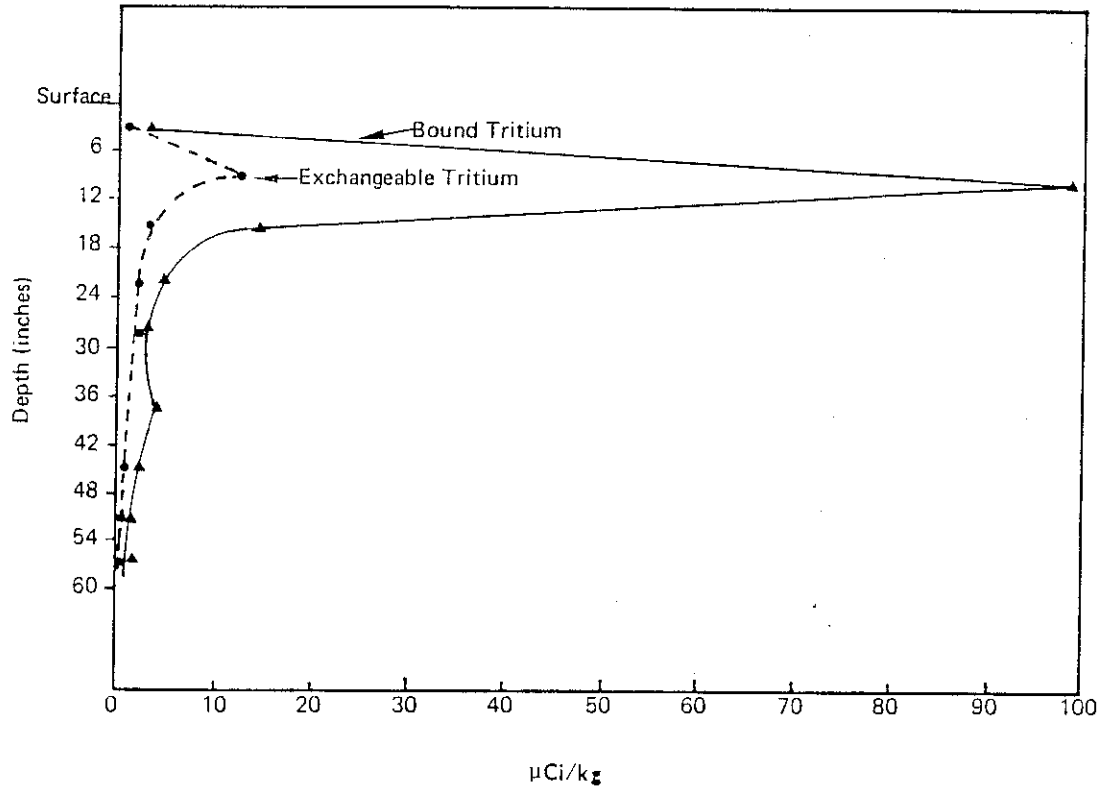

FIGURE 3 - Tritium depth profile HB3; center north canal; 150 ft north of dam.

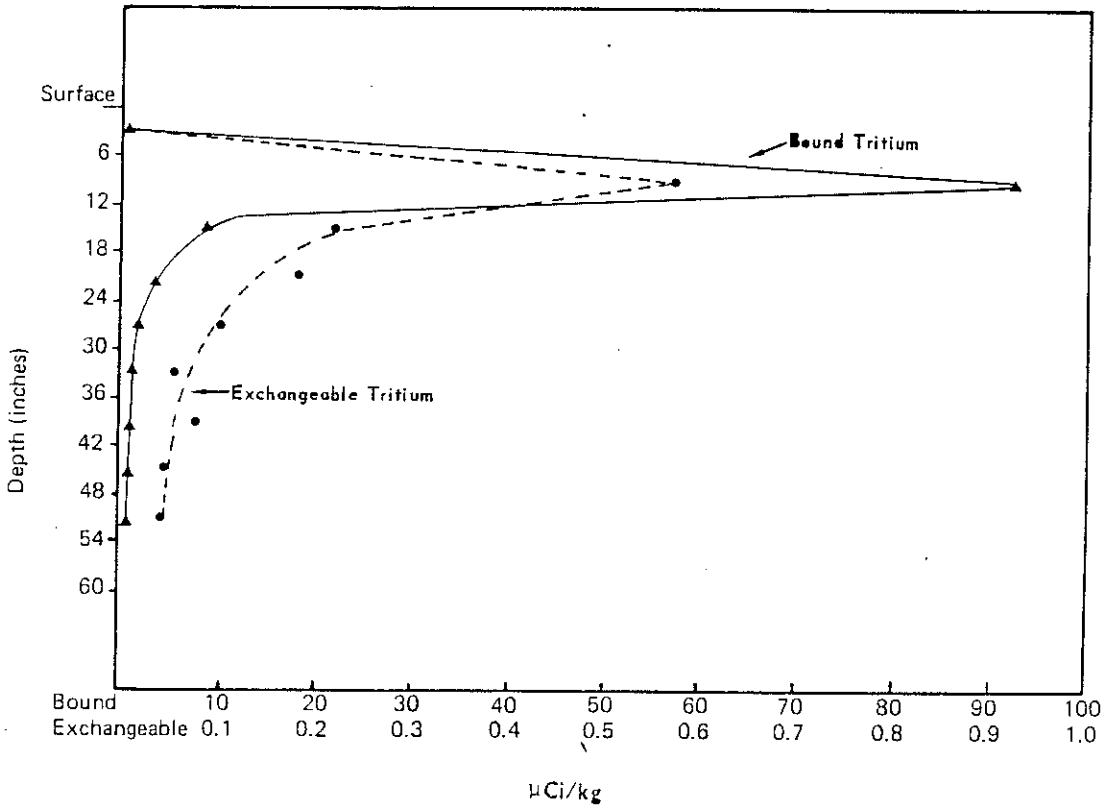

FIGURE 4 - Tritium depth profile HB13; center south canal; 150 ft south of dam.

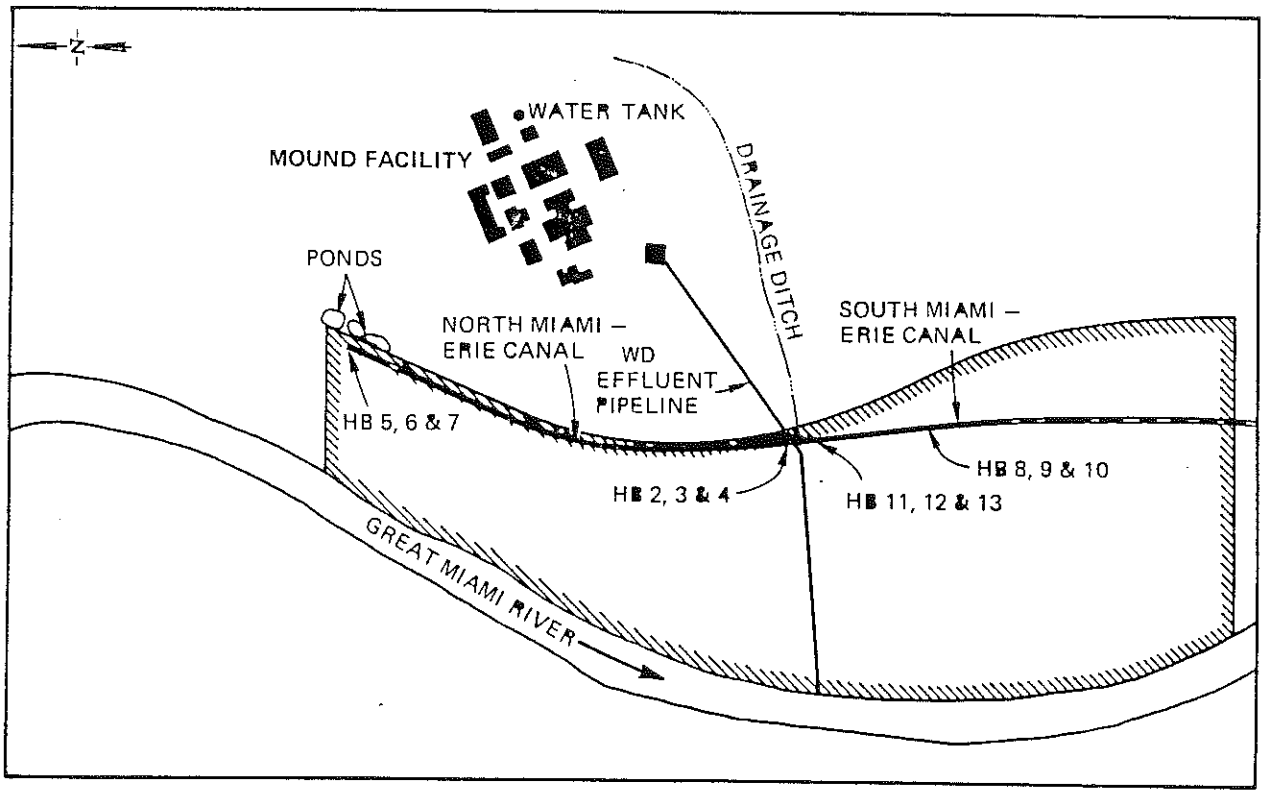

FIGURE 5 - Buried Valley Aquifer Affected by Canal.

The results of the HB series and the plutonium soil samples reveal a tritium contaminant that behaves quite differently from previous documented experience with tritiated water contamination in soil. In general, tritium as tritiated water has been found to follow the ground water movement with no significant isotopic fractionation or immobilization. The only appreciable fixation has been observed in an Oak Ridge study where nonlabile tritium in soil has been attributed to fixation in organic material via plant metabolism [4].

Tritium inventory calculation for canal

An estimate of the tritium inventory in the Miami-Erie Canal and the adjoining ponds has been made using the analytical and distribution data from the HB series of soil samples. Since this soil analysis campaign represents a limited number of sample locations, a conservative approach was employed which should correspond to a maximum inventory value.

The following assumptions were made for this estimate:

1. Sample locations HB3 and HB13 are representative center concentration distributions for the north and south canal areas, respectively.

2. HB4 and HB12 are representative of off-center concentration distributions for the north and south canal areas, respectively.

3. Canal depth and cross sectional profiles can be approximated with $N_Z = A\ e^{-BZ^2}$ and $N_X = A\ e^{-CX}$ distribution functions, where A, B, and C are empirically adjustable parameters.

4. The average specific gravity of the wet soil at the sample location is 2 g/cm^3 (125 lb/ft^3) and that the average soil water content is 25% [2].

It follows from assumption (3) that the total tritium in the canal can be estimated as

$$N_T = 2\Delta Y\ N_{oo} \int_o^\infty \int_o^\infty e^{-BZ} e^{-CX^2} dX dZ \qquad (1)$$

where ΔY represents the length of the canal area contaminated and N_{oo} the peak horizontal and vertical contamination. Upon integration of (1) and solving for the C and B parameters by curve-fitting to the empirical data for HB3 and HB4, a value of 3.1×10^4 µCi/ft is obtained for $N_T/\Delta Y$. It is next assumed that the entire length of the north canal, 2700 ft, and 2500 ft of the south canal represent the contaminated zone. Thus it follows that the tritium inventory in the soil in the area of the Miami-Erie Canal is approximately 162 Ci.

It is further estimated that the soil under the two ponds at the north end of the canal could contain as much as 23 Ci. This quantity is obtained by assuming that the contamination level is at least an order of magnitude lower in the ponds than the maximum found in the canal. This assumption is supported by both the HB series soil analyses for the north canal and previous soil analysis results for a sample location, SB8, in the south pond.

Thus the total tritium inventory for the canal/pond system is estimated to be 185 Ci. Since the average bound/exchangeable

ratio for all the HB series soil analyses was found to be 0.9, it is estimated that 167 Ci of the total inventory is in a bound form and only 18 Ci are presently available for transfer to the aquifer via soil water migration.

Affected aquifer volume and tritium inventory

The area of the buried-valley aquifer affected by the canal contamination is assumed to be as shown in Figure 5 (enclosed in hashmarks) and represents a surface area of approximately 7×10^6 ft^2. This represents a 4.9×10^9 liter volume of water for a saturation thickness of 70 ft and a 35% porosity [3]. If the average tritium concentration in this area of the aquifer is taken to be 20 nCi/liter, a total inventory of 98 Ci is estimated. This 20 nCi/liter appears to be a reasonable average concentration based on present values for the wells in the affected area [3].

Contamination characteristics and behavior studies

Several experiments were carried out to establish the identity of the radioactive species in the canal soil and to explore the physical and chemical nature of its carrier compound.

Initial studies involved confirming that the radioactivity observed by liquid scintillation counting in soil samples from the canal was due to tritium rather than some unknown radionuclide or scintillation counting anomaly. Using water samples from soil distillate and standard time dependent counting techniques, the possibility of chemiluminescence, bioluminescence, and scintillation enhancement was eliminated. A distillate water sample was also compared with a tritiated water standard, chlorine-36 and carbon-14 standards by the liquid scintillation counting channel ratio method. The tritiated water standard and the canal sample gave almost identical results, whereas there was no correlation between both the chlorine-36 and carbon-14 results and the tritiated water standard. To confirm that the active agent in the soil samples behaves as hydrogen, a reduction/oxidation train was assembled, and a sample of soil distillate was passed through it, collected with a glycol bubbler, and analyzed with a scintillation counter. Over 90% of the active agent followed the chemical path of hydrogen through the train. These data, together with the scintillation counting energy discrimination and channel ratioing data, rule out all other possible active agents and can be considered sufficient evidence to confirm the presence of tritium.

Early in the HB series soil sample analysis campaign, a water leach sample of HB3-2 was set aside as a long-term leach study. The sample was in its third leach when set aside, so that the major portion of the exchangeable tritium had been removed, and any increase of tritium levels in the leach water was due to transfer from the bound to the exchangeable form. The results for a 60-day period are shown in Figure 6. These data have been plotted as if the bound-to-exchangeable transfer follows first-order kinetics, a reasonable premise on the basis of the linearity of the plot. If first-order kinetics can be used to describe this transfer rate, a physically reasonable half-time of 3 yr is indicated. Thus one can calculate that, within the

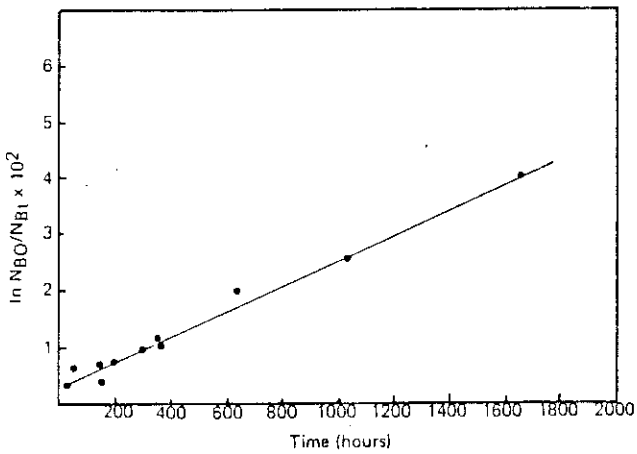

FIGURE 6 - In vitro transfer of tritium from bound to exchangeable form.

next year, as much as 30 Ci of the tritium inventory in the canal will be converted to the exchangegable form that is capable of reaching the aquifer.

A Freon extraction was performed on an HB13-2 aliquot to investigate the possibility that the tritium is bound in an organic compound. Freon 113, an oil and grease extractant used in EPA Standard Procedure STORET No. 00556, was used to leach the soil samples in much the same way as the water leaches were performed. After over 14 days of contact between a 110°C dried soil sample and an approximately equal weight of Freon 113, less than 0.5% of the bound tritium was extracted. Thus the tritium does not appear to be bound as a nonvolatile hydrocarbon, vegetable oil, animal fat, wax, soap, grease, or similar material, all of which are soluble in Freon 113.

Canal/aquifer interaction model

In order to better assess the effects and nature of the interaction between the tritium in the Miami-Erie Canal and the buried-valley aquifer, a three-compartment model was used. It should be pointed out that any such model is a gross simplification of a very complex interaction and can only be used for explaining qualitative features. Some of the complicating features of this interaction system are: (1) the tritium contamination distribution in the canal appears to be very heterogeneous; (2) the canal environs, a man-made waterway in the first place, have undergone a number of alterations which make it impossible to quantify the percolation rate of water from the canal to the aquifer; and (3) the Dames & Moore [3] hydrological study shows that the aquifer is neither homogeneous nor isotropic. Because of these features, a rigorous evaluation of the tritium levels and their rates of change would need to be made on the basis of each individual well, using the appropriate terms for the drawdown zone for that particular well and including the cross terms due to other well fields. Such an approach was not warranted, since it was both outside the scope of this study and impractical on the basis of the accuracy and completeness of the available hydrological data.

To arrive at a qualitative model for the canal/aquifer interaction within the boundaries of the above limitations the following assumptions were made:

1. Contamination incident or incidents occurred as discrete events - acute versus chronic exposure. The sharp vertical

distribution profiles found for the tritium in the canal support this assumption.

2. No significant releases to the canal via the drainage ditch have occurred since the installation of a ditch monitoring station in 1971.

3. The transport kinetics can be approximated by first-order expressions. This is obviously true for the nuclear decay terms and is reasonable for those terms involving water transport, since self-diffusion of water in soil has been found to be quite slow [5].

4. Sufficient time has elapsed since the contamination incident and the relative values of the rate constants are such that the quantity in the exchangeable compartment has approached steady-state. This assumption simplifies the mathematical analysis of the model and is reasonable on the basis of the relatively constant, low quantities of tritium found in the exchangeable fraction of the HB series samples.

The three-compartment model shown in Figure 7 has been postulated on the basis of the above assumptions, the results from the HB series canal soil analyses, the inventory estimates, and the Dames & Moore hydrological data. The symbol λ_N represents the nuclear decay rate for tritium (y^{-1}), λ_B is the transfer rate from the bound state to the water-exchangeable state (y^{-1}), λ_E is the transfer rate from the exchangeable compartment to the aquifer (y^{-1}), and R is the effective recharge rate of the aquifer (liter y^{-1}) for an aquifer of effective volume V(liter).

The rates of change for tritium in each of the compartments are:

$$\frac{dN_B}{dt} = -(\lambda_B + \lambda_N)N_B \qquad (2)$$

$$\frac{dN_E}{dt} = \lambda_B N_B - (\lambda_N + \lambda_E)N_E \qquad (3)$$

$$\frac{dN_A}{dt} = \lambda_E N_E - (\frac{R}{V} + \lambda_N)N_A \qquad (4)$$

If the steady-state assumption is applied to equation (3) and equation (2) is integrated between the limits of N_{BO} (the initial quantity of tritium released in the bound form) and N_B, the N_E variable can be eliminated from equation (4) to give

$$\frac{dN_A}{dt} = \left(\frac{\lambda B \lambda E}{\lambda N + \lambda E}\right) N_B - (\frac{R}{V} + \lambda_N)N_A \qquad (5)$$

or

$$\frac{dN_A}{dt} = \left(\frac{\lambda_B \lambda_E N_{BO}}{\lambda_N + \lambda_E}\right) e^{-(\lambda_B + \lambda_N)t} - (\frac{R}{V} + \lambda_N)N_A \qquad (6)$$

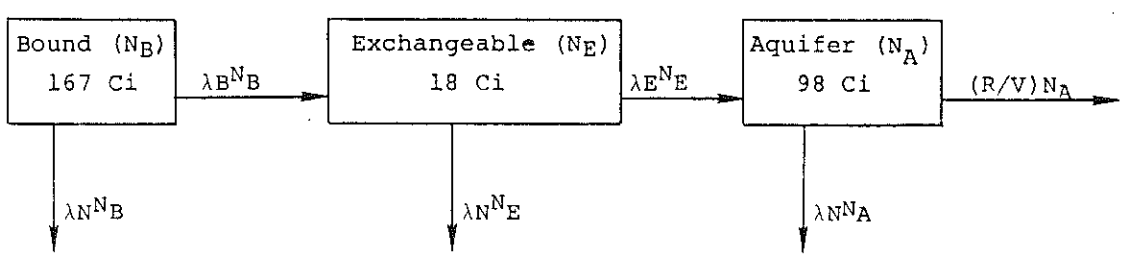

FIGURE 7 - Three-compartment migration model.

The time dependency of the tritium content of the aquifer is thus obtained by integration of equation (6) to give

$$N_A = \frac{\lambda B \lambda E \ NBO}{(\lambda_N+\lambda_E)(\lambda_B-R/V)} \left[e^{-(R/V+\lambda_N)t} - e^{-(\lambda_B+\lambda_N)t}\right] \qquad (7)$$

Thus in principle, if the rate constants for the various interactions were known, one could rigorously describe the time-dependent behavior of the tritium in the aquifer. Unfortunately, λE is not known, and R/V and λB can only be estimated with a great deal of uncertainty. Attempts were made to estimate λE, but the resultant expressions for N_A as a function of time were not consistent with the observed behavior of Mound and Miamisburg wells for the period 1971 through 1976. However, the dependencies and interactions described by expressions (5) and (7) can be used to assess the effects of various actions, such as removing the source term by excavating the tritium contaminated zone from the canal and/or increasing the aquifer recharge rate by pumping.

A generalized plot of equation (7) is shown in Figure 8. The values for the rate constants were chosen on the basis of being physically reasonable estimates that result in a time dependency that is comparable to those observed for the tritium concentrations in the Mound and Miamisburg City wells [3]. The variables λ_E and N_{BO} have been collected into an arbitrary constant, K. Since K is part of the pre-exponential in equation (7), its value does not affect the general features of the curve, only the position of the ordinate.

The general features of the relationship represented by equation (5) and shown in Figure 8 are such that the function will go through a maximum at some time after the contaminating event. Before the maximum, the N_B term dominates, and after the maximum, the N_A term dominates. The dominance of the latter steadily increases with time. These features are the most useful for this study, since they relate to the possible courses of action for lowering the aquifer tritium concentration. Thus both increasing the recharge rate R/V (pumping) and decreasing the source term $N_B\lambda_B$ (physical removal) can reduce the time needed to reach a certain contamination level in the aquifer. The latter action is more effective if taken as early as possible after the maximum has been passed. The dotted curves in Figure 8 represent the effect of such source removal action taken 3, 6, and 10 yr after the contamination incident.

Conclusion and discussion

The following conclusions can be drawn on the basis of the data from the HB series canal soil analysis campaign, the Dames & Moore hydrology studies, and the models and analyses put forth in this report.

1. Tritium is the canal contaminant.

2. As of the end of 1976 a total tritium inventory of approximately 200 Ci (0.02 g) is in the 5200 ft stretch of the Miami-Erie Canal and the adjoining ponds west of the Mound Facility site.

3. Approximately 90% of the tritium in the canal soil is in a bound, not water exchangeable, form.

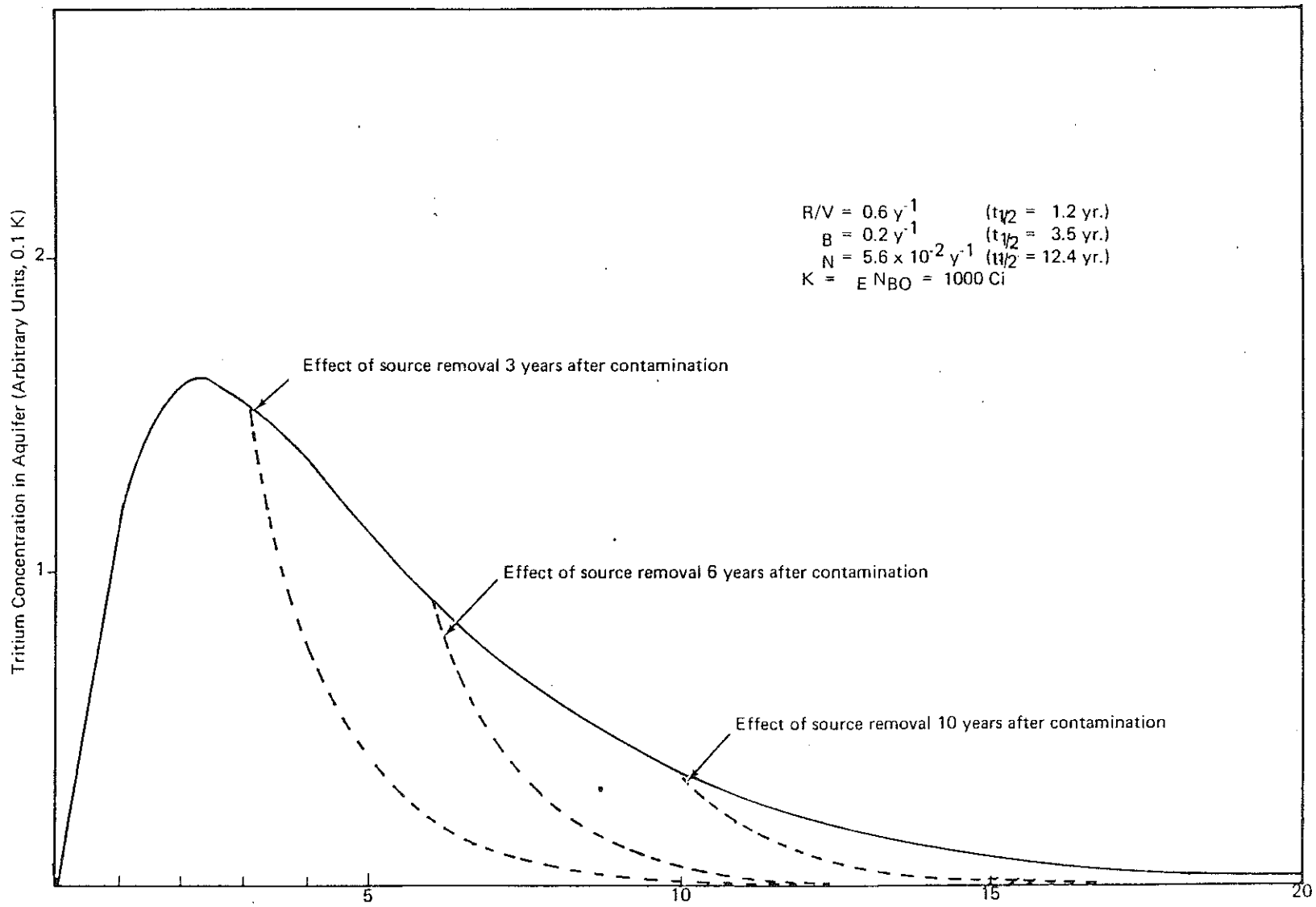

FIGURE 8 - Aquifer tritium content as a function of time.

4. In general, the contamination is highly concentrated in the center of the canal water-channel and within 2 ft of the surface. The contamination levels are highest near the Mound drainage ditch and canal confluence.

5. The tritium contamination distributions resemble the plutonium-238 contamination distributions, which were attributed to a particulate sedimentation deposition mechanism.

6. The bound-to-exchangeable transfer half-time is approximately 3 yr based on preliminary in vitro data.

7. The tritium in the canal area could contribute as much as 30 Ci to the aquifer in the next year.

8. The three-compartment canal/aquifer interaction model and the general decreasing trends recorded for the tritium concentration in on-site and surrounding wells since 1971 indicate that the time of maximum influence by the canal tritium is well past and the aquifer recharge dominates. Thus it appears that the most efficacious time for removing the tritium from the canal has passed. Moreover, pumping at a nominal 500 gal/min more than offsets the present magnitude of the source term estimated in (7) above. The relative cost of such pumping is minor compared to the cost of removing the tritium from the canal.

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1. B. M. Farmer, B. Robinson and D. G. Carfagno, "Annual Environmental Monitoring Report: Calendar Year 1976," MLM-2416 (April 25, 1977).

2. D. R. Rogers, "Mound Laboratory Environmental Plutonium Study," MLM-2249 (September 15, 1975).

3. Dames & Moore, Consultants in The Environmental and Applied Earth Sciences, Sciences, Cincinnati, Ohio, private communication.

4. C. W. Francis, Oak Ridge National Laboratory, Oak Ridge, Tennessee, private communication.

5. D. S. Sasscer, C. F. Jordan and J. R. Kline, 1971, in "Radionuclides in Ecosystems," Proceedings of the Third National Symposium on Radioecology (Edited by D. J. Nelson), CONF-710501-P1 (USAEC) p. 915.

Acknowledgement

The authors wish to thank Elizabeth Wallace for her valuable assistance on the soil sample analyses and Warren Sheehan for his advice and support in the radiocounting portion of this work.

Appendix A

Soil analysis results for HB series

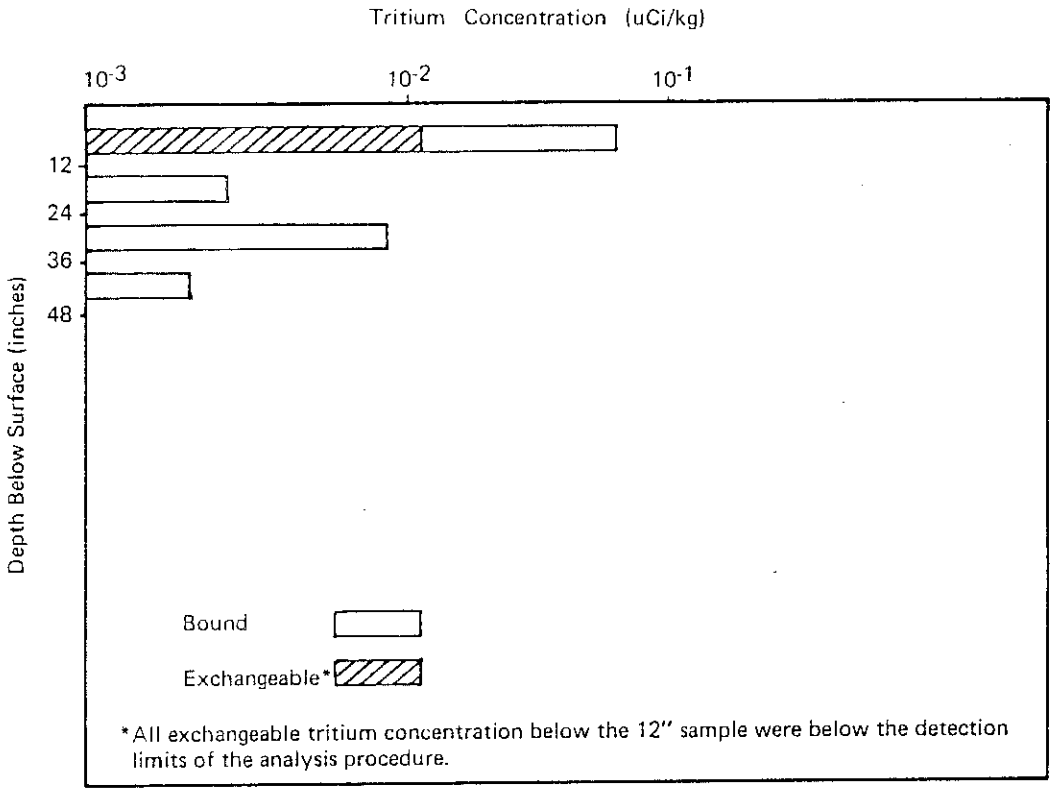

FIGURE A-1 - HB2 north canal (150 ft north of dam, 15 ft west of center).

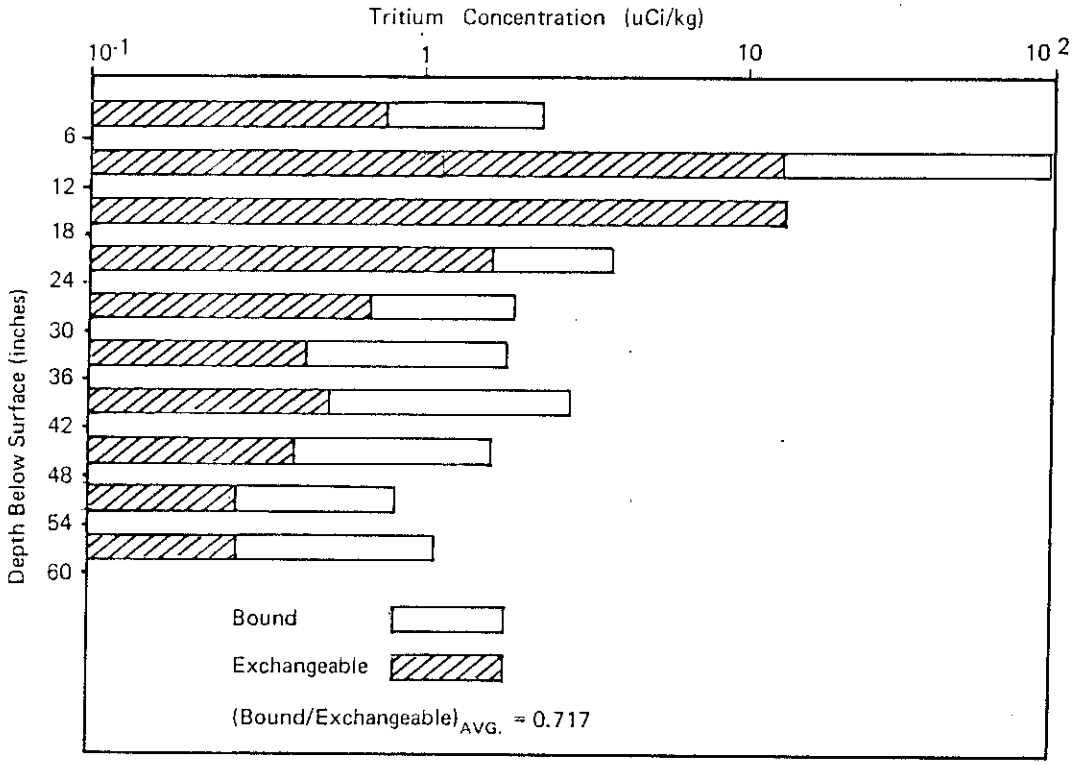

FIGURE A-2 - HB3 north canal (center, 150 ft north of dam).

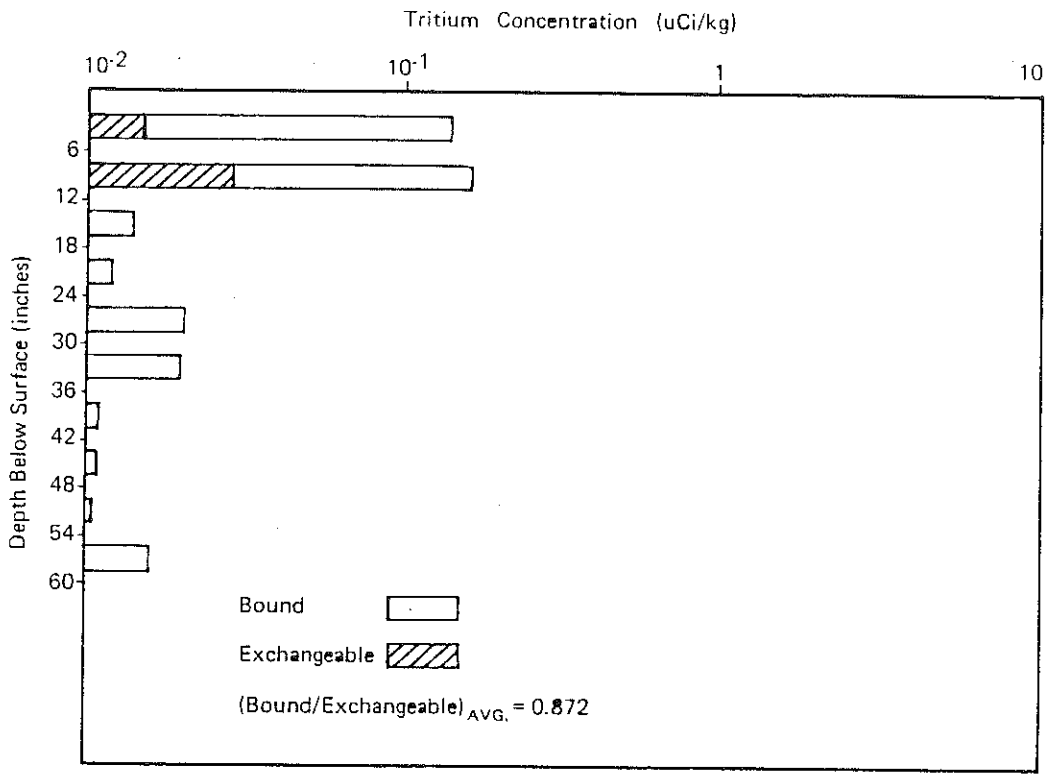

FIGURE A-3 - HB4 north canal (15 ft east of center, 150 ft north of dam).

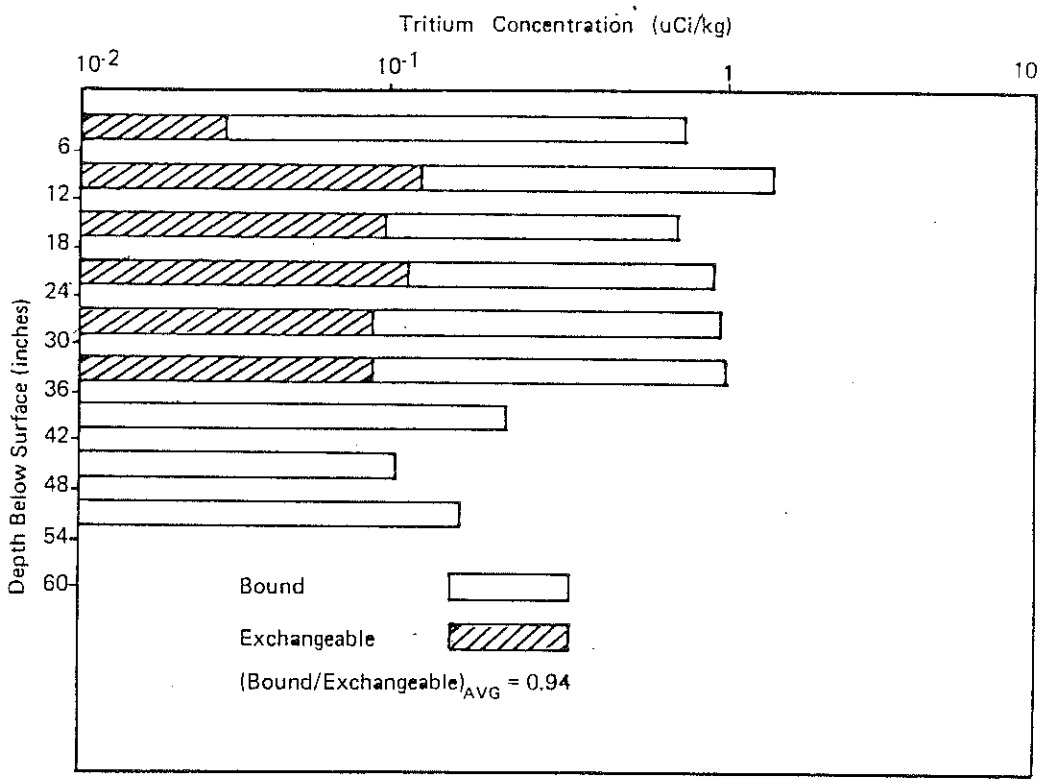

FIGURE A-4 - HB6 north canal (center, 2600 ft north of dam).

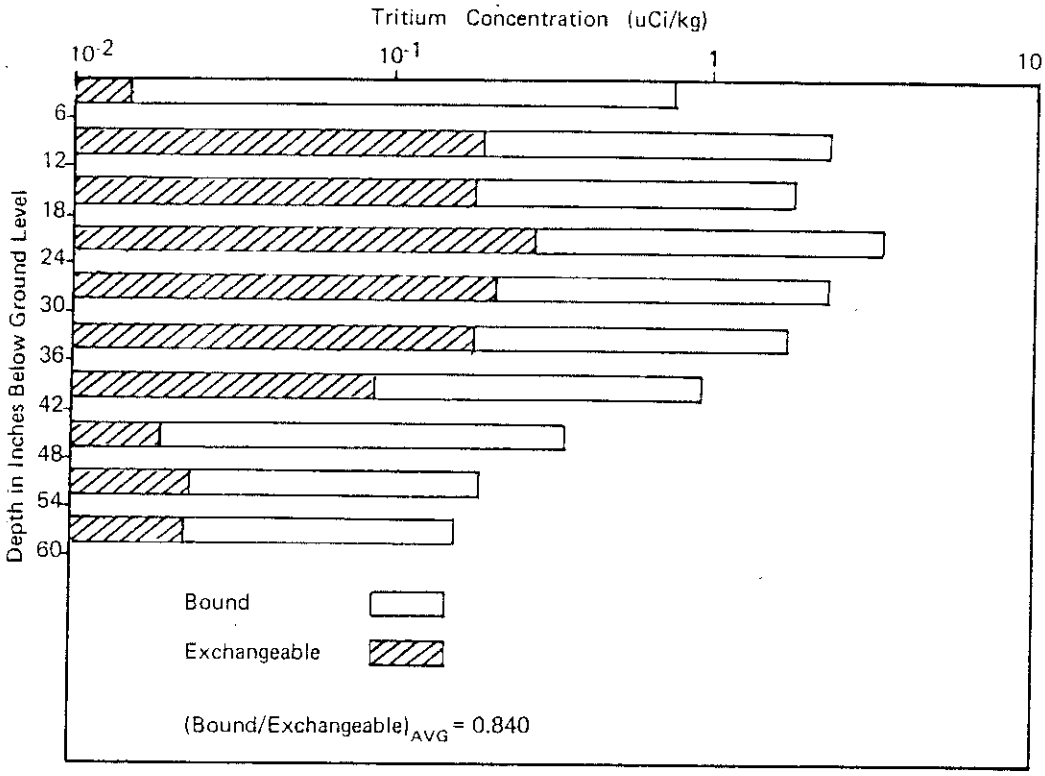

FIGURE A-5 - HB7 north canal (3 ft east of center, 2600 ft north of dam).

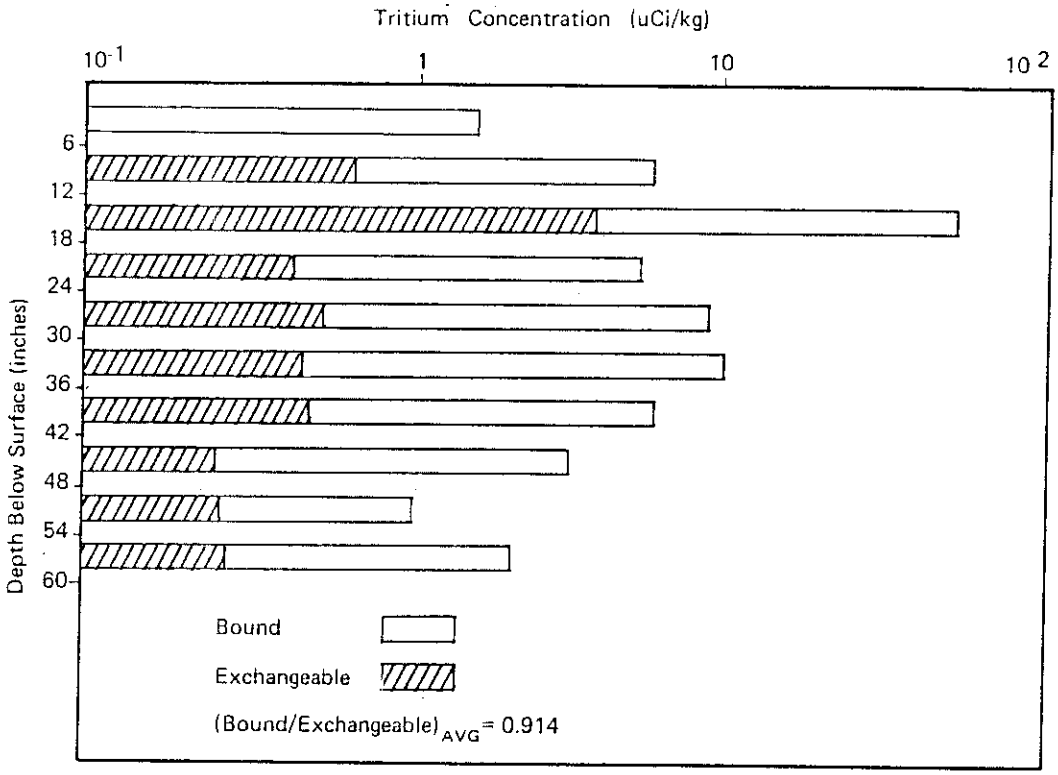

FIGURE A-6 - HB8 south canal (14 ft west of center, 900 ft south of dam).

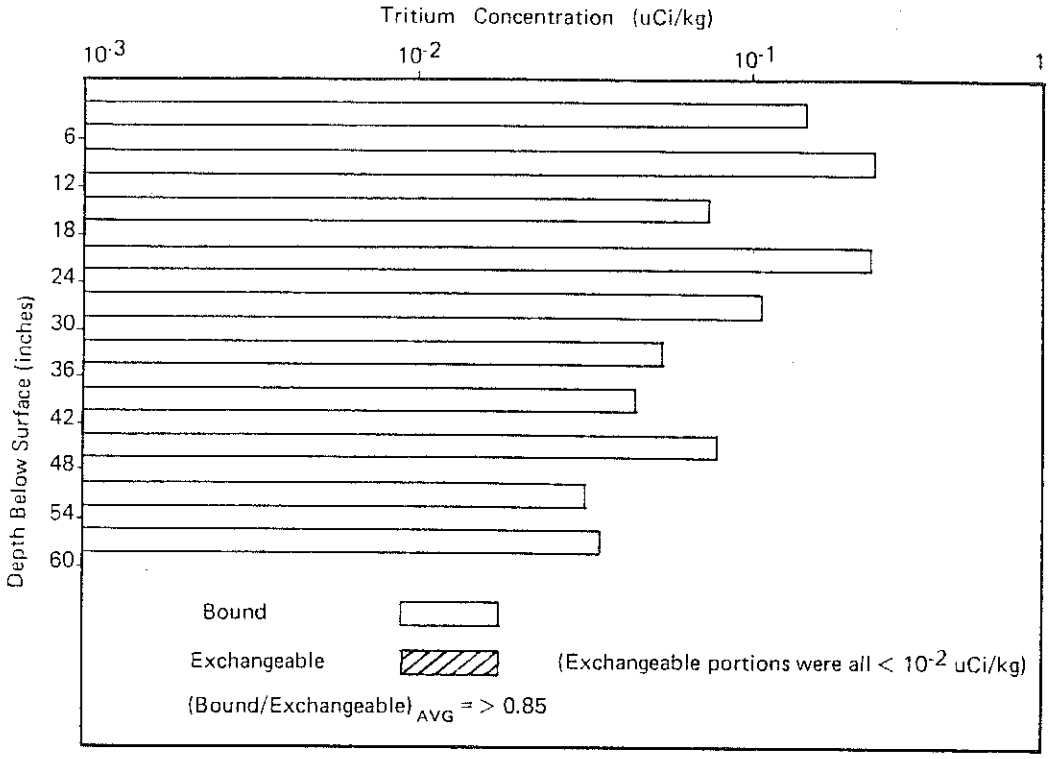

FIGURE A-7 - HB9 south canal (12 ft east of center; 900 ft south of dam).

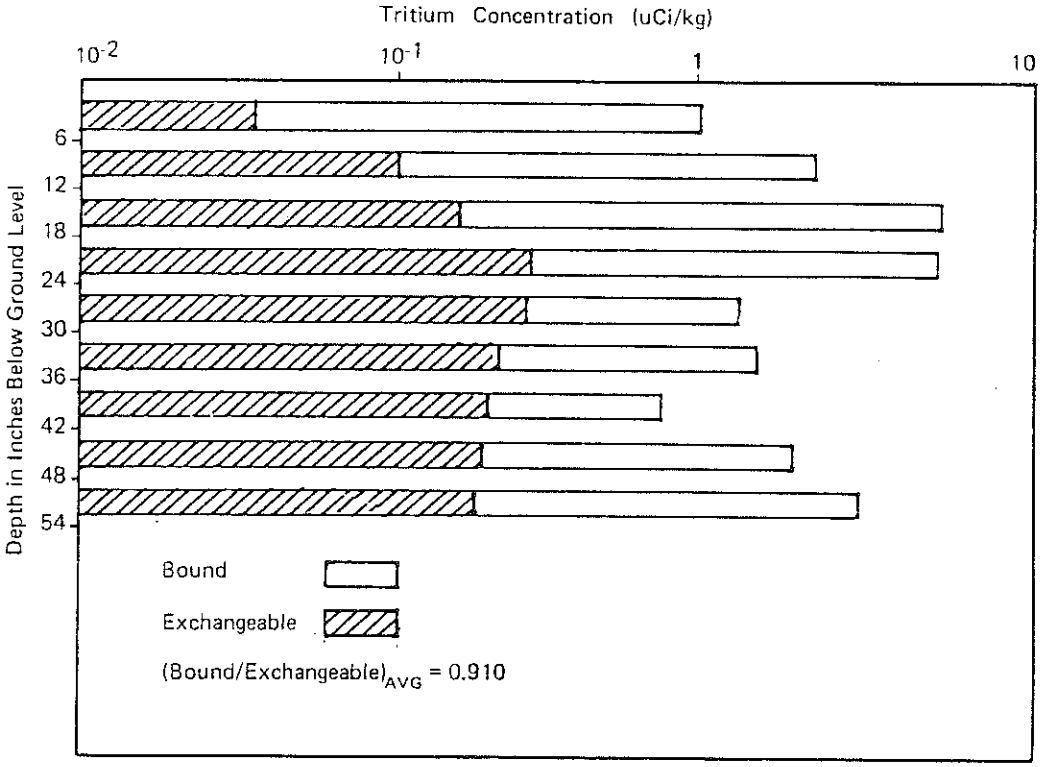

FIGURE A-8 - HB10 south canal (center, 900 ft south of dam).

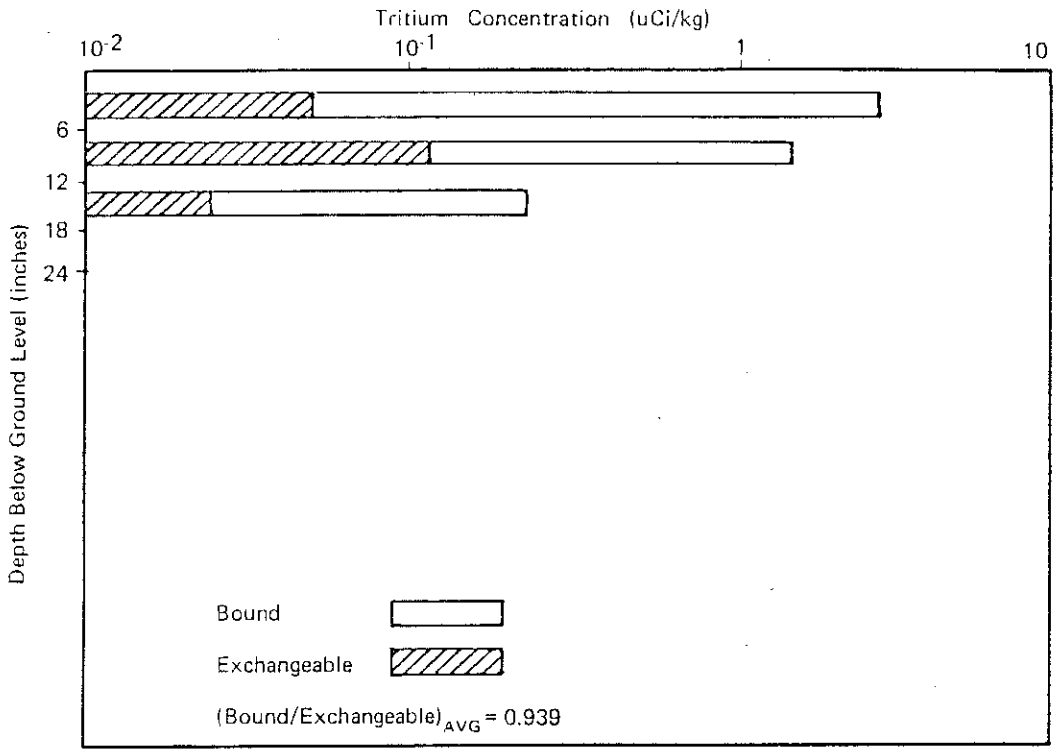

FIGURE A-9 - HB11 south canal (9 ft west of center, 150 ft south of dam).

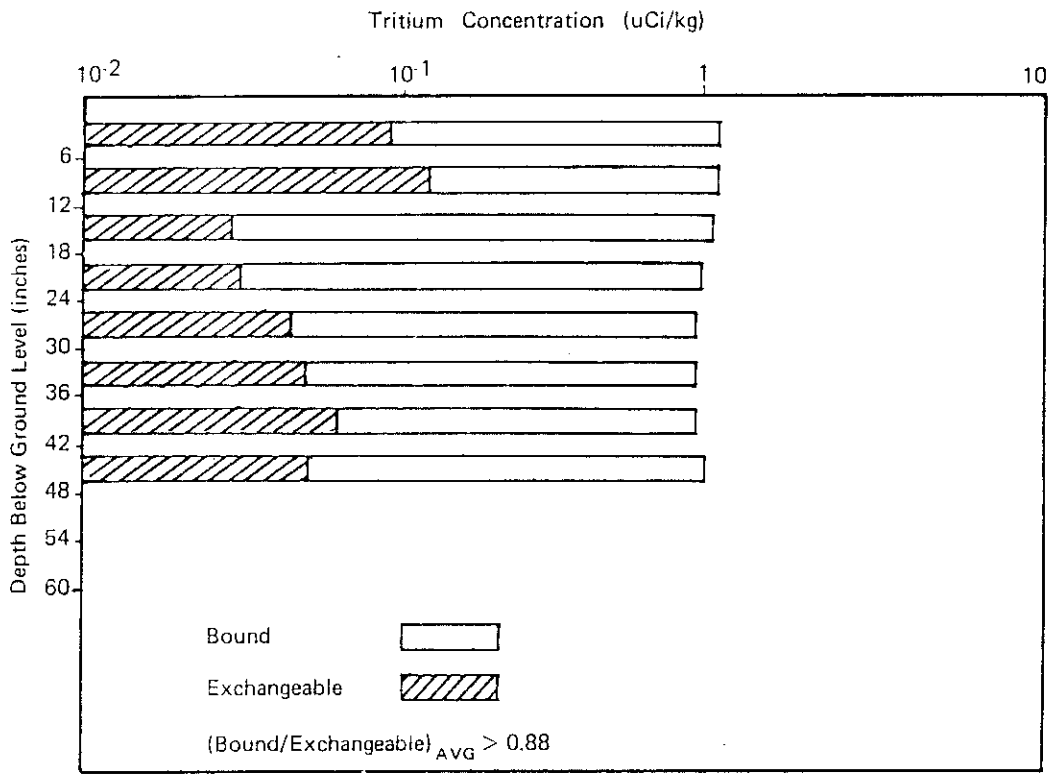

FIGURE A-10 - HB12 south canal (7 ft east of center, 150 ft south of dam).

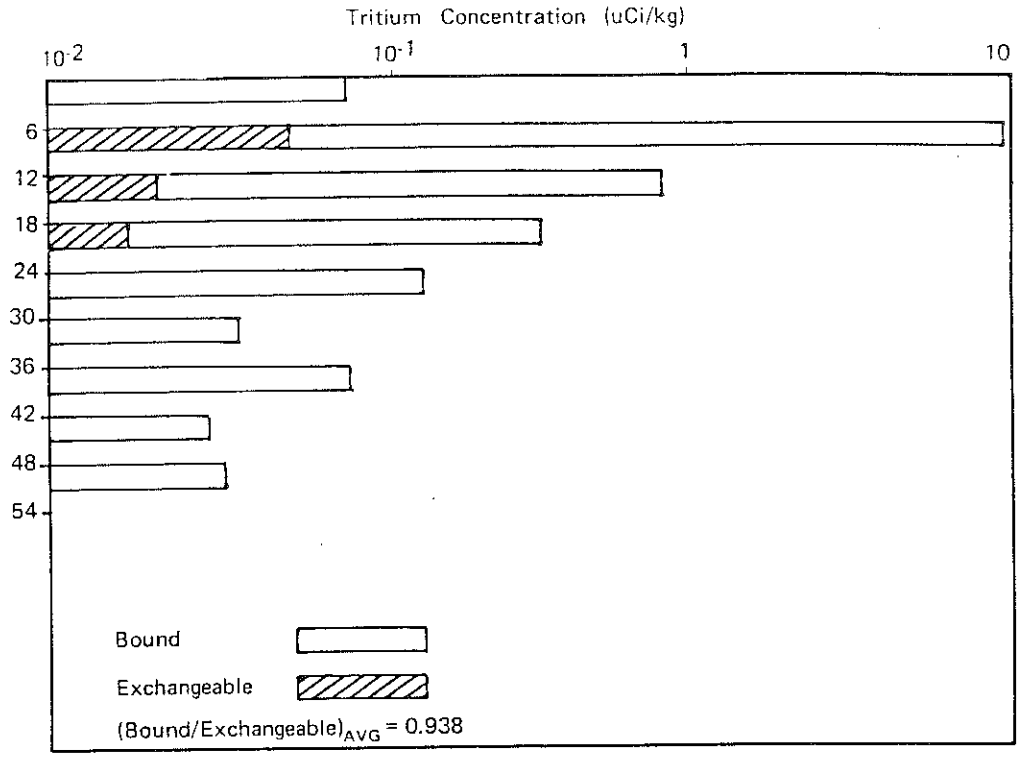

FIGURE A-11 - HB13 south canal (center, 150 ft south of dam).

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MOUND LABORATORY DOCUMENTS

Executive Summary

The Mound Laboratory is a U.S. Department of Energy facility that conducts research, development and production work in support of government weapons, aerospace and medical programs. Located in Mound, Ohio, a few miles outside Dayton, the plant has been operated under government contract by the Monsanto Research Corporation since its establishment as an outgrowth of the Manhattan Project in 1949. The two primary radioactive elements that Mound uses in its production and assembly activites are plutonium-238 and tritium.

The Government Accountability Project ("GAP") has begun to monitor Department of Energy ("DOE") facilities for compliance with environmental, safety and health regulations and statutes. GAP's primary focus has been on the Fernald facility, also located in Ohio, and more recently the Mound facility, the subject of this report. The enclosed documents are summaries of accident and exposure reports from the Mound facility for the period from 1960 to 1978. The documents were obtained through the Freedom of Information Act. GAP is pursuing more recent and thorough documentation from the DOE on the Mound facility.

The documents that are summarized and analyzed here are voluminous. Hopefully, this summary will lead to greater public

understanding of the Mound facility's functions and problems.

To capsulize the information, the documents reveal that in the period between 1960 and 1978 the Mound facility reported a total of 28 major "incidents" involving 90 employee over-exposures to radiation, dozens of spills and leaks on and off-site of radioactive plutonium and tritium, and the presence of plutonium-contaminated soil in a canal and a public park next to the facility. There were seven glovebox explosions or leaks, (a glovebox is a glass-enclosed box with gloves attached to the outside of the box, allowing a worker to work with highly hazardous material without touching it); five explosions involving the release of radioactive material; two broken capsules involving the release of radiation; five serious worker negligence incidents leading to contamination; four pipe breaks leading to contamination; one drain overflow of contaminated material; one major fire involving the outside release of plutonium, and two plastic bag ruptures.

All of the incidents required reporting to the government because they involved employee contamination above the allowable limits or involved off-site contamination. We, of course, have no guarantee that these problems are described in full or constitute all the incidents. Finally, the documents only focus on a limited portion of Mound's history from 1960 until 1978. The plant has operated since 1949.

Although DOE characterizes Mound as one its cleanest and safest facilities, its problems are severe. The plant has

contaminated a local public drinking supply with high levels of tritium, a radioactive element in use at Mound. The company has had to continually flush the aquifer to achieve compliance with applicable standards for tritium, which have been breached in the past.

Off-site presence of plutonium-238 is also a problem at Mound. In 1969, an underground pipeline burst at Mound, spilling plutonium-contaminated slurry. The area around the pipe was excavated, but three days of intense rainfall delayed the clean-up and spread the contamination. A plume of contaminated soil migrated off-site. Much of the plutonium was allowed to migrate for five years, into a local canal and into ponds and soil of a local public park located next to the plant. The problem was not detected until 1974. The failure of Mound officials to detect this problem for a five year period is unexplained.

Subsequent Monsanto studies have determined that there is no immediate health hazard from the plutonium off-site, but that if the land is disturbed, the soil allowed to dry up and blow around, there could arise an immediate health hazard.

CONCLUSION

The enclosed documents are illustrative only of a history of preventable accidents, worker exposures and contamination of both on and off-site soil and water resources. The workers who were over-exposed could well be suffering the results in medical terms

today. The legacy of the accidents also extends to the public through drinking water contamination and off-site plutonium contamination of the soil.

Any questions concerning these documents, or requests to see the actual documents, should be directed to Tom Carpenter, Citizens Clinic Director of GAP.

-Tom Carpenter, Director
Citizens Clinic
Government Accountability Project
1555 Connecticut Avenue N.W.
Suite 200
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(202) 232-8550

GLOSSARY OF TERMS

c/m - or counts per minute: a measure of radioactivity used in the earlier days of the nuclear age. A count per minute is the level of activity of a given radioactive source, used to measure the degree of contamination - the higher the c/m, the greater the extent of contamination.

d/m - or disintegration per minute: same as count per minute.

curie: a measure of the amount of radioactivity emitted by a given substance as compared to the amount of radiation emitted by a gram of radium in the period of a second (named after Madame Curie).

maximum permissible body burden: the amount of radiation that a nuclear worker is allowed to be exposed to as set out by government standards; i.e. the maximum permissible body burden for plutonium exposure to the lung is 40 nanocuries.

rem: a measure of a radiation dose based on the projected biological effects of a particular radioactive element. Members of the public are currently allowed to be exposed to no more than one half of a rem (500 millirems) as a result of a nuclear operation in a year's time. A nuclear worker is allowed to be exposed to up to 5 rems in a year's time, or up to 3 rems per quarter year.

millirem: one thousandth of a rem.

microcuries: a millionth of a curie.

nanocurie: a billionth of a curie.

RCG: Radioactivity Concentration Guide, a standard suggested by the government for a particular radioactive element.

alpha: a type of radiation in particle form. Alpha radiation is considered most dangerous when introduced into the body through inhalation, ingestion or through absorption through the skin or a wound. Plutonium emits alpha particulate radiation. The amount of the charge of the alpha particle determines its destructive power. The other two types of radiation are gamma and beta.

DTPA: a chemical used in treatment for radiation exposure, especially massive plutonium exposure, in the theory that it helps clean the body of the element quicker. A controversial treatment.

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Final Environmental Impact Statement

Mound Facility

Miamisburg, Ohio

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Final Environmental Impact Statement

Mound Facility

Miamisburg, Ohio

Responsible Official

James L. Liverman
for Ruth C. Clusen
Assistant Secretary for Environment

U.S. DEPARTMENT OF ENERGY
Washington, D.C. 20545

June 1979

FOREWORD

This Environmental Impact Statement (EIS) was prepared in compliance with the National Environmental Policy Act of 1969 (NEPA 42 U.S.C. 4231) by the U. S. Department of Energy (DOE) to assess the environmental implications of its continuing and future programs at the Mound Facility (formerly designated Mound Laboratory), located in Miamisburg, Ohio. Mound Facility is operated by Monsanto Research Corporation under contract to the DOE.

The Council on Environmental Quality (CEQ) issued revised Guidelines for the Preparation of Environmental Impact Statements (40 CFR 1500, FR Vol. 38, No. 147) on August 1, 1973, which required all Federal agencies to assess the environmental impacts of ongoing programs that were initiated prior to the promulgation of NEPA. In compliance with CEQ guidelines, the Energy Research and Development Administration (ERDA, whose functions were absorbed by the DOE on October 1, 1977) issued an Omnibus Environmental Assessment in July 1975 for activities conducted at Mound Facility. On July 8, 1976, ERDA announced its intent to publish an EIS for the Mound Facility operations and invited predraft comments and suggestions for consideration in preparation of a draft of the environmental impact statement (DEIS). The Omnibus Environmental Assessment and other related documents to be used in the preparation of the DEIS were made available to the public for review. Comments were received from five entities and were included in the preparation of the DEIS.

The DEIS was prepared in accordance with specific guidelines for preparation of environmental statements, as amended in "Guidelines for Environmental Review," 10 CFR 711 (42 FR 4826), and issued on April 27, 1978, for public review and comment (43 FR 17995). The comment letters were received during the public review period and the substantive issues raised in those letters have been considered in the preparation of this EIS. The major issues raised in the letters of comment concerned the effects of tritium release; plutonium-238 release and toxicity; additional data for releases in air and water effluents; occupational exposure of Plant workers; criteria for the evaluation of the effects of fire and storms; stabilization of contaminated soil; impacts of transportation of radioactive waste; waste disposal; and Mound's meteorological program. These letters with DOE responses are presented in Section 10, and specific references are made in that section to the text where the issues contained in these letters are addressed.

This document describes the activities performed at Mound Facility and discusses their actual and potential primary and secondary impacts on the surrounding environment. Impacts of routine and accidental releases are addressed. The existing environmental setting is described and the cumulative impact of Mound's mission is evaluated. Data presented are the latest available at the time of publication and include CY-1977 environmental information. Environmental studies are continuing as part of Mound's monitoring surveillance and environmental protection program. These are published annually.

Anticipated improvements to Facility operations and practices are designed to reduce even the existing minor releases to as low as practicable based on the best technology currently available. The alternatives considered include continued operations, relocation of operations, decrease and discontinuation of operations.

A concerted effort has been made to present the information in a straightforward manner, comprehensible to the nontechnical reader. To aid in understanding the text, a glossary of technical terms is included and a Table of Contents has been included to aid the reader in identifying topics of special interest.

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(10 mi) south-southwest of Dayton, Ohio and 50 km (31 mi) north-northeast of Cincinnati, Ohio (see Figures 2-1 and 2-2). The exact location is 39° 37' 42" N and 84° 17' 15" W.

The Plant is situated topographically upon a high area overlooking Miamisburg, the Great Miami River, and the river plain area to the west. The property is characterized by two high areas divided by a minor northeast-southwest trending valley which drains to the river. Most of the buildings are located atop the northwest high area. A smaller group of buildings lies atop the southeast high area, and several buildings are located in the valley and on the valley slopes. Figure 2-3 is an aerial view of the Facility complex.

2.1.3 PLANT HISTORY

Monsanto Research Corporation operates Mound Facility, a government-owned facility of the U. S. Department of Energy at Miamisburg, Ohio. Mound Facility is an integrated research, development, and production facility performing work in support of DOE weapon and nonweapon programs with emphasis on chemical explosives and nuclear technology.

Mound Facility originated as a technical organization in 1943 when Monsanto Chemical Company was requested to accept responsibility for determining the chemical and metallurgical properties of polonium as a project of the Manhattan Engineering District. Work was carried on at Monsanto's Central Research Department and several satellite units in the Dayton, Ohio area. Late in 1945, the Manhattan Engineering District determined that the research, development and production organization established by Monsanto at Dayton should become a permanent facility. A search for a suitable location in early 1946 led to the selection of a 728,000-m^2 (180-acre) tract adjacent to Miamisburg, about 16 km (10 mi) south-southwest of Dayton. Factors contributing to the choice of this location included proximity to Monsanto's Central Research Department in Dayton; existing roadways, railroads, power and water supplies; good drainage; and the availability of skilled labor. The desire to continue operations essentially uninterrupted without physical relocation of trained personnel also greatly influenced the selection of a site close to initial operations in Dayton.

Construction of Mound Facility, which was named after the Miamisburg Indian Mound adjacent to the site, began in February 1947 and was completed in 1949. The new laboratory was the first permanent facility of the Atomic Energy Commission which had succeeded the Manhattan Engineering District. There are 97 buildings with a total floor area exceeding 80,250 m^2 (863,800 ft^2). The present plant represents an investment of about $110,000,000.

All early programs were concerned with polonium-210 and its applications, particularly the fabrication of neutron and alpha sources for weapon and nonweapon use. During the

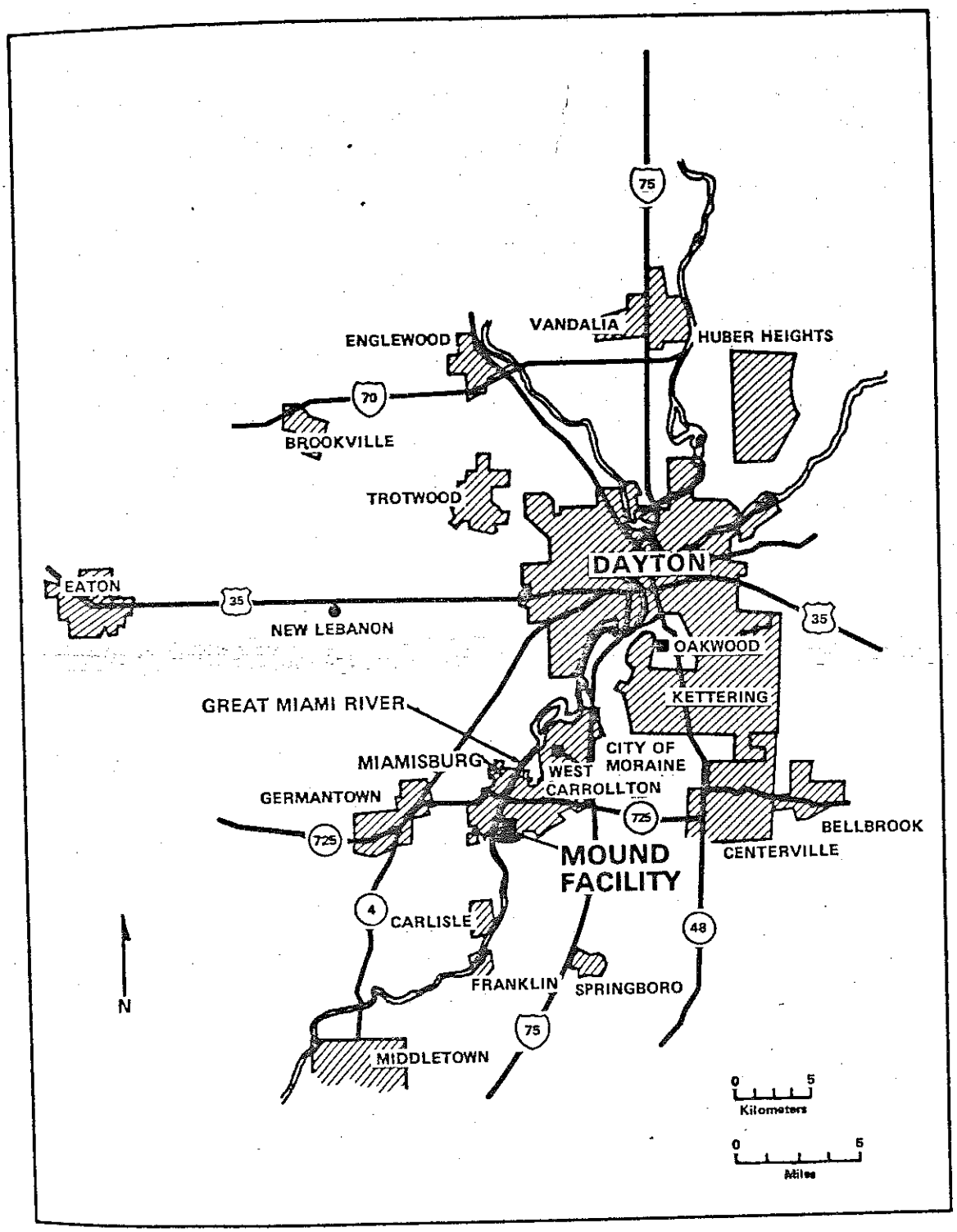


FIGURE 2-2 - Mound Facility and Immediately Adjacent Areas.

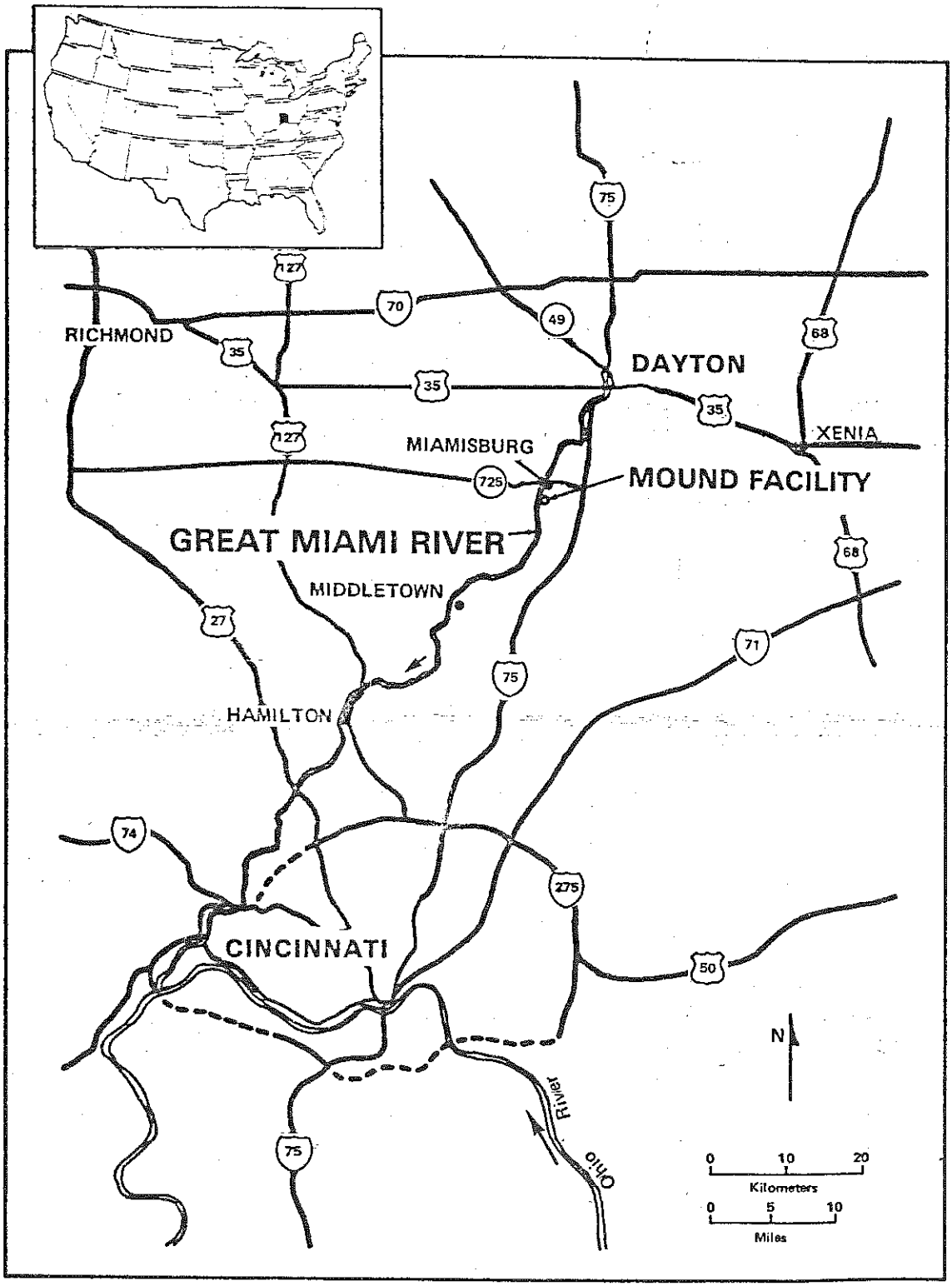


FIGURE 2-1 - Southwestern Ohio and Location of Mound Facility.

SECTION 2
BACKGROUND

2.1 DETAILED DESCRIPTION OF PLANT AND OPERATION

2.1.1 PLANT MISSION

The main function of the Mound Facility plant is to manufacture nonnuclear explosive components for nuclear weapons assembled at another site of the Department of Energy. The total objectives are as follows:

1. Manufacture detonators, explosive timers, explosive-actuated transducers and switches, and explosive pellets for the nuclear weapons program.
2. Develop and manufacture small chemical heat sources for the national defense program.
3. Perform surveillance on explosive detonators and radioactive components received from other DOE sites.
4. Develop materials and processes for potential future manufacturing of components and explosive-actuated mechanisms containing chemical explosives.
5. Recover and purify tritium from various wastes generated by tritium operations at various DOE sites.
6. Develop and fabricate a variety of radioisotopic heat sources fueled with plutonium-238 having thermal outputs ranging from 0.2 watt to several thousand watts for the National Space Program and the Department of Defense.
7. Separate, purify, and market stable (nonradioactive) isotopes of the noble gases and carbon-12, carbon-13, nitrogen-14, nitrogen-15, oxygen-16, oxygen-17, oxygen-18, and sulfur-34.
8. Conduct research and development investigations on chemical explosives and pyrotechnics; plastics, elastomers and adhesives of interest to the nuclear weapons program; fuel systems for thermonuclear energy research programs; joining of exotic metals; instrumentation for the Nuclear Safeguards program; separation techniques and gas dynamics relating to stable isotopes; energy conversion systems; and management of radioactive wastes.
9. Manage the program to convert coal to low-Btu gas for industrial process fuels.
10. Determine the fuel gas content of Devonian shale in the eastern United States.

2.1.2 PLANT LOCATION

Mound Facility is located on a 728,000-m^2 (180-acre) site in southern Montgomery County in southwestern Ohio, within the southern boundary of the Miamisburg city limits and 0.93 km (0.58 mi) due east of the Great Miami River. The site is 16 km

After evaluating the environmental impacts and the available alternatives, the continued operation of Mound Facility at its present location and level of operation is not expected to have greater impacts than those evaluated in this statement. However, the impacts of the operations will be continually evaluated to assure that the expected impacts are not exceeded.

1.10 DISCUSSION OF COMMENTS RECEIVED CONCERNING THE DRAFT ENVIRONMENTAL IMPACT STATEMENT

The draft Environmental Impact Statement for the Mound Facility was issued by the DOE in April 1978. Comments and suggestions for consideration in the preparation of the final statement were received from nine organizations. The substantive issues raised in these comment letters have been considered in the preparation of this final Environmental Impact Statement (FEIS) and, where appropriate, this FEIS has been revised to reflect the comments and suggestions received. Section 10 presents the issues raised by the comments; it identifies the parties who raised the issues, and it addresses each issue.

major alternative considered is continuing operations as they are, using CY-1977 as the point of reference or "now" time. For this situation, the environmental impact covering costs, risks, and benefits is discussed throughout Section 3 and summarized in Section 1.3. The remaining alternatives include: discontinuation of operations at Mound Facility; relocation of operations to another existing DOE facility or a completely new site; decrease work levels; and, lastly, continue operations at Mound and implement planned improvement. The environmental trade-off impacts of these alternatives are summarized in Section 1.9.

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

Mound Facility is committed for the immediate future to the development and production of components for nuclear weapons, production of radioisotope-fueled heat sources, and production and sale of stable isotopes. If these activities should cease, all facilities could be transferred to another user for long-term use after decontamination.

1.7 RELATIONSHIP OF PROPOSED ACTION TO LAND USE PLANS, POLICIES, AND CONTROLS

The continued federal use of Mound Facility for the development and production of components for weapons does not conflict with any planned land use programs in effect for the area.

1.8 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

At Mound Facility the consumption of natural resources for supplies, building materials, electrical power, and fuel is irretrievable.

1.9 ENVIRONMENTAL TRADE-OFF ANALYSIS

The benefits derived from operation of Mound Facility are the development, production and surveillance of components to maintain an up-to-date nuclear weapon stockpile for national defense, the development of peacetime uses of nuclear energy, and contributions to the National Energy Program. The Dayton community receives economic, social, and technological benefits from the operation of the plant. The cost to the environment is the use of energy resources, emission of very small amounts of chemical and radioactive substances, the unavailability of the land for other uses, and the potential risk to the environment of an accident or natural disaster causing the possible release and dispersal of significant amounts of radioactive materials.

materials or equipment. Physical protection includes the "two-man rule" for access to Special Nuclear Materials; the use of trained, equipped, and qualified armed guards; the use of special-safe secure transportation equipment; and the use of vaults for the storage of Special Nuclear Materials. In support of the Special Nuclear Materials Safeguards Program, Mound Facility has developed on-line nondestructive assay methods, on-line inventory, and highly automated and protected process operations to prevent unauthorized access to these materials. Safeguards and security requirements and operations are under continuing review.

Hazardous materials which are shipped to and from Mound Facility consist of explosives and radioactive materials and of commodities typically used by an industrial complex such as fuel oil, gasoline, commercial compressed gases, and common laboratory chemicals. The commodities are transported by commercial vendors. The shipments of all hazardous materials are controlled by federal, state, and local regulations. All manufactured products containing explosives or radioactive materials are shipped in accordance with the approvals received from the U. S. Department of Transportation (DOT). The explosive products are shipped in nonpropagating packaging configurations. Packages used for the shipment of radioactive materials are tested as required by the DOT to ensure that, under accident conditions, the integrity of the container will be maintained and radioactive material will not be released to the environment.

1.4 UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

The unavoidable environmental effects of Mound Facility's normal operations (i.e., nonaccidental) which might be considered adverse are the indefinite use of land for buildings and roads and the irretrievable consumption of natural resources in the form of supplies, building materials, electrical energy, and fuel. All land ultimately could probably be returned to its original condition for long-term unrestricted use without any residual environmental effects. However, the permanent construction of the major buildings does not make such an action feasible from an economic point of view. Likewise, the costs estimated for decontamination in order to release the facilities for unrestricted use may prove to be quite substantial. The potential for contamination from an occurrence either natural or man-caused does exist and cannot be ignored.

1.5 ALTERNATIVES

The process of evaluating the environmental effects of Facility operations includes an analysis of the operations as they currently exist as well as other alternatives that could be employed to modify the impact.

rced turnover of water in the adjacent area of the Buried Valley Aquifer, which is the source of local well water, in order to meet the stringent requirements of the new regulations as applied to tritium. Mound's program of high volume pumping of water from the aquifer has achieved compliance for Mound wells and most of the private wells. Those wells not yet in compliance are approaching it. Mound anticipates compliance throughout the area during CY-1979. Plutonium-238 concentrations in natural surface waters are less than 1% of the plutonium RCG. Nuclear operations are currently contributing to the atmosphere less than 0.02% of the RCG for tritium and a maximum of 1.4% of the RCG for plutonium-238. In the areas immediate to Mound Facility, the maximum quantity of plutonium-238 found in the soil at any location was about 100 millicuries per square kilometer. The maximum concentration, is well within the proposed EPA standard for transuranium elements in soil.

In one localized area in the abandoned Miami-Erie Canal adjacent to the west boundary of the plant site a maximum concentration of 4.6×10^{-3} microcuries of plutonium-238 per gram of silt was found. This deposition resulted from an onsite underground radioactive waste line break in 1969.

The worst potential accident which conceivably could result from the plant's operations would be a release of plutonium-238 on the surrounding area as a result of a fire or of a tornado possibly making a direct hit on the plutonium processing facility. This accident is considered to be of extremely low probability. Such an accident could expose onsite and offsite persons to radiation from dispersed plutonium-238. Some area of land surface onsite and offsite could be contaminated and require decontamination to prevent resuspension of the plutonium into the air. The resultant decontamination by soil removal could have a local environmental impact.

The types of potential occurrences which have been analyzed for possible impact in Section 3.10 are:

1. Fire in a plutonium-238 facility
2. Accidental release of tritium
3. Nuclear criticality accident
4. Nuclear explosion
5. Explosion of high explosives
6. Onsite transportation accident
7. Power outage
8. Natural disasters
9. Tornado
10. Earthquake

The Mound Facility Safeguards Program includes physical security measures; activities involving control and accounting measures to detect and deter diversion of Special Nuclear Materials; and activities necessary to prevent theft, diversion, or sabotage of

1.2.1 DETAILED DESCRIPTION

Most of the buildings house the administrative, manufacturing, development, surveillance, and support activities. An area for the burning of small amounts of high explosives is on the southern edge of the plant site. The sewage treatment plant is located in the west central part of the site. As a result of operations at Mound Facility some of the buildings have been contaminated with radioactive materials to an extent that they would require decontamination before they would be suitable for other types of operations.

Mound Facility is operated to produce weapon components for the nuclear weapons program, perform surveillance on weapon components, manufacture radioisotope-fueled heat sources for the nuclear weapon program and the national space program, market nonradioactive isotopes to the scientific community, and conduct several programs pertinent to the National Energy Program. In performing the foregoing functions Mound Facility fills a necessary role in the nation's nuclear weapons program, the peaceful applications of nuclear energy, and the overall energy program of the DOE. The Plant's operation also results in substantial economic, sociological, and technological contributions to the Dayton area.

Mound Facility is located in the Dayton suburban area of Montgomery County, Ohio. The plant is bordered by undeveloped agricultural lands on the south which are not cultivated but are in native grass and scrub tree growth. Land to the north, east, and west of the plant site is residential housing with relatively low population density.

1.3 ENVIRONMENTAL IMPACT

Normal plant operations produce no significant offsite air or water pollution, and have only a minor impact on the local area's land use by reason of the removal of the plant site from marginal agricultural or residential use. The plant site after decontamination could be used without restrictions. The impact of nuclear operations to date is that the tritium concentration in well water in the plant vicinity was increased above the natural background level but was kept well within the prevailing Radioactivity Concentration Guide (RCG) for drinking water. (From guidance of the former Federal Radiation Council and the National Committee on Radiation Protection, the RCG is that concentration of radioactive material present in the environment as a result of Facility operations that is determined to result in whole body or organ radiation doses that should not be exceeded without careful consideration of the additional benefits to be gained versus the risks involved.) In 1977, a new drinking water standard for public water supplies was promulgated by the U. S. EPA. The new standard resulted in noncompliance of Mound well water and that of a few private wells adjacent to the Mound site since the tritium concentration exceeded that permitted by the new regulations. Mound has undertaken a remedial program of induced infiltration/

SECTION 1
SUMMARY

1.1 PURPOSE

This environmental impact statement describes the ongoing work of all operations at the Mound Facility (formerly known as Mound Laboratory) and analyzes and evaluates the primary and secondary impacts on the environment of its continued operation. The majority of the activities at this plant were in operation before Congress enacted the National Environmental Policy Act of 1969 (NEPA); therefore, no environmental impact statement within the context of the NEPA was required or made on these facilities prior to their construction and operation. However, the continuing environmental monitoring program has been in place since operations started at the Mound Facility. The impacts of routine and accidental releases are addressed; however, the statement does not address any postulated effects of terrorists' actions. Discussion of the need for a nuclear weapon capability is beyond the scope of this document.

1.2 BACKGROUND

Mound Facility was established in 1946 on a 728,000-m^2 (180-acre) untillable portion of a farm which was adjacent to the city of Miamisburg, Ohio. The facility is operated for the Department of Energy (DOE) with the principal purposes being the manufacture of chemical explosive detonators, explosive timers, explosive-actuated transducers, explosive switches, and heat sources fueled with plutonium-238; surveillance of detonators and cables and of components containing radioactive materials; separation, purification, and sale of stable (nonradioactive) isotopes of noble gases, carbon, and several other elements of interest to the scientific community; recovery of tritium from wastes generated at Mound Facility and other DOE sites; and the peaceful applications of atomic energy. In addition, the coal conversion program to produce low-Btu gas and the evaluation of Devonian shale as a hydrocarbon source are the responsibility of Mound Facility.

Mound Facility does not manufacture or assemble nuclear weapons. As part of the manufacturing program for explosive components, some of the components containing explosives in gram and sub-gram quantities are detonated for quality assurance. The high-explosive materials are not produced at Mound Facility but are purchased from the Army or other producers and are processed (i.e., purified and pressed) in small quantities only in manufacturing operations at Mound. All components are manufactured at Mound Facility under carefully controlled conditions. The manufactured products are shipped in sealed containers in safe configurations to other DOE-owned plants for further assembly operations.

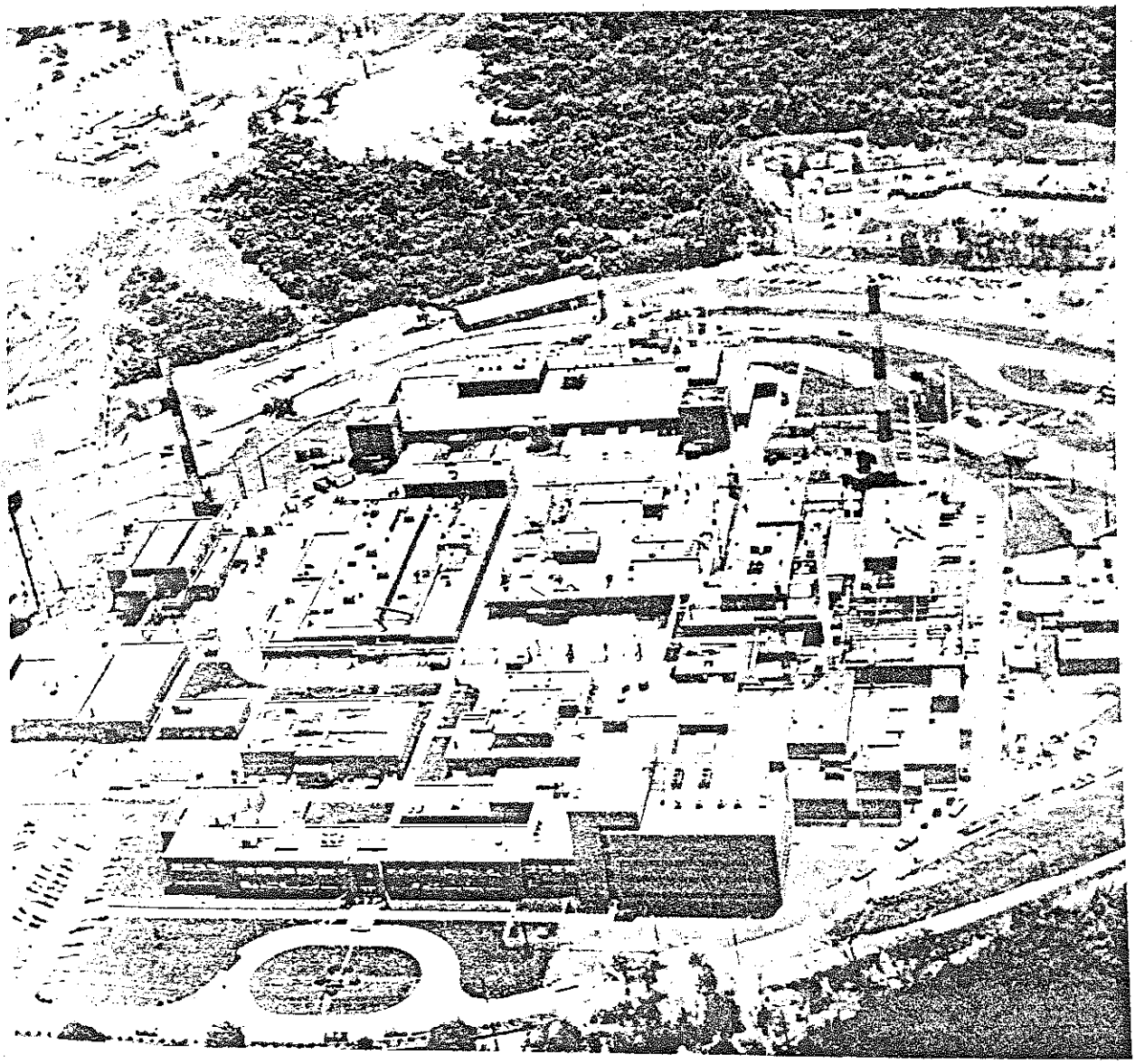


FIGURE 2-3 - Aerial View of Mound Facility Looking Toward the South.

period from 1950 to 1963, laboratory investigations involving uranium, protactinium-231, and plutonium-239 were conducted as part of the national civilian power reactor program. Separation of the stable isotopes of noble gases began in 1954.

In 1954 the thermoelectric generator fueled with polonium-210 was invented at Mound Facility. This invention utilized heat from the radioactive decay of polonium-210. The first Space Nuclear Auxiliary Power (SNAP) generator, SNAP-3A fueled with polonium-210, was demonstrated in 1959. The development of plutonium-238 heat sources was started at Mound Facility in 1961. Since that time, a large number of heat sources fueled with plutonium-238 have been developed and fabricated for use in thermoelectric generators and heat sources for lunar experiments, weather satellites, navigational satellites, and spacecraft. The SNAP-27 units left on the moon during the Apollo program and the satellite for the Jupiter Fly-by mission were powered by thermoelectric generators fueled with plutonium-238 heat sources built at the Facility. Power sources for the Mariner-Jupiter-Saturn mission were subsequently built. Other heat sources have been developed for use in life-support systems, swim suit heaters, artificial hearts, and cardiac pacemakers.

In 1957 Mound Facility began the development, production, and surveillance of detonators for military applications. Development of explosive timers in 1959 led to their manufacture starting in 1963. In 1962 the development and manufacture of ferroelectric transducers and firing sets (components which control initiation of detonators) were started. All these programs are continuing.

The first of several programs requiring tritium-handling technology was initiated in 1958. Today Mound Facility has an extensive capability directly applicable to the Controlled Thermonuclear Reactor program for handling and studying tritium and tritium compounds. A facility also exists for the recovery and purification of tritium from all types of wastes generated at DOE sites which handle tritium.

In the early 1970's, as national concerns about the environment and the conservation of resources mounted, Mound Facility expanded its comprehensive programs in environmental control, waste management, and energy conservation. Current research and development activities include several projects related to energy conversion systems. In January, 1975, Mound Facility formally came under the jurisdiction of the Energy Research and Development Administration upon dissolution of the Atomic Energy Commission. In October of 1977 Mound Facility was incorporated into the Department of Energy complex.

2.1.4 PLANT OPERATIONS

2.1.4.1 DEVELOPMENT, FABRICATION, AND SURVEILLANCE OF TRITIUM-CONTAINING COMPONENTS

Twenty years of experience with tritium and its compounds have been accumulated at Mound Facility. This experience includes the synthesis of tritiated compounds; fundamental studies of the behavior of these compounds; the characterization, processing, and subsequent encapsulation of tritiated materials; storage, surveillance, and testing of tritium or tritiated materials in hermetically sealed containers; and the recovery of tritium from various wastes. Technology developed over the years for the containment and handling of tritium to support these operations ensures the protection of the health and safety of employes and the surrounding community.

The surveillance operations involve destructive and nondestructive testing of encapsulated tritium to determine container reliability and overall safety. All such tests are conducted in hermetically sealed chambers.

Tritium recovered from various wastes generated at Mound Facility and other DOE sites is purified and concentrated by cryogenic adsorption and thermal diffusion technologies. Tritium is recovered from waste solids containing over 1.0 gram of tritium per 100 grams of waste.

At the present time, tritium is not recovered from waste liquids. Facility technology continues to minimize the quantities of liquids generated to maintain these liquids at the lowest volume practicable. These liquids are packaged as described in Section 3.7.1 for burial at DOE or approved commercial burial sites.

Waste gaseous effluents containing recoverable tritium are purified in the same fashion as the gas evolved from the reaction vessels used in the recovery of tritium from waste solids.

The stripped effluent (i.e., raffinate) containing an extremely small amount of tritium is exhausted to a recovery system which removes the tritium prior to release to the atmosphere.

Tritium Toxicity - The radiation hazard of tritium, a radioactive isotope of hydrogen, is relatively low. (2-1) It emits only "soft" beta particles with a maximum energy of approximately 18 keV and an average energy of 5.7 keV. Although the physical half-life of tritium is 12.3 years, (2-2) the biological half-life in the human body is short; depending on water consumption and elimination, it ranges from 6 to 12 days, with an average of 8.5 days. (2-3) Since no penetrating radiation is emitted by tritium, it presents no radiological hazard so long as it is prevented from entering the body. The primary consideration in controlling personnel exposures is thus the prevention of internal uptake.

The hazards associated with the radioactivity of tritium depend upon its form. In the undiluted elemental form, tritium is a gas and has an activity of about 2.60 curies per cubic centimeter at normal temperature and pressure. One gram of tritium in the elemental form has an activity of about 10,000 curies. Pure tritiated water, T_2O, has an activity of about 3000 curies per gram.

The hazard of internal uptake of elemental tritium is minimized by the fact that human absorption is less than 0.1% by the lung tissue and negligible through the skin. (2-4, 2-5) However, the oxides of tritium, HTO or T_2O, which are forms of water, are readily absorbed into the human body and become relatively uniformly distributed, with no preferential concentration throughout body fluids, within 90 minutes (References 2-4 through 2-8). Almost 100% of tritium water vapor entering the lungs at time of exposure is absorbed. (2-9)

Tritium in the oxide form is absorbed directly through intact skin, presumably by an exchange process with moisture in the skin. (2-10) The amount of tritium which appears in body fluids following chronic exposure to tritiated water vapor results almost equally from absorption through the total skin surface and through the lung tissue. (2-11) Therefore, protective measures for personnel working with tritium in any form emphasize the importance of controlling ingestion, inhalation, and absorption.

Tritium Environmental Control Systems - Air in laboratories, storage areas, and the ventilation exhaust stacks serving these areas is continuously monitored for tritium by ionization chambers which incorporate alarm systems. A "zone" concept for room monitoring systems is used so that a specific area in which a release has occurred can be immediately identified and isolated. Ionization-type monitors measure total airborne tritium, oxide and elemental form. Monitoring instruments are equipped with a loud Klaxon-type horn. These alarms, located in all areas in which radioactive materials are handled in quantities above a laboratory-bench level, have emergency power supplies that are automatically activated in case of a power failure so that the monitors are always in service. If the level of tritium in the area exceeds the monitoring level limit, the horn sounds and the area is immediately evacuated. An employe wearing appropriate protective clothing including respiratory protection and using monitoring instruments, and carrying a portable monitor re-enters the area, locates the cause of the increased concentration of tritium in the area, and immediately initiates corrective action. Laboratory personnel do not re-enter the area until corrective action has been taken and the airborne concentration has returned to permissible levels. To effect maximum environmental control, all tritium detected with ionization monitors is considered to be in the oxide form, the form most readily assimilated in biological systems.

To maintain control of tritium effluents, the zone concept is also utilized for monitoring stack effluents. The facility for tritium operations is served by four venti-

ation zones and exhaust stacks. Each of the four stacks is continuously monitored for total tritium and the composite value is used for reporting tritium effluents.

All work involving tritium is done under controlled conditions that assure containment and environmental control. The primary method of containment requires that tritium and its compounds be handled within a glovebox (an enclosure equipped with gloveports and fitted with low-permeability gloves so that operating personnel may perform their work without direct exposure of hands and arms to the tritium-contaminated atmosphere inside). Atmospheres within gloveboxes are automatically maintained at slightly less pressure than pressures in the laboratory rooms, and are equipped with alarms to indicate a control or pressure malfunction. Progressively negative pressures are maintained - building corridors, laboratories (work areas), and gloveboxes in that sequence with the gloveboxes maintained at the most negative pressure. All ventilation from corridors and laboratories is exhausted through stacks. Since the gloveboxes are on recirculatory drying systems, any venting is piped directly to the effluent removal system which removes all tritium from its inlet stream.

The most common type of glovebox unit in use has a recirculating inert atmosphere in which concentrations of air and water in the inert gas are kept at less than 100 ppm levels by means of a purifying system. A high-purity glovebox atmosphere is necessary to prevent the decomposition of exposed chemically reactive compounds and attendant release of tritium; the potential for tritium permeation through the gloves is consequently reduced and personnel exposures are also minimized. Viewing windows are provided in each glovebox so that operating personnel can see their work.

Fume hoods are also used in some areas to enclose supporting process equipment such as pumps and instrumentation in order to protect the work environment and personnel from potential leaks of tritium from the equipment. Fume hoods are also used to enclose passbox entry or exit ports to glovebox lines in order to reduce the potential for release of tritium to the work environment when materials are placed in or removed from gloveboxes.

An Effluent Removal System (ERS) removes tritium from the exhaust gases from glovebox systems before they are released to the atmosphere. These gases are passed first through desiccants and molecular sieves to remove water vapors and volatile organics from pump oils, then through an oxidizing medium to convert free tritium to tritium oxide, which is retained in another desiccant. Periodically the absorbers are regenerated, and the contaminated water and organic liquids are solidified in concrete and vermiculite, packaged in impermeable containers approved by the Department of Transportation (DOT), and shipped to burial grounds for radioactive waste.

Future Plans for Improvement of Tritium Monitoring - The present tritium monitoring system provides detection and alarm functions to control personnel radiation exposures well within radiation protection standards; however, present-day technology

opens several avenues of improvement which can enhance safety factors with respect t personnel exposure. A new, integrated automatic tritium monitoring system now in development will provide a more sensitive means of detecting warning levels and will be capable of measuring lower concentrations. Better control of radiation exposures will be realized in order to maintain radiation exposures at the lowest practical levels.

Tritium Control - Modifications of existing facilities resulted in a reduction of the total tritium (HTO and HT) effluent at Mound to 9000 curies (Ci) in 1975. Additional modifications in the process reduced the total gaseous tritium effluents from Mound to less than 6200 Ci for 1976 and less than 4900 Ci for 1977. In 1971, the AEC suggested to all its contractors an ultimate goal of limiting the effluent to 10% of the RCG as measured in the stack for both elemental tritium and tritium oxide. However, this degree of control poses problems that are beyond ready solution using current tritium processing technology. The objectives of monitoring and tritium control work now in progress are to develop technology and equipment to the point where control of tritium effluent concentrations to less than 10% of the present RCG can be assured and, further, to reduce total emissions to an "as-low-as-practicable" level. Work on systems for improved tritium control methods is currently proceeding. A new laboratory incorporating several experimental systems on a pilot scale is being used to develop and demonstrate technology and equipment.

2.1.4.2 DEVELOPMENT AND FABRICATION OF RADIOISOTOPIC HEAT SOURCES FUELED WITH PLUTONIUM-238

Plutonium-238 had been used in up to kilogram quantities in various research, development, and production operations. (A limited amount of research and development work with plutonium-239 has been conducted but only with gram quantities.)

The total quantity of plutonium-238 used in operations at Mound Facility was sharply reduced at the end of June 1977. The encapsulation of plutonium-238 for the components making up large heat sources containing in some cases over four kilograms of this material was terminated. At this time, plutonium-238 is handled in small quantities at Mound Facility to fabricate heat sources containing less than 20 grams each. As of the end of FY-79 (September 30, 1979), Mound Facility will no longer prepare the plutonium oxide feedstock for heat sources but will receive the material already in primary encapsulation.

Plutonium-238, a fissionable isotope (an isotope capable of sustaining a nuclear chain reaction), is essentially a pure alpha emitter with a half-life of 87.4 yr; however, low-energy gamma rays and x-rays are also emitted in about 1% of the disintegrations. The alpha particles are mainly in two energy groups, 5.49 MeV and 5.45 MeV. Plutonium-239, also fissionable, emits alpha particles with an average energy of 5.15 MeV and has a half-life of 24,390 yr.

urrent work with plutonium-238 is directed toward its use as the fuel in self-contained heat sources for aerospace and other applications. Current designs use plutonium-238 dioxide in a variety of forms, including microspheres and cermets of plutonium oxide compacted with molybdenum metal. By the end of June, 1977, Mound Facility had fabricated over 500 heat sources, ranging in thermal output from 0.13 to 2440 watts. The largest heat source produced approximately 2440 thermal watts for electric power generation aboard unmanned spacecraft. Other programs include heat sources for weapon systems, for the Cardiac Pacemaker Program, and for other applications in electric power generators.

No plutonium-238 scrap from the heat source fabrication operations is processed for recovery at Mound Facility. All recoverable waste is packaged in approved containers and shipped to another DOE site for recovery. Radioactive waste containing plutonium-238 in concentrations too low to be economically recoverable is packaged in approved containers and shipped to burial sites acceptable for transuranic wastes.

Because plutonium-238 is a toxic radioactive substance, processing facilities are quite sophisticated in terms of process control, compartmentalization, radiation shielding, material transfer techniques, and ventilation control. (2-12) Plutonium oxide is the principal form of both feed and product. The primary emphasis in the protection of laboratory workers from plutonium is to prevent inhalation of plutonium oxide particles.

Since metallic plutonium oxidizes rapidly, special fire protection measures are used in any operation involving plutonium metal. Dry nitrogen and inert gas atmospheres are used in the gloveboxes in which it is processed or studied. Extinguishing agents such as eutectic salts are kept ready for immediate use and constant vigilance is maintained to prevent any rapid oxidation and dispersal of plutonium into the working environment. (2-13, 2-14)

Plutonium Toxicity - Although plutonium, as a heavy metal element, is chemically toxic, its radioactivity is a greater health hazard. Once in the body, it is excreted extremely slowly and tends to concentrate in the liver and in bone structures. Evidence to date indicates that the chemistry of human assimilation of plutonium-238 is the same as for plutonium-239; however the dissolution and translocation of inhaled PuO_2 particles from the lung to other sensitive body organs is greater for plutonium-238 particles than for plutonium-239 particles. (2-15 - 2-17) The specific activity (the disintegration rate per unit weight) of plutonium-238 is about 275 times that of plutonium-239, and therefore more stringent requirements must be imposed in the design of process and containment systems to maintain the exposure of plutonium-238 workers to the lowest levels practical. Administrative controls to prevent internal uptake are necessarily very stringent.

The toxicology of plutonium has been given considerable attention through many animal studies conducted over the past several years (References 2-18 through 2-33). Actual

human experience through accidental internal deposition incidents during 30 years of plutonium production in AEC facilities has also been considered. To date no serious biological effects have been observed in a number of people who, as long as 25 years ago, accidentally inhaled quantities of plutonium several times the limit recommended by the National Committee on Radiation Protection (which was later adopted by the AEC as the radiation protection standard). (2-30 - 2-32)

To appreciate the need for the highly complex facilities, equipment, and processes utilized at Mound Facility and to understand the high degree of administrative control maintained over plutonium-238 operations, the reader should review the discussion on plutonium toxicity and impact analysis in Section 3.7.2 and Appendix D.

Plutonium-238 Environmental Control Systems - Operations in the locations where plutonium-238 oxide fuel forms are fabricated are conducted in gloveboxes and in remote-control, manipulator-operated boxes. Air pressures in work areas are controlled to promote containment of plutonium dioxide in the gloveboxes and to prevent the escape of any airborne particulates to the outside atmosphere. Progressively negative pressures are maintained in four zones - operating corridors, laboratories, access corridors, and gloveboxes in that sequence. The zones with the greatest contamination potential, the gloveboxes, are maintained at the most negative pressure. All ventilation air is passed through a minimum of two high efficiency particulate air (HEPA) filters prior to discharge through the stack to the atmosphere. These measures provide effective containment of plutonium dioxide particles which could potentially become airborne and respirable. Fixed air samplers and continuous air monitors are used throughout the work areas to detect airborne plutonium. The overall monitoring systems are designed to ensure that air effluents to the environment are monitored and measured as accurately as possible with current state-of-the-art technology. Emergency power is available for all ventilation, monitoring, and alarm systems.

Criticality could occur if a sufficient mass of fissionable material was brought together so that a self-initiating, uncontrolled chain of fission reactions results. However, such a criticality incident, if it should occur, would not be equivalent to an atomic explosion because the chain reaction does not continue, although considerable heat and nuclear radiation would be emitted. All areas where fissionable material, such as plutonium-238 oxide, is handled are monitored with criticality alarm systems. Stringent administrative control by the material accountability and control functions provides additional assurance that a nuclear criticality incident cannot occur.

Low-level liquid effluents from plutonium processing areas, including water generated from decontamination and laundry operations at levels of 200-2000 dis/min/ml, are transferred to the Waste Disposal facility (see Section 2.1.4.4) for treatment. Higher level liquid wastes from the processes themselves are collected and transferred onto an absorbent material contained within an approved 55-gallon drum package. These drums are then shipped to the DOE 20-year retrievable storage pad at Idaho National

Engineering Laboratory (INEL) in Idaho. The quantities of higher level waste are relatively small, averaging about 6000 liters/yr (1585 gal/yr).

Fixed automatic fire protection includes complete water sprinkler coverage and a Halon 1301 (bromotrifluoromethane) fire extinguishing system in each glovebox having an air atmosphere and in the transfer boxes. A 5% concentration of Halon 1301 in a glovebox will extinguish a fire within 10 seconds after the fire has been sensed by a thermal detector or after manual discharge by an operator. In addition, fire hose cabinets are located strategically throughout the work areas and fire hydrants are immediately outside. Signals from water flow alarms, pull-box alarms, and glovebox heat detector alarms are transmitted by the ADT system (an independent detection circuit installed by American District Telegraph Co.) to the continuously manned fire station and guard headquarters.

All filter banks for the exhaust air from plutonium-handling areas are protected by sprinklers and mist eliminators. Filter bank design criteria conform to DOE requirements and include the following components: (1) manual fire dampers for inlet and outlet sections; (2) heat detectors; (3) fog nozzles; (4) floor drains; (5) prefilters with moisture eliminators; (6) two banks of HEPA filters in series; and (7) access doors with wire glass viewing windows.

The integrity of all filter banks is routinely tested every six months. The testing technique is to generate a mist of dioctyl phthalate on the upstream side of the filter bank and to compare optically the concentration of the mist on the upstream side with that on the downstream side. Dioctyl phthalate is used in the mist generator since under the operating conditions, most of the particles generated are about 0.3 μm in diameter. If the testing reveals that the filtration efficiency is not 99.95% or better for particles in the size range, the filter banks are closely inspected and frame leaks are corrected or filters are changed depending on the cause of the leak. The efficiency for a filter in an air stream is based on the entrapment of 0.3 μm particles since this size is the most difficult to separate from an airstream.

The following essential support operations are associated with the processing of plutonium-238 fuels and the production of heat sources at Mound Facility:

- Analytical Operations
- Calorimetry
- Health Physics
- Material Control
- Metallography
- Nondestructive Evaluation
- Nuclear Material Accountability
- Nuclear Physics (Gamma Scanning and Neutron Spectrometry)
- Product Engineering
- Product Testing
- Quality Control
- Waste Management
- Weld Development

One support operation, Product Testing, is especially pertinent to this assessment since it is concerned with environmental testing of the integrity of capsules fueled

with plutonium-238. These tests are conducted in a separate building in sealed test cells equipped for shock, vibration, burial, pressure, and vacuum tests. The effects of severe dynamic environments on fueled heat sources are determined regularly.

2.1.4.3 SEPARATION AND PURIFICATION OF STABLE ISOTOPES AND SPECIAL RADIOISOTOPES

Nonradioactive isotopes of helium, neon, argon, krypton, and xenon are separated and purified in a separate building. The nonradioactive isotopes of carbon, nitrogen, and oxygen are separated by low-temperature distillation at Los Alamos Scientific Laboratory and shipped to Mound Facility for further processing. Enrichment of sulfur-34 (a nonradioactive isotope) in sulfur compounds is also performed. All these isotopes are distributed in the Stable Isotope Inventory Program to DOE facilities, other federal agencies, universities, commercial companies, and foreign users. Future products which will be added to the inventory include isotopes of chlorine and bromine. Some of these separation programs could be transferred to industry when there is economic justification.

Separation and purification processes include thermal diffusion, chemical exchange, cryogenic distillation, and gas and liquid chromatography. The separation and purification of the noble gases other than helium-3 present no health or environmental problems because these gases are nonradioactive and are chemically and biologically inert. In the case of helium-3, the feed gas is contaminated with traces ($\sim 10^{-4}$ mole %) of tritium and is therefore initially processed through a series of cryogenic adsorption systems where the tritium concentration is reduced to less than 10^{-6} mole %. Distillation is used to enrich the carbon-13 isotope in carbon monoxide. The process contains no radioactivity and its sole waste stream is a 90-liter/hr (24-gal/hr) discharge of depleted carbon monoxide through a flare pipe which extends 4.6 m (15 ft) above the roof of the processing building.

The enrichment of sulfur-34 is by chemical exchange between sulfur dioxide and aqueous sodium bisulfate in a series of five packed columns. The process produces a waste stream of sulfur dioxide which is discharged via the building exhaust system. The maximum quantity of sulfur dioxide discharged in any year is approximately 1350 kg (2980 lb) at a maximum concentration of approximately 35 ppm. This concentration is within EPA standards. The liquid waste stream containing sodium bisulfate is collected in a storage tank and disposed of by a commercial waste treatment firm.

Four radioisotopes - protactinium-231, thorium-230, thorium-229, and uranium-234 - are separated and purified in subgram quantities in another building and are then shipped to the Heavy Elements Pool at Oak Ridge National Laboratory.

Protactinium-231 and thorium-230 are separated from concentrated residues recovered from the processing of pitchblende ore. This work involves only gram quantities of the two isotopes.

Thorium-229, present as a daughter element in aged uranium-233, is separated from the uranium in milligram quantities. Since uranium-233 is fissile, that which is not in process is contained in special vessels which are stored in "bird cage" drums designed to maintain adequate separation from other fissile materials and locked in approved vaults. The process is limited to 100 g of uranium-233 at any time. Criticality limits cannot be approached.

Uranium-234, which is a decay product of aged plutonium-238, is separated from the plutonium in another chemical separation process. The preparation and purification involves only gram quantities of uranium-234 per year.

All ventilation effluents from the processes involving radioactive metallic elements are filtered through two high-efficiency filter systems before they are exhausted to the atmosphere. All liquid wastes are assayed to ensure that they are "low-level" with respect to radioactive content (typically less than 10^4 alpha dis/min/ml) before transfer to the waste treatment facility. Solid wastes are packaged in containers approved by the Department of Transportation for burial offsite at DOE or commercial burial sites.

2.1.4.4 TREATMENT OF RADIOACTIVE LIQUID AND SOLID WASTES

Treatment of radioactive liquid wastes primarily involves the processing of liquids containing plutonium-238. "Low-level" wastes are treated or packaged in the waste treatment building. "High specific activity" wastes are immobilized and packaged in the processing areas where they originate. The packaged wastes are shipped to offsite burial at the INEL 20-year retrievable storage pad in Idaho.

Liquid effluents containing low levels of plutonium-238 are received in the waste treatment building from the plutonium processing areas. The concentration of plutonium in low-level liquid wastes is typically less than 10^4 alpha dis/min/ml (i.e., less than 3.0×10^{-10} g/ml). This waste consists of cleaning solutions and wash water generated in areas where radioactive materials are handled and all water from the laundry where contaminated clothing is washed. Radioactive constituents in low-level wastes are removed by a flocculation/precipitation process, as indicated in Figure 2-4. This treatment will also separate other types of radioactive particulates.

High specific-activity liquid wastes containing plutonium in concentrations greater than 10^6 alpha dis/min/ml (i.e., greater than 3.0×10^{-8} g/ml) are usually process-related and generated in glovebox lines. These wastes are solidified and packaged without further treatment in the area where they originate, according to the simple scheme shown in Figure 2-5.

Low-level tritium liquid wastes consisting of cleaning solutions, mop water, and other wastes generated outside the gloveboxes are transferred to the waste treatment building

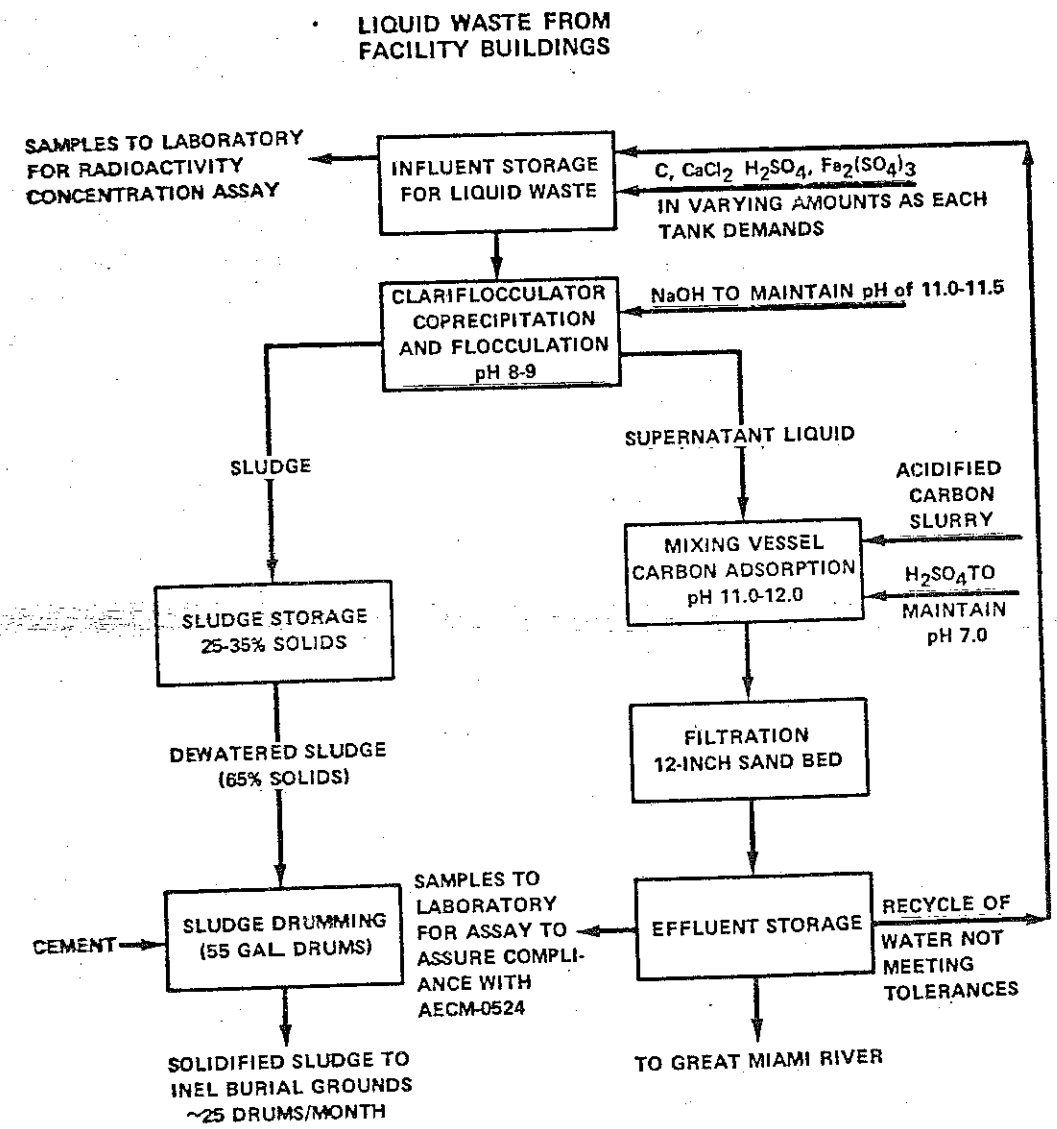


FIGURE 2-4 - Process Flow Diagram for Low Level Plutonium-238 Liquid Waste Disposal at Mound Facility.

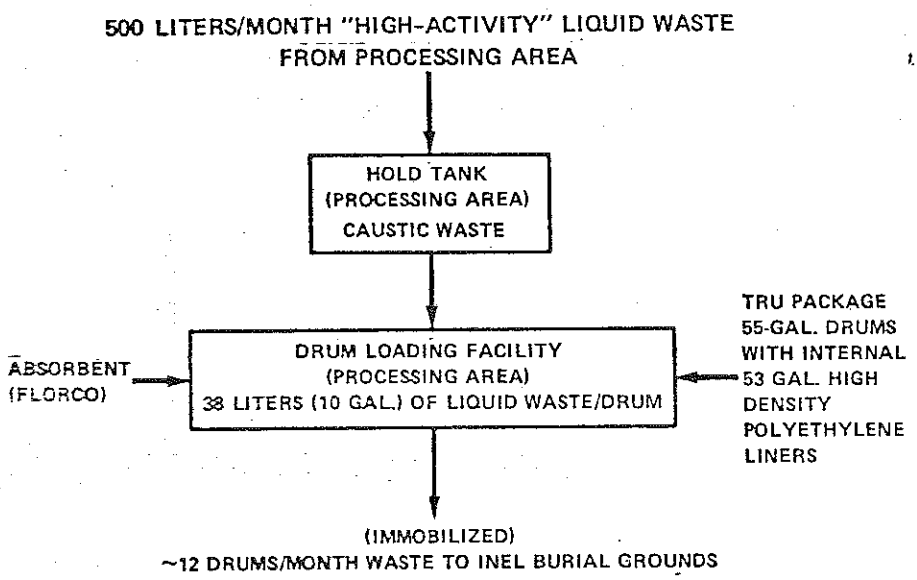


FIGURE 2-5 - Flow Diagram for Handling "High Activity" Plutonium-238 Liquid Waste at Mound Facility.

for solidification. These wastes contain tritium in microcuries per milliliter (μCi/ml) concentrations. Liquid wastes are drummed at the tritium facility and then trucked to the waste treatment building. There the liquids are solidified in a plaster absorbent mixture, packaged in DOT-approved, asphalt-coated containers, and shipped offsite for burial at another DOE site (Figure 2-6).

High specific-activity tritium liquid wastes, typically containing about one curie of tritium per milliliter, originate in tritium-handling gloveboxes or ancillary systems and include mainly aqueous condensates and pump oils. These wastes are solidified and packaged in a special facility in the tritium processing area. Aqueous wastes are solidified in a cement-plaster mixture, and oils are absorbed on vermiculite. As with low-level wastes, the high specific activity wastes are packaged in DOT-approved asphalt-coated containers and transported to another site for burial.

There is at present no permanent storage of radioactive waste materials at Mound Facility, and none is planned for the future.

There is a program to reduce the generation and volume of TRU (transuranic) contaminated solid waste. Since December 1974, Mound Facility has been operating a compactor to reduce the packaged volume of its LSA (low specific activity) TRU waste. More than 300 55-gallon drums have been compacted, resulting in an output of approximately 75 55-gallon drums of waste, a 4:1 volume reduction.

A formal program was implemented on July 1, 1974, to reduce the quantity of support materials introduced into gloveboxes where TRU contamination is possible. Specific actions implemented under this program include (1) unpacking of supplies and equipment in nonradiation areas; (2) timely radiation surveys of such materials introduced into contaminated areas to permit discarding as non-TRU; (3) storage of required supplies in controlled areas having very low potential for contamination; (4) thorough cleaning of gloveboxes prior to performing maintenance work; and (5) minimizing materials introduced into gloveboxes.

During CY-1975, Mound Facility developed a cyclone incinerator pilot plant and began cold testing this unit. In addition to its being used to develop parameters for the efficient volume reduction of Mound-generated LSA alpha wastes, the unit is also available to other DOE sites for use in developing a system to meet their individual needs. The design allows for incineration directly in a 55-gallon drum. The cyclonic effect achieved during burning allows for very efficient incineration of the waste, and the off-gas handling is designed to allow no radioactive contamination escape to the environment. The offgas from the pilot plant incinerator is processed through a spray tank, a high energy venturi scrubber, and a single stage HEPA filter before discharge to the building exhaust system which discharges to the environment through a filter bank using double HEPA filtration. Thus, besides the liquid scrubbing which removes about 95% of the particulates and virtually all the acid gases, the offgas goes through three stages of HEPA filtration.

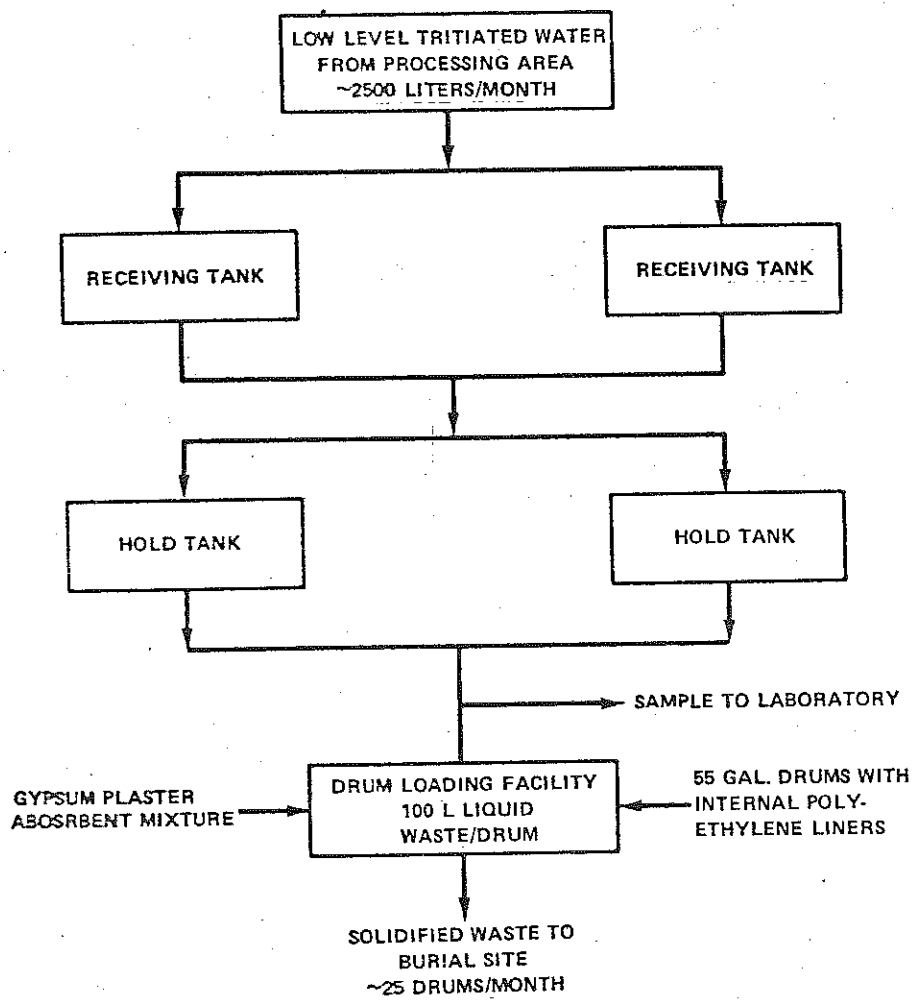


FIGURE 2-6 - Disposition of Low Level Tritiated Water at Mound Facility.

Although the incinerator is primarily a developmental unit and most of the developmental operations have been with nonradioactive simulated trash, all the LSA combustible TRU solid waste generated since December 1976 has been burned in the incinerator on an incidental basis. The stack effluent has been well under RCG (less than 8% of RCG). The volume reduction of waste to ash is approximately 20:1.

2.1.4.5 EXPLOSIVE MANUFACTURING, DEVELOPMENT AND SURVEILLANCE

Mound Facility is responsible for the development, manufacture, and surveillance of exploding bridgewire detonators. These detonators are installed in explosive timers, firing sets, and switches developed and manufactured at the Facility and shipped to other DOE production or design agencies for use in assembly of other nuclear weapon components and for use in testing programs. Detonators manufactured at Mound Facility have also been used in other systems - such as missile systems - which require rapid separation of assemblies.

No primary explosives, those which detonate when ignited, are used. Various high, or secondary explosives, such as PETN (pentaerythritol tetranitrate), PBX (plastic bonded explosives), and tetryl, are used in development and manufacturing programs. PETN is purified and recrystallized to develop desired physical properties. This processing is conducted in a building equipped with control facilities to ensure that all operations, including disposal of solvent, are not hazardous, and do not degrade the environment.

A plastic molding compound, diallyl phthalate, is formulated onsite for certain inert portions of explosive components. The formulation contains asbestos fibers as a filler material. The process facility is equipped to prevent dispersal of asbestos fibers and organic solvents to the environment.

One current program requires the use of small quantities of MOCA (methylene bis-2-chloroaniline) as an adhesive. Since MOCA is a suspected carcinogen (although not currently listed as such by the Federal Department of Labor), assembly operations are performed in hoods designed to prevent exposure. Workers are protected with special clothing and are monitored continually to ensure that they do not directly contact or inhale MOCA during its utilization. Air effluents from handling facilities are periodically sampled when work is in progress to determine if MOCA is being dispersed to the outside environment. To date, no concentration above the detection limit of 1.4 $\mu g/m^3$ in air has been found. At present there are no EPA standards for the airborne concentration of MOCA. There are no liquid effluents from these operations.

Components containing gram quantities of explosives are routinely tested onsite. Explosive materials are detonated in steel tanks designed to withstand ten times the maximum quantities tested. Exhaust gases from the test explosions are vented directly to the atmosphere and are quickly dispersed (see Section 3.6.4).

The development, manufacturing and surveillance functions involving explosive components are supported by the following technical functions:

- Analytical Chemistry
- Explosives Safety
- Industrial Engineering
- Industrial Hygiene
- Metallography
- Nondestructive Testing
- Product Engineering
- Quality Control
- Standards and Calibration

2.1.4.6 ACCIDENT PREVENTION AND EMERGENCY RESPONSE

Mound Facility has its own professional fire-fighting force on duty around-the-clock in a central fire station. In addition, emergency brigades located throughout the work areas provide immediate response to fires or other emergencies until the professional force arrives. The Miamisburg Fire Department, which is periodically trained at Mound Facility in special disciplines dealing with fires involving radioactive materials, is available to provide additional assistance if needed.

The industrial safety organization closely monitors the day-to-day safety efforts at the Facility and conducts formalized programs to identify and correct causes of accidents and near-accidents.

The industrial hygiene program provides special emphasis on the safe usage of toxic materials.

In the radiological safety program, the nuclear safety of all operations utilizing radioactive materials is monitored. Analytical support for this program is provided by in-house dosimetry and bioassay services. The Facility's capability includes a whole body counter which is used routinely to monitor for possible internal depositions of plutonium-238 in operating personnel.

A formal nuclear criticality safety program exists to ensure that safeguards and controls are incorporated into operations involving fissionable materials.

A comprehensive environmental monitoring program is conducted to detect and assess the impact that Facility operations with radioactive materials may have on the surrounding environment. This program also ensures effective performance of pollution control systems. Air, water, foodstuff, and soil samples are routinely collected out to a distance of 45 km (28 mi) around the Facility site and are analyzed for the specific radioisotopes handled at the Facility as well as nonradioactive pollutants. A detailed discussion of the environmental monitoring program is provided in Section 2.1.4.7.

The emergency preparedness program is described in more detail in Section 3.11.

A special decontamination facility is a part of the medical treatment facilities so that any injured person who is contaminated with radioactive material can be decontaminated. Arrangements have been made to place a contaminated patient requiring hospitalization in the Air Force Hospital at nearby Wright-Patterson Air Force Base which has the expertise and facilities to control the spread of contamination. This arrangement relieves other regional hospitals of any responsibility for this specialized service. To date this service has not been required.

2.1.4.7 ENVIRONMENTAL MONITORING

A comprehensive Environmental Control Program has been in continuous operation since work began at the Facility in 1949. Objectives of this program are the maximum practical containment of radioactive and other toxic materials, effective management of all solid wastes, and control of radioactive and nonradioactive effluents disharged to the environment to the lowest practical levels within existing or proposed discharge and environmental standards. (2-34, 2-35)

Monitoring activities include the collection of air, water, foodstuff, soil, and silt samples out to a distance of 45 km (28 mi) around the Facility. Samples are analyzed for potentially toxic pollutants including specific radioisotopes handled at this facility. Data obtained by the environmental monitoring program are used to ensure that operations at Mound Facility are conducted so that emissions comply with all applicable emission and environmental standards and to provide a local background or baseline for comparison in the event of an accidental release. The environmental monitoring program provides an alert system to take appropriate corrective actions. Results of this program are discussed in Section 3.

A comprehensive, unclassified environmental monitoring report is issued annually. (2-36) Also, a summary report is distributed to individuals in political and administrative positions within the general area. An annual pollution inventory is conducted of the amounts of radioactive and nonradioactive substances which are discharged to the environment. A report of this survey is submitted to DOE (see Table 3-2).

Air Monitoring - Continuous monitoring is provided for all stacks from facilities in which radioactive materials are processed. Monitors are fitted with alarm systems which are actuated if any discharge concentration exceeds the preset monitor level. Operations, health physics, and environmental control personnel respond to such alarms to apply corrective action and to maintain the effluent within control standards. Fixed-position, constant-flow, continuous samplers are also used to monitor air discharges; data obtained from these samplers provide a historical record of stack discharges.

Onsite open burning of small quantities of solid wastes contaminated with high explosives is carried out in a special isolated burning ground according to U. S. Army

Materiel Command Regulations 385-100 (Army Ordnance Manual). This small-scale burning is necessary for safe disposal of explosive wastes and is conducted with the knowledge and concurrence of the Ohio EPA and Montgomery County Combined General Health District.

Since a comprehensive recycling program was instituted early in 1974, there has been no onsite incineration of solid wastes such as paper and wood.

An offsite network of continuous air sampling stations measures the effectiveness of Facility systems controlling airborne emissions. This network was established by Mound Facility in conjunction with Montgomery County Combined General Health District. Data obtained from the air samplers are shared by the two organizations. The sampling sites were located on the basis of an atmospheric diffusion model developed from historical wind patterns by the MRC Dayton Laboratory for the geographical area. (2-37)

The offsite air sampling network consists of 14 continuously operating air sampling stations for tritium and plutonium-238 with 1 air sampler for plutonium-238 only. Nine sampling stations are located within a 3.2-km (2-mi) radius of the Facility. The samplers currently in operation sample at critical distances and directions based on the diffusion model developed for Mound Facility. The sampling sites are shown in Figure 2-7.

Water Monitoring - Water sampling locations along the bank of the Great Miami River were selected according to guidelines proposed by the Federal Environmental Protection Agency. (2-38) Water samples are collected daily at the five river sampling locations shown in Figure 2-8 and are subjected to specific analyses for radioactive pollutants pertinent to Mound Facility.

The incremental levels of nonradioactive pollutants in the Great Miami River resulting from Mound Facility's liquid waste effluent cannot be measured in the River itself because of the relatively high concentration of these pollutants already in the River as a consequence of the highly urbanized and industrialized areas which are upstream from the Facility to the north. However, the two effluent streams leaving the Facility are analyzed for various water quality parameters. Mound's low pollutant level discharges have little influence on the Great Miami River. Composite proportional samples are collected daily from each of the two effluent streams and are examined directly for some of the parameters and composited further for the analysis for plutonium.

Eight surface water locations, such as ponds and streams, are sampled quarterly. These locations are shown in Figure 2-8. Various public and private water supplies are monitored on a regular basis. Twelve municipal water supplies in the area are sampled and analyzed at least annually for tritium. All three Mound Facility wells are assayed monthly for tritium and for nonradioactive parameters such as dissolved solids and chlorides, quarterly for plutonium, and semiannually for heavy metals.

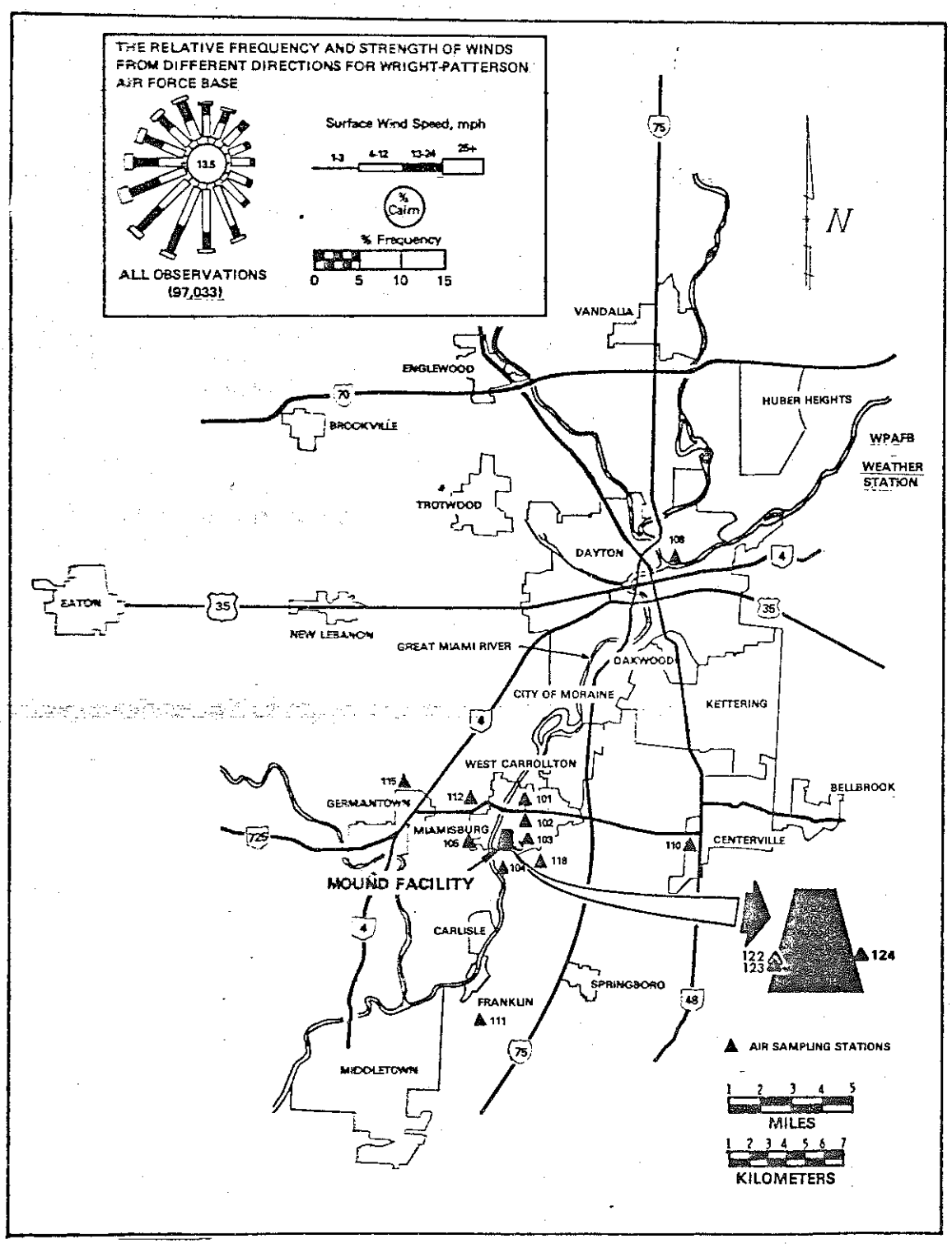


FIGURE 2-7 - Offsite Air Sampling Locations.

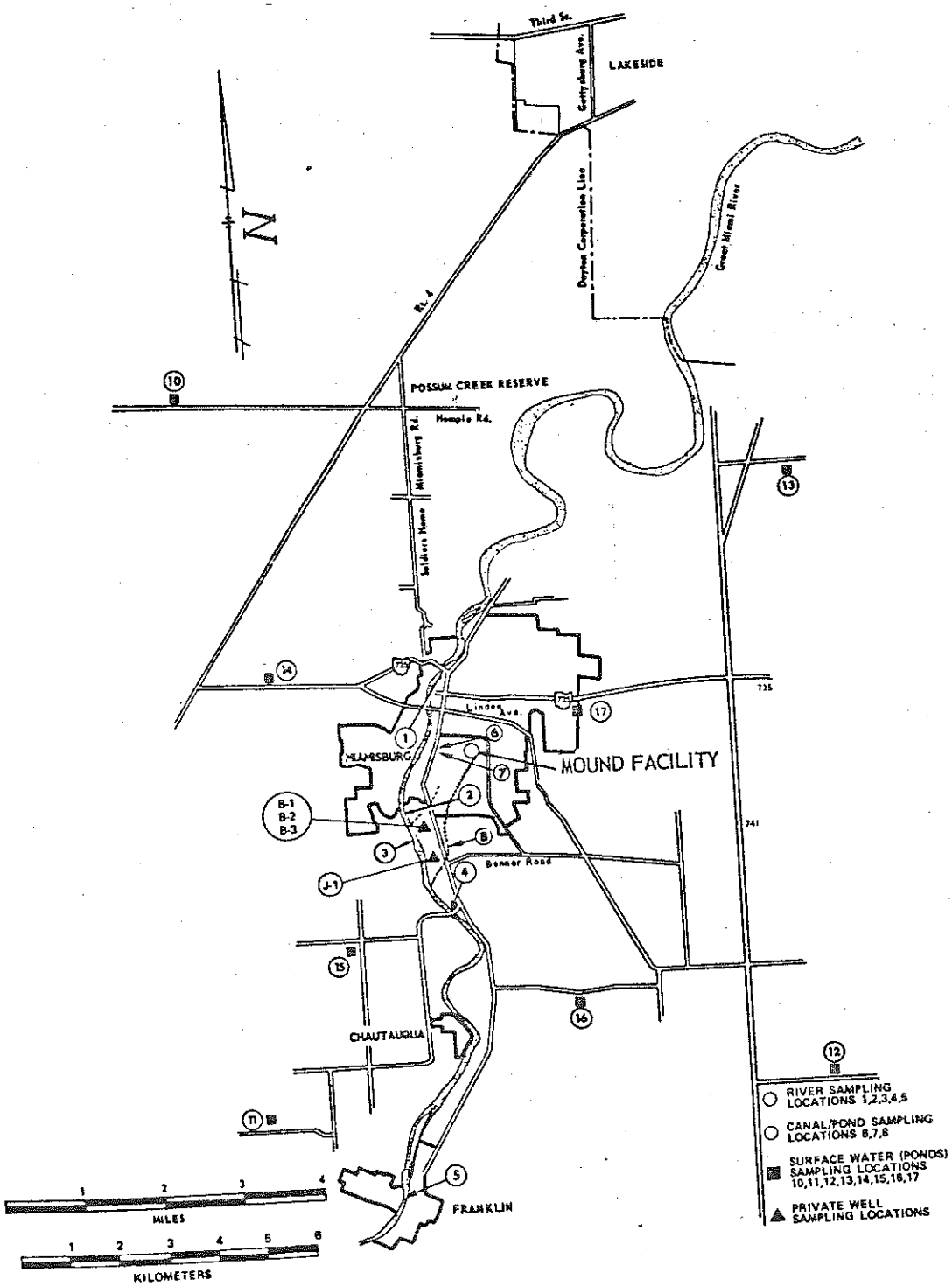


FIGURE 2-8 - Offsite Water and Silt Sampling Locations.

Food and Vegetation Monitoring - Various locally grown foodstuffs and vegetation samples are collected from the surrounding area to determine whether there is uptake and concentration of tritium and plutonium-238 in foodstuffs and vegetation. Where possible, sampling sites are chosen at maximum deposition locations predicted on the basis of the atmospheric diffusion model developed for Mound Facility. Milk is collected from individual farms closest to the Facility. Aquatic life for analysis is trapped from the Miami River both upstream and downstream from the Facility.

Soil Monitoring - The soil monitoring program includes two types of soil sampling. One is the sampling of undisturbed surface soil to evaluate concentrations of resuspendable plutonium-238 oxide, which potentially could be inhaled. Surface scrapings from a depth of approximately 0.3 cm (1/8 in.) are collected and analyzed from both onsite and offsite locations.

A second type of sampling is the core samples which are collected to document total accumulation and distribution of plutonium-238 oxide offsite and to verify the atmospheric diffusion model. Core samples approximately 8.9 cm (3.5 in.) in diameter and 30.5 cm (12 in.) deep are collected in each quadrant within a 32 km (20 mi) radius around the Facility. Additional core samples for background control data are taken out to a distance of 51 km (32 mi).

2.2 CONTINUING AND ANTICIPATED BENEFITS

2.2.1 NATIONAL DEFENSE

Mound Facility produces and conducts surveillance on components for nuclear weapons involving explosives and nuclear materials (but never containing both in the same component). The finished components are subsequently shipped to other DOE facilities. A need for the work performed at Mound Facility will remain as long as the United States has need for an up-to-date nuclear stockpile.

2.2.2. OTHER BENEFITS

Technological - Mound Facility develops and fabricates heat sources fueled with radioactive materials. Plutonium-238 heat sources have been used in power generators for the space program for scientific instrumentation on the lunar surface and on space probes, for terrestrial and marine applications, and for life sciences devices such as cardiac pacemakers. The basic development for the majority of the ultrasensitive calorimeters manufactured today was done at Mound Facility. Mound provides stable (nonradioactive) isotopes of the noble gases, carbon, oxygen, nitrogen, and sulfur for use in scientific research throughout the free world. A program initiated during CY-1974 is directed toward the development of fuel systems for controlled thermonuclear

[illegible] projects. Mound Facility is a recognized source of technology in the safe [illegible] of tritium.

[illegible] - Mound Facility as the largest employer in the City of Miamisburg during [illegible] an average employment of 1730 individuals, 1706 employed by Monsanto [illegible] Corporation and 24 by the Dayton Area Office of DOE. The payroll, including [illegible] fringe benefits, such as FICA, health and accident insurance and pension plans, [illegible] to $40,764,000; materials, supplies and services, including utilities, all [illegible] purchased locally cost $17,066,000; and construction operations cost $1,697,000 [illegible] this period. Nearly 17% of the employes live in the Miamisburg postal zone and [illegible] the immediately adjacent zones. Under the Impacted Schools program of the HEW, [illegible] school systems receive federal financial assistance in excess of $1,000,000 a year, [illegible] the "federally connected pupils" in relation to Mound Facility.

[illegible] - Mound Facility as an equal opportunity employer has continued to make [illegible] progress in the employment and professional development of minorities and [illegible]. Many Mound employes participate in local government and civic affairs and [illegible] community activities such as United Appeal, Junior Achievement, Scouting and [illegible] organizations, service clubs, public schools, and churches.

[illegible] CHARACTERIZATION OF EXISTING ENVIRONMENT

[illegible] GENERAL DESCRIPTION AND DEMOGRAPHY

Mound Facility is located within the southern city limits of Miamisburg in Montgomery County, Ohio, an extensively urbanized county dominated by the Dayton metropolitan area. The Facility is situated about 16 km (10 mi) south-southwest of the Dayton city [illegible]

The northern boundary of the site is approximately 0.2 km (0.13 mi) south of Mound [illegible] in Miamisburg. Mound Avenue curves south, becomes Mound Road and runs south-[illegible] the eastern boundary of the site. The southern boundary of the site lies [illegible] to an undeveloped 514,000-m^2 (127-acre) open space area. Tracks of the Penn [illegible] Railroad roughly parallel the western boundary at distances ranging from [illegible] 15 to 60 m (50 to 200 ft). The Great Miami River flows 460 to 600 m [illegible] to 2000 ft) west of the site. Figure 2-9 illustrates the general plan of the [illegible] i.e., boundaries, topography, and land utilization.

[illegible] Population Distribution - The 1970 population of Miamisburg was 14,797. The dis-[illegible] within city limits is shown in Figure 2-10. The Miamisburg Planning Board [illegible] Miamisburg population totals of 17,000 and 19,000 for 1975 and 1980, respec-[illegible] The resident population in the vicinity of Mound's plutonium and tritium [illegible] buildings is presented in Table 2-1.

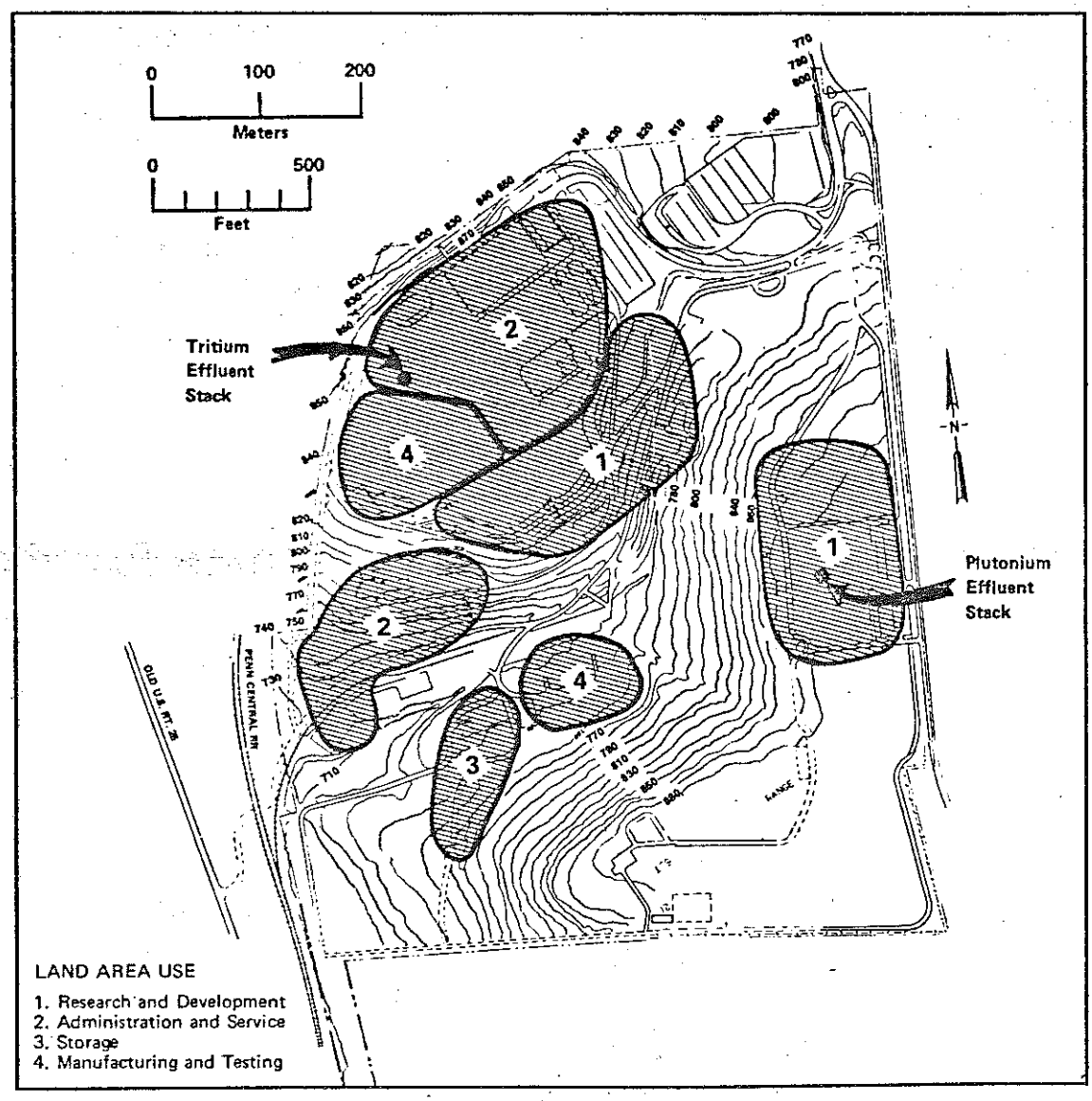


FIGURE 2-9 - Mound Facility Site Plan and Land Utilization.

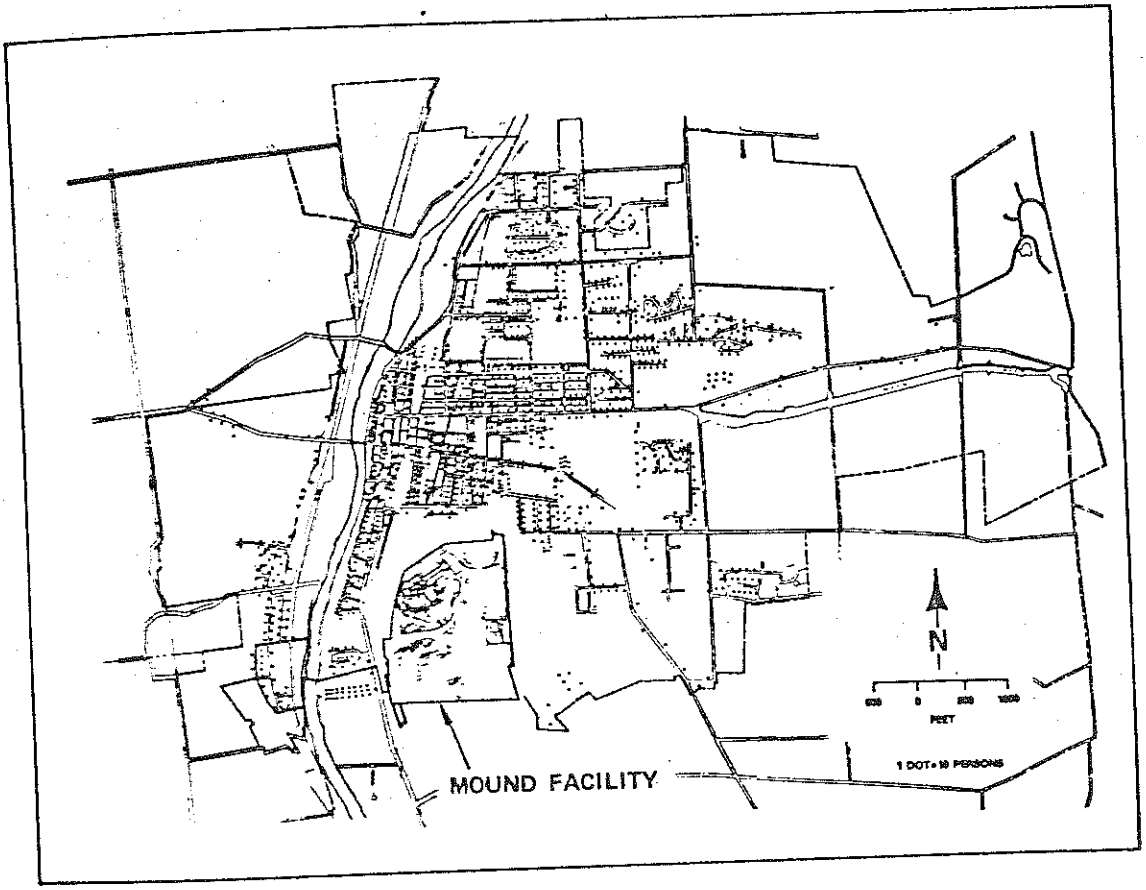


FIGURE 2-10 - Population Distribution of Miamisburg, Ohio (1970).

Table 2-1
PROJECTIONS OF POPULATION WITHIN TEN MILES OF MOUND FACILITY

Range (miles)	Actual 1970	Projection to: 1980	1990	2000	2010	2020
0-2	11,800	14,000	16,900	20,500	23,100	24,600
0-3	27,400	32,900	39,500	46,600	52,300	55,200
0-4	40,000	48,400	58,200	68,100	76,600	81,200
0-5	62,600	76,700	93,300	107,300	120,000	128,300
0-10	321,000	398,300	477,100	550,800	615,100	662,200
0-20	895,900	1,125,800	1,377,200	1,564,300	1,752,900	1,877,100
0-50	2,778,400	3,358,900	3,916,000	4,348,400	4,710,400	5,078,800

In 1970, the total population within a 3.2-km (2-mi) radius of the Facility was approximately 12,000 and a 16-km (10-mi) radius encompassed a total of 321,000 persons. Based on census data and estimated growth rates in 1970, projections of population changes for succeeding decades indicate that the regional population will approximately double in the next 50 yr. Estimated distributions are shown in Table 2-1. Most of the population increase will be along the corridor between Dayton and Cincinnati. The estimated population distribution within an 0.8 km (0.5 mi) and 1.6 km (1.0 mi) radius of Mound Facility, using the tritium and plutonium effluent stacks as points of reference, is presented in Table 2-2. Stack locations are shown on Figure 2-9. From studies made in 1972, it was projected that the total population in six counties surrounding the Facility will register an increase of approximately 300,000 from 1970 to 1980:

1970 - 1,110,600
1975 - 1,246,800
1980 - 1,404,600

Individual county projections are shown in Figure 2-11.

Transient Populations - There is no large seasonal variation in population for the local area surrounding Mound Facility. There are no major parks, major landmarks, or tourist attractions that draw a significant seasonal transient population to the area. Daily variations in the population do occur on the site and in the immediate Miamisburg area. There are approximately 1670 employes at the Facility from 7:00 AM to 5:00 PM during the 5-day work week. Most of these employes are concentrated in the northwest area. Approximately 100 employes work on Saturdays and 25 on Sundays and at night.

Local Traffic - Periods of the heaviest vehicular traffic on and immediately adjacent to the site occur between 7:00 and 8:00 AM and between 4:00 and 5:00 PM. The heaviest volumes of local Miamisburg traffic are concentrated on three thoroughfares: (1) The Dayton-Cincinnati Pike, 0.6 km (0.4 mi) west of Mound Facility; (2) State Route 725, 1.4 km (0.9 mi) to the north; and (3) Interstate 75, 5 km (3 mi) to the

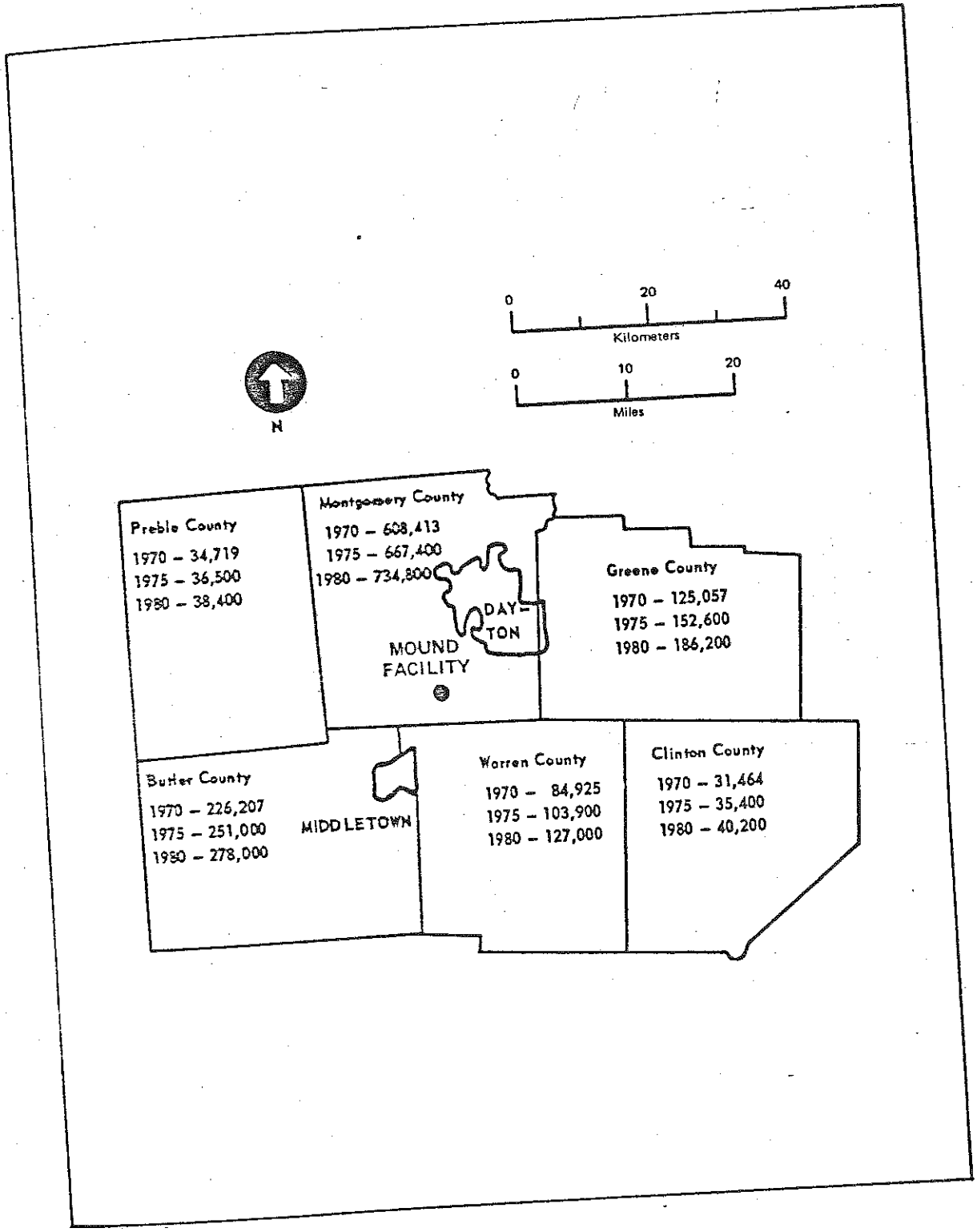


FIGURE 2-11 - The Numbers Show the Respective County Populations (1970) and As Projected.

Table 2-2

RESIDENT POPULATION IN VICINITY OF PLUTONIUM AND TRITIUM OPERATIONS BUILDINGS*

	Resident Population			
	Plutonium Building Stack Area		Tritium Building Stack Area	
Sector	<0.8 km (0.5 mi) Radius	<1.6 km (1 mi) Radius	<0.8 km (0.5 mi) Radius	<1.6 km (1 mi) Radius
North	12	642	130	391
NNE	91	432	106	845
NE	42	297	12	403
ENE	97	512	0	509
East	61	358	0	261
ESE	30	281	0	215
SE	55	58	0	55
SSE	27	33	0	6
South	3	6	0	73
SSW	0	27	167	397
SW	0	230	155	328
WSW	0	409	39	378
West	0	445	76	334
WNW	0	203	58	197
NW	0	145	67	100
NNW	9	349	130	385
Total Population	427	4427	940	4877

*The resident population within 1.6 km (1 mi) of Mound Facility is estimated on the basis of the number of residences in each sector. The most recent aerial photograph (July 1976) of Mound Facility and its adjacent areas was used to prepare these estimates.

east. Comparative traffic volumes measured on these roads and the other local Miamisburg roads indicate that primary traffic flows enter or leave Miamisburg and the Dayton metropolitan area and are associated with the employment of local residents. In a normal working day, it is likely that the highest concentrations of population surrounding Mound Facility will occur during nonworking hours.

Use of Adjacent Lands and Waters - The present land use configuration for a two-county (Warren and Montgomery) 8-km (5-mi) radial area surrounding Mound Facility is based upon field surveys, topographical map examinations, and land use data supplied by the Miami Valley Regional Planning Authority. The land use in Warren and Montgomery Counties is summarized in Table 2-3.

Table 2-3

PRESENT LAND USE WITHIN MONTGOMERY AND WARREN COUNTIES

Land Use	Montgomery County	Warren County
Residential		
Acreage	47,200	23,628
% of Total Land	16	9
Commercial		
Acreage	4,100	5,481
% of Total Land	1	2
Industrial		
Acreage	5,900	274
% of Total Land	2	1
Other Developed Land		
Acreage	21,904	10,735
% of Total Land	7	4
Agricultural and Vacant		
Acreage	216,946	221,370
% of Total Land	74	84
Total Acreage	296,050	261,488

Miamisburg is mostly a residential community, with some supportive commercial facilities and limited industrial development. Most of the residential, commercial, and industrial development within an 8-km (5-mi) radius of the site is concentrated on the Great Miami River flood plain. The adjacent upland areas are primarily used for residences and agriculture or are unused open spaces. Most of the residential development on the upland areas is relatively new in comparison to development on the flood plain. It is likely that most future development in the area will occur on the upland areas. Use of land in Miamisburg is shown in Figure 2-12 and the projected use of land is shown in Figure 2-13.

Miamisburg has 13 parks and four playgrounds. Mound Golf Course and Miamisburg Mound State Memorial Park, directly east of the Facility across Mound Road, are heavily used during favorable weather. The park is the site of a 21-m (68-ft) high ancient Indian mound which is located 120 m (380 ft) east-southeast of the Facility boundary. Within 1.6 km (1 mi) of the Facility, other recreational areas extensively used in summer include the municipal swimming pool, Harmon Athletic Field, and Library Park.

There are no large lakes within an 8-km (5-mi) radius of the site. Several fishing ponds are located 5.6 km (3.5 mi) north-northeast of the Facility in inactive gravel pits. Some vestiges of the old Miami-Erie Canal lie between the Penn Central Railroad and the Dayton-Cincinnati Pike to the west of the Facility site. The City of Miamisburg has maintained two very small recreation ponds in a small park in this area also. During 1978, Miamisburg converted one of the small ponds into a solar pond to heat

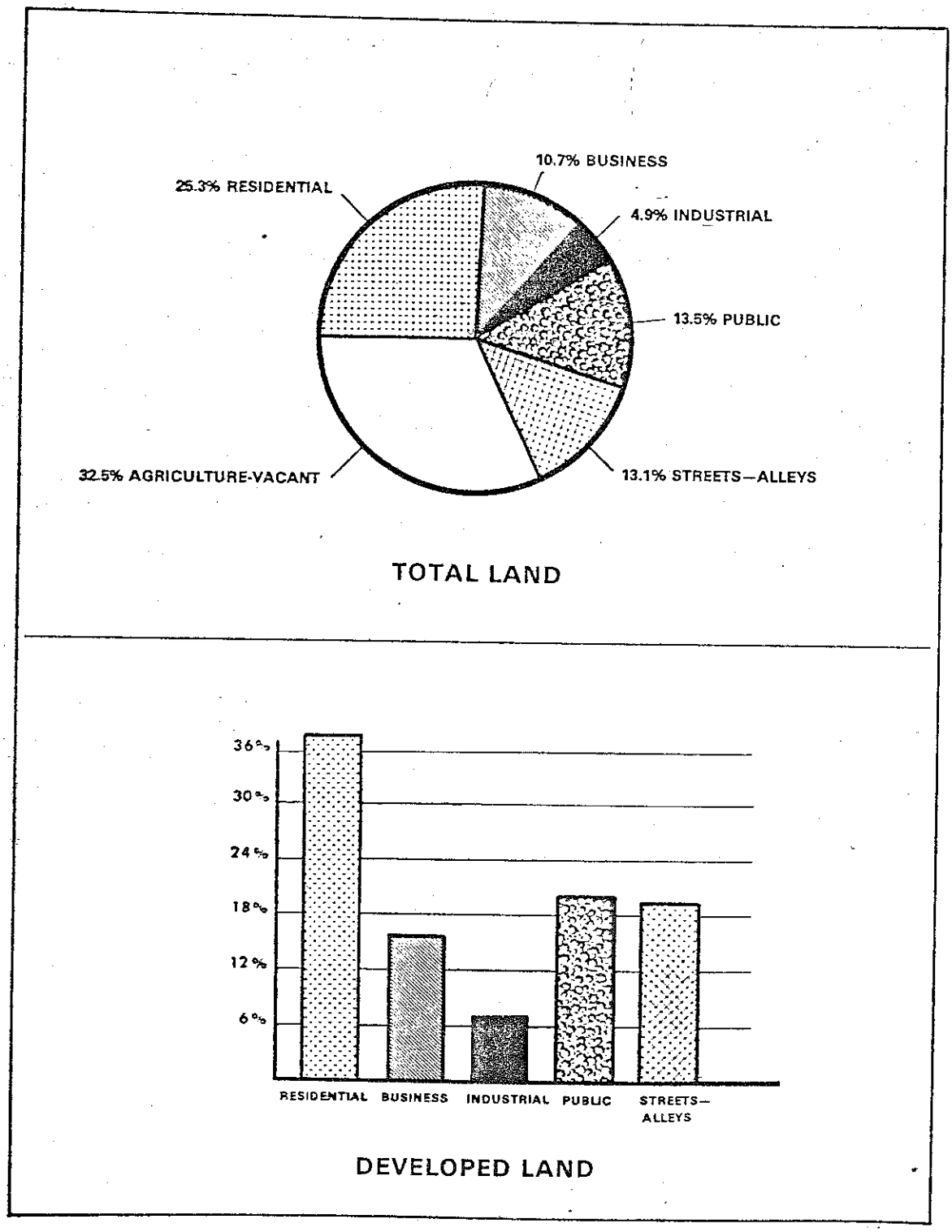


FIGURE 2-12 - Use of Land in Miamisburg.

(Reprinted from the Miamisburg Comprehensive Development Plan, 1968)

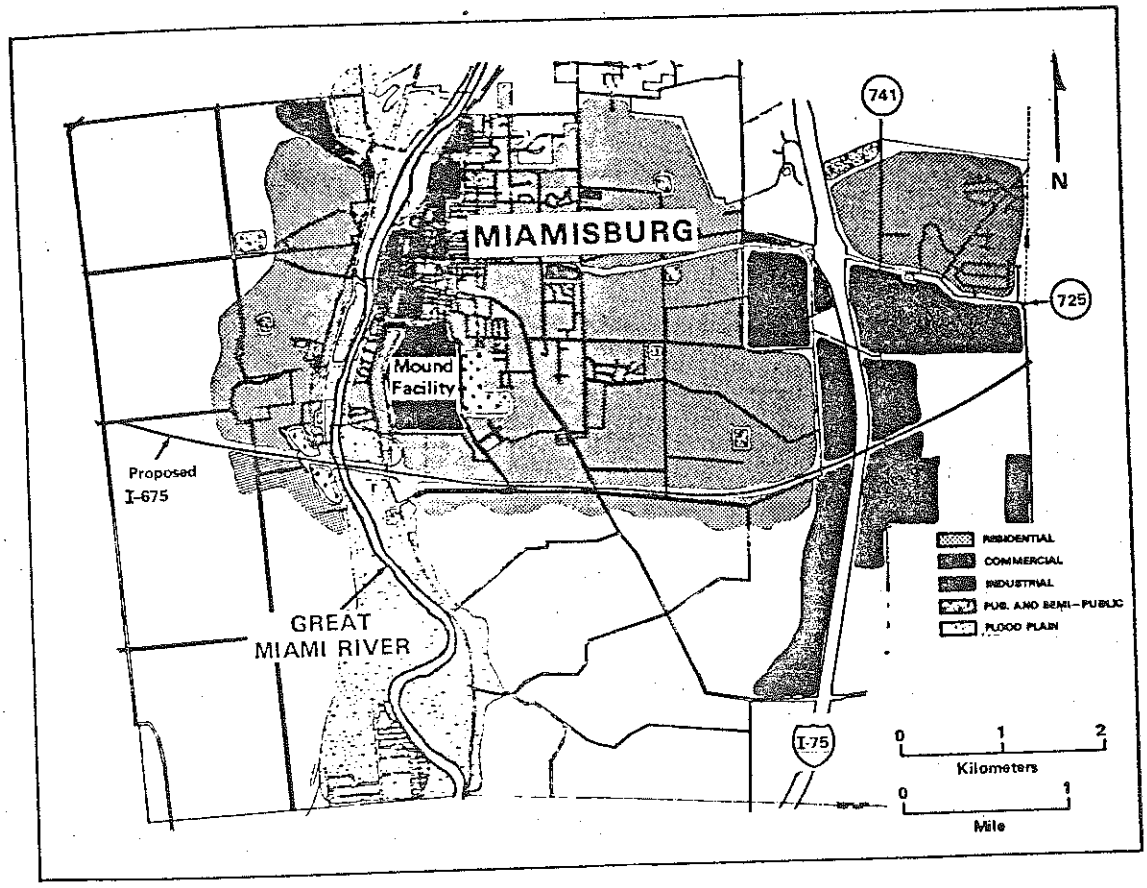


FIGURE 2-13 - Land use Projection for Miamisburg. (Reprinted from the Miamisburg Comprehensive Development Plan, 1968)

water for the municipal swimming pool. The City plans to expand this park area along the west boundary of the site.

The major water body in the vicinity of the plant site is the Great Miami River. It is approximately 46 to 60 m (150 to 200 ft) wide in this area. There is no commercial barge traffic or commercial fishing, but some pleasure boating and sport fishing do occur, primarily during the summer.

Agricultural land within an 8-km (5-mi) radial area around the Facility is primarily used for corn and soybean production and for livestock grazing. In 1970, 74% of Montgomery County was listed as agricultural or vacant land and 84% of Warren County was similarly classified. Table 2-4 indicates the principal food crops grown, the acreage devoted to their production, and the relative yield per acre. The nearest land to Mound Facility capable of supporting dairy cows is the Marjorie S. Penrod property situated adjacent to the southern boundary of Mound Facility. A small number of feeder cows currently graze on the Penrod property.

2.3.2 HISTORIC AND NATIONAL LANDMARKS

The only historic landmark in the vicinity of Mound Facility is the Miamisburg Mound, an ancient Indian mound located 120 m (380 ft) east-southeast of the Facility site in Miamisburg Mound State Memorial Park. The mound, a symmetrical conical earthwork 21 m (68 ft) high and 240 m (800 ft) in perimeter, is one of the largest of its type. It is believed to be the sepulcher of a chief of the Adena culture of Mound Builders which inhabited the Ohio region as early as 800 B.C.

Table 2-4

ACREAGE AND YIELD OF PRINCIPAL FOOD CROPS
FOR MONTGOMERY AND WARREN COUNTIES

County	Food Crop	Acreage	Yield (bushels/acre)
Montgomery	Soybeans	22,900	35
	Corn	40,500	83
	Wheat	10,500	45
	Oats	2,200	49
	All hay	11,400	1.6 (tons/acre)
Warren	Soybeans	25,000	31
	Corn	31,800	80
	Wheat	6,500	41
	Oats	1,700	47
	All hay	15,800	1.6 (tons/acre)

3.3 GEOLOGY

Regional Geology - Many different environments have existed in southwest Ohio throughout geologic history. Today the land is characterized by gently rolling till plains, where once there existed great thicknesses of ice or shallow transgressing seas. During the Quaternary time of the most recent era, the Cenozoic, numerous glaciers progressed and retreated through the area, causing massive surface changes. The Miamisburg region was last altered by the final glacial system, the Wisconsin ice sheet.

Miamisburg is located on the eastern portion of the Indiana-Ohio platform which is included in the Central Stable Province. This platform (also known as the "Cincinnati Arch") is a nearly flat structural element occupying eastern Indiana and Western Ohio for a width of 160 to 320 km (100 to 200 mi). It is a stable platform bounded by the Illinois Basin on the west, the Michigan Basin on the north, the Appalachian Basin on the east, and the Kentucky River Fault Zone on the south. The three surrounding basins are separated from one another by poorly defined structural arches - the Kankakee Arch between the Illinois Basin and the Michigan Basin, and the Findlay Arch between the Michigan Basin and the Appalachian Basin. These arches are occupied by several fault zones, monoclines (a type of fold), and structural sags.

The closest structural province adjacent to the position of Mound Facility on the Indiana-Ohio platform is the Appalachian Basin. The junction of these two structural elements is marked by a "hingeline" which trends north-south approximately 80 km (50 mi) east of the site. Deep-seated faulting in certain areas of the hingeline has been postulated, but there is no reason to assume that faults exist beyond the immediate vicinity of this junction. Hingeline faults have been discovered at the junction of the Illinois basin but not at the boundaries of the Michigan Basin.

The southern boundary of the Indiana-Ohio platform is the "38 parallel fault zone" which includes the Rough Creek Fault Zone in southern Illinois and the Kentucky River Fault Zone in Kentucky and West Virginia. The Maysville Fault, which extends from the Kentucky River Fault Zone north to the Ohio River near Adams County, Ohio, about 110 km (70 mi) from the Facility, is the closest defined fault system.

Regional Gravity Anomalies - Gravity anomaly maps published for the state (Heiskanen and Uotila, 1956) indicate that the entire state and the Facility site are in nearly perfect isostatic equilibrium. Five major anomalies have been detected throughout the state, but it is believed these are due to density contrasts in basement rocks and are not primarily related to structural factors or to composition of overlying strata.

Contrasts in composition of basement rocks can also be detected by aeromagnetic measurements. While most sedimentary rock is practically nonmagnetic, most igneous rock

and some metamorphic rocks contain appreciable quantities of ferromagnetic minerals which influence the earth's magnetic field. An aeromagnetic map of the Dayton-Columbus area which includes the site in the lower portion is presented in Figure 2-14. It was developed from a survey conducted in 1960 at a nominal height of 150 m (500 ft) above the ground surface. Two distinct features are evident. The western half of the map, including the Facility site, shows an area of relatively mild magnetic gradients; this zone is believed to represent the older granitic rocks of the Central Province. A zone of high aeromagnetic gradients on the east side of the map is believed to represent igneous and metamorphic formations associated with the southern extension of the Grenville Province of eastern Canada. It follows from these interpretations that Mound Facility is located over granitic basement rocks of the Central Province and is about 30 km (18 mi) west of the closest outlier of the Grenville Province. The map also shows that there is a strong positive magnetic anomaly about 24 km (15 mi) south-southeast of Anna, Ohio, which is the closest active seismic area to the Facility. Earthquake epicenters near the Anna area are in close coincidence with this magnetic high, which suggests a possible relationship to the anomaly.

Geothermal Gradients - A short distance below the surface of the ground [perhaps 3 to 6 m (10 or 20 ft)] temperatures in the subsurface are usually equal to the mean annual temperature at the ground surface. In the vicinity of Mound Facility, rock and soil below the ground surface are at a constant temperature of about 12°C (54°F).

Within the earth's crust, temperature increases at a fairly constant rate with increasing depth. The geothermal gradient for a specific area is the rate at which the temperature increases with depth. A low geothermal gradient is usually indicative of an area in which no deformation or igneous activity has occurred for a geologically long time. Areas having a high geothermal gradient are usually associated with geologically recent tectonic or igneous activity. These relationships are general because of the many independent factors which contribute to heat generation and heat flow in rocks.

An estimation of the geothermal gradient near Mound Facility was obtained from the temperature log of the Armco Deep Well No. 1 in Middletown, Ohio. The geothermal gradient across the paleozoic sedimentary section was computed to be approximately 0.24 C° (0.43 F°) for 30.5 m (100 ft) of depth, which is very low in comparison to the typical value for oil fields in North America of 0.56 C° (1 F°) per 30.5 m (100 ft) of depth. This low gradient is additional evidence of regional stability.

Regional Oil and Gas Production - The major oil-producing area closest to Mound Facility is the Lima-Indiana Field which trends northeast-southwest from northwest Ohio into central Indiana. This field produced both oil and gas from the Trenton Limestone, mostly between the years 1885 through 1910, but production is now largely abandoned. The closest area of petroleum activity is the Arcanum Field located in Darke County, Ohio, 40 km (25 mi) northwest of the site. This field was discovered in

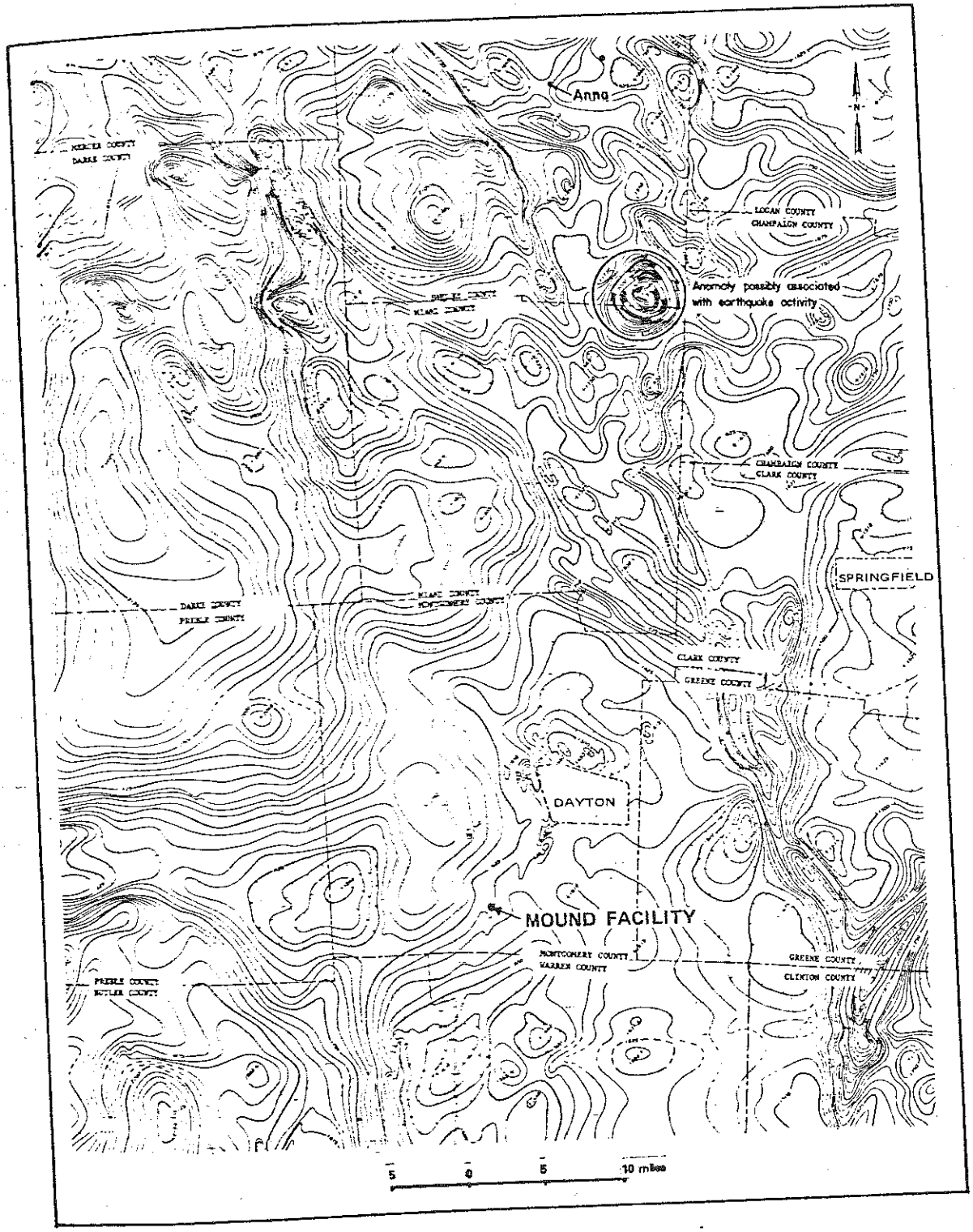


FIGURE 2-14 - Aeromagnetic Map of the Dayton-Columbus Area.

1887 and is now depleted. Gas production was from the Trenton Formation which is a an average depth of 350 m (1150 ft) below ground surface. Other wells penetrating the Trenton Formation have been drilled as close to Mound Facility as Dayton, but no signs of oil or gas have been reported.

Site Geology - The geology and seismicity of the Facility site have been extensively studied by experienced geologists in consultation with recognized authorities from the Ohio State Geological Survey and Miami University. Six widely-spaced geologic borings were made in 1973 to determine the lithology, structure, and physical properties of the subsurface strata. Soil and rock to a depth of 228.1 m (748.5 ft) were drilled and sampled. The deepest subsurface penetration was completed at an elevation of approximately 188 m (618 ft) above sea level, and the deepest continuous penetrations were 61 m (200 ft). At five of the borings geophysical profiles of the strata were obtained by electronic measurements. Data from these six borings have been supplemented and correlated with information from over 200 previous borings and from nearby deep wells to characterize local geology.

Stratigraphy - Figures 2-15 and 2-16 illustrate geologic cross sections of the Upper Ordovician horizon upon which Mound Facility is situated. The two topographic high areas are generally covered by a relatively thin layer [0.3 to 1.5 m (1 to 5 ft)] of glacial till composed of silt, clay, and some fine gravel. The lower valley is filled with a wedge of glacial outwash between the upper tills and the bedrock. All the core rock retrieved from the six borings are from the Richmond Group of the Upper Ordovician period. The nature of the geologic column below the formations defined in the figures is extrapolated from logs of the Armco Deep Well at Middletown, the closest deep well in the region. Strata below the Upper Ordovician formations are mainly limestone formations and it is concluded that the basement rocks beneath the Facility are Precambrian granite which begin 790 m (2,600 ft) below sea level.

Structure - The geologic record preserved in the rocks underlying Mound Facility indicates the area has been relatively stable since the beginning of the Paleozoic era, more than 500,000,000 years ago. There is no evidence to indicate subsurface structural folding, significant stratigraphic thinning, or subsurface faulting in the Richmond beds, which are nearly horizontal. Further, there is no evidence of sub-Richmond structural displacement in the immediate surrounding area. Limestone strata which are interbedded with protective shale layers at the site show no evidence of solution activity, and no evidence of solution cavities or cavern development has been observed in any borings or outcrops in the Miamisburg area.

Groundwater - Groundwater conditions at Mound Facility are variable due to the stratigraphic positions of different materials and their corresponding hydraulic properties. Bedrock, which underlies all but the first few feet of the hilltop and hillside areas, is virtually impermeable. Very small quantities of groundwater seep through joints and weathered cracks, although the rock itself is impervious. The

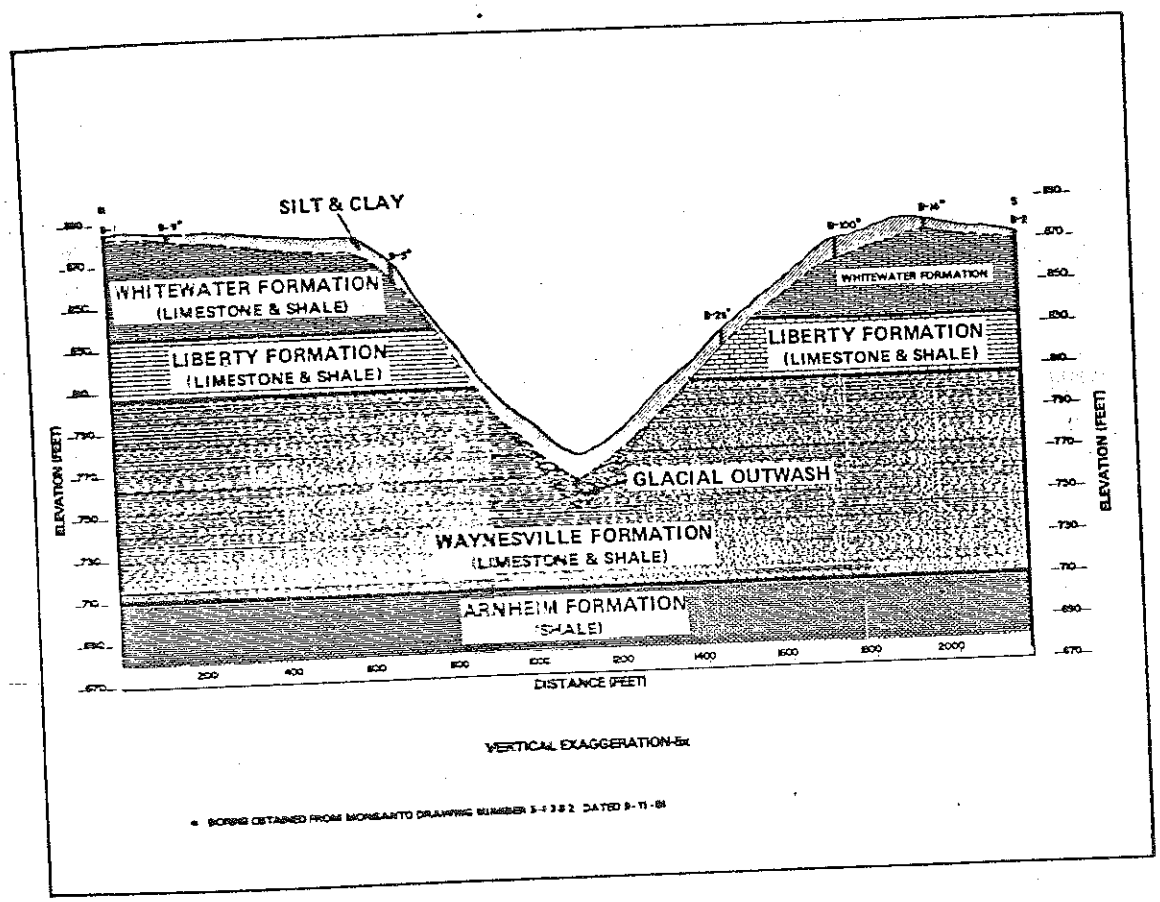


FIGURE 2-15 - North-South Cross Section Through Mound Facility.

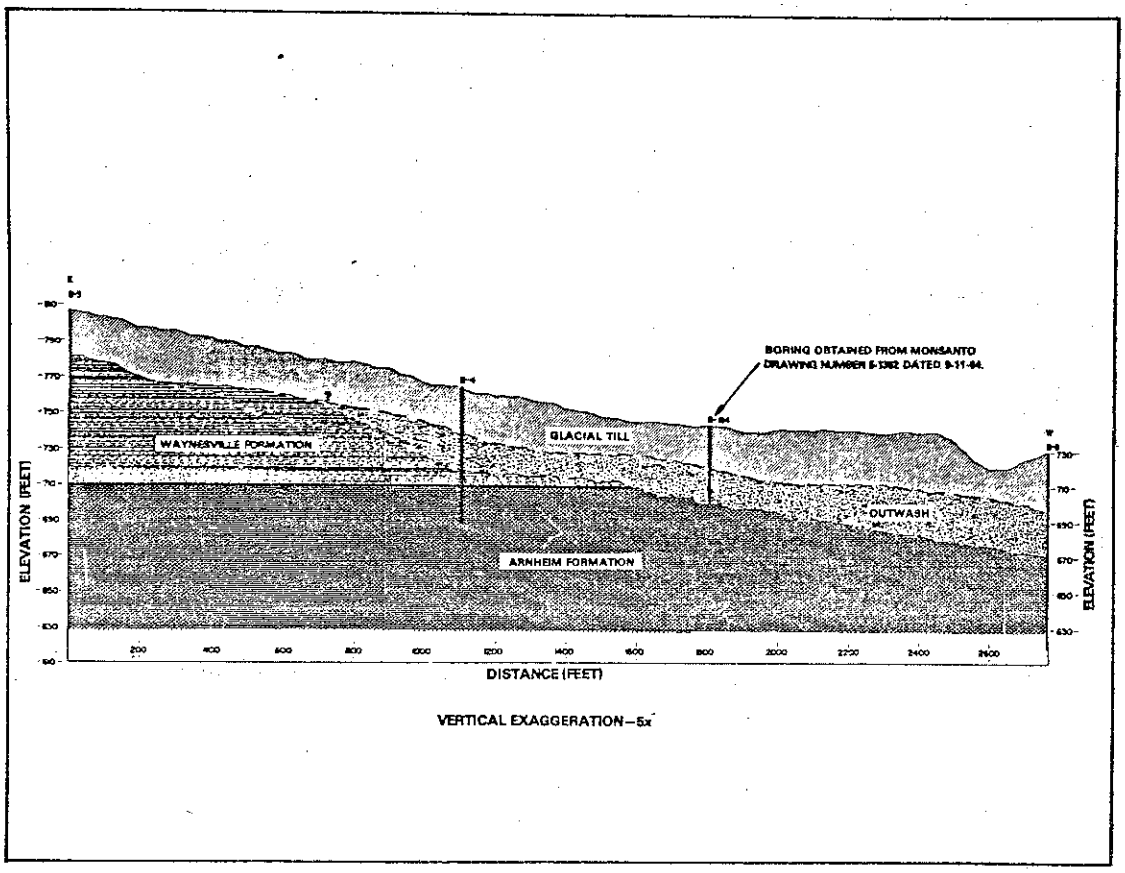


FIGURE 2-16 - East-West Cross Section through Mound Facility.

upper 6 m (20 ft) of bedrock is the most permeable where chemical weathering allows enlargement of cracks. Permeability of the upper 6 m (20 ft) of bedrock is estimated to range from 40 to 400 liters/day/m^2 (1 to 10 gpd/ft^2). Below this depth, bedrock permeability generally ranges from 8 to 0 liters/day/m^2 (0.2 to 0.0 gpd/ft^2).

Hydraulic properties of the glacial till soils which form a veneer over the entire site are variable and are dependent upon the relative proportions of fine-grained material to coarse-grained material at any given location. Values of permeability normally range from 0.0041 to 0.041 liters/day/m^2 (0.0001 to 0.001 gpd/ft^2), although values up to 2.8 liters/day/m^2 (0.07 gpd/ft^2) were measured in the upper weathered zones.

Below the glacial till in the lower valley area is a zone of glacial outwash composed of sand and gravel. The permeability of this zone is estimated to range from 40,700 to 81,400 liters/day/m^2 (1,000 to 2,000 gpd/ft^2). This horizon forms the eastern edge of the Buried Valley Aquifer and extends under the Great Miami River to the west. The three onsite wells draw water from this aquifer. Water levels under the Facility are ultimately controlled by the level of the Great Miami River which has a nonflood level at El. 208 m (682 ft). However, groundwater is normally perched and is forced to travel laterally within zones of outwash or fractures in the bedrock. For this reason, water levels measured in borings do not reflect the true static levels, but rather the dynamic equilibrium level between recharge and discharge at a given permeability interface for a particular date.

Foundation Considerations - There are 97 structures located at Mound Facility. Most of these structures, including all Category 1 structures (those in which significant quantities of radioactive materials are processed or handled outside of shipping containers or encapsulation systems or in which there is a potential for release of radioactive material from a containment system), are located on the flat hilltop areas and are founded directly on bedrock. Other structures are founded on stiff glacial till which overlies bedrock.

Analysis of actual design bearing pressures and recommended foundation loadings indicates that existing structures were conservatively designed. Recommended safe bearing pressures were never exceeded and in many cases were reduced by the designer. A safety factor of at least ten is estimated for structures founded on bedrock.

An examination of soil samples obtained from the field boring program indicates that all soils which overlie bedrock at Mound Facility are either cohesive or extremely dense. It is therefore concluded that the possibility of liquefaction (a phenomenon in which loose saturated granular soils lose shear resistance and behave as a high-density liquid) is extremely remote and not an important factor to be considered in the design or evaluation of Facility structures.

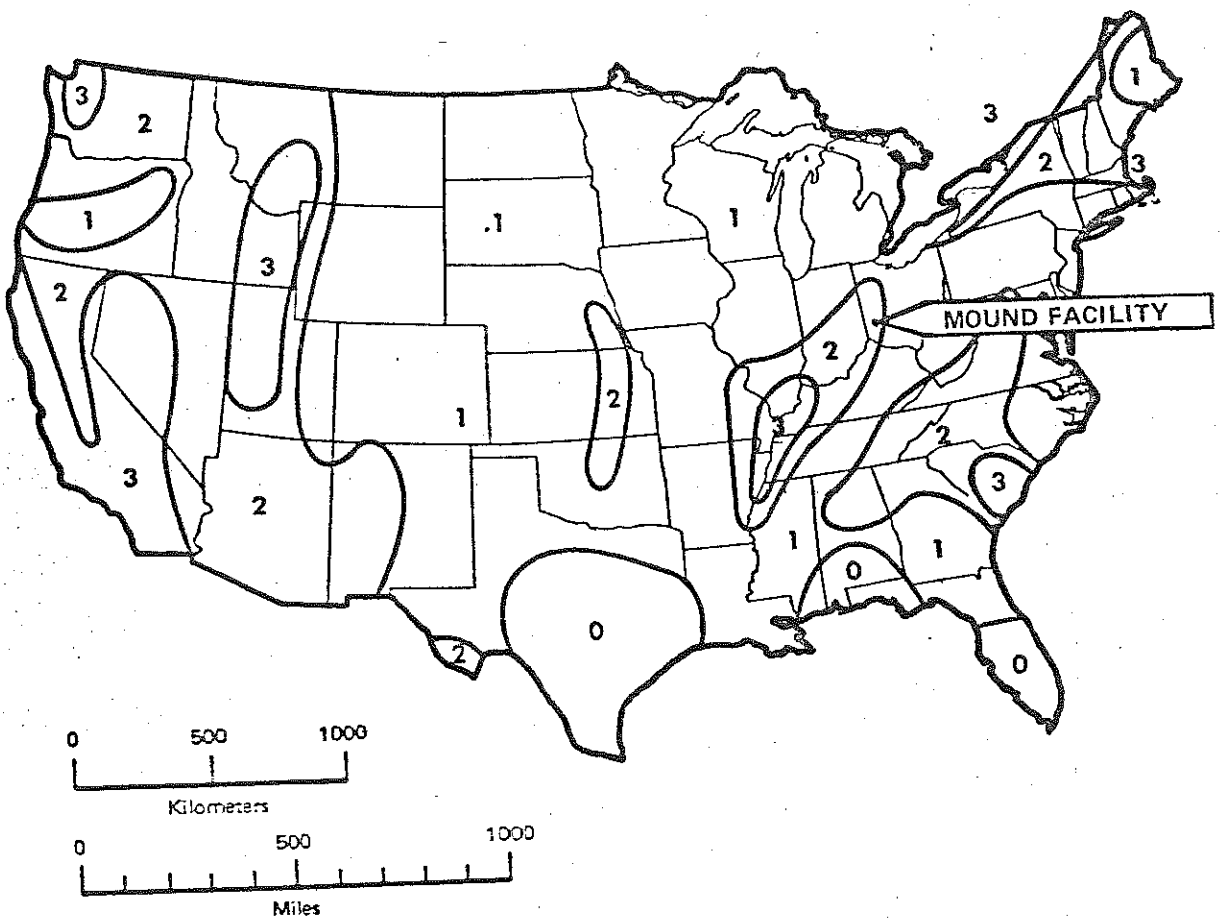
2.3.4 SEISMOLOGY

The Miamisburg area has never in historic times been seriously troubled by earthquakes. Although earth tremors have occurred in the area which is now Facility property, detailed geologic studies suggest that they were not strong enough to affect local surface or subsurface materials.

The Facility site is located about 85 km (53 mi) south of an active seismic area near Anna, Ohio, and about 240 km (150 mi) northeast of another active area in southern Illinois. A seismic risk map for the United States developed by Dr. S. T. Algermission of NOAA's Environmental Research Laboratories (Figure 2-17) indicates that Miamisburg is near the fringe of a Zone 2 region, a region in which moderate earthquake damage may be expected. However, no significant earthquakes - those with an intensity of V or above on the Modified Mercalli Intensity Scale (Table 2-5) - have originated in the area, as shown in Figure 2-18. It is estimated that the most severe vibration experienced in the area was an Intensity V shock associated with an Intensity VIII earthquake at Anna, Ohio, on March 9, 1937. The largest earthquakes ever recorded in the central and eastern United States - the Intensity XII shocks centered near New Madrid, Missouri, in 1811 and 1812 - probably resulted in Intensity IV or V vibrations at Miamisburg. Disturbances in the Anna area also resulted in Intensity IV vibration in 1931 and 1937. The closest earthquake may have occurred in 1950 when Intensity III vibrations were felt 16 km (10 mi) from the site; however, it could not be determined whether the disturbance resulted from seismic activity or a sonic boom.

The low seismicity of the region is related to the structural stability described in the previous section. The closest known fault is the Maysville fault which lies about 110 km (70 mi) to the southeast at its closest approach, but it, like most faults in the region, is believed to have been dormant since late Paleozoic time, at least 200,000,000 years ago. There are no known active faults (those in which there is evidence of displacement of Quaternary material) within 320 km (200 mi) of the site, though seismic activity has been associated with some of the structures within this area. Two Intensity VI events have tentatively been correlated with the Tekonsha oil field structure which trends northwest-southeast for an inferred length of 96 km (60 mi) and is 281 km (175 mi) from the site in its nearest approach. Faulting has been postulated in this structure, but only minor indications have been observed. The Mississippi Valley Fault Zone is tectonically active, but is farther than 320 km (200 mi) from the site at its closest approach. The Rough Creek Fault Zone in western Kentucky and southern Illinois extends to about 257 km (160 mi) from the site, but has not displaced Tertiary or Quaternary rocks. Shocks in the Anna, Ohio area, the closest seismically active zone, are associated with a zone of structural weakness and are not related directly to movement along faults.

At the site itself, there are no geophysical factors which would either cause or compound seismic disturbances. The subsurface is very stable. The two hilltop areas which provide foundation support to most of the buildings are composed of shale and



ZONE 0—No damage.

ZONE 1—Minor damage; distant earthquakes may cause damage to structures with fundamental periods greater than 1.0 seconds; corresponds to intensities V and VI of the M.M. * Scale.

ZONE 2—Moderate damage; corresponds to intensity VII of the M.M. * Scale.

ZONE 3—Major damage; corresponds to intensity VIII and higher of the M.M. * Scale.

This map is based on the known distribution of damaging earthquakes and the M.M. * intensities associated with these earthquakes; evidence of strain release; and consideration of major geologic structures and provinces believed to be associated with earthquake activity. The probable frequency of occurrence of damaging earthquakes in each zone was not considered in assigning ratings to the various zones.

* Modified Mercalli Intensity Scale of 1931.

FIGURE 2-17 - Seismic Risk Map for Conterminous United States.

Table 2-5

MODIFIED MERCALLI INTENSITY (DAMAGE) SCALE OF 1931
(Abridged)

I. Not felt except by a very few under especially favorable circumstances. (I Rossi-Forel Scale.)

II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing. (I to II Rossi-Forel Scale.)

III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibration like passing of truck. Duration estimated. (III Rossi-Forel Scale.)

IV. During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motorcars rocked noticeably. (IV to V Rossi-Forel Scale.)

V. Felt by nearly everyone, many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop. (V to VI Rossi-Forel Scale.)

VI. Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight. (VI to VII Rossi-Forel Scale.)

VII. Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motorcars. (VIII Rossi-Forel Scale.)

VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motorcars disturbed. (VIII+ to IX Rossi-Forel Scale.)

IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. (IX+ Rossi-Forel Scale.)

X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks. (X Rossi-Forel Scale.)

XI. Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII. Damage total. Waves seen on ground surface. Lines of sight and level distorted. Objects thrown upward into the air.

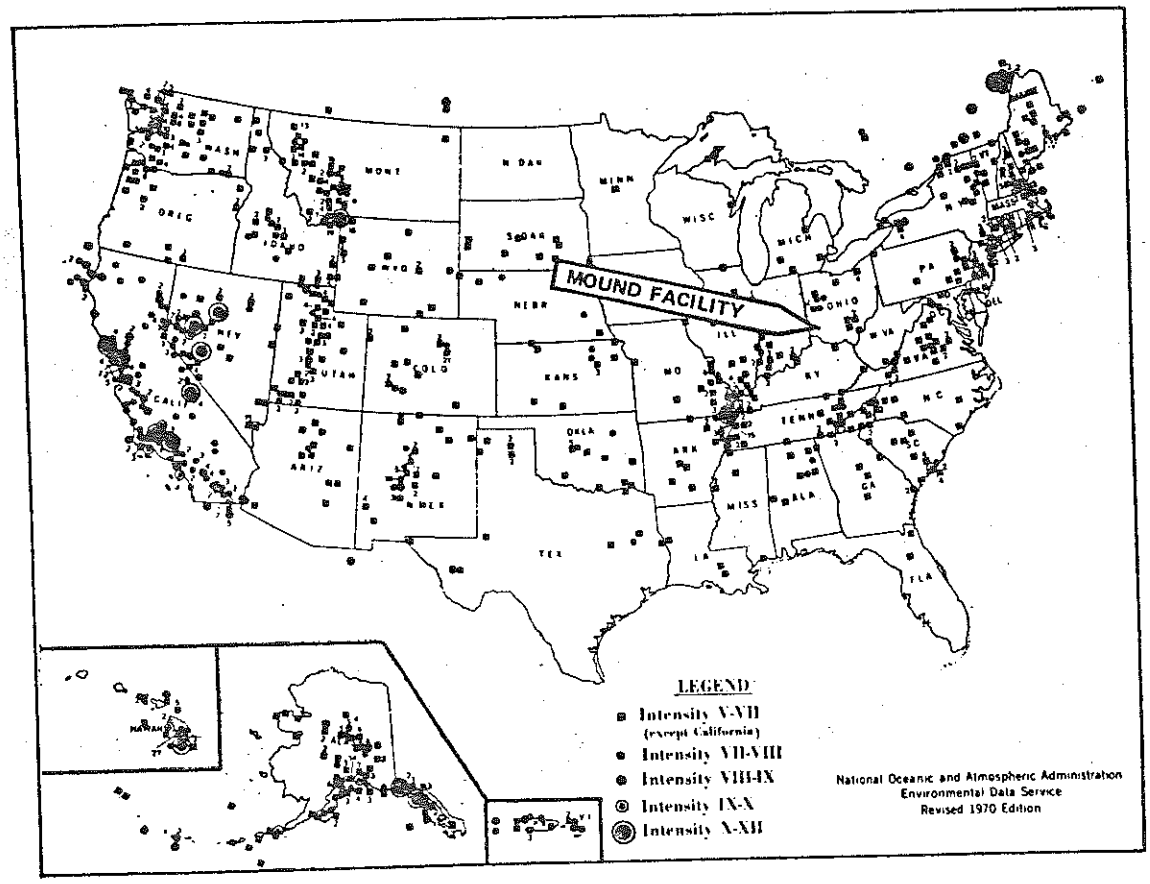


FIGURE 2-18 - Earthquakes (Intensity V and Above) in the U. S. Through 1970.

limestone bedrock supported by a thick sedimentary sequence of shale, dolomite, limestone, and sandstone which rest on precambrian basement rocks. The buildings located below El. 230 m (760 ft) are underlain by dense glacial soils supported by the same sedimentary sequence. No evidence has been found of faulting or folding within the Ordovician rocks which form the surface strata. Instability of the rocks because of mineralogy, lack of consolidation, attitude, structure, or undesirable response to seismic events is not considered a problem. As discussed previously, the relatively thick layer of glacial soils below El. 230 m (760 ft) is not subject to liquifaction effects which would lower structural stability. There is no evidence of natural underground cavities which could result in a sudden collapse or slow subsidence of rock foundations, and subsidence due to mining activity or petroleum production is not a potential problem since no such activity exists in the vicinity.

Slope failure onsite during vibratory ground motion is not considered likely. Natural slopes range from zero to approximately 20° from the horizontal. Most are composed of surficial soil (glacial till), 0.45 to 6.7 m (1.5 to 22 ft) thick, overlying bedrock. From analysis of compressive strength values for soil samples, these natural slopes are judged to be stable. Engineered backfills, which are compacted to at least 90% of maximum density and are limited to a maximum slope of 26°, are assumed to be substantially stronger than natural soil slopes.

The effect at the site of a possible future earthquake similar to a large historical shock has been investigated. Should a shock similar to the March 9, 1937 Intensity VIII earthquake near Anna, Ohio, recur in the vicinity of the southern portion of the confluence of the Findlay and Kankakee Arches, the attenuated ground acceleration of the site would be less than 15% of gravity (0.15 g), considerably less than the 0.20 g level associated with the Design Basis Earthquake discussed in Section 3.10.8. Recurrence of small earthquakes similar to the 1950 Intensity III event 16 km (10 mi) north of the site would result in a maximum horizontal ground acceleration at the rock surface of less than 1% of gravity (0.01 g).

2.3.5 HYDROLOGY

Stream Flows and Flooding - Major hydrologic features of the area and their relation to the Facility are shown in Figure 2-19. The site topography is indicated in Figure 2-9. Elevations at the site vary from 216 to 268 m (710 to 880 ft) above sea level; most of the site is above 240 m (800 ft). No radioactive material processing building is below El. 241 m (790 ft). The typical nonflood stage of the Great Miami River is at El. 208 m (682 ft). The normal pool elevation is controlled by the Hutchings Station dam about 2.4 km (1.5 mi) downstream from the site with a dam crest at El. 207 m (680 ft). The river bottom in the site vicinity is at El. 204 m (670 ft).

Flow in the Great Miami River nearby originates from three major and two minor subdrainage systems. The three major stream systems are: (1) Stillwater River, 1750 km^2

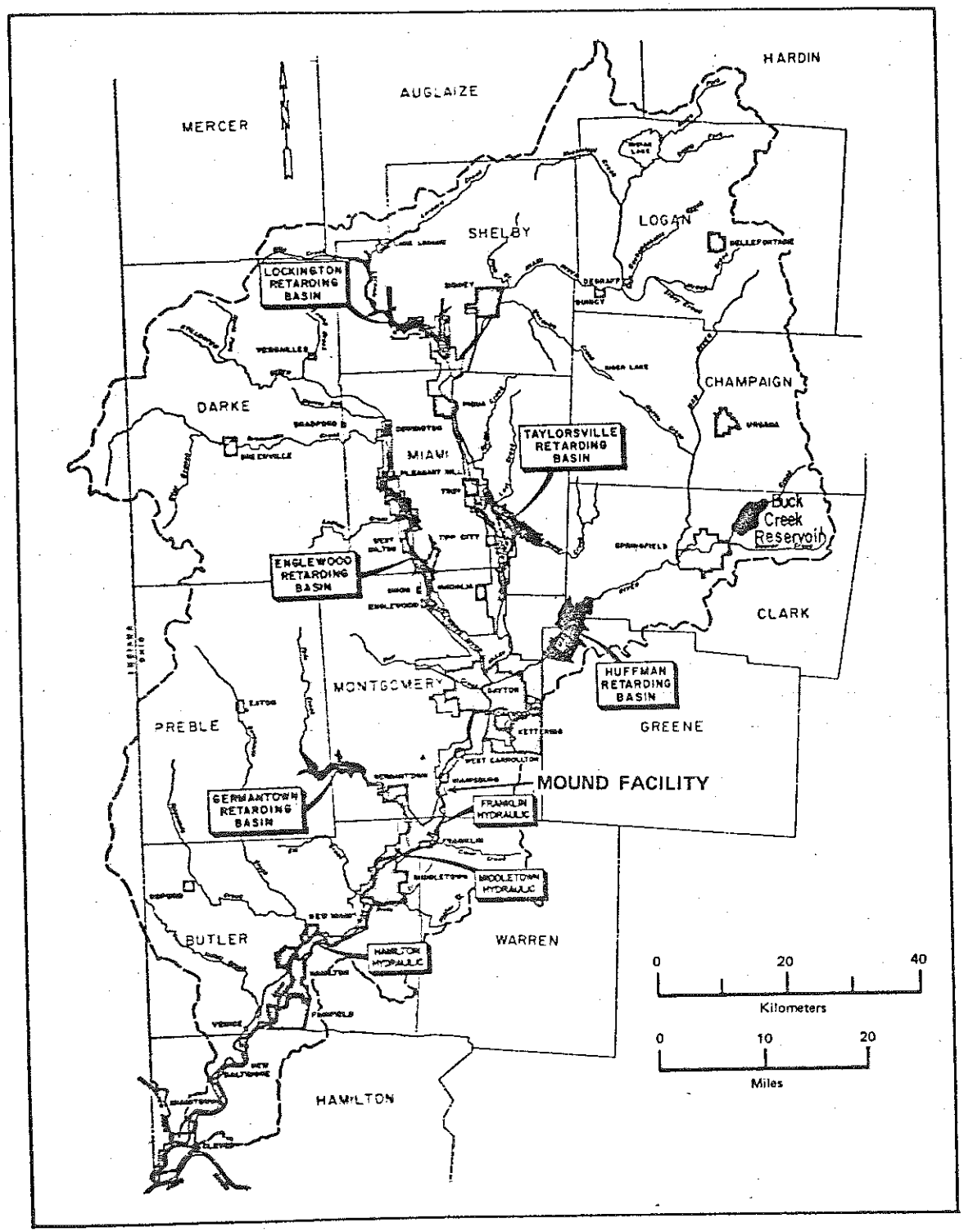


FIGURE 2-19 - Major Hydrologic Features of the Area.

(676 mi^2); (2) Great Miami River above Stillwater River, 3042 km^2 (1175 mi^2); and (3) Mad River, 1700 km^2 (657 mi^2). The minor sub-drainage systems are: (1) Bear Creek drainage area, 137 km^2 (53 mi^2) and (2) Wolf Creek, 181 km^2 (70 mi^2). Other small stream systems such as Holes Creek contributes 207 km^2 (80 mi^2) of drainage area. Total drainage area of the Great Miami River at Miamisburg is 7018 km^2 (2711 mi^2). Stream gage data have been obtained above Miamisburg at Dayton since 1866. A gaging station was established at Miamisburg in 1916 1.6 km (1 mi) upstream from where the Facility was later established. Prior to 1921, considerable flooding occurred throughout the Great Miami River basin. The greatest flood of record in the Miami Valley occurred after a record rainstorm in March 1913; the discharge was estimated to be 7280 m^3/sec (257,000 cfs) at Miamisburg. The Miami Conservancy District was later formed to develop a flood control system to protect population centers in the upper Miami River valley.

After extensive investigation of storms in the eastern United States the Miami Conservancy District concluded that the 1913 storm produced one of the greatest historical floods in the Miami Valley. The District subsequently based its flood protection on a design flood runoff approximately 40% greater than that of the 1913 flood. This design flood was estimated to be 15 to 20% above the greatest possible flood that will occur in the northern part of the Miami River basin over a 300 to 400-yr period.

Since construction of retarding basins in 1921, flooding on the Great Miami River has been greatly reduced and damage has been confined to tributaries and developed areas lying in the flood plain. Data for the six highest floods recorded since 1913 are presented in Table 2-6. The maximum flow recorded at Miamisburg since that time was 1750 m^3/sec (61,800 cfs) in January, 1959.

The highest water levels that can reasonably be postulated for the Great Miami River basin would be caused by either a flood wave resulting from a dam failure upstream from the site or by a Probable Maximum Flood estimated for the area. A Probable Maximum Flood is one which would result if all reasonably possible contributing factors reached their most critical values at the same time.

The Miami Conservancy District has developed and verified a flood routing model for the 9421 km^2 (3,639 mi^2) drainage basin of the Great Miami River above Hamilton, Ohio, which is located about 45 km (28 mi) downstream from Miamisburg. With incorporation of values for probable maximum precipitation patterns in the area, this model was used to estimate that the Probable Maximum Flood discharge rate at the Facility site would be 6740 m^3/sec (238,000 cfs). This flow would result in flooding to El. 216 m (710 ft) which is approximately the lowest elevation at the site. A flow of 7280 m^3/sec (257,000 cfs) - a duplication of the 1913 flood - would correspond to El. 216.5 m (710.3 ft) at the site. Thus no buildings at the Mound Facility are located on a floodplain or in areas considered as wetlands in 10 CFR Part 1022.

Table 2-6

PEAK STAGES AND DISCHARGES
GREAT MIAMI RIVER AT MIAMISBURG, OHIO

Date	Height Above Mean River Stage (feet)	Discharge (cfs)
Mar. 28, 1913	No Record	257,000*
Mar. 14, 1917	11.6	30,500
Apr. 21, 1920	16.8	51,800
Feb. 27, 1929	16.5	55,000
Jan. 10, 1930	16.16	50,800
May 15, 1933	16.13	51,800
Jan. 21, 1959	20.65	61,800

*Computed by Miami Conservancy District.

Remarks - Flow regulated by four retarding basins (combined capacity 735,000 acre-ft) since 1921. Bankfull stage is 22 feet. Data supplied by Miami Conservancy District.

The highest water level with associated wave runup is estimated to be El. 222 m (727 [illegible] assuming the extremely remote possibility of complete failure of Huffman Dam [illegible] Such a failure is considered extremely unlikely because all the dams in the watershed are continuously being monitored for their safety as well as being constantly upgraded and maintained by the Miami Conservancy District. It it did occur, the resulting water level would not reach Facility structures.

Formation of ice jams with consequent flooding is not a problem on the Great Miami River. Icing of the river is not common, and due to the wide channel and levee configurations at Miamisburg, it is unlikely, even with major ice accumulations, that damming of the main channel at bridges would cause an appreciable rise in water elevation.

There are no perennial streams on the site. There is a drainage basin associated with the deep valley which separates the two high areas, but it is generally limited to the site area. Since the drainage basin is relatively small and the slopes are relatively steep, runoff through site drainage features is rapid and does not pose a threat to Facility structures.

Low River Flows - A flow duration curve has been constructed for the years 1931 [illegible] 1960 from data collected at the Miamisburg gaging station. This curve (Figure 2-20) depicts the discharge that can normally be expected to be equalled or exceeded at the site and serves as an index of drought flow conditions. For example, a flow of at

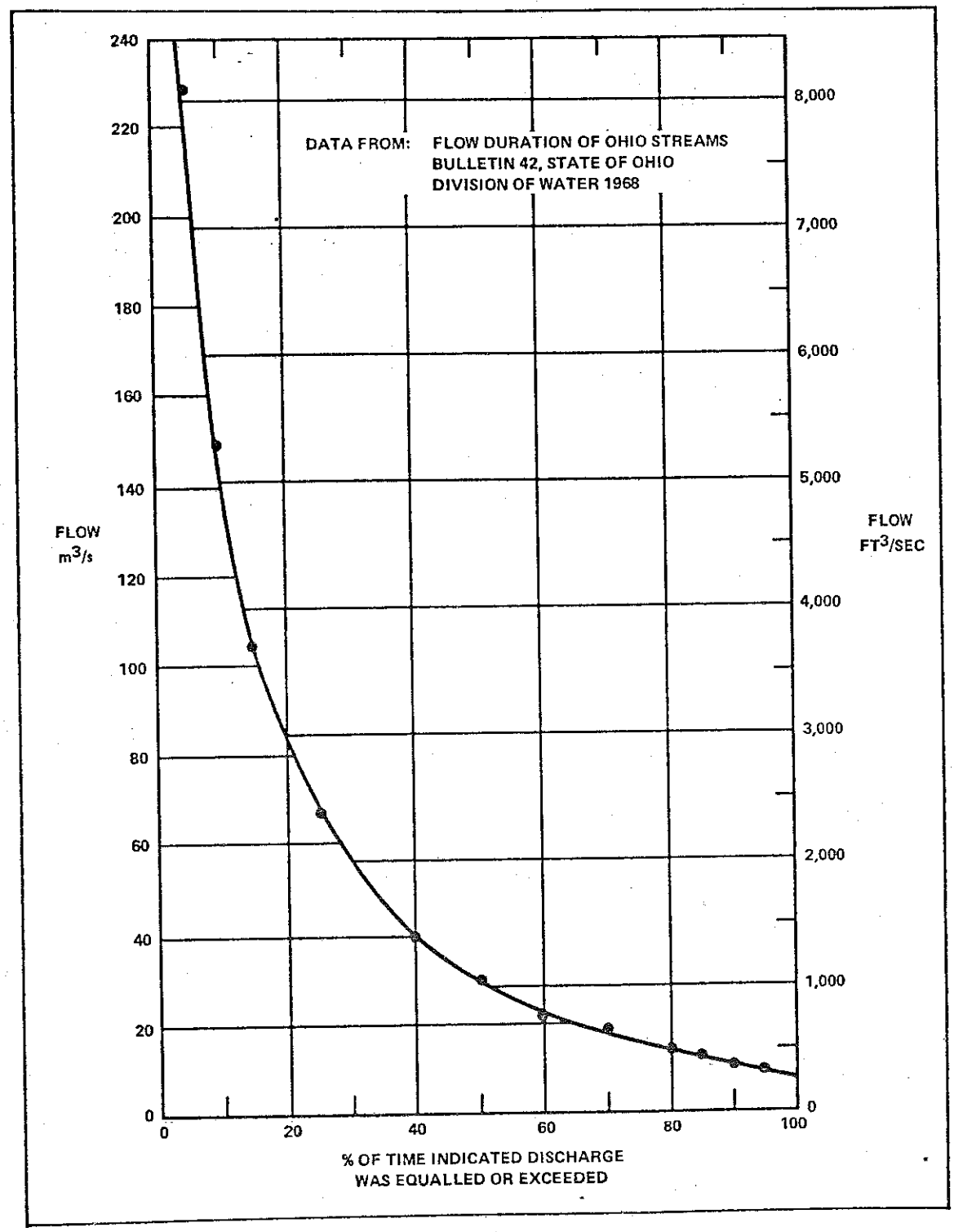


FIGURE 2-20 - Flow Duration at Miamisburg, Ohio.

st 8.8 m^3/sec (310 cfs) can be expected 95% of the time. The mean flow at Miamisburg, located at the 50% time coordinate on the curve, is 29.7 m^3/sec (1050 cfs). The minimum instantaneous low-flow on record is 4.19 m^3/sec (148 cfs) for September 7, 1925. During periods of severe drought, to be expected once in 20 years according to past experience, an average flow of about 5.1 m^3/sec (180 cfs) for seven consecutive days is projected. The low design flow at Miamisburg designated by the Miami Conservancy District is 6.00 m^3/sec (212 cfs).

River Water Usage - Principal surface and ground water users within the Great Miami River basin are depicted in Figure 2-21. No municipal system in this basin uses surface water for a public water supply below the Mound Facility effluent discharge point. Both surface and sub-surface waters are used by manufacturing and power companies within the basin for processing and heat exchange. The nearest downstream surface water user is the O. H. Hutchings Power Station which circulates 17.0 m^3/sec (600 cfs).

Regional Aquifers - Municipal and industrial water supplies in the vicinity of the site depend upon high-capacity wells drilled into unconsolidated sand and gravel aquifers. Buried valleys which trend in the general position of the present Great Miami River and its tributaries contain 30 to 61 m (100 to 200 ft) of Pleistocene sand, gravel, and fine-grained till and form the principal aquifer in the area. Good domestic groundwater supplies are available in upland areas which are blanketed by granular glacial deposits or deposits of granular soils interbedded within relatively impermeable till. A map showing hydrogeologic environments for a radius of 4.0 km (2.5 mi) from the site is presented in Figure 2-22. Industrial wells adjacent to the site have specific capacities ranging from 15 to 45 liters/sec/m (73 to 218 gpm/ft) of drawdown. Specific capacities as high as 281.5 liters/sec/m (1360 gpm/ft) of drawdown have been reported for a well at Chautauqua, about 2.4 km (1.5 mi) south of the site.

Recharge to aquifers is available from three major sources:

- Direct infiltration from the Great Miami River.
- Leakage along valley walls at the bedrock-outwash contact.
- Induced infiltration caused by hydraulic sinks due to pumping.

Recharge to the portion of the aquifer underlying the Mound Facility is primarily derived from direct infiltration from the Great Miami River and by precipitation and leakage from valley walls. This source of recharge is sufficient in quantity to balance withdrawals.

The Buried Valley Aquifer, located immediately west of Mound Facility and below an elevation of approximately 213 m (700 ft), is the major aquifer adjacent to the site. Within limits of the property, the maximum known thickness of the aquifer is about 21 m (70 ft) at the extreme southwest corner of the site. The aquifer reaches a maximum thickness of about 46 m (150 ft) near the river channel and is oriented in a north-

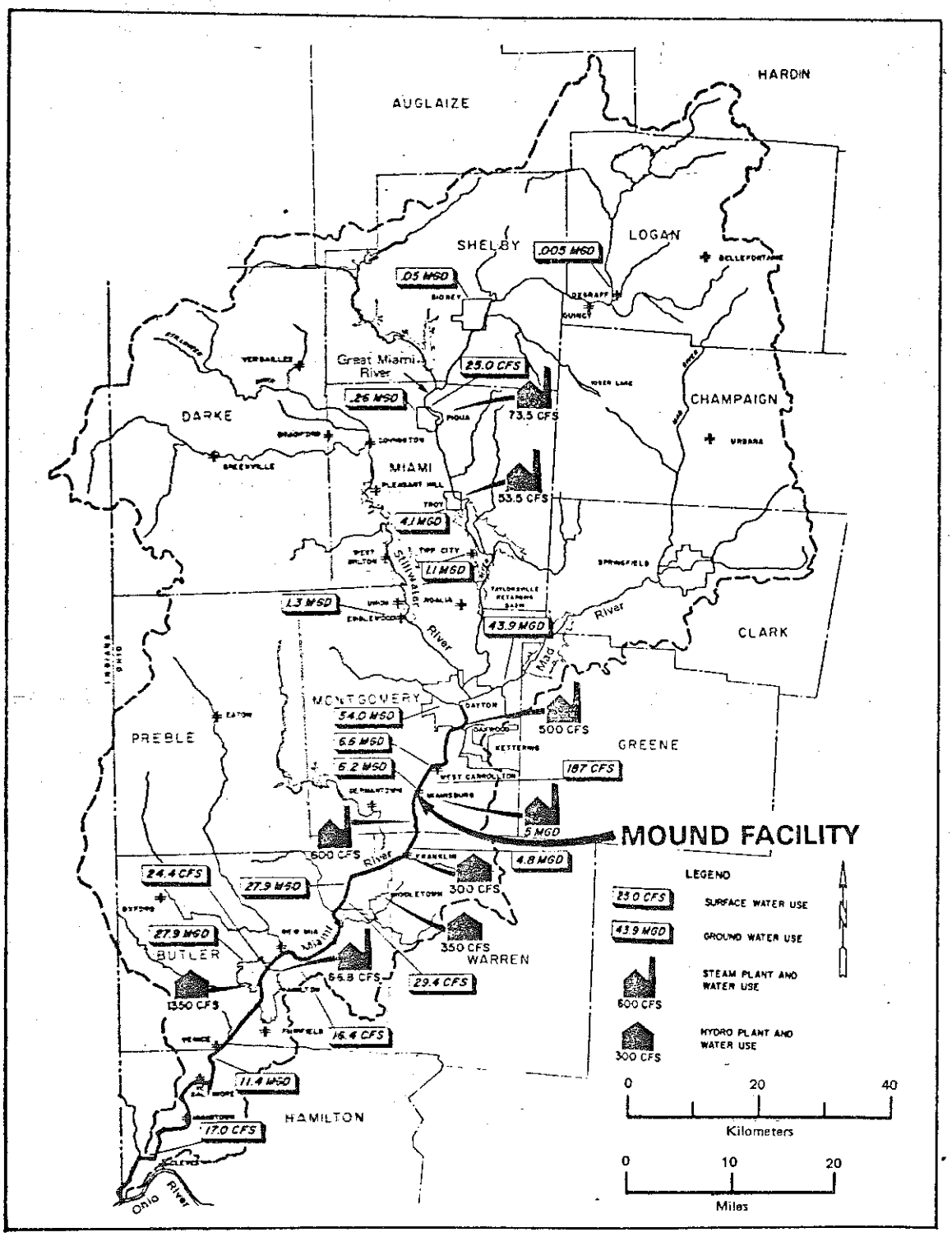


FIGURE 2-21 - Great Miami River Basin Water Use.

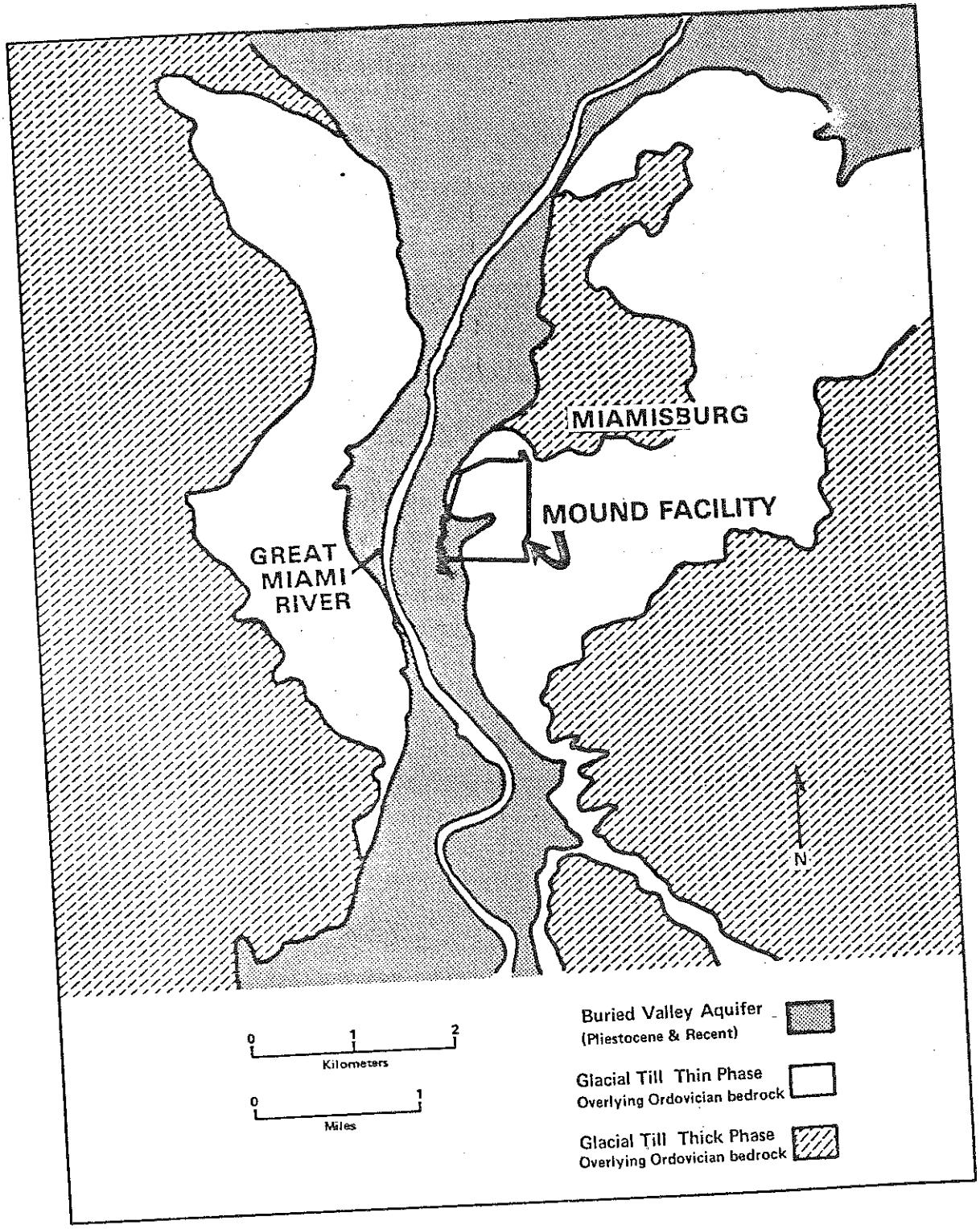


FIGURE 2-22 - Hydrogeologic Environments in the Vicinity of Mound Facility.

south direction, in coincidence with the course of the Great Miami River. Recharge by induced stream infiltration occurs, although the sand and gravel aquifer at this location contains extensive interstratified layers of clayish till which impede infiltration. The Buried Valley Aquifer west of the site is estimated to be capable of producing 35 to 47 million liters per day per kilometer (15 to 20 million gallons of groundwater per day per linear mile) of valley.

The direction of groundwater flow in the area is generally toward the south, following the downstream course of the Great Miami River. A map showing groundwater level gradients measured in 1968 is presented in Figure 2-23. Groundwater levels experience local reversals in areas of heavy pumpage, as indicated by closed contours on the map. Such reversals are expected to increase in both number and area as regional groundwater development increases in the future. Although the Buried Valley Aquifer is generally overdeveloped between West Carrollton and Dayton, relocation of well fields and artificial recharge through the use of infiltration lagoons will probably reduce the magnitude of groundwater gradient reversals within a few years. Currently, there is no evidence to indicate that the regional gradient is reversed south of the City of West Carrollton. At Miamisburg, the natural groundwater gradient is not influenced by pumping except locally near individual well fields.

There are six major public water supplies and numerous industrial users within an 8 km (5 mi) radius of Mound Facility. A map showing the locations of public water supply wells and distribution areas for municipal water service is shown in Figure 2-24. A tabulation of current and projected water demands is presented in Table 2-7.

The only industrial user within 8 km (5 mi) downstream is the O. H. Hutchings Power Generating Station. Industrial groundwater users located north (upstream) of the site are isolated from the Facility area by hydraulic barriers.

Miamisburg owns ten water wells into the aquifer, but only three are in use. All operational city wells are separated from the site by a minimum straight-line distance of over 0.8 km (0.5 mi).

Figure 2-25 shows the areas in close proximity to Mound Facility in which some users obtain their water from private wells. Water is supplied to area C from the granular deposits of the Great Miami River flood plain. Thus, some of the water available for charging private wells in this area originates in the runoff from the Mound Facility site. Low levels of tritium in this runoff have caused a slight but measurable increase above background in the tritium content. It is expected that the private wells will continue to be the major source of water for some residents of area C. Private wells in the other areas defined on Figure 2-25 have not shown any increases in tritium content above normal background. (See Section 3.7.1 on Liquid Waste Effluent Impact and new EPA Drinking Water Regulations.)

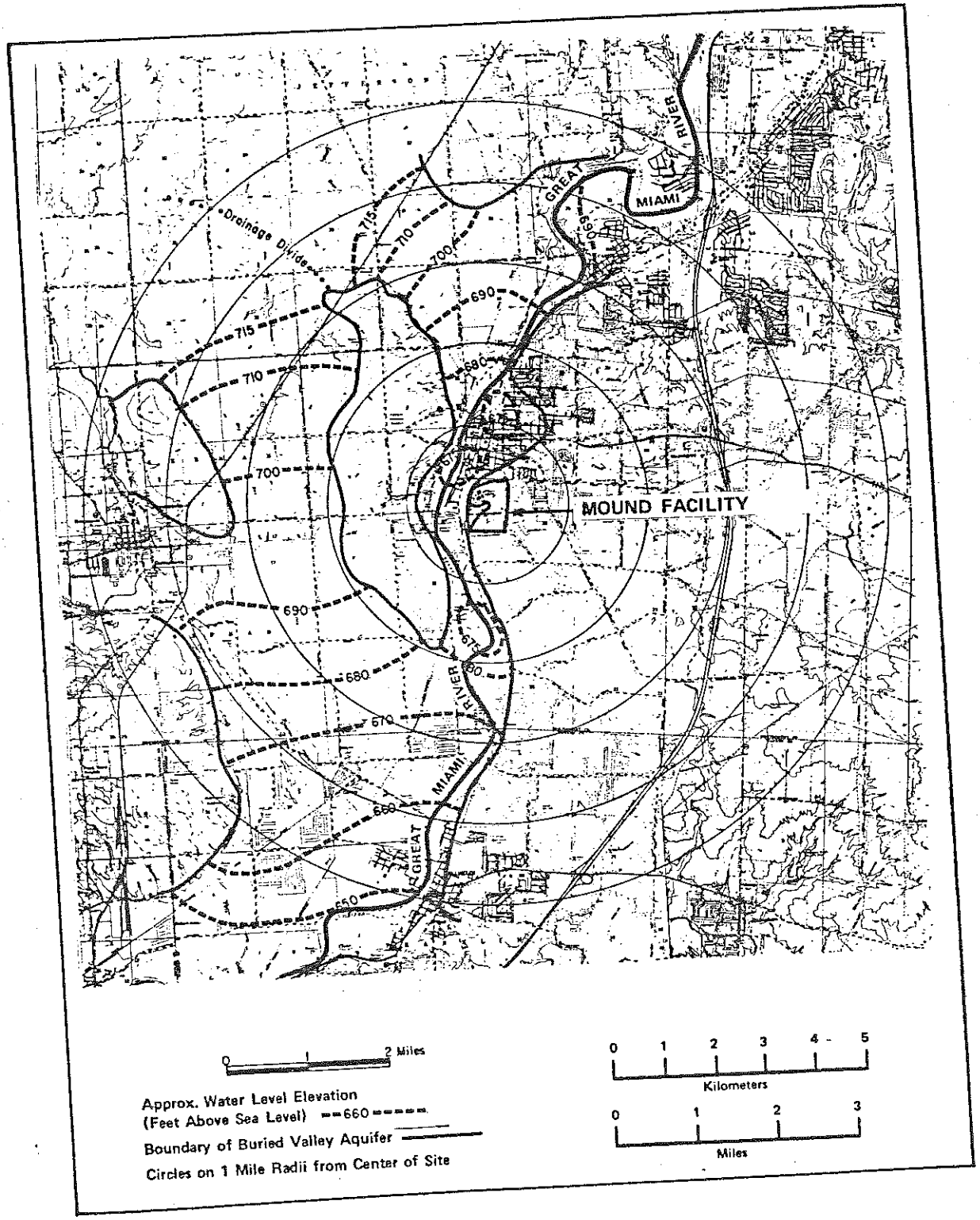


FIGURE 2-23 - Ground Water Gradients.

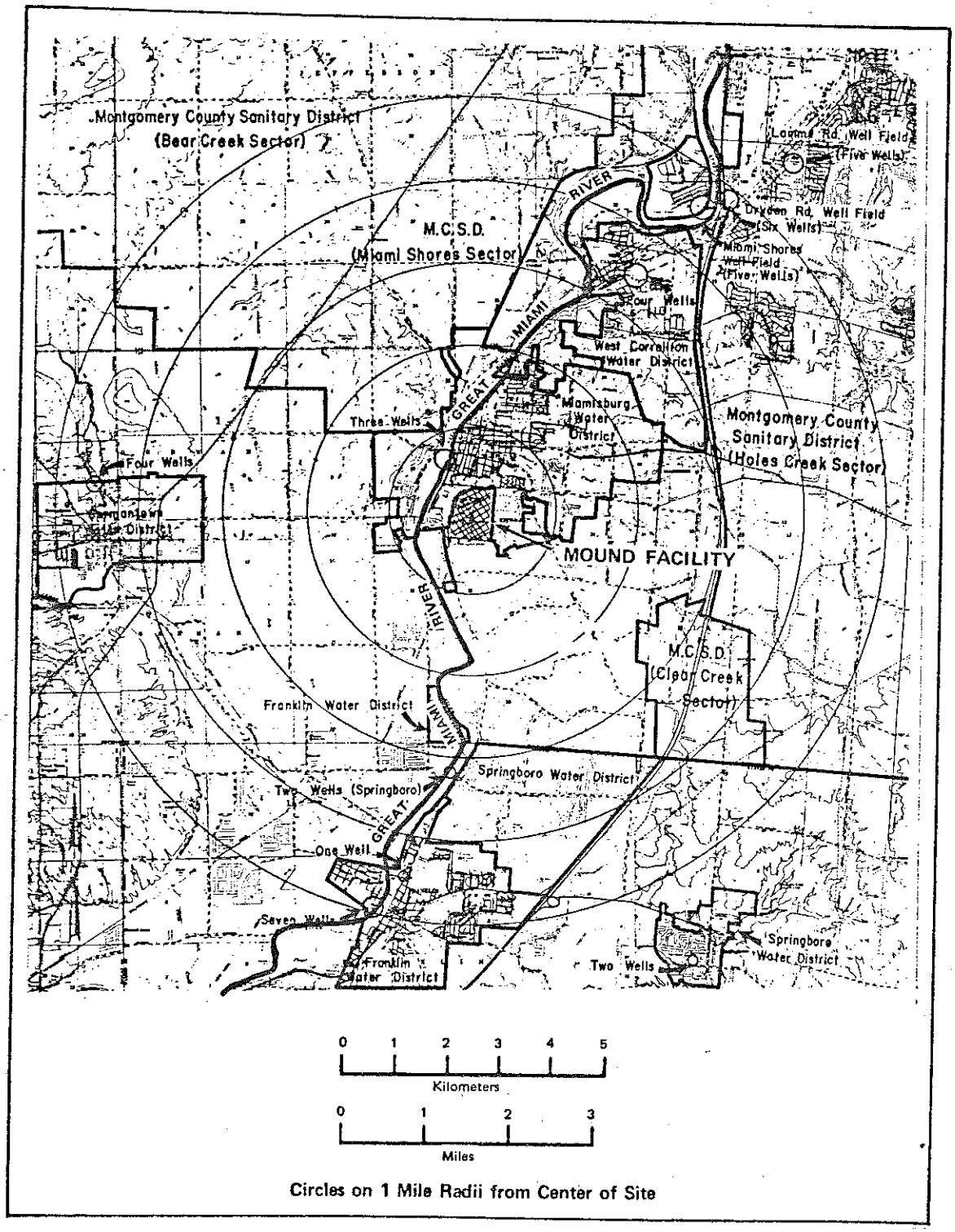


FIGURE 2-24 - Areas of Municipal Water Distribution from Public Supply Wells in January, 1973.

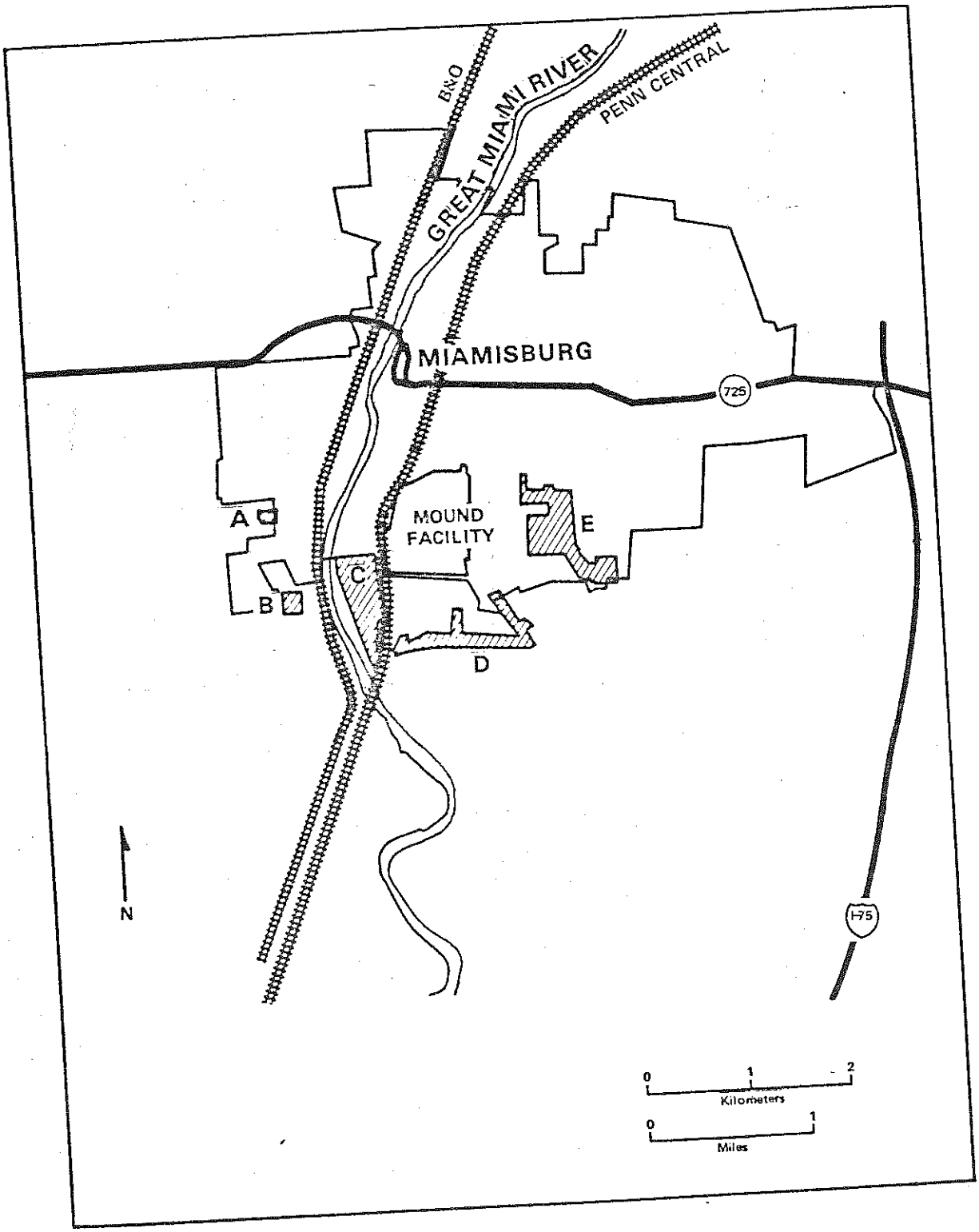


FIGURE 2-25 - Zones Highly Dependent on Private Well Water Within One Mile of Mound Facility.

Table 2-7

MUNICIPAL GROUNDWATER USE WITHIN THE GREAT MIAMI RIVER WATERSHED

Municipal Supplies	Upstream or Downstream of Site	Average Groundwater Use MGD,* 1969	Projected Average Demand MGD,* 2020	Projected Peak Demand MGD,* 2020
Within 5 miles of site				
Miamisburg	U	1.570	11.761	17.642
Germantown	U	0.444	2.157	3.775
Franklin	D	2.013	21.120	31.680
West Carrollton	U	0.928	5.634	9.860
Springboro	D	0.211	4.852	8.492
Within 10 miles of site				
Farmersville	U	0.069	0.663	1.160
New Lebanon	U	0.350	1.919	3.358
Oakwood	U	1.081	2.011	3.017
Middletown	D	7.815	20.168	30.252
Greater Moraine Sanitary District	U	14.295	61.446	92.169
Within 15 miles of site				
Dayton	U	67.142	192.836	289.254
Dayton State Hospital	U	0.016	0.023	0.040
Monroe	D	0.254	1.840	3.220
Trenton	D	0.363	2.404	4.207
Gratis	U	0.017	0.131	0.229
West Alexandria	U	0.124	0.280	0.490

*Million gallons per day.

Wells located on the DOE property at Mound Facility supply the plant site. Present water usage at the facility ranges from 19 to 32 liters/sec (300 to 500 gpm). The estimated maximum capacity of the water system exceeds the maximum water usage. A reserve water supply having a capacity of 63 liters/sec (1,000 gpm) is available from the City of Miamisburg in case of emergency. The water withdrawn from the wells is partially replenished by induced stream infiltration from the Great Miami River and by precipitation.

2.3.6 METEOROLOGY

The climate of the area is continental in nature, with moderate extremes in temperature. Summers are rather warm and humid, but temperatures rarely exceed 38°C (100°F). Winters are moderately cold with an average of about two days of subzero weather and frequent periods of extensive cloudiness. Autumns are predominantly cool, dry, and invigorating. Spring is the wettest season. Severe weather is mostly associated with heavy thunderstorms resulting in damaging winds and local flash flooding. Tornadoes occur in the region, but not frequently, and most have paths that are short and

narrow. The interplay between general atmospheric processes and topography is minimal; however, the lifting of moist air masses over the hills of the southern half of Ohio tends to increase the yield of rainfall, especially in winter and spring.

At present, meteorological data for the site itself are very limited, and only precipitation data exist for the Miamisburg area. Data from nearby locations have been used in the following discussions to estimate or indicate normals and extremes that may be expected locally. Official Dayton statistics are generated at the U. S. Weather Bureau station at Vandalia, Ohio, approximately 19 km (12 mi) north of Dayton, and 39 km (24 mi) north of Miamisburg.

Temperatures - Temperatures in the Dayton area range from an average daily minimum of -4.9°C (23.1°F) in January to an average daily maximum of 17.8°C (86.9°F) in July. A monthly tabulation is given in Table 2-8.

Precipitation - Precipitation is common in all seasons. The average annual rainfall equivalent is about 100 cm (40 in.), including about 69 cm (27 in./yr) of snow. The maximum 24 hr rainfall recorded in Dayton is 11.6 cm (4.56 in.). Normal monthly precipitation data for Miamisburg are presented in Table 2-9. Maximum monthly totals recorded at regional stations are listed in Table 2-10. Data for snowfalls are given in Table 2-11.

Humidity - The relative humidity in southwestern Ohio is moderately high, in correlation with precipitation patterns. Estimated average values for different times of the day at the Mound site range from 50 to 85% (Table 2-12).

Winds - The surface wind flow at Dayton is predominantly from the southwest quadrant. Average annual wind speeds range from about 11.2 to 16 km/hr (7 to 10 mi/hr). A study conducted to evaluate air pollution potentials in urban areas showed that the lowest wind speeds and the lowest mixing heights (the height above the surface through which relatively vigorous vertical mixing occurs) - and hence the greatest potential for air pollution - occur on summer mornings in Dayton (Table 2-13). The "fastest miles" on record at Dayton and Cincinnati for each month are listed in Table 2-14. (The "fastest mile" is the highest wind speed lasting for any time interval during which a length of air 1 mile long passes a wind instrument.) The highest value for Dayton is 125 km/hr (78 mi/hr).

Severe Weather - The maximum frequency of thunderstorms occurs in the summer season, generally in July. The minimum is reached in December. Annual distributions of thunderstorms in the Dayton area are indicated in Table 2-15.

A map showing the approximate paths of tornadoes which occurred in Ohio in the period 1953 to 1972 is presented in Figure 2-26. Thirty-one of these tornadoes occurred in a 1° square centered near Mound Facility. The annual frequency in this region is thus

Table 2-8

AVERAGE DAILY TEMPERATURES IN THE DAYTON, OHIO AREA*

Month	Temperature (°F) Average Daily Max.	Extreme Max.	Average Daily Min.	Extreme Min.
Jan	39.4	74	23.1	-14
Feb	41.8	73	24.0	-13
Mar	50.5	82	30.7	-3
Apr	63.7	89	41.1	19
May	73.9	95	51.2	27
Jun	83.2	103	60.9	40
Jul	86.9	107	64.2	48
Aug	85.5	104	62.6	42
Sep	79.1	102	55.1	29
Oct	67.8	91	44.4	19
Nov	52.0	81	33.2	-1
Dec	40.9	71	24.6	-13
Annual	63.7	107	42.9	-14

*Compiled through 1975

Table 2-9

MONTHLY PRECIPITATION IN MIAMISBURG, OHIO*

Month	Normal** (in.)	Number of Days Greater Than 0.5 in.***
Jan	3.66	2
Feb	2.62	2
Mar	3.61	2
Apr	3.74	2
May	4.14	3
Jun	4.71	4
Jul	3.40	2
Aug	3.03	1
Sep	3.28	2
Oct	2.53	1
Nov	3.12	2
Dec	2.75	2
Annual	40.59	25

*Compiled through 1975 **30-yr record ***10-yr

Table 2-10

MAXIMUM MONTHLY PRECIPITATION AT MIAMISBURG, DAYTON, AND CINCINNATI, OHIO*
(Totals expressed in inches)

Month	Miamisburg**	Dayton***	Abbe Observatory Cincinnati****
Jan	7.17	12.41	13.68
Feb	4.49	4.57	6.24
Mar	5.35	8.89	10.94
Apr	5.53	6.69	8.62
May	6.23	9.01	8.81
Jun	10.22	7.59	9.07
Jul	7.99	7.21	10.02
Aug	4.83	6.64	6.54
Sep	7.93	6.47	5.86
Oct	5.15	7.08	9.51
Nov	4.48	6.50	6.46
Dec	5.23	6.84	6.94

*Compiled through 1975

**10-yr record ***43-yr record ****42-yr record

Table 2-11

MAXIMUM PRECIPITATION RECORDED AS SNOW IN DAYTON AND CINCINNATI, OHIO*
(Totals expressed in inches)

Period	Dayton Airport**	Cincinnati Airport***	Abbe Observatory Cincinnati****
24 hr	11.3	9.8	11.0
Calendar Mo.	24.4	15.3	20.2
Season	54.7	46.0	-
Jan	24.4	15.3	20.2
Feb	15.2	13.3	11.6
Mar	13.8	13.0	13.0
Apr	4.3	3.3	5.2
May	0.5	Trace	Trace
Jun	0	0	0
Jul	0	0	0
Aug	0	0	0
Sep	0	0	0
Oct	2.8	1.7	4.7
Nov	12.7	12.1	8.9
Dec	15.6	12.5	16.3

*Compiled through 1975

**57-yr record ***21-yr record ****42-yr record

Table 2-12

ESTIMATED AVERAGE RELATIVE HUMIDITY AT MOUND FACILITY*
(Figures expressed in per cent)

Month	Hour (EST) 1 am	7 am	1 pm	7 pm
Jan	80	81	71	75
Feb	79	80	67	71
Mar	76	79	58	64
Apr	75	77	55	60
May	79	78	54	61
Jun	82	80	55	61
Jul	81	81	52	58
Aug	81	84	52	61
Sep	80	85	50	62
Oct	78	84	52	65
Nov	77	81	61	68
Dec	80	82	69	74
Annual	79	81	58	66

Based on 18 yr of record at Abbe Observatory, Cincinnati, Ohio and 17 to 43 yr of record at the Dayton, Ohio municipal airport.

*Compiled through 1975

Table 2-13

MEAN MIXING HEIGHTS AND WIND SPEEDS CALCULATED FOR DAYTON, OHIO*

Season	Morning Mixing Height (feet)	Morning Wind Speed (mph)	Afternoon Mixing Height (feet)	Afternoon Wind Speed (mph)
Winter	1830	16	2740	18
Spring	1820	15	5480	18
Summer	1230	9	5528	12
Autumn	1370	11	4416	15
Annual	1560	13	4540	16

*Compiled through 1975

Table 2-14

"FASTEST MILE" WIND SPEEDS ON RECORD*
AT DAYTON AND CINCINNATI, OHIO
(Speeds expressed in miles per hour)

Month	Dayton**	Abbe Observatory Cincinnati***
Jan	NW 60	SW 42
Feb	SW 72	SW 49
Mar	W 75	SW 49
Apr	SW 72	SW 47
May	SW 60	W 36
Jun	NW 78	W 40
Jul	NW 74	SW 43
Aug	W 70	W 38
Sep	W 65	SW 38
Oct	SW 56	SW 35
Nov	SW 68	SW 47
Dec	W 70	SW 41

*Does not include tornado winds

**43-yr record ***36-yr record

NOTE: Compiled through 1975

Table 2-15

MEAN NUMBER OF THUNDERSTORMS PER MONTH
IN DAYTON AND CINCINNATI, OHIO

Month	Dayton*	Cincinnati**	Abbe Observatory Cincinnati***
Jan	1	1	1
Feb	1	1	1
Mar	3	2	4
Apr	5	4	4
May	7	6	7
Jun	7	7	9
Jul	7	9	10
Aug	6	8	8
Sep	3	3	6
Oct	2	1	2
Nov	1	1	1
Dec	<1	<1	<1

*26-yr record **21-yr record ***42-yr record

NOTE: Compiled through 1975

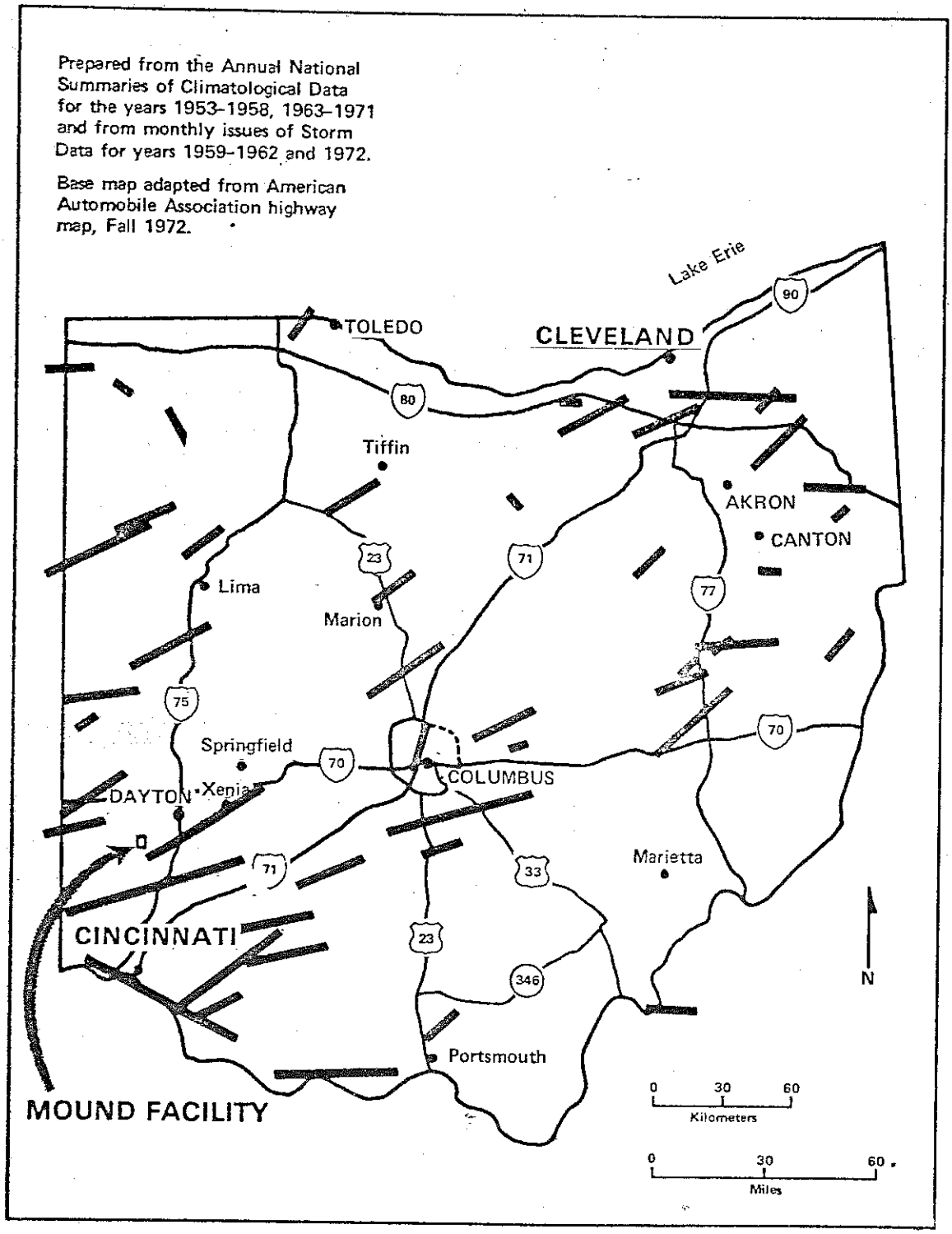


FIGURE 2-26 - Ohio Tornadoes 1953-1972.

indicated to be 1.55. The probability of a tornado hitting the site in any given year is calculated to be about 10^{-4}, frequency of once every 840 yr. Since Figure 2-26 is based on 1972 tabulations, it does not include the April 3, 1974, tornado at Xenia, which was one of the most severe recorded in the United States. This tornado is discussed further in Section 3.10.8.

Although hurricanes originating in the Caribbean area may greatly influence the weather in Ohio, there is no direct threat from these tropical storms, which lose strength as they move inland.

Essentially all Ohio is subject to damaging hailstones. The normal expectancy for the region is about two or three damaging hailstorms per year. Thus, due to their infrequent nature, there is no hailstone season as such, but the peak frequency (still less than one a month) for the region occurs during April. The most commonly reported hailstones are 1.3 to 1.9 cm (1/2 to 3/4 in.) in diameter and cause little or no property damage. However, much larger stones are associated with the more severe thunderstorms. Hard hail 2.5 cm (1 in.) in diameter and larger will cause heavy damage to roofs, will pit thin steel surfaces such as automobiles, and may break windows.

Ice Storms - Ice storms in the form of freezing rain and/or sleet occur occasionally in the region. One or two will be experienced each season; however, they usually result in such a slight accumulation of glaze ice that little or no damage is done other than slight inconveniences to traffic. Moderate to heavy ice storms occur about once every 4 or 5 yr and can be quite damaging to utility lines and trees, as well as being a serious traffic hazard.

Potential Influence of Mound Facility on Local Meteorology - Modifications to the local meteorology at the site, resulting from the existence and operation of the Facility, are minimal. The buildings and ancillary structures are expected to have some small influence on the local flow of air; specifically, some mechanical turbulence is expected downwind of the Facility in the lower layers. Also expected to be of minor influence is modification of the thermal radiative properties of the site area. Since there are no large cooling systems associated with the Facility, any changes to local temperature and humidity regimes are unmeasurable.

Onsite Meteorology - A program has been started to accumulate onsite meteorological data. A weather station was put into operation in 1973 to automatically accumulate data which will be used to update a diffusion model for atmospheric dispersion of airborne effluents.

Beginning in late 1978, Mound Facility will have Atmospheric Release Advisory Capability (ARAC). This capability is a computerized system for rapidly calculating the potential exposure of individuals in the event of an accidental airborne release of

toxic material. The central computer for ARAC is located at the Lawrence Livermore Laboratory at Livermore, California. In the event of an accidental airborne release of toxic material, Mound data will be used along with data from the U. S. Air Force Global Weather Control and the National Oceanic and Atmospheric Administration's Weather Services to plot the aerial movement of the release to the atmosphere.

2.3.7 FLORA AND FAUNA

Zoology - The most visible animal species in the Miami Valley are farm animals raised for food supply and breeding purposes, as well as for recreation purposes. However, the abundant woods of the area support many wild species of birds and mammals. Species commonly found in the Miami Valley and other nearby parts of Ohio are identified in Appendix A. There are no known records of rare and endangered species in the area.

Small wild animals are occasionally found on the Plant site because there are some wooded areas enclosed within the fence; these include rabbits, skunks, mice, rats and squirrels. Lizards, land turtles and several varieties of snakes have also been seen. Birds usually found on or near the Facility include sparrows, wrens, swallows, robins, pigeons, and an abundance of crows. Occasionally owls and hawks are also observed.

Botany - Much of the land near Mound Facility is under cultivation. The principal crops are soybeans and corn. Several areas on and near the site are heavily wooded, and in them an abundance of native flora can be found. Small trees and shrubs are common on the hilly areas; the flatter areas contain much scrub growth and grasses. A list of the trees and vegetation of the Miami Valley is found in Appendix A.

Endangered and Threatened Species - Federal and State of Ohio lists of endangered and threatened species have been reviewed, and personnel of the regional office of the U. S. Fish and Wildlife Service have been consulted. In consideration of the nature and habitats of those few species listed for the southwest Ohio area, the environmental requirements that would be supported by the land area occupied by the Facility, and the fact that the area has already been greatly altered through construction and use, it has been concluded that the probability of endangered or threatened species occurring onsite is extremely remote. There are no known records of endangered and threatened species for the site.

3.8 ARCHEOLOGY

Archeological Sites - The Facility site is immediately to the west of the Miamisburg Mound, a prehistoric Indian earthwork. To determine whether any sites of archeological importance might be situated on the property, the Curator of Anthropology for the Dayton Museum of Natural History was invited to inspect the plant grounds. No locations of specific archeological interest were identified. In the event of new construction in previously undisturbed areas, the ground will be examined for archeological significance.

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2-37. E. C. Eimutis, R. P. Quill and W. H. Westendorf, Development of an Atmospheric Diffusion Model for Optimum Location of Sampling Sites in the Mound Laboratory Environment, Final Report, Phase I, Monsanto Research Corporation, Dayton Laboratory, Dayton, Ohio (June 25, 1971).

2-38. Environmental Radioactive Surveillance Guide, June 1972, ORP/SID 72-2, U. S. Environmental Protection Agency, Office of Radiation Programs, Surveillance and Inspection Division, Washington, D. C.

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SECTION 3
ENVIRONMENTAL IMPACT

3.1 INTRODUCTION

Mound Facility is located at the southern edge of Miamisburg, Ohio, just within the city boundary and is immediately adjacent to a well-populated area on the north; a golf course and moderately populated area on the east; undeveloped agricultural land on the south; and an abandoned canal bed, a railroad right-of-way, a highway, and the Great Miami River on the west. The topography of the site causes all surface water from the industrial areas to flow into a central drainage ditch toward the west plant boundary, thence through offsite ditches and storm sewers into the Great Miami River. Thus, any site contamination carried by surface water cannot reach the residential areas, the golf course, or adjacent agricultural land. Effluents from the sanitary sewage plant and the radioactive waste treatment plant are carried by an underground pipe directly to the Great Miami River. Both effluent streams are continuously monitored at the plant boundary to determine that they satisfy all applicable federal, state, and local discharge standards.

Regional surface wind is predominantly from the southwest quadrant; consequently, any airborne effluents are dispersed over a moderately populated area and the adjacent golf course. All effluents from plant stacks are continuously monitored to help ensure that radioactive materials and other potentially toxic airborne substances emitted to the atmosphere are maintained "as low as practicable" (ALAP) and do not approach the limits of applicable health protection standards.

All testing of chemical explosive components is performed in confined steel tanks under controlled, muffled conditions so that no objectionable noise is produced.

The normal operations at Mound Facility produce minor air and water pollution, both chemical and radiological, and have a very slight impact on land use. This section describes the environmental impact of ongoing activities at Mound Facility. The impact evaluations include land use, consumption of resources and energy, operational radioactive and chemical effluents, waste disposal, radiological impact, socio-economic impact, and accident analyses.

3.2 LAND USE

The land acquired for the construction of Mound Facility was undeveloped agricultural land. The extremely rough terrain had prevented land use for crops. Only one portion, about 60,700 m^2 (15 acres) at the southeast corner, had been regularly used for pasturing a small number of farm animals. According to the U. S. Department of

Agriculture Soil Conservation Service, as of November 1976, no Prime and Unique Farmland Inventory for the State of Ohio has been prepared. Plans are under way for the preparation of such an inventory but completion will be sometime in the future. (Not yet available in October 1978.)

The Mound Facility plant site comprises approximately 728,000 m^2 (180 acres). In this area, 97 buildings have been erected which vary in floor area from over 9,300 m^2 (100,000 ft^2) to small service buildings of less than 9.3 m^2 (100 ft^2). The total floor area of all buildings combined approximates 80,250 m^2 (863,800 ft^2). There are 8.3 km (5.2 mi) of paved roads onsite, 0.5 km (0.3 mi) of railroad track (a spur from the Penn-Central line between Dayton and Cincinnati), and 43,700 m^2 (10.8 acres) of paved parking. An outline map of the Facility and vicinity is shown in Figure 3-1.

There is no known requirement for the land for any other purpose. The character of the land, except for approximately 60,700 m^2 (15 acres), is not suitable for any purpose other than the present industrial use. Return of the site property to its original condition, before construction of the Facility would not be practicable. If no longer required for DOE use, land and buildings could be transferred, after decontamination, to another federal agency or a state-supported institution or sold to a private organization for industrial use. (See Section 5.2)

3.3 RESOURCES AND ENERGY

Mound Facility as a research, development, and production operation uses water available from onsite wells and consumes electricity, natural gas, fuel oil, and production chemicals in normal day-to-day operations. The operation of a small fleet of motor vehicles also consumes gasoline.

3.3.1 PLANT WATER USAGE

The deep wells have a capacity that is considered adequate for all foreseeable water needs. The source of the water supply is the Buried Valley Aquifer beneath the plant site. The aquifer has a maximum known thickness of about 21 m (70 ft). Abundant direct recharge of the aquifer occurs chiefly as a result of precipitation and ensures that Facility operations are not depleting this resource.

The hydrology of the plant site is discussed in detail in Section 2.3.5.

During CY-1977 the Facility used 629 million liters (166 million gallons) of water from the three deep wells on the plant site. During CY-1978, it is estimated that approximately the same quantity will be used. Future usage is expected to remain at about the same level as the CY-1977 usage. The significant reduction in usage during the last four years (1200 million liters in CY-1974) is the result of the

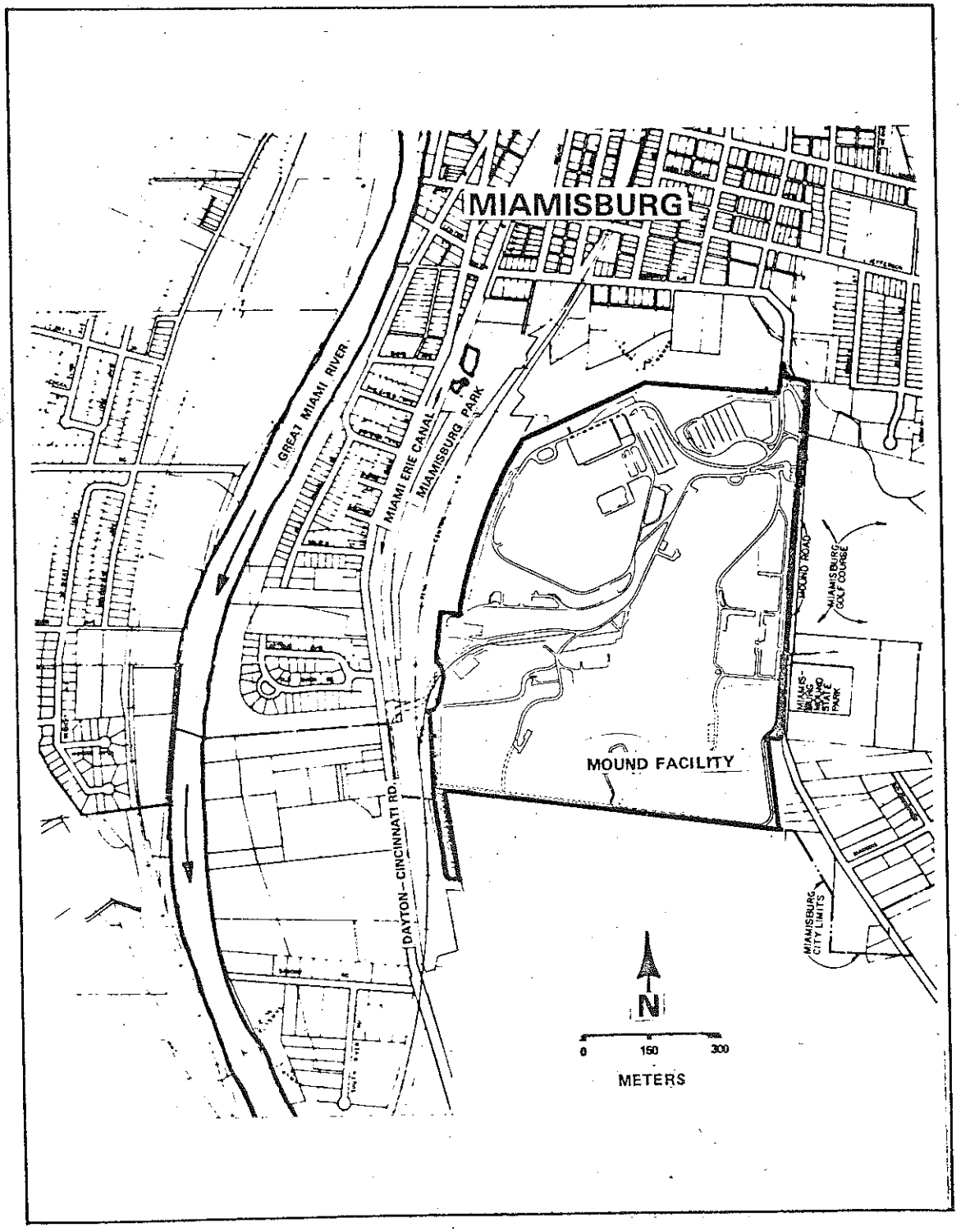


FIGURE 3-1 - Mound Facility and Vicinity.

installation of a recycle cooling water system and the elimination of the need for substantial amounts of diluent water in the radioactive waste water treatment facility. Past and projected use of water is plotted in Figure 3-2.

3.3.2 ENERGY AND FUEL USAGE

The plant used 40.1 million·kWh of electricity during CY-1977. This usage represented a decrease of 8.0% from CY-1974. An active Energy Conservation Program was started in November 1973 and is continuing to reduce energy consumption year by year. The past and projected use of electrical energy is plotted in Figure 3-3.

Natural gas and/or fuel oil are used to generate steam for general plant heating and some process needs. The plant used 2.86 million m^3 (233 million ft^3) of natural gas plus 4,165,000 liters (1,100,000 gallons) of fuel oil during CY-1977 (Figures 3-4 and 3-5). The contract for natural gas contains an interruptible demand clause and fuel oil is used as needed for the alternate energy source during the winter months. The Energy Conservation program which was begun in 1973 has effected a significant reduction in energy consumption. Projections of gas and oil usage are difficult to make because of the uncertainty of the future supply of natural gas. Alternative energy sources (coal, solar, etc.) may be considered in the future to meet Mound Facility requirements.

Fuel oil for the operation of boilers and diesel-powered emergency generators is stored in a 1,140,000-liter (300,000-gallon) storage tank and four smaller storage tanks with a combined capacity of 379,000 liters (100,000 gallons). The large aboveground tank is located within an earthen dike area which has a holding capacity of 150% of the storage tank volume. The four small tanks are located above grade-level adjacent to the Powerhouse. These tanks are contained within an earth mound which completely covers and contains them. The earthwork structure serves as storage tank reinforcement and secondary containment of the fuel oil in the unlikely event of a tank rupture. Therefore adequate precaution exists for the prevention of any significant amount of oil reaching the Great Miami River as a result of a break in any of the storage tanks.

The plant operates a fleet of 35 motor vehicles which used 147,000 liters (38,766 gallons) of "no-lead" gasoline during CY-1977. An increased commitment in the use of motor vehicles in CY-1977 resulted in a gasoline consumption increase of approximately 6% over CY-1976.

During 1977, the total number of vehicular trips transiting the facility was an average of 1390 during a 24-hour workday, which included an average of 190 trips by vehicles in the Mound Facility fleet. The breakdown of the trips by type of vehicle is as follows:

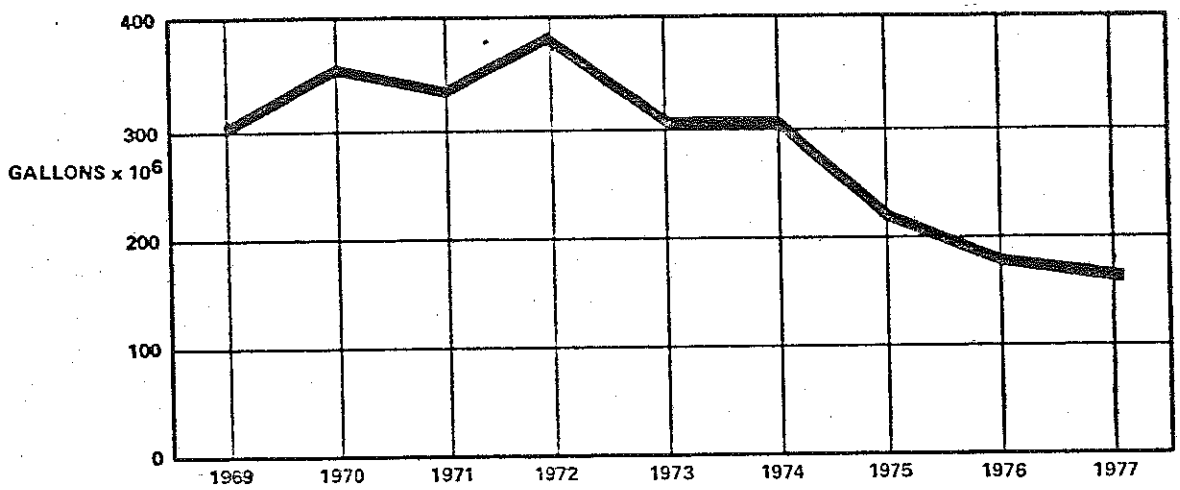


FIGURE 3-2 - Mound Facility Water Usage.

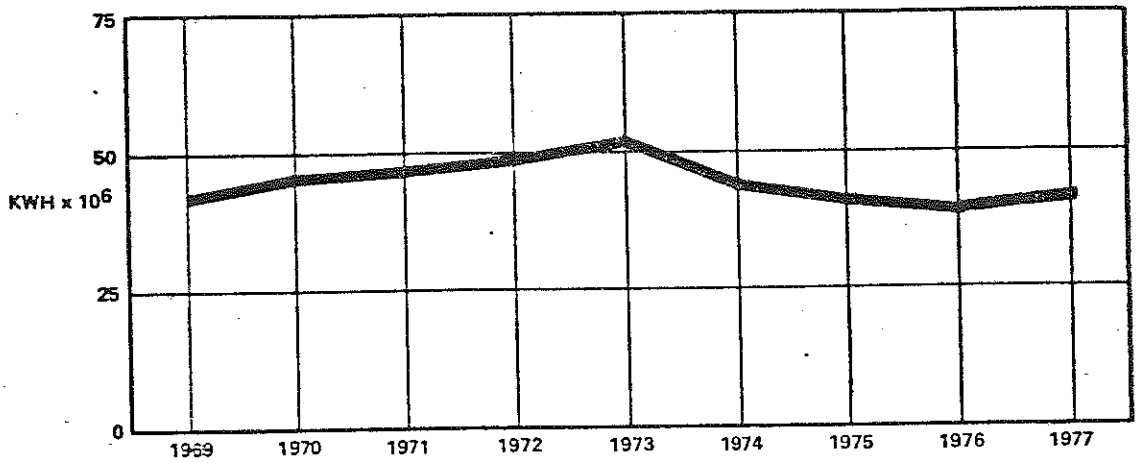


FIGURE 3-3 - Mound Facility Electric Power Consumption.

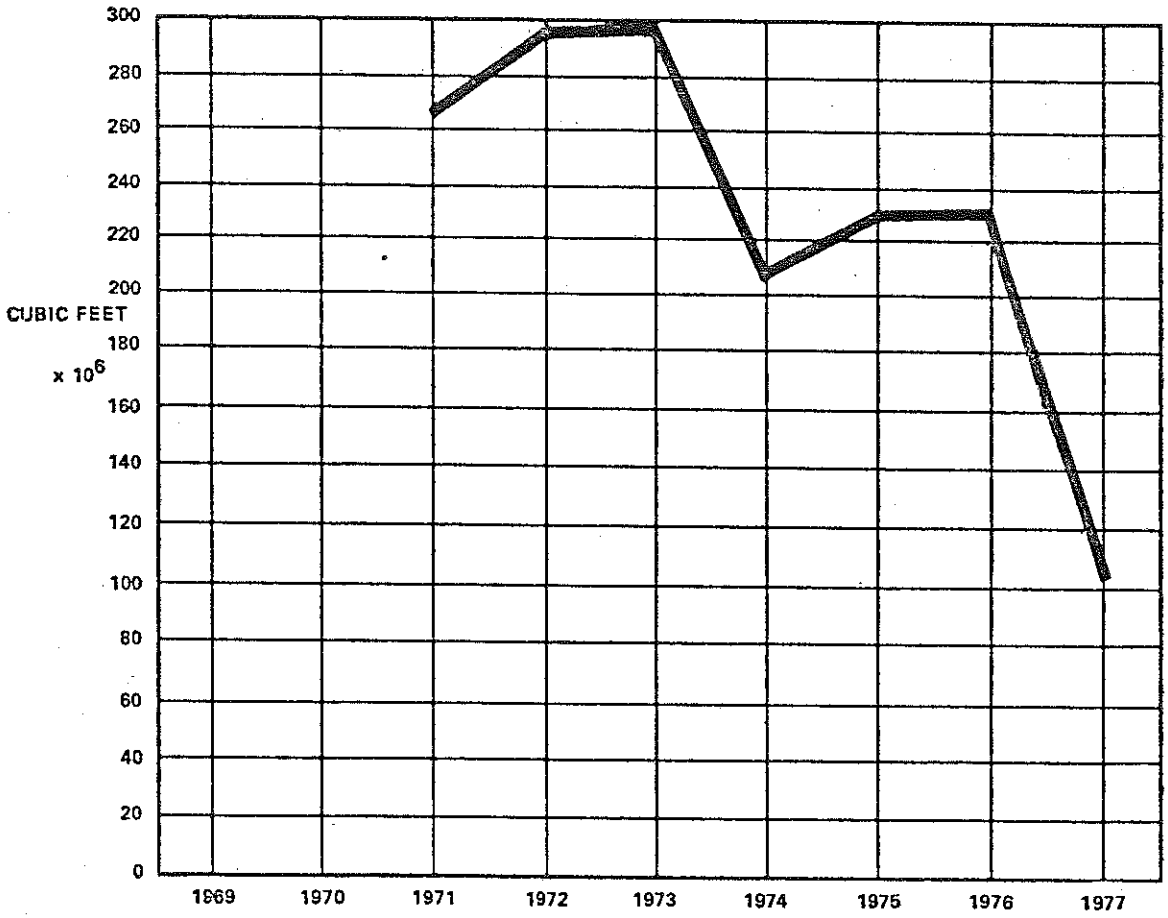


FIGURE 3-4 - Mound Facility Natural Gas Consumption. (It is impossible to project natural gas consumption in view of the fact the supplier has indicated that the supply may be terminated.)

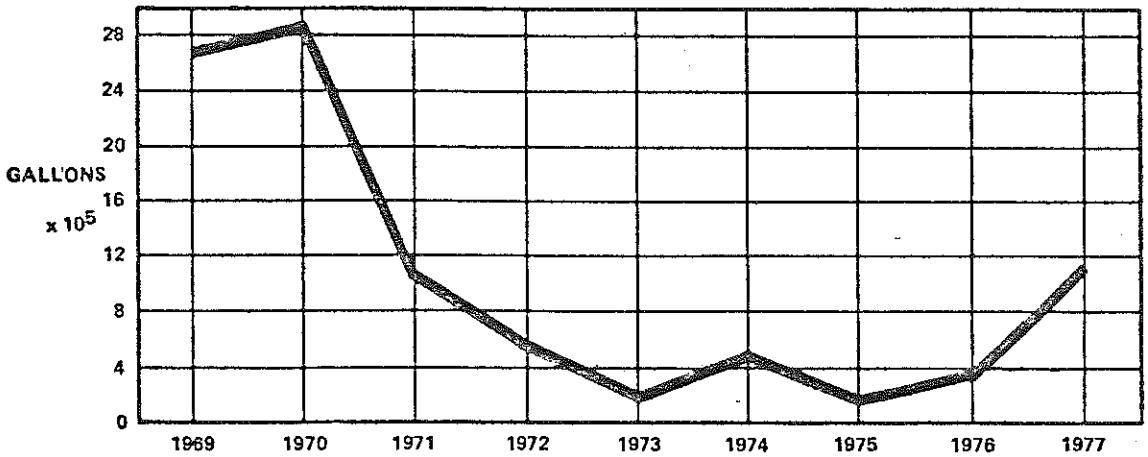


FIGURE 3-5 - Mound Facility Fuel Oil Consumption.

Trucks - diesel engine, gross vehicle weight over 17,000 lb, 40 trips (3%)
Trucks - gasoline engine, gross vehicle weight 12,500-17,000 lb, 80 trips (5%)
Cars and small trucks - gasoline engine, gross vehicle weight under 12,000 lb, 1270 trips (92%)

It is anticipated that there will be no significant change in the number of trips or fleet mileage during the next several years. During 1977, the fleet vehicles were driven 159,686 miles, the majority on the plant site.

3.4 CONSTRUCTION ACTIVITY

3.4.1 IMPACT

Construction activity at Mound will involve only excavation and grading for new buildings or additions to existing facilities. Only temporary minor environmental pollution is associated with or is the result of construction activity.

3.4.2 FUTURE CONSTRUCTION ACTIVITY

Major construction projects to be completed through FY-1979, itemized in Table 3-1, are either in evaluation, design, or construction stages. Their environmental impact will be similar to current operations; in several instances the projects are intended to further reduce the possibility of environmental pollution.

3.5 OPERATIONAL CHEMICAL EFFLUENT (NONRADIOACTIVE EFFLUENTS)

Manufacturing operations involving explosives produce a very limited amount of industrial liquid and airborne effluents, the principal process liquid being acetone. (Sanitary wastes are discussed in Section 3.6.1.) Waste liquors containing very small (grams per year) amounts of dissolved explosives are piped to open retaining/settling basins in which slow biodegradation of the explosives takes place and the acetone (approximately 4 m^3/year) evaporates. These materials are therefore not introduced into the Great Miami River. Because of the slow rate of biodegradation this method of disposal is not practical for large quantities of explosive waste.

Small quantities of wastes from operations where pyrotechnic materials are handled are dissolved in water to make the material inactive. These solutions after filtration are discarded by pouring onto the ground in a remote restricted area within the plant boundary since the inorganic salts in solution would not be removed by the plant's biological sewage treatment system. Natural weathering processes (hydrolysis) in the immediate soil render the chemicals harmless to the environment. Thus, none of the pyrotechnic materials reach the Great Miami River or the local aquifer.

Table 3-1

MAJOR PROJECTS TO BE COMPLETED DURING FISCAL YEARS 1979 THROUGH 1985

PROJECT TITLE	PLANNED FY OF COMPLETION	STATUS
Improved Treatment of Sanitary and Other Liquid Waste	1979	Authorized[1]
This project involves minor modifications to the Mound 492,000 liters/day (130,000 gallons/day) sanitary sewage plant to improve operations thereby reducing suspended solids in the effluent. The present solids discharge is an average of 12 mg/liter with a maximum of 33 mg/liter whereas the permit states it should be 10 mg/liter and 15 mg/liter respectively. This project will reduce the emission to meet this level.		
Overflow Pond	1979	Authorized[1]
A 20 million liter (5 million gallon) retention pond is being created by this project into which excess rain runoff will flow from the low flow retention basins. This earthen dam pond will also have the capacity to retain all Mound normal water effluents for 5 days should a contamination spill result which would necessitate entrapment. The retention time in this pond for rainwater outflows and any spills will effectively settle over 95% of all silt that would enter the pond. Although the present effluents do not exceed plutonium-238 or any other standards, this pond will collect most solids that might otherwise be carried by surface runoff during rainfall.		
Automatic Reset, Building Thermostats	1979	Authorized[1]
This project involves modifications to climatized ventilation systems in existing buildings. Exhaust air flows will be reduced where it is safely feasible to maximize air recirculation; hence, minimizing brine, cooling water, and steam usage. Timers will be installed on thermostats to reduce building temperatures to 10°C (50°F) during uninhabited times of the heating season. Creature comfort humidity control will be minimized. This project will have no impact on air pollutants emitted as no potentially contaminated air discharges will be affected. No significant reduction will result in the quantities of cooling water discharged, and this water is essentially clean.		
Ceramic Facility	1979	Authorized[1]
This facility will require the construction of a two-story building approximately 48 feet by 40 feet and the procurement and installation of mechanical and process equipment. This project will provide necessary space for process development programs relating to the utilization of ceramic materials in manufacturing programs. The construction and utilization of this facility will have no environmental impact.		

Table 3-1 (Continued)

PROJECT TITLE	PLANNED FY OF COMPLETION	STATUS
Site Drainage Improvements	1980	Authorized[1]
Storm water drainage from an eight-acre area adjacent to the plutonium processing facilities on the eastern part of the plant site will be improved. The changes will minimize silt runoff and direct the runoff water to the low-flow-retention basins. This project will minimize any hazards associated with the demolition of one of the buildings which had been used for the processing of plutonium and is no longer used.		
Fixation of Aqueous Tritiated Waste	1981	Requested[2]
This project involves a small building expansion to a tritium processing facility in which cement-filled drums will be prepared into which low-level tritiated liquid wastes will be introduced for solidification. The wastes will then be disposed offsite per accepted waste management methods (see Section 2.1.4.4). The process presently exists; however, it is to be expanded to meet needs and improve safe handling. The facility is designed to handle all low-level liquids generated. This is anticipated to be as much as 1,510 liters/week (400 gallons/week) containing less than one curie of tritium. No pollutants will be generated.		
Site Nuclear Materials Safeguards and Physical Security Improvements	1981	Requested[2]
This project consists of the procurement and installation of safeguards equipment and systems to prevent either unintentional or subversive removal of special nuclear materials from specified areas of five buildings. Provisions will include the installation of detection and assessment systems, and upgrading of the communication center.		
Relocate Water Storage Towers	1982	Requested[2]
This project consists of erecting a new 250,000 gallon water storage tower a safe distance south of the larger of two existing towers, tying the new tower into the existing distribution system, and dismantling the existing towers. The locations of the existing towers present potential hazards in event of a tornado which could possible topple a water tower onto a building housing operating personnel.		

Table 3-1 (Continued)

PROJECT TITLE	PLANNED FY OF COMPLETION	STATUS
Plutonium Building - Site Stabilization	1982	Requested[2]
This project involves the demolition and removal of a no-longer-used plutonium-238 handling building and associated storage tanks for contaminated liquids and the removal of some earth in the immediate area which is lightly contaminated. This project will remove over 95% of the radioactivity which remains as surface and buried contamination at this site. Although the building as it presently exists is not contributing plutonium to the environment in any significant amount, it does contribute over half of Mound's plutonium emissions. Plans are being made to ensure the containment of the plutonium-238 during the removal of the building and restoration of the site to a stable nonpolluting condition.		
Decontamination of Plutonium Processing Facilities	1985	Requested[2]
The project will decontaminate all facilities which have been involved in the processing and recovery of plutonium-238 and in the first encapsulation of fuel forms for heat sources. These activities will be terminated at Mound Facility at the end of FY-1979. All contaminated equipment will be removed and shipped to an approved receiving site. Rooms will be decontaminated. The project was initiated in unused parts of the facilities in FY-1978. This project will reduce to insignificance the potential for the release of contamination from these facilities.		

[1]Authorized - Approved by the U. S. Congress as a portion of the DOE budget.

[2]Requested - Requested by Mound Facility of ALO for consideration or inclusion in the DOE budget.

The Mound steam power supply has been converted from fuel oil to natural gas on an interruptable basis. During unusually cold weather, natural gas supply to Mound is interrupted and fuel oil with much less than 1% sulfur content is burned. Except for these occasions, virtually all sulfur dioxide emissions have been eliminated. None of the present operations at Mound Facility involves amounts of materials which would lead to significant particulate, carbon monoxide, photochemical oxidant, or hydrocarbon emissions from stationary sources. Therefore, no sampling for these nonradioactive pollutants is done at this time.

Less than 510 kg (1125 lb) of explosives and burnable wastes contaminated with explosives are burned annually in small batches with the formal knowledge and concurrence of the Montgomery County Combined General Health District and the Regional Air Pollution Control Agency of the Ohio EPA.

Air effluents from nuclear operations are filtered through multiple stages of High Efficiency Particulate Air Filters (HEPA) to remove essentially all radioactive particulates (see Section 3.7); other types of particulates and dust are removed as well. Total organics discharged from nuclear facilities ranged from 0.05 to 3.3% of the Ohio EPA standard in CY-1977. From facilities other than explosives and nuclear, total organics discharged ranged from 0.56 to 13.0% of the Ohio EPA standard.

Liquid discharges from nuclear operations are discussed in Sections 3.7.1 and 3.7.2. The disposal of the industrial waste solvents and other waste chemicals from nuclear operations, as well as from all activities which support nuclear and explosives operations, is discussed in Section 3.6.2.

Mound Facility was issued a discharge permit under the National Pollutant Discharge Elimination System (NPDES). The permit was issued by Region V of the USEPA effective July 1, 1975. Each of the two effluent streams from Mound which discharge to the Great Miami River has limitations specified by the discharge permit. The discharge from outfall number 001 includes the discharge from the sanitary waste treatment plant, radioactive waste treatment facility, single-pass cooling water, zeolite softener backwash, and some storm water runoff. The discharge from outfall number 002 consists of single-pass cooling water, cooling-tower blowdown, boiler-plant blowdown, zeolite softener backwash, and most of the storm water runoff. A 24-hr composite sample of each effluent stream is automatically collected daily. The volume of samples collected is proportional to the flow in the stream. The results of effluent stream analyses for 1977 are summarized in Table 3-2. Two exceptions to the permit limitations occurred during CY-1977. The exceptions were slightly elevated suspended solids discharged from outfall 001 during July. These waterborne effluents had no significant effect on the River since the River flow, even under low-flow conditions, was approximately 350 times the maximum flow discharge from Mound during CY-1977. These data show that the Mound releases to the Great Miami River did not cause the Ohio Stream Standards to be exceeded. (The Daily Maximum concentration of 24.6 mg/liter for suspended solids at outfall 002 occurred during the first half of CY-1977 and was

Table 3-2

CY-1977 NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT DATA

Parameter		Number Samples	Minimum	Daily Maximum	Daily Average
		Outfall 001			
Flow, MGD[b,d]	Reported	Continuous	0.07	0.34	0.18
	Permit through 6/30		-	0.92	0.53
	Permit as of 7/1		-	0.92	0.53
BOD_5	Reported	88	0.3	7.3	2.2
	Permit through 6/30		-	45	30
	Permit as of 7/1		-	15	10
Fecal Coliform[c]	Reported	12	ND[a]	52	15
	Permit through 6/30		-	400	200
	Permit as of 7/1				
Suspended Solids	Reported	104	1.2	32.5	12
	Permit through 6/30		-	45	30
	Permit as of 7/1		-	15	10
Dissolved Oxygen	Reported	240	5.2	10.9	8.4
	Permit through 6/30		-	-	>5
	Permit as of 7/1		-	-	>5
Residual Chlorine	Reported	52	ND	0.6	0.1
	Permit through 6/30		-	0.8	-
	Permit as of 7/1		-	0.5	-
Oil and Grease	Reported	52	ND	8.1	1.3
	Permit through 6/30		-	10	-
	Permit as of 7/1		-	10	-
pH	Reported	240	6.2	9	-
	Permit through 6/30		6	9	-
	Permit as of 7/1		6	9	
		Outfall 002			
Flow, MGD[b,d]	Reported	Continuous	0.18	0.90	0.38
	Permit through 6/30		-	-	0.53
	Permit as of 7/1		-	-	0.53
Suspended Solids	Reported	68	3.0	24.6	10.6
	Permit through 6/30		-	25	20
	Permit as of 7/1		-	20	15
Dissolved Oxygen	Reported	22	5.1	12	9.2
	Permit through 6/30		-	-	>5
	Permit as of 7/1		-	-	>8 (Oct-Apr)
			-	-	>5 (May-Sept)
Residual Chlorine	Reported	38	<0.05	<0.05	<0.05
	Permit through 6/30		-	0.10	-
	Permit as of 7/1		-	0.05	-
Oil and Grease	Reported	40	ND	7	0.8
	Permit through 6/30		-	10	-
	Permit as of 7/1		-	10	-
pH	Reported	180	6	9	-
	Permit through 6/30		6	9	-
	Permit as of 7/1		6	9	-
Dissolved Solids	Reported	65	242	2918	913
	Permit through 6/30		-	3000	2000
	Permit as of 7/1		-	2000	1500

[a]ND - none detectable

[b]MGD - million gallons per day

[c]Values for fecal coliform are number of coliform per 100 ml of water. All other values are in milligrams per liter, except pH.

[d]It is to be noted that the amount of water leaving the Facility site as effluent is greater than the water usage (Figure 3-2). Water "use" is that pumped from Mound's wells. Effluent water includes storm runoff water.

within the limitation. The high Daily Maximum for dissolved solids at outfall 002 also ırred during the first half of CY-1977 and was within the limitation.)

3.6 WASTE DISPOSAL (NONRADIOACTIVE)

Mound Facility has established an industrial waste program for the proper disposal of all industrial wastes. Radioactive wastes are discussed separately in Section 3.7.

3.6.1 LIQUID WASTES

Sanitary Wastes - A newly constructed, activated sludge sanitary sewage treatment plant which serves the site has a capacity of 490,000 liters/day (130,000 gallons/day). This facility provides more than adequate capacity for the foreseeable future. The treatment consists of primary settling, aeration, sludge digestion, clarification, and chlorination. After processing, the sanitary sludge is air dried and packaged for offsite disposal, and the sanitary effluent is discharged through a closed pipe to the Great Miami River. The quality of the sanitary effluent is monitored continuously to document compliance with the National Pollutant Discharge Elimination System permit issued to Mound Facility.

3.6.2 WASTE SOLVENTS

ations at Mound Facility used approximately 13,600 liters (3600 gallons) of organic solvents in addition to those required for processing explosives during CY-1977. The most widely used organic solvents are acetone, ethyl alcohol, trichloroethylene, toluene, and Freon TE and TF. Used solvents are accumulated for discard in 5-gallon safety cans and in 55-gallon drums. A commercial industrial waste disposal firm disposed of 8300 liters (2200 gallons) of these accumulated wastes. Forty-nine hundred liters (1300 gallons) are estimated to have evaporated during the year while being used in fumehood-protected operations and were released as airborne material, and 370 liters (100 gallons) were released as liquid effluents. The estimated 100 gallons released over the year in liquid effluent result from discards into laboratory sinks and fumehoods from intermittent use of small quantities not feasible for accumulation and collection. The sinks, fumehoods , and such disposal points are part of the Mound sanitary waste system and discharges receive treatment in the sanitary waste disposal plant. The effluent from the treatment plant is monitored. The non-volatile solvents would be detected by the oil and grease analysis and the biodegradable solvents, that is acetone and alcohol, would be included in the BOD analyses. Neither of these parameters exceeded NPDES limitations during CY-1977.

The commercial service disposed of the accumulated liquid waste using a Fluidized Bed ncinerator. Emissions from the incinerator were adequately scrubbed with a high-energy venturi scrubber.

Other Liquid Wastes - Annual accumulations of waste cutting-oils, discarded excess paints and thinners, and waste caustic solutions amount to about 1000, 1000, and 250 gallons, respectively. These liquid wastes are collected and disposed of by a commercial service along with the solvents. Spent plating-bath solutions of chromic acid, cadmium cyanide, nickel sulfate, nickel chloride, black oxide, and copper cyanide are also disposed of by a commercial industrial waste disposal firm. First rinse and clean-up waste from the preparation of fresh plating baths are used in new bath makeup; therefore these chemical solutions are never introduced to the Facility liquid effluent stream.

3.6.3 SOLID WASTES

Waste Explosives - Waste and excess explosives are destroyed by open burning according to U. S. Army Materiel Command Regulation 385-100 (Army Ordnance Manual). Such burning is supervised to ensure all aspects of safety and proper security of the material. The burning site is fenced in. All access is controlled. Although only small quantities of material are burned, the burning site is located in a remote area of the Facility grounds to ensure safe distances for plant personnel and property as well as persons and property outside the plant. This operation is being conducted with the knowledge and concurrence of the Ohio EPA and Montgomery County Combined General Health District.

Wastes consist of small amounts of mild detonating fuse (MDF), pyrotechnic materials, rejected components containing small amounts of explosives, and operational waste such as tissue and cardboard that have been contaminated with explosives or pyrotechnics. Only one type of waste is burned at a time. The amounts of materials that may be burned at one time are shown in Table 3-3.

Table 3-3

LIMITS FOR BURNING EXPLOSIVE WASTES

Material	Pounds Per Pan	Pans Per Burn
Explosive-Contaminated Flammables	20	4
Fabricated Components	10	4
Mild Detonating Fuse	10	4
Pyrotechnic Material	1	3
Bulk Explosives*		

*In train no more than 6 inches wide by 1-1/2 inches deep in any convenient length as long as adjacent portions are at least 5 feet apart.

he ...nts of explosive wastes burned in CY-1977 are shown in Table 3-4. These onsisted of small amounts of waste materials, such as explosive-contaminated paper and lastic trash. The explosives content is estimated at less than 37% of the 509-kg 1121-pound) total.

he major products resulting from the burning of explosive wastes are carbon dioxide and water vapor. The amounts of products designated as pollutants are shown in Table 3-5.

Table 3-4

EXPLOSIVES WASTES BURNED FOR CY-1977

Material	Amount (kg)	Amount (lb)	Number of "Burns"
Bulk Explosives	0.05	0.1	1
Pellets and Detonators	197	434	12
MDF (Mild Detonating Fuse)	0.64	1.4	7
Pyrotechnic Materials	16.2	35.8	20
Paper and Plastic Contaminated with Explosives	295	650	8
Total	508.89	1121.3	48

Table 3-5

POLLUTANTS RELEASED TO THE ENVIRONMENT FROM THE BURNING OF EXPLOSIVE WASTES FOR CY-1977

Nature of Pollutant	Method of Release	Total Quantity Released (kg)*	Average Concentration in Air ($\mu g/m^3$)**	Ohio Ambient Standard ($\mu g/m^3$)
Particulates	Airborne	0.91	0.003	60
Carbon monoxide	Airborne	3.8	0.014	10000
Nitric oxide	Airborne	9.4	0.025	100
Nitrous oxide	Airborne	1.8	0.005	100
Nitrogen dioxide	Airborne	2.5	0.007	100

*Total combustion products released by explosives wastes were determined experimentally; these data were used to calculate the total quantity of each pollutant released during CY-1977.

**The average concentration of each pollutant was calculated for typical (average) burn operations and represents the maximum concentration in the ambient air immediately above the waste as it burns.

Waste Paper - Waste paper was transported during CY-1977 to a nearby reclamation facility at Franklin, Ohio, for processing and recycling.

Waste Wood and Metals - Waste wood and metals are segregated on the plant site and sold periodically to salvage dealers.

Garbage - The collection and disposal of garbage is contracted to a commercial landfill company whose operation is licensed by Montgomery County and approved by the Ohio EPA.

3.6.4 TEST-FIRING OPERATIONS

The performance of explosives and explosive devices is determined in firing tests. The devices or test units are set up in a firing chamber, a large steel tank with a sealable door for access of personnel, ports for instrumentation, and a restricted exhaust opening containing baffles and/or filters for the release of the gaseous products of explosion to the outdoors, while the particulate matter is retained in the tank. The chemical products of explosion are gaseous: carbon dioxide, water vapor, and oxides of nitrogen, all of which are dispersed into the atmosphere by the explosive forces. Testing operations released 0.45 kg (1 lb) of nitrogen oxides to the atmosphere during CY-1977.

3.6.5 PROCESSING OF HIGH EXPLOSIVES

The explosives processing buildings are located in a section of the site with a low population density. Both buildings house processes involving significant amounts of explosives and flammable solvents. Should an explosion occur, major damage would be concentrated in the immediate vicinity and the explosion would not be propagated to adjacent rooms or areas; the shock wave would dissipate in the air and cause very limited damage outside the incident zone. An explosion in this area would blow out windows and the door of the processing room and could rupture the roof above the room.

One of the explosives processing buildings house[illegible] other operation where an explosion might occur. This is a dry blending operation f[illegible] [illegible].7-kg (50 lb) batches of explosive. The bay in which the operation is conducted has three explosion-resistant walls and a ceiling of heavy concrete and is covered with thick layers of earth; the fourth wall is steel and will blow out upon explosion. The area in which the blowout is directed is fenced and, for safety, is kept clear of personnel during operation of the blender. Effects of an explosion would be localized within the fenced area and the shock wave would dissipate in the air and cause very little damage outside the incident zone.

3.7 RADIOLOGICAL EFFLUENTS AND IMPACT

Mound Facility missions which have contributed to or have had the potential to make some impact on the environment are those which involved the processing of specific

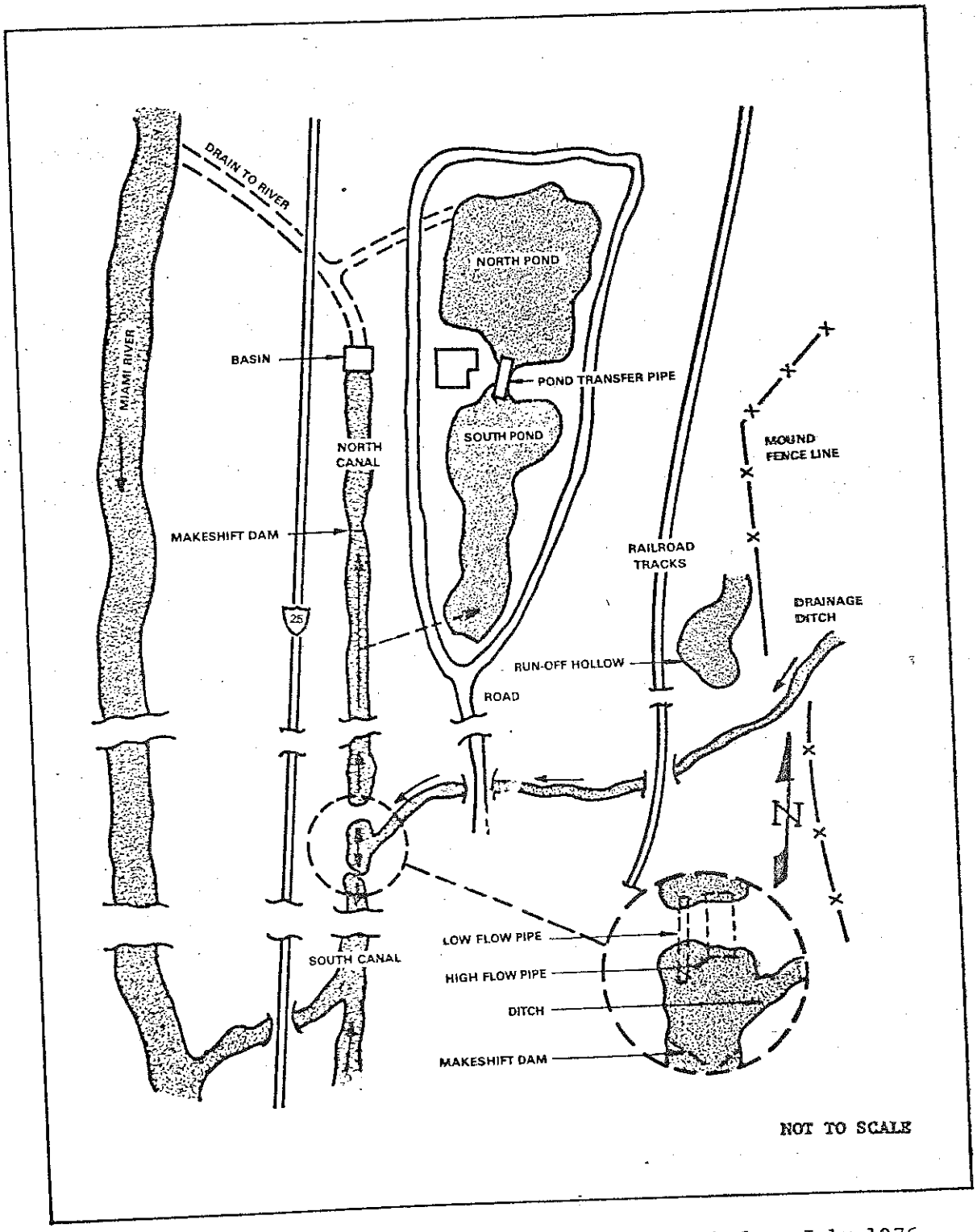


FIGURE 3-16 - Waterways adjacent to Mound Facility before July 1976.

Table 3-20

CONCENTRATION OF PLUTONIUM-238 IN THE GREAT MIAMI RIVER FOR CY-1977

Location[a]	Number of Samples[b]	Range[c] (10^{-10} μCi/ml)	Average[d] (10^{-10} μCi/ml)	Percent of RCG[e]
1	210	<LDL	<0.10 ± 0.01	<0.0005
2	210	<0.1 - 0.21	<0.16 ± 0.02	<0.0008
3	210	0.16 - 0.23	0.20 ± 0.01	0.0010
4	210	<0.1 1.5	<0.80 ± 0.05	<0.0040
5	210	<LDL	<0.10 ± 0.03	<0.0005

[a]Locations are given in Figure 3-7.

[b]Two composite large volume water samples are analyzed for each location from water collected during CY-1977.

[c]Lower Detection Limit (LDL) for ^{238}Pu in water is 0.1×10^{-10} μCi/ml which is 0.0005% of the RCG.

[d]Error limits are counting statistics only at 95% confidence level.

[e]Radioactivity Concentration Guide (RCG) = $20,000 \times 10^{-10}$ μCi/ml for the general population and the soluble form of plutonium-238.

Table 3-21

PLUTONIUM-238 IN SILT FROM THE GREAT MIAMI RIVER FOR CY-1977

Location[a]	Samples	^{238}Pu Range[b] (10^{-6} μCi/g)	^{238}Pu Average[c] (10^{-6} μCi/g)
1	2	0.51 - 1.1	0.8 ± 0.05
2	2	0.48 - 14.4	7.4 ± 0.07
3	2	2.6 - 2.8	2.7 ± 0.12
4	2	4.4 - 5.1	4.7 ± 0.15
5	2	<0.3 - 1.6	<0.9 ± 0.04

[a]Locations are given in Figure 3-7.

[b]Lower Detection Limit (LDL) for ^{238}Pu in silt is 0.3×10^{-6} μCi/g.

[c]Error limits are counting statistics only at 95% confidence level.

ıoisotopes. Environmental monitoring has been conducted routinely for the assay of radioactive substances since Mound Facility commenced its operations in 1949. This section discusses the environmental impact, measured by the monitoring program, in terms of air, water, soil, vegetation, and foodstuffs contamination, and estimates the resultant radiation exposure (dose commitment) to individuals, population groups, and the total population surrounding the Facility in an 80-km (50-mi) radius. The most recent annual data available, that for 1977, are used in this analysis. The disposal of radioactive waste materials is also addressed in this section.

3.7.1 TRITIUM

The processes involving tritium and resultant waste effluents are described in Section 2.1.4.1. The environmental concern with tritium involves its physical characteristics with human and animal biological response. Research and development programs at the Facility utilize tritium, the heaviest isotope of hydrogen, in both elemental and combined forms. Elemental tritium released to the atmosphere is slowly converted to oxide since the tritium exchanges with normal light hydrogen in atmospheric moisture. Tritium chemically combined in atmospheric moisture is rapidly assimilated into human and animal bodies through respiration and skin contact, whereas elemental tritium is not appreciably incorporated either by absorption or respiration. (3-1,3-2) Therefore, the Radioactivity Concentration Guide (RCG) used to determine the degree of environmental impact of tritium operations is that for tritium in the oxide form.

Since tritium has a radiological half-life of 12.3 years, any contribution to the environmental load remains for an extended period of time. Offsetting this significant environmental parameter is the fact that tritium emits only weak beta particles and, when taken into the human body, its residence is brief (a biological half-life of ∿9 days) and it is eliminated rapidly. It is considered to be a relatively low-hazard radionuclide and the RCG has been set accordingly. The toxicity of tritium is discussed in Section 2.1.4.1

Airborne Effluent Impact - In order to protect personnel working with tritium, work is performed in gloveboxes containing an inert atmosphere in rooms with high-velocity airflows. The exhaust air from work areas is discharged to the ambient environment at high velocity through tall stacks to obtain optimum atmospheric dispersion. The location of the tritium and plutonium stacks is shown on Figure 2-9. The exhaust ventilation from gloveboxes and process equipment which contain small concentrations of tritium is routed to the atmosphere through a catalytic recovery system in which the tritium is removed from the effluent stream and recovered as tritiated water. Tritium discharges to the environment are therefore maintained at a minimum level. Total tritium discharge to the atmosphere during CY-1977 was 4896 curies (∿0.5 gram or ∿1.7 liters). Annual tritium stack discharges for the past eight years were:

CY-1970	17.947 grams	CY-1974	1.003 grams
CY-1971	7.350 grams	CY-1975	0.886 grams
CY-1972	3.048 grams	CY-1976	0.621 grams
CY-1973	1.533 grams	CY-1977	0.490 grams

The most important meteorological factors that would influence the environmental impact of airborne releases of tritium are the average wind speed, average wind direction, and atmospheric stability. These meteorological factors are discussed in Section 2.3.6. The average wind speed is approximately 3.6 m/sec (8 mph) and the predominant wind direction is out of the southwest. Mound Facility's offsite tritium air sampling stations are located at optimum sites to measure the Facility's contribution to the environment. The routine air-monitoring program is supplemented by a mobile monitoring laboratory which may be used to assist in determining the impact of an accidental release of tritium to the environment.

A description of the offsite air sampling program, including locations monitored, is contained in Section 2.1.4.7. Table 3-6 presents a summary of air monitoring results for CY-1977. Figure 3-6 shows the locations of the air sampling stations. As may be seen from Table 3-6, the average values observed range from $<0.40 \times 10^{-11}$ µCi/ml to $<1.24 \times 10^{-11}$ µCi/ml. These values are approximately <0.006% and <0.018%, respectively, of the Radioactivity Concentration Guide of 7000×10^{-11} µCi/ml. The background concentration of tritium in air for the Miamisburg area in CY-1974 was approximately 0.2×10^{-11} µCi/ml (3-3) and is expected to be the same for CY-1977.

Table 3-6

CONCENTRATION OF TRITIUM OXIDE IN AIR AT OFFSITE SAMPLING LOCATIONS FOR CY-1977

Location[a]	Samples	Range[b] (10^{-11} µCi/ml)	Average[c] (10^{-11} µCi/ml)	Percent of RCG[d]
101	52	<0.29 - 2.16	<0.64 ± 0.43	<0.009
102	52	<0.29 - 9.73	<1.24 ± 0.44	<0.018
103	52	<0.29 - 2.77	<0.72 ± 0.43	<0.010
104	52	<0.29 - 1.27	<0.44 ± 0.42	<0.006
105	52	<0.29 - 1.45	<0.40 ± 0.42	<0.006
108	52	<0.29 - 0.94	<0.37 ± 0.42	<0.005
110	52	<0.29 - 1.22	<0.40 ± 0.42	<0.006
111	52	<0.29 - 7.53	<0.62 ± 0.43	<0.009
112	52	<0.29 - 2.10	<0.59 ± 0.43	<0.008
115	52	<0.29 - 2.66	<0.56 ± 0.42	<0.008
118	52	<0.29 - 2.37	<0.57 ± 0.42	<0.008
123	52	<0.29 - 4.36	<0.88 ± 0.43	<0.013
124	52	<0.29 - 5.98	<0.94 ± 0.43	<0.013

[a]Locations are shown on Figure 3-6.

[b]Lower Detection Limit (LDL) for tritium oxide in air is 0.29×10^{-11} µCi/ml which is 0.004% of the RCG.

[c]Error limits include only coutning statistics at 95% confidence level.

[d]Radioactivity Concentration Guide (RCG) = 7000×10^{-11} µCi/ml for the general population and for soluble form of tritium.

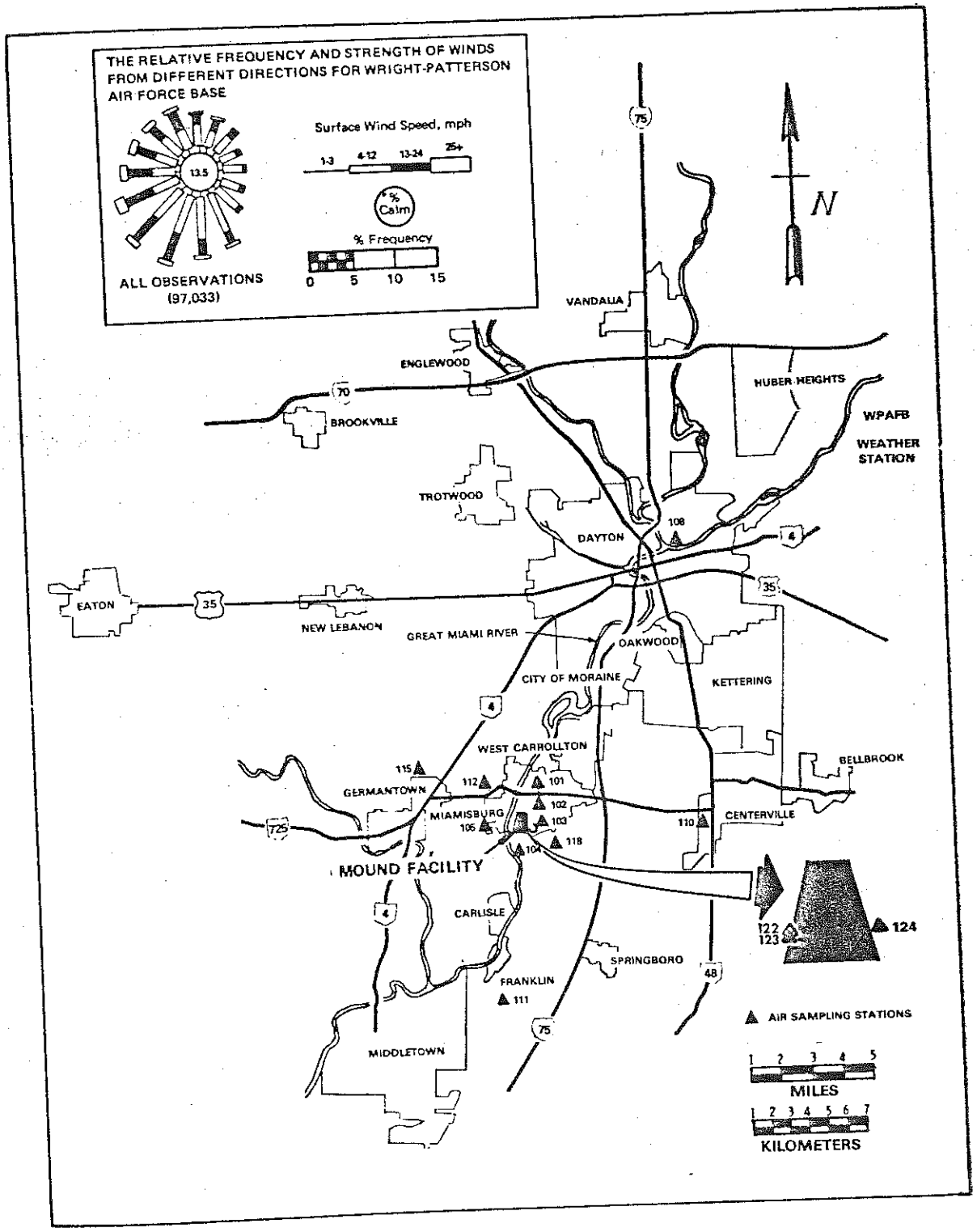


FIGURE 3-6 - Offsite Air Sampling Locations.

Foodstuffs and vegetation samples in the vicinity of Mound Facility are analyzed to determine the possible uptake and concentration of tritium in plant life and milk as a result of airborne releases from the Facility.

A description of the foodstuffs and vegetation sampling program is given in Section 2.1.4.7. However, no data are available for the tritium concentration in aquatic life for CY-1976 or CY-1977. Values in CY-1975 averaged $<4.4 \pm 2.9 \times 10^{-6}$ μCi/g. Also, no data are available for the tritium concentration in field crops for CY-1977. Values in CY-1976 averaged $<3.0 \pm 3.0 \times 10^{-6}$ μCi/g. It should be noted that there are no RCG's for foodstuffs. Water RCG's are used for reference purposes (See Reference 3-4). Table 3-7 presents the results of the milk sampling done for CY-1977. Where possible, sampling sites were chosen at maximum deposition locations predicted on the basis of the atmospheric diffusion model developed for the Facility. As may be seen in the table, the values observed ranged from 0.27×10^{-6} μCi/g to 0.45×10^{-6} μCi/g. The values ranged from 0.027% to 0.045% of the Radioactivity Concentration Guide. Since there is no RCG specified for foodstuffs/vegetation, the normally accepted procedure of comparing the data to the RCG for water (1000×10^{-6} μCi/ml or g) was used. (3-4) The U. S. Environmental Protection Agency's established background concentration in drinking water in 1975 was approximately 0.02×10^{-3} μCi/ml. (3-5); this value is used for drinking water and foodstuffs.

Water samples are collected from local area ponds and streams by Mound Facility personnel to determine whether there is any measurable concentration of tritium in these waters attributable to Facility airborne effluents. A description of this sampling program is given in Section 2.1.4.7. Tables 3-8, 3-10, and 3-11 summarize the results of the sampling program for CY-1977. (Locations are shown in Figure 3-7).

Table 3-7

TRITIUM IN FOODSTUFFS AND VEGETATION FOR CY-1977

Type Sample	Number of Samples	Range[a] (10^{-6} μCi/g)	Average[b] (10^{-6} μCi/g)
Milk	4	0.27 - 0.45	0.38 ± 0.23

[a]LDL for tritium in milk = 0.16×10^{-6} μCi/g.
[b]Error limits include only counting statistics at 95% confidence level.

Table 3-8

SUMMARY OF SURFACE WATER MONITORING FOR TRITIUM FOR CY-1977

Location[a]	Number of Samples	Range[b] (10^{-6} µCi/ml)	Average[d] (10^{-6} µCi/ml)	Percent of RCG[c]
10	3	<0.4 - 1.4	<0.8 ± 0.6	<0.08
11	4	<0.4 - 0.9	<0.6 ± 0.6	<0.06
12	4	<0.4 - 0.7	<0.5 ± 0.6	<0.05
13	4	1.0 - 1.3	1.1 ± 0.6	0.11
14	4	<0.4 - 1.4	<1.1 ± 0.6	<0.11
15	4	0.8 - 1.5	1.3 ± 0.6	0.13
16	4	0.6 - 1.0	0.8 ± 0.6	0.08
17	3	1.5 - 2.3	1.9 ± 0.6	0.19

[a]Locations are shown in Figure 3-7.

[b]Lower Detection Limit (LDL) for tritium in water is 0.4×10^{-6} µCi/ml which is 0.04% of the RCG.

[c]DOE Radioactivity Concentration Guide (RCG) which is compared to tritium concentration in water not used for drinking purposes = 1000×10^{-6} µCi/ml for the general population and soluble form of tritium.

[d]Error limits are counting statistics only at 95% confidence level.

As may be seen in the table, the average values observed ranged from $<0.5 \times 10^{-6}$ to 1.9×10^{-6} µCi/ml, compared to the RCG of 1000×10^{-6} µCi/ml. The values thus ranged from <0.05% to 0.19% of the RCG. The background concentration for tritium in surface water in CY-1977 is assumed to be approximately $0.5 \times 10^{-6} \pm 0.2 \times 10^{-6}$ µCi/ml. (3-5)

The most significant pathway for exposure to man as a result of Mound Facility's airborne releases of tritium oxide is the direct pathway via inhalation and skin absorption. Estimates of dose commitments based on measured concentrations in the environment during CY-1977 are given in Table 3-9. Dose commitment values are given for the whole body (which is the critical organ for tritium oxide) and represent the radiation dose received during CY-1977.

The dose commitment estimates within 32 km (20 mi) of Mound Facility were based on environmental monitoring data for CY-1977. The estimate of dose which could be received by the Maximum Individual in the Offsite Population was based on the single highest annual average of all onsite continuous air sampling stations since the samplers are in close proximity to the site boundary.

The maximum dose to Population Group - Offsite was calculated from the single highest annual average of all offsite continuous air sampling stations. In line with the current thinking on the radiological safety guides for power reactors in expressing exposure in total "person rem" to the population out to a distance of 80 km, Table 3-9 also presents the effect of airborne releases of tritium from Mound Facility operations.

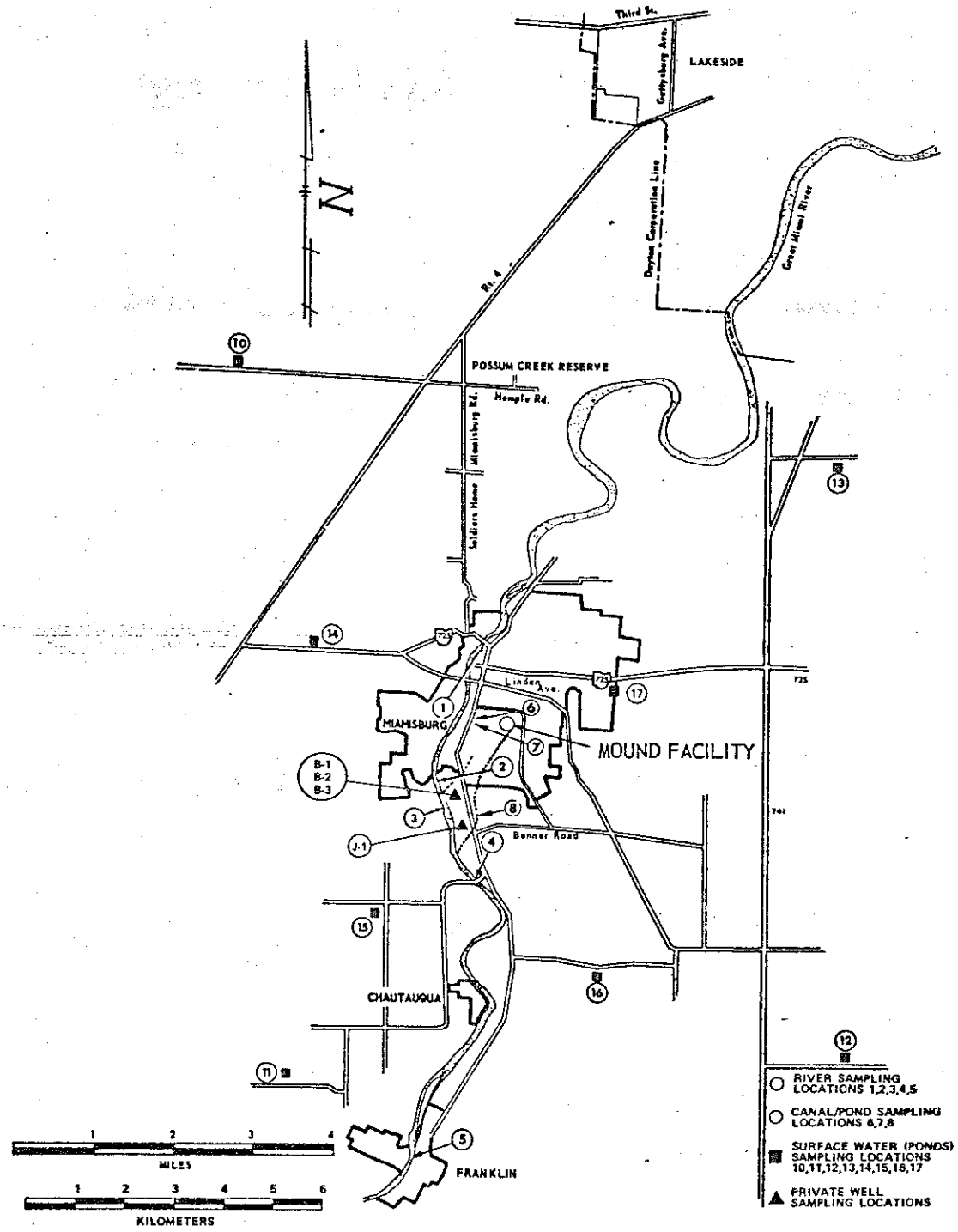


FIGURE 3-7 - Offsite Water and Silt Sampling Locations.

Table 3-9

ESTIMATED DOSE COMMITMENTS RESULTING FROM AIRBORNE TRITIUM RELEASES FOR CY-1977

Type of Exposure	Organ	Annual Commitment[a]
Maximum Individual in the Offsite Population	Total Body	0.041 mrem
Population Group - Offsite (average exposure to individuals in this group)	Total Body	0.015 mrem
Population within 3.2 km (2 mi) Radius (includes Miamisburg)[b]	Total Body	0.11 person rem[d]
Population within 3.2 km to 32 km Radius (2 to 20 mi)[b]	Total Body	3.53 person rem[d]
Population within 32 km to 80 km Radius (20 to 50 mi)	Total Body	No Dose Commitment Above Background
Total Population within 80 km (50 mi) Radius of Facility Site[c]	Total Body	3.64 person rem[d]

[a]Dose commitment based on Mound Facility tritium contribution to the environment; this excludes background tritium.

[b]Dose commitment calculated from average of actual monitoring data obtained from site boundary out to a distance of 3.2 km (2 mi), and from 3.2 km to 32 km (20 mi). Demonstrates compliance with ERDA Manual Chapter 0524 "Standards for Radiation Protection."

[c]Annual Dose commitment to total population within 80 km (50 mi) radius due to natural background tritium in air is approximately 30 person rem; therefore, Mound Facility contribution to air is some 10% of the natural tritium background. Annual dose commitment to the individual from natural background tritium is 0.01 mrem.

[d]The term "person rem" is used when the radiation exposure involves the whole body of the exposed person and equals the sum of the exposures (dose commitment) of all the people in the group specified. For example, if there are 1 million people in the 50-mile radius and each person receives a dose commitment of 0.1 mrem, the annual dose commitment would equal 100 person rem. The larger the population involved the larger the person rem value becomes.

Two ranges of dose estimates were considered to obtain the 80 km (50 mi) person-rem dose estimate. The first range was from 0 to 3.2 km (2 mi). The second range was from 3.2 km to 80 km. The distance breakdown was used because of the placement of samplers in the Mound diffusion model.

The 0 to 3.2 km (2 mi) range dose estimate for airborne tritium oxide was obtained from the average concentration (less background) of nine offsite tritium samplers.

The 3.2 to 80 km (2 to 50 mi) range estimate was obtained by finding the midpoint distance where the average tritium concentration of the remaining offsite samplers would be located. This value is estimated at 6.2 km. From this distance and average concentrations of tritium at sampling locations from 3.2 to 32 km (2 to 20 mi), it was determined that the maximum distance of influence from Mound Facility is approximately 32 km. Beyond 32 km the levels are calculated to be background concentrations. The dose commitment for tritium from 3.2 to 32 km was based on the average of the remaining tritium offsite monitoring stations.

The dose commitment values given in Table 3-9 are considered to be upper limits and therefore very conservative. Actual doses received from tritium from Mound Facility would be expected to be much lower since individuals in the offsite population and even population groups are highly mobile and would not be continuously present for a whole year in areas of maximum potential concentration. From the data presented in Table 3-9, it is demonstrated that the concentration of tritium in the environment surrounding the Facility has had minimum impact considering the annual dose of 120 mrem from natural sources. The dose commitment, or in this case, the dose potentially received by individuals and population groups was well within the guidelines set by recognized authoritative groups such as the former Federal Radiation Council and adopted by the AEC, (3-6) the National Committee on Radiation Protection and Measurements, (3-4) and the International Commission on Radiological Protection.

Table 3-7 presents data on the concentration of tritium in foodstuffs and vegetation for CY-1975, 1976 and 1977. The data indicate some uptake and presence in these substances. Since tritium is readily absorbed in biological systems, it is expected that concentrations in the range of those monitored would be present in other life forms. The average concentrations would be to the extent of 2 to 22% of the RCG for human drinking water. This very low concentration of tritium would be expected to have no observable radiological impact on these food stuffs or on humans if the substances, milk, vegetation, etc., were consumed routinely and exclusively. As anticipated, there has been no observable radiological impact on regional life forms.

The low-level concentration of tritium in area surface waters for CY-1977 is presented in Table 3-8. There is no restriction to onsite or offsite land use as a result of Mound Facility tritium operations.

The concentration of airborne tritium in the environment surrounding Mound Facility and the estimated dose commitment to individuals and population groups are well within the guidelines given in DOE Manual Chapter 0524. Exposures are being maintained at the lowest practical levels. There has been no known or observable effect on people or other life forms in the surrounding environment nor has there been any impact on land areas or restriction on current land use or future development.

Liquid Waste Effluent Impact - Prior to CY-1970, process water contaminated with tritium was discharged to an onsite radioactive waste treatment facility where it was collected in large holding tanks and the concentration determined. Since tritium cannot be economically recovered from large volumes of water, the contaminated water was diluted with raw well water to below the ERDA RCG for tritium and discharged to the Great Miami River via the site open drainage ditch and old Miami-Erie Canal (see Figures 3-8 and 3-9). Annual tritium oxide discharges for the past eight years were:

CY-1970	0.025 grams	CY-1974	0.011 grams
CY-1971	0.040 grams	CY-1975	0.006 grams
CY-1972	0.024 grams	CY-1976	0.005 grams
CY-1973	0.015 grams	CY-1977	0.006 grams

Since CY-1970 and continuing at the present time, all process liquid wastes containing tritium have been collected and disposed of by packaging, solidification, and offsite approved burial at DOE and commercial burial sites. Only very low-concentration tritiated water from shower baths and lavatories in the process areas and from the Laundry is presently discharged to the Great Miami River via the underground pipe effluent line after processing through the sanitary waste disposal facility (see Figure 3-8). This waste water has no measurable environmental impact.

Prior to CY-1969, several thousand curies of tritium were discharged in liquid effluents. The exact quantities are unknown since liquid waste disposal regulations required only that the concentration of tritium in the effluent be in compliance with the prevailing RCG which is a concentration standard. A record of the total quantity in curies released was not an operating requirement.

At the beginning of CY-1970, a continuous monitoring system was installed in the site drainage ditch and by 1971 a continuous monitoring system was installed in the underground pipe effluent stream in order to accumulate data on the total quantity of tritiated water leaving the site as part of a planned program to increase the scope of the environmental monitoring and control program at the Facility.

Therefore, since 1970 and 1971, the effluent water in the onsite drainage ditch and the underground pipe discharge, respectively, have been continuously sampled proportionally to water volume flow and records have been maintained for the total curies of tritium discharged as well as the concentration.

Reflecting actions taken in CY-1970 to collect, solidify, package, and ship offsite for burial all process liquid tritiated water, the annual quantity of tritium discharged in Mound effluents was steadily reduced from a total of some 2330 curies (Ci) in CY-1969 to a total of only 57 curies in CY-1977. Subtracting the tritium already present in the aquifer water used by Mound Facility Mound processes contributed only 40 curies to the environment in liquid effluents during CY-1977.

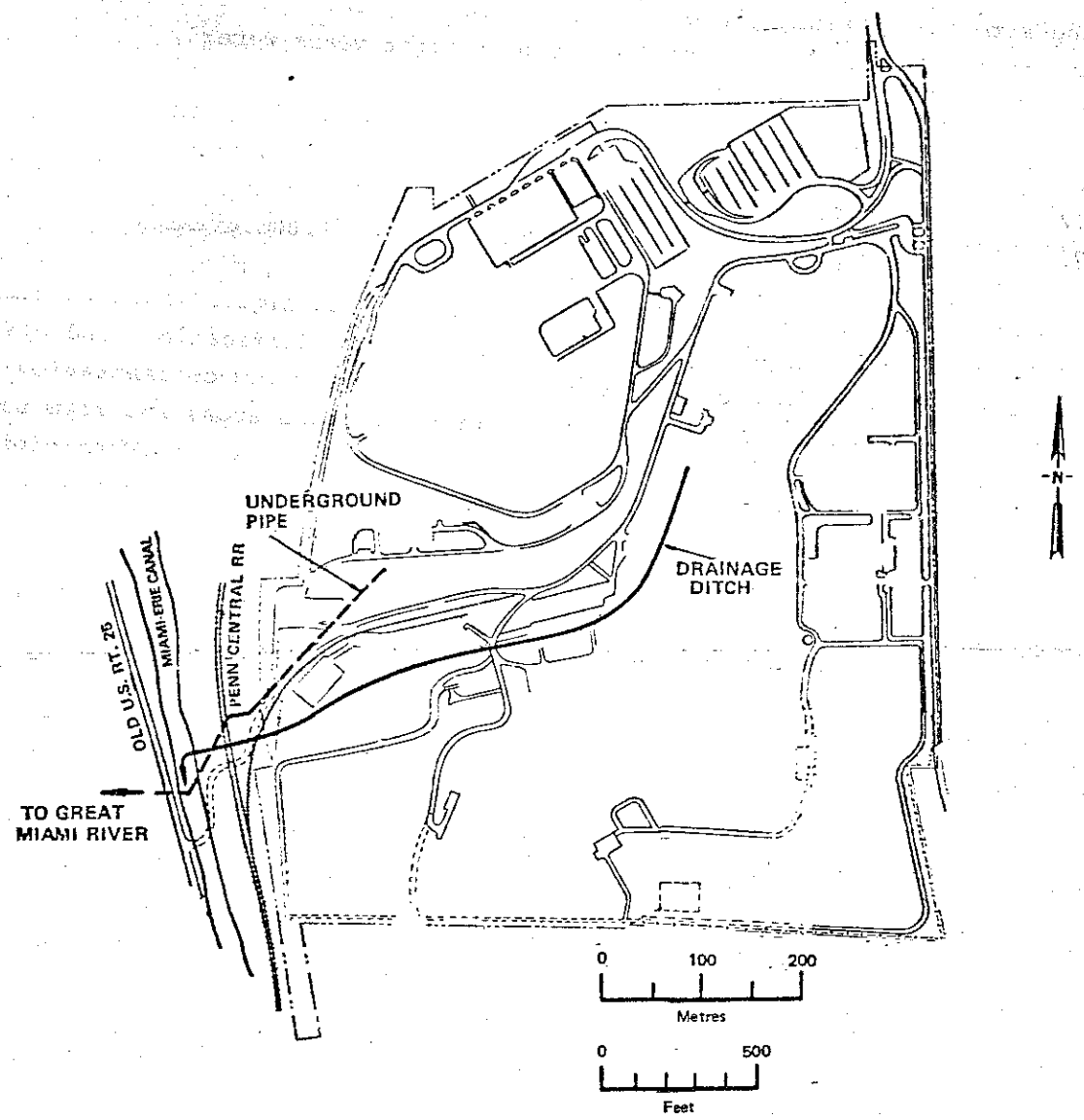
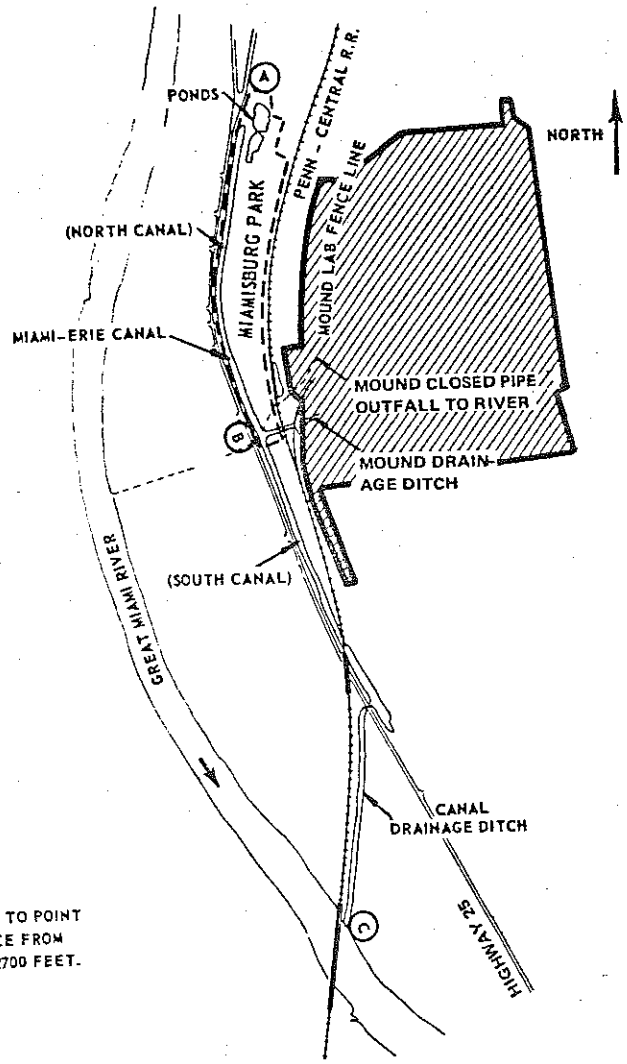


FIGURE 3-8 - Mound Facility Drainage Ditch and Underground Pipe.



DISTANCE FROM POINT A TO POINT B IS 2800 FEET. DISTANCE FROM POINT B TO POINT C IS 2700 FEET.
NOT TO SCALE

FIGURE 3-9 - Mound Facility Drainage Ditch in Relation to Miami-Erie Canal and Great Miami River.

Figure 3-10 shows the progressively reduced quantity of tritium in Mound liquid discharges over the years from CY-1969 through CY-1977.

During CY-1975, the average tritium concentration in the effluent discharged from the Facility via the drainage ditch was 0.04×10^{-3} µCi/ml. This represented 1.3% of the effluent discharge RCG. This concentration was essentially the same as the average concentration of tritium in Mound domestic water well #3 which was the primary well used during CY-1975. The average concentration of tritium oxide in the Facility underground pipe effluent during CY-1976 was 0.080×10^{-3} µCi/ml. This was 2.6% of the effluent discharge RCG and reflects Facility tritium operations discharges as well as the tritium present in the well water source.

During CY-1977, the average tritium concentration in the effluent discharged from the Facility via the drainage ditch was reduced to 0.027×10^{-3} µCi/ml. This represents 0.9% of the effluent discharge RCG. The average concentration of tritium oxide in the Facility underground pipe effluent during CY-1977 was reduced also, to a level of 0.056×10^{-3} µCi/ml. This was 1.9% of the effluent discharge RCG and reflects Facility tritium operations discharges as well as the tritium present in the well water source.

Tritiated water discharged from the Facility behaves in the environment as ordinary water. It is biologically assimilated the same as ordinary water. Released as surface

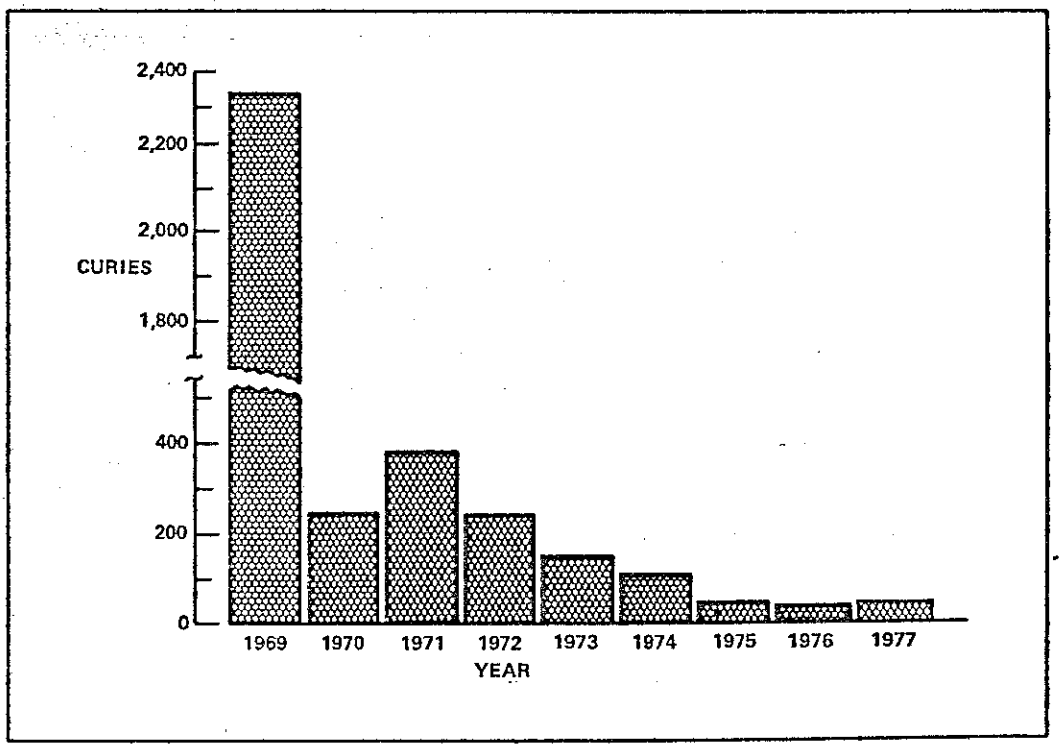


FIGURE 3-10 - Tritium in liquid effluents.

er, it passes through the soil into underground streams, water wells, or other water sources such as an aquifer in the same way as ordinary water. Once dispersed into the environment it is slowly but ultimately distributed throughout the total ecosystem. Since tritium has a physical half-life of 12.3 years, its disappearance from the environment is relatively slow.

One of the many reasons for locating Mound Facility at the site at the southern edge of Miamisburg was the abundant supply of potable water. As shown in Figure 3-11, the site lies adjacent to a large aquifer known as the Buried Valley Aquifer. A small portion of the aquifer juts into the site along the western boundary. The topography of the site is such that storm water runoff and natural drainage flow into an open ditch which carries the water westward to the Miami-Erie Canal at the western perimeter of the site. The Miami-Erie Canal discharges into the Great Miami River (see Figures 3-8 and 3-9). The western reach of the site drainage ditch and the Miami-Erie Canal lie above the eastern boundary of the southward trending Buried Valley Aquifer. This large aquifer provides potable water to Mound Facility, the City of Miamisburg, some commercial establishments, and private users in the local area.

From recent studies of the aquifer recharge system, it has been determined that any contaminant which may be carried on or from the site by water can enter the Buried Valley Aquifer at the site either by direct infiltration through the glacial outwash deposits below an approximate elevation of 216 m (710 ft), or through leakage from the bedrock valley walls which enter the outwash deposits. The bedrock hills which pport most of the Facility buildings may be considered as being virtually impermeable because of lithology and horizontal bedding structure.

The local area of the Buried Valley Aquifer is recharged directly by the site drainage ditch and adjacent bodies of water which receive the Facility effluent discharge. The aquifer is also recharged from rainfall onto the eastern land slopes to the Great Miami River, including the Facility site. Three wells which supply water to the Facility are drilled into the eastern perimeter of the Buried Valley Aquifer.

A continuing program of environmental monitoring showed the CY-1971 tritium concentration in water from Mound Well #1 as a result of past Facility operations assayed an average concentration of 0.22×10^{-3} μCi/ml. Mound Well #2 water showed an average concentration of 0.12×10^{-3} μCi/ml and Mound Well #3 water was 0.07×10^{-3} μCi/ml. The highest concentration was 22% of the RCG in CY-1971. Although the concentration in prior years was likewise well within the standard, and no environmental impact had been detected, a management decision was made in CY-1970 to reduce the tritium in Mound effluents to the lowest levels achievable in order to reduce the tritium in the aquifer. As stated previously in this section, beginning in CY-1970, all process liquids have been collected, solidified, packaged in strong, tight containers, and shipped offsite for burial in approved DOE and commercial burial sites.

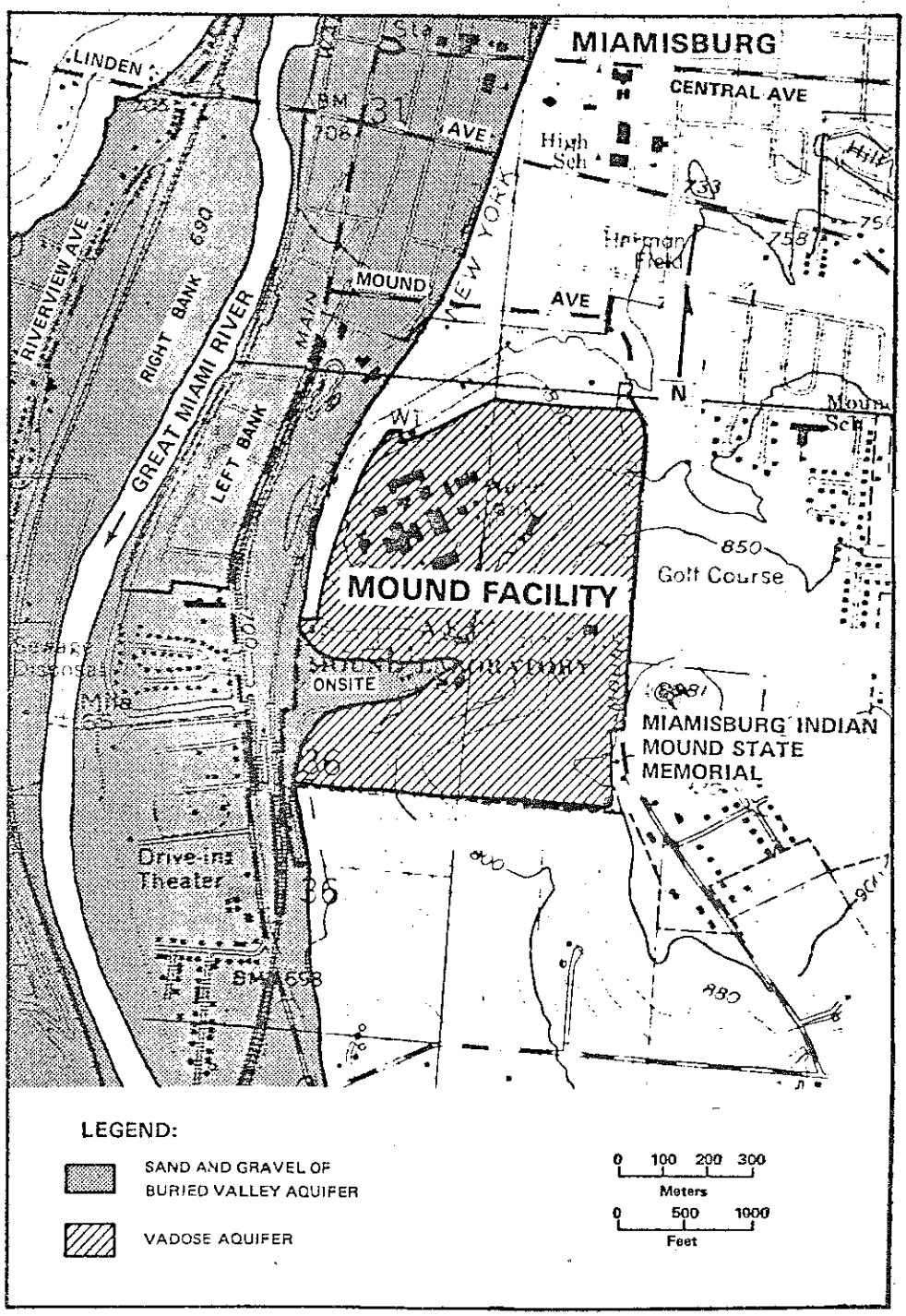


FIGURE 3-11 - Areal Extent of Vadose and Buried Valley Aquifers.

tack emissions of tritium to the atmosphere play a role in the recharge of tritiated water to the aquifer when rain falls through the stack plume and washes out some of the tritium oxide. These emissions have also been reduced through process changes and strict management from 315,000 curies in 1969 to 4896 curies in 1977. During this period the inventory of tritium at the Facility remained essentially constant.

The significant reduction of tritium in air and liquid discharges since CY-1971 has been reflected in reduced tritium concentration in the local aquifer as indicated by Mound Facility's well water (Figure 3-12). In CY-1977, the average concentration of tritium in Mound well #1 was 0.027×10^{-3} μCi/ml, well #2 was 0.033×10^{-3} μCi/ml, and the concentration in well #3, which has been the primary source of Mound water since CY-1973, was 0.020×10^{-3} μCi/ml. The highest of these levels represents 3.3% of the CY-1977 DOE RCG. The slight increase in levels, in CY-1976, mainly noticeable in well #2 and shown in Figure 3-12, resulted from Mound's investigative activities in probing and analyzing the aquifer and preliminary actions to test the possibility of removing the tritiated water. The notable reduction of tritium in CY-1977 resulted from Mound's corrective actions with high volume pumping of water from the aquifer. (See discussion in section on "Impact of New Federal Drinking Water Regulations.")

The environmental monitoring program took cognizance of the fact that there were other users of water from the locally affected aquifer and several other water supplies have been monitored for gross radioactivity and specifically for tritium.

The routine monitoring program also included regional water supplies which do not obtain their water from the local aquifer and could not be affected by Mound's liquid discharges but could, however, be impacted by Mound's stack effluents through the rainout mechanism.

The CY-1977 range and average concentration of tritium in the drinking water from 12 municipalities surrounding Mound Facility out to a distance of 24 km (15 mi) are presented in Table 3-10. The highest concentration detected was in Miamisburg drinking water which is drawn from the local aquifer. The average level was 14% of the new EPA Drinking Water Standard for tritium. Sampling data for the other locations which do not use water from the local aquifer are within the fluctuations of background data published by the EPA. (3-7).

The highest concentration of tritium detected in private wells during CY-1975 near the western perimeter of the Facility site ranged from 0.065×10^{-3} to 0.090×10^{-3} μCi/ml. The average concentration was 0.075×10^{-3} μCi/ml which is 7.5% of the RCG. Other adjacent private wells showed a CY-1975 average concentration of 0.052×10^{-3} μCi/ml which is 5.2% of the RCG. During CY-1976, the highest concentration of tritium in private wells adjacent to the Facility site ranged from 0.043×10^{-3} to 0.070×10^{-3} μCi/ml. During CY-1977, the range of highest concentration decreased to 0.036×10^{-3}

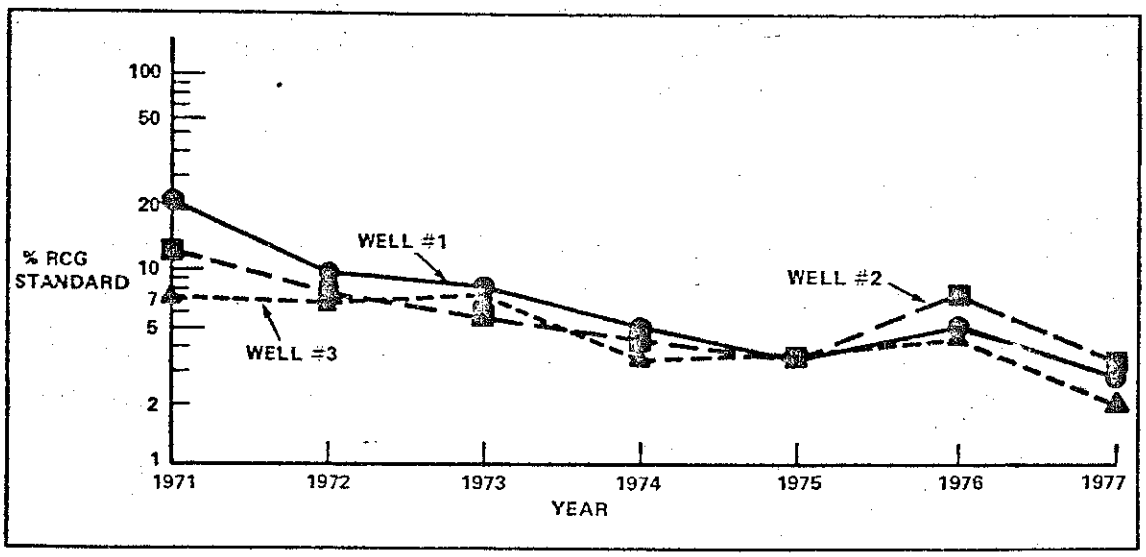


FIGURE 3-12 - Reduction of Tritium in Mound Well Water.

to 0.059 x 10^{-3} µCi/ml. During CY-1976, these wells showed an average concentration of 0.038 x 10^{-3} µCi/ml. The average concentration for CY-1977 was 0.036 µCi/ml which is 3.6% of the DOE RCG. Area drinking water containing tritium at a fraction of the DOE RCG would not be expected to have any deleterious effects on the public or on wildlife or vegetation.

During the period of tightening controls on the discharge of tritium effluents from the Facility, Mound also turned its attention to nonradioactive operations which could have impacted the local aquifer. An old onsite landfill (which is no longer used) containing cardboard, paper, wood, machine shop wastes, plating room wastes, and other

Table 3-10

SUMMARY OF TRITIUM OXIDE LEVELS IN COMMUNITY DRINKING WATER FOR CY-1977

Location	Number of Samples	Range (10^{-6} µCi/ml)	Average[a,c] (10^{-6} µCi/ml)	Percent of EPA Std[b]
Bellbrook	1	-	0.5 ± 0.4	2.5
Centerville	1	-	1.1 ± 0.4	5.5
Dayton	1	-	0.5 ± 0.4	2.5
Franklin	1	-	1.3 ± 0.4	6.5
Germantown	1	-	0.8 ± 0.4	4.0
Kettering	1	-	0.8 ± 0.4	4.0
Miamisburg	3	1.9 - 4.6	2.8 ± 0.6	14.0
Middletown	1	-	0.9 ± 0.4	4.5
Moraine	1	-	0.7 ± 0.4	3.5
Springboro	1	-	1.3 ± 0.4	6.5
Waynesville	1	-	0.6 ± 0.4	3.0
West Carrollton	1	-	2.0 ± 0.4	10.0

[a]Lower Detection Limit (LDL) for tritium oxide is 0.25 x 10^{-6} µCi/ml which is 1.2% of the EPA Standard for community drinking water.

[b]EPA Drinking Water Standard for tritium = 20 x 10^{-6} µCi/ml for community drinking water systems.

[c]Error limits are counting statistics only at 95% confidence level.

miscellaneous materials, including laboratory and cafeteria wastes, is located in the zone of glacial soil, several hundred feet northeast of Mound well #1. In order to evaluate the possible effects of landfill leachate on well water quality, water samples were collected and analyzed between January and September 1971. The employed consultant detected only an anomalous variation in the hardness and chloride content of the well water. He concluded from his analysis that the contaminants (nonradioactive) probably entered the aquifer by induced infiltration from the site drainage ditch. The source of hardness and chloride contamination was postulated to have been the backwash from the Facility's zeolite water softeners.

Tritium monitoring data for regional ponds and surface waters were discussed in the section on "Airborne Effluent Impact" since the presence of tritium in these specific bodies of water would be due only to the deposition from airborne effluents. During CY-1977, the average concentration of tritium oxide in the north leg of the Miami-Erie Canal was 0.005×10^{-3} μCi/ml (0.5% of the RCG); in the south leg of the canal the average concentration was 0.024×10^{-3} μCi/ml (2.4% of the RCG). The average concentration of tritium in the Miamisburg North Pond for the same time period was 0.009×10^{-3} μCi/ml (0.9% of the RCG) (Figure 3-9). The value for the south leg of the canal represents essentially the elevated background concentration of tritium in the aquifer used as Facility supply water.

The Great Miami River flows south near the western boundary of the Facility site and empties into the Ohio River west of Cincinnati, Ohio. Mound Facility is located at River Mile 65 (see Figure 3-13). All the site's liquid effluent is discharged to the Great Miami River. Figure 3-7 shows the river locations which were monitored for tritium oxide during CY-1977. A brief discussion of the river monitoring program is presented in Section 2.1.4.7. Table 3-11 presents a summary of the river sampling data for CY-1977. As may be seen in the table, the average values observed ranged from $<1.0 \times 10^{-6}$ to $<1.9 \times 10^{-6}$ μCi/ml, or from <0.10 to <0.19% of the RCG. The background concentration of tritium oxide in surface water in CY-1975 was approximately $0.5 \pm 0.2 \times 10^{-6}$ μCi/ml. (3-5)

As a result of improvements in tritium process technology and the application of stringent administrative operating controls over the past several years, the Facility has significantly reduced the tritium level in liquid discharges to the Great Miami River.

Fish from the Great Miami River have been routinely analyzed in past years. (Last evaluation made in CY-1975.) This is the only aquatic life form studied periodically. The concentration of tritium in the water recovered from the edible portion of fish ranges from 50 to 100% of the river water concentration at the location where the fish is caught. It would be expected that the water in the body cells of aquatic life would be in equilibrium with the tritium concentration of its aqueous environment because of the hydrogen exchange mechanism. Like man, fish do not concentrate tritium in specific organs to any significant degree. There has been no apparent deleterious effect in any of the fish analyzed from the presence of tritium at the low tritium concentrations found where the Mound effluent enters the river. The pronounced clean water plume of the Facility effluent into the river can be routinely observed as a local habitat for various species of fish, literally by the dozens, which apparently congregate for relief and refuge from the surrounding polluted river water.

Essentially all the impact from the discharge of tritium oxide in liquid effluents from operations results from the tritium which penetrates to local aquifers and wells

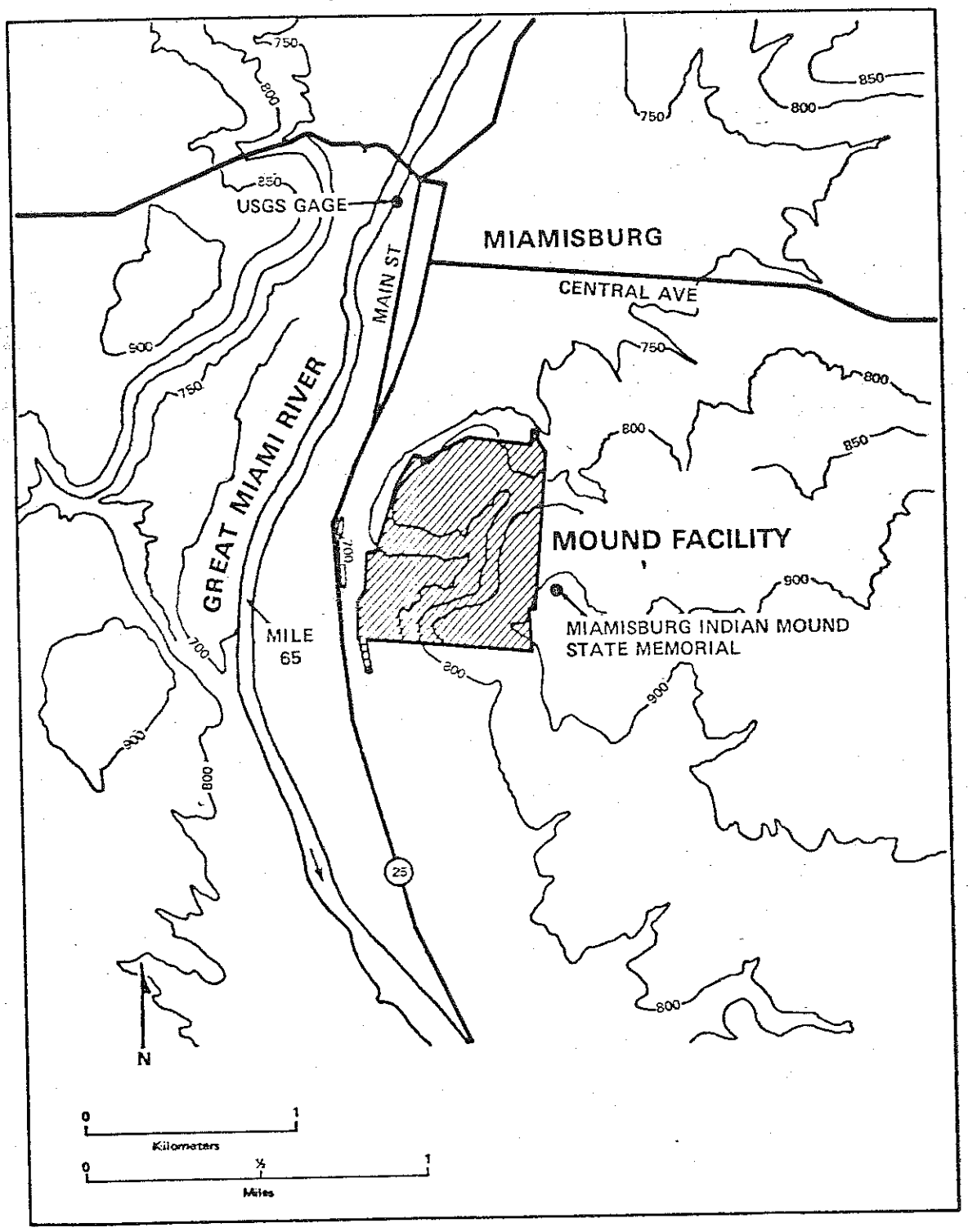


FIGURE 3-13 - Topographic Features of Site Area.

Table 3-11

CONCENTRATION OF TRITIUM IN THE GREAT MIAMI RIVER FOR CY-1977

Location[a]	Number of Samples	Range (10^{-6} μCi/ml)	Average[b,d] (10^{-6} μCi/ml)	% of RCG[b,c]
1	210	<0.20 - 4.3	<1.0 ± 0.35	<0.10
2	210	<0.20 - 16.8	<1.5 ± 0.36	<0.15
3	210	<0.20 - 8.3	<1.9 ± 0.36	<0.19
4	210	<0.20 - 23.4	<1.6 ± 0.36	<0.16
5	210	<0.20 - 4.5	<1.0 ± 0.35	<0.10

[a]Locations are shown on Figure 3-7.

[b]Lower Detection Limit (LDL) for tritium in water is 0.20×10^{-6} μCi/ml which is 0.02% of the RCG.

[c]DOE Radioactivity Concentration Guide (RCG) which is compared to tritium concentration in water not used for drinking purposes $= 1000 \times 10^{-6}$ μCi/ml for the general population and the soluble form of tritium

[d]Error limits are counting statistics only at 95% confidence level.

used to provide drinking water to the local community. Estimates of annual dose commitments are given in Table 3-12. Values are given for the whole body as the critical organ, since tritium oxide is associated with water in all body tissues. The dose commitment values given represent the annual whole body dose that would be received by persons whose total and continuous liquid intake was from local well water or community drinking water supplies.

The data indicate that the dose commitment to the total population within an 80 km (50 mi) radius of the Facility is considerably greater from natural background tritium than from that contributed by Facility tritium operations.

Since effluents are discharged to the Great Miami River either through a closed pipe or through natural drainage systems which carry runoff water to the river, Mound Facility has not appropriated any land or altered the natural water course for the discharge of liquid effluents. It is presently anticipated that public land used for drainage and effluent discharge could be utilized for other purposes and the natural drainage route altered. The Facility does not currently anticipate any restrictions on land usage.

The concentration of tritium oxide in the community drinking water and the estimated dose commitment to individuals and population groups is well within the guidelines given in ERDA Manual Chapter 0524 and the EPA Drinking Water Standard for tritium. There has been no known or observable effect on people or other life forms in the surrounding environment. There has been no impact on land areas or any restriction on current land use or future development.

Table 3-12

ESTIMATED DOSE COMMITMENT RESULTING FROM LIQUID TRITIUM RELEASES FOR CY-1977

Type of Exposure	Organ	Annual Dose Commitment[1]
Maximum Individual in the Offsite Population[2]	Total Body	3.43 mrem
Population Group - Offsite[2] (average exposure to individuals in this group)	Total Body	0.19 mrem
Population Within 3.2 km (2 mi) Radius[2] (including Miamisburg)	Total Body	3.77 persons rem[5]
Population Within 3.2 km to 32 km Radius (2 to 20 mi)[2]	Total Body	4.85 person rem[5]
Population Within 32 km to 80 km Radius[3] (20 to 50 mi)	Total Body	No Dose Commitment Above Background
Total Population Within 80 km (50 mi) Radius of Facility Site[4]	Total Body	8.62 person rem[5]

[1] Dose Commitment based on Mound Facility's tritium contribution to area drinking water; this excludes natural background tritium in drinking water.

[2] Dose commitment calculated from drinking water data.

[3] This area determined to be at background. It is not affected by liquid discharges from the Facility.

[4] Dose commitment to total population within 80-km (50-mi) radius due to natural background tritium in water is 240 person rem; therefore, Mound Facility contribution is less than natural background. Annual dose commitment to the individual from natural background tritium is 0.08 mrem.

[5] The term "person rem" is used when the radiation exposure involves the whole body of the exposed persons and equals the sum of the exposures (dose commitment) of all the people in the group specified. For example, if there are 1 million people in the 50-mile radius and each person receives a dose commitment of 0.1 mrem, the annual dose commitment would equal 100 person rem. The larger the population involved, the larger the person rem value becomes.

Total Tritium Dose Commitment - Airborne and Liquid Releases - The radiation dose commitment to the public surrounding Mound Facility from airborne tritium oxide in the environment is presented in Table 3-9. The radiation dose commitment from water-borne tritium (oxide) is presented in Table 3-12. Table 3-13 presents total dose commitment, both airborne and waterborne, from tritium operations at Mound Facility.

Radiation exposure - total dose commitment - to the public surrounding Mound Facility at current levels of tritium operations, with CY-1975 used as current baseline, is well within the guidelines of the National Committee on Radiation Protection and DOE radiation protection standards. The person rem values reflect the high population density in the Dayton, Ohio, metropolitan area. Person-rem values out to a distance of 80 km (50 mi) were calculated by extrapolation of the monitoring data obtained within 32 km (20 mi)

Table 3-13

ESTIMATED TOTAL DOSE COMMITMENTS RESULTING FROM AIRBORNE AND LIQUID TRITIUM RELEASES FOR CY-1977

Type of Exposure	Organ	Annual Dose Commitment
Maximum Individual in the Offsite Population	Total Body	3.47 mrem
Population Group - Offsite (average exposure to individuals in this group)	Total Body	0.205 mrem
Population Within 3.2 km (2 mi) Radius (including Miamisburg)	Total Body	3.88 person rem
Population Within 3.2 km to 32 km Radius (2 to 20mi)	Total Body	8.38 person rem
Population Within 32 km to 80 km Radius (20 to 50 mi)	Total Body	No Dose Commitment Above Background
Total Population Within 80 km (50 mi) Radius of Facility Site*	Total Body	12.26 person rem

*Dose commitment to total population within 80-km (50-mi) radius due to natural background tritium is approximately 270 person rem. The Mound Facility contribution is less than natural background.

NOTE: Tritium is the only radioisotope released from Mound Facility for which the critical organ is the total body.

of the Facility. In terms of Mound Facility's impact, people in the 32 to 80 km area are exposed to tritium oxide at near background levels. The 12.26 person-rem value compares with the total background dose for the 80-km (50 mi) area from all natural radiation sources, cosmic and terrestrial, of approximately 360,000 person rem/yr. (3-7)

Impact of New Federal Drinking Water Regulations - On December 16, 1974, new environmental legislation known as the "Safe Drinking Water Act" was signed into law. During 1975, the Federal Environmental Protection Agency (EPA) as the responsible implementing agency formulated a detailed set of regulations to further control certain chemical, microbiological, and radioactive substances in public drinking water. Proposed regulations for chemical and biological substances were published in the Federal Register on March 14, 1975. Final regulations were promulgated in the December 24, 1975, issue of the Federal Register. Proposed regulations for radionuclides in public drinking water were published in the Federal Register on August 14, 1975, and the final regulations were promulgated in the July 9, 1976, issue. These regulations are known as the "National Interim Primary Drinking Water Regulations," Title 40-Code of Federal Regulations, Part 141.

When the EPA-proposed regulations for radionuclides were published in August 1975, it was noted that, if the regulations were adopted, the Federal radiation protection standard for man-made radionuclides in public drinking water would in effect be reduc

by a factor of approximately 50. The standard for tritium would be reduced from 1 μCi/liter to 0.02 μCi/liter. As noted in the previous section of this report under "Liquid Effluent Impact", the 1975 annual average concentration of tritium in local drinking water supplies measured up to a maximum of 0.075×10^{-3} μCi/ml (0.075 μCi/liter). Although this concentration was only 7.5% of the prevailing ERDA standard, it exceeded the EPA proposed standard. Mound therefore undertook an extensive drinking water monitoring program to determine the extent and degree to which Facility effluents had infiltrated local drinking water supplies. Also, employing the assistance of consultants with expertise in geohydrology and other required earth sciences, Mound undertook a comprehensive investigation program to determine the mechanisms by which tritium effluents impact local water supplies, the relative effect of past and present operations, and possible methods of reducing the tritiated water burden present in the aquifer.

As a result of Mound's comprehensive studies of tritium in the local environment the following conclusions were derived:

1. Only the local area of the Buried Valley Aquifer adjacent to the Facility site has been significantly impacted by Mound's tritium operations.
2. The primary source of tritium reaching the aquifer has been process waste water discharged through the site drainage ditch and Miami-Erie Canal to the Great Miami River. Direct infiltration of tritiated water to the aquifer resulted.
3. Rainout of stack emissions from the Facility has had a minor impact on tritium infiltrating local drinking water supplies.
4. Wells which do not draw water from the local aquifer have a tritium concentration close to the natural background level.
5. The concentration of tritium in the local aquifer has been diminishing steadily since CY-1970 in response to progressively reduced liquid emissions from the Facility.
6. Current concentrations of tritium in the aquifer are primarily residuals of past discharges.
7. Although past liquid effluent control practices were guided by a Federal standard for tritium in public water supplies of 1 μCi/liter, a reduction of the standard by a factor of 50 resulted in eight private water supplies and Mound Facility water exceeding the new Federal standard.
8. Current concentrations of tritium in the aquifer are not a significant health risk to people using the water.
9. The highest concentration of tritium in the local aquifer occurred at the junction of the Facility site drainage ditch and the old Miami-Erie Canal. (The measured concentration in April 1976 was 0.115×10^{-3} μCi/ml. This location is some 500 to 600 feet from the nearest drinking water well.)

As shown in Figure 3-12, the concentration of tritium in the local aquifer has been considerably reduced. Since 1970, the most significant force in effecting a continuing reduction has been the high level pumping of water from the aquifer for Mound Facility operations. Most of this water when discharged from the Facility goes to the Great Miami River where it receives considerable dilution and flows southward. Some of this water infiltrates the aquifer in a continuing recharge-recycle pattern; therefore, the rate of tritium reduction in the aquifer becomes slower and slower. The assimilative capacity of the aquifer has been more than adequate in the past to maintain local potable well water within the DOE RCG. The assimilative capacity is adequate to maintain the water within even the new EPA standard, but the present tritium burden must be removed. The goal of Mound's intense program to evaluate all aspects of tritium in local drinking water has been to reduce the tritium to the lowest level practical at the earliest possible time.

Although the suddenness of the regulation put local aquifer water into a noncompliance situation, it does not mean that the water is unsafe for continued use. The EPA regulations do not condemn such noncompliant water systems. The new EPA standard for tritium is essentially a nondegradation standard adopted to maintain tritium in national drinking water supplies which use surface water sources (streams and rivers) at the lowest levels practical. The standard is a strict control on the tritium emissions from the increasing number of nuclear power reactors in the United States. For Mound Facility, the new very conservative standard for tritium is an after-the-fact regulation. Mound studies have identified potential methods of reducing the tritium concentration in the aquifer which supplies local wells. Since tritium cannot be filtered out of the water as it is used, the application of remedial corrective measures has proved quite challenging.

In 1977, after the completion of a thorough evaluation of the infiltration of tritium into the aquifer and after test pumping to determine the effectiveness of high-volume water removal and recharge of the aquifer, Mound initiated a high-volume long-term pumping program utilizing Mound Facility Well #1 and an old, unused Miamisburg well (Well #2). Both wells operate at a discharge flow rate of 450 gallons/minute. Under natural environmental conditions, the Buried Valley Aquifer supplies water southwestward to the Great Miami River. In Mound's pumping program, the water table is lowered sufficiently to cause a reverse flow in the aquifer between the River and the high capacity pumps thus sweeping the tritiated water eastward from the area of the private wells to the pumps before discharging it to the River. The reduction of the tritium concentration in the various water wells is achieved by displacement and dilution through the forced infiltration of river water. During the pumping program from April 1977 through January 1978, some 400,000,000 gallons of water were removed from the aquifer and replaced by natural recharge water from the River and from rainfall. Natural recharge is totally adequate to support all water withdrawals, public, private and industrial. Between April 1977 and June 1978, the area in which the tritium content exceeded the EPA standard had been reduced some 67%, from 52 acres to 17 acres.

This reduction of the affected area brought Mound Facility wells and most of the private wells into compliance with the new EPA standard, and those wells not yet in compliance were approaching it. Mound currently anticipates reducing the tritium level to less than the EPA standard throughout the area during CY-1979.

The tritium concentration in four private wells monitored routinely during CY-1977 as an indication of the tritium level in the affected area of the aquifer is presented in Table 3-14.

Local drinking water impacted by Mound operations has been analyzed for all other radioactive, chemical, and microbiological parameters specified in the new EPA standards and found to be in compliance.

Solid Wastes - There is no onsite burial of solid waste contaminated with tritium at Mound Facility. This policy has been in effect since the introduction of tritium at the Facility. Environmental monitoring also substantiates that there is no source of tritium originating as contaminated solid waste. Mound Facility disposes of its tritium-contaminated solid waste by shipment of such waste in DOT-approved containers, to approved offsite burial grounds. Classified tritium-contaminated wastes are sent to the DOE Savannah River Plant for burial. Unclassified tritium-contaminated waste is packaged and transported to the Barnwell, S.C., radioactive waste burial ground operated by Chem Nuclear Systems, Inc., and to the DOE Nevada Test Site at Mercury, Nev.

Table 3-14

TRITIUM IN PRIVATE WELLS FOR CY-1977

Location[a]	Number of Samples	Range (10^{-6} µCi/ml)	Average[b,c,e] (10^{-6} µCi/ml)	Percent Standard[b]
B-1	25	33.0 - 59.0	46.7 ± 1.4	233
B-2	25	23.6 - 35.7	29.9 ± 1.1	149
B-3	25	22.4 - 37.3	31.1 ± 1.2	155
J-1	24	19.4 - 49.3	33.3 ± 1.2	165

[a]Locations are shown in Figure 3-7.

[b]These concentrations are the average levels for 1977. Data obtained through June 1978 show that these levels have been reduced considerably as follows: B-1 = 13, B-2 = 18, B-3 = 19, and J-1 = 26 (x 10^{-6} µCi/ml). All private wells are approaching compliance with the new EPA standard of 20 x 10^{-6} µCi/ml.

[c]Lower Detection Limit (LDL) for tritium in water is 0.4 x 10^{-6} µCi/ml which is 0.04% of the EPA Standard.

[d]EPA Standard for tritium in community drinking water systems = 20 x 10^{-6} µCi/ml. Mound is using the EPA Standard as a guide for the private water supplies.

[e]Error limits are counting statistics only at 95% confidence level.

3.7.2 PLUTONIUM

The physical and toxicological properties of plutonium are described in Section 2.1.4.2. Mound Facility has worked with multigram quantities of plutonium-238 and gram quantities of plutonium-239. Because of the predominant use of plutonium-238 and its higher specific activity, essentially all the environmental impact of Mound's plutonium operations has been from this isotope. For this reason, the discussion of the impact of plutonium operations in the following section is limited to the impact of plutonium-238.

Airborne Effluent Impact - All plutonium process operations at Mound Facility are conducted inside gloveboxes containing air or an inert atmosphere. Air-atmosphere gloveboxes are protected by an automatic fire detection and extinguishing system using Halon 1301 extinguishing agent. Gloveboxes are maintained at negative pressure with respect to the operating laboratory.

The exhaust from every plutonium glovebox is passed through at least two stages of high-efficiency particulate air (HEPA) filters immediately upon leaving the glovebox. The exhausts from all gloveboxes in a building are then combined and passed through another two stages of high-efficiency filters in series before the air is discharged through a 61-m (200-ft) high stack. Exhaust air from the laboratories containing gloveboxes is also filtered before release to the environment through the same stack. The location of the plutonium stack is shown on Figure 2-9. The annual plutonium stack discharges for the past eight years were:

CY-1970	0.271×10^{-3} grams	CY-1974	0.002×10^{-3} grams
CY-1971	0.025×10^{-3} grams	CY-1975	0.001×10^{-3} grams
CY-1972	0.005×10^{-3} grams	CY-1976	0.001×10^{-3} grams
CY-1973	0.005×10^{-3} grams	CY-1977	0.001×10^{-3} grams

The most important meteorological factors that would influence the environmental impact of airborne releases of plutonium are the average wind direction, wind speed, and atmospheric stability. These factors are discussed in Section 2.3.6.

Because all air which may contain plutonium oxide is filtered before release, the particle size of the airborne oxide is in the submicrometer range. The small particle size permits the use of diffusion calculations as if the oxide were a gas. Agglomeration of plutonium particles or attachment to "host" particles of dust in the ambient air may occur in the environment and may influence the rate of deposition by rain or fallout.

A description of the offsite air sampling program, including locations monitored, is contained in Section 2.1.4.7. Table 3-15 presents a summary of the plutonium air-monitoring results for CY-1977. The average values observed ranged from $<0.09 \times 10^{-17}$

Table 3-15

CONCENTRATIONS OF PLUTONIUM IN AIR AT OFFSITE SAMPLING LOCATIONS FOR CY-1977

Location[a]	Number of Samples	^{238}Pu Range (10^{-17} µCi/ml)	^{238}Pu Average[b,e] $^{-17}$ µCi/ml)	Percent of RCG[c]	^{239}Pu Average[d,e] (10^{-17} µCi/ml)	$^{238}Pu/^{239}Pu$
101	51	0.15 - 3.2	1.0 ± 0.05	0.05	2.4 ± 0.13	0.42
102	52	0.52 - 1.3	0.81 ± 0.08	0.04	2.2 ± 0.13	0.39
103	51	0.42 - 0.88	0.62 ± 0.07	0.03	2.1 ± 0.13	0.30
104	52	0.22 - 0.50	0.37 ± 0.06	0.02	2.2 ± 0.13	0.17
105	52	<0.076 - 0.23	<0.15 ± 0.04	<0.01	2.0 ± 0.12	<0.08
108	48	<0.076 - 0.29	<0.15 ± 0.04	<0.01	2.7 ± 0.14	<0.06
110	51	<0.076 - 0.15	<0.09 ± 0.04	<0.01	2.3 ± 0.13	<0.04
111	52	<0.076 - 0.32	<0.21 ± 0.05	<0.01	2.5 ± 0.14	<0.08
112	48	<0.076 - 0.21	<0.16 ± 0.04	<0.01	2.1 ± 0.13	<0.08
115	51	<0.076 - 0.21	<0.13 ± 0.04	<0.01	2.5 ± 0.14	<0.05
118	51	0.25 - 1.2	0.75 ± 0.08	0.04	2.5 ± 0.14	0.30
122	47	0.61 - 6.3	2.1 ± 0.22	0.11	1.6 ± 0.19	1.3
123	52	0.54 - 9.6	2.9 ± 0.26	0.15	2.1 ± 0.22	1.4
124	52	0.35 - 4.2	1.7 ± 0.20	0.09	2.4 ± 0.23	0.71

[a]Locations are shown in Figure 3-6.

[b]Lower Detection Limit (LDL) for ^{238}Pu in air for samplers 101 through 118 is 0.076 x 10^{-17} µCi/ml and the LDL for samplers 122 through 124 is 0.258 x 10^{-17} µCi/ml. This is 0.004% and 0.013%, respectively of the RCG.

[c]Radioactivity Concentration Guide (RCG) = 2000 x 10^{-17} µCi/ml for the soluble form of ^{238}Pu for the general population.

[d]The LDL for ^{239}Pu in air for samplers 101 through 118 is 0.033 x 10^{-17} µCi/ml and the LDL for samplers 122 through 124 is 0.121 x 10^{-17} µCi/ml.

[e]Error limits are counting statistics only at 95% confidence level.

to 2.9 x 10^{-17} µCi/ml. These values are <0.01 to 0.15% of the Radioactivity Concentration Guide of 2000 x 10^{-17} µCi/ml. The background concentration of plutonium-238 in air for the Miamisburg area is approximately 0.3 ± 0.1 x 10^{-17} µCi/ml. (3-8, 3-9)

Foodstuffs and vegetation samples in the vicinity of Mound Facility are analyzed to determine whether there is uptake and concentration of plutonium-238 in these substances as a result of airborne releases. A description of the foodstuffs and vegetation sampling program is given in Section 2.1.4.7. Table 3-16 presents a summary of this sampling program for CY-1977. The average values observed ranged from <2.0 x 10^{-10} to 13.1 x 10^{-10} µCi/g. There is no RCG specific for foodstuffs and vegetation; however, in the table they are compared to the RCG for drinking water, which is 20,000 x 10^{-19} µCi/g. The average values ranged from <0.01 to <0.07% of the drinking water RCG. There is no reference data for background of plutonium-238 in foodstuffs and vegetation; however, the background for plutonium-238 in surface water for the Miamisburg area, considered to be about 7 x 10^{-13} µCi/ml, is used for surface water and foodstuffs calculations. (3-10)

Table 3-16

SUMMARY OF FOODSTUFFS AND VEGETATION ANALYSES
FOR PLUTONIUM-238 FOR CY-1977

Type of Sample	Location	Number of Samples	Plutonium Content (10^{-10} µCi/g) Range	Average*	% of RCG**
Milk	Local Dairy Farms	3	<2.0 - 2.1	<2.0 ± 0.8	<0.01
Vegetables	Local Fields	4	<7.5 - 11.0	<8.4 ± 2.8	<0.04
Grass	At Surface Water Sites (Fig. 3-7)	25	<6.6 - 44.6	<13.1 ± 6.2	<0.07
Aquatic Life (primarily fish)	Great Miami River	4	<5.3 - 9.6	<6.7 ± 1.4	<0.03

NOTE: There are no RCG's for foodstuffs. Water RCG's are used for reference purposes. (See Reference 3-4).

*Lower Detection Limit (LDL) for ^{238}Pu in milk is 2.0×10^{-10} µCi/g
Lower Detection Limit (LDL) for ^{238}Pu in vegetables is 7.5×10^{-10} µCi/g
Lower Detection Limit (LDL) for ^{238}Pu in grass is 6.6×10^{-10} µCi/g
Lower Detection Limit (LDL) for ^{238}Pu in aquatic life is 5.3×10^{-10} µCi/g

**Radioactivity Concentration Guide for ^{238}Pu in water = $20,000 \times 10^{-10}$ µCi/ml. This percent is calculated from the "Average" column.

Error limits are counting statistics only at 95% confidence level.

Water samples are collected from ponds and streams which do not receive and are not affected by liquid discharges from Mound Facility to determine whether there is a measurable concentration of plutonium-238 in these waters as a result of airborne effluents. A description of this sampling program is given in Section 2.1.4.7. Table 3-17 presents a summary of this sampling program for CY-1977. As may be seen in the table, the average values observed ranged from $<0.1 \times 10^{-10}$ (which is the lower limit of detection) to $<0.12 \times 10^{-10}$ µCi/ml, compared to the RCG of $20,000 \times 10^{-10}$ µCi/ml. The average values ranged from <0.0005 to 0.0006% of the RCG. The background concentration for plutonium-238 in surface water for the Miamisburg area is about 7×10^{-13} µCi/ml. Silt samples obtained from the bottom of the ponds indicate in general a concentration less than the lower limit of detection or $<0.3 \times 10^{-6}$ µCi/g. (See Table 3-18) The highest average concentration was 0.4×10^{-6} µCi/g.

The only significant pathway for exposure to man as a result of Mound Facility's airborne releases of plutonium is a direct pathway by inhalation. Estimates of dose commitments (radiation exposure) based on measured values in the environment in CY-1977 are given in Table 3-19. Values are given for both lung and bone as critical organs using conservative (i.e., worst case) assumptions that all plutonium to the lung was insoluble and that all plutonium to the bone was soluble. The dose estimates obtained for the Maximum Individual in the Offsite Population were based on the single highest

Table 3-17

SUMMARY OF SURFACE WATER MONITORING FOR PLUTONIUM-238 FOR CY-1977

Location[a]	Number of Samples[b]	Range[c] (10^{-10} µCi/ml)	Average[d] (10^{-10} µCi/ml)	Percent of RCG[e]
10	4	<0.1 - 0.13	<0.12 ± 0.02	<0.0006
11	4	<LDL	<0.1 ± 0.01	<0.0005
12	4	<LDL	<0.1 ± 0.01	<0.0005
13	4	<LDL	<0.1 ± 0.01	<0.0005
14	4	<LDL	<0.1 ± 0.01	<0.0005
15	4	<LDL	<0.1 ± 0.01	<0.0005
16	4	<LDL	<0.1 ± 0.01	<0.0005
17	4	<LDL	<0.1 ± 0.01	<0.0005

[a]Locations are shown in Figure 3-7.

[b]One sample is collected each quarter at each location. The 4 samples obtained are then composited into 2 large volume samples for analysis for optimum sensitivity.

[c]Lower Detection Limit (LDL) for ^{238}Pu in water = 20,000 x 10^{-10} µCi/ml which is 0.0005% of the RCG.

[d]Error limits are counting statistics only at 95% confidence level.

[e]Radioactivity Concentration Guide (RCG) for ^{238}Pu in water = 20,000 x 10^{-10} µCi/ml for the general population and soluble form of plutonium-238.

Table 3-18

PLUTONIUM-238 IN SILT FROM SURFACE WATER MONITORING LOCATIONS FOR CY-1977

Location[a]	Number of Samples	^{238}Pu Range[b] (10^{-6} µCi/g)	^{238}Pu Average[b,c] (10^{-6} µCi/g)
10	2	<LDL	<0.3 ± 0.02
11	2	<LDL	<0.3 ± 0.01
12	2	<LDL	<0.3 ± 0.01
13	2	<LDL	<0.3 ± 0.03
14	2	<LDL	<0.3 ± 0.02
15	2	<LDL	<0.3 ± 0.001
16	2	<LDL	<0.3 ± 0.05
17	2	<0.3 - 0.55	<0.4 ± 0.05

[a]Locations are shown in Figure 3-7.

[b]Lower Detection Limit (LDL) for ^{238}Pu is 0.3 x 10^{-6} µCi/g.

[c]Error limits are counting statistics only at 95% confidence level.

Table 3-19

ESTIMATED DOSE COMMITMENTS RESULTING FROM PLUTONIUM STACK EFFLUENTS FOR CY-1977

Type of Exposure	Organ	Annual Dose Commitment (mrem)
Maximum Individual in the Offsite Population		
Soluble	Bone	0.044
Insoluble	Lung	0.110
Population Group - Offsite		
Soluble	Bone	0.016
Insoluble	Lung	0.036

yearly average of onsite samplers since the samplers are in close proximity to the site boundary. The maximum dose to the population groups was based on the data obtained from the maximum offsite average concentration of plutonium-238 in air. The dose commitment values given for these categories in Table 3-19 are considered to be high estimates, and actual organ doses would be expected to be much lower because the area population is highly mobile and would not be continuously present in any given area of plutonium concentration.

The concentration of airborne plutonium in the environs of Mound Facility and the estimated dose commitments to individuals and population groups is well within the guidelines given in DOE Manual Chapter 0524.

As a result of airborne releases of plutonium, there has been some minor deposition of plutonium on the land surrounding the site.

During CY-1977, emphasis was placed on completing Mound's Soil Inventory for plutonium-238. Essentially all the soil samples taken and analyzed during CY-1977 were related to the Soil Inventory Program.

The purpose of the soil inventory was to establish the quantity of plutonium which was deposited in the environment from the Mound Facility stack effluents. A preliminary soil inventory was performed in CY-1975; however, soil sampling was not completed, and additional samples were taken in CY-1977 to extend the soil isopleths to environmental background concentrations.

Soil core sample values around and within the Facility site boundary were used to arrive at an estimate of the ground deposition of airborne plutonium-238 from all past Facility operations.

series of soil sampling locations sampled in CY-1975 was reinforced by 31 additional locations in 16 different directions and distances from the Facility. A total of 79 soil sampling locations was used in the inventory.

Soil background levels were obtained by collecting four additional samples at 0°, 90°, 180°, and 270° at distance ranging from 34 to 51 km (21 to 32 mi). The ratio of plutonium-239 to plutonium-238 found in these samples ranged from 22 to 27. This is in good agreement with accepted values for fallout or background plutonium (3-11). The plutonium-238 values in these samples averaged 0.1 mCi/km^2, and any value exceeding that level was assumed to be the result of past emissions from Mound facilities.

The soil sampling values along each of 16 equally spaced radials originating in the center of Mound Facility were fit to power function curves by a least squares program. The distances between each radial were obtained by a data smoothing technique. The isopleths were then completed and the area between isopleths was measured by planimetry. The concentration calculated at the midpoint distance between each isopleth was used as the average concentration for the area between the isopleths. The isopleth plot is shown in Figure 3-14.

The total quantity of plutonium-238 in the offsite environment due to all past airborne emissions from Mound operations is estimated by this technique to be 360 mCi. The error associated with this value is estimated to be $\pm 35\%$ which includes errors due to chemical analysis, counting, area measurement, and sampling. Radiation dose to the public due to resuspended plutonium, even from the areas of maximum concentration, is well within the proposed EPA standard for transuranium elements in soil.

Liquid Effluent Impact - Liquid wastes from plutonium operations are processed to recover the plutonium when economically feasible. Liquid wastes which do not contain sufficient plutonium to be recovered are solidified and shipped offsite for storage at a disposal site. If a liquid waste contains over 10^6 dis/min/ml, it is classified as "high-specific activity" waste and solidified, packaged in Department of Transportation (DOT)-approved containers and shipped offsite for burial. "Low-level" liquid wastes, i.e., those containing less than 10^6 dis/min/ml, are transferred via underground lines to the waste disposal building where they are processed chemically for plutonium removal and assayed before batch discharge to the Great Miami River. Historically, routine batch discharges of low-level liquid plutonium wastes to the Great Miami River have always been at or below the RCG for the soluble form of plutonium. Annual plutonium discharges in liquid effluents during the past eight years were:

CY-1970	0.464×10^{-3} gram	CY-1974	1.235×10^{-3} gram
CY-1971	0.952×10^{-3} gram	CY-1975	1.116×10^{-3} gram
CY-1972	3.787×10^{-3} gram	CY-1976	0.186×10^{-3} gram
CY-1973	1.003×10^{-3} gram	CY-1977	0.224×10^{-3} gram

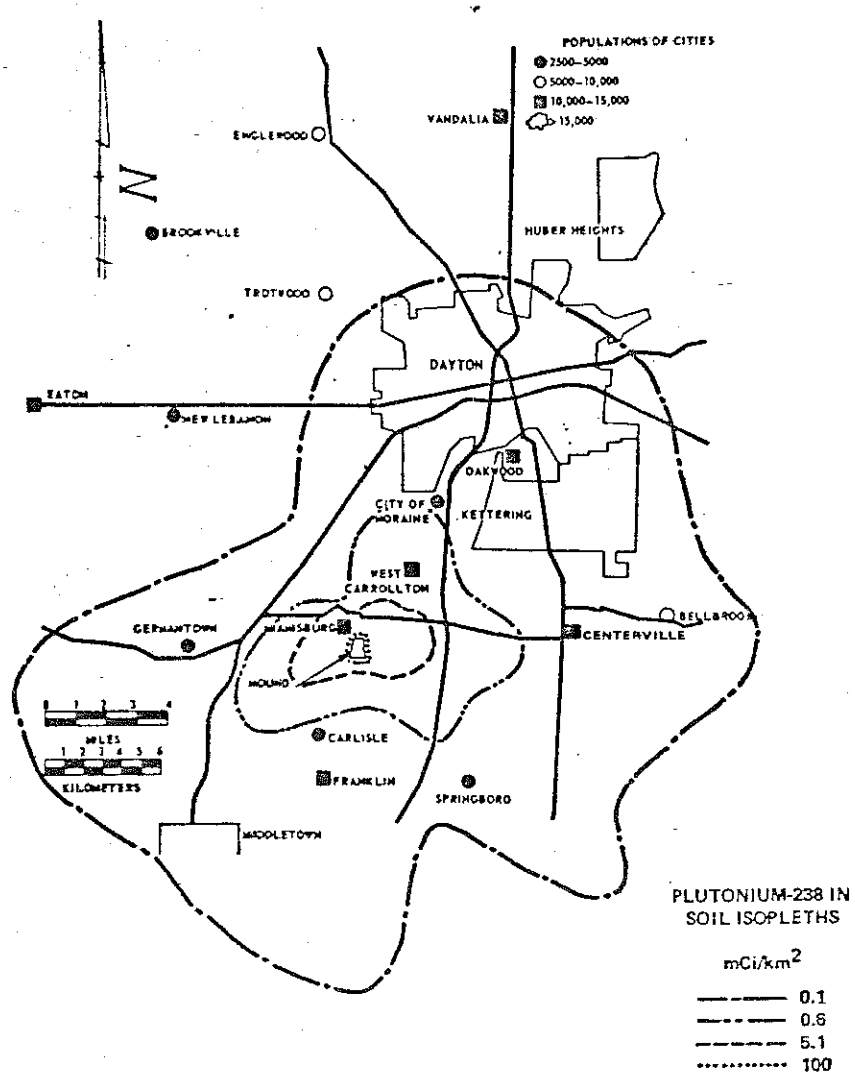


FIGURE 3-14 - Millicurie per square kilometer isopleths.

There are two liquid effluent streams leaving the Mound Facility site. These streams are: (1) a drainage ditch which provides natural drainage for the site and carries storm sewer and some cooling water discharges; and (2) an underground pipeline which carries the sanitary and industrial waste effluents after processing to the Great Miami River. In terms of volume, the average flows are approximately 1.4 million liters/day (0.38 million gallons/day) via the ditch and 0.68 million liters/day (0.18 million gallons/day) via the pipeline.

After water from the surface drainage ditch leaves the site, it flows south through the remnants of the abandoned Miami-Erie Canal system, to a second open ditch which passes under a highway and continues to the river. At the point where the main drainage ditch meets the Miami-Erie Canal, the City of Miamisburg built a small diversion some years ago which caused some of the liquid effluent to flow north into another

:ion of the abandoned canal and then via transfer pipes into two small ponds in the immediate area. Overflow from the ponds and the canal was into a Miamisburg storm drain and to the river. Figure 3-15 is a photograph of the adjacent waterways as they were prior to July 1976 and Figure 3-16 is a sketch of the area.

In July 1976 a project was completed to correct the situation that existed. Currently water leaving Mound Facility through the drainage ditch can flow only into the South Canal and then to the River.

The limit for the concentration of plutonium-238 in liquid effluents is based upon the soluble form of plutonium since the RCG for soluble plutonium is the most restrictive. The waste treatment does not dissolve the suspended plutonium, so most of the plutonium in the liquid effluents is in an insoluble form suspended in the liquid. When released to the natural environment, any plutonium contamination present in the liquid discharges becomes firmly bonded with host particles of clay-forming silt. Migration of plutonium with the groundwaters is thus not significant.

A description of the offsite water sampling program, including locations sampled, is contained in Section 2.1.4.7. Table 3-20 presents a summary of the river monitoring results for CY-1977. The average values observed ranged from $<0.10 \times 10^{-10}$ to $<0.80 \times 10^{-10}$ μCi/ml. These values are minimal, amounting to <0.0005 to 0.004% of the RCG of $20,000 \times 10^{-10}$ μCi/ml. Small amounts of plutonium bound to bottom silt in a localized stretch of the Great Miami River is shown in the data presented in Table 3-21.

:he two effluent streams leaving Mound Facility are monitored continuously. The average value of plutonium concentration measured in the drainage ditch during CY-1977 was 48×10^{-10} μCi/ml. The average value measured in the underground pipe leaving the site was 62×10^{-10} μCi/ml. These values are 0.10 and 0.12% of the RCG.

The average value of plutonium-238 obtained in CY-1977 monitoring of three onsite wells was 0.20×10^{-10} μCi/ml. This value is 0.001% of the RCG of $20,000 \times 10^{-10}$ μCi/ml. Water samples were collected from the Miami-Erie Canal adjacent to the Mound Facility site. The average values for plutonium observed in the water ranged from 26×10^{-10} to 45×10^{-10} μCi/ml. These values are 0.13 to 0.23% of the RCG.

Four private wells and Miamisburg city water were sampled and analyzed for plutonium-238. These samples were large-volume water samples averaging 40 liters. The average plutonium-238 concentration in these samples was $<0.46 \times 10^{-10}$ μCi/ml which is <0.002% of the RCG for the general population. These results are shown in Table 3-22.

The radiation dose during CY-1977 to an individual consuming Miamisburg drinking water has been calculated to be <0.00037 mrem. This radiation exposure is insignificant when one considers that the average annual background radiation to bone (from the natural

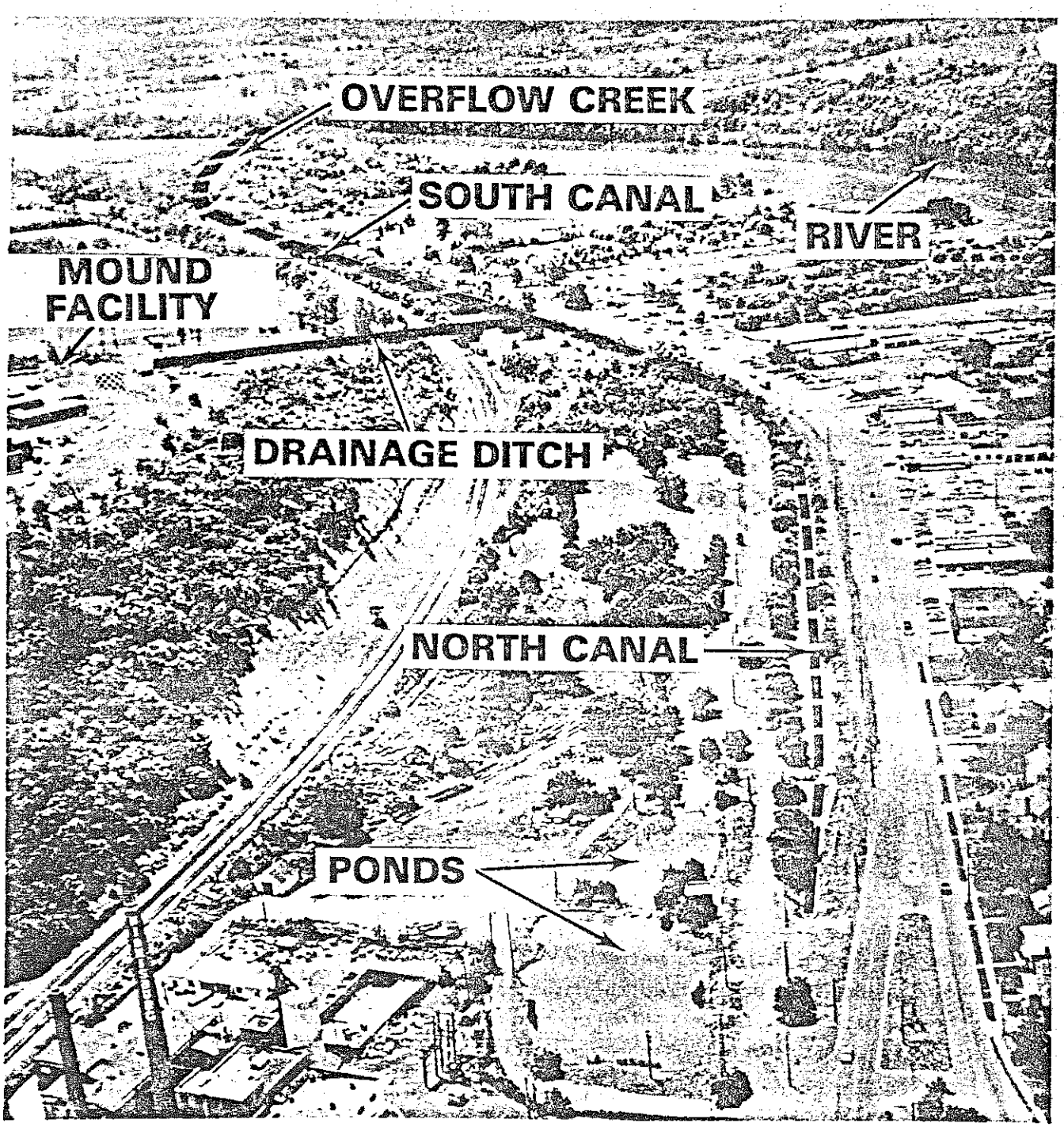


FIGURE 3-15 - View of adjacent ponds and canal. (1974)

Table 3-22

PLUTONIUM-238 IN PRIVATE WELLS AND MIAMISBURG MUNICIPAL DRINKING WATER FOR CY-1977

Location[a]	Number of Samples[b]	Range[c] (10^{-10} µCi/ml)	Average[d] (10^{-10} µCi/ml)	Percent of RCG[e]
Miamisburg	2	<LDL	<0.1 ± 0.01	<0.0005
B-1	2	<LDL	<0.1 ± 0.01	<0.0005
B-2	2	<LDL	<0.1 ± 0.01	<0.0005
B-3	2	0.21 - 2.8	1.5 ± 0.08	0.0075
J-1	2	<0.1 - 0.9	<0.5 ± 0.02	<0.0025

[a]Locations are shown in Figure 3-7.

[b]Two composite large volume water samples were analyzed from each location from water collected during CY-1977.

[c]Lower Detection Limit (LDL) for ^{238}Pu is 0.1 x 10^{-10} µCi/ml which is 0.0005% of the RCG.

[d]Error limits are counting statistics only at 95% confidence level.

[e]Applicable DOE Radioactivity Concentration Guide (RCG) for ^{238}Pu in water = 20,000 x 10^{-10} µCi/ml for the general population and soluble form of ^{238}Pu.

internal presence of radioactive materials) of people in the United States is about 60 mrem.* Since the concentration of plutonium-238 in area drinking water approaches and may be indistinguishable from background level with a resultant insignificant dose commitment to the public offsite, the dose commitment table, such as presented for tritium in water, has been omitted.

The aquatic life listed in Table 3-16 includes samples captured in the River. The average concentration of plutonium in specimens analyzed during CY-1977 ranged from <5.3 x 10^{-10} to 9.6 x 10^{-10} µCi/g. There is no RCG for plutonium in foodstuffs, but the values range from <0.01 to <0.07% of the RCG for plutonium in drinking water. (3-4)

Preliminary soil and silt samples collected in CY-1974 from offsite sediment in the Miami-Erie Canal area near Mound Facility indicated that plutonium-238 concentrations were substantially above baseline levels. A comprehensive Environmental Survey Plan was developed to obtain data necessary for a thorough evaluation of the questioned area. The resultant 5-month Mound Plutonium Study in which the AEC, Federal EPA, Ohio EPA, Ohio Health Department, Montgomery County Health Department, and the City of Miamisburg participated with the operating contractor, Monsanto Research Corporation, determined that a total of approximately 5 curies of plutonium-238 had accumulated in the canal and ponds. The highest concentration, in one location of the canal, was 4.6 nCi/g. The average concentration was 1 to 2 orders of magnitude less than the highest

*Natural Background Radiation in the United States, NCRP 45, November 15, 1975.

concentration. The probable cause of the offsite deposition of plutonium in the canal pond area was determined to be a fracture in CY-1969 of an underground waste transfer line which carried high-specific activity liquid plutonium waste solution to the radioactive waste disposal building for processing. The pipe break was repaired immediately following its discovery in CY-1969 to correct the leak. Use of this waste transfer line was discontinued in CY-1974. Since then, high-specific activity liquid waste has been packaged in the building where it originates.

The Mound Plutonium Study showed that plutonium in liquid discharged into a soil environment becomes strongly adsorbed on host particles of clay-forming silt. Migration of plutonium is therefore associated with silt migration and not water flow. A detailed hazard analysis of the presence of plutonium in the silt of the canal/ponds indicates that there is no significant radiological impact on the area.

As a result of a study by an "Ad Hoc Committee to Evaluate the Health and Safety Aspects of the ^{238}Pu in the Environment Adjacent to Mound Laboratory," it was estimated that soil of the hillside adjacent to the transfer line break contained about 36 Ci of plutonium-238. Sampling results indicated about 9 Ci were transported offsite by the ditch to the canal. The committee examined the results of the Mound Facility study, reviewed the health and safety analysis performed, and made a determination concerning whether the deposit in the offsite areas of the canal, ditch, overflow creek, ponds, and river constituted either a present or future hazard to the general population. The Ad Hoc Committee determined that the plutonium-238 released to the environment from the process waste line rupture was not a health hazard to those living in the vicinity of Mound Facility. The concentration of plutonium-238 in canal bottom silt at location 8 (Figure 3-7) is presented in Table 3-23.

Table 3-23

PLUTONIUM-238 IN SILT FROM CANAL/POND AREA FOR CY-1977

Location[a]	Number of Samples	^{238}Pu Range (10^{-6} µCi/g)	^{238}Pu Average[c] (10^{-6} µCi/g)
8 (South Canal)	2	61.1 - 263.9	162.5 ± 0.63

[a]Location is shown in Figure 3-7.
[b]Lower Detection Limit (LDL) for ^{238}Pu in silt is 0.3×10^{-6} µCi/g.
[c]Error limits are counting statistics only at 95% confidence level.

The Committee recommended increasing the scope of the air sampling program near the ponds and the canal, improvement of onsite drainage and elimination of the flow of drainage ditch water into the north canal, sediment sampling of the contaminated hill-

e to monitor translocation of plutonium, construction of a large-volume retention basin, and stabilization of the area of highest plutonium concentration in the canal. All recommendations of the committee were implemented. A follow-up study conducted in 1977 showed a continuing stable condition for the canal-bound plutonium. (Ref. MLM-2483 Stability of Plutonium Contaminated Sediments in the Miami-Erie Canal, March 1, 1978.)

Solid Wastes - There is no onsite burial of plutonium-contaminated solid wastes at Mound Facility. The contaminated solid wastes are disposed of by shipment in DOT-approved containers to approved offsite burial grounds.

There are areas of known radioactive contamination in the soil. A description of these isolated areas is given in Table 3-24. Figure 3-17 shows the contaminated areas on a site map.

No significant environmental impact can be ascribed to the plutonium-238 activities at Mound Facility or the handling of wastes generated in the operations.

3.7.3 POLONIUM

Mound Facility was involved in many programs using polonium-210, an alpha emitter with a half-life of 138 days. All operations with polonium-210 terminated in June 1972. The facilities have been completely decontaminated. Polonium levels measured in the environment are at background levels. Mound Facility's past polonium operations had no detectable environmental impact.

3.7.4 OTHER ISOTOPES

Over the years, Mound Facility has been engaged in a variety of programs involving miscellaneous isotopes. Work involving these isotopes has generally been on a much smaller scale than with the plutonium, tritium, and polonium isotopes discussed. The principal isotopes included in the miscellaneous category are thorium-232, uranium-233, uranium-235, radium-226, and actinium-227.

Thorium-232 - Late in CY-1954, Mound Facility received 400 tons of thorium sludge from Brazilian ore residues. In 1975, the thorium-232 ore residues were removed from Mound Facility as a result of their sale to a commercial organization.

The only significant environmental impact of this storage has been the contamination of soil near the storage building as a result of redrumming operations and transferring the bulk ore into the building. This is detailed in Table 3-24 and Figure 3-17. Core samples taken in rainwater runoff areas near this building show maximum thorium

Table 3-24

ISOLATED SOIL AREAS - CONTAMINATED
(For Map - Figure 3-17)

Area	Isotopes	Description
1	^{232}Th	1964, 1973 - Bulk transfer of thorium from drums to storage basin. 1965, 1973 - Area cleaned up and backfilled with clean soil. Area approx. 136,000 ft^2.
2	^{210}Po ^{238}Pu	1965. Disposed of sand contaminated with polonium. Sand resulted from cleaning of metal framework of sand filters. (Polonium is essentially decayed out; however, recent data also indicate possibility of very slight plutonium contamination.) Area approx. 15,000 ft^2.
3	^{232}Th	1965. Storage and redrumming area cleaned up and area backfilled with clean soil. Area approx. 69,000 ft^2.
4	^{210}Po ^{60}Co	1965. Waste tanks overflowed. Sewage disposal sludge drying pits also contaminated. (Polonium is essentially decayed out; however, residual cobalt-60 remains.)
5	^{238}Pu	Sewage disposal sludge drying pits contain trace plutonium-238 contamination.
6	^{210}Po ^{60}Co	1969. Radioactive waste line broke. Polonium has essentially decayed out leaving residual cobalt-60. Area approx. 6800 ft^2.
7	^{232}Th ^{226}Ra ^{227}Ac ^{228}Th	1954-1965. Buried empty thorium drums; ^{226}Ra, ^{232}Th, ^{228}Th and ^{227}Ac contaminated dirt. Area approx. 22,000 ft^2.
8	^{232}Th	1965. Buried contaminated dirt from Areas 9 and 1. Area approx. 25,000 ft^2.
9	^{232}Th	1965. Thorium storage and redrumming area cleaned up and backfilled with clean soil. Area approx. 40,000 ft^2.
10	^{238}Pu	Prior to 1965. Contaminated from processing operations. Area approx. 2,600 ft^2.
11	^{232}Th	1965. Buried contaminated dirt from Area 1. Area approx. 19,000 ft^2.
12	^{238}Pu	1969. Plutonium underground waste line broke. 964 ft^3 of contaminated soil removed and shipped offsite for disposal. Area backfilled with clean soil. Contaminated soil had been eroded and washed offsite to Miami-Erie Canal and two adjacent ponds. 2700 ft^3 of remaining contaminated soil removed from hillside and area sodded for soil stabilization.
13	^{225}Ra ^{227}Ac ^{228}Th	1958-1960. Steel crane, tracks, and shielding panels from previous operations are buried under new concrete floor. Area approx. 1,000 ft^2.
14	^{238}Pu	1960-1965. Sanitary-sewage septic tank and leach basin. Area approx. 15,500 ft^2.

Table 3-24 (Continued)

Area	Isotopes	Description
15	^{238}Pu	1960-1970. Area under and immediately surrounding processing building. The contamination is largely the result of activity located beneath the concrete floor of the "hot" side and the previous utilization of outside low-risk tanks. Area approx. 40,000 ft^2.
16	^{238}Pu	1971-1974. Silt and dredgings from onsite drainage ditch used as cover for certain sections of land fill. Approx. 3200 ft^3 spread over an area of 60,000 ft^2.

NOTES: The natural runoff water drainage ditch, which flows through the site at the topographically low area, contains minor residual contamination since this ditch at one time carried effluent waste water from the radioactive waste disposal processes in two buildings as well as the runoff from the above noted surface areas. Settling basins have been created in the drainage ditch so that any silt, particulate matter, etc., carried by the water will drop out before the carrier stream leaves the property.

An aerial survey of Mound Facility for gamma radiation was performed by EG&G, Inc., during the week of July 5, 1976. The only detected gamma radiation identified was a minor amount adjacent to a building near the southern boundary of the site. Subsequent investigation identified the source as a drum containing 25 slugs (1.5 kg each) of bismuth jacketed in aluminum. These slugs had been irradiated prior to 1972 to produce polonium-210. Minor impurities in the aluminum jacket resulted in the production of a very small amount of cobalt-60. These slugs have been removed and shipped to an offsite burial site. At the present time there are no sources of gamma radiation onsite detectable by aerial survey.

contamination levels up to approximately 25 dis/min/g compared to a nominal background of approximately 1 dis/min/g in the Miamisburg area. Although some samples indicate contamination above background, no adverse environmental impact would be expected to result from this low specific activity material.

Uranium-233, Uranium-235 - Mound Facility conducts small-scale operations involving uranium-233 and uranium-235. Air sampling data of the airborne effluents from the operating areas have indicated no detectable quantities of these radioisotopes being released to the environment. Because there are no indications that these isotopes are being released to the atmosphere, environmental samples are not specifically analyzed for these radioisotopes. There are no liquid wastes containing uranium-235 released to the environment. Liquid wastes containing uranium-233 are processed in the waste disposal facility. During CY-1977 3.34 millicuries of uranium-233 were discharged. This quantity in terms of RCG is 0.01% of the most restrictive RCG for individuals in the population.

Radium-226, Actinium-227 - In the early years of Mound Facility operations, research programs were conducted with radium-226 and actinium-227. The only radium at Mound Facility is in the form of sealed sources and the only actinium-227 is in the form of residual activity remaining as contamination identified in Table 3-24 and Figure 3-17.

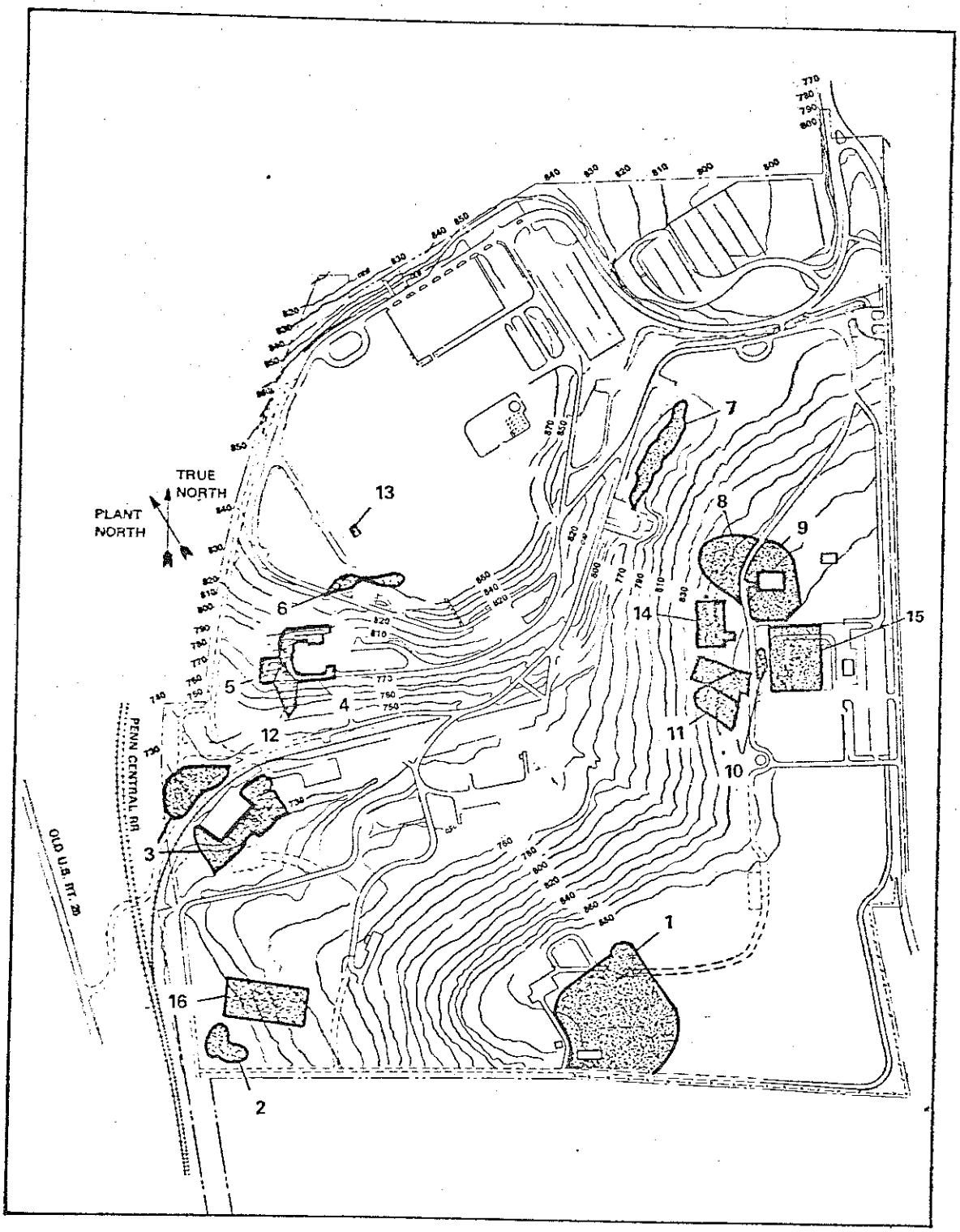


FIGURE 3-17 - Isolated Onsite Contaminated Soil Areas.

3.8 WEED, PEST, AND ICE CONTROL

The normal maintenance of the grounds within the boundary of the plant site includes the use of fertilizer and herbicides plus the use of ice-removal material during winter months. The general purpose fertilizer is a 24-6-6 formulation. Weed control is accomplished with a 2,4-D product. Weed control of the railroad siding, security fence lines, and gravel-covered areas, where no growth is desired, is accomplished by soil sterilization with "Simazine."

A formal program has been established for the use of pesticides at Mound Facility. These products are used only after approval of an industrial hygienist and review by the Federal Working Group on Pest Management. A licensed pest control firm is contracted to dispense the approved pesticides. Mound Facility does not store pesticides.

Ice removal and control on sidewalks are accomplished by the use of ammonium nitrate fertilizer. The use of fertilizer avoids salt burn in adjacent grassy areas. The plant will use approximately one ton of this material during an average winter. Ice control of streets, roadways, and parking lots utilizes commercial-grade rock salt. Approximately 60 tons of salt are used during an average winter. Melting snow and rainfall carry this material into the storm sewer system and ultimately into the Great Miami River. The environmental effect of this discharge is negligible and is only a small fraction of that caused by the total ice control salt used by municipalities upstream from Mound Facility.

3.9 SOCIOLOGICAL AND ECONOMIC IMPACT

3.9.1 SOCIOLOGICAL IMPACT

Over 1700 people are employed at Mound. The programs at Mound demand a large population of professional employes; 580 of the employes are professionals. Through construction of new buildings and major refurbishing projects on older buildings, employment is also provided for several area contractors.

A Tuition Reimbursement Program is available for all employes who choose to work toward a college degree or take courses in a job-related field. Employes may be granted academic leaves of absence to complete requirements for advanced degrees. The Maintenance Training Program provides on-the-job training in the skilled trades (i.e., sheet metal work, pipefitting, welding, masonry, carpentry, etc.). Courses are also offered for employes interested in the chemical operator, mechanical operator, water tender, and machinist classifications. Mound Facility also offers to its supervisory and managerial personnel a number of management training programs.

Mound Facility's Equal Opportunity Policy is to take "positive action to ensure that all candidates for employment are given fair and equal consideration without regard to race, color, sex, age, religion, or ancestry." Following employment, the Facility provides to all persons the opportunity for job advancement and assistance in qualifying for such advancement and does not discriminate against anyone with respect to any of the Facility's advantages, facilities, privileges, or services. Specific hiring and promotional goals for minorities and females were established in the Fiscal Year 1978 Affirmative Action Plan. Under the Minority Enterprise Program, $436,500 in purchases were placed with minority firms during CY-1977.

The employes of Monsanto Research Corporation at Mound Facility have an extensive impact on the cultural and civic areas of the community. Nearly every exempt employe is a member of at least one professional or technical society with a local section which meets monthly; many have been or are officers in these local sections. Employes are active in local political groups serving as precinct leaders; members of central and executive committees; and other elected positions including mayor, vice mayor, and members of village councils. Other employes are serving on planning boards, local civil service commissions, political nominating and screening committees, school boards; as officers in PTA groups, church organizations, fraternal lodges, etc.; and as leaders in activities such as Junior Achievement, Scouting, and similar programs. A Black and White Realities Program acquaints students of area high schools with experiences unique to the black population. The Mound speakers bureau made over 60 presentations in Dayton high schools during FY-1977.

Immediate and long-range benefits to the public have resulted from the technologies developed and the spin-off from AEC, ERDA and DOE programs. Environmental Control programs have developed systems and techniques to improve the containment of radioactive material and thus significantly reduce release of these materials to the environment. This technology has been made available through publications, seminars, conferences, etc. to all segments of the general public. Stable (nonradioactive) isotopes for all types of research work, particularly biological, medical, and agricultural systems, are made available in relatively abundant quantities at low cost. In the area of long-range community benefit, Mound Facility's technological activity has resulted in development of the nuclear fueled cardiac pacemaker and techniques of fuel fabrication for isotopic heat sources. These technological advances are beneficial not only to the local community but to citizens of every community in the United States.

The transportation of employes, materials, and services to and from the Facility prior to, immediately after, and during workhours does not create a traffic problem. Desirable action to reduce traffic and fuel consumption includes 298 carpools transporting 810 employes. The program began in early CY-1974, decreasing the average number of private vehicles transporting Mound personnel by about 400 vehicles (30 to 35%) for over 1650 employes. At present employment, by carpooling, Mound employes are driving approximately 10,000 fewer miles each day. Based upon statistics provided by the American Automobile Association, the savings in gasoline amounts to over 750

gallons of gasoline each day; over 185,000 gallons each year. In all, 51% of the people working at Mound participate in the carpool program. Inbound deliveries to the plant average 35 to 40 per day; outbound shipments average 15 to 20 per day.

3.9.2 ECONOMIC IMPACT

The economic impact of Mound Facility on the community is considered in terms of employment categories, monies paid out into the economy, and the extra financial support to local school districts.

During FY-1978, the employment at Mound Facility averaged 1730 employes, 1706 employed by Monsanto Research Corporation and 24 by the Dayton Area Office of DOE. Mound Facility accounts for approximately 0.5% of the total employment in Montgomery County, Ohio.

At the end of FY-1978 the total employment was 1714. The breakdown by professional disciplines, work skills, etc., was as follows: the 691 exempt salaried employes included 438 physical scientists and engineers, 142 other professional disciplines, and 111 others such as specialists and supervisors not in the other two groups. The 589 nonexempt salaried employes were comprised of 291 technicians and health physics personnel, 56 model makers, 22 designers, and 220 clerical persons. The 434 hourly rated personnel include 140 in the trade crafts, 111 in production work, and 183 in other remaining service functions.

For FY-1978, the employment at Mound Facility averaged 1730 employes. The salaries and wages paid to these employes was approximately $32.1 million; an additional $8.7 million was paid indirectly as fringe benefits for these employes.

The following schedule shows the annual spending by Mound Facility for various commodity groups for the past five-year period.

MOUND FACILITY'S CONTRIBUTION TO THE ECONOMY
(amounts shown in thousands of dollars)

	FY-1974	FY-1975	FY-1976	FY-1977	FY-1978
Salaries, Wages and Fringe Benefits	$28,386	$30,789	$32,387	$37,166	$40,764
Materials, Supplies and Services Purchased	6,945	11,258	10,807	17,291	17,066
Capital Equipment Purchased	2,391	3,527	2,214	2,630	1,514
Construction	2,877	2,405	2,143	4,425	1,697
Total	$40,599	$47,979	$47,551	$61,512	$61,041
Average Man-Years	1752	1730	1579	1656	1730

The monetary support by the federal government to the local school systems as a result of the Facility's operations is significant under the Impacted Schools program of the Department of Health, Education, and Welfare (HEW). The U. S. Government provides payment to school systems for part of the costs for Type B students, i.e., dependents of personnel who work in federally owned facilities. This payment is based on 50% of the cost of educating each child. For this presentation, the payment per school is considered to be 50% of the school district per-pupil cost multiplied by the number of students whose parents are employes and live in the particular school district. The school districts with more than 50 employes are: Miamisburg, $400,000; Franklin, $155,000; Middletown, $150,000; Kettering, $114,000; Centerville, $93,000; West Carrollton, $68,000; Carlisle, $56,000; Germantown, $55,000.

3.10 ACCIDENT ANALYSIS

The purpose of this section is to identify and discuss those accidents and mitigating actions which can be postulated for Mound Facility operations and which have the potential for causing adverse impacts on the environment or are considered of possible special interest to the reader because of the nature of the operations at the Facility. Mound's actual significant accident experience is presented in Table F-1 of Appendix F which has been added based upon the comments received regarding worker safety. Table F-3 shows a pronounced decrease in occupational exposures from 1965 through 1977. In 1977, out of 1510 employes monitored, 1500 received radiation exposures less than 1 rem during the year; 8 employes received between 1 and 2 rem; and two employes received between 2 and 3 rem. No exposures exceeded 3 rem for the year. The philosophy of ALAP ("As Low as Practicable") is being applied on a continuing basis to all impacts of Mound's operations. Other tables in Appendix F cover internal deposition of radioactive material and show a low deposition incidence for lung exposures and systemic body burdens above the radiation protection standards during the whole history of the project.

Appendix F also includes statistics on Disabling Injuries to Employees and shows that during the period 1948 through 1977, Mound had only eight disabling injuries. A table covering Plant Property Losses Exceeding $5,000 is also presented and shows only nine such incidents since operations were initiated in 1948.

In the following accident descriptions, the consequences are stated without a detailed description of the calculations used to arrive at the conclusions. Sufficient information of this type is contained in Appendices B, C, and E for the benefit of the reader who wishes to pursue how such values were determined.

3.10.1 FIRE IN A PLUTONIUM FACILITY

Consideration was given to the possible occurrence of a serious fire in various buildings. It was concluded that a release of plutonium would pose the greatest potential for adverse environmental impact via this type of accident. This accident is also considered to be the maximum credible accident for Mound Facility.

The postulated fire is assumed to occur in a plutonoum-238 processing facility which has the largest in-process inventory at the time of the fire. The laboratory where the postulated fire is assumed to originate is also assumed to have the highest

ncentration of combustible materials and the greatest potential, due to location, to adversely affect the building's HEPA filtration system. The glovebox line postulated for the fire is assumed to contain 100 grams of plutonium-238 in process at the time of the fire. It is estimated that even in a serious room fire, no more than 10 grams of plutonium would be expected to be released from the glovebox into the operating laboratory. The released plutonium would be in a cloud of combustion products created in the area of the fire. It would be anticipated that the plutonium would conglomerate with the combustion products thereby resulting in an effectively large particle size of plutonium. For the purpose of this analysis one gram of plutonium-238 (10 mg/m^3) is assumed to remain airborne for a sufficient time to be carried out of the laboratory via the ventilation system to the building filter banks.

For the purpose of assessing maximum potential impact on the environment, it was assumed in this hypothetical study that the protection afforded by the filter banks is partially defeated either by partial breaching of the filters by fire or by excessive pressure drop. Another remote possibility would be that excessive smoke would plug the filters and pressurize the building which in turn might be intentionally or unintentionally vented by fire fighters attempting to extinguish the fire. Irrespective of how the release might occur, in spite of the protection systems, the upper limit of airborne plutonium released to the environment was assumed to be about one gram of plutonium-238 (approximately 16 curies).

To assess the potential environmental impact of the postulated fire, a particle size distribution of the plutonium was assumed. For this analysis 50% of the plutonium is assumed to be greater than 50 μm in diameter. The remainder of the plutonium is assumed to be in particles approximately 1 μm in diameter. Particles 50 μm and greater in size will have an impact on the land because of the short time required to drop out of the air stream and be deposited on the ground but will have virtually no impact on the population because of the small percent which will be retained in the lungs. Particles 1 μm in size are readily inhaled and deposited in the lungs but have little impact on the land because they remain airborne for a long time (resulting in dilution in the airstream) before they are deposited on the ground. This particle size distribution was selected so that an evaluation could be made of the potential impact on both the land and the population. A further refinement of the distribution is not considered necessary because of the other uncertainties that are inherent in an analysis of this nature.

It was assumed that the release would have an effective stack height of 70 m (230 ft), either because it was released through a stack or because of the rise of the column of heated smoke. Pasquill Type A meteorological stability condition with a wind speed of 1.5 m/s (3.3 mph) is assumed to exist during the incident. This condition results in the highest "maximum downwind concentration" as shown on page 3 of Appendix B.

Dose calculations were performed utilizing the assumptions and method presented in Appendix C. An individual standing at the point of maximum concentration of plutonium

[340 m (1100 ft) downwind] for two hours would be exposed to an average concentration of 2.5×10^{-8} μCi/ml. This individual would receive an uptake of plutonium-238 via inhalation. The resulting dose to his lungs during the first year after the incident would be approximately 10 rem. The total lifetime dose commitment to his lungs would be approximately 15 rem.

As would be expected, the heavier particles would fall out close to the point of release. Particles of 100 μm would begin reaching the ground at a downwind range of approximately 100 m (325 ft). Based on the distance 50 μm particles would begin deposition, it is predicted that 50% of the material would be deposited within 500 m (1600 ft) of the point of release. The resulting average surface contamination level would be approximately 40 μCi/m^2. The area affected would be approximately 202,000 m^2 (50 acres). The large particle size of the deposited plutonium would minimize the potential hazard for members of the general public receiving an exposure due to inhalation of resuspended plutonium. Fallout of plutonium on the ground would have no impact on public water systems since drinking water for this geographical area comes from underground aquifers. Plutonium becomes bound to the soil and does not enter the aquifer. Therefore, dose commitment to the public from a fire involves inhalation only.

Although there is currently no approved federal standard for plutonium surface soil contamination, EPA proposed standards which are currently under consideration and proposed interim standards by Healy (3-12) indicate that decontamination of the affected area would be required. Evacuation of some members of the general public from a small area would be required until decontamination was accomplished.

An assumed westerly wind allows the plume to pass over the site boundary which is closest to the plutonium handling facility. The sector east of the site includes the Mound Golf Course [235,000 m^2 (58 acres)] and the Miamisburg Mound State Memorial Park [20,200 m^2 (5 acres)]. If decontamination of the area were required, it could be accomplished without a long-term adverse impact by soil removal.

The population in a sector 0-1.6 km (0-1 mi) due east of the center of the site is approximately 150 people. The first residential area due east of the plutonium processing building is approximately 0.8 km (0.5 mi). The ground level concentration at approximately 0.8 km (0.5 mi) would be one-fifth that of the maximum concentration. The average dose to an individual in the population would be 2.5 rem for a total integrated dose to the total population of 375 person-rem.

There are many built-in safeguards in the plutonium handling buildings at Mound Facility which would limit or control any fire that might reasonably be expected to occur. All plutonium is handled in inert atmosphere gloveboxes or in air atmosphere gloveboxes protected by Halon 1301 fire detection and extinguishing systems. All laboratories have been designed and equipped to minimize the amount of combustible material and to

ıpartmentalize the layout of laboratories which would inhibit fire spread. All plutonium handling areas have 100% automatic sprinkler protection. Manual action can be taken by the volunteer emergency brigade members who work in the area using the fire extinguishers and hoses provided. All filter banks have been upgraded in recent years at considerable expense and now provide two stages of high efficiency particulate filtration, automatic deluge sprinkler protection, mist eliminators, and fire dampers. These high-efficiency filtration systems reduce the environmental release of plutonium to insignificant levels. The possibility of any fire breaching these filtration systems is very remote.

Finally, Mound Facility has a full-time professional firefighting force onsite around the clock. The fire response vehicles include a high-pressure, high-volume pumper, a high expansion foam truck, a small auxiliary pumper, and an ambulance. Contact is also maintained with the City of Miamisburg Fire Department, which will respond within an estimated time of five minutes, upon request, to a fire at Mound Facility.

Because of these safeguards, in reality a fire in a plutonium processing building would be expected to have a much less adverse impact on the environment than the fire described in this section.

3.10.2 ACCIDENTAL RELEASE OF TRITIUM

nd Facility conducts a number of operations involving the processing of tritium. ccident is postulated to occur which would involve a standard tritium storage tank containing 20 grams (2×10^5 Ci) of tritium. This quantity is considered to be an upper limit of the amount of tritium that could be released at any one time. Tritium released from a storage tank, as postulated in this accident, would be in the elemental form. If the release from a storage tank were accompanied by a fire, some of the tritium released may be converted to tritium oxide. Pinson and Langham (3-13) indicate that the potential health hazard of being exposed to tritium oxide is several orders of magnitude greater than being exposed to elemental tritium. Dose commitments, assuming a release of elemental tritium and tritium oxide, are given to reflect the relative hazard of each.

The tritium would be released to the environment out a stack with an effective height of 70 m (230 ft). The release is assumed to occur over a 3-minute period. Pasquill Type A meteorological stability condition with a windspeed of 1.3 m/sec (3 mph) is assumed to exist during the incident. An assumed southwesterly wind allows the released tritium to involve the largest offsite population nearest the source of contamination.

An individual located approximately 1000 feet (0.3 km) downwind of the release point would receive the maximum uptake of tritium. The individual would absorb equal amounts

of tritium through the skin and through the lungs during the passage of the cloud of tritium. No credit was taken for the protection offered by the clothing an individual may be wearing or the possibility that some tritium may diffuse outward from the epidermis due to the short exposure time. The whole body dose commitment an individual could receive from a tritium oxide release would be 0.1 rem. If the release was in the form of elemental tritium, the whole body exposure would be approximately 8.1×10^{-5} rem.

Approximately 650 people live within 1.6 km (1 mi) north-northeast of Mound Facility. An integrated population dose of approximately 11.4 person rem could occur as a result of this postulated accident. If the release was elemental tritium, the integrated dose would be 8.6×10^{-3} person rem.

Bainbridge (3-14) gives a mean deposition velocity of 0.8 cm/sec (0.025 ft/sec) for tritium oxide. The possibility therefore exists that some vegetation could become contaminated with tritium oxide as the cloud passes. Kline and Stewart (3-15) have reported rapid decontamination (half-time of 25-35 min) of vegetation due to transpiration. It would therefore not be anticipated that any decontamination efforts would be required. No restriction on usage of crops or water supplies would be anticipated as a result of this postulated accident.

Mound Facility has used a philosophy of assured containment throughout its tritium facility. The use of two containment features in many areas where large quantities of tritium are present requires that two breaches must occur before a major release of tritium into the work area can occur. Other areas utilize an emergency holding tank concept whereby released tritium would be transferred to the tank before it could escape to the environment. The tritium facility also has an Effluent Removal System which recovers tritium from a contaminated atmosphere before it is exhausted to the environment. The effectiveness of assured containment is reflected in the fact that airborne tritium effluents from Mound Facility have been reduced by a factor of 30 since 1969. These factors significantly reduce the possibility of a major release of tritium at the Facility. In the event of a major tritium release, however, the environmental impact would be minor and short term.

3.10.3 NUCLEAR CRITICALITY ACCIDENT

Operations at Mound Facility include the handling of fissile materials such as uranium-233, uranium-235, plutonium-238, and plutonium-239. If these materials are handled in large quantities, the potential for a criticality accident exists. Operations involving fissile materials include research, development, fabrication, and sub-gram chemical separations. Quantities handled during any given operation range from milligram amounts to a maximum of several kilograms.

ne probability for a criticality accident at Mound Facility is considered to be very remote. To ensure that all accidents which have the potential to cause an adverse environmental impact are considered, the potential hazard to the general population as a result of a criticality accident is evaluated in the following paragraphs.

It was postulated that the accident took place as the result of the inadvertent rearrangement of several subcritical plutonium parts to form a critical mass. It has been estimated (3-16) that this type of accident will have a total yield of 10^{18} fissions, with no substantial explosive force. Higher yields have been reported during past accidents (at other locations), (3-16) but those accidents have involved large amounts of plutonium solutions, a situation which cannot physically occur at Mound Facility.

Calculations as discussed in Appendix E were made to estimate the radiation dose commitment to an individual standing at the point of maximum concentration due to the fission products released and escaping from the building after the postulated nuclear excursion. Two types of radiation doses were considered in the analysis: external dose to the whole body (gamma and beta radiation) and the internal dose to the thyroid. Release fractions of radioactive particulates and gases are given in the last column of Table 1 on page 2 of Appendix E.

The external dose to the body due to the entire fission product cloud is estimated to be 1.1 rem. This is in compliance with the limits in 10 CFR 100, (3-17) which specify that a person standing at the edge of the excursion area for two hours must not receive a dose of more than 25 rem. Although 10 CFR 100 guidance was developed for nuclear power reactors Mound deemed it appropriate to use the dose criteria since this is the only known published guidance for evaluating a nuclear criticality accident.

The radiation dose delivered to the thyroid of an individual adult located at the point of maximum concentration was estimated at 0.11 rem. For a child, the maximum thyroid dose was estimated at 2.2 rem. These figures include the doses contributed by the inhaled iodine and the iodine decay products. The limit set by 10 CFR 100 is a dose to the thyroid of 300 rem for a two-hour exposure at the outer boundary of the excursion area or during the passage of the entire fission product cloud. The estimated radiation dose to the thyroid is well within 10 CFR 100 limits.

The postulated criticality accident could be expected to result in the release of approximately 1 Ci of iodine-131 and 635 Ci of other isotopes of iodine. Also released would be approximately 70,000 Ci of other radioisotopes. Most of these radioisotopes have a short physical half-life. The HEPA filter banks would not be adversely affected by such an accident and would, therefore, prevent any particulate materials from escaping the building. It is anticipated that no decontamination of the surrounding

land would be required. The lack of a major commercial dairy industry in the immediate area indicates that such actions as restriction of milk supplies will not be required. The environmental impact of a nuclear criticality accident would be minor and short term.

Mound Facility has established a formal Nuclear Criticality Safety Program to minimize the possibility of a nuclear criticality incident. The objectives of the Nuclear Criticality Safety Program are to ensure that all operations with fissile materials are guided by up-to-date approved procedures within existing regulations and standards, to establish guidelines and parameters for operations involving fissile material, and to maintain a comprehensive training program in criticality safety.

The nuclear-safe mass for a specific fissile isotope, known as the Criticality Unit Value (CUV), has been defined as 1/2.3 of the minimum critical mass for the specific isotope. Optimum conditions such as spherical geometry, isotope theoretical density, and full neutron reflection are assumed to determine the minimum critical masses. Written procedures are required for any operation involving one-tenth or more of a CUV. The fissile material areas at Mound Facility process fissile material in amounts well below one CUV. There are a few areas, such as storage vaults, where inventories over one CUV are kept, but within any storage vault the material is stored in DOT-approved fissile material shipping containers. These containers are designed to be nuclear safe. Only amounts under one CUV are handled at a given time outside the shipping containers. This approach practically eliminates the possibility for accidental criticality excursions.

3.10.4 NUCLEAR EXPLOSION

Mound Facility's assigned function, as part of the nuclear weapons programs, requires that various nuclear and explosive components be at the site. Operations do not include the assembly or disassembly of nuclear warheads. There is no possibility that all required components would be available at Mound Facility to assemble a functional nuclear device. An accidental nuclear explosion is, therefore, impossible at Mound Facility.

3.10.5 DETONATION OF HIGH EXPLOSIVES

Mound Facility conducts research, development, and production of explosive detonators for the DOE weapons program. The principal explosive stored and processed is pentaerythritol tetranitrate (PETN). The only primary explosives at Mound are contained in fully assembled components received from other sites.

Actual process operations with explosives involve much smaller quantities than are present in the storage magazines. The two largest magazines are approved for storage of up to 900 kg (2000 lb) of PETN each.

This amount of PETN is approximately equivalent to 1300-1800 kg (3000-4000 lb) of TNT. In the unlikely event of an explosion in a magazine, the area of possible destruction, 60° from the horizontal to the face of a magazine and from the door opening, would be totally restricted by the steep embankments opposite each magazine. No structural damage would be expected offsite although there may be some broken windows. The smoke cloud would dissipate with no adverse effects. Such an explosion would not damage any nuclear facility or cause any environmental release of radioactive material.

All explosive processing is conducted in facilities designed, equipped, and operated within the strict requirements of Army Materiel Command Regulations AMCR 385-100 (Safety Manual). The maximum quantity of bulk explosives permitted in any manufacturing area is 0.45 kg (1 lb). If any detonation were to take place, no damage would occur to any structure where radioactive materials are handled and no radioactivity would be released.

3.10.6 ONSITE TRANSPORTATION ACCIDENT

At Mound Facility the transportation of explosive, radioactive, or toxic materials between buildings involves small quantities for short distances. Explosives and radioactive materials are never transported in the same vehicle at the same time.

Radioactive materials transported between buildings are packaged in DOT-approved shipping containers or in other sealed metal containers adequate to ensure positive containment even under accident conditions. Any release of radioactive material postulated in an onsite transportation accident would be less serious than the radioactive releases described elsewhere in this assessment.

The most serious potential onsite transportation accident from an environmental standpoint is considered to be one involving a tank truck of fuel oil making a delivery to Mound Facility If such a truck were to be involved in an accident, up to 11,400 liters (3000 gal) of fuel oil could be spilled onto the ground and enter the drainage ditch which drains the site. Mound Facility has constructed at the site boundary a retention basin which is equipped with subsurface drainage ports that will prevent a major release of oil to the offsite environment. The very small amount of oil that could reach the offsite waterways would not cause injury to members of the general public or aquatic life. An emergency plan to cope with this type of accident has been formulated (See Section 3.11). The plan helps to minimize the time required to take action to minimize the quantity of oil released and the area affected.

3.10.7 POWER OUTAGE

The effect of a major power outage at Mound Facility was considered for its potential to cause an adverse environmental impact. Such an occurrence may result from a local thunderstorm or ice storm. The loss of power to the ventilation systems for radioactive material processing facilities is considered to have the greatest potential for an adverse environmental impact. Because of the importance of pressure differentials and air flows in maintaining effective contamination control, diesel-powered emergency generators have been provided. These emergency generators provide power to critical parts of the ventilation systems as well as to critical operating equipment. The emergency generators are tested weekly to ensure proper operation. The loss of electrical power would not be expected to result in any adverse environmental impact.

3.10.8 NATURAL DISASTERS

Natural phenomena were considered to the extent that they may be the source of a serious impact on the environment. Floods and hurricanes are not discussed in this section because of Mound Facility's location high above the flood plain of the neighboring river valley and well away from the coastal areas subject to hurricanes. No buildings at the Mound Facility are located on a flood plain or in areas considered as wetlands in 10 CFR Part 1022.

The only natural phenomena that offer any significant potential for serious consequences are tornados and earthquakes. The study of the structural effects of such extreme natural forces on the major processing facilities at Mound Facility has been completed under contract with the Corporate Engineering Department of Monsanto Company. The analyses were prepared in support of Mound Facility's ongoing effort to prepare Final Safety Analysis Reports (FSAR's) for its major buildings.

The potential effects of tornados or earthquakes rupturing a plutonium processing facility are deemed to present the greatest hazard to the environment of any of the natural disasters which can be postulated for Mound Facility. It is difficult to assess the potential effects of a tornado or an earthquake without slipping off into nonscientific conjecture involving unbounded consequences. In order to avoid these extremes as much as possible, analyses were based upon a sound engineering evaluation of the structural effects of a tornado or an earthquake on the plutonium processing building followed by a middle-of-the-road approach in postulating the release and movement of plutonium-238 as a consequence of the structural effects.

Where applicable, the reader is given some estimate or indication of the probability of occurrence of the natural disaster being analyzed. The frequency of occurrence of tornados was calculated by standard methods and is reported in the following section. Earthquakes of the type treated in this report were simply assumed to occur since the is apparently no standard way to predict their frequency. Second and third-order

effects inside the building that are required for breach of containment and a release out of the building were assumed to occur where professional judgment indicated they might be expected. They were not assumed to occur just for the sake of achieving upper limit type of effects.

Tornado Analysis - The evaluation of the offsite consequences of tornados was based primarily upon work by DeWhitt. (3-18) The extreme weather conditions during a tornado eliminated the use of analytical tools such as diffusion calculations in evaluating the dispersal of released plutonium. Estimates of the total cost of these accidents, including offsite decontamination, are given as broad ranges. A report by Guthrie and Nichols was used in part to estimate costs. (3-19).

The reader should not lose sight of the fact that the accidents discussed in this section would be classed as disasters on their own merit, irrespective of any possible plutonium-238 contamination as a result of the destruction of the plutonium processing building. Realistically, the greatest immediate threat to the public would be the tornado or earthquake itself. The immediate area would probably be classed as a Federal disaster area. The cost of removing plutonium-238 contamination would overlap, in some cases, the costs normally encountered in natural disasters such as the costs of rescue, recovery, and debris removal.

To place this accident into perspective, the frequency of occurrence of a tornado had to be determined. The method suggested by Thom (3-20) provides estimates of the probability of a tornado of unspecified intensity striking a point within a 1° square centered at Mound Facility. The probability of a tornado striking a point was determined to be 0.00119 or approximately 10^{-3}. The return period would be 840 years. However, only those tornados of sufficient intensity to damage facilities such that significant radioactive materials would be dispersed are of concern. A scale quoted from Fujita (3-21) which classifies the type of damage expected from various storm intensities is provided in Table 3-25.

Mound Facility is in the geographical area specified as Region I in the "Minimum Design Criteria of New Plutonium Facilities." (3-22) By definition, the DOE Model Tornado for this region is a tornado of the intensity of 480 km/hr (300 mph) rotational and 100 km/hr (60 mph) translational. This yields a combined velocity of 580 km/hr (360 mph) which is classified as (F6) on the Fujita Scale. Abbey (3-23) has estimated probabilities of tornados of various windspeeds for different regions of the United States. The probability of a tornado with windspeeds of 150 mph occurring within the vicinity of Mound Facility is one in 100,000 years or 10^{-5}. All the buildings at Mound which house operations involving radioactive materials will survive tornados within 150 mph windspeeds. The probability of a DOE model tornado is estimated as one in 100,000,000 years or 10^{-8}.

In evaluating potential effects of tornados, it should also be recognized that a building may not lie in the direct path of the tornado but may be damaged by a near-

Table 3-25

FUJITA SCALE DAMAGE SPECIFICATIONS

(F 0) 40 - 72 mph, LIGHT DAMAGE
Some damage to chimneys and TV antennae; breaks twigs off trees; pushes over shallow-rooted trees.

(F 1) 73 - 112 mph, MODERATE DAMAGE
Peels surface off roofs; windows broken; light trailer houses pushed or overturned; some trees uprooted or snapped; moving automobiles pushed off the road; 73 mph is the beginning of hurricane wind speed.

(F 2) 113 - 157 mph, CONSIDERABLE DAMAGE
Roofs torn off frame houses leaving strong upright walls, weak buildings in rural areas demolished; trailer houses destroyed; large trees snapped or uprooted; railroad boxcars pushed over; light object missiles generated; cars blown off highway.

(F 3) 158 - 206 mph, SEVERE DAMAGE
Roofs and some walls torn off frame houses; some rural buildings completely demolished; trains overturned; steel-framed hangar-warehouse type structures torn; cars lifted off the ground; most trees in a forest uprooted, snapped, or leveled.

(F 4) 207 - 260 mph, DEVASTATING DAMAGE
Whole frame houses leveled, leaving piles of debris; steel structures badly damaged; trees debarked by small flying debris; cars and trains thrown some distance or rolled considerable distances; large missiles generated.

(F 5) 261 - 318 mph, INCREDIBLE DAMAGE
Whole frame houses tossed off foundations, steel-reinforced concrete structures badly damaged; automobile-sized missiles generated; incredible phenomena can occur.

(F6-12) 319 mph to sonic speed, INCONCEIVABLE DAMAGE
Should a tornado with the maximum wind speed in excess of (F 6) occur, the extent and types of damage may not be conceived. A number of missiles such as ice boxes, water heaters, storage tanks, automobiles, etc., will create serious secondary damage on structures.

miss type situation. For this analysis a near-miss was determined to be approximately 180 m (600 ft) from the facility. (3-24)

The tornado analyses given in the following sections treat three different tornado incidents. These incidents are: (1) near-miss by a DOE Model Tornado; (2) direct strike by a Moderate Tornado; and (3) direct strike by a DOE Model Tornado.

Near-Miss by DOE Model Tornado - Structural analysis of the plutonium processing building substantiates that the integrity of the building would be maintained. The primary containments feature (i.e., gloveboxes, conveyor, filter bank, etc.) would not be breached. An additional structural analysis of the containment features revealed that they could withstand a pressure drop of 690 N/m^2 sec (0.1 psi/sec) without any adverse effects.

Operating personnel and the general public in the vicinity of the building would not be exposed to concentrations of plutonium-238 in excess of guidelines given in NBS Handbook 69. (3-25) No personnel injuries are anticipated nor would this accident result in any program interruptions. Dollar loss would be minor and would consist of repairing structural cracks.

Direct Hit by a Moderate Tornado - Structural analysis of the plutonium processing building was conducted utilizing a total windspeed of 321 km/hr (200 mph) and a pressure drop of 8300 N/m^2 (1.2 psi) in 3 seconds. The building's structure will survive a direct hit by a moderate tornado. Some breaching of the facility in the form of cracks will occur. The outer wall of the building may also be punctured by airborne missiles. The major threat to containment, however, is the rate of pressure drop that is applied to the primary containment features of the building. The rate of pressure drop created by the passage of the storm will result in 1400-2800 m^3 (50,000-100,000 ft^3) of air being vented out of the building by way of the ventilation system and the exterior doors. Primary containment features such as gloveboxes, conveyor system, and filters are expected to fail due to the loads imposed on them.

Plutonium released to the environment would originate from loose surface contamination in the ventilation and glovebox systems. Material in sealed containers was not considered vulnerable to release. It was estimated that the quantity of plutonium released offsite would be in the range of 0.1 to 10.0 g of the vulnerable plutonium. It would be expected that some of the material would enter the vortex of the tornado and be carried for many miles by the storm. Some of the plutonium made airborne by the tornado would be scavenged out of the atmosphere by the 5 to 15 cm (2 to 6 inches) of rain that accompanies a tornado. Plutonium particles 25 μm and larger would be expected to be washed out locally in this manner. The resulting surface contamination would probably require some decontamination. It is anticipated that the building would be isolated from the outside environment within hours, thus preventing a continuing release of plutonium.

Some serious injuries (including fatalities) would probably result from flying debris. Also some operating personnel and some members of the general public would receive uptakes of plutonium in excess of guidelines given in NBS Handbook 69. The primary containment features of the building would require major repairs and the entire facility would require decontamination. Significant programmatic interruptions would be anticipated. The total property loss, decontamination, and other associated costs can only be estimated to be in excess of $10,000,000.

Direct Hit by DOE Model Tornado - To document the upper limit of risk associated with accidents involving tornados, structural analysis of the plutonium processing building was conducted utilizing the forces of a DOE Model Tornado [rotational speed of 480 km/hr (300 mph), translational speed of 100 km/hr (60 mph), and a rate of pressure drop of 20,700 N/m^2 (3 psi) for 3 seconds].

The forces imposed on the plutonium processing building would destroy the facility. It would be anticipated that containment features such as gloveboxes and conveyor would be breached in the collapsing structure. There also exists the possibility that gloveboxes, material storage containers, and any other object in the building could become airborne. Gloveboxes, for example would be expected to remain within 300 m (1000 ft) of the facility.

Structural analysis revealed that the water tower adjacent to the building would also collapse. This would result in approximately 946,000 liters (250,000 gal) of water flowing over the ground, washing some plutonium contamination offsite.

It would be anticipated that members of the general population would be exposed to concentrations of plutonium-238 in excess of those levels specified in NBS Handbook 69. The general public would have to be evacuated during decontamination of the region. Fatalities, serious injuries, and significant uptakes of plutonium-238 would be anticipated to occur to operating personnel. It is assumed that it will take several days to confine the plutonium-238 in the debris of the building. The building would be a total loss. The total property loss, decontamination, and other associated costs can only be estimated to be in excess of $25,000,000.

Since Mound Facility is advised of the possibility of severe weather approaching the area by way of the National Warning System (NAWAS), standard procedure is to place loose plutonium-238 in sealed containers and return it to the storage vault. The maximum quantity of plutonium-238 vulnerable to release is less than 90 grams. This material consists of box line contamination, material in filters, and process material in a form which cannot easily be placed in assured containment vessels. The possibility of process material (which constitutes the bulk of potential loss) being released will be negated by discontinuing the preparation of plutonium oxide feedstock at Mound Facility by September 30, 1979.

Comments on the Tornado at Xenia, Ohio, on April 3, 1974 - It is pertinent to this discussion to consider evaluation of a recent major tornado in the greater Dayton area. On April 3, 1974, a tornado struck the community of Xenia, Ohio, which is located approximately 20 miles northeast of Mound Facility. This tornado was intensively studied by Professor Fujita's group at the University of Chicago as well as by the U. S. Weather Bureau. It has been termed one of the most severe and most damaging tornados that has ever occurred in the United States. The National Severe Storm Forecast Center, Kansas City, Missouri, assigned the classification (F 5) to the tornado.

Representatives from Mound Facility and the Corporate Engineering Department of Monsanto toured the Xenia area to inspect for damage to buildings of similar construction. As a result of this inspection, it was Monsanto's structural engineer's opinion that the plutonium processing building would probably have been seriously damaged, but would have survived this tornado. The type of damage observed in other substantial buildings in Xenia was not inconsistent with the type of damage that was predicted by the computer analysis of the structure of the plutonium processing building.

Such an inspection is not conclusive, and no such claim is made; however, the direct observations do tend to lend credibility to the general accuracy of the above tornado analysis.

Earthquake Analysis - Structural analyses of the plutonium processing building were performed for two seismic loading conditions. These seismic loading conditions represented a Design Basis Earthquake (DBE) and an Operating Basis Earthquake (OBE). DBE was determined from the maximum ground motion possible considering both seismic history and geological structure. The OBE was determined from seismic history. The DBE was considered to produce a maximum horizontal ground acceleration of 20% of gravity and the OBE 10% of gravity.

Operating Basis Earthquake - During the Operating Basis Earthquake the basic integrity of the plutonium processing building will be maintained. Damage to the structure would be in the form of cracks in the walls and roof. This minor breaching may alter the pressure differential maintained under normal conditions. Adequate air flow would be maintained to prevent plutonium-238 from escaping through the breaches in the structure. It is possible that the conveyor system and other primary containment features may experience some cracking, thereby releasing plutonium-238 into the operating area. In this analysis, it is presumed that 0.1 g of plutonium-238 would be released into the operating area. Another assumption utilized in this analysis, is that the filtration system would be damaged. It is postulated that cracks would develop in the seals of the filter frame or the filters would be damaged. For the purpose of this analysis, the damage is assumed to be extensive enough to effectively eliminate one bank of HEPA filters. This would reduce the overall efficiency of the filtration system to 99.9%. Of the 0.1 g released to the operating areas, 0.01 g would enter the ventilation system. The remaining material would stay in the operating

area as surface contamination. Assuming a 99.9% efficiency of the filtration system, a total of 160 μCi of plutonium-238 would be released to the environment. The maximum lifetime dose commitment to individuals in the general public as a result of such a release would be 5×10^{-4} rem to the lung. The exposures are well below Federal guidelines given in NBS Handbook 69. No surface contamination would be detectable offsite.

A fire resulting from damage due to the Operating Basis Earthquake may occur. For example, ignition sources such as damaged electrical circuits could start a fire. The available combustibles for propagation of such a fire are very limited. The lack of fuels such as quantities of flammable gas and solvents significantly reduces the probability that a large-scale fire would result from an earthquake. The sprinkler system for the building may not be operable due to breaks in the fire water supply line. The Halon 1301 fire suppression systems for the gloveboxes are less susceptible to damage from earthquakes by virtue of their design as independent units. Any fire not automatically extinguished that may be caused by the Operating Basis Earthquake would be minor and could be extinguished in its incipient stage by operating personnel or fire fighters using portable extinguishers. It is anticipated that the building would be isolated from the outside environment (within a few hours) by emergency repairs and thus prevent a continuing release of plutonium.

Significant biological uptakes of plutonium would not be anticipated. The total property loss, decontamination, and other associated costs can only be estimated to be in excess of $1,000,000.

A potentially serious consequence of an Operating Basis Earthquake is the remote possibility that the adjacent water tower may collapse and strike the plutonium processing building. The tower would be expected to twist and collapse upon itself without striking the building. If it did topple and strike the building, approximately 25% of the facility could be destroyed. Some containments such as gloveboxes and the conveyor system may be breached. The 946,000 liters (250,000 gal) of water would act as a pathway for plutonium to be released to the environment. It would be anticipated that part of the area surrounding the building would require decontamination. If a containment system is breached and air dispersion of particulates occurs, it may be necessary to evacuate some members of the general public living in the vicinity. It is assumed that some members of the general population would be exposed to concentrations of plutonium-238 in excess of the levels specified in NBS Handbook 69. Fatalities, serious injuries and exposures to operating personnel would be expected under this condition. Dollar loss to the building and decontamination cost can only be estimated to be in excess of $25,000,000.

Design Basis Earthquake (DBE) - By definition the Design Basis Earthquake (DBE) causes a ground acceleration twice that of the OBE. Based on the historical data, Mound Facility considers such an event incredible.

All the damage of the OBE will occur in the DBE plus the following damages. The DBE will breach all containment features of the plutonium processing building. The collapsing roof could provide a mechanism by which loose plutonium powder would be blown from the building. It is estimated that the total amount of plutonium released offsite would be in the range of 0.1 to 10 g. High-level contamination would result onsite in the area of the building and extensive decontamination efforts would be required to return the land to unrestricted use. Some members of the general public offsite near Mound Facility might have to be evacuated while homes and other structures were decontaminated by hosing down with copious volumes of water under pressure, and plutonium in the soil was either removed or fixed by deep plowing. Action would be taken to confine the plutonium-238 in the debris of the building to prevent a continuous source. This action may take several days to complete.

Since the postulated event may occur without any prior warning, the possibility exists that operating personnel would be exposed to the collapsing facility. Some of the operating personnel would be fatally injured. Rescue efforts would be hampered due to the presence of high airborne and surface contamination. Some operating personnel would receive internal exposures of plutonium-238 in excess of guidelines given in NBS Handbook 69. Members of the general public in the vicinity of the building may receive significant internal exposures to plutonium-238. The building would be totally destroyed, amounting to a dollar loss of $14,000,000. Decontamination and other costs would cause the total dollar loss to be in excess of $25,000,000.

3.11 EMERGENCY PLANNING SYSTEM

The Mound Facility emergency preparedness program maintains all emergency response elements ready to systematically cope with any unusual situation in Facility operations which poses an immediate threat to the health and safety of Mound employes and facilities as well as to the public and environment offsite. (See Section 2.1.4.6.) The purpose of the emergency planning system is to ensure immediate control of abnormal situations in order to prevent or minimize personal injuries, property damage, and environmental degradation.

The Facility is prepared to cope with situations such as fires, explosions, personnel injuries, and power losses. Emergency plans include handling bomb threats, civil disturbances, and guidance for responding to terroristic activities. The nature of the operations at the Facility requires emergency response capability to cope with both the onsite and offsite effects of a spill involving radioactive and other toxic or hazardous materials. Plans and facilities for handling personnel involved in such emergencies and for monitoring of the environment onsite and offsite have also been developed.

Coordination of Mound Facility emergency plans with the emergency plans of offsite agencies is an important element in the total emergency preparedness effort. Contacts

are made and periodically reinforced with elected officials of neighboring communities as well as with governmental agencies which may have emergency responsibilities. Ongoing working relationships are maintained with the Montgomery County Combined General Health District, Miami Valley Disaster Services Authority, Miami Valley Conservancy District, Ohio Disaster Services Agency, Wright-Patterson Air Force Base, and the City of Miamisburg. An emergency mutual aid fire fighting agreement is in effect between the City of Miamisburg and Mound Facility. Mound has an Air Pollution Episode Plan. This plan is consistent with the Ohio Environmental Protection Agency regulations and the Montgomery County Health Department regulations. Actions to be taken by the Plan are dependent upon the level of the air pollution episode declared by the Health Department. The actions are as follows:

Air Pollution Alert

1. Discontinue fire training
2. Discontinue the burning of waste explosives and combustible wastes contaminated with explosives.

Air Pollution Warning

1. Take actions listed under Alert
2. Curtail the use of motor vehicles

Air Pollution Emergency

1. Take actions listed under Warning
2. Reduce operations of the power plant to provide only minimum heating and cooling to buildings
3. Reduce any processing operations which may emit hydrocarbons to those operations vital to national defense
4. Request personnel to curtail use of private automobiles
5. Sharply reduce use of government vehicles to absolute necessities

Special efforts are made to acquaint agencies that might respond to an emergency situation at Mound Facility with the operations and the personnel with whom the agency representatives will interface. Examples of such agencies are: The Miamisburg Police and Fire Departments, the bomb disposal squad of the Dayton Police Department, the U. S. Army Explosive Ordnance Detachment at Rickenbacker Air Force Base in Columbus, Ohio, and the Ohio National Guard (both on a local and state level). A written agreement with the Department of the Air Force allows the Wright-Patterson Air Force Base Medical Center to provide hospital care to injured contaminated patients from the Facility. Continuing liaison with the Medical Center personnel is conducted to maintain adequate preparations and communications. Contact is also maintained with the local post of the Ohio State Highway Patrol.

In conjunction with the Miami Valley Disaster Services Authority, the Facility has identified fallout shelter spaces on the Facility site for approximately 4400 people. These shelters are available to the public in event of nuclear attack.

or all emergency situations, it is anticipated that the Mound Facility emergency planning system will help ensure a minimum adverse impact on the local population and environment. In addition, radiological assistance is readily available from other DOE offices and contractor sites through the Radiological Assistance Program. (3-26)

3.12 SAFEGUARDS PROGRAM

The Mound Facility safeguards program relates to all its nuclear material and its facilities.

The term "safeguards" is used in its broadest sense, including physical security measures, and embraces all activities involving control and accounting measures to detect and deter diversion of materials and all activities necessary to prevent theft, diversion, or sabotage of materials or equipment.

In general, the policies and techniques developed to protect nuclear material are based on the principles of defense-in-depth.

The general objective of the safeguards program is to prevent malevolent acts involving nuclear materials and facilities. This objective can be met through an in-depth approach that looks to: 1) deterring attempts, 2) minimizing possibilities of success, and 3) minimizing consequences.

Mound Facility's approach to the safeguarding of nuclear facilities and materials is one of a systematic analysis to determine the most cost-effective measures that will guard against the sabotage of nuclear facilities and/or the illegal removal of nuclear material over a wide range of possible adverse actions. The goal is to arrive at the design of an integrated safeguards system. To achieve this goal, Mound uses a combination of employee trustworthiness determination (security clearance), physical protection, and material control and accountability.

Strict safeguards measures are used at Mound Facility. These include fences; alarms; prohibition of personal vehicles within protected areas; two means of communication for security guards; backup guard forces; written records of all persons visiting Special Nuclear Material areas; search of packages, briefcases, containers, and vehicles entering or leaving Special Nuclear Material areas; and required DOE clearance by persons granted access to special nuclear material or, in lieu thereof, permitting such access only under escort by a person with such clearance. Special Nuclear Materials include enriched uranium and plutonium.

There also are rigid standards for processing or storage of material. This must take place in protected areas meeting specific levels of protection. For example, Special Nuclear Material must be stored in approved containers and in turn in vaults.

The Mound Facility nuclear program uses every advancement in the field of physical protection. These include 1) the "two-man rule" for access to Special Nuclear Materials; 2) the requirement for trained, equipped and qualified armed guards; and 3) the use of special secure transportation equipment.

Mound Facility continues to tighten requirements for containment, control, and accounting of Special Nuclear Materials, concurrently with the development of new hardware and systems. These involve use of portal monitors which have been developed to detect a gram or less of unshielded plutonium on a person passing through the portal monitor. Sensitive portable instruments have been developed to search for nuclear materials in vehicles and other hiding places. Extensive development and application is being made of on-line nondestructive assay methods, on-line inventory, and highly automated and protected process operations to minimize access to Special Nuclear Materials. Process operating rooms and vaults incorporating alarms are designed to help deter theft and diversion of Special Nuclear Materials.

Since material in transport is recognized to be inherently more vulnerable to theft, sophisticated systems have been designed to protect it. These include safe, secure truck trailers with numerous protective and disabling devices, armed escorts with orders to use their weapons to prevent the theft of Special Nuclear Materials, point-to-point shipments with no loading or unloading between points, a nationwide communications system which enables truck occupants to call for help or automatically signal need for help in the event of an overt action, preferential routing, continuous surveillance, and preplanning to ensure delivery at a time when the receiving facility is available to accept shipment.

The increase of terrorist and politically militant acts, recognized as a factor requiring explicit attention in the development of special nuclear materials safeguards, has resulted in a greater emphasis on research and development in this area.

To guide its development program, the following threats have been identified to which the safegurds program is aimed:

1. Terrorist-type attacks involving theft and sabotage at facilities or during transit; and
2. Thefts by knowledgeable employees or groups having legitimate access to special nuclear materials or by persons having no authorized access.

Assuming that national and international acts of terrorism may continue, a comprehensive threat analysis study is continuing to identify motivations and capabilities of

personnel and groups who could pose threats to nuclear plants and special nuclear materials.

In-depth studies have been completed to upgrade plant and materials protection. Safeguards and security requirements are under continuing review.

Safeguards reliability depends in part on system redundancy. One redundant part of the system, search and recovery of nuclear material, is an FBI and DOE responsibility. Procedures exist for responding to threats involving special nuclear materials and overt actions. If a threat arises outside a nuclear facility, notification to DOE could come from local law enforcement agencies, other government agencies including the military, or from concerned citizens. A nuclear facility operator, either government or private, is required to inform DOE promptly, and will normally notify local law enforcement agencies in the event of a suspected or actual theft of nuclear material or of a threat of sabotage or terrorist act.

Upon being informed of any of these circumstances, DOE would immediately notify the Federal Bureau of Investigation, which has statutory responsibility for investigating all alleged, suspected, or actual criminal violations of the federal code. DOE would support the FBI with specialized technical assistance, particularly in connection with the recovery of material.

The Department of Energy has at its disposal means to detect, identify, and recover stolen nuclear materials and, in carrying out this mission, can draw from a vast reservoir of technical expertise generally spread throughout the nation.

3.13 TRANSPORTATION

This section identifies the types of hazardous materials transported and the safeguards implemented to protect the public from any adverse impact associated with the transport of these materials to and from Mound Facility. Some of the hazardous materials that are transported to and/or from the Facility are materials common to most industrial complexes, such as fuel oil and gasoline. However, Mound Facility's mission also requires that uncommon hazardous materials, such as explosives and radioactive materials, be transported to and from the Facility. The shipments of all hazardous materials are controlled by Federal, State, and local regulations.

3.13.1 COMMON COMMODITIES

The daily operation of Mound Facility requires that hazardous materials common to most large industrial complexes be transported. Table 3-26 lists the number of inbound and outbound shipments of hazardous materials for CY-1977.

Table 3-26

INBOUND AND OUTBOUND SHIPMENTS OF HAZARDOUS COMMON COMMODITIES FOR CY-1977

Classification	Shipments Inbound	Shipments Outbound
Flammable compressed gas	52	27
Nonflammable compressed gas	135	224
Flammable liquid	64	6
Flammable solid	10	17
Oxidizing material	6	0
Poisonous gas or liquid, Class A	2	0
Poisonous liquid or solid, Class B	5	11
Corrosive material	53	11
Total	327	296

Those commodities which could cause the most significant environmental impact include fuel oil, gasoline, commercial compressed gases, and common laboratory chemicals. These materials are purchased from and transported by commercial vendors. The criteria for shipment of these materials to Mound Facility are the same as those for any private industry in the area. (3-27) Mound Facility does not stockpile large quantities of any of these materials and, therefore, excessive volumes are not transported. The quantities and frequencies of transportation are the same as for private industries of similar size in this area.

3.13.2 EXPLOSIVES

Mound Facility's assigned operations as a manufacturer of components containing explosives requires that explosives be routinely transported to and from the site. Table 3-27 lists the inbound and outbound shipments of explosives for CY-1977. Essentially all explosives that are transported are secondary explosives. Secondary explosives will burn without detonation if unconfined. Mound-manufactured products containing explosives are shipped in accordance with the approvals received from the U. S. Department of Transportation. (3-28)

Mound Facility explosive products are shipped in packages that have been tested to ensure that they are in a nonpropagatory configuration. Even in the unlikely event that one item in a package would detonate, the other items would not be adversely affected. This ensures that if such an event did occur, there would be no property damage or personnel injury.

Table 3-27

INBOUND AND OUTBOUND SHIPMENTS OF
EXPLOSIVES FOR CY-1977

Classification	Shipments	
	Inbound	Outbound
Class A Explosives*	10	8
Class B Explosives**	2	4
Class C Explosives***	73	187

*Solid explosives which can be caused to deflagrate by contact with sparks or flame, but cannot be detonated.

**Explosives which in general function by rapid combustion rather than detonation.

***Manufactured articles which contain Class A or Class B explosives or both, as components but in restricted quantities.

3.13.3 RADIOACTIVE MATERIALS

The radioactive materials most frequently transported to and from Mound Facility are tritium and plutonium-238. Table 3-28 lists the number of inbound and outbound shipments of radioactive materials according to U.S. DOT classification during CY-1977. The shipments include feed materials for processing, manufactured products, and waste resulting from operations. All shipments are governed by the criteria established by the U.S. Department of Transportation. (3-29) Packages used by Mound for shipment of radioactive materials are tested as required by the DOT to ensure that under hypothetical accident conditions the integrity of the container will be maintained and radioactive material will not be released to the environment.

Table 3-28

INBOUND AND OUTBOUND SHIPMENTS OF
RADIOACTIVE MATERIAL FOR CY-1977

Classification*	Shipments	
	Inbound	Outbound
LSA	26	51
Type A	6	15
Type B	32	30
Large Quantity	27	29
Total	91	125

*Classification specifications according to Title 49 Code of Federal Regulations Parts 173.389 and 173.390; also published as Hazardous Materials Regulations of the Department of Transportation, R. M. Graziano's Tariff No. 32.

The packages are submitted to a series of specific tests designed to simulate a number of over-the-road accident conditions. These tests are described in DOT Tariff 49 CFR 173.398 and include the following: (1) The package is dropped through a distance of 30 feet onto an unyielding surface oriented such that maximum damage is expected. This test simulates the force a package could see upon impact in an accident; (2) The package is dropped a distance of 40 inches onto a steel bar 6 inches in diameter and at least 8 inches in length resting upon an unyielding surface. This test demonstrates the ability of the package to withstand penetration by any flying projectiles during an accident; (3) The package is exposed to a thermal environment of at least 1475°F for 30 minutes. The thermal test is representative of a road accident involving a fire; e.g., collision with an oil tanker; (4) The package is immersed in at least 3 feet of water for not less than 8 hours to simulate accident conditions leading to the package falling into a river or lake. It should be noted that this series of tests is performed consecutively on the same test package. There must be no release of radioactive material from the package in a successful test.

Waste contaminated with radioactive materials constitutes the largest volume of radioactive shipments. These materials are transported under DOT regulations by commercial motor carriers. During 1977, approximately 753 m^3 (26,534 ft^3) of "Low Specific Activity" waste in 18 shipments was made to offsite commercial burial grounds. Mound Facility's waste that contains concentrations of plutonium-238 in excess of 10 nanocuries per gram of waste are transported to a DOE site for retrievable storage. During 1977, eight shipments containing approximately 257 m^3 (9052 ft^3) of waste were shipped by railroad. A special government-owned railcar is used for transportation of this category of waste. This railcar has been designed and tested to ensure that it will withstand hypothetical accidents.

Heat sources and components containing radioactive material produced at Mound Facility have accounted for approximately 110 shipments to and from the Facility during CY-1977. These products are shipped in containers that comply with the requirements of the DOT and are transported in specially designed vehicles operated by personnel trained and equipped to handle any credible incident which may arise. These specially designed vehicles are called SST's (Safe Secure Transports). They are owned and operated by DOE and are headquartered in Albuquerque, New Mexico and Amarillo, Texas. The tractor and trailer are both armor-plated and contain elaborate communications equipment and intrusion deterrent systems to negate the possibility of hijacking of special nuclear material by terrorist attack. Obviously the details surrounding such deterrent systems must remain classified. This vehicle was developed primarily for security reasons. It should be noted that absolutely no credit is taken for the vehicle with regard to containment of the radioactive cargo it is transporting. The individual packages within the vehicles must pass the hypothetical accident conditions described above. It is clear, however, that the armor-plated trailer adds a great deal to the total integrit of the shipment.

Currently, the shipment of feed materials to Mound Facility presents the greatest potential for an adverse environmental impact because of the quantity of material involved. Plutonium-238 is transported from another DOE facility to Mound Facility. A typical shipment contains 2-3 kg of plutonium-238 in an oxide form. Even the minimal risk involved, as discussed below, will be curtailed by the end of CY-1979, by which time Mound will receive only small lots of the oxide feed material already sealed in primary containers for the final assembly of only small heat sources. Special vehicles are used for transporting the plutonium-238. Tests conducted on the shipping container have shown that even under the most severe accident conditions, no radioactive material will be released. This particular package consists of a primary container enclosed in a secondary container and a tertiary container. This package was first subjected to a series of three 30-foot drop tests. After each test the primary container was removed and its seal checked. With a gas leak test, the criterion of $<1 \times 10^{-3}$ atm cc/sec was met. In a second test, phosphorescent zinc sulfide powder was placed in the primary container before the drop to simulate PuO_2 powder. After the drop a check of the primary container, using ultraviolet light, showed no trace of powder on the outside.

After the container sustained a 30-foot drop test without releasing its contents, it was next dropped through a distance of 40 inches onto a 6-inch diameter steel bar. The only damage was to the paint on the tertiary container; there was no effect on the primary or secondary containers. Therefore, it is concluded that the package would be undamaged by flying projectiles in the event of an accident.

The third test involves placing the primary container in a thermal environment of 925°C. It was held at this temperature and the internal pressure was then increased in 100 psi increments until a seal failed at 825 psig. After cooling, the primary container could be resealed and pressurized to over 1500 psig with no leakage. The test results were utilized to establish a PuO_2 loading which would result in an internal pressure that would leave the seals intact (with a safety factor of at least 2).

Since the primary container is not damaged by the hypothetical accident conditions of a 30-foot drop, puncture test and fire, it will withstand immersion in water for an indefinite period of time without inleakage. (3-30) The demonstrated integrity of the containment and the availability of trained personnel accompanying such shipments significantly reduces the possibility of environmental impact associated with an accident.

Concerning the potential environmental risks and effects of shipping radioactive materials in general, the U.S. Nuclear Regulatory Commission reviewed this subject thoroughly for the preparation of NUREG-0170, "Final Environmental Statement on the Transportation of Radioactive Materials by Air and Other Modes." (3-31) According to this review the NRC determined that the environmental impacts of normal transportation of radioactive material, and the risks attendant to accidents involving radioactive material shipments are sufficiently small to allow continued shipments by all modes.

Because transportation conducted under present regulations provides adequate safety to the public, the NRC concluded that no immediate changes to the regulations are needed at this time.

The NRC analysis shows that radiation exposure from normal transportation, averaged over the persons exposed, amounts to 0.5 mrem/yr compared to the average natural background exposure of about 100 mrem/yr. This represents a very low value for transportation (approximately 0.5% of natural background) of all radioactive material. Taking into account the contribution due only to radioactive waste shipments (approximately 15%), then the radiation exposure to the public becomes approximately 0.08 mrem/yr (0.08% that of natural background). Again, this is a very small or negligible individual contribution.

With respect to potential consequences of an accident, the report stated; "The accident risk for the 1975 level of shipping activity, as determined from the 1975 survey, is very small..." Only approximately 10% of this low potential "accident risk" arises due to transport of radioactive waste.

As demonstrated in Table 5-16 of NUREG-0170, "...an individual is 10^5 times as likely to be killed as a result of being struck by lightning as he is to die from radiological causes within one year following a transportation accident involving a shipment of radioactive material." The table shows that there are commonly accepted accident risks (fires, drownings, electrocution, hurricanes, etc.) that are very much greater than the accident risk of transporting radioactive materials.

The Department of Transportation has compiled data on the number of accidents which involved all types of radioactive material. Radioactive material was involved in less than 0.5% of all incidents from 1971 through 1975 associated with the transportation of hazardous materials. No death or injury to people has resulted from these incidents. (3-32)

Mound Facility currently ships its radioactive wastes to four offsite burial/storage grounds. These are:

1) Chem Nuclear Systems, Inc., Barnwell, S.C.
2) Savannah River Plant, Aiken, S.C. (DOE Facility)
3) Nevada Test Site, Mercury, Nevada (DOE Facility)
4) Idaho National Engineering Laboratory, Scoville, Idaho (DOE Facility)

Mound neither stores nor buries any radioactive wastes onsite.

The waste form, method of packagi g, and mode of shipment differ for Mound's utilization of each of these disposal sites as follows:

'hem Nuclear Systems, Inc.

This is a commercial site operated by Chem Nuclear near Barnwell, South Carolina. They are licensed by the State and also by NRC for any special nuclear material they might receive. The site is very well run with "state-of-the-art" techniques in use for shallow land burial, a well-trained staff strong in Health Physicists, and an elaborate monitoring program. Mound ships to Barnwell low-level LSA waste with packages typically containing between 1 μCi to 1 mCi of alpha or beta activity. Containers utilized are 55-gallon DOT Spec 17C or 17H steel drums and "strong, tight" wooden boxes. Shipments are made inside closed vans by a commercial carrier with sole use of the vehicle. Mound has never had a release of activity involving shipments of this material. Even in the event of a serious accident, any release of activity would be quite small and highly localized. With regard to the design life of the containers in the ground, it is recognized that the drums and boxes will be breached within a few years. However, the activity within the package is safely contained within the burial trenches as demonstrated by Chem Nuclear's Monitoring Program.

Savannah River Plant

Mound Facility ships a limited number of packages to the Savannah River Plant for storage containing classified hardware very slightly contaminated with tritium. The waste is doubly contained using a 30-gallon steel drum inside of a 55-gallon steel drum. Transport to Savannah River is in the SST vehicle. Since the amount of contamination minutely small, there is no hazard to the environment in either the transport or disposal mode.

Nevada Test Site

The Nevada Test Site is utilized for disposal of Mound Facility's higher activity tritiated waste. These packages contain from 100 to several thousand curies of tritium in an immobilized waste form. Mound has developed a package consisting of several containers within each other with barriers of thick polyethylene and asphalt to prevent migration of the tritium out of the package. This container has been demonstrated to be highly impervious to outward tritium movement. Shipments to Nevada are made in the DOT-approved Type B package called the Super Tiger. It is a large cubicle structure which is carried upon a special flat bed truck and can hold 42 55-gallon drums. It has been tested under accident conditions and approved for shipments of this type. At the test site, the Mound package is overpacked in a stainless steel container, which will hold approximately 15 drums, and then buried. The total inventory of tritium in the Mound waste is a small portion of the total tritium activity on the test site from prior weapon tests. The Nevada Test Site operates a continuous monitoring station at the burial site.

Idaho National Engineering Laboratory (INEL)

The transuranic or TRU waste generated at Mound Facility is sent to the 20-yr retrievable storage site at the INEL. This is alpha contaminated waste containing greater than 10 nCi/gram of alpha activity.

The waste is packaged in approved 20-yr retrievable packages. These consist of a 55-gallon 17C drum containing a 90-mil high-density-polyethylene liner and a fiberglass-coated plywood box. These packages were originally developed and tested by Rocky Flats. Recent excavations at the Idaho Site indicated that the packages will remain intact through their design life of 20 years.

The shipments to Idaho are made inside of specially constructed railcars, the ATMX 500 and 600 series. These have been issued a special DOT permit for transporting Type B and large quantity wastes. The safety record of this transport mode, while excellent, is just another example of the safety and containment integrity designed into packages for shipping radioactive material.

As with the other burial sites, the contractor at INEL maintains a thorough monitoring program on and around the specially constructed 20-year storage pads for environmental impact assessment.

The procedures required for the transportation of hazardous materials to and from Mound Facility minimize the potential for, and mitigate the potential consequences of, an accident. The environmental impact resulting from an incident involving hazardous materials would be anticipated to be minor and short term.

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SECTION 4
UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

Unavoidable effects which could be adverse to the local environment as a result of operations at Mound Facility include the use of land, production chemicals, and supplies; a minor contribution to local vehicle traffic on public roads; vehicular environmental pollution; the use of building materials, electric power, fuel oil, and natural gas; solid waste generation; residual effects of past landfill disposal; open burning of small amounts of high explosive waste; and a contribution to ambient air and water pollution levels. The impact of these factors, though not great, is being steadily reduced by a comprehensive management program for environmental control.

The site was originally untilled farm land. Development as a permanent federal facility did not constitute an adverse encroachment on local area land use. The land use patterns surrounding Mound Facility have been predominantly rural-agricultural. However, the location is within the Dayton metropolitan area, and as the Dayton urbanized area continues to expand rapidly, the agricultural land use pattern is being replaced by a residential-commercial pattern. The Facility site fits in with this pattern.

If Mound Facility facilities were no longer required by DOE, they could be transferred to other federal agencies or sold to private interests. Nuclear facilities and some localized land areas onsite would require extensive decontamination prior to release. (See Section 5.3)

Mound Facility contributes to offsite area vehicular traffic, but the impact in terms of percent of area traffic and resultant vehicular pollution emissions is very small, less than 0.3% of the vehicles registered in Metropolitan Dayton.

Since Mound Facility is a research, development, and light manufacturing operation, its activities do not require operation of noise producing equipment. The noise peaks, as high as 54 decibels, occur during the morning and afternoon when employes arrive and depart from work.

Mound Facility, located adjacent to the Buried Valley Aquifer, has an abundant source of raw water. Although the Facility is not considered a large user of water, it did use an average of 3,785,000 liters/day (1,000,000 gal/day) in CY-1971. A water conservation program was initiated at that time. During CY-1977 the Facility used water at an average rate of about 1,720,000 liters/day (455,000 gal/day).

In CY-1973, in line with the federal program to alleviate the impact of the energy crisis, Mound Facility undertook a program to conserve electric power. An aggressive energy conservation program has achieved the following savings since its inception in FY 1973:

	Annual Savings	Percent Reduction in Current Usage as Compared with FY-1973 Usage
Electricity	11.5×10^6 kilowatt hours	22
Natural Gas	$.76 \times 10^5$ cubic feet of natural gas	23
Gasoline	6350 gallons	16
Overall	215×10^9 BTU	21

The power house furnishes steam to operate some of the ventilation and heating systems in various facilities at the Facility. Original boiler installations utilized low-sulfur oil for fuel. Emission of combustion products to the environment was thus maintained well within ambient air standards. The boilers were converted to the use of natural gas in CY-1971. Low-sulfur fuel oil is used during prolonged winter cold spells when the supplier of natural gas is unable to deliver or after monthly allocations of natural gas have been used.

A sanitary landfill operation which was conducted at the Facility for several years for the disposal of solid nonradioactive wastes was discontinued in CY-1973. All solid radioactive wastes have always been packaged and shipped offsite for ground burial at DOE-operated or commercial burial sites. Some isolated land areas of the site contain residual low level contamination as indicated in Table 3-24. An active program for the collection of waste for recycle was instituted in CY-1973. All solid industrial wastes, except onsite salvage, was sent to a reclamation center in nearby Franklin, Ohio, during CY-1977 (see Section 3.6.2). Currently, two activities involve open burning onsite: (1) disposal of scrap high-explosive waste materials, and (2) training of fire-fighting personnel in outdoor exercises. Both activities are kept to the minimum consistent with actual needs. The disposal of scrap high explosives is conducted according to U.S. Army Materiel Command Regulations, 385-100. Twelve fire training sessions in the extinguishing of all types of fires are conducted each year. A total of 50 gal of Stoddard solvent, a hydrocarbon, was burned during CY-1977. Both activities have been reviewed by and received the concurrence of the Regional Air Pollution Control Agency of the Ohio Environmental Protection Agency.

By its very existence, the Facility of course has a visual impact in the surrounding area. The overall appearance is that of a laboratory-office complex, not a conventional manufacturing installation. A large percentage of the natural wooded areas has been preserved, and constructed areas are landscaped to blend with the natural terrain.

Evaluation of the unavoidable adverse environmental effects resulting from operation of Mound Facility indicates that these effects are of little significance and that actions taken to minimize energy consumption have effectively reduced the impact to a very low level of significance.

SECTION 5
ALTERNATIVES

The process of evaluating the environmental effects of Mound Facility operations includes an analysis of the operations as they currently exist as well as other alternatives that could be employed to modify the impact. The first alternative is that of continuing all operations as they were performed during CY-1977. Such a "no action" alternative establishes a well-defined set of operating conditions including work activities, procedures, facilities, and equipment for which the environmental impact has been described in Section 3. In comparison to this status quo, other action alternatives may be considered and analyzed for cost/benefit. Other alternatives include (1) discontinue production of nuclear weapons components, nuclear fueled heat sources, and stable isotopes, thus causing the closing of the Facility; (2) relocate all Facility activities to another DOE facility or to a new site, which could include the transfer of part of the stable isotopes separation program to private industry; (3) decrease the work levels; and (4) continue operations with currently planned improvements and employ alternative procedures and technologies to reduce the potential environmental impact.

5.1. CONTINUE OPERATIONS

The impact of the many operations conducted at Mound Facility during CY-1977 is discussed in detail in Section 3. Environmental conclusions are supported by many tables of data and information in the appendices.

5.2 DISCONTINUE OPERATIONS

The beneficial effect on the local environment that would result from closing the Facility would be the elimination of normal treated sanitary waste water and small quantities of radioactive and nonradioactive pollutants in liquid and airborne emissions from Facility operations, although these effluents are well within federal standards. The discontinuation of Mound-contributed tritium to the local air and water environment would reduce the annual total body average radiation exposure of the offsite populations by 0.205 mrem per person. This compares to 120 mrem/per year from natural background sources for the Dayton area. Transfer or discontinuation of the helium-3 stable isotope program would reduce the annual average radiation exposure by about 0.0001 mrem per person. This reduction would be insignificant.

The discontinuation of Mound-contributed plutonium to the local air and water environment would reduce the annual lung radiation exposure to persons in the offsite population by 0.036 mrem. The combined tritium and plutonium annual radiation reduction would, therefore, be some 0.241 mrem which amounts to a relatively small radiation reduction impact.

Decontamination and decommissioning of the physical plant would incur large costs, roughly estimated in the hundreds of millions of dollars. The radiation reduction benefit discussed above would not be fully realized until the completion of the decontamination and decommissioning actions.

If the facilities were turned over to other governmental use or sold to industry for nonnuclear use, the release of small quantities of radioactive materials would cease in this geographical area; however, discontinuing the operations performed at Mound Facility would not be consistent with the United States' defense policy and need to maintain an up-to-date war-deterrent weapons stockpile.

Other industries which could become the successive user of the facilities at Mound Facility may well produce an even larger environmental impact in terms of industrial waste and effluents and the consumption of natural resources such as water, electric power, gasoline, natural gas, and oil.

Closing of the Facility would mean an annual financial loss to the local community of approximately $32,000,000 in direct salaries and wages, and $13,000,000 in Laboratory-related expenditures. Part or all of this economic loss may be offset should there be a successive user of the site.

5.3 RELOCATE OPERATIONS

Operations currently conducted at Mound Facility could be transferred to another existing DOE facility, to a completely new DOE site or some operations might be transferred to private industry's sites. If the operations were transferred to other existing DOE facilities technologically equivalent to the Mound facilities, the net effect on the environment and the economy of the new area would be about the same as those discussed in Section 3. The new location would have to have the immediate capability to supply 630 million liters (166 million gallons) of treated water annually; 40.7 million kWh of electric power annually; and the annual energy equivalent of 2.86 million m^3 (101 million ft^3) of natural gas plus 4,165,000 liters (1,100,000 gallons) of fuel oil. Because of fuel oil and natural gas shortages, the new site may have to provide the energy for recirculating brine and steam for climate control in the buildings through the burning of coal. If coal became the energy source, the cost of providing the same service as rendered by Mound Facility would be significantly increased because of the expensive stack gas cleaning equipment required to bring air emissions into compliance with EPA air quality standards. The discharge of CO, SO_x, and NO_x would have a notable environmental impact, whereas Mound's effluents are essentially free of these pollutants.

If the operations at Mound Facility were transferred to another site and new facilities were built using the latest technology, the adverse environmental impacts of the present operations could possibly be lessened. Natural resources such as

w[illegible], electrical power, and low-sulfur fuel oil are completely adquate for the growing needs of the Dayton metropolitan area. Therefore, a change in location would not be a significant benefit to the Dayton area but could, on other hand, be a proportionately large drain on these resources at a new location. Concerning the potential upgrading of pollution control systems by the construction of new facilities at another location, primary public concern would probably concentrate on radioactive materials. If the new facilities would be more effective than the current Mound facilities in reducing the amount of radioactive material in its effluents, the annual radiation exposure to the public would be reduced by less than one mrem per year since Mound operations currently result in a total body radiation exposure of only 0.241 mrem per year. The cost of decontaminating and decommissioning the present physical plant is estimated in the hundreds of millions of dollars. Such cost would be added onto the cost of the new facilities if operations were relocated.

5.4 DECREASE WORK LEVELS

It is sometimes possible that some operations could be scaled down or extended over a longer period of time in order to reduce resource consumption and releases of certain types of effluents. However, such curtailments cannot be expected to have more than a minimal effect on the overall environmental impact since the maintenance of the facilities under a reduced level of work still requires consumption of threshold amounts of materials and natural resources.

5.5 CONTINUE OPERATIONS WITH PLANNED IMPROVEMENTS

The most reasonable and productive alternative is to continue operations at Mound Facility with continuing improvements in procedures and technologies to reduce environmental impacts. Over the past several years, the modification of systems and procedures as well as the upgrading of facilities have significantly lessened the environmental impact of Mound operations. Specific cases are indicated in Figures 3-2, 3-3, 3-4, 3-5, 3-10, and 3-12, and others are discussed throughout Section 3.

Planned activities and operations are fully expected to further reduce the overall environmental impact. These plans include:

1. Modification of the sanitary sewage plant to reduce suspended solids in the effluent. This project will reduce the suspended solids in the effluent to meet the new EPA standard by 1979.

2. Erection of a new 250,000-gal water storage tower to replace an existing storage tower. The present tower presents a potential safety hazard in the event of a tornado which could possibly topple the tower onto a building housing nuclear

operations. Relocation of the tower removes a potential accident and contamination hazard.

3. The planned construction of a retention basin for site drainage runoff and effluent water and an associated overflow pond to collect runoff water during periods of heavy rainfall will provide an appropriate system of settling basins to collect better than 95% of all silt resulting from site soil erosion. Since plutonium and its compounds attach firmly to clays in the soil, the removal of silt from the site drainage ditch will reduce the potential escape of plutonium from the plant site via surface water runoff. Although site effluent water does not normally exceed effluent water quality standards including that for plutonium, the retention basin and overflow pond will collect most pollutants that could otherwise be released offsite from a spill even during periods of heavy rainfall. Polluted silt can then be removed and disposed of in an appropriate fashion.

4. The site drainage improvement plan includes several specific storm water runoff improvements to reduce soil erosion and to direct runoff water to the site retention basin where any suspended solids will be precipitated out.

5. Modifications are planned for climatized ventilation systems in existing buildings to maximize air recirculation wherever possible. This program will minimize brine, cooling water, and steam usage and will reduce energy requirements.

6. The planned SM Site Stabilization project involves the demolition and removal of the no-longer-used SM-Building, associated low-level waste water storage tanks, and earth in the area which are contaminated with residual plutonium. As this facility presently stands, it does not contribute any significant amount of plutonium to the environment. It does, however, contribute more than half of Mound's plutonium stack emissions. Upon removal of this facility, the site location will be restored to a stable nonpolluting condition. The controls and containment techniques to be used in the SM site stabilization project will reduce the possibility of a detectable increase in offsite contamination to a very low probability.

7. Mound operations are being modified to eliminate plutonium fuel form preparation and the encapsulation of plutonium at the site at the end of FY-1979. In a continuing program, the plutonium processing building is being inactivated. Removal of obsolete equipment and decontamination of these portions of the building will reduce the potential for release of plutonium contamination to insignificance.

   Continued upgrading of other plutonium facilities will remove the possibility of any residual contamination being released to the environment. After this is completed, the release of plutonium to the environment from routine operations will be negligible.

Tritium handling will be continued under steadily improving state-of-the-art. Improvements in techniques have already affected a better than 98% reduction during the past seven years in the amount of tritium released to the environment in both liquid and air effluents. In CY-1977 this amounted to 4896 Ci in airborne emissions and 57 Ci in liquid effluents. Reductions in these emissions will continue to the lowest level practical, although in view of the very low toxicity of tritium as discussed in Section 2.1.4.1, these levels are not significant.

Other possible improvements may be achieved in the following areas provided the necessary capital funds and technological capabilities are made available.

5.5.1 WATER RECYCLING

As indicated in Section 3.3.1, annual plant water usage was approximately 630,000,000 liters (166,000,000 gal) for CY-1977. The Buried Valley Aquifer in which the wells for the plant are located is fully recharged as a result of induced stream infiltration plus natural precipitation and leakage from the valley wall east of the well field. Thus, there is no indication that operations at Mound Facility are depleting this resource. However, there are two environmental factors in the use of water that must be considered. The first is the use of energy, electrical and/or petroleum, to pump the water from the well field to the elevated water tanks which is a lift of over 76 m (250 ft); the second is that practically all the water pumped from the wells is softened and becomes an effluent to the Great Miami River either through the surface drainage ditch or the closed pipe directly to the river. The total effluent in these two streams which includes runoff following natural rainfall on the plant site averages approximately 775,000,000 liters (200,000,000 gal) per year and contains approximately 635 tonnes (700 tons) of salt from the water conditioning operations. Since most of Mound's water is used for cooling in heat exchangers, compressors, and process equipment, one viable alternative is to recycle the cooling water after passage through cooling towers. Recycling the cooling water in main processing and development areas reduced the volume of the water leaving the plant site in CY-1977 to 790,500,000 liters (204,000,000 gal) per year or a reduction of 585,125,000 liters (151,,000,000 gal) per year in the quantity of water pumped from the deep wells and softened prior to plant use as compared to CY-1975. The amount of dissolved salt introduced into the river would be reduced by approximately 205 tonnes (225 tons) per year.

Another alternative to be considered is the installation of a second water system in the plant so that raw (untreated) water can be used for all process and equipment cooling and fire-lines. The requirements for conditioned (potable) water would be sharply reduced and would be limited to water used for human consumption, lavatories, showers, laundry, and the like. If dual water distribution systems were installed, the effluents from the sewage disposal building, approximately 132,000,000 liters

(35,000,000 gal) per year, and from the waste disposal building, approximately 15,000,000 liters (4,000,000 gal) per year, could be used as process water. Coupled with recycling of cooling water, the volume of the effluent water and the dissolved salt would be reduced essentially to runoff from rainfall.

5.5.2 ENERGY CONSERVATION

The achievement of greater reductions in the consumption of energy and energy sources is an extremely pertinent alternative. To date, the conservation program has been effective in reducing the consumption of electrical energy for FY-1977 by approximately 22% as compared to energy utilization during FY-1973.

Long range alternatives to reduce the consumption of critical energy forms are

1. Conversion of gas-oil fired steam boilers in power house to coal-fired units This action, estimated to cost approximately $3,000,000, will practically eliminate dependency on natural gas and fuel oil for the operations of Mound Facility. This action would considerably increase Mound's discharge of the CO, SO_x, and NO_x combustion products into the atmosphere in an area where the air quality is already strained.

2. Install solar heating and solar cell systems At the present time, Mound Facility has approximately 40,400 m^2 (10 acres or 435,000 ft^2) of flat roofs which are feasible to use for installation of solar energy collectors. It is anticipated that the emerging solar energy collection and conversion technologies will provide systems that in time will yield economical thermal and electrical energy for a sizable portion of Mound's space heating and cooling requirements.

3. Use of waste heat from local power plant for preheating The Hutchings generating plant of the Dayton Power and Light Company, located approximately 3.2 km (2 mi) south of Mound Facility, is currently dumping into the Great Miami River the cooling water from its spent steam condensers. The thermal energy in this water could be used to preheat incoming ventilation air at Mound Facility. A proposal for such a project is being evaluated. It is estimated that the installation of a 30.5-cm (12-in.) diameter pipe loop, one leg insulated, with pumps, between the Hutchings plant and Mound Facility would cost approximately $1,000,000. The cost of operation and maintenance would be less than $12,000 per year. At today's prices, the thermal energy from this condenser cooling water using a heat pump would cost less than $2.00 per million Btu's. Current prices are approximately $1.76, $2.36, and $6.56 per million Btu's for natural gas, fuel oil, and electricity, respectively. The heat obtained from this water is economically competitive and would reduce the consumption of petroleum products.

It has been calculated that the amount of thermal energy available would be 3.5×10^{10} Btu/yr, which is equivalent to that obtainable from 1×10^6 m^3 (3.5×10^7 ft^3) of natural gas or 8.7×10^5 liters (2.3×10^5 gal) of fuel oil. Use of this waste heat would provide some thermal energy for plant operations and reduce the depletion of natural resources.

4. Use of electric-powered instead of petroleum-powered vehicles Mound Facility maintains a small fleet of gasoline-powered vehicles for the transportation of personnel and materials and for emergency services. Technology available in the near-term future will provide electrically powered vehicles to replace 70% of the standard vehicles, i.e., automobiles, vans, light duty trucks, carryalls, and buses. Currently all the utility cars, one-person capacity, are electrically powered. Replacement of gasoline-fueled vehicles with electrically powered vehicles would reduce substantially the utilization of gasoline for transportation by over 117,000 liters (31,000 gal) annually and the emissions to the environment from the gasoline-powered vehicles that had been replaced.

5.5.3 INCINERATION OF WASTES

Mound Facility has evaluated this alternative in the overall scheme of waste management since Facility operations generate two types of wastes that can be disposed of by carefully controlled incineration without impact upon the environment. One type, high explosive wastes, includes paper contaminated with explosives, explosive materials not acceptable for use, and rejected components containing small amounts of explosives. Currently these wastes amount to less than 800 pounds per year. They are burned in open trenches and release very small amounts of carbon, hydrogen, oxides of nitrogen, and unburned hydrocarbons. An incinerator designed for the controlled burning of explosives could be installed; however, based upon the minimal environmental impacts of open trench burning and an estimated incinerator cost of $500,000, the controlled incineration of Mound's explosive wastes is deemed unjustifiable.

A second type of waste that can be incinerated is burnable material contaminated with low-level transuranium elements such as plutonium. The bulk quantity of this waste was equivalent to over 650 drums (55-gal capacity) for FY-1977. Incineration could reduce the volume by a factor of 20 and also make the contained transuranium elements more readily retrievable. Facility and pilot studies have demonstrated that controlled incineration coupled with stack gas scrubbing and demisting achieve an acceptable effluent from the incineration process. In fact, all LSA combustible TRU solid waste generated since December 1976 has been burned on an incidental basis in the developmental incinerator unit. The stack effluent has been well under the RCG for plutonium. Any aqueous solutions generated would be handled through existing facilities. It is estimated that two incinerators, one of which would be built into the processing line

for these low-level radioactive wastes, would cost approximately $500,000. In this case, the alternate technology would significantly reduce the volume of low-level radioactive waste to be shipped offsite for burial. Based upon the stack effluent information from the developmental incinerator unit and the estimated cost savings from reducing the volume of material to be buried would not be sufficient to justify the capital investment of $500,000 plus annual operating and maintenance costs for such incinerators.

SECTION 6

RELATIONSHIP BETWEEN SHORT-TERM USE AND LONG-TERM PRODUCTIVITY

Mound Facility will continue, for the planned future, to conduct activities in support of the programs of the U. S. Department of Energy as outlined in Section 2.1.1, Plant Mission. If the need for the accomplishment of these objectives outlined in the Plant Mission were to cease at some future time, the facilities are adaptable for other federal activities or by other government or private units after appropriate decontamination to the levels required. In the long-term aspect, the buildings could be completely decontaminated in accordance with standard operating procedures and a part of the land could be made available for residences and light industry. Such a course of action, however, would involve costs of hundreds of millions of dollars. The remainder of the land is not topographically acceptable for general construction activities.

The short-term use of this land for Mound Facility will have no long-term effect on other productivity in this geographical area. Any future alterations to the site for new construction will be conducted to minimize impacts on both short-term and long-term use of the land. New building projects are planned so that any artifacts of archeological interest are protected, short-term disruptions to drainage patterns are accommodated, and dust and debris during construction are minimized. Wherever possible natural contours and vegetation are preserved, and construction sites are landscaped to blend with their surroundings.

SECTION 7
RELATIONSHIP OF PRESENT ACTIONS TO ANY OTHER LAND USE PLANS, POLICIES, AND CONTROLS

At this time, there are no federal, state, or local land-use plans that conflict in any way with the present or foreseeable future operations of Mound Facility. The use of the land for light industrial-office-research purposes conforms to the land-use pattern in the general vicinity. Immediately adjacent to the western boundary of the plant site, several commercial and light-industry operations are located. The use of the land for its present purpose has not been a restriction upon the normal growth of the City of Miamisburg. Sufficient undeveloped land with desirable construction terrain exists immediately east and south of the City of Miamisburg to satisfy any projected population growth.

The long-range programmatic plans for the use of Mound Facility do not require any substantial building program. Current plans call for the construction of new facilities within existing structures and the addition of small annexes onto existing structures.

The City of Miamisburg is currently proceeding with long-term plans to build a Community Park Project for the present small city park along the west perimeter of the Facility site. The construction of a solar pond in an existing pond to heat a new swimming pool was completed in CY-1978. The long range plan includes the addition of various recreational facilities; the construction of an amphitheatre; the building of a sled run, a bike trail, and a hiking trail; and possibly enlargement of a limited section of the old Miami-Erie Canal to put in a short canal boat ride.

Neither the continued operation of Mound Facility nor the presence of residual plutonium in the bottom silt of the small recreational pond and the canal in the community park, as discussed in Liquid Effluent Impact in Section 3.7.2, constrains the future development of the park project. Any proposed modification of the pond or the canal will be reviewed in the design phase with the DOE office at Mound Facility to ensure that possible translocation of bottom silt is adequately considered from the standpoint of contamination control.

SECTION 8
IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The only irretrievable resources committed to use at Mound Facility are construction and operating materials and chemicals, fuel oil, natural gas, and electricity. As a result of an active conservation program, the rate of consumption of these resources has been decreased. It is planned that usage rates will continue to decrease below present levels. These resources would readily be available to the consuming public if operations were to cease. However, the quantities used, as shown in Figures 3-2 to 3-5 are not large enough to make a significant change in the national supply.

SECTION 9
ENVIRONMENTAL TRADE-OFF ANALYSIS

This section of the impact statement reviews and analyzes environmental effects as well as national and local community benefits associated with the operation of Mound Facility. Alternatives discussed are:

1. Continue present operations
2. Cease operations
3. Relocate
4. Decrease work levels
5. Continue operations with planned improvements

Analysis includes land use, demands on natural resources, and funding to support all activities.

Risk analysis includes the routine emission of pollutants (both nuclear and nonnuclear), the accidental release of radioactive material, transportation of toxic materials, and noise generation.

Benefits analysis includes the Facility's contribution to national defense preparedness, the advancement of technology in many fields, and the economic and sociological support provided to the community.

This analysis considers CY-1977 as the point of reference for "current operations" and then reviews the same impacts for the various alternatives postulated in Section 5.

9.1 CONTINUE PRESENT OPERATIONS

This alternative, as described in Section 5, considers a "no change" current level of operations. The cost-risk-benefit of maintaining the status quo is as follows.

9.1.1 COSTS

The cost of operating Mound Facility is approximately $60 million annually. This includes payroll, the purchase of materials, supplies, and services, the acquisition of capital equipment, and construction activities.

Staffing of the Facility has an impact on the City of Miamisburg, Ohio, where the Facility is located, and on many surrounding communities from Dayton to Cincinnati. It impacts housing, transportation, schools, recreational facilities, and municipal services for the employes and their families. Mound employes and their families

currently constitute a population group of approximately 5500 people. Mound Facility families are distributed throughout the metropolitan area which has a population of some 1.5 million persons. The Mound population has been established since operations began in 1949 and has little current impact and no new requirements for housing, transportation, municipal services, schools, recreational facilities, natural resources, etc.

The cost to the environment for the operation of the Facility is the annual consumption of energy and natural resources, emission of small amounts of chemical and radioactive substances, and the present precluding of the land for other uses. Mound uses approximately 40 million kWh of electricity annually. This demand creates no significant drain on the output of the local electric utility which maintains the capacity to serve this highly industrialized area of Ohio. Power generating capability is currently about 10% greater than peak demands. The local utility uses coal for power generation. For heating buildings, Mound uses low-polluting natural gas. Since the supply of gas is diminishing, the Mound contract contains an "interruptible demand" clause, and low-sulfur fuel oil is used as necessary for an alternate fuel source during the winter months. The Facility employs a small fleet of 35 motor vehicles which use approximately 38,800 gal of gasoline annually. Employes' automobiles (approximately 850, the number driven to work is minimized through an active car pooling program) annually burn some 340,000 gal of gasoline.

Annual water usage totals approximately 166 million gallons and is obtained from three onsite deep wells. These wells, only one of which is used, pump water from a huge natural underground reservoir known as the Buried Valley Aquifer. This aquifer, which constitutes a renewable resource, has the capacity to support all local area water requirements. Vigorous energy and resource conservation programs employed at the Facility have steadily reduced Mound's natural resource demands over the past three years.

The environmental cost related to the emission of chemical and radioactive substances is analyzed in Section 9.1.2.

There is no known requirement for the land devoted to Mound operations for any other purpose. Prior to Mound usage, it was undeveloped agricultural land. The extremely rough terrain made it unsuitable for raising crops. One small area, approximately 15 acres, had been used regularly for pasturing a small number of farm animals. Currently, the site contains 97 buildings. Major buildings are of permanent construction with red brick veneer. The site is well maintained and blends aesthetically with the surrounding community. Continued Federal use of Mound Facility does not conflict with any planned land-use programs in effect for the area.

9.1.2 RISKS

Normal plant operations produce no significant offsite air or water pollution or neighborhood noise. The plant site, after decontamination to background levels, could be used for other activities without restriction. Decontamination would be conducted in accordance with standard operating procedures and supervised by health physics monitors.

Mound periodically conducts environmental noise surveys around the site perimeter. Data from these surveys indicate that ambient noise levels are very low and would be acceptable in any residential suburban location.

Airborne and liquid effluents from routine operations contain no offending odors. Stack emissions produce no visible plumes. Both liquid effluents are observably clear water streams and meet the parameter limitations specified in the US EPA NPDES permits.

Normal, current radioactive emissions plus the remaining accumulated radioactivity from past emissions result in an annual radiation dose commitment of 12.26 person-rem to the combined general public in the area surrounding the Facility out to a distance of 80 km (50 miles). This total body exposure results from tritium operations at the Facility. Total body exposure from natural background tritium in the 80-km area amounts to 270 person-rem; therefore, tritium operations result in a total population total body exposure less than natural background. The annual average total body exposure of persons in the population in the vicinity of the plant is 0.205 mrem.

Plutonium emissions result in potential lung exposure. The calculated theoretical annual lung exposure of individual persons in the population in the vicinity of the Facility is 0.036 mrem. (A maximum exposure of 0.11 mrem per year would be received by an individual who lived continuously at the site perimeter fence. Although this exposure would still be insignificant for an individual, the probability of such an existence is extremely low and unrealistic.) Total lung exposure from tritium and plutonium-238 emissions to individual persons in the offsite population is 0.241 mrem per year. This total exposure to the individual from nuclear operations amounts to less than 0.20% of the radiation exposure that individuals receive in this area of the United States from natural background radiation. As far as the total body radiation exposure of all people living within an 80-km distance from the Facility, the 12 person-rem annual exposure amounts to 0.003% of the exposure that this same population group receives from total natural background radiation which is 360,000 person-rem.

Individuals in the Mound Facility area could receive a radiation exposure greater than that from normal Facility operations in the event a "maximum credible accident" were to occur. In Mound's operations, the most serious accident that could be postulated within the realm of possibility was a major fire in the plutonium-238 processing

building. The significant release of plutonium which might result therefrom would pose the greatest potential for adverse environmental effects. Radiation exposure calculations indicate that an individual located at the point of maximum airborne plutonium-238 concentration offsite would receive as much as 10 rem to his lungs during the first year as a result of such an accidental exposure. The total lifetime dose commitment to his lungs would be approximately 15 rem. The average radiation dose commitment to the lungs of all persons in the population located in the area affected by plutonium-238 fallout would be 2.5 rem, and a total integrated dose to the lungs of the combined population would be 300 rem.

Fallout of plutonium on the ground would have no impact on public water systems since drinking water for this geographical area comes from underground aquifers. Plutonium becomes bound to the soil and does not enter the aquifer; therefore, dose commitment to the public from a fire involves inhalation only. Evacuation of some members of the general public from a small area may be required until soil contaminated with plutonium above a safe radiological level could be removed. This could be accomplished without long-term adverse impact.

Because of the many safeguards built into the plutonium-238 processes, an actual fire would be expected to have a much less adverse impact on the environment than the "maximum credible" fire discussed in this statement.

The maximum credible accidental release of tritium or an accidental criticality involving plutonium-238 would not result in as great a radiation exposure to the public as that discussed for a fire involving plutonium.

Natural disasters such as an earthquake or a tornado striking Mound buildings would have a lesser impact than the maximum credible accidental fire discussed above.

Concerning the handling of high explosives at the Facility, a maximum theoretical detonation would not result in any structural damage to any buildings offsite although there may be some broken windows. The smoke cloud would dissipate with no adverse effects. Such an explosion would not damage any nuclear facility or cause any environmental release of radioactive material.

9.1.3 BENEFITS

In accomplishing its primary function, Mound Facility fulfills a necessary role in the nation's nuclear weapons program, the peaceful application of nuclear energy, and the development of new energy sources. The plant's operation results in substantial economic, sociological, and technological contributions to the Dayton metropolitan area as well as more distant communities.

Mound Facility accounts for approximately 0.5% of the total employment in Montgomery County, Ohio. The area's economic environment receives the benefit of the $60 million applied directly for salaries and wages to employes; the purchase of supplies, services (acquired throughout the country), and capital equipment; and construction activities. The $41 million payroll directly affects the local economy because these dollars are respent many times in the local area.

The Facility's payroll also contributes significantly to national, state, and local tax income. Some of the Federal tax dollars are returned to the area school districts for Type B students; that is, dependents of personnel who work in Federally owned facilities.

Immediate and long-range benefits to the public have resulted from the technologies developed and the spin-off from DOE programs. Technological advances such as the nuclear fueled cardiac pacemaker and techniques of fuel fabrication for isotopic heat sources for outer space applications are beneficial not only to the local community, but to citizens of every community in the United States.

Employes of the Facility also have an extensive impact on the cultural and civic activities of the community. Employes are active in professional organizations, local political groups, church groups, and social groups and accept positions of responsibility in many of these activities.

9.2 DISCONTINUE OPERATIONS

9.2.1 COSTS

This alternative would incur costs considered to be hundreds of millions of dollars to completely decontaminate and decommission those facilities that have been used for nuclear operations. Complete decontamination so that all buildings could be used for other nonnuclear work would take considerable time, perhaps as much as ten years. Therefore, the discontinuation of operations would not produce an immediate return to natural background radiation. The annual total body radiation exposure to the public amounts to 0.205 mrem above background. Reducing this exposure to the natural background levels, about 120 mrem/year, would not be fully realized until the decontamination period would be completed. The impact of this 0.2% reduction in the radiation exposure of the public around the Facility would not be measurable.

9.2.2. RISKS

Discontinuation of operations as an alternative would be undertaken for the purpose of removing all current risks to the public in the vicinity of the Facility. Current

routine operations pose no significant risks to the public. Normal nuclear operatior currently increase radiation exposure of the public by only 0.205 mrem/year above natural background. An elimination of Mound's contribution would amount to a total radiation reduction of about 0.2%. The most significant impact would be the elimination of the potential risk to the environment of an accident or natural disaster which could release as much as 1 gram of plutonium-238, thus eliminating the potential for an accidental total lifetime exposure of 15 rem to the lungs of individuals in the exposed population.

9.2.3 BENEFITS

The only significant benefit is the elimination of the risk of an accidental release of plutonium-238. However, all economic and sociological benefits would be lost to the community.

9.3 RELOCATE OPERATIONS

If Mound Facility operations were transferred to another DOE site, the associated cost benefit and reduction in risks would be the same to the local community as the Discontinuation of Operations alternative. In terms of environmental impact, the net effect on the total ecosystem of the United States essentially would be zero since Mound's impact would merely be moved to another location with the only reductions in environmental impact being that which may be realized from the new facilities at the new site being constructed to higher standards (i.e., it would realize the advantages of the "planned improvement" enumerated in Section 9.5). Relocation of the stable isotope separation program to another site would not significantly reduce the local radiation exposure. However, such a transfer to industry would contribute to the gross national product.

9.4 DECREASE THE WORK LEVELS

Some operations can be scaled down or stretched out over a longer period of time in order to reduce resource consumption and releases of certain types of effluents. However, such curtailments cannot be expected to have more than a minimal effect on the overall environmental impact since maintenance of the facilities under a reduced level of work still requires consumption of threshold amounts of materials and natural resources.

9.5. CONTINUE OPERATIONS WITH PLANNED IMPROVEMENTS

Over the past several years, the modification of systems and operating procedures as well as the upgrading of facilities has lessened the environmental impact of Mound operations. The current total negative impact is relatively small as discussed in Section 9.1. The most economical and environmentally beneficial alternative involving continuation of the work performed at Mound is, therefore, to continue operations at Mound Facility while implementing improvements already planned to further reduce the environmental effects and the risk of accidents to approach a zero impact.

9.5.1 COSTS

The costs associated with planned and projected upgrading programs for the next several years is approximately $45,000,000.

9.5.2 RISKS

Of the projects planned for future completion, four would reduce the radiation exposure of the offsite public. A precise figure for the overall exposure reduction cannot be calculated since in some cases the reduction will depend on technological advancements. All reductions would follow the philosophy of "as low as practicable."

One project would reduce the risk of an accident associated with the handling of radioactive materials. Two projects would reduce the discharge of nonradioactive pollutants in liquid effluents and five projects would reduce the amount of natural resources required to support operations.

All planned projects have a beneficial effect in reducing the Facility's impact on the environment.

9.5.3 BENEFITS

In addition to continuation of the various benefits to the local area from maintaining operations at Mound Facility, the area economy would be further sustained by the costs associated with the many upgrading projects. Those projects that result in a reduction in the concentration of radioactive material in airborne and liquid effluents are beneficial to the environment and public in the area surrounding the Facility as are reductions in emission of nonradioactive pollutants and decreases in the amount of natural resources needed to support operations at this location.

Only one of the upgrading projects makes any notable, visible, physical change to the plant site itself. This project concerns the demolition and removal of an old, unused plutonium-handling building. The land area will be cleared and landscaped thus improving the aesthetics of the site. Adverse environmental effects during demolition would be temporary. When the project is completed, the site environment would be much improved.

The primary national benefit from the operation of Mound Facility would not be changed by this alternative; that is, Mound would continue its function for the national defense.

Table 9-1

SUMMARY ANALYSIS OF ALTERNATIVES

Alternative	Time to Complete Alternative (yr)	General Impact	Annual Total Body Radiation Dose Commitment Above Background to Local Public After Action (mrem): Total From Onsite Sources	Annual Total Body Radiation Dose Commitment Above Background to Local Public After Action (mrem): Total From Offsite & Onsite Sources	Maximum Credible Accidental Radiation Exposure to Persons in General Population
1. No change from CY-77 activities	Continuing	Contributes to national defense and technological advancements in peaceful application of nuclear energy. Natural background radiation dose increased by 0.2%. Nonradioactive pollutants are insignificant. Use of natural resources and land have no effect on local area. Large benefit to local economy and to social, political, professional, and church activities.	0.015	0.205	10 rem to lungs during first year after exposure; 15 rem total lifetime.
2. Discontinue operations	10	Eventual return to natural radiation background level. Zero accident potential. High cost. Loss of defense capability and of economic, social, and technological benefits.	0.000	0.000	None
3. Relocate operations	12	Eventual return to natural radiation levels locally. No benefit to national environment. Very high cost. Risks and benefits transferred to another location.	0.000* ≤0.015**	0.000* ≤0.205**	None* ≤15 rem total lifetime**
4. Decrease work levels	-	Current work levels are minimal in relation to capacity.	≤0.015	≤0.205	Same as #1 above.
5. Continue operations with planned improvements.		Area economy would continue to benefit and be increased by new construction. (See specific impacts below.) Radiation exposures will be reduced. Emission of radioactive & nonradioactive pollutants would be reduced, & demand for natural resources would be reduced.	≤0.015	≤0.205	10 rem to lungs during first year after exposure; 15 rem total lifetime.

*At Miamisburg
**At new site

Table 9-1 (Continued)

Alternative	Time to Complete Alternative (yr)	General Impact	Annual Total Body Radiation Dose Commitment Above Background to Local Public After Action (mrem)		Maximum Credible Accidental Radiation Exposure to Persons in General Population
			Total From Onsite Sources	Total From Offsite & Onsite Sources	
a) Modify sanitary sewage plant.	2	Reduces suspended solids in effluent	-	-	-
b) Relocate existing 250,000 gal water tower.	3	Removes possibility of tower being toppled onto nuclear building by tornado. Removes radiation accident risk.	-	-	-
c) Improve particulate air filtration systems in nuclear facilities.	1	Provides added protection against accidental release of radioactive materials.	-	-	-
d) Construct runoff water retention basin.	1	Reduces slit in site runoff water and minimizes potential of plutonium spill to escape the site.	-	-	-
e) Site drainage improvement.	4	Reduces site soil erosion.	-	-	-
f) Recycle cooling water.	3	Reduces water, electric power, and water conditioning requirements.	-	-	-
g) Maximize ventilation air recirculation.	3	Minimizes brine, cooling water, steam usage, and energy requirements.	-	-	-
h) Partial Inactivation of plutonium processing building	6	Reduction to insignificance of potential for release of plutonium to environs.	-	-	-

Table 9-1 (Continued)

Alternative	Time to Complete Alternative (yr)	General Impact	Annual Total Body Radiation Dose Commitment Above Background to Local Public After Action (mrem): Total From Onsite Sources	Annual Total Body Radiation Dose Commitment Above Background to Local Public After Action (mrem): Total From Offsite & Onsite Sources	Maximum Credible Accidental Radiation Exposure to Persons in General Population
i) Demolition and removal of SM-Bldg	5	Removes unused building and residual radioactive contamination.	0.036(lungs)	0.000	Same as #5 above.
j) Continue improvement in technology of handling tritium.	Continuing	Follows policy of achieving "lowest practicable level" of radiation exposure to public.	0.015	0.000	Same as #5 above.
k) Water recycle (Dual water system and reuse water.)	LR*	Reduces water consumption	-	-	-
l) Energy conservation (Long-range program)					
i) Electrical and petrochemical	LR	22% reduction 1973 through 1977. Future curtailments to be achieved wherever possible.	-	-	-
ii) Conversion of boilers from gas/oil to coal.	LR	Conservation of diminishing natural resources. Combustion products in Mound's effluents would be increased.	-	-	-
iii) Use solar energy	LR	Reduces demand for nonreplaceable energy sources.	-	-	-
m) Incinerate wastes	-	Not cost effective in forseeable future.	-	-	-

*-LR = Long-range program.

SECTION 10
DISCUSSION OF COMMENTS RECEIVED CONCERNING THE DRAFT ENVIRONMENTAL IMPACT STATEMENT DOE/EIS-0014-D

On April 27, 1978, a Federal Register notice (43 FR 17995) announced the availability of a Draft Environmental Impact Statement for the Mound Facility, Miamisburg, Ohio. DOE requested comments and views from interested government agencies, organizations and individuals for consideration in the preparation of the final environmental impact statement. The statement addresses the environmental impacts associated with continued operations at the Facility. In response to the Federal Register notice, W. H. Pennington, Director, Office of NEPA Coordination, U. S. Department of Energy, Washington, D. C. 20545, received letters of views and comments from the following.

Mr. Charles L. Weaver, Consultant, Office of Medical Affairs, Bureau of Radiological Health, Public Health Service, Food and Drug Administration, Department of Health, Education, and Welfare, Rockville, Maryland 20857

Mr. Larry E. Meierotto, Deputy Assistant Secretary, Office of the Secretary, United States Department of the Interior, Washington, D. C. 20240

Mr. Donald T. Williams, Chief Engineer, The Miami Conservancy District, 38 East Monument Avenue, Dayton, Ohio 45402

Mr. Voss A. Moore, Assistant Director for Environmental Projects, Division of Site Safety and Environmental Analysis, U. S. Nuclear Regulatory Commission, Washington, D. C. 20555

Mr. Ronald L. Mustard, Director, Office of Federal Activities, Region V, U. S. Environmental Protection Agency, 230 South Dearborn Street, Chicago, Illinois 60604

Mr. Barry R. Flamm, Coordinator, Office of Environmental Quality Activities, Office of the Secretary, Department of Agriculture, Washington, D. C. 20250

Ms. Marian S. Simmons, Chairperson, Miami Valley Environmental Coalition, 1460 Tait Wood Drive, Centerville, Ohio 45459

The major issues raised in the above letters concerned the effects of tritium release; plutonium-238 release and toxicity; additional data for releases in air and water effluents; occupational exposure of Plant workers; criteria for the evaluation of the effects of fire and storms; stabilization of contaminated soil; impacts of transportation of radioactive waste; waste disposal; and Mound's meteorological program.

All issues were addressed individually in letters of response to the commenters. Appropriate text revisions of the above listed major issues were accommodated as follows:

Tritium release and effects

The discussion of tritium in local drinking water as expanded for clarification on pages 3-31 through 3-41. Environmental control systems are discussed on pages 2-8 through 2-10.

Plutonium-238 release and toxicity

The health effects of Mound's operations are reviewed in a completely revised and expanded section on Toxicity presented in Appendix D. Environmental control systems are described on pages 2-12 and 2-13.

Additional data for releases in air and water effluents

The principal release points for tritium and plutonium to air are identified on page 2-28; resident population in close proximity is presented on page 2-32; annual effluent totals for tritium and plutonium-238 in air and water are listed on pages 3-17, 3-25, 3-42 and 3-47.

Occupational exposure of Plant workers

A review of internal and external radiation exposures has been added by a new Appendix F. Application of the DOE ALAP policy is covered on pages 2-10, 2-11, 3-1, and 3-40.

Criteria for evaluation of effects of fire and storms

Beyond the discussion of criteria in the text starting on page 3-62, additional consideration of the applicable criteria is reviewed in the letter of response to Mr. Voss A. Moore, U. S. NRC, on pages 7 and 8, with an appropriate modification in the FEIS text on page 3-67 and a future change in operations as indicated at the bottom of page 3-74.

Stabilization of contaminated soil

The presence of plutonium-238 in the Miami-Erie Canal is reviewed on pages 3-53 through 3-55. A followup study which shows continued stable conditions is referenced on page 3-55.

Impacts of transportation of radioactive waste

Section 3.13, Transportation, pages 3-81 through 3-88, was completely revised to present an appropriate review of this issue.

Waste disposal

The text concerning compliance of liquid discharges with NPDES permits was updated on page 3-11 and the text revised to clarify the discussion of

waste solvents on page 3-13, other liquid wastes on page 3-14 and waste explosives on page 3-14. Additional discussion of this issue is included on pages 2 through 4 of the letter of response to Mr. R. L. Mustard, U. S. EPA.

Meteorology program

The Mound program is upgraded to have fully computerized Atmospheric Release Capability (ARAC) as indicated on page 2-67.

In addition letters were received from:

Mr. John W. Laney, City Manager, City of Kettering, 3600 Shroyer Road, Kettering, Ohio 45429

Dr. Van G. Whaler, Ph.D., Community Planner, Springfield Planning Division, 117 S. Fountain Avenue, Springfield, Ohio 45502

who supported the continued operation of Mound Facility.

Copies of the letters received and DOE responses are contained in the following pages of this section.

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
FOOD AND DRUG ADMINISTRATION
ROCKVILLE, MARYLAND 20857

MAY 11 1978

Mr. W. H. Pennington, Director
Office of NEPA Coordination
Department of Energy
Washington, D.C. 20545

Dear Mr. Pennington:

The Department of Health, Education, and Welfare has reviewed the health aspects of the Draft Environmental Statement related to the Mound Facility, Miamisburg, Ohio, DOE/EIS - 0014-D and have the following comments to offer.

The radiological assessment of plant operations indicates that the dose to the population offsite is well within current radiation protection standards. It is noted that the concentration of tritium in the local environment at several locations exceeds the new EPA Standard for drinking water which became effective on June 24, 1977. This situation is currently being evaluated and a program initiated to reduce the tritium concentration to meet the Federal standard.

The statement does not include a discussion of the occupational exposure of plant workers. In order to fully evaluate the radiological impact, this source of exposure should be evaluated and added to the Statement.

Continued normal operations of the Facility can be expected to result in a minimal environmental impact and to provide adequate protection of the public health and safety.

Sincerely yours,

Charles L. Weaver
Consultant
Office of Medical Affairs
Bureau of Radiological Health

Department of Energy
Washington, D.C. 20585

JUL 3 1979

Mr. Charles L. Weaver, Consultant
Office of Medical Affairs
Bureau of Radiological Health
Department of Health, Education,
and Welfare
Rockville, MD 20857

Dear Mr. Weaver:

Thank you for your letter of May 11, 1978, with comments on the U.S. Department of Energy's (DOE) draft Environmental Impact Statement (EIS) on the Mound Facility, Miamisburg, Ohio, DOE/EIS-0014-D.

As you stated in the second paragraph of your letter, the radiation dose to the population offsite is well within current radiation protection standards and the concentration of tritium at several locations in the Buried Valley Aquifer exceeds the new Environmental Protection Agency standard for drinking water. The forced turnover of water in the aquifer through high-volume pumping in 1977 and 1978 has brought the water in the majority of the private offsite wells into compliance with the new regulations. Mound's water from its three wells also meets the new standard. Although the aquifer water underneath about 52 acres exceeded the new standard in April 1977, only that water underneath 17 acres exceeded the standard in June 1978. Pumping was discontinued during several months of 1978 to determine the effect on tritium levels during a no-pumping mode. As expected, until the tritium is depleted, the level showed an increase at some wells. High-volume pumping has resumed and Mound anticipates that all area well water will be in compliance in CY 1979.

With respect to your concern about occupational exposure, a summary discussion has been added in Section 3.10 and Appendix F, "Property Losses, Lost Time Injuries and Radiation Exposures Reported Through CY-1977", has been added to the final EIS to present the occupational radiological exposure to plant workers. Serious attention to personnel radiation exposures, to employee safety in general, and to facility property protection is demonstrated in this appendix. Attention to radiological safety is indicated in various sections of the impact statement text. Tritium environmental control systems using the

principles of containment, isolation, and air flow control for the protection of radiation workers is discussed on pages 2-8 to 2-10. Plutonium-238 environmental control systems are discussed on pages 2-12 and 2-13. A revised appendix concerning the health effects on the public from plutonium-238 operations at the Mound Facility is presented in Appendix D, "Plutonium Toxicity".

The accident prevention and emergency response capability of the facility is presented on pages 2-21 and 2-22. The various elements of a comprehensive environmental monitoring program are described on pages 2-22 through 2-26. Mound's As Low As Practicable program has achieved a low radiation exposure experience for the facility employees as well as for the public surrounding the site.

A discussion of the disposition of all the comments received, copies of all comment letters, and DOE responses are included in Section 10 of the enclosed final EIS.

Sincerely,

James L. Liverman

Ruth C. Clusen
Assistant Secretary for Environment

Enclosure

cc: Mr. Charles Custard, Director
Office of Environmental Affairs
Department of Health, Education,
and Welfare

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

ER 78/361

JUN 2 1978

Mr. W. H. Pennington, Director
Office of NEPA Coordination
Department of Energy
Washington, D. C. 20545

Dear Mr. Pennington:

Thank you for your letter of April 20, 1978, transmitting copies of the Department of Energy's draft environmental impact statement for the Mound Facility, Montgomery County, Ohio [EIS-0014].

Our comments are presented according to the format of the statement or by subject.

On page 3-1, we were pleased to note that the environmental impacts of the sewage plant and radioactive waste treatment plant are continuously monitored. We would also recommend monitoring the radiochemical quality of storm-water runoff draining industrial areas of the site, since this runoff presently flows through offsite ditches and storm sewers, into the Great Miami River.

The final statement should address, in greater depth, the high volume, long-term pumping program to reduce tritium levels in ground water, which is on page 3-41. The discussion should include the desired flow effects in the aquifer, the magnitude of the withdrawals, and the routing or disposition of the large volumes of water withdrawn. It is not clear whether dilution or actual removal of tritiated water is the goal. Page 3-40 (item 8) states that the highest concentration in the local aquifer is 1.38×10^{-4} uCi/mi; however, page 3-34 states that the CY-1976 concentration in the off-site private wells was 0.060×10^{-3} uCi/mi. It is not clear whether this difference is due to a possible time or location factor.

Plutonium

On page 3-51, it is stated that "a total of approximately 5 curies of plutonium-238 had accumulated in the canal and ponds." On page 3-52, however, it is then stated that "sampling results indicated about 9 curies were transported offsite by the ditch to the canal." Since the time of this plutonium leak in 1969, about 10^{20} disintegrations have taken place; this then would appear to be a significant amount of radioactive material. Consequently, we think that additional information should be provided on the disposition of the material as well as the potential for migration in the canal. As it stands now, only a brief reference has been made, on page 3-52, to "stabilization of the area of highest plutonium concentration in the canal." We would hope that the final statement will provide information on the methods of stabilization that have been applied.

As a minor comment, we note that on page F-6, "RBE" is used in the definition of REM, but is not defined in the glossary.

We hope these comments will be helpful to you in the preparation of a final statement.

Sincerely,

Larry E. Meierotto
SECRETARY

Deputy Assistant

Department of Energy
Washington, D.C. 20585

JUL 3 1979

Mr. Larry E. Meierotto
Assistant Secretary for Policy,
Budget, and Administration
U.S. Department of the Interior
Washington, DC 20240

Dear Mr. Meierotto:

Thank you for your letter of June 2, 1978, with comments and suggested changes to the U.S. Department of Energy's (DOE) draft Environmental Impact Statement (EIS) on the Mound Facility, Miamisburg, Ohio, DOE/EIS-0014-D.

Your letter recommended that the radiochemical quality of the storm-water runoff be monitored. The runoff water has been monitored for a number of years. All water leaving the plant through the drainage ditch and the underground pipe is sampled by means of 24-hour continuous proportional sample collection systems operating at the fence line of the property. Section 3.7.1 TRITIUM, Liquid Waste Effluent Impact, and Section 3.7.2 PLUTONIUM, Liquid Effluent Impact, state that the streams are sampled for analyses. The topographical lines in Figure 2-9 (and see Figure 3-8) indicate that most of the storm water that does not enter the ground flows into the drainage ditch which flows toward the southwest and bisects the plant site. Recent engineering studies of site drainage showed that approximately 125 acres of the 180 acres in the plant site have runoff into the drainage ditch. All industrial areas are drained by the drainage ditch. Areas not drained through the central drainage ditch include the large parking lot in the northeast section of the plant, a strip of land on the north edge of the site, and a strip of land on the south edge of the site. None of these areas is used for any industrial purposes.

Several commentators, in addition to yourself, commented on Mound's program to reduce tritium levels in ground water (ref. draft EIS page 3-41). The final EIS has been revised to provide a more complete discussion on the aquifer pumping program.

In 1977, after the completion of a thorough evaluation of the infiltration of tritium into the aquifer and after test pumping to determine the effectiveness of a high-volume water removal and recharge of the aquifer, Mound initiated a high-volume long-term pumping program utilizing Mound Facility Well #1 and an old unused Miamisburg Well (Well #2). Both wells operate at

a discharge flow rate of 450 gallons/minute. Under natural environmental conditions, the Buried Valley Aquifer supplies water westward to the Great Miami River. In Mound's pumping program, the water table is lowered sufficiently to cause a reverse flow in the aquifer between the river and the high capacity pumps in order to sweep the tritiated water eastward from the area of the private wells to the pumps and then discharge to the river. The reduction of the tritium concentration in the various water wells is achieved by displacement and dilution through the forced infiltration of river water. During the pumping program from April 1977 through January 1978, some 400,000,000 gallons of water were removed from the aquifer and replaced by natural recharge water from the river and from rainfall. Natural recharge is totally adequate to support all water withdrawals--public, private, and industrial. Between April 1977 and June 1978, the area in which the tritium content exceeded the 20 nCi/l standard had been reduced some 67 percent; from 52 acres to 17 acres. In reducing the affected area, Mound Facility wells and most of the private wells were brought into compliance with the new Environmental Protection Agency (EPA) standard, and those wells not yet in compliance (4 wells) were approaching it. Mound currently anticipates reducing the tritium level to less than the EPA standard throughout the area during CY 1979.

The difference in tritium concentration between the junction of the Facility drainage ditch and the Miami-Erie Canal (item 8, page 3-40) and the CY 1976 concentration in the offsite private wells (page 3-34) is due to the relative location to the tritium source. The private well nearest the ditch-canal junction lies some 500-600 feet to the southwest.

The statements regarding the plutonium content of the canal and the total released offsite are correct to the best of our knowledge. Out of the estimated 300 curies of plutonium dissolved in nitric acid released onsite when the waste pipe ruptured, sampling of the contaminated soil-rock agglomerate in the vicinity of the leak accounted for approximately 291 curies of plutonium in the adjacent waterways (South and North Canal) was estimated from the data obtained from 1750 chemical analyses to be $5.2\ ^{+2.5}_{-1.0}$ curies. It was estimated from the discharge volume, suspended solids, and concentration of plutonium-238 per gram of suspended load that about 3.8 curies of plutonium-238 may have reached the Great Miami River. The plutonium discharged to the river on these erosion products was apparently diluted to less than 10^{-4} nCi/g after a short distance (approximately 2,000 feet) in the river to the sampling location.

The "stabilization of the area of the highest plutonium concentration in the canal" refers to the reaction which took place between the waste solution and the dolomitic glacial till in the vicinity of the waste

line rupture. The nitric acid was neutralized and the plutonium adhered to the clay soil particles in an ion exchange reaction and fixation. Thus, a particle of silt eroded into the drainage ditch by the heavy rains settled out at the region of low flow in the abandoned Miami-Erie Canal. Since the incident, additional silt deposited as a result of heavy rains has covered the plutonium-contaminated clay particles.

During a nine-month period in 1977, Mound undertook an extensive continuous air monitoring program in the canal area to determine any lack of stability which would be indicated by resuspension of soil/plutonium by wind blowing through the area. This study extended through seasonal wet and dry periods and calm and very windy periods, and included a prolonged period during which the City of Miamisburg was excavating soil and doing considerable regrading of the area for the construction of a solar pond to provide tempered ventilation air to a bath house and heated water to an adjacent municipal swimming pool. This concerted air surveillance program showed that the nine-month average concentration of plutonium-238 in the air was less than one percent of the Radioactivity Concentration Guide. Dose equivalents, conservatively calculated from the actual air data, were well within existing DOE standards and proposed EPA guidance. It was concluded that the contaminated sediment present in the canal area is quite stable and further action such as removal or covering up is not warranted. This study, Stability of Plutonium Contaminated Sediments in the Miami-Erie Canal, was published as MLM Report 2483 on March 1, 1978. A reference to this followup study has been included in the discussion of page 3-55 of the final EIS.

A discussion of the disposition of all the comments received, copies of all comment letters, and DOE responses are included in Section 10 of the enclosed final EIS.

Sincerely,

James L. Liverman for
Ruth C. Clusen
Assistant Secretary for Environment

Enclosure

cc: Mr. Bruce Blanchard, Director (20)
Environmental Project Review
Department of the Interior

THE MIAMI CONSERVANCY DISTRICT
38 EAST MONUMENT AVENUE
DAYTON, OHIO 45402
513 223-1271

Board of Directors
ROBERT S. OELMAN
President
WILLIAM H. HOBART, JR.
Vice President
LLOYD GOGGIN

WATER
RESPONSIBILI

June 22, 1978

Mr. W. H. Pennington
Director
Office of NEPA Coordination
Mail Station E-201
U.S. Department of Energy
Washington, D.C. 20545

Re: Mound Laboratory

Dear Mr. Pennington:

The District staff has reviewed the "Draft Environmental Impact Statement Mound Facility, Miamisburg, Ohio". The following comments are offered as they relate to references made in the impact statement to The Miami Conservancy District:

1) On Page 2-23 reference is made to a contractual agreement between the ERDA Dayton area office and the District. This contract was initiated on December 1, 1972 and had been extended through December 31, 1975. As a part of the District's regional water quality program, the District continued to provide information to the Mound Facility on an informal basis through 1977. But, as the regional water quality program has been terminated and the operation of the water quality monitors has ceased, the District will not be in a position to provide Mound Laboratory with additional water quality monitor data.

2) On Page 2-26 the report states, "The Miami Conservancy District is undertaking a ground water quality monitoring study under the

Mr. W. H. Pennington

June 22, 1978

sponsorship of Mound Laboratory". The District last worked with the Mound Laboratory in 1975 on this project. The quoted statement above seems to imply that the study is still underway; this is not the case.

If additional information or verification is needed, please contact this office.

Very truly yours,

THE WATER CONSERVATION SUBDISTRICT
OF THE MIAMI CONSERVANCY DISTRICT

By: Donald T. Williams

Donald T. Williams
Chief Engineer

Department of Energy
Washington, D.C. 20585

JUL 3 1979

Mr. Donald T. Williams
Chief Engineer
The Miami Conservancy District
38 East Monument Avenue
Dayton, Ohio 45402

Dear Mr. Williams:

Thank you for your letter of June 22, 1978, with comments on the U.S. Department of Energy's (DOE) draft Environmental Impact Statement (EIS) on the Mound Facility, Miamisburg, Ohio, DOE/EIS-0014-D.

The reference made to the contract between the DOE Dayton Area Office and the Miami Conservancy District (MCD) will not be included in the final EIS for the Mound Facility since the operation of the water quality monitors by the MCD has terminated.

The reference on page 2-26 of the draft EIS to the planned ground water quality monitoring study sponsored by Mound will also be deleted. This reference was overlooked in the development of the draft statement. We appreciate your noting the error.

A discussion of the disposition of all the comments received, copies of all comment letters, and DOE responses are included in Section 10 of the enclosed final EIS.

Sincerely,

James L. Liverman

Ruth C. Clusen
Assistant Secretary for Environment

Enclosure

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

JUN 26 1978

Mr. W. Herbert Pennington, Director
Office of Assistant Secretary for
Environment
Department of Energy
Washington, D. C. 20545

Dear Mr. Pennington:

In a letter of April 20, 1978, you requested comments from the Nuclear Regulatory Commission (NRC) regarding the Department of Energy's (DOE) draft Environmental Impact Statement (EIS), Mound Facility DOE/EIS-0014-D. The EIS has been reviewed by the NRC staff, and the comments are enclosed.

If you have any comments regarding the review and comments of the Mound Facility EIS, please do not hesitate to contact Dr. F. S. Echols (492-8445), the Environmental Project Manager assigned to supervise the review.

Sincerely,

Voss A. Moore

Voss A. Moore, Assistant Director
for Environmental Projects
Division of Site Safety and
Environmental Analysis

ENCLOSURE 1

1. Paragraph 1 on page 2-8 (Tritium Environmental Control System) should be expanded to explain how the alarm systems and failsafe features are incorporated in the area monitoring system. Does an alarm automatically isolate an area or is it isolated manually? Explain how isolation is achieved.

2. The fifth sentence on page 2-9 (Tritium Control) should be rewritten to reduce total emissions to an "as low as reasonably achievable" (ALARA), in order to be compatible with the most recent use of terminology in this subject area.

3. On page 2-8 - 2-11 (Tritium and Plutonium-238 Environmental Control System), we recommend that the report address the frequency and consequences of errors in operation or minor malfunctions of equipment and abnormal laboratory operations, i.e., unplanned releases of plutonium caused by leakage in cells or glove boxes which may result in airborne and respiratory problems, high concentrations of fissile materials in an extraction unit, excessive pressure or vacuum in a cell or glove box, and high temperature of solvent system. Further, we recommend that information be included which addresses safety limits or limiting conditions for operations and automatic protective or procedure controls which are used to return the situation to normal or to shut the process down before the limit is reached. If these are not available, then the additional environmental impact of not providing these controls should be addressed.

4. On page 2-15 (Treatment of Radioactive Liquid and Solid Wastes), indicate 1) the considerations taken to eliminate radioactive material buildup in components such as glove boxes, cells, process lines and equipment, i.e., to eliminate radioactive crud traps, and 2) the treatment for contaminated organic wastes from the laboratory and maintenance operations. Further, this section should describe the method that will be used to prevent spills from liquid waste handling and to assure solidification of solid waste. Discuss any decontamination that may occur in the event of a spill.

   We also recommend that additional information or a reference be provided for the cyclone incinerator pilot plant, i.e., discuss in more detail 1) the off-gas handling and 2) the tests which indicate that plutonium-238 waste concentrations as high as 100 uCi/g can be burned with no release of contamination. If possible, update this section with the results of the CY-1977 test program using LSA TRU waste (page 2-19, paragraph 2).

5. On page 2-22, paragraph 1 (Air Monitoring), define the corrective actions available to be used during anticipated labotatory occurrences and postulated accidents.

6. The report does not address the environmental impact of wastes which are shipped to other sites (DOE and commercial) for disposal. The environmental impact of this waste disposal and a discussion of alternatives should be addressed; if the waste disposal sites have addressed the impact in their respective Environmental Impact Statements then the statements should be referenced.

7. Section 3.10 has discussed a spectrum of potential on-site accidents and has discussed the consequences of these. The dose from one of these, a postulated nuclear criticality accident, has been compared with the dose criteria given in 10 CFR Part 100. Part 100 is used for guidance by the Nuclear Regulatory Commission (NRC) in the evaluation of the suitability of proposed sites for stationary power and testing reactors. Part 100 suggests as an aid in evaluating a proposed site that a fission product release from the core should be assumed "...based upon a major accident, hypothesized for purposes of site analysis or postulated from consideration of possible accidental events, that would result in potential hazards not exceeded by those from any accident considered credible".

8. The guideline values in Part 100 are normally used for comparison with accidents of extremely low probability of occurrence in which very conservative assumptions are employed regarding activity release, performance of engineered safety features, meteorology. Since the DEIS has identified a large fire in a plutonium facility as the "maximum credible accident" for the Mound Facility, we believe it to be more appropriate that the consequences of a large fire and resulting plutonium release be compared against the criteria of Part 100. Although the dose guidelines given in 10 CFR Part 100 are not directly related to releases involving plutonium, the NRC staff developed guidance in this regard during the course of the Clinch River Breeder Reactor (CRBR) review, and established that dose guideline values of 75 rem to the lung and 150 rem to the bone were comparable to the values of 25 rem whole body and 300 rem thyroid given in 10 CFR Part 100. The DEIS indicates that the resulting lifetime dose commitment to the lungs of an individual standing at the point of maximum concentration is calculated to be 15 rem (page 3-61) which is well within the guideline value, but also note that this value is sensitive to the assumed distribution of plutonium particulates as well as other assumptions. We suggest that additional sensitivity studies be performed regarding quantity of release, particulate distribution and filter system performance to provide assurance that the consequences of such an event are acceptable. Also

in this regard, we wish to commend the proposed upgrading of the High-Efficiency Filtration System, as indicated in Table 3-1, and suggest that Mound Facility initiate a program to test the performance of the centilation and filtration system and to maintain it at a high level of efficiency.

9. The DEIS mentions no planned improvements or upgrading for increases in tornado protection to prevent or mitigate accidental releases of plutonium. The DEIS has estimated offsite releases of plutonium ranging from 0.1 to 10.0 gram (1.6 to 160 curies) in the event of being struck by a moderate tornado (Fujita Scale F3), and has estimated the probability of such an event as approximately 10^{-3} per year. With regard to tornado and tornado missile protection the NRC staff requires that the safety structures and equipment of nuclear power reactors be protected against the equivalent of the much more severe and rarer tornado comparable to the DOE Model Tornado (Fujita Class F6), and generally requires that any external event, that can result in large releases of radioactivity (greater than the guideline values of 10 CFR Part 100) and whose probability of occurrence is greater than about 10^{-7} per year must be accommodated in the design of the plant.

10. Although dose calculations cannot be easily performed for atmospheric conditions approximating tornadoes, based upon the significant quantities of plutonium estimated in the DEIS to be released as a result of such an event, and based upon its probability of occurrence, the NRC would require an applicant under similar circumstances to regard this as a design basis event and to show acceptable protective or mitigative capability to prevent such releases. DOE should consider implementing measures that will significantly enhance the capability of the Mound Facility under tornado conditions to prevent or mitigate the consequences of such releases.

11. The DEIS also notes (page 1-1) that effects of offsite transportation accidents are not regarded within the scope of the document. The staff does not agree. Where offsite transportation accidents impact the facility to the extent that any releases of radioactivity can result, we believe it appropriate that the facility DEIS discuss such accidents and compare their probability and consequences with the spectrum of accidents already considered. We believe the DEIS should be extended to include this area.

12. The environmental radiological monitoring program is unbalanced in frequency of sampling the various media. For example, contrast the 210 samples per year from each of five locations on the Great Miami River (Table 3-11) with only one sample per year from community water (Table 3-10) and two samples per year of mile (Table 3-7).

13. It is stated (page 2-67) that an onsite meteorology program was initiated in 1973, yet no data are apparently available from the program (page 2-61). The reason for the lack of onsite data should be presented. We note that Appendix B details the calculation of atmospheric dispersion, yet the report is devoid of any presentation of atmospheric dispersion papameters for any potential receptor locations. We note that Figure 3-6 shows the approximate locations of air sampling stations and presents a wind rose from Wright-Patterson Air Force Base.

14. In Figure 3-6, location 119 would appear to be a control location, yet the data for this location (Table 3-6) are not employed for this purpose, and a tritium background value from another reference is cited on page 3-20. The same is true of the plutonium data in Table 3-14.

15. Principal release points should be identified on one of the site maps which also identifies the site boundaries. Distances to the nearest site boundary and the nearest residence shold be tabulated for each direction section from the release points.

16. The Statement presents dose predictions which are based on the measured concentrations, but it is not stated how these concentrations are extended in distance and direction from the site. Since the majority of the measurements in the environment are near or below the minimum detection limits, it would be more appropriate to calculate the doses using meteorological data representative of the site.

17. Population should be presented at least as a function of distance from the facility for atmospheric releases. For liquid effluents, the population served by each intake point should be provided. All the dhownstream cities appear to use riverbank wells which can be affected by the tritium effluents.

18. The information on tritium in liquid effluents and the resulting exposures contain some discrepancies and confusing items of information. For instance, on page 3-2 it is stated that the facility "used" (presumably withdrew from its wells) 173 million gallons of water in 1976. However, in Table 3-2, the data indicate that the total discharge was 0.61 mgd, which amounts to 223 million gallons per year. This discrepancy will cause a corresponding error in effluent concentrations.

    The information on tritium in ground water is confusing since no doses are presented, even though the measured concentrations appear to be much higher than in the surface water. In view of the high porosity of the soils in this area, and the large amounts of local recharge available from rainfall (page 3-30), it would appear that much of the tritium found in the ground water at up-gradient locations (page 2-56) must have been delivered from the site in the past by rainfall. This is in conflict with statement No. 3 on page 3-40.

19. Regarding the efforts to reduce the tritium [illegible]ations in ground water by pumping, estimates of the [illegible] in population dose expected as a result of this action s[illegible]ade. This benefit should be weighed against the add[illegible]pulation exposure produced downstream by tritium released in[illegible]eat Miami River.

Department of Energy
Washington, D.C. 20585

JUL 3 1979

Mr. Voss A. Moore, Assistant Director
for Environmental Projects
Division of Site Safety and
Environmental Analysis
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Moore:

Thank you for your letter of June 26, 1978, with comments and suggested changes to the U.S. Department of Energy's (DOE) draft Environmental Impact Statement (EIS) on the Mound Facility, Miamisburg, Ohio, DOE/EIS-0014-D. The disposition of your comments is provided.

1. Paragraph 1 of Tritium Effluent Control Systems in Section 2 has been expanded to explain the use of monitoring systems for tritium laboratory areas.

2. An As Low As Practicable (ALAP), or As Low As Reasonably Achievable (ALARA), program was implemented in 1970 and has been continued to date. Excellent results have been achieved in reducing airborne tritium emissions from 17.947 grams in 1970 to 0.490 gram in 1977 and tritium in liquid effluents from 0.025 gram in 1970 to 0.006 gram in 1977.

3. Accidental or unexplained releases of radioactive material have been examined. A small number of tritium and plutonium-238 releases have been detected by the stack monitors, but none were reportable incidents according to DOE reporting standards and requirements since the quantities were very small. During February through May 1974, the concentration of tritium in the stack effluent was found to be above the normal operating average. A review of the operations and equipment indicated that the efficiency of the tritium stack gas cleanup system (ERS) was below standard. The resulting increased amount of tritium released was very small; however, corrective maintenance on the ERS returned the stack level to normal. In January 1975, 530 curies (0.053 gram) of tritium above the average were released in airborne effluents. The cause for this elevated stack level was not found. In February 1977, 210 curies (0.021 gram) of tritium above the average were released. The cause for this elevated stack level was not found. In March 1978, equipment failure released 1300 curies (0.13 gram) of tritium. In June 1978, a faulty valve on a storage tank released 2200 curies (0.22 gram) of tritium to the stack effluent.

Specific incidents of the release of plutonium-238 to the environment were all linked to high efficiency particulate air (HEPA) filter changings except for the break in the waste line which is discussed in the statement. In 1973, there were five filter-change incidents which released a total of 66 μCi, the largest single incident being 20 μCi. In 1974, the only filter-change incident released 2.5 μCi. No detectable releases to the airborne effluents have occurred since.

Attention to radiological safety, in terms of ventilation control in work areas, effluent control, facilities, and worker response to unplanned releases of contamination, is indicated in various sections of the final EIS. Tritium environmental control systems using the principles of containment, isolation, and air flow control for the protection of radiation workers are discussed on pages 2-8 to 2-10. Plutonium-238 environmental control systems are discussed on pages 2-12 and 2-13. A completely revised appendix (Appendix D, Plutonium Toxicity) has been developed for the final EIS and demonstrates the minimal health effects on the public from plutonium operations at the Mound Facility. The accident and emergency response capability of the facility is presented on pages 2-21 and 2-22 and the various elements of a comprehensive environmental monitoring program are described on pages 2-22 through 2-26.

In addition, a new appendix (Appendix F) has been incorporated in the final EIS to present the occupational radiological exposure of plant workers. Such information serves to demonstrate the effectiveness of facilities, procedures, and management for nuclear operations. In this appendix, Table F-3, "External Radiation Exposure of Employes", shows a pronounced decrease in occupational exposures from 1965 through 1977. The philosophy of ALAP is being applied on a continuing basis to all impacts of Mound's operations. Other tables in Appendix F cover internal deposition of radioactive material and show a low-deposition incidence for lung exposures and systemic body burdens above the radiation protection standards throughout the history of the project.

Appendix F also includes statistics on "Disabling Injuries to Employes", Table F-2, which shows that during the period of 1948 through 1977, Mound had only eight disabling injuries. The last occurred in August 1966. A table covering "Plant Property Losses Exceeding $5,000", Table F-1, shows only nine such incidents, six of which were radiological, since operations were initiated in 1948. Serious attention to personnel radiation exposures, to employee safety in general, and to facility property protection is demonstrated in this appendix. Mound's ALAP program has achieved a low-radiation exposure experience for the facility employees as well as for the public surrounding the site.

4. All plutonium-238 waste recovery operations ceased in 1973. All related equipment, piping, etc., were removed and shipped to designated burial and storage sites. All heat source production, which involved plutonium-238 metal, was discontinued in 1970. Subsequent heat sources were fueled with plutonium dioxide.

Buildup or radioactive material is not permitted in glove boxes or in equipment inside of glove boxes. As stated in comment #3 above, plutonium processing does not involve wet chemistry. Plutonium is received as plutonium dioxide and used directly to make the solid heat source fuels. Buildup of plutonium dioxide powder is controlled by normal good-housekeeping techniques to ensure that glove failure would release only minimal amounts of plutonium dioxide to the laboratory work area. Also, health physics personnel routinely monitor glove boxes and post radiation readings on the front of each box. If any radiation level above a predetermined control level is found, an extensive cleanup of the glove box interior is done. All work areas are routinely surveyed and air monitored for contamination to ensure that proper control is being maintained. Any area showing a level exceeding the control level is shutdown and decontaminated before operations are resumed.

Tritium is handled as a gas, liquid waste (tritiated water or contaminated vacuum pump oil), or solid tritide. Glove boxes are filled with inert atmospheres which are recirculated through drying columns. Piping is encapsulated with a vacuum annular space which is continuously monitored for evidence of leakage of the inner pipe. Liquid wastes are packaged in containers filled with absorbent or mixed into cement to form concrete in an inner container which is in turn placed in a sealed outer shipping container and all voids filled with asphalt. Tests have revealed no leakage over long-term storage.

All tritium handling laboratories are continuously monitored for airborne material and routinely surveyed by health physics personnel. Any area showing unacceptable contamination is decontaminated immediately. Absorbent materials are used to collect a spilled liquid. Decontamination of the area is continued with detergents and chemicals selected for their complexing properties until the level of contamination meets Mound's conservative contamination control standard.

Additional information has been incorporated into the EIS about the incinerator. The draft EIS did contain a "typo" when it gave the concentration of the waste incinerated as 100 μCi/g; the value should have been 10 μCi/g.

5. The alarms on stack monitors are set to respond to concentrations of radioactive material above normal levels in the effluent, yet well below that concentration which would result in the radiation protection standard being exceeded in the offsite environment. Depending on the concentration of the radioactive material in the stack and the nature of the source of contamination that is causing the above-normal stack effluent, the personnel responding to the alarm have the option of shutting down the offending operation or shutting down the ventilation system for the whole building in order to stop the stack discharge completely and then correct the problem. For example, primary filters at some glove boxes may need to be changed or all operations suspended and the ventilation system shutdown so that secondary and final filters in the building filter bank(s) can be replaced.

6. The discussion of Mound's radwaste shipments and subsequent disposal has been expanded in the final EIS, Section 3.13, beginning on page 3-81. In addition to a thorough discussion of shipping-container integrity to comply with stringent U.S. Department of Transportation regulations and special-permit transportation, the discussion covers the various wastes which are shipped to four burial sites. The four sites are identified and their disposal/storage methods indicated. Each site's activities are conducted according to good radwaste management practices. Other than the fact that each site is adequately staffed with professional personnel and operate monitoring programs to assure that wastes are stabilized at the burial location, Mound does not have monitoring information or site environmental assessments. These would have to be obtained from the burial site operators.

   The Mound Facility currently ships its radioactive wastes to the following offsite burial/storage grounds:

   a. Chem Nuclear Systems, Inc., Barnwell, South Carolina

   b. Savannah River Plant, Aiken, South Carolina (DOE facility)

   c. Nevada Test Site, Mercury, Nevada (DOE facility)

   d. Idaho National Engineering Laboratory, Scoville, Idaho (DOE facility)

   Mound neither stores nor buries any radioactive wastes onsite. The waste form, method of packaging, and mode of shipment differs from Mound's utilization of each of these disposal sites.

7. The Mound Facility recognizes that 10 CFR 100 is generally utilized to evaluate the acceptability of a site for power and testing reactors. It is also recognized that guidance has been provided in TID-14844 defining the source term to be used and the accident is typically the "maximum credible accident." The major difference between operations at the Mound Facility and those at a reactor required the use of a different source term and, additionally, the criticality accident was determined not to be the maximum credible accident. Although the differences exist, the Mound Facility deemed it appropriate to use 10 CFR 100 dose criteria because the postulated accident was a nuclear criticality and 10 CFR 100 is the only known guidance for evaluating such an accident. The Mound Facility has incorporated into the final EIS, on page 3-67, a statement qualifying the usage of 10 CFR 100.

8. The Mound Facility utilized extremely conservative assumptions related to the source term, safety features, and meteorology in the development of the accident scenario for the "maximum credible accident." The source term represents one percent of the total inventory available which is similar to the Nuclear Regulatory Commission (NRC) guidance on the Clinch River Breeder Reactor as specified in Docket No. 50537-149. Although engineering evaluations have shown that the filter banks will not be adversely affected by the heat generated from the fire, the extremely conservative assumption was made that the filter banks would be bypassed. The meteorological conditions selected represent the situation whereby an individual would receive the maximum possible dose. These factors indicate that the accident presented approaches the limits of what can be considered "credible." Additional sensitivity studies, as suggested by the NRC staff, would provide justification for the development of a less conservative accident scenario than the one presented. As the NRC staff indicates, the impact of the "maximum credible accident" presented is well within the guidelines developed for the Clinch River Breeder Reactor. The Mound Facility did not use these guidelines for comparison since they are not officially part of 10 CFR 100 and it was assumed to indicate that they may be site specific and possibly not applicable to the Mound Facility.

   The Mound Facility supports NRC's position that a formal testing program for ventilation and filtration systems is required. On page 2-13 of the final EIS is a description of the program at Mound which has been in existence for a number of years.

9. The Mound Facility has received authorization to move the water tower which could potentially fall on the major plutonium building. This action will eliminate a potential mechanism by which plutonium could be released. Policies have been implemented which limit the quantity of unencapsulated plutonium in process to the minimum. In the event of severe weather, all plutonium which can feasibly be repackaged is placed back into storage containers.

   Since the development of the draft EIS, studies such as those conducted by R. F. Abbey, Jr., of the NRC staff indicate that the probability of a F3 tornado strike is on the order of 10^{-5} instead of the value of 10^{-3} presented in the draft EIS. The probability of a F6 tornado has been estimated to be less than 10^{-8} which is considered to be an incredible event.

10. During the development of the draft EIS, a major effort in the form of literature searches and personnel contacts was made to determine if there was a method by which to determine dose under the extreme weather conditions which result under tornado conditions. As a result of this effort, the Mound Facility concluded that any dose calculations would be meaningless because of the lack of an analytical model to determine concentrations. The impact of such an event occurring, however, will be negated by discontinuing the preparation of the plutonium oxide feedstock at the Mound Facility by September 30, 1979. Feedstock for heat sources will be received already in primary encapsulation. Discussion of this operational change has been included in the DOE Model Tornado Assessment in the final EIS on page 3-74 and also on page 2-10 under "Development and Fabrication of Radioisotopic Heat Sources Fueled With Plutonium-238".

11. The inclusion of the statement on page 1-1 of the draft EIS, that the effects of offsite transportation accidents are not regarded within the scope of the document, was an editing oversight and should have been deleted since this subject was addressed in Section 3.13, beginning on page 3-79. We appreciate your noting this. Section 3.13, beginning on page 3-81 of the final EIS, has been revised to more appropriately address the subject as in comment #6 above.

    Concerning the potential environmental risks and effects of shipping radioactive materials in general, the NRC reviewed this subject thoroughly for the preparation of NUREG-0170, "Final Environmental Statement on the Transportation of Radioactive Materials by Air and Other Modes." According to this review, the NRC determined that

the environmental impacts of normal transportation of radioactive material and the risks attendant to accidents involving radioactive material shipments are sufficiently small to allow continued shipments by all modes. Because transportation conducted under present regulations provides adequate safety to the public, the NRC concluded that no changes to the regulations are needed at this time.

The NRC analysis shows that radiation exposure from normal transportation, averaged over the persons exposed, amounts to 0.5 millirem per year compared to the average natural background exposure of about 110 millirem per year. This represents a very low value for transportation (approximately 0.5 percent of natural background) of all radioactive material. Taking into account the contribution due only to radioactive waste shipments (approximately 15 percent), then the radiation exposure to the public becomes approximately 0.08 millirem per year (0.08 percent of natural background). Again, this is a very small or negligible individual contribution.

With respect to potential consequences of an accident, "The accident risk for the 1975 level of shipping activity, as determined from the 1975 survey, is very small ...." Only approximately 10 percent of this low potential "accident risk" arises due to transport of radwaste (NUREG-0170).

As demonstrated in Table 5-16 of NUREG-0170, "... an individual is 10^5 times as likely to be killed as a result of being struck by lightning as he is to die from radiological causes within one year following a transportation accident involving a shipment of radioactive material." The table shows that there are commonly accepted accident risks (fires, drownings, electrocution, hurricanes, etc.) that are very much greater than the accident risk of transporting materials.

12. We believe that the "unbalanced" frequency in monitoring these environmental media is justified. The Miami River is a direct receiver of effluents from the Mound Facility while the other environmental media are indirect receivers. Daily samples are taken at five locations in the Miami River. These samples are taken to monitor any possible direct contribution of Mound's effluents to the river. Community drinking water in locations away from the Mound Facility is sampled less frequently since there is no direct pathway. Milk is an even more indirect environmental medium than community drinking water and, therefore, would require less frequent sampling.

13. The onsite meteorology program was initiated in 1973, and was intended to provide meteorological data only in the event of an emergency. For this reason, the wind rose developed at Wright Patterson Air Force Base has been used. During CY 1978, the system was modified to be on DOE's Atmospheric Release Advisory Capability (ARAC) system and became a functional part of that system during the last quarter of the year.

    Atmospheric dispersion parameters used for "Fire in a Plutonium Facility" are presented in the final EIS on pages 3-63 and 3-64, for "Accidental Release of Tritium" on page 3-65, and for "Nuclear Criticality Accident" on page E-1.

14. Through CY 1977, there was some doubt as to the ability of our technique for tritium analysis to monitor atmospheric tritium at levels which references have quoted as "background." Therefore, Location 119 has been eliminated in Figures 2-7 and 3-6 and Table 3-6 of the final EIS. (Beginning with CY 1978, Location 119 is used as a "background" value since we have improved our lower detection limit.) As far as plutonium-238 is concerned, there was no problem with the lower detection limit; however, in order to be consistent concerning the total program, plutonium-238 was handled in a similar manner in Table 3-15 of the final EIS. (The plutonium-238 results will be handled the same as the tritium results in CY 1978.)

15. The plutonium and tritium stacks, or "release points," are identified on Figure 2-9 of the final EIS and Table 2-2 (page 2-32) added to present the number of people living within a one-half and a one-mile radius for each direction section from the release points.

16. It is the opinion of the personnel at the Mound Facility that actual monitoring data are much more accurate over longer time periods than that calculated by atmospheric dispersion. Also, for CY 1978, improvements in the analysis of those radionuclides which are at the lower detection limit have been made. Therefore, better quantitative values will be obtained for these radionuclides.

17. Concerning atmospheric effluents, population data are presented in Table 2-1 and Figure 2-11 of the final EIS. Additional population data have been provided by Table 2-2 as indicated in comment #15 above.

    In regard to tritium liquid effluents, it is to be noted in Table 3-11 of the final EIS that the concentration of tritium in the Great Miami River below Mound's outfalls is the same concentration ($<1.0 \times 10^{-6}$ μCi/ml or <10 percent of the Environmental Protection

Agency (EPA) Drinking Water Standard) as in the river above Mound's outfalls. This concentration is in the range of the tritium concentration observed in area surface water and indicated in Table 3-8. The level is also in the range of tritium background values for ground water in the United States. (See reference 3-7 of the final EIS.) Because of the tritium background level in the river downstream and since very few area or downstream cities use riverbank wells or wells drilled into the Buried Valley Aquifer, we believe it would not be meaningful to provide the population for all downstream communities for dose calculations. The contribution of tritium to the affected population is presented in Table 3-12 on page 3-37.

18. A total of 125 acres of the site is drained by the central ditch. Since the area receives about 40 inches of rainfall per year, this means approximately 135 million gallons of rainfall on the 125 acres. Due to the character of the soil and underlying glacial till, approximately half of this rainfall is drained directly from the site and monitored at the exit weir. Since the effluent is monitored at the site boundary, the total effluent is measured and recorded.

    Except for the tritium concentration noted in Mound wells, the Miamisburg wells, and the private wells immediately adjacent to the Mound site and discussed on pages 3-31 through 3-36, the concentration of tritium in regional surface and ground water is in the same range. This can be noted in Table 3-8 and 3-10. Most of the data indicate levels which are within the fluctuations of background data published by the EPA. The annual dose commitment from tritium above background levels is included in the estimates presented in Table 3-12. This table explicitly indicates that there is no dose commitment beyond the 32 km radius from tritium released in Mound's liquid effluent. The 3.2 to 32 km area does include dose commitment from tritium in drinking water.

    Statements made on pages 3-31 and 3-34 address the fact that the aquifer adjacent to the facility site, as well as upgradient locations, may be impacted by tritium rainout from stack emissions. Tritium in ground water supplies which are not hydraulically connected to the Buried Valley Aquifer could have a tritium concentration above natural background only as a result of rainout from stack emissions; however, since the highest average tritium concentration in surface water and ground water is 1.3×10^{-6} μCi/ml and 1.9×10^{-6} μCi/ml at West Carrollton and Location 17 (see Tables 3-10 and 3-8), it is apparent that rainout has no major impact. The tritium levels at upgradient locations are well within the new EPA tritium standard.

Mound's comprehensive investigation of tritium in area water supplies resulted in a determination that the local area of the Buried Valley Aquifer supporting Mound wells, Miamisburg wells, and several private wells was directly impacted over several years by the tritiated liquid effluent discharged through Mound's drainage ditch and the Miami-Erie Canal. A large percentage of the ditch/canal water infiltrates the aquifer as recharge. The liquid effluent prior to 1970 was the predominant source by far of tritium reaching the aquifer adjacent to the Mound site. A year-long study of tritium in rainwater and its contribution to the aquifer adjacent to the Mound site showed that the stack effluent was a minor source of the tritium levels found in the aquifer. Since the conclusion of Mound's investigation, as presented on pages 3-39 and 3-40 of the draft EIS, omitted the direct impact of liquid discharges of tritiated water through the ditch and canal, we can understand that statement #3 on page 3-40 of the draft EIS could lead to conflict and confusion in following the discussion of the impact of the new EPA drinking water regulations. The text has been amended accordingly in the final EIS.

19. As indicated in our response to #17, the tritium concentration in water consumed at downstream locations is essentially background even during our pumping program; therefore, we do not believe there is an available trade off for lowering the tritium dose to the upstream population versus increasing the dose to the downstream population. Mound's efforts to bring local well water concentrations into compliance with the new EPA drinking water standard for tritium will be continued until this primary objective is achieved. We anticipate that all well water will meet the standard early in CY 1979. Pumping will be sustained until the lowest possible tritium level, commensurate with the program cost, is attained.

A discussion of the disposition of all the comments received, copies of all comment letters, and DOE responses are included in Section 10 of the enclosed final statement.

Sincerely,

James L. Liverman

Ruth C. Clusen for
Assistant Secretary for Environment

5 Enclosures

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
REGION V
230 SOUTH DEARBORN ST.
CHICAGO, ILLINOIS 60604

JUN 23 1978

Dr. James L. Liverman
Acting Assistant Secretary
for Environment
Department of Energy
Washington, D.C. 20545

RE: 78-025-1805
D-DOE-F06009-OH

Dear Mr. Liverman:

The U.S. Environmental Protection Agency (EPA) has completed its review of the Draft Environmental Impact Statement (EIS) for the continued operation of the Mound Facility, Miamisburg, Montgomery County, Ohio. We have environmental reservations regarding the facility's impact upon private groundwater supplies, noncompliance with its National Pollutant Discharge Elimination System (NPDES) permit, and potential public health effects from disposal of solid and liquid wastes. We also believe additional information is required in the EIS.

Groundwater

Prior to 1970, tritium contaminated water at the facility was diluted with raw water to below the Radiation Concentration Guideline (RCG) of 1 microcurie per liter for tritium in potable water and discharged to the Great Miami River via an open drainage ditch. We understand that since then, tritium waste waters have been collected, packaged, solidified and disposed of in approved offsite burial sites to reduce the tritium quantities in the facilities' effluents, and thus in the Buried Valley Aquifer, to the lowest level achievable. Furthermore, an environmental monitoring program for tritium and other radionuclides was established in 1970 to insure compliance with the RCG standards. In 1975, the National Interim Primary Drinking Regulations (NIPDR) reduced the RCG standard for tritium to .02 microcurie per liter. To comply with this new standard, we note that the facility undertook a comprehensive study to develop a program for attainment of the tritium NIPDR. It was decided to conduct high level pumping of water from the Buried Valley Aquifer to remove its "tritium burden" by dilution with recharge waters.

According to Monsanto Research Corporation's Annual Environmental Monitoring Report: Calendar Year 1977, dated April 25, 1978, the Mound Facility drinking water and some of the nine affected private wells have been brought into compliance with U.S. EPA's NIPDWR for tritium. While we are pleased to see the progress that has been made by the Mound Facility, it is important that this effort be continued to bring the

remaining wells into compliance as expeditiously as possible. U.S. EPA will continue to have environmental reservations about the continued operation of this plant until all private or public drinking water supplies in the vicinity of the plant meet the NIPDWR for tritium.

Liquid Wastes

Monsanto's report also indicates that in 1977, it was in compliance with its National Pollutant Discharge Elimination System (NPDES) permit except for two minor violations involving suspended solids during July. We have additional information from our Enforcement Division that the Mound Facility also violated its permit conditions for suspended solids nine times between January and April of this year. We understand that Monsanto has requested a modification of their NPDES permit to allow for a greater discharge of suspended solids. This request is currently being reviewed by the Ohio Environmental Protection Agency and our Permits Branch.

It is stated on page 2-23 of the EIS that "incremental levels of non-radioactive pollutants in the Great Miami River resulting from Mound Laboratory's liquid waste effluent cannot be measured in the river itself because of the relatively high concentration of these pollutants in the river...." Past water quality data upstream and downstream of the facility should be provided to substantiate this conclusion. Further clarification of the statement on page 2-23 concerning composite proportional sampling is necessary. We do not understand what is meant by "some characteristics and composited further for other analyses.." According to the Monsanto report, each 24-hour composite sample for each effluent stream is collected automatically and is analyzed for those water quality parameters specified in the NPDES permit.

Organic waste solvents used in 1976 at the facility included acetone, ethyl alcohol, trichloroethylene, toluene, and Freon TE and TF. According to the EIS, of the 3600 gallons of organic solvents used at the facility, 2200 gallons were disposed of by a commercial industrial waste disposal firm using a Fluidized Bed Incinerator, 1300 gallons were released as airborne material, and 100 gallons were released as "liquid effluents." It should be explained how these "liquid effluents" were disposed and if waste solvents of this kind are usually released in the manner described. Clarification also should be provided on how it is known that concentration of the waste solvent "releases are within EPA standards." The EIS should discuss the toxic properties of these organics and their carcinogenic characteristics. Trichloroethylene has been shown to be carcinogenic in animals.

The method of storage and ultimate disposal of Other Liquid Wastes by a "commercial service" should be outlined more clearly for waste cutting-oils, excess paints, thinners, and waste caustic solutions. Also, the reconstitution of chromic acid, cadmium cyanide, nickel sulfate, nickel chloride, black oxide, and copper cyanide should be

more clearly defined and testing results should be presented to show that these chemical solutions are "never introduced to the laboratory liquid effluent stream" or the facility's storm sewers from clean-up practices.

Solid Wastes

We note that "waste and excess explosives are destroyed by burning..." The EIS should clarify the actual method used and its benefits over other disposal methods. The burning site is said to be located in a remote area of the plant which affords safe distances for plant personnel and property as well as persons and property outside the plant. An explanation should be provided on why the burning site is thought to be at a safe distance from persons both inside and outside the facility. The chemical composites of the waste and excess explosives, and/or the presence of toxic materials in air emissions, should be mentioned.

The EIS should also discuss the potential environmental risks and effects of shipping and disposing radwaste in approved offsite burial grounds. Problems associated with the release of classified and unclassified radwaste pollutants (associated with tritium, plutonium, polonium, thorium-232, uranium-233, uranium-235, radium-226 and actinium-222) into the environment from the burial ground via air or water pathways should be addressed in detail. The design life of "DOT-approved containers" for radwaste and the environmental monitoring programs that exist to insure the integrity of the containers at the approved disposal site should be disclosed.

In accordance with U.S. EPA regulations, we have classified the project as ER (environmental reservations) and the EIS as 2 (additional information necessary). The date and classification of our comments will be published in the Federal Register. Should you have any questions regarding this letter, please contact Mr. Robert Kay at 312/353-2307.

Sincerely,

Ronald L. Mustard

Ronald L. Mustard, Director
Office of Federal Activities

Department of Energy
Washington, D.C. 20585
JUL 3 1979

Mr. Ronald L. Mustard, Director
Office of Federal Activities
U.S. Environmental Protection Agency
230 South Dearborn Street
Chicago, IL 60604

Dear Mr. Mustard:

Thank you for your letter of June 23, 1978, with comments on the U.S. Department of Energy's (DOE) draft Environmental Impact Statement (EIS) on the Mound Facility, Miamisburg, Ohio, DOE/EIS-0014-D.

We concur with your summary of the source of the tritium prior to 1970 which entered the portion of the aquifer that is the source of potable water for several private wells and the Mound Facility.

The corrective action instituted in 1976 to reduce the tritium burden of the aquifer in order to achieve compliance with the Environmental Protection Agency's (EPA) new National Interim Primary Drinking Water Regulation (NIPDWR) involved high-volume pumping from the portion of the aquifer with an elevated tritium content. The pumping program reduced the area of the aquifer with a tritium content above 20 nCi/liter from 52 acres in April 1977, to 17 acres in June 1978. It is anticipated that continuing the pumping will reduce the tritium content of the water from all wells in the aquifer to meet the NIPDWR for tritium by early in CY 1979. Routine status reports on the effectiveness of Mound's aquifer pumping program have been given to the Director, Air and Hazardous Materials Division, EPA, Region V, since April 1977, in order to keep the EPA apprised of this corrective action program.

Under the subject of Groundwater, your letter stated that "...an environmental monitoring program for tritium and other radionuclides was established in 1970 to insure compliance with the RCG standards." Mound's environmental monitoring program was established before operations were undertaken at this facility in 1949. In 1970, Mound voluntarily tightened its effluent control program by progressively reducing the annual quantity of tritium in stacked effluent and by discontinuing the discharge of tritium process liquid waste in favor of collection, solidification, and offsite burial in order to reduce the environmental impact on the Buried Valley Aquifer. As the draft EIS recounts, the programmatic change in liquid waste processing made

a very significant reduction in the observed concentration of tritium in the Buried Valley Aquifer. The current effort of pumping the aquifer will be continued to achieve compliance with the NIPDWR at an early date rather than waiting for the aquifer to be cleansed or flushed by its own natural devices.

On the subject of liquid waste, as discussed in your comments, it is correct that the concentration of suspended solids exceeded the National Pollutant Discharge Elimination System (NPDES) limit nine times between January and April of 1978. The draft EIS, in covering operations through CY 1976, indicated that there were no violations of the NPDES permit. The final EIS covers operations through CY 1977 and indicates that there were two violations of the suspended solids limit during July. It is important to note that in Mound's NPDES permit, a more restrictive limit was placed on the discharge of suspended solids for operations after July 1, 1977, for discharge outfall 001. Since monitoring and analysis of water at outfall 001 includes storm water runoff, it is sometimes impossible to meet the more restrictive limit in the permit. The issuance of separate permits for outfall 001 and the effluent from the sanitary treatment facility would enable Mound to show compliance of the sanitary waste effluent with the permit requirements and not have this effluent degraded by storm water runoff with naturally high suspended solids.

The statement on draft EIS page 2-23 that "incremental levels of nonradioactive pollutants in the Great Miami River resulting from Mound Laboratory's liquid waste effluent cannot be measured in the river itself because of the relatively high concentration of these pollutants already in the river ..." is substantiated by recent river analyses showing, for example, iron in the range of 2 to 118 mg/l whereas Mound's effluents were in the range of 0.34 to 1.2 mg/l. Ohio's stream standard for iron is 1.0 mg/l and allows for a mixing zone below an outfall. A mixing zone would provide a minimum dilution factor of 350. Mound's iron contribution to the river would be below the standard by two orders of magnitude and have no detectable influence on the high levels of iron already in the river. The same can be shown for other parameters for which Ohio has stream standards. Using a table in the EIS showing the level of pollutants above and below Mound can be very confusing even to an informed layman since on many occasions the levels are higher downstream than upstream because of the location of various storm water discharges to the river and the fact that the Miamisburg sewage treatment discharge is located adjacent to Mound's southern discharge point carrying outfall 002. For those parameters for which Ohio has a stream standard, we find that the level in Mound's effluent is normally within or very close to the standard without the considerable dilution the river mixing zone would provide.

The discussion on page 2-23 in regard to some water samples being "...examined directly for some characteristics and composited further for other analyses..." covers both radioactive and nonradioactive parameter analyses. Daily samples are composited into weekly composite samples for plutonium analyses since specific analysis for plutonium involves a lengthy chemical separation, electrodeposition onto a phanchet and then a long-term alpha pulse height counting technique. The daily samples are screened for plutonium content by a gross alpha procedure for an early indication of plutonium levels.

In regard to the organic waste solvents disposal, the estimated 100 gallons released over the year in liquid effluent result from discards into laboratory sinks, fumehoods, etc., from intermittent uses of small quantities not feasible for accumulation and collection. The sinks, fumehoods, etc., are part of Mound's sanitary waste system and discharges receive treatment in the sanitary waste disposal plant. The effluent from this treatment plant is monitored. No specific analyses are performed for these solvents; however, the chlorinated solvents would be detected by Mound's oil and grease analyses and the others (acetone, alcohol, etc.) would be included in the biological oxygen demand analyses. Neither of these parameters exceeded NPDES limitations during 1976 or 1977.

"Other liquid wastes" are stored in 55-gallon Department of Transportation (DOT) 17E drums prior to pickup by a commercial industrial waste disposal firm. Ultimate disposal by this firm is achieved by utilizing a substantial amount of the wastes to neutralize other wastes at their waste disposal facility and by reclamation of waste oils for use in "coal oiling."

Concerning plating bath solutions, the baths are never discharged into the plant liquid effluent. These solutions are disposed of through a commercial industrial waste disposal firm. The first rinse and clean-up wastes are collected and used for new bath makeup. Subsequent rinsing solutions are discharged into Mound's sanitary waste system. The discharge from the plating shop feeds into a "deepened" manhole which serves as an equilization tank of several hundred gallons capacity. A 24-hour composition sample was collected from this tank on two different days and analyzed. The samples represent the plating shop effluent prior to mixing with other waste streams. The laboratory analyses are listed below.

Metal	Concentration (mg/l)	
Chromium	<0.05	0.11
Cadmium	0.02	0.09
Nickel	0.24	0.15
Copper	0.1	0.28
Cyanide	0.02	1.0

Section 3.6.2 has been revised in the final EIS on pages 3-13 and 3-14 to clarify the issues you raised under "Liquid Wastes."

Excess explosives and waste materials contaminated with explosives are destroyed by open burning as discussed on page 3-14 of the final EIS. This is done according to U.S. Army Materiel Command Regulations 385-100 (Army Ordnance Manual). This is currently the safest and best method available to the Mound Facility for deactivating this material. The burn site is in the south central section of the facility site, remote from all other plant operations. The burn site is fenced and access is controlled by a locked portal. The nearest public residence is some 1,000 feet away, outside another fence which controls and restricts public access to the Mound Facility. Since only small quantities of explosives materials are burned in open air in a physically confined area under direct supervision, safety for employees and the public is assured. This small scale burning is conducted with the knowledge and concurrence of the Ohio EPA and Montgomery County Combined General Health District. The possible presence of pollutants in air emissions is covered in Table 3-5 on page 3-15.

The discussion of Mound's radwaste shipments and subsequent disposal has been expanded in the final EIS, Section 3.13, beginning on page 3-81. In addition to a thorough discussion of shipping container integrity to comply with stringent DOT regulations and special-permit transportation, the discussion covers the various wastes which are shipped to four burial sites. The four sites are identified and their disposal/storage methods indicated. Each site's activities are conducted according to good radwaste management practices. Other than the fact that each site is adequately staffed with professional personnel and operate monitoring programs to assure that wastes are stabilized at the burial location, Mound does not have monitoring information or site environmental assessments. These would have to be obtained from the burial site operators.

The Mound Facility currently ships its radioactive wastes to the following offsite burial/storage grounds:

a. Chem Nuclear Systems, Inc., Barnwell, South Carolina

b. Savannah River Plant, Aiken, South Carolina (DOE facility)

c. Nevada Test Site, Mercury, Nevada (DOE facility)

d. Idaho National Engineering Laboratory, Scoville, Idaho (DOE facility)

Mound neither stores nor buries any radioactive wastes onsite. The waste form, method of packaging, and mode of shipment differs for Mound's utilization of each of these disposal sites.

A discussion of the disposition of all the comments received, copies of all comment letters, and DOE responses are included in Section 10 of the enclosed final EIS.

Sincerely,

James C. Liverman for
Ruth C. Clusen
Assistant Secretary for Environment

Enclosure

cc: Mr. William N. Hedeman, Director
Office of Federal Activities (Code A-104)
U.S. Environmental Protection Agency

DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D. C. 20250

June 30, 1978

Mr. W. H. Pennington, Director
Office of NEPA Coordination
Department of Energy
Washington, D.C. 20545

Dear Mr. Pennington:

We have had the draft environmental statement for the Mound Facility, Miamisburg, Ohio, (DOE/EIS-0014-D) reviewed in the relevant agencies of the Department of Agriculture, and comments from Forest Service are enclosed.

Sincerely,

Barry R. Flamm

BARRY R. FLAMM
Coordinator
Office of Environmental Quality Activities

Enclosure

Forest Service Comments

Re: DRAFT ENVIRONMENTAL STATEMENT (DOE/EIS-0014-D)
MOUND FACILITY, MIAMISBURG, OHIO

Since construction of this facility is complete, we anticipate little adverse effect on forested land from continued operation. When the land returns to private ownership, if firewood is taken off and burned, there should be assurance that radioactive substances (e.g., I 131, I 132, I 133, etc) will not be inhaled by persons or animals.

Department of Energy
Washington, D.C. 20585

JUL 3 1979

Mr. Barry R. Flamm, Coordinator
Office of Environmental Quality Activities
Office of the Secretary
Department of Agriculture
Washington, DC 20250

Dear Mr. Flamm:

Thank you for your letter of June 30, 1978, with comments on the U.S. Department of Energy's (DOE) Draft Environmental Impact Statement (EIS) on the Mound Facility, Miamisburg, Ohio, DOE/EIS-0014-D.

Operations at the Mound Facility involve only two radionuclides which could be considered as significant to the comment forwarded from the Forest Service. These radionuclides are tritium and plutonium-238. Only trace quantities of fission products are used.

Since tritium readily exchanges with the hydrogen in the water molecules, tritium uptake is readily accomplished if the root system of a tree has a water source containing tritium. Equilibrium would exist between the tritium in the water of the tree and the water in the soil. No long-term buildup or concentration of tritium in trees would occur.

Plutonium does exhibit a very slight buildup in trees. A recent journal article, "A Compartment Model of Plutonium Dynamics in a Deciduous Forest Ecosystem," C. T. Garten, Jr., et al., published in Health Physics, Volume 34, No. 6, June 1978, pages 611-620, discusses a study at the Oak Ridge National Laboratory of a 30-year-old forest growing in an area whose soil had an average plutonium concentration of 65 picocuries per gram. The investigators estimated under those conditions that the annual transfer coefficients were 1.7×10^{-4} for soil to roots and 1.7×10^{-4} for roots to wood of the tree or 2.9×10^{-8} for soil to wood of tree. The investigators also found that most of the plutonium remained in the residue after burning and was not airborne. Therefore, it is believed that the use of firewood from any trees on the plant site would not constitute any hazard.

Mr. Barry R. Flamm 2

A discussion of the disposition of all the comments received, copies of all comment letters, and DOE responses are included in Section 10 of the enclosed final EIS.

Sincerely,

James L. Liverman for
Ruth C. Cluse
Assistant Secretary for Environment

4 Enclosures

MIAMI VALLEY ENVIRONMENTAL COALITION

CITIZENS FOR CLEAN AIR COMMITTEE of the MIAMI VALLEY LUNG ASSOCIATION • DAYTON AUDUBON SOCIETY
LEAGUE OF WOMEN VOTERS OF THE GREATER DAYTON AREA • STILLWATER RIVER ASSOCIATION, INC.
AMERICAN ASSOCIATION OF UNIVERSITY WOMEN, DAYTON BRANCH • TECUMSEH GROUP, SIERRA CLUB

MVEC

Please Reply to:

July 10, 1978

W. H. Pennington
Director
Office of NEPA
Coordination
Department of Energy
Washington, D.C. 20545

Dear Mr. Pennington:

We appreciate the extension your office gave our organization so that we might submit comments on the draft environmental impact statement for the Mound Facility.

Sincerely,

Marian S. Simmons

Marian S. Simmons, Chairperson
Miami Valley Environmental Coalition

MSS:krw

Enclosure

In April 1978, the Department of Energy issued a document entitled, "Draft Environmental Impact Statement, Mound Facility, Miamisburg, Ohio." Serial number DOE/EIS-0014 The purpose of this document was to comply with the National Environmental Policy Act of 1969 (NEPA). The first comment is that this document is, for the most part, a verbatim copy of a document issued in July 1975. This earlier document is entitled, "Omnibus Environmental Assessment, Mound Laboratory, Miamisburg, Ohio." Its serial number is MLM-MU-75-67-0001.

Basically the two documents are the same. The most important difference between them is that in many of the tables, the 1976 data is used in the later document, while 1974 data is used in the earlier one. However, it appears as if 80-90 percent of the words and statements in the two documents is identical. Therefore, the conclusion is that the draft environmental impact statement is not an up-to-date document. It is truly not based on new thoughts, new ideas, new analysis of data. It is rather just a self-serving document the main purpose of which is to perpetuate whatever is going on at Mound Facility. . .be it beneficial or not.

An examination of the Federal Regulations, which were enacted pursuant to NEPA and are found in 40 CFR, 1500, says that the purpose of an impact statement is to have all the Federal agencies "to the fullest extent possible, direct their policies, plans and programs to protect and enhance environmental quality." Among the requirements of the regulations is that the Federal agencies shall circulate a draft environmental statement not only to other Federal agencies and local agencies but also to the public as well and to consider the comments of the agencies and the public, and finally, to issue an environmental impact statement that is responsive to the comments received. Three years ago, comments were presented on Omnibus Environmental Assessment Statement However, the current document, the Draft Environmental Impact Statement, shows no evidence that any comments have been considered in the past three years. Since the two documents are so very similar, were the previous comments completely ignored?

Another general criticism of the EIS is that there is no consideration of the impact of the Mound Facility on other Federal activities in the area. This requirement is found in 40 CFR 1500.8. It is evident that there are at least two other large Federal sites in the general area of Mound Facility. One of these installations, Wright Patterson Air Force Base (WPAFB), could be adversely affected by airborne radioactive material in various ways. Two possible effects on WPAFB of radioactive material are an increase of air pollution which would cut down on visibility and the presence of ionizing radiation which may interfere with the communication system.

The very first paragraph of the EIS indicates that there is a major omission in the statement because it is said that a discussion of off-site transportation is deemed to be beyond the scope of this document. If such off-site transportation of radioactive and hazardous material is not included in this document, it is difficult to see how the document can comply with the requirements that the plans and program at the Mound Facility protect and enhance environmental quality to the fullest extent possible. The document itself states that over 650,000 people live in Montgomery County. This great number of people are being put at risk due to the transportation of radioactive and other hazardous and dangerous materials through the community en route to and from Mound Facility. Therefore, we believe the lack of consideration given to off-site transportation is a major defect in this EIS. How can this omi be justified?

Several places in Section I of the EIS contain comments concerning decontamination of the facilities. How much would such decontamination cost? What percent of decontamination could be achieved? And, most importantly, how would the decontamination be accomplished? This latter issue raises several important questions. How would the waste from the decontamination be handled? How would it be transported? What wouldits final destination be? If this decontamination is so readily achieved, why not decontaminate the Miami-Erie Canal?

Also found in Section I on Page 1-2 the statement that the land north, east and west of the facility is residential housing with relatively low population density. This is a meaningless statement because it is not clear what the population density is and why it is called "relatively low." (MVEC commented on this subject in the previous Assessment document). There are in Miamisburg surrounding Mound Lab residential homes, apartments, schools--both elementary and high school, shopping areas, and churches. Even if there were "relatively low" population density, the question still remains, should even a few people be exposed to any unnecessary risk? What criteria were used in designating population density?

There is a statement on page 1-2 concerning the concentration of tritium in well water near the plant which is in total contradiction to statements made on pages 3-38, 3-41. In view of the new Federal Drinking Water Standards, apparently wells in the vicinity of Mound Laboratories are not in compliance with the proposed EPA standards. Also, the waters at the junction of the drainage ditch and the Miami-Erie Canal are approximately seven times the proposed standard. In passing it is noted that on page 3-40, this concentration is expressed, for some reason, in microcuries per milliliter rather than microcuries per liter, which are the units of the standard. Also, on the same page, is the statement that the current concentration of tritium at the eight locations which are not in compliance with the proposed drinking water standards are not a health hazard to the people using the water. This statement is repeated twice. However, there is no justification given for this statement. What is the basis for this statement? The implication is that there is somehow a safe level to which human beings can be exposed with no health hazard. The fact of the matter is, of course, that such levels have not been established by unanimous agreement among the experts. There is substantial body of evidence that there is no threshold below which no adverse health effects occur due to radiation

On page 2-8 is described a tritium control system. There does not appear to be any control or any method to report tritium emissions that do not occur through the stacks. Is this correct? Such emissions could occur when the tritium is first being unloaded, but such emissions could also occur when gas containing small amounts of tritium are stored and accidentally vented. One example of such gas is the gas containing helium 3.

The last paragraph on page 2-9 entitled, "Tritium Control," is almost a verbatim copy of the first paragraph on page 2-13 of the "Omnibus Environmental Assessment." This paragraph talks about the new work in progress to develop methods to control tritium emissions. The paragraph says that work on such systems is currently proceeding. . . that a new laboratory, incorporating several experimental systems on a pilot scale, is being completed to develop and demonstrate technology and equipment. It is almost ridiculous to read the same words after three years! One really has to doubt the sincerity of this Environmental Impact Statement. What is the status of this project?

As stated in the comments made to the document issued three years ago, in order to study the environmental impact of the Mound Facility to the fullest extent possible, consideration must be given to the effect of emitting ironizing radiation into the atmosphere around Dayton, Ohio. It is a well-established fact that the Dayton area suffers from the highest concentration of photochemical oxidants in the entire state. It is difficult to understand these high concentrations of photochemical oxidants when the density of automobile traffic is not so high as it is in some other parts of the state. One plausible explanation for such high concentrations of photochemical oxidants is that the radioactive emissions from Mound act as a catalyst for the formation of these pollutants. Other chemical reactions which are stimulated by small amounts of radioactive material are known in the field of chemistry. Therefore, in order to do a full Environmental Impact Statement, some consideration should be given to Mound Facility's possibly important and unique contribution to the photochemical oxidant problem in Dayton.

Also mentioned in previous comments on the Omnibus Environmental Assessment was the fact that the presence of ionizing radiation in the atmosphere causes the total resistance of the atmosphere to change and become smaller. This decrease in the resistance of the atmosphere could have significant effect upon the climate of the Dayton area. Was consideration given to this effect when this draft was being prepared?

On page 3-19 of the EIS, it says that the total tritium discharge into the atmosphere during calendar year 1976 was approximately 6200 curies. On page 3-22 of the Omnibus Environmental Assessment, it says that the total discharge of tritium to the atmosphere in calendar year 1974 was approximately 10,000 curies. Thus, it appears as if there has been a 60 percent decrease in the amount of airborne tritium discharged. However, a comparison of the figures given in the table 3-11 on page 3-30 of the Omnibus Environmental Assessment with the figures given in table 3-9 on page 3-24 of the EIS show that the estimated dose commitments given in the Environmental Impact Statement are much smaller than those given in the Omnibus Environmental Assessment. The difference is of the order of 10 percent and not 60 percent of the older figures. In other words, the implication is that a 40 percent decrease in the emissions has resulted in a 90 percent decrease in the estimated dose commitments. This does not appear to be logical. How were these tables figured?

There is a most serious omission in this Environmental Impact Statement--the complete lack of air data. Surely monitoring has been done over the years, and yet we find no table indicating emissions over any period of time. What have these been for the past five years? What emissions are projected for the coal-fired steam boilers mentioned on page 9-3? What about incineration of wastes--Section 5.5.3?

Certainly Mound Facility operations do fulfill a necessary role for the nation's nuclear weapons program, but we do not agree with Section 9.3 that relocation would produce a net effect of zero if, for example, the facility were moved to the desert. Wouldn't there then be less risk to people?

Department of Energy
Washington, D.C. 20585

JUL 3 1979

Ms. Marian S. Simmons, Chairperson
Miami Valley Environmental Coalition
1460 Tait Wood Drive
Centerville, OH 45459

Dear Ms. Simmons:

Thank you for your letter of July 10, 1978, with comments on the U.S. Department of Energy's (DOE) draft Environmental Impact Statement (EIS) on the Mound Facility, Miamisburg, Ohio, DOE/EIS-0014-D.

The similarity between the draft EIS of the Mound Facility and the Omnibus Environmental Assessment is to be expected. The Omnibus Environmental Assessment was prepared in the format defined for an EIS in 10 CFR Part 711. The mission of the Mound Facility has remained essentially the same over the past several years. Therefore, the Assessment and the Statement both in the same format and both related to the same program activities have much of the same information except for the updating of data and the inclusion of recent events as you noted. I am sure that you found that the updated data showed significant reductions in the emissions from the Mound Facility.

The previous comments submitted by you were examined. Prior to the preparation of the draft EIS, your letter and comments to the letter were circulated to various Federal agencies. The final EIS reflects all comments received.

The availability of the draft EIS was announced in the Federal Register on April 27, 1978. Prior to that date on April 20, 1978, copies of the draft EIS were sent out from the Office of National Environmental Policy Act Affairs, DOE/Headquarters, with transmittal letters to all interested parties, as well as those who had received copies of the Assessment. All Federal agencies had an opportunity to review the draft EIS. Thus, if other Federal agencies had any considerations that the Mound Facility has an effect on any of their own Federal facilities, the information would have been forwarded to my office. There are no known effects on the parameters you cite of even relatively large concentrations of radioactive materials in the atmosphere.

An error was made when the first paragraph of the summary was prepared for the draft EIS. The words, "of offsite transportation and," should have been deleted. It was recognized when the draft EIS was in preparation that a discussion of offsite transportation was pertinent. Such a discussion was prepared and included in the draft EIS under 3.13, "TRANSPORTATION," pages 3-79 through 3-81.

You raised several questions in your comments regarding the decontamination of facilities. The cost of decontamination is a function of the radioactive materials which had been handled in the facility and the level to which the contamination is to be reduced. For example, the program at the Mound Facility to process plutonium-238 for heat sources will be terminated at the end of FY 1979 (September 30, 1979). The two buildings used for the program will be decontaminated. However, the contaminated areas will not be decontamined to a pristine state. The aim of the decontamination will be to reduce the "wipe" level to less than 22 disintegrations/minute/100 square centimeters. The areas will require very limited protective clothing such as smocks and shoe covers. It is estimated that the cost of this effort scheduled for completion in 1986 will exceed $19 million. No estimates of the cost of decontamination to these areas to original "as-built" conditions have been made; however, the cost would be many times the above estimate. Decontamination techniques include the removal of highly contaminated items followed by repeated cleaning of equipment with decontaminating solutions and high-pressure hot-water steam sprays containing decontaminating chemicals. Before decontamination is started, all floor drains are closed and sealed so that no liquid can leave the area being decontaminated. Dispersion of loose material is prevented through the use of temporary enclosures, strippable coatings on surfaces, temporarily covering a surface with paper or plastic sheets securely taped at all edges, etc. All waste from decontamination operations is packaged in containers approved by the Department of Transportation (DOT). Before approval, such containers have been subjected to extensive testing which includes drop, high-speed impact, puncture, fire, and water immersion tests. Low-level waste, such as tritium-contamination waste, is shipped to approved burial sites in closed trailer vans (exclusive use); transuranium (TRU) waste is shipped to a 20-year retrievable storage site in closed railcars specially constructed to withstand accidents and authorized by the DOT for the transportation of such materials. The excellent safety record for shipments of radioactive wastes from the Mound Facility is well documented.

Although the abandoned Miami-Erie Canal could be decontaminated by removal of all contaminated earth, studies have demonstrated that the small amount of plutonium-238 present represents no hazard to mankind or the environment nor is likely to in the future. The studies are discussed in "Mound Laboratory Pu-238 Study, Off-site Analytical Data, May-Dec. 1974," by B. Robinson, et al., and "Mound Laboratory Pu-238 Study, Presentation to Scientific Review Panel, February 19, 1975," by D. R. Rogers, et al. "The Report of the Ad Hoc Committee to Evaluate the Health and Safety Aspects of Plutonium-238 in the Environment Adjacent to Mound Laboratory," prepared in February 1976, confirms the conclusions of the studies. These reports are available upon request.

The population in the immediate vicinity of the Mound Facility was evaluated. The findings are presented in Table 2-2 on page 2-32 of the final statement. The words "relatively low" are used to convey the information that the vicinity is not completely developed but rather is an open space area with recent housing construction on one-third acre lots as contrasted to a large number of multifamily units on limited land.

The data presented on pages 3-38 through 3-41 and the associated narrative explain in detail the impact of the recent Environmental Protection Agency (EPA) regulations on local drinking water. The summary statements on page 1-2 were revised to ensure that they reflect adequately the details appearing in Section 3. The discussion of the impact of recent EPA drinking water regulations does indicate that some local well waters do not meet the new potable water standard in respect to tritium content. The program initiated to reduce the tritium content of the aquifer is discussed. Between April 1977 and June 1978, the program reduced the acres of aquifer above the standard from 52 acres to 17 acres. It is anticipated that early in CY 1979 the entire aquifer will be within the EPA standard.

The concentration of tritium is presented in μCi/ml throughout the document so that comparisons with DOE standards may be readily made; similarly, μCi/ml is the basis for data reported in documents such as the Annual Environmental Monitoring Reports. The recent EPA standards are expressed in picocuries per liter (pCi/l). However, these units were not used because of possible layperson unfamiliarity with this different term and for direct comparison with other reports.

Your brief comments on the linear dose response theory were noted. We are familiar with the position of some individuals who advocate zero nuclear radiation risk and other individuals who believe that there is a threshold for the effects of nuclear radiation. The EPA addressed this

subject in the "Drinking Water Regulations - Radionuclides" (FR Vol. 41, No. 133, page 28408, July 9, 1976) under the heading, "Linear nonthreshold response functions." The EPA, however, did not set "zero" as the standard for radionuclides in drinking water. When the EPA initially proposed the new drinking water standards (FR Vol. 40, No. 158, page 34325, August 14, 1975), it was stated "the 4 millirem per year standard for manmade radioactivity was chosen on the basis of avoiding undesirable future contamination of public water supplies as a result of controllable human activities." On the same page, the following appeared: "Considering the sum of the deposited fallout radioactivity and additional amounts due to effluents from other sources currently in existence, the total dose equivalent from manmade radioactivity is not likely to result in a total body or organ dose to any individual that exceeds 4 millirem per year. Since present ambient levels of manmade radioactivity are small, EPA does not believe that this standard will result in a need to remove manmade radioactivity from public water systems nor subject the public to excessive risk."

The tritium control system discussed in Section 2 under "Tritium Environmental Control System" has been expanded in the final EIS so that the reader will understand that the ventilation of all areas where tritium is handled or stored is maintained through successive negative pressures as in the plutonium handling areas to ensure than any tritium inadvertently released into a laboratory area is exhausted through the stack and thus measured.

It is understandable that you may have some questions about the progress of "The new laboratory...to develop and demonstrate technology and equipment" for tritium control. Research and development in this technology is understandably slow since it is beyond the known state-of-the-art. Although the program was initiated in 1971, specialized equipment had to be designed and built. In 1974, the critical equipment for the concept was received from the vendor and installed in the especially designed laboratory facility. The equipment was designed to remove free hydrogen from atmospheric air which is normally 0.5 ppm hydrogen. During the next three years, the system was tested with improvements in equipment and reactants being made. In 1977, the system was tested with tritium. Tests showed satisfactory performance to remove tritium from the laboratory room and to reduce effectively venting of the tritium to the building ventilation system.

A question was raised in your comments regarding "the effect of emitting ionizing radiation into the atmosphere around Dayton." The beta decay of tritium and the alpha decay of plutonium-238 in air produces ion pairs. One ion pair is produced in the air per 35 eV of these radiations. Plutonium-238 alpha particles produce a maximum of 5.8×10^{15} ion parts

per Ci-sec and tritium beta particles a maximum of 6.0×10^{12} ion pairs per Ci-sec. These values multiplied by the concentrations measured at the offsite sampling stations relate to the atmospheric production of ion pairs in the Miami Valley. The maximum sampling station value for plutonium-238 found in 1977 was 9.6×10^{-17} μCi per ml or 0.56 ion pairs per cubic meter-second. The maximum sampling station value for tritium in 1977 was 9.73×10^{-11} μCi/per ml or 6×10^{2} ion pairs per cubic meter-second. Natural radioactive materials in soil and air together with cosmic radiation produce approximately 10^{7} ion pairs per cubic meter-second in air at sea level (Handbook of Chemistry and Physics, 58th Edition, page F-211). Thus, the maximum contribution to the ion content of the atmosphere by radiochemical effluents from the Mound Facility is six one hundred thousandths (0.00006) that of the natural background. Using the maximum value obtained at the sampler in the city of Dayton, the effect is six millionths (0.000006) that of the natural background. Since the production of ion pairs caused by radioactive emissions from the Mound Facility is very small as compared to that from natural radiation and cosmic rays, the effect on natural resistance of the air must be insignificant. Cloud chamber experiments have not indicated any catalytic effect of ion pair production on atmospheric reactions.

There are many factors which affect pollutant dispersion, such as atmospheric stability, wind speed and direction, precipitation, topography, etc. Atmospheric diffusion models are developed with confidence for short-term releases. The variability of factors makes for an inadequate long-range model. Therefore, it is the policy at the Mound Facility to conduct a comprehensive environmental monitoring program and to use the data from the monitoring program for dose calculations as the data becomes available. The basis for the dose calculations is discussed in Section 3.7.1, "TRITIUM," under the topic, "Airborne Effluent Impact." If actual data are not available, theoretical atmospheric diffusion modeling employing calculated data based on best estimates is used. The 1974 atmospheric release of 10,031 curies and the 1976 release of 6,206 curies were as reported. The data for "maximum individual (exposure) in the offsite population" in both documents was calculated by using the highest annual average concentration found onsite, since the maximum individual is assumed to be at the fence line and the nearest air samplers are onsite. During 1974, the highest annual average concentration onsite was 32×10^{-11} μCi/ml. During 1976, the highest annual average concentration onsite was 2.6×10^{-11} μCi/ml. Thus, using these data, the maximum individual (exposure) in the offsite population calculate to be 0.5 millirem and 0.038 millirem, respectively. The same approach was used for the maximum population group; i.e., the highest annual average concentration found offsite was used. It is the policy of the Mound Facility to be very conservative in preparing these estimates based on the actual field monitoring data.

Tabulations of the airborne and liquid tritium and plutonium-238 emissions for the past several years (since 1970) have been added to the statement as you suggested. Tritium emissions are given on pages 3-17 and 3-25. Plutonium-238 emissions are given on pages 3-42 and 3-47.

The conversion of the powerplant from gas-oil fired to coal fired has not been funded at this time. If this project is approved, the Federal emission standards will be part of the performance specifications and strict adherence to these standards will be required.

The incinerator under development to burn extremely low-level TRU-contaminated combustible wastes uses a total deluge scrubber. The only products of combustion exhausted to the atmosphere are carbon dioxide and water vapor.

One of the paramount factors considered in the selection of the present site for the Mound Facility was the availability of skilled individuals. Relocation to a remote region would shut off the availability of such individuals and the work could not be accomplished.

A discussion of the disposition of all the comments received, copies of all comment letters, and DOE responses are included in Section 10 of the enclosed final EIS.

Sincerely,

James L. Liverman

Ruth C. Clusen
Assistant Secretary for Environment

4 Enclosures

City of Kettering

3600 Shroyer Road / Kettering, Ohio 45429 / Phone (513)296-2400

June 7, 1978

U.S. Department of Energy
Office of NGPA Coordination
Mail Station E-201
Washington, D. C. 20545

RE: Federal Register, Vo. 43, No. 82, dtd April 27, 1978 to the DOE draft Environmental Impact Statement DOE/EID-11014D for the Mound Laboratory Facility, Miamisburg, OH

Kettering is a city of 70,000 in the vicinity of the Mound Facility in Miamisburg. While we have not reviewed the Environmental Impact Statement document for the Mound in any detail, we concur with the idea of continued operations at the Mound Facility and have confidence that such operations will be conducted safely and without environmental hazard. This confidence has grown out of a long working relationship with the laboratory which has convinced us of their skill and thorough efforts on behalf of protecting surrounding communities.

We have no misgivings relative to work in the nuclear energy field by the Mound Facility and hope that they will be given favorable approval.

We would be happy to answer any questions which you might have.

Sincerely,

JOHN W. LANEY
City Manager

jwl:pp

Department of Energy
Washington, D.C. 20585

JUL 3 1979

Mr. John W. Laney
City Manager
City of Kettering
3600 Shroyer Road
Kettering, Ohio 45429

Dear Mr. Laney:

Thank you for your letter of June 7, 1978, supporting the continuation of the Mound Facility at its present location. We are encouraged by your support and confidence in our efforts to operate the facility with the least environmental impact.

A discussion of the disposition of all the comments received, copies of all comment letters, and Department of Energy responses are included in Section 10 of the enclosed final Environmental Impact Statement.

Sincerely,

James L. Liverman
for Ruth C. Clusen
Assistant Secretary for Environment

4 Enclosures

SPRINGFIELD PLANNING DIVISION

(513) 325-0511
117 S. Fountain Ave., Springfield, Ohio 45502 **Richard W. Weimer, Director**

June 8, 1978

Mr. W. H. Pennington, Director
Division of Program Review and Coordination
Office of NEPA Affairs
Department of Energy
Washington, D.C. 20545

Re: Draft EIS: DOE/EIS-0014-D Mound Facility, Miamisburg, Ohio.

Dear Mr. Pennington:

I want to thank you for the opportunity to review the Draft EIS for the Mound Facility at Miamisburg, Ohio.

After reviewing the document, I would like to reiterate the following two points which appeared in document:

1. Mound Laboratory fills a necessary role in the nation's nuclear weapons program and the peaceful applications of nuclear energy for DOE.

2. The plant's continual operation will result in substantial economic, sociological and technological contributions to the Dayton area.

After weighing the benefits against the environmental costs and considering the available alternatives, I would like to urge the continuation of Mound Laboratory operations at Its' present location.

Thank you for your attention on this matter.

Sincerely yours,

Van G. Whaler

Van G. Whaler, Ph.D.
Community Planner

VGW:mc

Department of Energy
Washington, D.C. 20585

JUL 3 1979

Dr. Van G. Whaler
Community Planner
Springfield Planning Division
117 South Fountain Avenue
Springfield, Ohio 45502

Dear Dr. Whaler:

Thank you for your letter of June 8, 1978, supporting the continuation of the Mound Facility at its present location. We are encouraged by your support and confidence in our efforts to operate the facility with the least environmental impact.

A discussion of the disposition of all the comments received, copies of all comment letters, and Department of Energy responses are included in Section 10 of the enclosed final Environmental Impact Statement.

Sincerely,

James L. Liverman
for Ruth C. Clusen
Assistant Secretary for Environment

4 Enclosures

APPENDIX A

FLORA AND FAUNA OF THE MIAMI VALLEY

A-1 MAMMAL CHECKLIST

Pouched Mammals - Marsupialia

Opposum: Didelphis marsupialis

Insect Eaters - Insectivora

Common Mole: Scalopus aquaticus
Star Nose Mole: Condylura cristata
Short-tailed Shrew: Blarina brevicauda

Winged Mammals - Chiroptera

Little Brown Bat: Myotis lucifugus
Red Bat: Lusiurus borealis

Hares and Rabbits - Lagomorpha

Eastern Cottontail Rabbit: Sylvilagus floridanus

Gnawing Mammals - Rodentia

Woodchuck: Marmota monax
Thirteen-lined Ground Squirrel: Citellus tridecemlineatus
Eastern Chipmunk: Tamias striatus
Red Squirrel: Tamiasciurus hudsonicus
Eastern Gray Squirrel: Sciurus carolinensis
Eastern Fox Squirrel: Sciurus niger
Southern Flying Squirrel: Glaucomys volans
Beaver: Castor canadensis
White-footed Mouse: Peromyscus leucopus
Meadow Mouse: Microtus pennsylvanicus
Muskrat: Ondatra zibethica
Norway Rat: Rattus norvegicus
House Mouse: Mus musculus
Woodland Jumping Mouse: Napaeozapus insignis

Meat-Eaters - Carnivora

Raccoon: Procyon lotor
Long-tailed Weasel: Mustela frenata
Mink: Mustela vison
River Otter: Lutra canadensis
Spotted Skunk: Spilogale putorius
Striped Skunk: Mephitis mephitis
Red Fox: Vulpes fulva
Gray Fox: Urocyon cinereoargenteus

Even-Toed Hoofed Mammals - Artiodactyla

Whitetailed Deer: Odocoileus virginianus

The following list follows the "Check-list of North American Birds," Fifth Edition, American Ornithologist's Union, 1957. A bird recorded in the Dayton area as "accidental," i.e., so far from its normal range that its presence is the result of exceptional circumstances such as a hurricane or as "visitors," i.e., occurrence does not conform with regularly established migration periods and outside the unusual range as observed for most birds, is not included in the list. The notation after each specie is that commonly used in recording bird population and is defined as follows:

Rare - reported more or less regularly over a period of years, or during a season of the year but always in small numbers.

Uncommon - observed rather frequently, in large or small numbers during certain seasons or throughout the year.

Common - regularly recorded in considerable numbers at certain seasons or throughout the year.

Permanent resident - observed throughout the entire year and known to breed locally.

Summer resident - arriving from the south in the spring, breeding locally and returning to the south in the fall.

Winter resident - arriving from the north in the fall, wintering in the area and returning to the north in the spring.

Migrant - Passes through the area, not remaining to breed or spending a season.

No bird on this list appears in the "Rare and Endangered Fish and Wildlife of the United States" (1969), compiled by the U. S. Department of the Interior.

A-2 BIRD CHECKLIST

Order Gaviiformes

Common Loon: Gavia immer; uncommon migrant

Order Podicipediformes

Horned Grebe: Podiceps auritus; uncommon migrant

Pied-billed Grebe: Podilymbus podiceps; common migrant

Order Ciconiiformes

Great Blue Heron: Ardea herodias; uncommon migrant
Green Heron: Butorides virescens; common summer resident
Little Blue Heron: Florida caerulea; rare summer resident
Common Egret: Casmerodius albus; rare migrant
Black-crowned Night Heron: Nycticorax nycticorax; common migrant, common summer resident
Yellow-crowned Night Heron: Nyctanassa violacea; rare summer resident
Least Bittern: Ixobrychus exilis; rare migrant
American Bittern: Botaurus lentiginosus; uncommon migrant

Order Anseriformes

Canada Goose: Branta canadensis; uncommon migrant
Wavy: Chen caerulescens; rare migrant
Mallard: Anas platyrhynchos; common migrant, common winter resident
Black Duck: Anas rubripes; common migrant, common winter resident
Gadwall: Anas strepera; uncommon migrant
Pintail: Anas acuta; common migrant
Green-winged Teal: Anas carolinensis; uncommon migrant
Blue-winged Teal: Anas discors; common migrant
American Widgeon: Mareca americana; common migrant
Shoveler: Spatula clypeata; uncommon migrant
Wood Duck: Aix sponsa; common migrant, uncommon summer resident
Redhead: Aythya americana; uncommon migrant
Ring-necked Duck: Aythya collaris; common migrant
Canvasback: Aythya valisineria; uncommon migrant, rare winter resident
Lesser Scaup: Aythya affinis; common migrant, rare winter resident
Common Goldeneye: Bucephala clangula; common migrant, uncommon winter resident
Bufflehead: Bucephala albeola; common migrant, rare winter resident
Ruddy Duck: Oxyura jamaicensis; uncommon migrant
Hooded Merganser: Lophodytes cucullatus; uncommon migrant
Common Merganser: Mergus merganser; common migrant, uncommon winter resident
Red-breasted Merganser: Mergus serrator; uncommon migrant, rare winter resident

Order Falconiformes

Turkey Vulture: Cathartes aura; common migrant, uncommon summer resident
Sharp-skinned Hawk: Accipiter striatus; rare migrant, rare winter resident
Cooper's Hawk: Accipiter cooperii; uncommon permanent resident
Red-tailed Hawk: Buteo jamaicensis; uncommon permanent resident
Red-shouldered Hawk: Buteo lineatus; uncommon permanent resident
Rough-legged Hawk: Buteo lagopus; uncommon migrant and winter resident
Broad-winged Hawk: Buteo platypterus; uncommon migrant, rare summer resident
Marsh Hawk: Cirucs cyaneus; uncommon migrant, uncommon winter resident
Osprey: Pandion haliaetus; uncommon migrant
Sparrow Hawk: Galco sparverius; common permanent resident

Order Galliformes

Bobwhite: Colinus virginianus; common permanent resident

Ring-necked Pheasant: Phasianus colchicus; common permanent resident

Order Gruiformes

Virginia Rail: Rallus limicola; rare migrant

Sora: Porzana carolina; uncommon migrant

Common Gallinule: Gallinula chloropus; rare migrant

American Coot: Fulica americana; common migrant

Order Charadriiformes

Semipalmated Plover: Charadrius semipalmatus; uncommon migrant

Killdeer: Charadrius vociferus; common summer resident

American Golden Plover: Pluvialis dominica; rare migrant

American Woodcock: Philohela minor; uncommon migrant, rare summer resident

Common Snipe: Capella gallinago; common migrant

Upland Plover: Bartramia longicauda; uncommon migrant, rare summer resident

Spotted Sandpiper: Actitis macularia; common summer resident

Solitary Sandpiper: Tringa solitaria; common migrant

Greater Yellowlegs: Totanus melanoleucus; uncommon migrant

Lesser Yellowlegs: Totanus flavipes; common migrant

Knot: Calidris canutus; rare migrant

Pectoral Sandpiper: Erolia melanotos; common migrant

Least Sandpiper: Erolia minutilla; uncommon migrant

Dunlin: Erolia alpina; rare migrant

Short-billed Dowitcher: Limnodromus griseus; rare migrant

Semipalmated Sandpiper: Ereunetes pusillus; uncommon migrant

Herring Gull: Larus argentatus; common migrant

Ring-billed Gull: Larus delawarensis; common migrant

Bonaparte's Gull: Larus philadelphia; uncommon migrant

Forster's Tern: Sterna forster; rare migrant

Common Tern: Sterna hirundo; uncommon migrant

Caspian Tern: Hydroprogne caspia; rare migrant

Black Tern: Chlidonias niger; uncommon migrant

Order Columbiformes

Rock Dove (Domestic Pigeon): Columbia livia; common permanent resident

Mourning Dove: Zenaidura macroura; common permanent resident

Order Cuculiformes

Yellow-billed Cuckoo: Coccyzus americanus; common summer resident

Black-billed Cuckoo: Coccyzus erythropthalmus; uncommon summer resident

Order Strigiformes

Barn Owl: Tyto alba; uncommon permanent resident
Screech Owl: Otus asio; common permanent resident
Great Horned Owl: Bubo virginianus; rare permanent resident
Barred Owl: Strix varia; rare permanent resident
Long-eared Owl: Asio otus; rare permanent resident
Short-eared Owl: Asio flammeus; rare migrant
Saw-whet Owl: Aegolius acadicus; rare permanent resident

Order Caprimulgiformes

Whip-poor-will: Caprimulgus vociferus; uncommon migrant, rare summer resident
Common Nighthawk: Chordeiles minor; common summer resident

Order Apodiformes

Chimney Swift: Chaetura pelagica; common summer resident
Ruby-throated Hummingbird: Archilochus colubris; common summer resident

Order coraciiformes

Belted Kingfisher: Megaceryle alcyon; common permanent resident

Order Piciformes

Yellow-shafted Flicker: Colaptes auratus; common permanent resident
Pileated Woodpecker: Dryocupus pileatus; rare summer resident
Red-bellied Woodpecker: Centurus carolinus; uncommon permanent resident
Red-headed Woodpecker: Melanerpes erythrocephalus, uncommon summer resident
Yellow-bellied Sapsucker: Sphyrapicus varius; common migrant
Hairy Woodpecker: Dendrocopos villosus; uncommon permanent resident
Downy Woodpecker: Dendrocopos pubescens; common permanent resident

Order Passeriformes

Eastern Kingbird: Tyrannus tyrannus; common summer resident
Great Crested Flycatcher: Myiarchus crinitus; common summer resident
Eastern Phoebe: Sayornis phoebe; common summer resident
Yellow-bellied Flycatcher: Empidonax flaviventris; rare migrant
Arcadian Flycatcher: Empidonax virenscens; uncommon summer resident
Traill's Flycatcher: Empidonax traillii; uncommon summer resident
Least Flycatcher: Empidonax minimus; uncommon migrant
Eastern Wood Pewee: Contopus virens; common summer resident
Horned Lark: Eremophila alpestris; common permanent resident
Tree Swallow: Iridoprocne bicolor; uncommon migrant
Bank Swallow: Reparia riparis; uncommon summer resident
Rough-winged Swallow: Stelgidopteryx ruficollis; common summer resident
Barn Swallow: Hirundo rustica; common summer resident

Cliff Swallow: Petrochelidon pyrrhonota; uncommon migrant
Purple Martin: Progne subis; common summer resident
Blue Jay: Cyanocitta cristata; common permanent resident
Common Crow: Corvus brachyrhynchos; common permanent resident
Carolina Chickadee: Parus carolinensis; common permanent resident
Tufted Titmouse: Parus bicolor; common permanent resident
White-breasted Nuthatch: Sitta carolinensis; common permanent resident
Red-breasted Nuthatch: Sitta canadensis; rare migrant
Brown Creeper: Certhia familiaris; common migrant, common winter resident
House Wren: Troglodytes aldon; common summer resident
Winter Wren: Troglodytes troglodytes; uncommon winter resident
Bewick's Wren: Thrycmanes bewickii; uncommon migrant
Carolina Wren: Thryothorus ludovicianus; common permanent resident
Long-billed Marsh Wren: Telmatodytes palustris; uncommon migrant, uncommon summer resident
Mockingbird: Mimus polyglottos; common permanent resident
Catbird: Dumetella carolinensis; common summer resident
Brown Thrasher: Toxostoma rufum; common summer resident
Robin: Turdus migratorius; common migrant, common summer resident, uncommon winter resident
Wood Thrush: Hylocichla mustelina; common summer resident
Hermit Thrush: Hylocichla guttata; common migrant
Swainson's Thrush: Hylocichla ustulata; common migrant
Gray-cheeked Thrush: Hylocichla minima; uncommon migrant
Veery: Hylocichla fuscescens; uncommon migrant
Eastern Bluebird: Sialia sialis; common summer resident
Blue-gray Gnatcatcher: Polioptila caerulea; common summer resident
Golden-crowned Kinglet: Regulus satrapa; common migrant, common winter resident
Ruby-crowned Kinglet: Regulus calendula; common migrant, rare winter resident
Water Pipit: Anthus spinoletta; uncommon migrant
Cedar Waxwing: Bombycilla cedrorum; common summer resident; uncommon winter resident
Loggerhead Shrike: Lanius ludovicianus; uncommon migrant
Starling: Sturnus vulgaris; common permanent resident
White-eyed Vireo: Vireo griseus; uncommon migrant
Yellow-throated Vireo: Vireo flavifrons; uncommon summer resident
Solitary Vireo: Vireo solitarius; rare migrant
Red-eyed Vireo: Vireo olivaceus; common summer resident
Philadelphia Vireo: Vireo philadelphicus; rare migrant
Warbling Vireo: Vireo gilvus; common summer resident
Black-and-White Warbler: Mniotilta varia; common migrant
Prothonotary Warbler: Protonotaria citrea; uncommon summer resident
Worm-eating Warbler: Helmitheros vermivorus; rare migrant
Golden-winged Warbler: Vermivora chrysoptera; rare migrant

Blue-winged Warbler: Vermivora pinus; uncommon migrant, rare summer resident
Tennessee Warbler: Vermivora peregrina; common migrant
Orange-crowned Warbler: Vermivora celata; rare migrant
Nashville Warbler: Vermivora ruficapilla; common migrant
Parula Warbler: Parula americana; rare migrant
Yellow Warbler: Dendroica petechia; common summer resident
Magnolia Warbler: Dendroica magnolia; common migrant
Cape May Warbler: Dendroica tigrina; uncommon migrant
Black-throated Blue Warbler: Dendroica caerulescens; uncommon migrant
Myrtle Warbler: Dendroica coronata; common migrant
Black-throated Green Warbler: Dendroica Virens; common migrant
Cerulean Warbler: Dendroica cerulea; uncommon summer resident
Blackburnian Warbler: Dendroica fusca; common migrant
Chestnut-sided Warbler: Dendroica pensylvanica; common migrant
Bay-breasted Warbler: Dendroica castenea; common migrant
Blackpoll Warbler: Dendroica striata; uncommon migrant
Palm Warbler: Dendroica palmarum; common migrant
Ovenbird: Seiurus aurocapillus; common migrant
Northern Waterthrush: Seirus noveboracensis; uncommon migrant
Louisiana Waterthrush: Seiurus motacilla; uncommon migrant
Kentucky Warbler: Oporornis formosus; uncommon summer resident
Connecticut Warbler: Oporornis agilis; rare migrant
Mourning Warbler: Oporornis philadelphia; uncommon migrant
Yellowthroat: Geothlypis trichas; common summer resident
Yellow-breasted Chat: Icteria virens; uncommon summer resident
Hooded Warbler: Wilsonia citrina; rare migrant
Wilson's Warbler: Wilsonia pusilla; uncommon migrant
Canada Warbler: Wilsonia canadensis; uncommon migrant
American Redstart: Setophaga ruticilla; common migrant
House Sparrow: Passer domesticus; common permanent resident
Bobolink: Dolichonyx oryzivorus; common summer resident
Eastern Meadowlark: Sturnella magna; common summer resident
Redwinged Blackbird: Agelaius phoeniceus; common summer resident
Orchard Oriole: Icterus spurius; uncommon summer resident
Baltimore Oriole: Icterus galbula; common summer resident
Rusty Blackbird: Euphagus carolinus; common migrant
Common Crackle: Quiscalus quiscula; common summer resident
Brown-headed Cowbird: Molothrus ater; common summer resident
Scarlet Tanager: Piranga olivacea; uncommon summer resident
Summer Tanager: Piranga rubra; rare summer resident
Cardinal: Richmondena cardinalis; common permanent resident
Rose-breasted Grosbeak: Pheucticus ludovicianus; uncommon migrant
Indigo Bunting: Passerine cyancea; common summer resident
Dickcissel: Spiza americana; uncommon summer resident

Purple Finch: Carpodacus purpureus; uncommon migrant
Pine Siskin: Spinus pinus; rare migrant
American Goldfinch: Spinus tristis; common permanent resident
Rufous-sided Towhee: Pipilo erthrophthalmus; common summer resident
Savannah Sparrow: Passerculus sandwichensis; uncommon migrant, rare summer resident
Grasshopper Sparrow: Ammodramus savannarum; common summer resident
Henslow's Sparrow: Passerherbulus henslowii; uncommon summer resident
Vesper Sparrow: Pooecetees gramineus; common summer resident
Bachman's Sparrow: Aimophila aestwalis; rare summer resident
State-colored Junco: Junco hyemalis; common winter resident
Tree Sparrow: Spizella arborea; common winter resident
Chipping Sparrow: Spizella passerine; common summer resident
Field Sparrow: Spizella pusilla; common summer resident
White-crowned Sparrow: Zonotrichia leucophrys; common migrant
Fox Sparrow: Passerella iliaca; common migrant
Lincoln's Sparrow: Melospiza lincolnii; rare migrant
Swamp Sparrow: Melospiza georgiana; uncommon migrant
Song Sparrow: Melospiza melodia; common permanent resident

A-3 FISH CHECKLIST

Herrings: Family Clupeidae

Skipjack Herring: Pomolobus chrysochloris
Eastern Gizzardshad: Dorosoma cepedianum

Suckers: Family Catostmidae

Smallmouth Buffalofish: Ictiobus bubalus
Central Quillback Carpsucker: Carpiodes cyprinus hinei
Northern River Carpsucker: Carpiodes carpio carpio
Highfin Carpsucker: Carpiodes velifer
Golder Redhorse: Moxostoma erythrurum
Hog Sucker: Hypentelium nigricans
Common White Sucker: Catostomus commersoni commersoni

Carps and Minnows: Family Cyprinidae

Carp: Cyprinus carpio
Goldenshiner: Notemigonus crysoleucas
Western Blacknose Dace: Rhinichthys atratulus meleagris
Northern Creek Chub: Semotilus atromaculatus atromaculatus
Western Tonguetied Chub: Parexoglossum laurae hubbsi
Southern Redbelly Dace: Chrosomus erythrogaster
Common Emerald Shiner: Notropis atherinoides atherinoides

Silver Shiner: Notropis photogenis
Ohio Rosefin Shiner: Notropis ardens lythrurus
Central Common Shiner: Notropis cornutus chrysocephalus
Spotfin Shiner: Notropis spilopterus
Northeastern Sand Shiner: Notropis deliciosus stramineus
Silverjaw Minnow: Ericymba buccata
Northern Fathead Minnow: Pimephales promelas promelas
Bluntnose Minnow: Pimephales notatus
Ohio Stoneroller Minnow: Campostoma anomalum anomalum

Catfishes: Family Ictaluridae
Channel Catfish: Ictalurus punctatus
Black Bullhead: Ictalurus melas

Troutperch: Family Percopsidae
Troutperch: Percopsis omiscomaycus

Blackbasses, Crappies, Sunfish: Family Centrarchidae
White Crappie: Pomoxis annularis
Northern Rockbass: Amblopites rupestris rupestris
Northern Smallmouth Blackbass: Micropterus dolomieui dolomieui
Green Sunfish: Lepomis cyanellus
Northern Bluegill Sunfish: Lepomis macrochirus machrochirus
Central Longear Sunfish: Lepomis megalotis megalotis

Walleyes, Perch, Darters; Family Percidae
Blackside Darter: Percina maculata
Central Johnny Darter: Etheostoma nigrum nigrum
Greenside Darter: Etheostoma blennioides
Eastern Banded Darter: Etheostoma zonale zonale
Variegated Darter: Etheostoma variatum
Rainbow Darter: Etheostoma caeruleum
Northern Orangethroat Darter: Etheostoma spectabile spectabile
Barred Fantail Darter: Etheostoma flabellare flabellare

Sculpins: Family Cottidae
Central Redfin Sculpin: Cottus bairdi bairdi

The above checklist does not include fish stocked into private fishing ponds. Such species usually do not breed under such conditions and thus do not contribute to natural fish of the area.

A-4 AMPHIBIANS AND REPTILES CHECKLIST

Salamanders

Ambystomids: Family Ambystomatidae

- Spotted Salamander: Ambystoma maculatum
- Marbled Salamander: Ambystoma opacum
- Small-mouthed Salamander: Ambystoma texanum
- Jefferson Salamander: Ambystoma jeffersonianum
- Blue-spotted Salamander: Ambystoma laterale
- Eastern Tiger Salamander: Ambystoma tigrinum tigrinum

Newts: Family Salamandridae

- Red-spotted Newt: Notophthalmus viridescens viridescens
- Central Newt: Notophthalmus viridescens louisianensis

Mudpuppies and Their Allies: Family Proteidae

- Mudpuppy: Necturus maculosus maculosus

Lungless Salamanders: Family Plethodontidae

- Northern Dusty Salamander: Desmognathus fuscus fuscus
- Northern Two-lined Salamander: Eurycea bislineata bislineata
- Long-tailed Salamander: Eurycea longicauda longicauda
- Four-toed salamander: Henidactylium scatatum
- Red-backed and Lead-backed Salamander: Plethodon cinereus cinereus
- Ravine Salamander: Plethodon richmondi richmondi
- Slimy Salamander: Plethodon flutinosus glutinosus
- Northern Red Salamander: Pseudotriton ruber ruber

Frogs and Toads

True Frogs: Family Ranidae

- Bullfrog: Rana catesbeiana
- Green Frog: Rana clamitans melanota
- Wood Frog: Rana sylvatica
- Northern Leopard Frog: Rana pipiens pipiens
- Pickerel Frog: Rana palustris

Toads: Family Bufonidae

- American Toad: Bufo americanus americanus
- Fowler's Toad: Bufo woodhousei fowleri

Tree Frogs and Their Allies: Family Hylidae

- Eastern Gray Treefrog: Hyla versicolor versicolor
- Northern Spring Peeper: Hyla crucifer crucifer
- Blanchard's Cricket Frog: Acris crepitans blanchardi
- Western Chorus Frog: Pseudacris triseriata triseriata

Turtles

Snapping Turtles: Family Chelyridae

Common Snapping Turtle: Chelydra serpentina

Mud and Musk Turtles: Family Kinosternidae

Stinkpot: Sternothaerus odoratus

Fresh Water, Marsh and Box Turtles: Family Emydidae

Spotted Turtle: Clemmys guttata

Eastern Box Turtle: Terrapene carolina carolina

Map Turtle: Malaclemys geographica

Midland Painted Turtle: Chrysemys picta marginata

Red-eared Turtle: Chrysemys scripta elegans

Softshell Turtles: Family Tronychidae

Easter Spiny Softshell: Trionyx spiniferus spiniferus

Mississippi Smooth Softshell: Trionyx muticus muticus

Lizards

Iguanids: Family Iguanidae

Northern Fence Lizard: Sceloporus undulatus hyacinthinus

Skinks: Family Scincidae

Five-lined Skink: Eumeces fasciatus

Broad-headed Skink: Eumeces laticeps

Snakes

Colubrids: Family Colubridae

Northern Copperbelly: Natrix erythrogaster neglecta

Northern Water Snake: Natrix sipedon sipedon

Queen Snake: Natrix septemvittata septemvittata

Kirkland's Water Snake: Natrix kirtandi

Eastern Ribbon Snake: Themnophis sauritus sauritus

Northern Brown Snake: Storeria dekayi dekayi

Midland Brown Snake: Storeria dekayi wrightorum

Butler's Garter Snake: Thamnophis butleri

Eastern Plains Garter Snake: Thamnophis radix radix

Eastern Garter Snake: Thamnophis sirtalis sirtalis

Eastern Earth Snake: Virginia valeriae valeriae

Eastern Hognose Snake: Heterodon platyrhinos

Northern Ringneck Snake: Diadophis punctatus edwardsi

Midwest Worm Snake: Carphophis amoenux helenae

Northern Black Racer: Coluber constrictor constrictor

Black Rat Snake: Elaphe obsoleta obsoleta

Eastern Milk Snake: Lampropeltis triangulum triangulum
Southeastern Crowned Snake: Tantilla coronata coronata

Pit Vipers: Family Vipseridae
Northern Copperhead: Agkistrodon contortrix mokasen
Eastern Massasauga: Sistrurus catenatus catenatus
Timber Rattlesnake: Crotalus horridus horridus

A-5 CHECKLIST OF VASCULAR FLORA

Microphyllophyta

Lycopodiaceae - Clubmoss Family
Ground Cedar or Trailing Clubmoss: Lycopodium complanatum flabelliforme

Selaginellaceae - Selaginella Family
Creeping Selaginella: Selaginella apoda

Arthrophyta

Equisetaceae - Horsetail Family
Common Horsetail: Equisetum arvense
Common or Great Scouring Rush: Equisetum hyemale pseudohyemale

Pterophyta

Ophioglossaceae - Adder's-tongue Family
Cut-leaf Grape Fern: Botrychium dissectum dissectum
Oblique Grape Fern: Botrychium dissectum obliquum
Rattlesnake Fern: Botrychium virginianum
Adder's-tongue: Ophioglossum vulgatum

Polypodiaceae - Polypody Family
Maidenhair Fern: Adiantum pedatum
Smooth Cliff-brake: Pellaea glabella
Common Polypody: Polypodium vulgare virginianum
Ohio Wall Rue Spleenwort: Asplenium ruta-muraria ohionis
Ebony Spleenwort: Asplenium platyneuron
Walking Fern: Camptosorus rhizophyllus
Lady Fern: Anthyrium filix-femina michauxii
Bulblet Fern or Berry Bladder Fern: Cystopteris bulbifera
Fragile Fern or Brittle Fern: Cystopteris fragilis protrusa
Marsh Fern: Thelypteris polustris pubescens
Makai: Dryopteris thelypteris pubescens
Spinulose Wood Fern: Dryopteris austriaca spinolusa
Christmas Fern: Polystichum acrostichoides

Coniferophyta

Taxaceae - Yew Family

American Yew or Ground Hemlock: Taxus canadensis

Pinaceae - Pine Family

Balsam Fir: Abies balsemea (planted)
Hemlock: Tsuga canadensis (planted)
Norway Spruce: Picea abies (planted)
European Larch: Larix decidua (planted)
White Pine: Pinus strobus (planted)
Red Pine: Pinus resinosa (planted)
Scotch Pine: Pinus sylvestris (planted)
Table-mountain Pine: Pinus pungens (planted)
Austrian Pine: Pinus nigra (planted)
Jack Pine: Pinus banksiana (planted)
Yellow Pine or Shortleaf Pine: Pinus echinata (planted)
Scrub Pine or Virginia Pine: Pinus virginiana (planted)
Douglas Fir: Pseudotsuga taxifolia (planted)

Taxodiaceae - Bald Cypress Family

Bald Cypress: Taxodium distichum (planted)
Pond Cypress: Taxodium ascendens (planted)

Cypressaceae - Cypress Family

White Cedar or Arbor Vitae: Thuja occidentalis (planted)
Common Juniper: Juniperus communis depressa (planted)
Red Cedar: Juniperus virginiana
Common Pfitzer or Pfitzer's Juniper: Juniperus chinensis pfitzeriana (planted)

Ginkgoaceae - Ginkgo Family

Ginkgo: Ginkgo biloba (planted)

Anthophyta - Monocotyledoneae (Monocotyledons)

Typhaceae - Cattail Family

Cattail: Typha latifolia

Sparganiaceae - Bur-reed Family

Giant Bur Reed: Sparganium eurycarpum

Najadaceae - Pondweed Family

Curly Pondweed: Potamogeton crispus
Leafy Pondweed: Potamogeton foliosus

Alismataceae - Water Plantain Family

Water Plaintain: Alisma subcordatum

Common Arrowhead, Wapato or Duck Potato: Sagittaria latifo.

Hydrocharitaceae - Frog's-bit Family

Waterweed: Elodea canadensis

Waterweed: Anacharis canadensis

Gramineae - Grass Family

Downy Chess: Bromus tectorum

Hungarian or Smooth Brome: Bromus inermis

Canada Brome: Bromus purgans

Hairy Chess: Bromus racemosus

Japanese Chess: Bromus japonicus

Meadow Fescue: Festuca elatior

Nodding Fescue: Festuca obtusa

Fowl Mannagrass: Glyceria striata

Annual Bluegrass or Speargrass: Poa annua

Canada Bluegrass: Poa compressa

Kentucky Bluegrass: Poa pratensis

Rough Bluegrass: Poa trivialis

Woodland Bluegrass: Poa sylvestris

Creeping Eragrostis: Eragrostis hypnoides

Purple Lovegrass: Eragrotis spectabilis

Frank's Lovegrass: Eragrotis frankii

Nees: Eragrotis pectinacea

Stink Grass: Eragrotis cilianensis

American Korycarpus: Diarrhena americana

Orchard Grass: Dactylis glomerata

Tall Redtop or Purpletop: Triodia flava

Quackgrass or Cordgrass: Agropyron repens

Wheat:

Triticum aestivum (planted)

Elymus villosus (planted)

Elymus reparius (planted)

Virginia Wild Rye: Elymus virginicus

Bottlebrush Grass: Hystrix patula

Foxtail Barley or Squirreltail: Hordeum jabatum

Perennial or English Ryegrass: Lolium perenne

Slender Wedgegrass: Sphenopholis intermedia

Oats: Avena sativa (planted)

Tall Oat Grass: Arrhenatherum elatius

Poverty Grass or Common Wild Oat Grass: Danthonia spicata

Redtop: Agrotis stolonifera major

Thingrass: Agrostis perennans aestivalis

Woodreed Grass: Cinna arundinacea
Timothy: Phleum pratense
Nimblewill: Muhlenbergia schreberi
Wirestem Muhly: Muhlenbergia frondosa
Sheathed Rush Grass or Poverty Grass: Sporobolus vaginiflorus
Cattail Grass: Heleochloa schoenoides
Brachyelyrum: Brachyelytrum erectum
Prairie Three-awn: Aristida oligantha
Goose Grass or Yard Grass: Eleusine indica
Tall Grama Grass or Side Oats Grama: Bouteloua curtipendula
Reed Canary Grass: Phalaris arundinacea
Rice Cut-grass: Leersia oryzoides
White Grass: Leersia virginica
Large Crabgrass: Digitaria sanguinalis
Smooth Crabgrass: Digitaria ischaemum
Vasey: Paspalum pubiflorum
Witchgrass: Panicum capillare capillare
Fall Panicum: Panicum dichotomiflorum
Hairy Panicum: Panicum lanuginosum
Hispid Panic Grass: Panicum clandestinum
Broad-leaved Panic Grass: Panicum latifolium
Bosc's Panic Grass: Panicum boscii
Forked Panic Grass: Panicum dichotomum
Barnyard Grass:
    Echinochloa crusgalli
    Echinochloa muricata
    Echinochloa pungens
Yellow Foxtail: Setaria glauca
Italian Millet: Setaria italica
Green Foxtail:
    Setaria viridis
    Setaria faberii
Bur Bristlegrass: Setaria verticillata
Little Bluestem: Andropogon scoparius
Broomsedge: Andropogon virginicus
Maize or Indian Corn: Zea mays (planted)

Cyperaceae - Sedge Family
Yellow Cyperus:
    Cyperus flavescens poaeformis
    Cyperus rivularis
Michaux's Cyperus: Cyperus odoratus
Slender Cyperus: Cyperus filiculmis
Straw-colored Cyperus: Cyperus strigosus

Small's Spike Rush: Eleocharis smallii
Great Bulrush: Scirpus validus creber
Darkgreen Bulrush: Scirpus actrovirens
Reddish Bulrush: Scirpus lineatus
Capillary Beak Rush: Rhynchospora capillacea
Oval-headed Sedge: Carex cephalophora
Convolute Sedge: Carex rosea
Stellate Sedge: Carex rosea sensus strictus
Radiate Sedge: Carex radiata
Bur Reed Sedge: Carex sparganioides
Yellow Fox Sedge: Carex annectens
Fox Sedge: Carex vulpinoidea
Awl-fruited Sedge: Carex stipata
Blunt Broom Sedge: Carex tribuloides
Crested Sedge: Carex cristatella
Larger Straw Sedge: Carex normalis
Prairie Straw Sedge: Carex suberecta
James Sedge: Carex jamesii
Bristle-stalked Sedge: Carex leptalea
Black-margined Sedge: Carex migromarginata
Pennsylvanic Sedge: Carex pensylvanica
Pubescent Sedge: Carex hirtifolia
Bristle Leaf Sedge: Carex eburnea
Woodland Sedge:
- Carex laxiflora laxiflora
- Carex laxiflora latiflolia
- Carex abursina
- Carex laxiflora blanda
- Carex blanda

Meadow Sedge:
- Carex granularis
- Carex obigocarpa

Gray Sedge: Carex grisea
Hirsute Sedge: Carex complanata
Woolly Sedge: Carex lasiocarpa
Short's Sedge: Carex shortiana
Porcupine Sedge: Carex hystericina
Frank's Sedge: Carex frankii
Shallow Sedge: Carex lurida

Araceae - The Arum Family

Jack-in-the-pulpit: Arisaema atrorubens
Green Dragon or Dragonroot: Arisaema dracontium
Skunk Cabbage: Symplocarpus foetidus

Sweetflag: Acorus calamus
Sweetflag: Acorus americanus

Leminaceae - Duckweed Family
Water Flaxseed or Great Duckweed: Spirodela polyrhiza
Lesser Duckweed: Lemna minor

Commelinaceae - Spiderwort Family
Zigzag Spiderwort: Tradescantia subaspera
Asiatic Dayflower: Commelina communis

Juncaceae - Rush Family
Path Rush or Slender Rush: Juncus tenuis
Dudley's Rush: Juncus dudleyi
Torrey's Rush: Juncus torreyi
Sharp-fruited Rush: Juncus acuminatus
Wood Rush: Lozula campestris echinata

Gramineae - Bamboo Family
Cane or Large Cane: Arundinaria gigantea

Liliaceae - Lily Family
Day Lily: Hemerocallis fulva
Lemon Lily: Hemerocallis flava
Wild Leek or Ramp: Allium tricoccum
Wild Garlic: Allium canadense
Praire or Michigan Lily: Lilium michiganense
Yellow Adder's-tongue or Trout-Lily: Erythronium americanum
White Dog's-tooth Violet: Erythronium albidum
Wild Hyacinth: Camassia scilloides
Star-of-Bethlehem: Ornithogalum umbellatum
Grape-hyacinth: Muscari botryoides
Asparagus: Asparagus officinalis
False Spinard or False Solomon's Seal: Smilacina racemose
Big Merrybells or Bellwort: Uvularia grandiflora
Hairy Solomons Seal: Polygonatum pubescens
Large Solomons Seal: Polygonatum commutatum
Toadshade or Wake-robin: Trillium sessile
Large-flowered Trillium: Trillium grandiflorum
Nodding Trillium: Trillium gleasoni
Snow Trillium: Trillium nivale
Smooth Carrion Flower: Smilax herbacea herbacea
Erect Greenbrier: Smilax ecirrhata
Bristly Greenbrier: Smilax hispida
Common Greenbrier or Sawbrier: Smilax rotundifolia

Dioscoreaceae - Yam Family
Wild Yam: Dioscorea villosa

Amaryllidaceae - Amaryllis Family
Daffodil: Narcissus pseudo-narcissus (planted)
Yellow Star Grass: Hypoxis hirsuta

Iridaceae - Iris Family
Dwarf Crested Iris: Iris cristata (planted)
Southern Blue Flag: Iris shrevei
White Blue-eyed Grass: Sisyrinchium albidum
Blue-eyed Grass: Sisyrinchium angustifolium

Orchichaceae - Orchid Family
Autumn Coralroot: Corallorhiza odontorhiza

Anthophyta - Dicotyledoneae - (Dicotyledons)

Saururaceae - Lizard's-tail Family
Common Lizard's-tail or Water-dragon: Saururus cernuus

Salicaceae - Willow Family
Black Willow: Salix nigra
Carolina Willow or Ward's Willow: Salix caroliniana
Peach-leaf Willow: Salix amygdaloides
Sandbar Willow: Salix interior
Bog Willow: Salix pedicellaris
Heart-leaf Willow:
Salix rigida rigida
Salix rigida angustata
Pussy Willow:
Salix discolor discolor
Salix discolor latifola
Silky Willow: Salix serica
Upland Willow: Salix humilis humilis
Dwarf Upland Willow: Salix tristis
Purple Osier or Basket Willow: Salix purpurea
Silver Popular or White Popular: Populus alba
Balm-of-Gilead: Populus gileadensis (planted)
Cottonwood: Populus deltoides
Carolina Poplar: Populus canadensis (planted)
Lombardy Poplar: Populus dilatata (planted)
Bigtooth Aspen: Populus grandidentata
Quaking Aspen: Populus tremuloides (planted)

Myricaceae - Bayberry Family

Bayberry: Myrica pensylvanica (planted)

Juglandaceae - Walnut Family

White Walnut, Oil Nut or Butternut: Jugland cinera
Black Walnut: Juglans nigra
Pecan: Carya illinoensis (planted)
Swamp Hickory or Bitternut Hickory: Carya cordiformis
Shellbark, White or Shagbark Hickory: Carya ovata
Big Shellbark or Kingnut: Carya laciniosa
White heart, Big-bud or Mockernut Hickory: Carya tomentosa
Pignut Hickory: Carya glabra
Small-fruited or Pignut Hickory: Carya microcarpa

Betulaceae - Birch Family

Hazel: Corylus americana
Hardhack, Leverwood, Hop Hornbeam or Ironwood: Ostrya virginiana
Water Beech, Hornbeam or Blue Beech: Carpinus caroliniana
Swamp Birch: Betula pumila (planted)
White, Canoe or Paper Birch: Betula papyrifera (planted)
Red Birch or River Birch: Betula nigra
Black, Cherry, Sweet or Mahogany Birch: Betula lenta
Common Alder, Smooth Alder or Tag Alder: Alnus serrulata

Fagaceae - Beech Family

Beech: Fagus grandifolia
Chestnut: Castanea dentata
Chinquapin: Castanea pumila
White Oak: Quercus alba
English Oak: Quercus robur (planted)
Post Oak or Iron Oak: Quercus stellata
Bur Oak, Cork Oak or Mossy Cup: Quercus macrocarpa
Rock Chestnut Oak: Quercus prinus
Scrub Chestnut Oak: Quercus prinoides
Yellow Oak, Chestnut Oak, Chinquapin Scrub Oak or Pigeon Oak: Quercus muhlenbergii
Swamp White Oak: Quercus bicolor
Red Oak: Quercus borealis or rubra
Scarlet Oak: Quercus coccinea
Black Oak, Golden Oak or Quercitron: Quercus velutina
Pin Oak or Swamp Oak: Quercus palustris
Shingle Oak: Quercus imbricaria
Shumard Red Oak: Quercus shumardii

Ulmaceae - Elm Family

White Elm, American Elm, Water Elm or Swamp Elm: Ulmus americana
Slippery Elm, Red Elm or Moose Elm: Ulmus rubraea or fulva
Rock Elm, Cork Elm, Cliff Elm or Hickory Elm: Ulmus thomasii
Hackberry, Sugarberry, Nettle Tree or False Elm: Celtis occidentalis

Moraceae - Mulberry Family

Osage Orange or Hedge Apple: Mulclura pomifera
Red Mulberry: Morus rubra
White Mulberry: Morus alba (planted)
Paper Mulberry: Broussonetia papyrifera (planted)

Cannabinaceae - Hemp Family

Hemp or Marijuana: Cannabis sativa

Urticaceae - Nettle Family

Stinging Nettle: Urtica dioica
Wood Nettle: Laportea canadensis
False Nettle: Boehmeria cylindrica
Clearweed: Pilea pumila
Pennsylvania Pellitory: Parietaria pensylvanica

Santalaceae - Sandal-wood Family

Bastard Toadflax: Comandra umbellata

Aristolochiaceae - Birthwort Family

Wild Ginger: Asarum canadense canadense
Robins: Asarum canadense reflexum
Virginia Snakeroot: Aristolochia serpentaria

Polygonaceae - Smartweed Family

Sheep Sorrel or Red Sorrel: Rumex acetossella
Great Waterdock: Rumex orbiculatus
Waterdock: Rumex verticillatus
Sour Dock or Yellow Dock: Rumex crispus
Pale Dock: Rumex altissimus
Bitter Dock: Rumex obtusifolius
Erect Knotweed: Polygonum erectum
Knotweed: Polygonum aviculare
Pale Persicaria: Polygonum lapathifolium
Pinkweed: Polygonum pensylvanicum
Water Smartweed or Dotted Smartweed: Polygonum punctatum
Water Smartweed or Common Smartweed: Polygonum hydropiper
Mild Water Pepper: Polygonum hydropiperoides

Lady's Thumb: Polygonum persicaria
Jumpseed: Polygonum virginianum
Black Bindweed: Polygonum convolvulus
Climbing False Buckwheat: Polygonum scandens

Chenopodiaceae - Goosefoot Family
Lamb's-quarters: Chenopodium album
Oak-leaved Goosefoot: Chenopodium glaucum
Many-seeded Goosefoot: Chenopodium polyspermum
Orach or Spearscale: Atriplex patula

Amaranthaceae - Amaranth Family
Mat Amaranth: Amaranthus graecizans
Tumbleweed: Amaranthus albus
Rough Pigweed: Amaranthus retroflexus
Pigweed or Prince's Feather: Amaranthus hybridus
Water Hemp: Amaranthus tuberculatus

Nyctaginaceae - Four O'clock Family
Wild Four-o'clock or Heart-leaf Umbrellawort: Oxybaphus nyctagineus or Mirabilis nyctaginea

Phytolaccaceae - Pokeweed Family
Pokeweed or Pokeberry: Phytolacca americana

Aizoaceae - Carpetweed Family
Carpetweed: Mollugo verticillata

Portulacacea - Purslane Family
Common Purslane: Portulaca oleracea
Spring Beauty: Claytonia virginica

Caryophyllaceae - Pink Family
Forked Chickweed or Slender Anychia: Paronychia canadensis
Common Chickweed: Stellaria media
Stitchwort: Stellaria graminea
Nodding Chickweed: Cerastium nutans
Mouse-ear Chickweed: Cerastium vulgatum
Jagged Chickweed: Holosteum umbellatum
Thyme-leaved Sandwort: Arenaria serpyllifolia
White Campion: Lychnis alba
Corn Cockle or Corn Campion: Agrostemma githago
Sleepy Catchfly: Silene antirrhina
Night-flowering Catchfly: Silene noctiflora
Bladder Campion: Silene cucubolus

Fire Pink: Silene virginica
Soapwort or Bouncing Bet: Saponaria officinalis
Deptford Pink: Dianthus armeria

Ceratophyllaceae - Hornworth Family
Coontail or Hornwort: Ceratophyllum demersum

Nymphaeaceae - Water-Lily Family
Water Lily: Nymphaea tuberosa

Magnoliaceae - Magnolia Family
Tulip Tree, Tulip Poplar, Yellow Poplar, White Wood, or Canoe Wood: Liriodendron tulipifera
Cucumber Tree or Mountain Magnolia: Magnolia acuminata

Annonaceae - Custard-apple Family
Pawpaw: Asimina triloba

Ranunculaceae - Crowfoot Family
Goldenseal: Hydrastis canadensis
White Baneberry: Actaea alba
Wild Columbine: Aquilegia canadensis
Dwarf Larkspur: Delphinium tricorne
Marsh Marigold or "Cowslip": Caltha palustris
Small-flowered Crowfoot or Kidneyleaf Buttercup: Ranunculus abortivus
Prairie Buttercup: Ranunculus recurvatus
Swamp Buttercup: Ranunculus septentrionalis
Bristly Buttercup: Ranunculus hispidus
Early Meadow Rue: Thalictrum dioicum
Tall Meadow Rue: Thalictrum polygamum
Purple Meadow Rue: Thalictrum dasycarpum
Thimbleweed: Anemone virginiana
Canadian Anemone: Anemone canadensis
Wind Flower or Wood Anemone: Anemone quinquefolia interior
Acute-lobed Hepatica: Hepatica acutiloba
American Hepatica or Round-lobed Liverlead: Hepatica americana
Rue Anemone: Anemoella thalictroides
Virgin's Bower: Clematis virginiana
Leather Flower: Clematis viorna

Berberidaceae - Barberry Family
Mayapple or Wild Jalap: Podophyllum peltatum
Twinleaf: Jeffersonia diphylla
Blue Cohosh or Papoose-root: Caulophyllum thalictroides
Japanese Barberry: Berberis thunbergii (planted)

Menispermaceae - Moonseed Family

Moonseed Vine or Yellow Parilla: Menispermum canadense

Lauraceae - Laurel Family

Sassafras or Ague Tree: Sassafras albidum

Spice Bush, Feber Bush, Wild Allspice or Benjamin Bush; Lindera benzoin

Papaveraceae - Poppy Family

Bloodroot or Red Pucoon: Sanguinaria canadensis

Celandine: Chelidonium majus

Fumariaceae - Fumitory Family

Dutchman's Breeches: Dicentra cucullaria

Squirrel Corn: Dicentra canadensis

Crociferae - Mustard Family

Black Mustard: Brassica nigra

Field Cress or Cow Cress: Lepidium campestre

Peppergrass or Poor Man's Pepper: Lepidium Virginicum

Field Pennycress: Thlaspi arvense

Perfoliate Pennycress: Thlaspi perfoliatum

Shepherd's Purse: Capsella bursa-pastoris

Spring Cress or Bulb Bitter Cress: Cardamine bulbosa

Northern or Purple Bitter Cress: Cardamine douglassii

Cut-leaved Toothwort: Dentaria laciniata

Sicklepod: Arabis canadensis

Smooth Rock Cress: Arabis laevigata

True Watercress: Nasturtium officinale

Common Watercress or Yellow Rocket: Barbarea vulgaris

Purple Rocket: Iodanthus pinnatifidus

Dame's Rocket or Dame's-violet: Hesperis matronalis

Garlic Mustard: Alliaria officinalis

Hedge Mustard: Sisymbrium officinale

False Flax: Camelina microcarpa

Crassulaceae - Orpine Family

Ditch Stonecrop: Penthorum sedoides

Goldmoss or Mossy Stonecrop: Sedum acre

Live-forever or Garden Orpine: Sedum telephium

Mountain Stonecrop: Sedum ternatum

Saxifragaceae - Saxifrage Family

Bishop's Cap, Mitrewort or Coolwort: Mitella diphylla

Rock Geranium or Alum Root: Heuchera americana brevipetala

Mock Orange or Syringa: Philadelphus coronarius
Wild Hydrangea: Hydrangea arborescens
Dogberry or Prickly Gooseberry: Ribes cynosbati
Missouri Gooseberry: Ribes missouriense
Smooth Gooseberry: Ribes hirtellum
Garden Gooseberry: Ribes grossularia (planted)
Wild Black Currant: Ribes americanum
Garden or Red Currant: Ribes sativum (planted)

Hamamelidaceae - Witch-hazel Family
Witch Hazel, Winter Bloom or Snapping Hazel Nut: Hamamelis virginiana

Altingiaceae - Sweet Gum Family
Sweet Gum, Red Gum, Star-leaved Gum or Bilster: Liquidamdar styraciflua

Platanaceae - Plane Tree Family
Sycamore, Plane Tree, Buttonball or Buttonwood: Plantus occidentalis

Rosaceae - Rose Family
Ninebark: Physocarpus opulifolius
Meadowsweet or Meadow Spiraea: Spiraea albus
Bridal Wreath: Spiraea vanhoutteii (planted)
American Wood Strawberry or Sow-teat Strawberry: Fragaris vesca
Wild Strawberry: Fragaria virginiana
Old-field Cinquefoil: Potentilla simplex
Rough Cinquefoil: Potentilla norvegica
Sulfur Cinquefoil: Potentilla recta
Shrubby Cinquefoil: Potentilla fruticosa
Queen of the Prairie: Filipendula rubra
Spring Avens: Geum vernum
White Avens: Geum canadense
Rough Avens: Geum laciniatum
Dewberry:
- Rubus flagellaris
- Rubus enslenii

Southern Dewberry: Rubus trivialis
Common Blackberry:
- Rubus allegheniensis
- Rubus pensilvancus
- Rubus frondosus
- Rubus recuvans

Black Raspberry: Rubus occidentalis
Red Raspberry: Rubus idaeus (planted)
Agrimony: Agrimonia gryposepala

Woodland Agrimony: Agrimonia rostellata
Small-flower Agrimony: Agrimonia parviflora
Soft Agrimony: Agrimonia pubescens
Prairie Rose or Climbing Rose: Rose setigera
Multiflora Rose: Rosa multiflora (planted)
Sweetbrier Rose or Eglantine: Rosa eglanteria
Dog Rose: Rosa canina (planted)
Swamp Rose: Rosa palustris
Wild Rose:
    Rosa carolina
    Rosa blanda
Black Cherry, Cabinet Cherry or Rum Cherry: Prunus serotina
Choke Cherry: Prunus virginiana
Mahaleb Cherry or Perfumed Cherry: Prunus mahaleb (planted)
Sweet Cherry: Prunus avium (planted)
Sour Cherry: Prunus cerasus (planted)
Wild Plum: Prunus americana
Chickasaw Plum: Prunus angustifolia (planted)
Wild Goose Plum:
    Prunus munoniana
    Prunus hortulana
Peach: Prunus persica (planted)
Pear: Pyrus communis (planted)
Apple: Pyrus malus (planted)
Wild Crab Apple: Pyrus coronaria
Black Chokeberry: Pyrus melanocarpa
Purple Chokeberry: Pyrus floribunda
Mountain Ash: Pyrus aucuparia (planted)
Cockspur Thorn: Crataegus crus-galli
Hawthorn, Thorn or Red Haw:
    Crataegus punctata
    Crataegus disperma
    Crataegus intricata
    Crataegus biltmoreana
    Crataegus margaretta
    Crataegus macrosperma
    Crataegus pruinosa
    Crataegus rugosa
    Crataegus pedicellata
    Crataegus mollis
    Crataegus calpodendron
Fire Thorn: Cotoneaster pyracantha (planted)
Downy Serviceberry or Common Juneberry: Amelanchier arborea
Washington Thorn: Crataegus phaenophyrum

Leguminosae - Legume Family

Redbud or Judas Tree: Cercis canadensis
Honey Locust or Sweet Locust: Gleditsia triacanthos
Kentucky Coffee Tree: Gymnocladus dioica
Yellowwood: Cladrastis lutea (planted)
Black Locust: Robinia pseudo-acacia
Red Clover: Trifolium pratense
White Clover: Trifolium repens
Alsike Clover: Trifolium hydridum
Low Hop Clover: Trifolium procumbens
White Sweet Clover or White Melilot: Melilotus alba
Yellow Sweet Clover or Yellow Melilot: Melilotus officinalis
Black Medic or Nonesuch: Medicago lupulina
Alfalfa or Lucerne: Medicago sativa
Pointed-leaf Tickclover: Desmodium glutinosum
Few-flower Tickclover: Desmodium pauciflorum
Hoary Tickclover: Desmodium canescens
Canada Tickclover: Desmodium canadense
Panicled Tickclover: Desmodium paniculatum
Dellenius Tickclover: Desmodium dillenii
Large-bract Tickclover: Desmodium cuspidatum
Violet Bushclover: Lespedeza procumbens
Japan Clover: Lespedeza striata
Hairy Vetch: Vicia villosa
Wild Bean or Groundnut: Apios americana
Hog Peanut: Amphicarpa bracteata

Oxalidaceae - Wood Sorrel Family

Upright Yellow Wood Sorrel: Oxalis stricta
Lady's Sorrel: Oxalis europaea
Great Yellow Wood Sorrel: Oxalis grandis
Violet Wood Sorrel: Oxalis violacea

Geraniaceae - Geranium Family

Wild Geranium or Wild Cranesbill: Geranium maculatum

Rutaceae - Rue Family

Northern Prickly Ash or Toothache Tree: Xanthoxylum americanium
Common Hop Tree or Wafer Ash: Ptelea trifoliata

Simaroubaceae - Quassia Family

Ailanthus or Tree of Heaven: Ailanthus altissima

Euphorbiaceae - Spurge Family

Prairie Tea: Croton monanthogynus
Three-seeded Mercury: Acalypha rhomboidea
Eyebane or Nodding Spurge: Euphorbia preslii
Wortweed or Milk Purslane: Euphorbia maculata
Flowering Spurge: Euphorbia corollata
Toothed Spurge: Euphorbia dentata
Wood Spurge: Euphorbia commutata

Anacardiaceae - Sumac Family

Poison Ivy: Rhus radicans
Fragrant Sumac: Rhus aromatica
Winged Sumac: Rhus copallinum
Smooth Sumac: Rhus glabra
Staghorn Sumac: Rhus typhina
Poison Sumac: Rhus vernix
Smoke Tree: Cotinus coggygria (planted)

Aquifoliaceae - Holly Family

American Holly: Ilex opaca (planted)
Winterberry: Ilex verticillata

Celastraceae - Staff-tree Family

Climbing Bittersweet: Celastrus scandens
Oriental Bittersweet: Celastrus orbiculatus (planted)
Wahoo or Burning Bush: Euonymus atropurpureus
Winged Spindle Tree: Euonymus alatus (planted)
Running Strawberry Bush: Euonymus obovatus

Staphyleaceae - Bladdernut Family

Bladdernut: Staphylea trifolia

Aceraceae - Maple Family

Hedge Maple: Acer campestre (planted)
Sugar Maple or Hard Maple: Acer saccharum
Black Maple or Black Sugar Maple: Acer saccharum nigrum
Mountain Maple: Acer spicatum (planted)
Red Maple: Acer rubrum
Silver Maple, White Maple, or Soft Maple: Acer saccharinum
Box Elder or Ash-leaved Maple: Acer negundo

Hippocastanaceae - Horse-chestnut Family

Horse Chestnut: Aesculus hippocastanum
Ohio Buckeye: Aesculus glabra

Balsaminaceae - Touch-me-not Family

Spotted Touch-me-not or Jewelweed: Impatiens biflora
Pale Touch-me-not or Jewelweed: Impatiens pallida

Rhamnaceae - Buckthorn Family

New Jersey Tea: Ceanothus americanus
Common Buckthorn: Rhamnus catharticus
Lance-leaf Buckthorn: Rhamnus lanceolata
Alder Buckthorn: Rhamnus alnifolia

Vitaceae - Grape Family

Summer Grape: Vitis aestivalis
Frost Grape: Vitis vulpina
Riverbank Grape: Vitis reparia
Vine (no common name): Amelopsis brevipedunculata
Vine (no common name): Amelopsis cordata
Virginia Creeper or Woodbine: Parthenocissus quinquefolia
Creeper: Parthenocissus inserta
Fox Grape: Vitis labrusca
Sweet Winter Grape: Vitis cinerea

Tiliaceae - Linden Family

Basswood or American Linden: Tilia americana
White Basswood: Tilia heterophylla

Malvaceae - Mallow Family

Hollyhock: Althaea rosea (planted)
Common Mallow: Malva neglecta
Velvet-leaf or Piemarker: Abutilon theophrasti
Flower-of-an-hour: Hibiscus trionum (planted)
Rose of Sharon: HIbiscus syriacus (planted)

Hypericaceae - Sant-john's-wort Family

Common Saint-john's-wort: Hypericum perforatum
: Hypericum punctatum
: Hypericum mutilum
Shrubby Saint-john's-wort: Hypericum spathulatum
Saint-andrew's-cross: Ascyrum hypericoides multicaule

Violaceae - Violet Family

Meadow Violet or Common Blue Violet: Viola papilionacea
Woolly Blue Violet: Viola sororia
Arrow-leaf Violet: Viola sagittata

Trilobed Violet: Viola triloba
Smooth Violet: Viola eriocarpa
Cream Violet: Viola striata

Thymelaeaceae - Merzereum Family
Leatherwood, Wicopy or Ropebark: Dira palustris

Lythraceae - Loosestrife Family
Wingangled Loosestrife: Lythrum alatum

Onagraceae - Evening-primrose Family
Water or Marsh Purslane: Ludwigia palustris
Willow Herb: Epilobium coloratum
Evening Primrose: Oenothera biennis
Gaura: Gaura biennis
Enchanter's Nightshade: Circaea quadrisulcata

Elaeagnaceae - Russian Olive Family
Russian Olive: Elaegnus angustifolia (planted)
Goumi: Elaeagnus multiflora (planted)

Nyssaceae - Sour Gum Family
Black Gum or Sour Gum: Nyssa sylvatica

Araliaceae - Ginseng Family
Wild Sarsaparilla: Aralia nudicaulis
American Spikenard: Aralia racemosa
Ginseng: Panax quinquefolium
Devil's-walkingstick or Hercules'-club: Aralia spinosa

Umbelliferae - Parsley Family
Black Snakeroot or Sanicle: Sanicula gregaria
: Sanicula canadensis
: Sanicula trifoliata
Harbinger-of-Spring: Erigenia bulbosa
Honewort: Cryptotaenia canadensis
Erect Hedge Parsley: Torilis japonica (planted)
Sweet Cicely or Sweet Jarvil: Osmorhiza claytoni
Sweet Anise or Anise-root: Osmorhiza longistylis
Wild Carrot or Queen Anne's Lace: Daucus carota
Spreading Chervil: Chaerophyllum procumbens
Yellow Pimpernel: Taenidia integerrima
Golden Alexanders: Zizia aurea
Goutweed: Aegopodium podagraria

Poison Hemlock: Conium maculatum
Water Hemlock or Spotted Cowbane: Cicuta maculata
Meadow Parsnip: Thaspium trifoliatum
Hairy-jointed Meadow Parsnip: Thaspium barbinode
Purple Angelica or Alexanders: Angelica atropurpurea
Cowbane: Oxypolis rigidior
Parsnip: Pastinaca sativa

Cornaceae - Dogwood Family
Flowering Dogwood: Cornus florida
Pagoda Dogwood or Alternate-leaf Dogwood: Cornus alternifolia
Silky Dogwood: Cornus purpusi
Roughleaf Dogwood: Cornus drummondi
Gray Dogwood: Curnus racemosa
Red Osier: Cornus stolonifera

Ericaceae - Heath Family
Indian Pipe: Monotropa uniflora
Pinesap: Monotropa hypopithys
Leatherleaf: Chamaedaphne calyculata (planted)
Dewberry or Squaw-huckleberry: Vaccinium stamineum
Spotted Pipsissewa: Chimaphila maculata (sometimes in Pyrolaceae)

Primulaceae - Primrose Family
Shooting Star: Dodecatheon meadia
Water Pimpernel: Samolus floribundus
Fringed Loosestrife: Lysimachia ciliata
Lance-leaf Yellow Loosestrife: Lysimachia lanceolata
Moneywort: Lysimachia nummularia
Common Pimpernel: Anagallis arvensis

Ebenaceae - Ebony Family
Persimmon: Diospyros virginiana

Oleaceae - Olive Family
White Ash: Fraxinus americana
Green Ash: Fraxinus pennsylvanica subintegerrima
Red Ash: Fraxinus pennsylvanica pennsylvanica
Pumpkin Ash: Fraxinus tomentosa
Blue Ash: Fraxinus quadrangulata
Black Ash: Fraxinus nigra
Fringe Tree: Chronanthus virginicus (planted)
Privet: Ligustrum vulgare (planted)
Lilac: Syringa vulgaris (planted)

Gentianaceae - Gentian Family

American Columbo: Swertia caroliniensis

Apocynaceae - Dogbane Family

Periwinkle: Vinca minor

Spreading Dogbane: Apocynum androsaemifolium

Indian Hemp: Apocynum cannabinum

Asclepiadaceae - Milkweed Family

Butterfly Weed or Pleurisy Root: Asclepias tuberosa

Swamp Milkweed: Asclepias incarnata

Common Milkweed: Asclepias syriaca

Purple Milkweed: Asclepias purpurascens

Four-leaved Milkweed: Asclepias quadrifolia

Convolvulaceae - Morning Glory Family

Common Morning Glory: Ipomoea purpurea

Wild Potato Vine: Ipomoea pandurata

Field Bindweed: Convolvulus arvensis

Hedge Bindweed: Convolvulus sepium

Upright Bindweed or Low Bindweed: Convolvulus spithamaeus

Gronovius Dodder: Cuscuta gronovii

Polemoniaceae - Phlox Family

Blue Phlox: Phlox divaricata

Garden Phlox or Fall Phlox: Phlox paniculata

Wild Sweet William Phlox or Spotted Phlox: Phlox maculata

Jacob's Ladder or Greek Valerian: Polemonium reptans

Hydrophyllaceae - Waterleaf Family

Large Waterleaf: Hydrophyllum macrophyllum

John's Cabbage or Virginia Waterleaf: Hydrophyllum virginianum

Lavender Waterleaf or Appendaged Waterleaf: Hydrophyllum appendiculatum

Boraginaceae - Borage Family

Blueweed or Viper's Bugloss: Echium vulgare

Corn Gromwell: Lithospermum arvense

True Forget-me-not: Myosotis scorpioides

Hound's-tongue: Cynoglossum officinale

Wild Comfrey: Cynoglossum virginianum

Stickseed or Beggar's-lice: Hackelia virginiana

Virginia Bluebells: Mertensia virginica

Verbenaceae - Vervain Family

White Vervain: Verbena urticifolia
Blue Vervain or Simpler's-joy: Verbena hastata
Fogfruit: Phyla lanceolata

Labiatae - Mint Family

American Germander or Wood Sage: Teucrium canadense
Mad-dog Skullcap: Scutellaria lateriflora
Small Skullcap: Scutellaria leonardi
Common Horehound: Marrubium vulgare
Yellow Giant Hyssop: Agastache nepetoides
Catnip: Nepeta cataria
Large-flower Ground Ivy or Gill-over-the-ground: Glechoma hederacea
Self-heal, Heal-all or Carpenter Weed: Prunella vulgaris
Henbit: Lamium amplexicaule
Purple Dead Nettle: Lamium purpureum
Motherwort: Leonurus cardiaca
Smooth Hedge Nettle: Stachys hispida
Cordate Hedge Nettle: Stachys riddellii
Basil Balm: Monarda clinopodia
Wild Bergamot: Monarda fistulosa
Downy Blephilia: Blephilia ciliata
Wood Mint or Hairy Blephilia: Blephilia hirsuta
American Pennyroyal or Pudding Grass: Hedeoma pulegioides
Slender Mountain Mint: Pycnanthemum flexuosum
Virginia Mountain Mint: Pycnanthemum virginianum
Virginia Bugleweed or Virginia Water Horehound: Lycopus virginicus
American Bugleweed or Cutleaf Water Horehound: Lycopus americanus
American Wild Mint or Field Mint: Mentha arvensis
Spearmint: Mentha spicata
Peppermint: Mentha piperita

Solanaceae - Nightshade Family

Ground Cherry: Physalis heterophylla
Black Nightshade: Solanum nigrum
Horse Nettle: Solanum carolinense
Climbing Nightshade or Bittersweet: Solanum dulcamara (planted)
Tomato: Lycopersicon esculentum (planted)
Common Matrimony Vine: Lycium halimifolium (planted)
Jimsonweed or Stramonium: Datura stramonium

Scrophulariaceae - Figwort Family

Figwort: Leucopora multifida
Violet Monkey Flower: Mimulus ringens

Sharp-winged Monkey Flower: Mimulus alatus
Common Mullein: Verbascum thapsus
Moth Mullein: Verbascum blattaria
White Turtlehead: Chelone glabra
Eastern Penstemon: Penstemon hirsutus
Foxglove Penstemon: Penstemon digitalis
Carpenter's Square or Maryland Figwort: Scrophularia marilandica
Butter-and-eggs: Linaria vulgaris
Dwarf Snapdragon or Lesser Toadflax: Chaenorrhinum minus
Culver's Root: Veronicastrum virginicum
Thyme-leaved Speedwell: Veronica serpyllifolia
Neckweed or Purslane Speedwell: Veronica peregrina
Corn Speedwell: Veronica arvensis
Common Speedwell: Veronica officinalis
Mullein Foxglove: Dasistoma macrophylla
Large-flowered Agalinis: Gerardia purpurea
Common Lousewort or Wood Betony: Pedicularis canadensis

Bignoniaceae - Trumpet-creeper Family
Trumpet Creeper: Campsis radicans
Northern Catalpa or Cigar Tree: Catalpa speciosa

Orobanchaceae - Broom-rape Family
Beechdrops: Epifagus virginiana

Acanthaceae - Acanthus Family
Smooth Ruellia: Ruellia strepens
Dense-flowered Water Willow: Justicia americana

Phymaceae - Lopseed Family
Lopseed: Phryma leptostachya

Plantaginaceae - Plantain Family
Rugel Plantain: Plantago rugelii
English Plantain or Ribgraas: Plantago lanceolata

Rubiaceae - Madder Family
Partridgeberry: Mitchella repens
Buttonbush: Cephalanthus occidentalis
Goosegrass or Spring Cleavers: Galium aparine
Wild Licorice: Galium circaezans
Sweet-scented Bedstraw: Galium triflorum
Pretty Bedstraw: Galium concinnum

Caprifoliaceae - Honeysuckle Family

Black Haw, Stag Bush or Sloe: Viburnum prunifolium
Southern Black Haw: Viburnum rufidulum
European Cranberry Bush: Viburnum opulus (planted)
Mapleleaf Viburnum or Arrowwood: Viburnum acerifolum
Downy Arrowwood: Viburnum rafinesquianum
Nannyberry or Blackthorn: Viburnum lentago
Common Elder, Elderberry or Sweet Elder: Sambucus canadensis
Red-berried Elder: Sambucus pubens
Japanese Honeysuckle: Lonicera japonica (planted)
Wild Honeysuckle: Lonicera dioica glaucescens
Grape Honeysuckle: Lonicera prolifera
Coralberry or Indian Current: Symphoricarpos orbiculatus
Common Horse Gentian: Triosteum perfoliatum perfoliatum

Valerianaceae - Valerian Family

Corn Salad or Lamb's-lettuce - Valerianella radiata

Dipsacaceae - Teasel Family

Wild Teasel: Dipsacus sylvestris

Cucurbitaceae - Gourd Family

Wild Balsam Apple or Wild Cucumber: Echinocystis lobata
Bur Cucumber: Sicyos angulatus

Campanulaceae - Harebell Family

Tall Bellflower: Campanula americana
Venus's Looking-glass: Triodanis perfoliata

Lobeliaceae - Lobelia Family

Large Blue Lobelia: Lobelia siphilitica
Indian Tobacco: Lobelia inflata
Pale-spike Lobelia: Lobelia spicata

Compositae - Composite Family

Common Sunflower: Helianthus annuus
: Helianthus hirsutus
Paleleaf Wood Sunflower: Helianthus strumosus
Jersualem Artichoke: Helianthus tuberosus
Wingstem or Yellow Ironweed: Verbesina alternifolia
Sunflower Heliopsis or Smooth Oxeye: Heliopsis helianthoides
Black-eyed Susan: Rudbeckia hirta
Showy Coneflower: Rudbeckia speciosa
Brown-eyed Susan: Rudbeckia triloba

Cutleaf Coneflower: Rudbeckia laciniata
Prairie Coneflower: Ratibida pinnata
Nodding Bur Marigold: Bidens cernua
Swamp Bur Marigold: Bidens tripartita
Black Beggar-ticks or Sticktight: Bidens frondosa
Tall Beggar-ticks or Sticktight: Bidens vulgata
Tickseed Sunflower: Bidens coronata
Small-flower Leafcup: Polymnia canadensis
Cup Plant: Silphium perfoliatum
Whorled Rosinweed: Silphium trifoliatum
Giant Ragweed: Ambrosia trifida
Common Ragweed: Ambrosia artemisiifolia
Cocklebur: Xanthium strumarum
Common Dogfennel or Mayweed: Anthemis cotula
Common Yarrow or Milford: Achillea millefolium
Oxeye Daisy: Chrysanthemum levacnthemum
Common Tansy or Golden Buttons: Tanacetum vulgare
Sweet Wormwood: Artemisia annua
Round-leaved Groundsel: Senecis obovatus
Golden Ragwort or Squaw-weed: Senecis Aureus
Fireweed or Pilewort: Erechtites hieracifolia
Pale Indian Plantain: Cacalia atriplicifolia
Zig-zag Goldenrod: Solidago flexicaulis
Wreath Goldenrod or Blue-stem Goldenrod: Solidago caesia
Roughleaf Goldenrod: Solidago patula
Elmleaf Goldenrod: Solidago ulmifolia
Canada Goldenrod: Solidago canadensis
Bush Fragrant Goldenrod: Solidago graminifolia
Common Blue Wood Aster: Aster Cordifolius
Arrowleaf Aster: Aster sagittifolius
New England Aster: Aster novae-angliae
Purple-stem Aster: Aster puniceus
Smooth Aster: Aster laevis
Crooked-stem Aster: Aster prenanthoides
Heath Aster or Hairy Aster: Aster pilosus
White Woodland Aster or Starved Aster: Aster lateriflorus
Panicled Aster: Aster simplex
Robin's Plantain or Snowy Fleabane: Erigeron pulchellus
Philadelphia Fleabane: Erigeron philadelphicus
Daisy Fleabane or White Top: Erigeron strigosus
: Erigeron annuus
Horseweed: Conyza canadensis
Plantain-leaf Pussytoes or Everlasting: Antennaria plantaginifolia

Spotted-stem Joe-pye Weed: Eupatorium maculatum
Purple-stem Joe-pye Weed: Eupatorium purpureum
Tall Thoroughwort: Eupatorium altissimum
Common Boneset or Thoroughwort: Eupatorium perfoliatum
White Snakeroot: Eupatorium rogosum
Tall Ironwood: Vernonia altissima
Common Burdock: Arctium minus
Bull Thistle or Common Thistle: Cirsium vulgare
Field Thistle: Cirsium discolor
Tall Thistle: Cirsium altissimum
Canada Thistle: Cirsium arvense
Tall Rattlesnake Root, Gall of the Earth: Prenanthes altissima
Hawkweed: Hieracium scabrum
Common Dandelion: Taraxacum officinale
Common Sow Thistle: Sonchus oleraceius
Spiny-leaved Sow Thistle: Sonchus asper
Tall Yellow Lettuce: Lactuca canadensis
Prickly Lettuce: Lactuca serriola
Florida Lettuce: Lactuca floridana
Common Chicory or Blue-sailors: Cichorium intybus
Goatsbeard: Trogopogon pratensis

The foregoing checklist lists species existing in the Miami Valley. Agriculture food crop and ornamental species excepting trees are not entered on this list. Certain species are indicated as "planted." These particular entries indicate species which are considered as "escaped from cultivation" or raised as ornamental trees. It should be noted that only two conifers, the Ground Hemlock (American Yew) and the Red Cedar, are native to the Miami Valley. All other conifers listed have been planted and propagated in the area.

APPENDIX B
ATMOSPHERIC DISPERSION CALCULATIONS

All calculations of atmospheric dispersion are based on a Gaussian Dispersion Plume model as suggested by Pasquill (1961) and modified by Gifford (1961). (1) The equation used is

$$\chi(x, y, z; H) = \frac{Q}{2\pi\sigma_y\sigma_z u} \exp\left[-\frac{1}{2}\left(\frac{Y}{\sigma_y}\right)^2\right]\left\{\exp\left[-\frac{1}{2}\left(\frac{Z-H}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{Z+H}{\sigma_z}\right)^2\right]\right\}$$

where χ = concentration (Ci/m^3)

x, y, z = rectangular coordinates downwind, transverse (horizontal), and vertical with the origin at the base of the stack (m)

H = effective stack height, $\Delta h + h$, where h represents the stack height and Δh is the plume rise, $3W_oD/u$, calculated on the basis of the simple expression suggested by Briggs, (2) where

W_o = Stack flow (m/sec)

D = stack diameter (m)

u = wind speed (m/sec)

Q = emission rate (Ci/sec)

σ_y, σ_z = standard deviations of plume concentration distribution in the horizontal and vertical planes, respectively. The values of both σ_y and σ_z are evaluated in terms of the downwind distance, x.

If the concentration is to be calculated along the centerline and at ground level, i.e., y = 0 and z = 0, the equation simplifies to:

$$\chi(x, 0, 0; H) = \frac{Q}{\pi\sigma_y\sigma_z u} \exp\left[-\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right].$$

The dispersion computation can be modified for the situation where a stable layer of air will have the effect of restricting the vertical diffusion:

$$\chi(x, 0, 0; H) = \frac{Q}{\sqrt{2\pi}\sigma_y Lu}$$

from any z from 0 to L for $x > 2$; $\sigma_z = 0.47L$, where L is the height (m) to the base of the stable layer of air.

Graphical solutions to these equations for all categories are presented in Figures B-1 to B-6.

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2. G. A. Briggs, Plume Rise, AEC Critical Review Series, USAEC, Division of Technical Information Extension, Oak Ridge, Tennessee, 1969 (TID-25075).

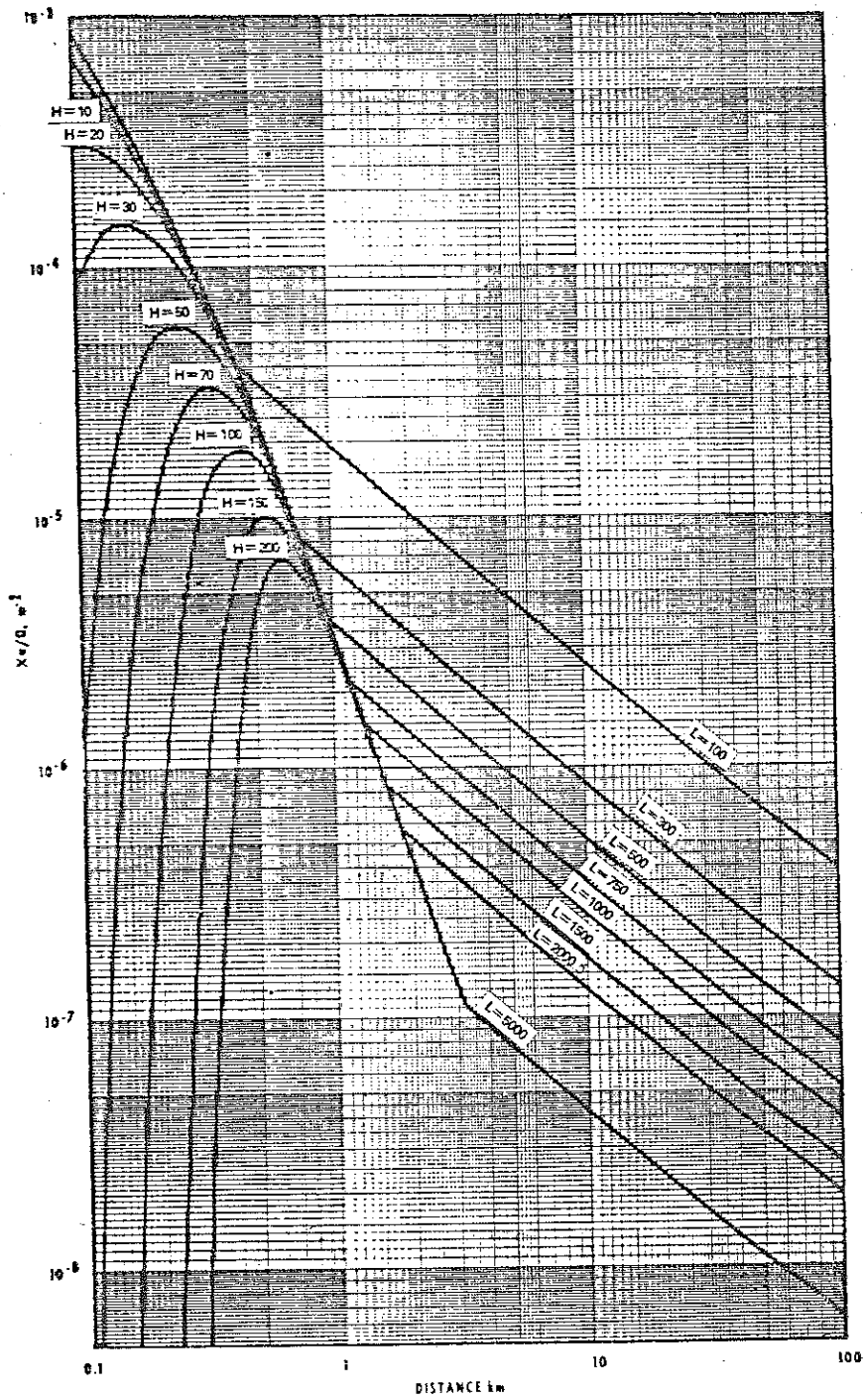

FIGURE B-1 - χu/Q with distance for various heights of emission (H) and limits to vertical dispersion (L), A stability.

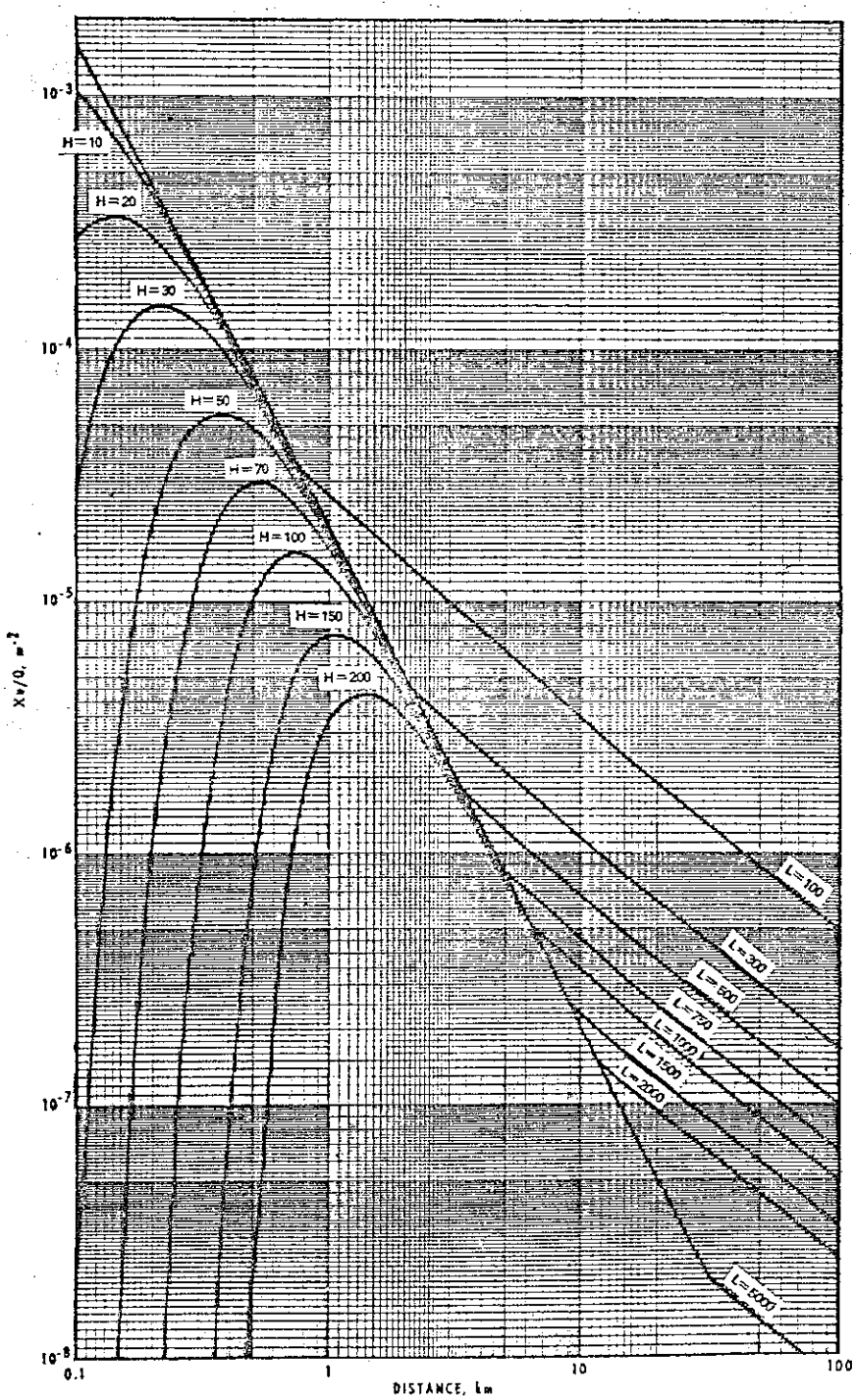

FIGURE B-2 - $\chi u/Q$ with distance for various heights of emission (H) and limits to vertical dispersion (L), B stability.

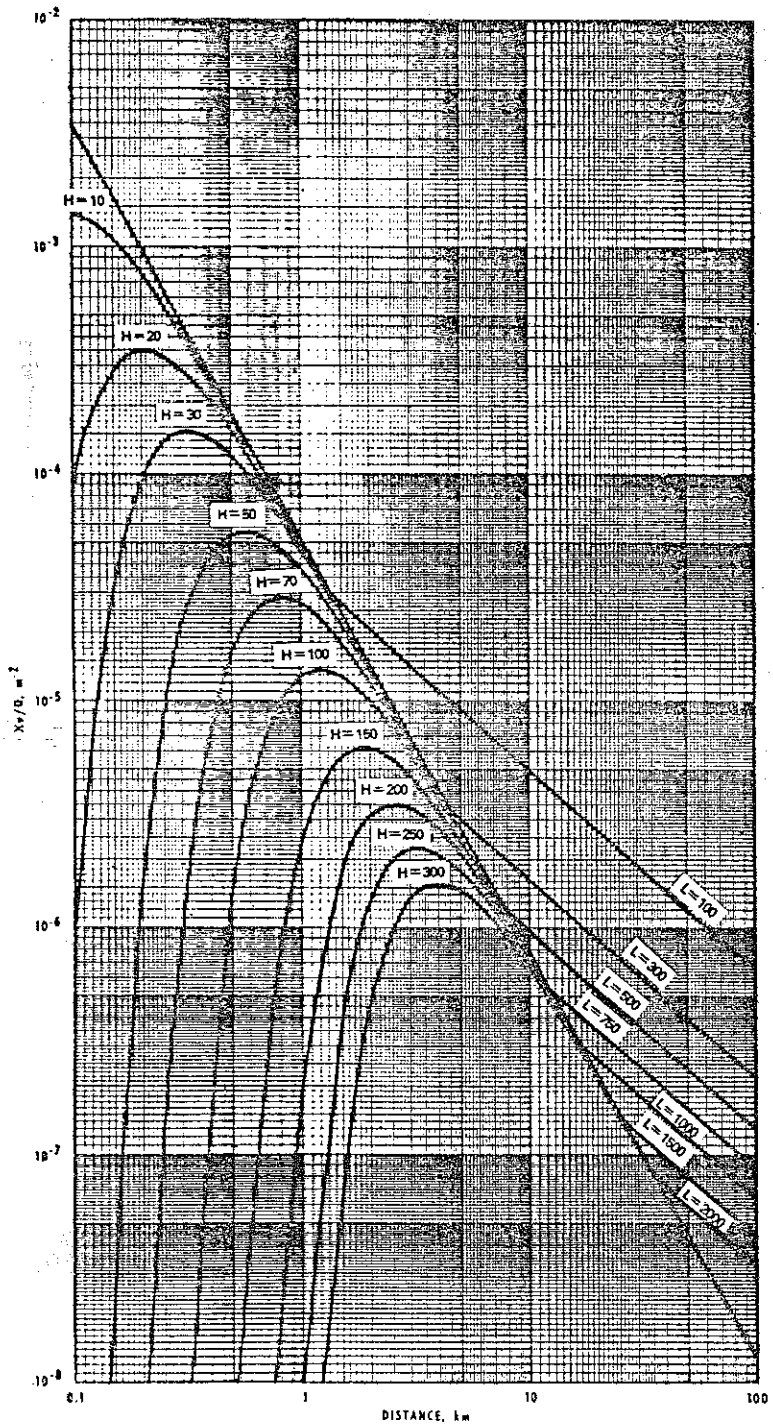

FIGURE B-3 - χu/Q with distance for various heights of emission (H) and limits to vertical dispersion (L), C stability.

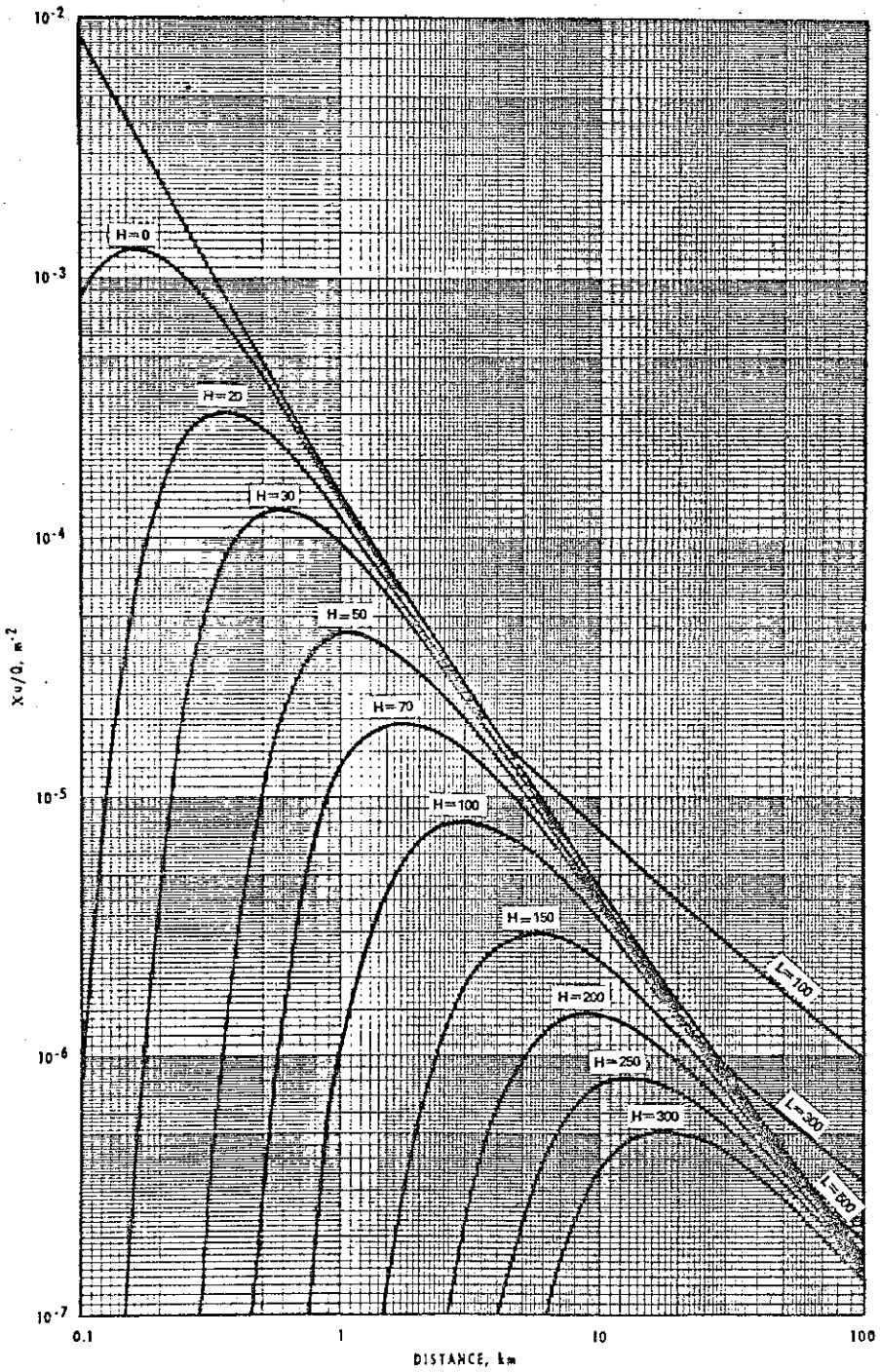

FIGURE B-4 - $\chi u/Q$ with distance for various heights of emission (H) and limits to vertical dispersion (L), D stability.

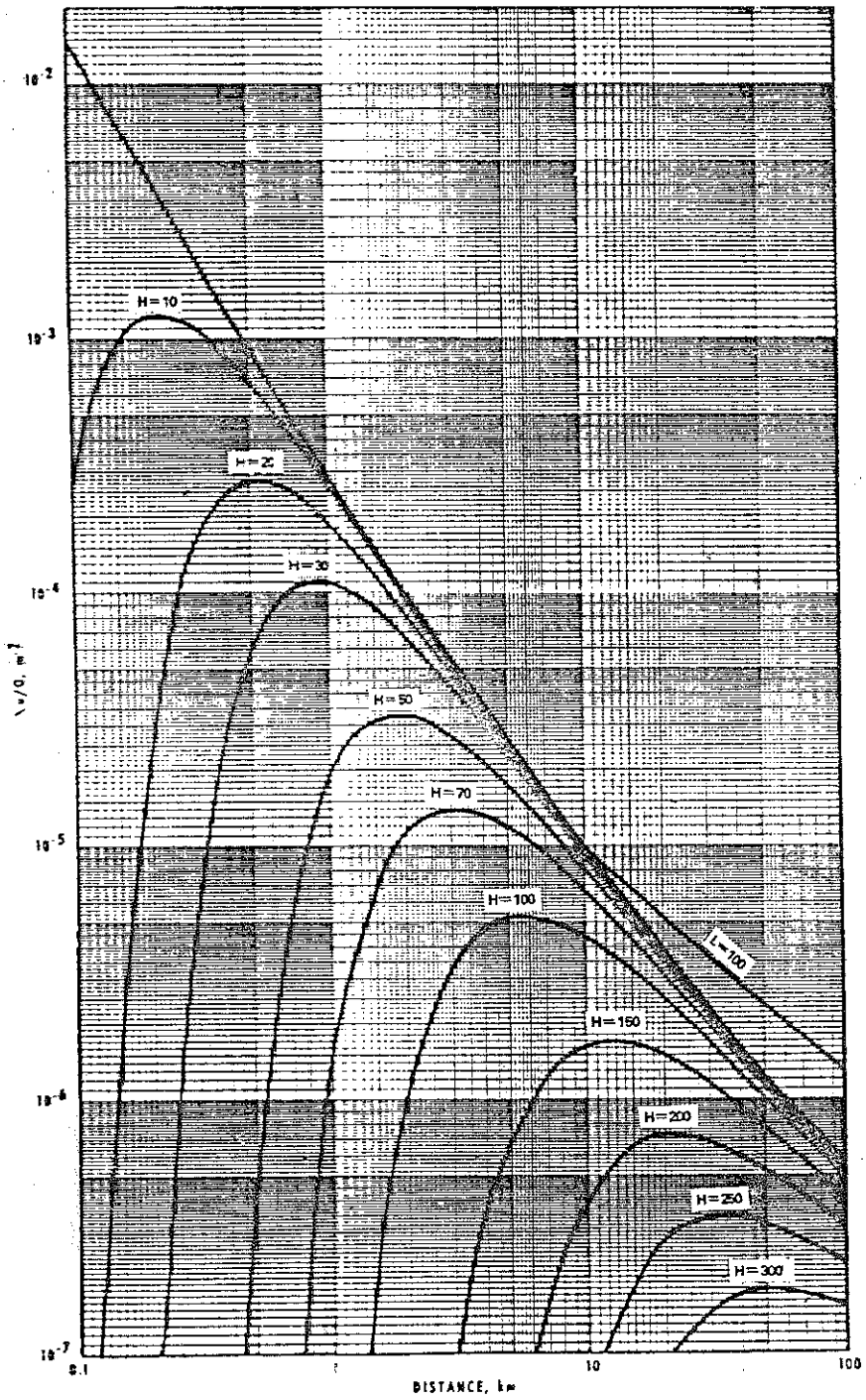

FIGURE B-5 - $\chi u/Q$ with distance for various heights of emission (H) and limits to vertical dispersion (L), E stability.

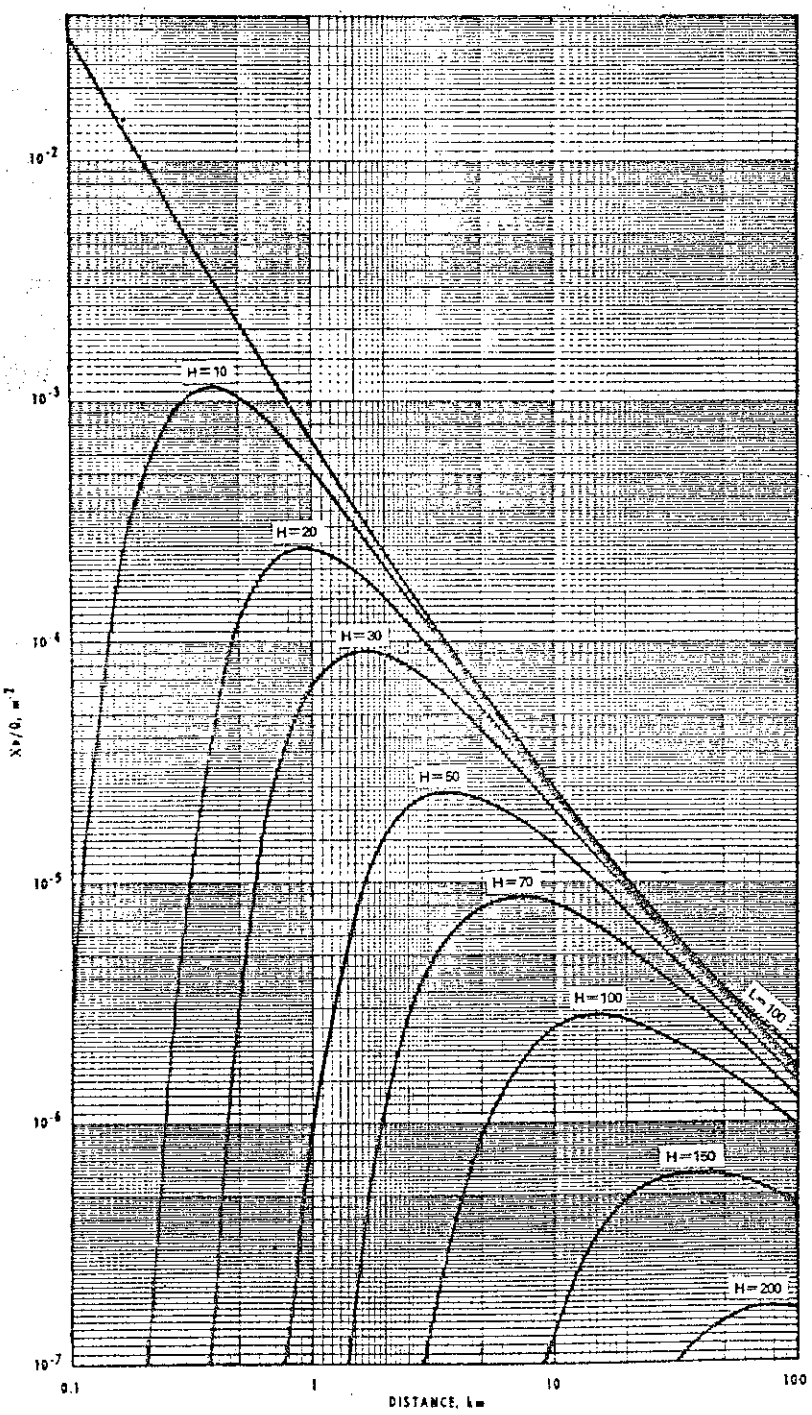

FIGURE B-6 - $\chi u/Q$ with distance for various heights of emission (H) and limits to vertical dispersion (L), F stability.

APPENDIX C
CALCULATIONS FOR RADIONUCLIDE UPTAKE

I. Methodology and Assumptions Utilized for Dose Commitment Calculations as a Result of Acute Uptake of a Radionuclide

Assumptions

1. An individual remains at the point of maximum ground level concentration for the duration of the release.
2. An individual breathes at a rate of 2.0×10^4 ml/min.
3. Lung deposition is based on the model suggested by the Task Group on Lung Dynamics. (1)
4. Duration of lifetime is 70 years.
5. Tritium oxide is assimilated through the lungs at a rate of about 10 μCi of tritium absorbed per minute per μCi of tritium per liter of ambient air. (2)
6. The quantity of elemental tritium assimilated through the lungs is based on the following equation. (3)

$$K = \frac{C}{V}\left[(0.4 \times 10^{-4})t + (1.7 \times 10^{-4})\left(\frac{t^2}{2} + \frac{t}{2}\right)\right]\left[20 \times 10^{-3}\right] m^3 \qquad (1)$$

where K = Ci assimilated

$\frac{C}{V}$ = concentration (Ci/m^3)

t = period of exposure (min)

7. The amount of tritium absorbed through the skin is equal to the amount absorbed through the lungs.

Calculations

The integrated dose commitment was arrived at by the following:

$$D_o^t = \frac{51.1\ q[\Sigma EF(RBE)n]f_2}{\lambda m}(1 - e^{-\lambda t}) \qquad (2)$$

where D_o = integrated dose (rem)

q = body burden (μCi)

$\Sigma EF(RBE)n$ = effective energy term (E in MeV)

f_2 = fraction in organ of reference of that in total body

λ = effective decay constant = 0.693/T

T = effective half life (days)*
m = mass of organ (grams)
t = period of exposure (days)

The values of the parameters used in the calculations are presented in Table 1.

Table 1

VALUE OF PARAMETERS[4]

Isotope	ΣEF(RBE)n	Organ of Reference	Mass m(g)	Effective T	f_2
Pu-238	57	Lung	1000	240[5]	1
H-3	0.0057[5]	Whole Body	70000	12	1

II. Methodology and Assumptions Utilized for Dose Commitment Calculations as a Result of a Chronic Uptake of a Radionuclide

The integrated dose an individual would receive from the observed concentrations of tritium in the environment was computed by a direct comparison with the Radiation Concentration Guide.

$$D = \frac{\chi}{RCG} (D_{RCG}) \qquad (3)$$

where D = dose (rem/year)
χ = observed average concentration (μCi/ml)
RCG = Radiation Concentration Guide (μCi/ml)
D_{RCG} = dose resulting from an exposure to a radionuclide at a concentration equal to the RCG (rem/year).

The dose resulting from exposure to tritium was reduced by a factor of 1.7 to reflect an RBE of one.

The dose equivalent to the lung resulting from continuous inhalation of airborne plutonium-238 was calculated by:

$$D(t) = \frac{51.1\ C\ I_a t\ f_a f_r \Sigma EF(RBE)\chi}{\lambda m} \left(1 - \frac{1 - e^{-\lambda t}}{\lambda t}\right) \qquad (4)$$

*The effective half life is a combination of the biological and radioactive half lives of the ingested material and, by definition, is $(T_{\frac{1}{2}} T_b)/(T_{\frac{1}{2}} + T_b)$ where T_b and $T_{\frac{1}{2}}$ are the biological and radioactive half lives, respectively.

where $D(t)$ = dose equivalent delivered to the lung in 365 days of continuous exposure to plutonium-238 in air, rem/yr

C = average airborne concentration, μCi/ml

I_a = average air intake = 2×10^7 ml/day

t = time exposed, 365 days

f_a = fraction of inhaled material reaching organ of interest = 0.7 (max.) pulmonary region (1)

f_r = fraction of pulmonary deposition undergoing long-term retention = 0.6 for actinide (class Y) (1)

$\Sigma EF(RBE)_\chi$ = effective energy deposition per disintegration = 57

λ = effective decay rate, 0.0014 day^{-1} for actinides (class Y) from the pulmonary region (7)

m = lung mass, 1000 g

The dose equivalent to bone resulting from continuous inhalation of airborne plutonium-238 was calculated by:

$$D(t) = \frac{51.1\ C\ I\ f\ t\ \Sigma EF(RBE)_\chi}{\lambda m} \left(1 - \frac{1 - e^{-\lambda t}}{\lambda t}\right) \qquad (5)$$

where f = 0.2 (Ref. 1)

$\Sigma EF(RBE)_\chi$ = 284 (Ref. 1)

m = 7×10^3 g (Ref.1)

λ = 3×10^{-5} day^{-1} (Ref. 1)

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1. "Deposition and Retention Models for Internal Dosimetry of Human Respiratory Tract," Health Physics, Vol. 12, No. 2.
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3. H. L. Rarrick, G. E. Tucker, Jr., An Approximation of Radiation Dose Resulting from an Accidental Release of Tritium Gas, SCTM-406-59(33), United States Atomic Energy Commission, Technical Information Service.
4. Report of Committee II on Permissible Dose for Internal Radiation, 1959, ICRP Publication 2.
5. W. R. Wood, Jr., and W. E. Sheehan, "Evaluation of the PUQFUA Method of Calculating Systemic Burdens," American Industrial Hygiene Association Journal, Vol. 32, Jan. 1971.
6. Environmental Radiation Dose Commitment: An Application to the Nuclear Power Industry, U. S. Environmental Protection Agency, Office of Radiation Programs, EPA-520/4-73-002.
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APPENDIX D
PLUTONIUM TOXICITY

The following discussion of health effects of exposure to plutonium has been adapted for application to Mound Facility operations from a review of transuranium exposure health effects by R. C. Thompson and W. J. Bair of the Battelle, Pacific Northwest Laboratory, Richland, Washington. [1]

Prediction of the human health consequences attributable to the release of plutonium to the environment is necessarily indirect and highly uncertain. There is a lack of any positive information on effects of this element in either man or experimental animals at the very low exposure levels anticipated. There also is a lack of understanding of the mechanisms by which such effects occur. This understanding, if available, would aid in the extrapolation of data obtained at much higher exposure levels. Data relevant to such predictions are considered in this Appendix under four general headings: (1) experience with transuranic elements in man, (2) experience with natural radiation in man, (3) data from animal experiments on plutonium toxicity, and (4) data on effects of other types of radiation on man. Consideration is given to the general problems of extrapolation from animal to man, and extrapolation from the exposure levels producing observable effects, to the very much lower exposure levels predicted to result from Mound Facility operations. The controversy regarding the influence of spatial distribution of dose on resultant biological effects is also addressed.

The general approach followed in this appendix is that of Appendix II.G of the LMFBR Environmental Statement [2] with modifications reflecting the newer information now available.

D.1 EXPERIENCE WITH TRANSURANIC ELEMENTS IN MAN

No serious health consequences have been observed in man attributable to the transuranic elements. Evidence of effects at the cellular level (e.g., histologically observed effects surrounding a plutonium-contaminated wound [3,4] and possible increases in chromosome aberrations following accidental exposure [5] cannot be related to exposure levels in any manner useful to predictive analysis. Consideration must therefore be limited to the kind and magnitude of exposures that have occurred without evidencing effects. Such exposures arise from two principal sources: the world-wide plutonium fallout from atmospheric testing of nuclear weapons and other devices, and the accidental exposure of plutonium workers.

Exposure to Fallout Plutonium

As the result of atmospheric testing of nuclear weapons, an estimated 320 kilocuries of long-lived plutonium isotopes have been deposited on the surface of the earth, of which about 250 kilocuries is deposited on the northern hemisphere and 16 kilocuries

on the United States [6,7]. Measurements of this plutonium in the air, in soil, in foods, and in man constitute a "natural" experiment of pertinence to the estimation of the biological behavior of transuranic elements in general and specifically for plutonium released from the Mound Facility.

Estimates of human organ burdens and doses resulting from fallout plutonium have been made by Bennett, employing the ICRP lung model and the data on New York City plutonium air concentrations (measured since 1965 and estimated prior to that date by analogy with measured strontium-90) [8]. Assuming no intake subsequent to 1972 and calculating dose commitment to the Year 2000, Bennett arrived at the estimates given in Table D-1. These estimates assume no intake by ingestion and involve a cumulative inhalation intake from 1954 to 1972 of 42 picocuries (1 picocuries = 10^{-12} curies) per person, or 8 millicuries total for a present U. S. population of about 2×10^{8}. For comparison, Table D-1 also lists the 23-year dose commitments estimated to result from Mound Facility operations from 1977 cumulative to the Year 2000 assuming the plutonium airborne concentration in the metropolitan area remains constant to the Year 2000.

Direct measurements have been made of fallout plutonium in autopsy samples. Because the plutonium levels are at the lower limits of analytical capabilities, many of the earlier values reported were highly uncertain. The best available data are those reported from the Los Alamos Scientific Laboratory on samples from Colorado and New Mexico [8,9]. These determinations employed larger tissue samples than have usually been available, and improved analytical procedures. The measured organ burdens are compared in Table D-2 with calculated organ burdens based on the New York plutonium air concentrations and the ICRP lung model. The agreement is quite good, except for lymph

Table D-1

ESTIMATED RADIATION DOSE TO THE MIAMISBURG METROPOLITAN AREA POPULATION FROM FALLOUT PLUTONIUM AND FROM MOUND FACILITY OPERATIONS TO THE YEAR 2000

Organ	Dose Equivalent from Fallout Pu[a] (million man-rem)	Dose Equivalent from Mound Routine Operations[b] (million man-rem)
Lung	0.021	0.0013
Bone	0.046	0.0025
Liver	0.023	0.0004

[a]Per capita estimate of Bennett, based on New York City air concentrations, multiplied by 1,330,000 population (estimated average) for the Miamisburg metropolitan area. [8]

[b]Assumes an incremental increase in population from 1977 to the Year 2000 (1980 = 1,126,000; 1990 = 1,377,000; and 2000 = 1,564,000

Table D-2

FALLOUT PLUTONIUM IN MAN
(Colorado and New Mexico, 1970-1978)

Organ	Number of Samples	Plutonium in Organ (10^{-12} curies) Measured	Calculated from New York Air Concentration[a]
Lung	96	0.3	0.3
Bone	96	1.4	0.9
Liver	88	1.4	0.8
Lymph Nodes	73	0.03	0.6
Kidney	73	0.1	–
Total		3.2	2.6

[a]Calculated by Bennett using ICRP lung model. (8)

nodes. The low measured value in lymph nodes may reflect a greater solubility of fallout plutonium than assumed in the model. Proportionately larger amounts of plutonium are observed in the lymph nodes of experimental animals and plutonium workers exposed to insoluble plutonium oxide.

Although these data on fallout plutonium in man cannot be linked to any measured effects, they do suggest that effects in the general population around the Rocky Flats site from material deposited in man as a result of Rocky Flats operations would be insignificant compared to the effects from fallout plutonium. Since the deposition of fallout plutonium in the population in Ohio would be similar to that calculated for New York and measured in autopsy material from Colorado and New Mexico, because of equal latitudinal distribution of plutonium fallout it can be stated that the effects of Mound's plutonium operations on the surrounding population would also be insignificant as compared to fallout since the amount of plutonium released from Mound operations has been less than that from the Rocky Flats Plant operations.

Occupational Exposure

More than 9,000 persons have been specifically identified as having been employed in operations that might lead to significant plutonium exposure (Table D-3). [10] The total number of potentially exposed persons is considerably larger. About 3,000 of the more than 9,000 persons have shown some measurable evidence of internal plutonium deposition. Data on employeees of contractors operating AEC-owned facilities are summarized for the period 1957-1970 in Table D-4, which lists the numbers of persons with estimated plutonium depositions in excess of 10 nanocuries (1 nanocurie = 10^{-9} curies)

Table D-3

STATISTICS ON OCCUPATIONAL EXPOSURE FROM THE U.S. TRANSURANIUM REGISTRY - OCTOBER 1975 [10]

Location	Specific Identification	Number of Persons for Whom Registry Has: Release of Health Physics and Medical Health Data	Authority For Autopsy	Autopsy Performed
Hanford	2367	2174	533	14
Rocky Flats	1772	1611	173	34
Los Alamos	3024	257	127	3
Savannah River	1567	0	0	0
Mound	333	8	9	1
Oak Ridge	0	0	0	1
Total	9063	4050	842	53

Table D-4

USAEC CONTRACTOR EMPLOYES WITH ESTIMATED PLUTONIUM DEPOSITIONS IN EXCESS OF 10 NANOCURIES FOR THE PERIOD 1957 - 1970[a]

Number of Persons	Deposition Range (10^{-9} Ci)
118	10 - 20
35	20 - 30
13	30 - 40
15	40 - 80
15	80 - 200
7	200 - 400
203	

[a]Data from Reference 11 supplemented by more recent data from the ERDA Division of Operational and Environmental Safety.

grouped according to deposition level [11]. If all persons are assumed to contain the minimum of their range, the total deposition in these 203 persons is about 5 microcuries (1 microcurie = 10^{-6} curies). This may still be too high a value, since estimates of individual deposition, based on urine assay, are almost always high. However, if one considers the much larger number of persons with deposits of less than 10 nanocuries, the persons exposed prior to 1957 and after 1970, and the exposed licensee employees not tabulated, then it seems reasonable to conclude that at least 5 microcuries of plutonium are deposited in approximately 3,000 workers.

The U. S. Transuranium Registry was established in 1968 to obtain information from these occupationally exposed persons. It is operated by the Hanford Environmental Health Foundation, with cooperation from Pacific Northwest Laboratory, Los Alamos Scientific Laboratory, the Rocky Flats Plant and Mound Facility. The Registry seeks to identify potentially exposed workers, obtain their health physics and medical records, and their permission for post-mortem sampling. Permission for post-mortem sampling and for access to medical records is at the workers' discretion. Registry operations are summarized in Table D-3 [10]. The accumulating autopsy data are in general agreement with data on the distribution of plutonium in experimental animals, and thus support the extrapolation of animal toxicity data to man.

One group of exposed persons is of particular interest because of their early exposure, their relatively high level of exposure, and the thoroughness of the followup studies. [12] These 25 laboratory workers were exposed during 1944 and 1945 while working at what is now the Los Alamos Scientific Laboratory, under conditions that would be judged crude and unacceptable by today's standards. Their individual body burdens are estimated to range from 5 to 420 nanocuries, totaling, in the aggregate, about 2.5 microcuries. These burdens have now been retained for more than 30 years. One of the 25 died of a coronary occlusion at age 33, and another died as the result of an automobile accident. None have shown medical findings attributable to internally deposited plutonium.

Another group of plutonium workers of particular interest are the 25 workers with initial lung burdens greater than 0.04 microcuries who were exposed during the Rocky Flats Plant fire of 1965 [13]. Aside from the cytogenetic effects noted below, there have been no detectable medical effects observed in these workers.

An increased incidence of chromosome aberrations in lymphocyte culture is a very sensitive indicator of radiation exposure. An increased incidence of such chromosome aberrations has been reported in plutonium-exposed Rocky Flats Plant employes [5]. Even though continuing studies on these workers indicate a linear dose-response relationship between systemic plutonium burden and aberration frequency, the results do not appear to be useful for predicting ultimate health effects. An increased incidence of chromosome aberrations was also observed in English plutonium workers, but could not be differentiated from possible effects of external irradiation [14]. In any case, the occurrence of these chromosome aberrations in cultured lymphocytes is not known to relate, in any way, to ultimate biological effects influencing survival.

In view of the relatively small number of persons with sizable plutonium depositions, it seems unlikely that statistically valid inferences with regard to toxic effects will ever be made. This would not be true, however, if plutonium were markedly more toxic than is currently believed. Thus, the 2.5 microcuries presently retained by the Los Alamos subjects must have amounted to about 10 microcuries originally

deposited, which, after 30 years, should have shown significant effects if the canc risk were as high as postulated by Tamplin and Cochran [15]. This point was convincingly made in a paper by Cave and Freedman [16].

D.2 EXPERIENCE WITH NATURAL RADIATION IN MAN

Experience with transuranic elements in man is limited to the present generation. Other alpha-emitting elements, however, are a natural part of man's environment. He has lived with these internally deposited radioelements and with radiation from other natural sources throughout the history of the species. A comparison of the radiation doses from these natural sources with those predicted to result from Mound Facility operations should be instructive.

Table D-5 summarizes data from a recent NCRP Report on natural background radiation in the United States [17]. Also shown in Table D-5 are estimates of radiation exposures due to Mound Facility's routine operations. Whether one compares the maximum exposed individual or the average Miamisburg area resident, Mound Facility's contribution is a very small fraction of the background exposure.

Table D-5

NATURAL BACKGROUND RADIATION EXPOSURE COMPARED WITH ESTIMATED EXPOSURE FROM ROUTINE MOUND FACILITY OPERATIONS

Source	Annual Dose Equivalent (mrem/person)				
	Bone				
	Surface	Marrow	Lung	Liver	Gonad
Natural Background[a]					
Cosmic radiation	28	28	28	-	28
Cosmogenic radionuclides	0.8	0.7	0.7	-	0.7
Externalterrestrial	26	26	26	-	26
Inhaled radionuclides[b,c]	-	-	100 (100)	-	-
Radionuclides in body[c]	60 (44)	24 (8)	24 (4)	-	27 (8)
Total	120	80	180		80
Mound Facility Routine Operations					
Maximum Individual[d]	0.044[e]		0.110	0.013	0.001[f]
Average Metropolitan Area Resident[g]	0.004[e]		0.010	0.001	0.0001[f]

[a] United States average; data from Tables 43, 44, and 45 of Reference 17.
[b] Almost entirely alpha emitters.
[c] Alpha component in parentheses, balance is largely due to ^{40}K.
[d] Taken from Table 3-19.
[e] Average bone dose.
[f] Total body dose.
[g] Calculated average dose commitment to all individuals in the Miamisburg Metropolitan area (approximately 880,000 people).

D.3 EFFECTS OF TRANSURANIC ELEMENTS IN EXPERIMENTAL ANIMALS

Direct information on the toxicity of transuranic elements is available only from studies in experimental animals. The radiobiological literature suggests that the biological effects observed in such animal experiments will at least qualitatively approximate those that would occur in man exposed under the same conditions. For this reason, it is important to look to the extensive results of animal experimentation for guidance in estimating the health risks from exposure to transuranic elements.

The acute toxicity of injected plutonium is due primarily to destructive effects on the blood-forming system, resulting from irradiation of the bone marrow by plutonium deposited on bone surfaces, or released from these surfaces into the marrow [18,19].

In the case of inhaled plutonium, acute death in experimental animals results from pulmonary edema, hemorrhage, and inflammatory destruction of the functional tissue of the lung [19,20].

Acute toxicity is conventionally expressed in terms of an "LD_{50}" dose; i.e., the dose required to kill 50% of the animals within some specified period of time, usually 30 days. For intravenously injected tetravalent plutonium-239 citrate, in rats, the $LD_{50/30}$ is about 70 microcuries per kilogram. A similar value was observed for mice. A somewhat lower value, 20 microcuries per kilogram was observed in dogs; however, this was with injected hexavalent plutonium. The $LD_{50/30}$ for inhaled plutonium in rats and dogs was not very different from the values for injected plutonium. All of these dose values will vary somewhat depending on the compound administered and the valence state of the plutonium. It seems unlikely, however, that acute death would result from an internally deposited dose of less than 10 microcuries per kilogram, which translates to 700 microcuries for a 70-kilogram man. This amounts to about 10 milligrams of plutonium-239, or about 40 micrograms of plutonium-238 [19].

Long-term effects occur at very much lower exposure levels than those required to produce acute death, and it is these long-term effects that are the only concern at the very low exposure levels that might result from Mound Facility releases. The incidence of cancer appears to be the most sensitive measure of these long-term effects. The organs in which plutonium is retained in highest concentrations are the bone, liver, lung, and lymph nodes. In all of these organs, tumor formation has been observed in animals as a result of plutonium deposition, most significantly in bone and lung.

Effects in Bone

An informative experiment on the toxic effects of plutonium in bone is the beagle study in progress at the University of Utah. This experiment was initiated in 1952 and was designed to compare the long-term effects of intravenously injected plutonium and radium. The comparison with radium is of particular interest because extensive data are available on the toxicity of radium in man.

Table D-6 shows the status of the plutonium-injected animals in this experiment. [21] In the earliest injected groups, all animals are now dead. In all of these groups, there was a very substantial incidence of bone cancers. With decreasing dose, the time to tumor appearance increased until, in the lowest dose group, the average life span was not significantly different from that of the controls. Additional groups at lower dose levels were exposed beginning in 1964; nearly all of these animals are still alive.

Of more interest than absolute cancer incidence figures, is the finding in the Utah studies that plutonium-239 is radiologically 16 times more toxic than radium-226, on the basis of the same total energy delivered to bone [21]. This difference is attributable to the more hazardous localization of plutonium on bone surfaces, near the cells from which bone tumors originate.

Numerous long-term studies in rodents have also pointed to bone cancer as the most sensitive indicator of the toxicity of injected plutonium. Cancer incidence data from some of these studies are summarized in Table D-7. These data were selected from a more extensive tabulation by Bair, [22] and include only experiments or experimental groups meeting the following criteria: (1) radiation dose to bone was evaluated in the study, (2) more than one exposure level was studied, (3) cancer incidence did not exceed 50 percent, and (4) life shortening was not excessive. These criteria should help to exclude results showing a misleadingly low cancer incidence due to saturation effects or early death from other causes.

Table D-6

PLUTONIUM-INDUCED BONE CANCERS IN UTAH DOG STUDY [21]

Injected Dose (uCi/kg)[a]	Tumor Incidence	Dogs with Bone Cancer		
		Years to Death	Dose to Skeleton[b] (rad)	(rem)
2.9	7/9 = 78%	4.1	4710	235,500
0.9	12/12 = 100%	3.6	1410	70,500
0.3	12/12 = 100%	4.5	581	29,050
0.1	10/12 = 83%	7.2	231	11,550
0.05	10/14 = 71%	8.9	135	6,750
0.016	4/14 = 29%	9.9	55	2,750
Controls	0	9.9(for all control dogs)		

[a]Additional studies are in progress at dose levels of 0.016, 0.006, 0.002, and 0.0006 microcurie per kilogram.

[b]Cumulative dose to one year before death.

Table D-7

PLUTONIUM-INDUCED BONE CANCERS IN EXPERIMENTAL ANIMALS [22]

Species	Administration		Bone Dose Equivalent (rem)	Bone Cancer Incidence	
	Compound	Route		Fractional	Per rem
Mouse	Citrate	Intravenous	2000	0.039	2.0×10^{-5}
			4200	0.08	1.9×10^{-5}
			6500	0.180	2.7×10^{-5}
			20000	0.430	2.2×10^{-5}
Rat	Citrate	Inhaled	830	0.013	1.6×10^{-5}
			1640	0.056	3.4×10^{-5}
			3820	0.025	0.7×10^{-5}
			6700	0.032	
			12200	0.11	0.9×10^{-5}
			17800	0.19	1.0×10^{-5}
Rat	Citrate	Oral	1650	0.03	1.8×10^{-5}
			2850	0.074	2.6×10^{-5}
Rat	Citrate	Intra- and Subcutaneous	2600	0.04	1.5×10^{-5}
			25650	0.25	1.0×10^{-5}
Rat	Carbonate	Inhaled	180	0.01	5.6×10^{-5}
			320	0.011	3.4×10^{-5}
			1260	0.031	2.5×10^{-5}
			6000	0.12	2.0×10^{-5}
Rat	Nitrate	Intratracheal	2565	0.016	0.6×10^{-5}
			5850	0.04	0.7×10^{-5}
			20900	0.09	0.4×10^{-5}
			44000	0.13	0.3×10^{-5}
Dog[a]	Citrate	Intravenous	2750	0.29	10.5×10^{-5}
			6750	0.71	10.5×10^{-5}
			11550	0.83	7.2×10^{-5}

[a]Date of Reference 22 altered to reflect more recent data reported in Reference 21.

It should be noted that calculation of the rem doses listed in Table D-6 involves the use of a quality factor of 10 and a distribution factor of 5; rem doses are therefore 50 times the rad doses. The bone cancer incidence per rem shows rather close agreement, both within and between experiments. This suggests that cancer incidence is an approximately linear function of radiation dose to bone over the ranges studied; that it is not greatly influenced by the compound or route of administration; and that mice, rats, and dogs show a similar sensitivity, although dogs appear to be more sensitive than rodents. These similarities of behavior lend confidence to the use of these numbers for the estimation of effects in man.

Effects in Lung

The toxicity of inhaled plutonium may be illustrated with data from an experiment conducted at Pacific Northwest Laboratory, involving the inhalation of $^{239}PuO_2$ by beagle

dogs [23]. This experiment was initiated in the late 1950's; it involved some 65 dogs the last of which died in 1973. Of the 21 dogs that survived more than 4.5-years post-exposure, 20 had malignant lung tumors. Tumor incidence figures are therefore of little help in interpreting these results. Life-shortening, however, showed a dose-effect relationship, as indicated in Figure D-1. Each point in this figure represents a dog. Most of the dogs died early, within a year or two following plutonium exposure, with symptoms of respiratory distress occasioned by severe pulmonary fibrosis. There appears to be about a 3-year minimum latency period before a lung cancer can develop; a longer latency period is associated with smaller doses. A line fitted to all of these points intersects the normal life span of the beagle dog at a deposition of about 5 nanocuries per gram of lung. This extrapolation is very uncertain, however. If one draws the best line through the closed circles (the tumor-bearing animals), a steeper slope is obtained. Clearly, more data are needed from dogs exposed at lower levels. Experiments to obtain these data are in progress [23].

The utility of the Pacific Northwest Laboratory beagle data is limited because of the relatively few animals in the study and the high exposure levels, which resulted in essentially 100% lung cancer incidence. These data are included only to illustrate the relationship between latency prior to the appearance of lung tumors and the quantity of plutonium inhaled - a relationship which suggests that at lower concentration levels, the latency period may exceed the normal life span of these animals.

Data on the induction of lung tumors in rats that inhaled compounds of plutonium or americium were recently reviewed by Bair and Thomas [24]. Their conclusions are summarized in Table D-8. The rem doses for lung are 10 times the rad doses, reflecting a quality factor of 10, but no distribution factor. The incidence per rem is substantially higher for lung tumors in rats than for bone tumors in rats (Table D-7).

Effects in Other Organs

In terms of plutonium content and radiation dose received, liver is in the same class with bone and lung. However, the liver seems less radiosensitive than bone and lung. Malignant liver tumors were the primary cause of death in two of 96 plutonium dogs in the Utah experiment [25]. Small, benign, bile duct tumors were incidental findings at autopsy in eight other dogs, but such tumors were also seen in controls at a somewhat lower incidence. The liver tumors showed a typically long latent period, which suggests that at lower dose levels and lower incidences of bone and lung tumors, liver tumors might become more important relative to bone and lung tumors.

Lymph nodes draining the lung, or sites of intramuscular plutonium deposition, may accumulate plutonium concentrations many times higher than concentrations seen elsewhere in the body. Various histopathologic changes have been observed in the trach bronchial lymph nodes of dogs that inhaled plutonium, but these changes were not

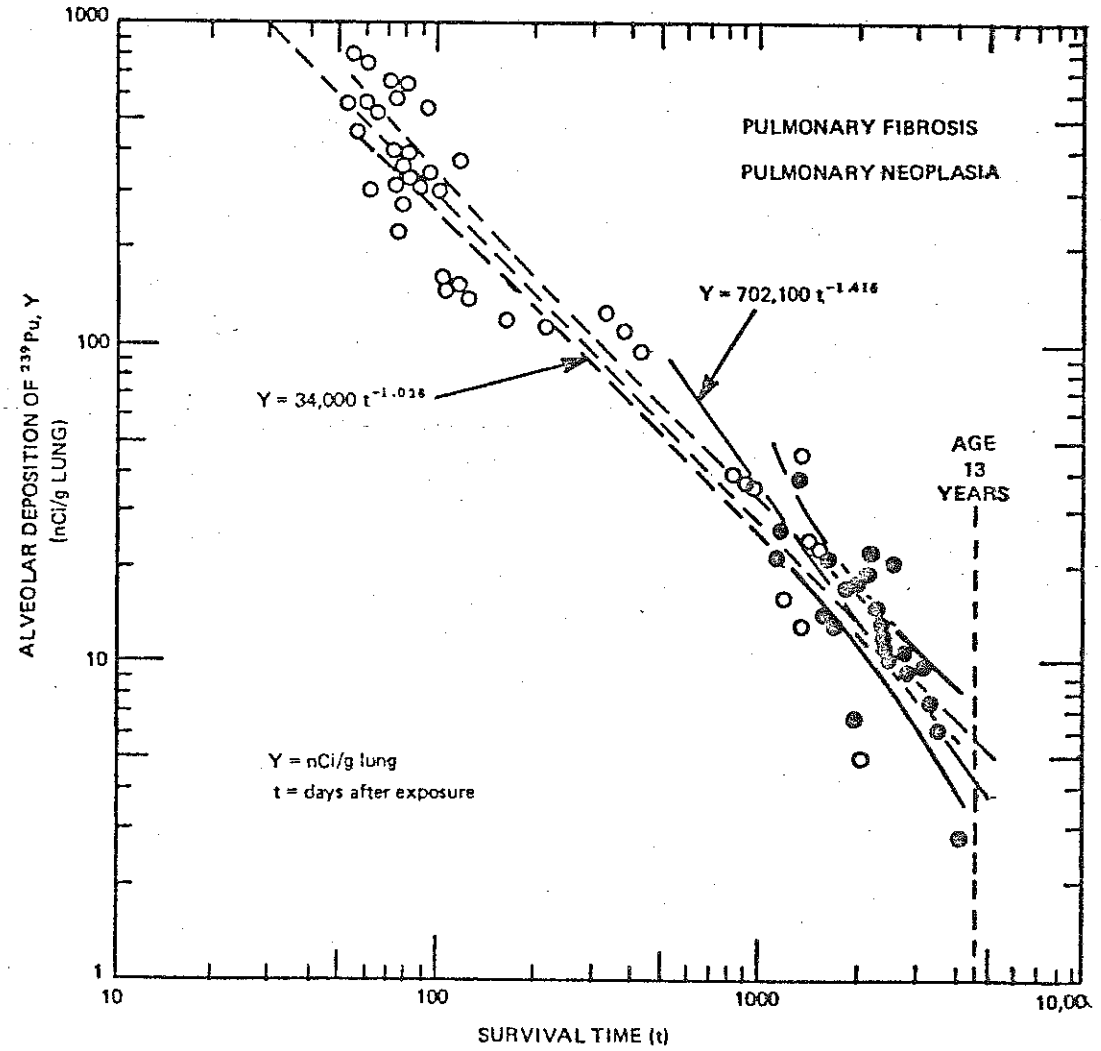

FIGURE D-1 - Relationship Between the Quantity of Inhaled $^{238}PuO_2$ Deposited and Survival Time of Dogs.[22]

Table D-8

LUNG CANCER IN RATS FOLLOWING INHALATION OF ALPHA-EMITTING PLUTONIUM OR AMERICIUM COMPOUNDS[a]

Chemical Form Inhaled	Cancer Incidence Per Rem		
	Mean	Maximum	Minimum[b]
"soluble"	8×10^{-5}	10×10^{-5}	6×10^{-5}
"insoluble"	16×10^{-5}	20×10^{-5}	13×10^{-5}

[a]Data from Reference 24.
[b]95% confidence interval.

obviously detrimental. Tumors have been seen only rarely, and their relationship to plutonium exposure is uncertain. Indirect effects on immune capability or on lymph drainage are considered most unlikely at the low levels of exposure projected [22,23]. The ICRP, while recognizing the higher burdens and dose commitments in the lymph nodes relative to the lungs, skeletal system, and liver, has not considered the thoracic lymph nodes to be a critical organ [26].

Effects on the production or survival of the various types of blood cells have been studied in many of the experiments on plutonium toxicity. A variety of such effects are noted at high exposure levels [19]. The most sensitive of these effects is probably the reduction in blood lymphocytes following deposition of plutonium in the lung. [23] One cannot rule out the possibility of a relationship between this effect on lymphocytes, lymph node pathology, decreased immunological capability, and the pathogenesis of plutonium-induced lung tumors.

Since plutonium on bone surfaces will irradiate portions of the bone marrow, concern has been expressed that leukemia might be an important delayed effect of plutonium exposure. Although leukemias have, in rare instances, been reported to result from plutonium exposure, they have occurred only following rather large doses, and at a much lower incidence than bone tumors [18,27].

Effects in testes or ovaries at the cellular or tissue level have been observed only following plutonium doses much higher than the doses which would have resulted in other evidences of toxicity. [28,29] Although studies of multi-generation genetic effects have not been performed, an investigation of cytogenetic effects in the testes of hamsters showed no significant increase in the frequency of chromosome aberrations after calculated radiation doses of 1 and 4 rads. [30]. The exposures employed in this study would result in significant life shortening and cancer-induction, suggesting that genetic risks are small compared to somatic risks. Studies of chromosome aberrations in the germ cells of male mice after protracted exposure to ^{239}Pu, with doses ranging from 14 to 44 rads, showed significant effects, in agreement with predictions based on previous studies with gamma ray and neutron exposures and

assumed radiobiological effectiveness (RBE) and distribution factors. [31] Recent studies in mice have indicated that the critical spermatogonial stem cells of the testis may receive a 2 to 2.5 times higher dose from deposited plutonium than the average for the testis, due to inhomogeneties of distribution. [32] However, the total deposition of plutonium in the gonads is low, in all animal species studied, so that even allowing for preferential exposure of stem cells, the dose to these cells would not be expected to exceed the total body average. [33]

D.4 EFFECTS OF OTHER TYPES OF RADIATION IN MAN

In the absence of data on the effects of transuranic elements in man, some inferences regarding these effects may be drawn from observations of the effects from other forms of ionizing radiation in man. Such inferences would be based on data derived from medical, occupational, accidental, or wartime exposure of humans to different radiation sources: external X radiation, atomic-bomb gamma and neutron radiation, radium, radon and radon daughters, etc. Such information was recently summarized by the National Academy of Sciences - National Research Council Committee on the Biological Effects of Ionizing Radiations [34] and by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). [35] Both groups arrived at comparable risk estimates for the expected mortality from radiation-induced cancer. The NAS-NRC document, commonly referred to as the BEIR report, presents these estimates in a form that is conveniently applicable to the estimation of risks in populations that include the normal age distribution, and will be used here as a source document for cancer risk estimates. The BEIR report will also be employed to derive genetic risks that might be attributed to a retained burden of transuranic elements in the gonads. Risk estimates derived in the BEIR report are all linearly extrapolated from human experience at relatively high dose rates and total doses; the validity of such extrapolations will be discussed later in this Appendix.

Cancer Effects

The extensive human data considered in the BEIR report will not be reviewed here; it should be noted, however, that effects of irradiation from external rather than internal sources, in particular the data from Japanese atomic bomb survivors and irradiated spondylitics, were heavily weighted in arriving at risk estimates. The BEIR report makes estimates of both absolute risk and relative risk and for each of these assumes either a 30-year or a duration-of-life interval following the latent period, during which risk remains elevated. This leads to four risk estimates. Only the two estimates which lead to the lowest and the highest predictions of cancer mortality are considered here; the lowest being the absolute risk model with a 30-year plateau, referred to as the "absolute model," and the highest being the relative risk model with a lifetime plateau, referred to as the "relative model." Each of these models makes separate risk estimates for the in utero, 0-9 years, and 10+ years age periods, reflecting age differences in the sensitivity to irradiation. The derivation of these

risk estimates and their application to the U. S. population is summarized in tables on pages 169 and 171 of the BEIR report, [34] where the excess deaths due to cancers other than leukemia for the U. S. population, per 0.1 rem, per year, are predicted as 1,210 by the "absolute model" and 8,340 by the "relative model."

The fraction of these non-leukemia cancers that are bone cancers is given as 0.04, and the fraction that are lung cancers is given as 0.26. No fraction is given for liver cancers, which fall in the BEIR report's "GI including stomach" category, which is 0.20 of the non-leukemia cancers. It is assumed that these cancers will be induced in direct proportion to their incidence in the Hiroshima-Nagasaki survivors, where primary liver cancers accounted for about 0.08 of the GI cancers. Therefore, 0.016 (the product of 0.08 and 0.20) is considered the fraction of the total non-leukemia risk that is attributed to liver cancers.

Taking the fraction of the predicted non-leukemia cancers attributable to each cancer type and converting population dose to a man-rem basis, one arrives at the risk estimates shown in Table D-9. Leukemia risks were not estimated because dose to bone marrow from bone-deposited transuranic elements is small compared to the dose to other organs, and because leukemia has been rarely seen in animal experiments with plutonium [18,27].

The cancer risk from irradiation of thoracic lymph nodes was also neglected, even though these nodes, in experimental animals, receive a radiation dose from plutonium that is higher than the dose to any other organ. [22] The incidence of lymphosarcoma, reticulosarcoma, Hodgkin's disease, and/or multiple myeloma has been observed to be increased in Japanese atomic bomb survivors, [36-38] in patients receiving radiotherapy for ankylosing spondylitis, [39] and in radiologists who entered practice in the days preceding current restrictions on occupational exposure. [40] For this reason, the lymphoid and reticular tissues were classified by the ICRP Task Group [41] as being "apparently" high in susceptibility to the carcinogenic effects of radiation; however, it was noted by the Task Group that at least some of the neoplasms included in this group (e.g., multiple myeloma) appear to arise in the bone marrow. Whether, in fact, any of these neoplasms is attributable to transformation of cells in lymphoid tissues, as opposed to transformation of precursor cells in the bone marrow, is debatable in light of current concepts of cell population kinetics in the lymphatic and reticular system. At present, therefore, in the absence of evidence that localized irradiation of lymphatic tissue is carcinogenic in human or animal populations, it seems inappropriate to attempt to estimate such cancer risks.

England's Medical Research Council (MRC), considering nearly the same information covered in the BEIR and UNSCEAR reports, arrived at somewhat different, single estimates of fatal cancer risk from irradiation of the tissues of concern. [42] The MRC risk estimate for lung was 25×10^{-6} per man-rem, which falls between the two BEIR estimates listed in Table D-9. The MRC risk estimate for bone was 5×10^{-6} per man-rem,

Table D-9

DERIVATION OF CANCER MORTALITY RISK ESTIMATES FROM BEIR REPORT ESTIMATES

1	2	3	4	5
Cancer Type	Risk Model[a]	Fraction of Non-Leukemia Cancers[b]	Predicted Excess Deaths per Year per 0.1 Rem per Year Continuous Exposure of U.S. Population[c]	Predicted Excess Deaths per Man-Rem[d]
Non-leukemia	"Absolute"	1.0	1,210	
	"Relative"	1.0	8,340	
Lung	"Absolute"	0.26	315	16×10^{-6}
	"Relative"	0.26	2,168	110×10^{-6}
Bone	"Absolute"	0.04	48	2×10^{-6}
	"Relative"	0.04	334	17×10^{-6}
Liver	"Absolute"	0.016	19	1×10^{-6}
	"Relative"	0.016	133	7×10^{-6}

[a] "Absolute" refers to BEIR report absolute risk model with 30-year plateau following latent period during which risk remains elevated. "Relative" refers to BEIR report relative risk model with lifetime plateau.

[b] Fractions given in BEIR report (p. 171) for age 10 or more assumed to apply to all categories. Fraction for liver cancers is not given in BEIR report, but estimated as explained in text.

[c] Non-leukemia deaths taken from BEIR report (p. 169). Others calculated by application of fractions listed in Column 3.

[d] Calculated from numbers in Column 4 by multiplying by 10 (converting to rem basis) and dividing by 2×10^8 (U.S. population total employed in derivation of Column 4 numbers).

which also falls between the two BEIR estimates listed in Table D-9. The MRC considered its bone risk estimate as possibly "much too large." The MRC risk estimate for liver was 20×10^{-6} per man-rem, which is substantially higher than either of the estimates listed in Table D-9. This liver risk estimate was based upon recently summarized data on the induction of liver cancer by "Thorotrast," a preparation of thorium dioxide. [43] As pointed out by the MRC, these data are of uncertain relevance because of the large quantities (grams) of thorium involved, which might be chemically carcinogenic, and which might reduce the effective radiation dose because of self-absorption.

Also of interest are recently accumulated data on the carcinogenicity of radium-224 in human bone. [44,45] These data are particularly relevant to risks from plutonium since radium-224 has a very short half-life (3.62 days) and, because of this, irradiates only the surface layer of bone, in much the same manner as plutonium. When administered repeatedly, as it was to a large number of German patients shortly after the Second World War, the resultant exposure of bone should closely mimic that received from plutonium. Based on these data, Mays, et al., estimate a bone cancer risk of 4×10^{-6} per man-rem

and present convincing arguments for concluding that, at the high dose level employed, this estimate cannot be too high or too low by more than a factor of ten. [21]

Genetic Effects

The genetic risks considered in the BEIR report include the full spectrum of genetic defects seen in the U. S. and other Western nations. Their effects upon the carrier may range from a lethal action occurring at any time of life (from before birth until death), to minor metabolic consequences that may be nearly undetectable. The genetic spectrum ranges from dominant single gene mutants whose effects may be categorically recognized, to subtle genetic contributions to disease conditions that are predominantly of environmental or non-genetic origin. As a consequence, it is not appropriate to compare or equate estimates of genetic risk directly with cancer risks, where case incidence and case mortality are substantially one-to-one.

The BEIR report (pp. 54-57) summarizes its risk estimates for genetic defects in terms of a 5 rem per generation dose to a population of one million. [34] Converting these numbers to a man-rem basis, one obtains the risk estimates of Table D-10. The range of these estimates reflects a 10-fold uncertainty in the value of the mutation rate doubling dose, which is assumed to lie in the range of 20-200 rem. There is a further uncertainty with regard to the magnitude of the genetic component of the defects with complex etiology.

Table D-10

DERIVATION OF GENETIC DEFECT RISK ESTIMATES FROM BEIR REPORT ESTIMATES

1	2	3
Type of Risk	Predicted Defects per Million Persons per 5 Rem per Generation at Equilibrium[a]	Predicted Defects per Man-Rem[b]
Specific Genetic Defects[c]	250 - 2500	50×10^{-6} to 500×10^{-6}
Defects with Complex Etiology[d]	50 - 5000	10×10^{-6} to 1000×10^{-6}

[a]Values taken from Table 4, page 57 of BEIR report. [34]

[b]Equal to values of Column 2 divided by 5×10^{-6}.

[c]Includes dominant diseases, chromosomal and recessive diseases.

[d]Includes congenital anomolies, anomolies expressed later, constitutional and degenerative diseases.

An additional category of genetic risk discussed in the BEIR report is that concerned with general "ill health" of uncertain genetic determination. This risk was conservatively estimated as a 0.5 to 5.0 percent increase in the equilibrium incidence of ill health per 5 rem per generation. Thus, for the total U. S. population, 10^9 man-rem per generation would increase ill health by 0.5 to 5 percent.

Many uncertainties are involved in these genetic risk estimates, as reflected in the following statement from page 59 of the BEIR report: [34]

> "It is clear that these estimates are subject to great uncertainty. The ranges of plausible values are broad, and there is no assurance that the true values are within these ranges. We are well aware that future information will necessitate revisions. The estimates are presented, not as accurate scientific information (as scientists we would prefer to defer judgment until the information is solid), but as reasonable values based on current knowledge which, crude and uncertain as they are, may serve as a better guide to rational uses of radiation than no estimates at all."

Some of the uncertainty referred to above would seem to have been resolved by recent data gleaned from the vital statistics records of the Canadian province of British Columbia. [46] These exceptionally well-organized statistics covering two million people indicate an incidence of simple dominant hereditary disease of 0.08 percent as compared to the 1 percent incidence employed in obtaining the BEIR report risk estimates. Newcombe has argued persuasively that "the bulk of the most directly pertinent experimental studies thus fail to demonstrate any important effect of irradiation on the irregularly inherited diseases, or on general health and well being," and concludes that only the dominant hereditary diseases "are likely to increase in direct proportion to the mutation rate...." [47] On the basis of these newer data, Newcombe's estimate of total genetic risk is 10×10^{-6} per man-rem. [47]

D.5 ESTIMATION OF THE EFFECTS OF TRANSURANIC ELEMENTS IN MAN

Data relevant to the estimation of health effects in man have been presented in the preceding sections of this Appendix. These data, or for that matter, any experimentally obtainable data, are not adequate for the precise prediction of such possible health effects. Many assumptions must be employed, and the conclusions that are reached are meaningful only in the light of these assumptions. Particularly critical are the assumptions involved in the various extrapolations required and the assumptions involved in reducing plutonium exposure to the common denominator of radiation dose. A discussion of these problems is presented in this section, followed by the conclusions employed in evaluation of health effects in this Environmental Statement.

Extrapolation from Animal to Man and to Very Low Exposure Levels

Estimation of the human risks associated with the uptake of very low levels of transuranic elements involves several kinds of extrapolation. Whether based on observations

in experimental animals or man, there is the problem of extrapolating to much lower exposure levels than are covered by the data. The available human data are for types of radiations that do not include internally deposited transuranic elements; one must extrapolate, based largely on experience with external irradiation. Experimental animal data are available for transuranic element toxicity, but one must extrapolate from animal to man.

The extrapolation of toxicity data from animal to man is the most familiar of these extrapolation processes. That such extrapolation can be justified is an underlying assumption of most toxicological research. Where data from several animal species are in reasonable agreement, it is assumed, in the absence of conflicting evidence, that man will behave similarly. This assumption is more confidently made in the case of acute effects. For long-term effects, species differences have more opportunity to manifest themselves, and differences in life span may be of significance.

Fortunately, for the case of bone-deposited alpha-emitters, one can make some direct comparisons between human and experimental animal toxicity data. Table D-11 compares data on radium toxicity in man and in experimental animals. [21,48] In most studies, the incidence of bone cancers per rad is higher in animals than in man. For radium, the extrapolation error, from animal to man, would thus result in a conservative overestimate of effect in man. Although such a conclusion cannot be confidently assumed to apply to the case of transuranium elements, the agreement in radium data for man is at least encouraging.

As noted in the previous section, the data on the effects of radium-224 in man are the most applicable data for the estimation of plutonium effects in man. This is because radium-224, with its short half-life (3.62 days), irradiates only the surface layer of bone, as does plutonium. [21]

Aside from the human radium data, experience with alpha-emitters in man is of little help in these evaluations. Data on alpha-radiation-induced lung tumors in uranium miners, and liver tumors in thorotrast patients, suffer from inherent dosimetric complexities that seriously limit their usefulness. Recent studies have shown no significant excess of lung cancer in uranium miners in the dose range of 120 Working Level Months. [34,49] This dose of 120 WLM has been variously related to doses ranging from 60 rad [34] to 1,800 rad [50] to the basal cell layer of the respiratory epithelium, with 240 to 840 rad often being the range suggested. [49,51] The uranium miner data were, nevertheless, considered as one source of input in the derivation of BEIR report risk estimates for radiation induced lung cancer.

The thorotrast-injected patients do show an increased liver cancer and leukemia incidence; however, this incidence results from the very inhomogeneous deposition of about 5 grams of thorium in the liver, which bears little dosimetric relationship to

Table D-11

COMPARISON OF RADIUM TOXICITY DATA IN EXPERIMENTAL ANIMALS AND MAN

	Bone Cancer Incidence per 10^6 Bone-Rad			
Radionuclide	Male Mice	Female Mice	Dog	Man
^{226}Ra	77[a]	70[a]	320[a]	
		430[b]		
^{228}Ra			1300[b]	
$^{226+228}Ra$				6 - 53[a]
^{224}Ra	73[b]	1200[b]		100 - 200[a]

[a]Data summarized in Reference 21.
[b]Data summarized in Reference 48.

a plutonium deposition. The BEIR report does not give risk estimates for radiation-induced liver cancer; the MRC report derives an incidence estimate of 20 x 10^{-6} per man-rem, based on the thorotrast data.

All observations on radiation effects, whether in animals or in man, have been made for total radiation doses, and for radiation dose rates that are much higher than the average tissue doses and dose rates that might result from releases of plutonium from Mound Facility. The low incidence of effects that might still be of concern when applied to large populations are simply unmeasurable in either animal experiments or human epidemiological studies. It is necessary, therefore, to interpolate between the doses from which data on effects are available and zero dose, where zero effect can be assumed. For the estimates of health effects made in this Statement, we have based this interpolation on an assumed linear dose-effect relationship. The BEIR report (page 97) justifies such a procedure in the following words: [34]

> "In view of the gaps in our understanding of radiation carcinogenesis in man, and in view of its more conservative implications, the linear, non-threshold hypothesis warrants use in determining public policy on radiation protection; however, explicit explanation and qualification of the assumptions and procedures involved in such risk estimates are called for to prevent their acceptance as scientific dogma. Furthermore, the linear hypothesis is the only one which permits the selection of the mean accumulated tissue dose to characterize the radiation exposure of a group under conditions of nonuniform exposure and exposure rate. The mean accumulated tissue dose is the only practical quantity that can be used to estimate the risk of cancer in such populations until the influence of the many interacting variables can be better specified."

While agreeing with the practical utility of this procedure, it is most important that the results not be accepted as "scientific dogma." It is not the objective of this Environmental Statement to "determine public policy on radiation protection."

Its objective is to present all the evidence, so that public policy, as eventually determined, may reflect all relevant risks and benefits. In this light, it must be emphasized that the interpolated risk estimates do rest on conservative assumptions, and that there is no direct experimental evidence on which to base a choice between these estimates and an estimate of zero effect.

Pertinent to the assumption of a linear dose-effect relationship is the recent caution voiced by the NCRP:

> "The NCRP wishes to caution governmental policy-making agencies of the unreasonableness of interpreting or assuming "upper limit" estimates of carcinogenic risks at low radiation levels, derived by linear extrapolation from data obtained at high doses and dose rates, as actual risks, and of basing unduly restrictive policies on such an interpretation or assumption." [52]

Because there is considerable experimental evidence to indicate that low-dose-rate exposures are less damaging, rad-for-rad, than high-dose-rate exposures, it has often been suggested that linearly extrapolated estimates of effects at very low dose rates should be corrected by some "dose-effectiveness factor." Such an approach was taken in the Reactor Safety Study [53] (Rasmussen Report), where it was recommended that at dose rates of less than 1 rem per day, or at total doses of less than 10 rem, the effect estimated by linear extrapolation should be reduced by a factor of five. The credibility of this approach is supported by an Advisory Group on Health Effects, including among its 17 members, five who also served on the BEIR Committee.

Application of the "risk-effectiveness factor" as employed in the Rasmussen Report was not limited to low-LET (linear energy transfer) radiation. Most of the experimental support for the concept, however, derives from studies with low-LET radiation. From theory, one may argue convincingly that the high LET of alpha radiation, and consequent lack of repair of cellular effects, demands a linear relationship at low dose between cells killed or damaged and alpha particles traversing the tissue. This linear relationship would not necessarily apply to the total process of carcinogenesis, however, since there is no accepted theory (linear or nonlinear) which describes the process by which dead or damaged cells lead to the production of cancers. Because of this uncertainty in their applicability to high-LET radiation, risk effectiveness factors have not been employed in this Environmental Statement. The probable conservatism of this approach must be kept in mind.

Spatial Averaging of Doses

Throughout this Environmental Statement, each estimated radiation dose has been calculated as a spatially averaged value for the total organ. Such doses are, in fact, not uniformly distributed throughout the organ. In particular, the transuranic elements are inhaled and deposited in the lung as particles exhibiting a distribution of sizes and shapes, which leads to an obviously nonuniform distribution of dose.

The validity of this spatial averaging of dose has been the subject of recent controversy, stimulated in large part by a petition from the Natural Resources Defense Council (NRDC) to the Atomic Energy Commission and the Environmental Protection Agency. This petition requested a reduction of the maximum permissible concentration of plutonium in air by a factor of 115,000 when this plutonium was present in the form of "hot particles." [15] The petition was presented in February 1974; it was denied by the Nuclear Regulatory Commission, as successor to the Atomic Energy Commission, in April 1976. [54] In their denial of the NRDC petition, the Nuclear Regulatory Commission expressed the following conclusions with respect to the validity of averaging organ doses:

> "In summary, the uniform dose model is generally recognized by the scientific community and supported by experimental evidence as a conservative basis for standards for personnel protection. The NRC finds, in agreement with the recommendations of the organizations quoted, that available data support the use of the uniform dose assumption as an appropriately conservative approach. That is, the available data indicate that while the biological risk from a uniform lung dose of 15 rems per year is low, an equivalent dose delivered in a nonuniform manner is at least as low. Therefore, standards for insoluble, alpha-emitting radionuclides, as based on a uniform dose assumption, are believed to be adequately conservative." [54]

As noted in the above quotation, [54] several organizations have studied the "hot particle" problem and have, without exception, concluded that the NRDC proposal is without merit. [55] The ICRP has given the problem repeated consideration; [41] the NCRP has published a recent report on the subject, [56] as have also the National Radiological Protection Board [57,58] and the Medical Research Council [42] in England. The conclusions of all these groups were reviewed by the Nuclear Regulatory Commission and are summarized in their denial of the NRDC petition. [54]

Aside from the highly publicized "hot particle hypothesis," other questions have been raised concerning the conservatism of exposure limits, or health risk estimates, based on average organ dose. Martell has argued that naturally occurring, very small, alpha-emitting, insoluble particles, in the 10^{-16} to 10^{-18} curie activity range, are responsible for the carcinogenicity of tobacco smoke. [59] By analogy, he concludes that very small plutonium particles should have a similar effect, and has proposed a reduction in plutonium"...air concentration and lung burden standards by a factor of between 100 and 1000..." [60] This highly speculative hypothesis is supported by no experimental or clinical verification of substantial accumulation of such radioactive particles in radiosensitive regions of the lung, and upon no evidence of a casual relationship between such particles and human lung cancer. It is opposed by considerable evidence for the involvement of other carcinogens known to be present in tobacco smoke.

Gofman has postulated a greatly enhanced carcinogenicity for plutonium in cigarette smokers, whose impaired ciliary clearance mechanisms will, he contends, result in a

greatly increased dose to the radiosensitive bronchial epithelium. [61,62] Again, this speculation is supported by no relevant experimental or clinical evidence, and is opposed by specific data attesting to the slight effect of cigarette smoking on clearance from the lung. [63,64]

Recent suggestions by Morgan for reduction of plutonium exposure limits, seem appropriately considered at this point, since they are, in part, concerned with questions of spatial distribution of dose. [65] Morgan suggests a 240-fold reduction in permissible plutonium burden, based on four factors which he argues imply a greater hazard to bone than is envisioned by present standards. The first of these factors relates to new information on the relative toxicity of plutonium-239 and radium-226 in dogs. As noted in Section D.3, this toxicity ratio, on the basis of average dose to bone, is 16, whereas current standards are based on a ratio of five [21] Morgan does not consider the fact that current standards are based on an assumed 90 percent deposition of systemic plutonium in bone, rather than ICRP's presently preferred estimate of 45 percent deposition. [26] The net effect of these two changes would be a 1.5-fold reduction in the permissible body burden based on bone as critical organ, rather than the factor of three proposed by Morgan.

Morgan's second reduction factor, with a value of two, is based on his conclusion that "...the surface-to-volume ratio for the trabecular bone of the dog...is about twice that for man. Thus the same amount of plutonium-239 in man would have twice the concentration of plutonium-239 near the trabecular surface as that in the dog." [65] There is, in fact, no present basis for defending a significant difference in this parameter between man and dog. Lloyd and Hodges have reported data that would support Morgan's contention, [66] but more recent data of Spiers and Whitwell show essentially identical ratios in man and dog. [67]

Morgan's third reduction factor, with a value of 10, is based on the estimate of a 10-fold higher rate of turnover of surface deposited plutonium in dog bone as compared to human bone. Accepting this uncertain estimate, it does not follow that the same initial concentration of surface-deposited plutonium should be 10 times as hazardous in man as in the dog. The hazard is assumed to result from a lifetime of exposure, and man has five times the lifespan of the dog. A 10-fold higher absolute turnover rate in the dog therefore decreases the relative lifespan turnover rate, compared with man, by only a factor of two. The situation is more complex than this, however. The same processes that bury plutonium on bone surfaces will also bury radium on bone surfaces; and these same turnover processes will release plutonium and radium to redeposit on other surfaces. These complex interactions have been estimated by Marshall and Lloyd to increase the relative hazard of plutonium to radium in man, as compared to dog, by a factor of three (not 10 as claimed by Morgan). [68] Spiers and Vaughan, on the other hand, proceeding from human dosimetric considerations, without relation to the dog, conclude that the present permissible body burden for plutonium "...is not in need of major revision in respect to bone." [69]

Morgan's fourth reduction factor, with a value of four, is based on a presumed four-fold greater radiation sensitivity of man relative to dogs. This presumption he derives from a preliminary report of results from PuO_2 inhalation studies in baboons. [70] These results involved acute effects in lung and are therefore hardly applicable to considerations of long-term effects in bone. Moreover, the early observations have not been confirmed and the baboon now appears to be less sensitive than the dog to the induction of lung tumors by plutonium. [71]

Morgan's overall factor of 240 would therefore, more realistically, be re-evaluated as something between one and five. His is, moreover, only a partial approach to the evaluation of plutonium hazards; many other factors might be considered. All such factors are under continual review by national and international bodies charged with the responsibility for such evaluations. While some changes in plutonium exposure standards may be expected to result from the continuing accumulation of better data, there is no present indication that such changes will be large.

Conclusions

The more relevant dose-effect relationships discussed in previous sections of this Appendix are summarized and compared in Table D-12. In view of the extreme uncertainty in all of these estimates, as applied to very low-level irradiation of man, only the two extreme BEIR Report estimates have been employed in this statement. This choice is based on the stature of the BEIR Committee and the widespread employment of these numbers in other Environmental Statements, and on the rather close agreement between all of the tabulated estimates. It should be noted that liver risks may be relatively underestimated by the number indirectly derived from the BEIR report, and the genetic defects may be grossly overestimated if Newcombe's conclusions are accepted.

The BEIR risk estimates have been applied in Table D-13 to the predicted dose commitment from one year's routine operation of the Mound Facility. The dose commitment to the maximum individual leads to a risk of fatal cancer of 13×10^{-9} on the high estimate, or 2×10^{-9} on the low estimate; the estimate of genetic risk is 1.5×10^{-9} or 6×10^{-11}. Total effects in the exposed population are 0.001 fatal cancers and 0.0001 genetic defects on the high estimate, or 0.0002 fatal cancers and 0.000006 genetic defects on the low estimate.

Table D-14 presents the total health effects from operations extending to the year 2000. Even over this 23-year period (1977-2000), the high estimates of fatal cancers and genetic defects are still less than one.

Because the number of predicted health effects in Tables D-13 and D-14 are so small, it is perhaps unnecessary to stress that they are based upon conservative estimates of exposure, multiplied by conservative estimates of the risk from this exposure, and

Table D-12

COMPARISON OF TRANSURANIC HEALTH RISK ESTIMATES

(Tumor deaths or genetic defects per 10^6 organ-rem.)

	Human Risk Estimates					Data from Animals
	BEIR[34]				New-	
	High[a]	Low[b]	MRC[42]	Mays[48,72]	combe[47]	
Lung Tumors	100	16	25	20		60-200[c]
Bone Tumors	17	2	5	4		10-100[d]
Liver Tumors	7	1	20	10		
Genetic Defects	500[e]	50[e]	50[g]		10	
	1000[f]	10[f]				

[a]Relative risk model with lifetime plateau (see Table D-9).
[b]Absolute risk model with 30-year plateau (see Table D-9).
[c]Data from Reference 24 (see Table D-8).
[d]Data from Reference 21 (see Table D-7).
[e]"Specific genetic defects" (see Table D-10).
[f]"Defects with complex etiology" (see Table D-10).
[g]MRC estimate doubled to reflect irradiation of both parents.

that whether the actual risk approaches these numbers, or is zero, can in no way be inferred from our present knowledge. Whether one should place any credence in the absolute value of these numbers is an arguable proposition.

Of perhaps greater validity for decision making purposes are those gross comparisons of relative radiation exposure that require no uncertain extrapolations and that make no pretense to absolute prediction. In this category are the comparisons of exposures from Mound releases with the exposures from natural background radiation and from fallout plutonium. The predicted exposure of Miamisburg-metropolitan area residents from Mound Facility releases is less than one-thousandth of their radiation exposure from natural background and about one-tenth of their exposure from fallout plutonium.

Table D-13

HEALTH EFFECTS FROM ONE YEAR OF ROUTINE MOUND FACILITY OPERATIONS

	Maximum Individual[a]			Total Population[b]		
	Dose Commitment (rem)[c]	Risk ($\times 10^{-6}$)[d] High	Risk ($\times 10^{-6}$)[d] Low	Dose Commitment (man-rem)[e]	Effects[d] High	Effects[d] Low
Fatal Cancers						
Lung	1.1×10^{-5}	0.012	0.002	9	0.001	0.00015
Bone	4.4×10^{-5}	0.0008	0.0001	3.5	0.00006	0.000007
Liver	1.3×10^{-5}	0.00005	0.00001	0.9	0.000003	0.000001
Total		0.0128	0.002		0.001	0.00016
Genetic Effects						
Specific Genetic Defects	1×10^{-6}[f]	0.0005	0.00005	0.08[f]	0.00005	0.000005
Defects with Complex Etiology	1×10^{-6}[f]	0.001	0.00001	0.08[f]	0.00008	0.000001
Total		0.0015	0.00006		0.00013	0.000006

[a]Maximum individual considered to be at the fence line.
[b]Calculated using the average exposure to all individuals in the metropolitan area.
[c]Taken from Table 3-19.
[d]Based on BEIR risk estimates as given in Table D-12.
[e]Taken from Table 3-19. Average area resident exposure x area population of approximately 880,000.
[f]Dose commitment to total body.

Table D-14

TOTAL PLUTONIUM HEALTH EFFECTS FROM MOUND FACILITY OPERATION TO THE YEAR 2000[a]

	High Estimate	Low Estimate
Fatal Cancers		
Lung	0.14	0.02
Bone	0.04	0.005
Liver	0.0014	0.0004
Total	0.1844	0.0254
Genetic Defects		
Specific Genetic Defects	0.03	0.003
Defects with Complex Etiology	0.06	0.0007
Total	0.09	0.0037

[a]Annual risks from Table D-13 evaluated for the period 1977-2000. No credit taken for improved methodology during 1978-2000 interval.

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APPENDIX E

METHODS FOR CALCULATING POTENTIAL DOSE COMMITMENTS

This section describes the methodology and assumption utilized for determining the potential dose commitment an individual could receive as a result of a nuclear excursion at Mound Facility.

Calculations were made to estimate the radiation commitment to an individual standing at the point of maximum concentration due to the fission products released and escaping from the building after the nuclear excursion. Two types of radiation doses were considered in the analysis: external dose to the whole body (gamma and beta radiation) and the internal dose to the thyroid.

The calculations were made assuming the following conditions:

1. The total yield of 10^{18} fissions was assumed to occur in a few microsecond burst.

2. Only fission products capable of escaping the building were considered. These include noble gases, krypton and xenon, volatile iodine isotopes, and important daughter products of krypton, xenon, and iodine. Table 1 lists the fission product spectrum used during the calculations.

3. It was assumed that 100 percent of the noble gases and 50 percent of the iodine isotopes escaped from the building. It was assumed that the HEPA filters would stop all particulate fission products. An effective stack height of 70 m was assumed.

4. Following the instantaneous criticality, the fission products were released within a period of 3 min.

5. Pasquill Type A meteorological conditions with a windspeed of 1.5 m/sec were assumed. This condition results in the highest "maximum downwind" concentration offsite at a distance of 340 m.

6. An active "standard man" breathing rate of 2.0×10^4ml/min was used in the determination of the number of curies of radioactive iodine inhaled by the receptor.

7. Primary fission product decay and production of secondary fission products were considered during the calculations.

The dose an individual could receive as a result of an acute uptake of radioactive iodine was arrived at utilizing the following formula: (1)

$$D_o^t = \frac{51.1\ q[\Sigma EF(RBE)n]f_2}{\lambda m}\ (1 - e^{-\lambda t}) \qquad (1)$$

Table 1

SOURCE TERMS FOR CRITICALITY ACCIDENT

Isotope	E_γ (Mev)	E_β (Mev)	Yield**	λ (sec^{-1})	q (Curies) (10^{18} fissions)
^{83m}Kr	0.02	0.83*	0.0029	1.01×10^{-4}	7.9
^{85m}Kr	0.2	0.83	0.0054	4.41×10^{-5}	6.4
^{87}Kr	2.0	3.8	0.0091	1.48×10^{-4}	36.4
^{88}Kr	2.0	2.8	0.0014	6.95×10^{-5}	26.3
^{89}Kr	0.6	3.9	0.017	3.63×10^{-3}	1667.8
^{131}I	0.4	0.61	0.038	9.96×10^{-7}	1.0
^{132}I	0.8	2.1	0.053	8.02×10^{-5}	114.9
^{133}I	0.55	1.4	0.069	9.25×10^{-6}	17.3
^{134}I	1.3	2.5	0.075	2.20×10^{-4}	445.9
^{135}I	1.5	1.4	0.074	2.89×10^{-5}	57.8
^{133}Xe	0.08	0.35	0.069	1.52×10^{-6}	2.8
^{135m}Xe	0.52	0.53	0.074	7.40×10^{-4}	1480.0
^{137}Xe	0.15	3.5	0.065	3.04×10^{-3}	5340.5
^{138}Xe	0.4	2.4	0.063	6.79×10^{-4}	1156.1
^{139}Xe	0.73	2.4*	0.060	0.0173	28054.0
(secondary fission products)				(Maximum production)	
^{89}Rb	2.4	4.5	-	7.6×10^{-4}	Same as ^{89}Kr
^{138}Cs	2.15	3.4	-	3.5×10^{-4}	Same as ^{138}Xe
^{139}Cs	1.28	2.4	-	1.15×10^{-3}	Same as ^{139}Xe

*assumed
**fraction of isotope produced per fission

where D_o = integrated dose (rem)
q = body burden (μCi)
$\Sigma EF(RBE)n$ = effective energy term (E in MeV)
f_2 = fraction in organ of reference of that in total body
λ = effective decay constant = 0.693/T
T = effective half life (days)
m = mass of organ (grams)
t = period of exposure (days)

Parameters utilized for the various radioisotopes of iodine are presented in Table 2. Table 3 is a summary of the dose commitment.

Table 2

VALUE OF PARAMETERS

Isotope	$\Sigma EF(RBE)n$	Organ of Reference	Mass m(g)	Effective T	f_2
^{131}I	0.69	Thyroid	20	7.6	0.2
^{132}I	0.74	Thyroid	20	0.097	0.2
^{133}I	0.54	Thyroid	20	0.87	0.2
^{134}I	0.52	Thyroid	20	0.035	0.2
^{135}I	0.52	Thyroid	20	0.27	0.2

Table 3

THYROID DOSE AT 340 METERS

Isotope	Internal Dose (rem)
^{131}I	0.015
^{132}I	0.024
^{133}I	0.023
^{134}I	0.023
^{135}I	0.023
Total Dose	0.108

The whole body integrated dose commitment resulting from submersion in a cloud of beta-emitting radionuclides was arrived at through the use of the following formula: (2)

$$D_o^I = \frac{51\ \chi\ \overline{E}\ P_t\ t}{\rho_a} \qquad (2)$$

where: D = Integrated Dose (rem)
χ = Concentration of radionuclide (μCi/ml)
$\overline{E}$ = Average energy (MEV)
P_t = Relative Mass stopping power for tissue
ρ_a = Density of air (g/cm^3)
t = Exposure time (days)

The dose in roentgens delivered per day from submersion in a cloud of gamma-emitting radionuclide was calculated utilizing the following formula: (3)

$$\frac{dr}{dt} = \frac{4.7 \times 10^4\ QE\ (\mu-\sigma_s)\ (1-e^{-\mu_1 r_1})}{\mu_1} \qquad (3)$$

where: $\frac{dr}{dt}$ = Dose (R/day)

Q - Concentration (μCi/ml)
E = Effective Energy (MEV)
μ = Total Linear absorption coefficient (m^{-1})
σ_s = Scattering Coefficient (m^{-1})
μ_1 = Linear Absorption Coefficient (m^{-1})
t = Exposure Time (days)
r_1 = Radius of Cloud (m)

Table 4 is a tabulation of the resulting whole body exposure.

Table 4

RADIATION WHOLE BODY DOSE AT 340 METERS

Isotope	Gamma Dose (rem)	Beta Dose (rem)	Total Dose (rem)
^{83m}Kr	0.000032	0.000027	0.000064
^{85m}Kr	0.000015	0.000023	0.00004
^{87}Kr	0.00072	0.00055	0.0014
^{88}Kr	0.00052	0.00028	0.00087
^{89}Kr	0.0055	0.027	0.0332
^{131}I	0.0000019	0.0000025	0.0000047
^{132}I	0.00040	0.0010	0.00145
^{133}I	0.000045	0.000096	0.000147
^{134}I	0.0022	0.00045	0.00295
^{135}I	0.033	0.00033	0.0373
^{133}Xe	0.000024	0.0000037	0.0000064
^{135m}Xe	0.0084	0.0032	0.0127
^{137}Xe	0.0044	0.076	0.081
^{138}Xe	0.0049	0.011	0.0166
^{139}Xe	0.0051	0.274	0.2798
(secondary fission products)			
^{89}Rb	0.019	0.016	0.038
^{138}Cs	0.34	0.0022	0.006
^{139}Cs	0.32	0.303	0.663
Total Dose	0.407	0.715	1.122

REFERENCES

1. Report of Committee II on Permissible Dose for Internal Radiation, 1959, ICRP Publication 2.
2. Karl Z. Morgan and Herbert M. Parker, Health Control and Nuclear Research, Chapter VI, External Exposures, pp. 31-34 (Class notes, Vanderbilt University, 1959).
3. op. cit., pp. 43-44.

APPENDIX F

PROPERTY LOSSES, LOST TIME INJURIES AND RADIATION EXPOSURES REPORTED THROUGH CY-1977

Table F-1 lists all property losses and decontamination costs (resulting from an accidental contamination) in excess of $5000 that have occurred at Mound Facility since it became operational in 1948.

The personnel safety record compiled at Mound Facility through CY-1977 was the best of all DOE facilities. Eight disabling injuries occurred as listed in Table F-2 since operations began in CY-1948 through CY-1977. A comprehensive safety program has been responsible for limiting the number of disabling injuries to the employes.

Radiation exposure to an employe may occur from external and/or internal sources. Health physics programs at Mound Facility are designed and operated to detect, measure, and document any radiation exposure to an employe. Exposures to external radiation are detected and measured by a radiation-sensitive badge worn on the upper front portion of the body of each employe who is in any area where the employe may be exposed to radiation. These badges are calibrated for various types of radiation. Results recorded on the badges are reported in rem units. The established maximum permissible exposure level for radiation is 5(N-18) rem* where N equals the employe's age. This maximum limit has never been exceeded by any exposure experienced at the Mound Facility. Table F-3 tabulates the external radiation exposures of employes since CY-1960 as determined from film badge data.

Radiation exposures to personnel reported as required by regulations are listed according to external exposures, systemic body burden estimates of plutonium, and positive whole body counter (lung) cases.

Exposures resulting from an uptake of a radioactive substance (internal) are determined by urine bioassay and by whole body counting. Urine bioassay determines an employe's systemic burden by measuring the amount of a radioactive substance remaining in the employe's body. Each Urine sample from an individual is used in conjunction with all the previous samples from that individual. A systemic burden is calculated as a percent of the maximum permissible systemic burden (MPSB). For example the MPSB for plutonium is 0.04 microcuries.

The number of active and former employes in each major category of exposure according to systemic burdens for plutonium is tablulated in Table F-4.

*Standards for Radiation Protection, ERDAM, Chapter 0524, U. S. Department of Energy.

Table F-1

PLANT PROPERTY LOSSES EXCEEDING $5000
(CY-1948 through CY-1977)

During the years encompassed, property losses and cost associated with incidents have been held to a minimum and well below levels accepted by DOE (formerly the AEC and ERDA) loss criteria. In 29 years, losses totaled $240,680; this loss was associated with nine (9) incidents.

Calendar Year	$ Loss	Incident
1960	31,360	Decontamination cost associated with radioisotope cleanup following a spill in a laboratory.
1964	35,922	Property and decontamination losses associated with the rupture of a container containing a radioactive material in a laboratory.
1969	40,000	Decontamination cost associated with a release of minute quantities of radioactive materials from a leak in a transfer pipe for radioactive liquids.
1970	11,000	Property loss and decontamination cost associated with an accidental release of a radioactive isotope in a fume hood.
1971	15,000	Decontamination cost associated with a spill of a radioactive material in a laboratory.
1973	23,000	Property loss associated with a structural failure of an operating centrifuge.
1974	18,000	Property loss associated with exposure of inprocess products to oxidizing gas.
1974	14,021	Decontamination cost associated with leak of a waste material transfer container onsite.
1977	52,077	Property loss resulting from severe winter freezing damage such as ruptured sprinkler pipes and domestic water pipes.

The whole body counting program began in CY-1964. The equipment used measures gamma ray energies (penetrating radiation) originating within the body. Gamma ray energies from plutonium-238 and plutonium-239 are insufficient for measurement within the sensitivity required. Since plutonium-238 (half life - 87.4 yr) decays to uranium-234, the penetrating radiation from the uranium-234 is measured. On the basis of the time lapsed since the uranium-234 was removed chemically from the plutonium-238, the quantity of uranium-234 found can be used to calculate the plutonium-238 present in the body. To calculate plutonium-239, the radiation from the americium-241 present in the plutonium-239 is measured. The ratio of the americium-241 to plutonium-239 in the plutonium-239 is determined by analytical techniques and used to calculate the plutonium-239 present. Whole body counting techniques can be used to measure the quantit of plutonium or other radioactive material in the body (chest region). Inhaled dusts usually leave the lungs through the normal elimination process. The amount of material in the lungs (body burden) will therefore decrease with time.

Table F-2

DISABLING INJURIES TO EMPLOYES
(CY-1948 through CY-1977)*

Date		Injury
Month	Calendar Year	
March	1948	Broken collar bone during training of a security guard
April	1954	Broken knee suffered by a heavy equipment operator
December	1956	Back injury suffered by a heavy equipment operator
October	1957	Ligament damage to finger after laceration suffered by a machinist
September	1962	Amputation of first joint of one finger of a carpenter
December	1964	Fracture of both wrists by a carpenter
June	1966	Fracture of wrist and compression of vertebra by an electrician as a result of a fall
August	1966	Flash burns to both eyes of a research chemist using plasma torch
		This was the last disabling injury recorded at Mound under the American National Standards Institute (ANSI) system until that system was retired at the end of CY-1977. From August 16, 1966, through December 31, 1977, Mound accumulated 42,281,480 manhours without a disabling injury. Also during this period MRC-Mound was named the safest chemical laboratory in the world by the National Safety Council. At the retirement of the record on December 31, 1977, Mound held the position of the safest plant in Monsanto and the DOE.

*Disabling injuries listed were classified under the guidelines outlined in American National Standard Institutes Code Z 16.1.

Table F-3

EXTERNAL RADIATION EXPOSURE OF EMPLOYES

CY	Total Employes Badged	Number of Employes in Dose Range*												
		0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
1960	454	426	19	5	2	2	0	0	0	0	0	0	0	0
1961	556	523	19	8	3	2	1	0	0	0	0	0	0	0
1962	599	569	23	7	0	0	0	0	0	0	0	0	0	0
1963	731	612	75	27	8	3	4	0	2	0	0	0	0	0
1964	942	596	145	68	43	26	19	12	9	7	6	10	1	0
1965	984	656	112	66	34	23	20	16	14	18	17	6	2	0
1966	1284	846	203	71	57	38	24	23	16	5	1	0	0	0
1967	1359	1137	130	50	14	9	8	4	3	4	0	0	0	0
1968	1406	1263	92	25	16	10	0	0	0	0	0	0	0	0
1969	1489	1415	65	9	0	0	0	0	0	0	0	0	0	0
1970	1508	1395	82	24	6	1	0	0	0	0	0	0	0	0
1971	1420	1346	50	16	7	1	0	0	0	0	0	0	0	0
1972	1409	1381	19	9	0	0	0	0	0	0	0	0	0	0
1973	1409	1393	11	5	0	0	0	0	0	0	0	0	0	0
1974	1321	1307	12	1	1	0	0	0	0	0	0	0	0	0
1975	1445	1439	3	2	1	0	0	0	0	0	0	0	0	0
1976	1449	1438	9	2	0	0	0	0	0	0	0	0	0	0
1977	1510	1500	8	2	0	0	0	0	0	0	0	0	0	0

*Dose range in rem

Table F-4

SYSTEMIC BURDEN ESTIMATES OF PLUTONIUM

Employe Status	Total Number	Employes in Exposure Category*			
		10-25%	25-50%	50-100%	>100%
Active	641	30	24	11	6
Former	814	37	19	7	6

*Percent of maximum permissible systemic burden.

Table F-5 shows year-end body counting results (lungs) at Mound Facility since CY-1969.

Table F-5

POSITIVE BODY COUNTER CASES

CY	>100% MPLB[a]		50-100% MPLB		<50% MPLB	
	Active[b]	Former[c]	Active	Former	Active	Former
1969	2	2				
1970	1					
1971	1					
1972			1	1	4	2
1973						
1974						
1975						
1976	1					
1977	1					

[a]MPLB: Maximum Permissible Lung Burden

[b]Active: Employe is currently at Mound Facility

[c]Former: Individual has terminated employment at Mound

APPENDIX G
GLOSSARY

Absolute Filter A fire-resistant, high efficiency type filter that is at least 99.95% efficient for 0.3 micrometer particles. (Also designated as HEPA filter.)

ALAP As low as technically and economically practicable.

Alpha Particle A positively charged particle emitted by certain radioactive materials. It is made up of two neutrons and two protons bound together, hence is identical with the nucleus of a helium atom. It is the least penetrating of the three common types of radiation (alpha, beta, gamma) emitted by radioactive materials, and can be stopped by a sheet of paper. It is not dangerous to plants, animals or man unless the alpha-emitting substance has entered the body.

Beta Particle An elementary particle emitted from a nucleus during radioactive decay, with a single electrical charge and a mass equal to 1/1837 that of a proton. A negatively-charged beta particle is identical to an electron. Beta radiation may cause skin burns, and beta emitters are harmful if they enter the body. Beta particles are easily stopped by a thin sheet of metal, however.

Body Burden The amount of radioactive material present in the human body.

Category I Building Structures in which significant quantities of radioactive materials are processed or handled outside of shipping containers or encapsulation systems or in which there is a potential for release of radioactive material from a containment system.

Contamination The presence of unwanted radioactive matter. Deposition of radioactive material in any place where it may result in a dose commitment to people through external radiation or by ingestion, invalidate experiments, or make products or equipment unsuitable or unsafe for some specific use. Also radioactive material found on the walls of vessels in used fuel processing plants, or radioactive material that has leaked into a reactor coolant. Often referred to only as contamination.

Cosmic Radiation Radiation of many sorts but mostly atomic nuclei (protons) with very high energies, originating outside the earth's atmosphere. Cosmic radiation is part of the natural background radiation. Some cosmic rays are more energetic than any man-made forms of radiation.

Critical Organ The body organ receiving the radionuclide that results in the greatest overall damage to the body. Usually, but not necessarily, it is the organ receiving the greatest concentration or the organ receiving the greatest damage.

Criticality A term used in weapon and reactor physics to describe the state of a given fission system when the specified conditions are such that the mass of active material present in the system is precisely a critical mass. Thus, the fission neutron production rate is a constant and is exactly balanced by the total of neutron loss and utilization rate, and the neutron population remains constant. The word "criticality" alone is often used improperly to describe the degree of criticality of a system which is a relative term describing a variable physical property of the fissionable assembly. The degree of criticality is expressed in terms of the effective neutron multiplication factor (K_{eff}). A "just" critical system has a K_{eff} of one.

Curie The basic unit to describe the intensity of radioactivity in a sample of material. The curie is equal to 37 billion disintegrations per second, which is approximately the rate of decay of 1 gram of radium. A curie is also a quantity of any nuclide having 1 curie of radioactivity. Named for Marie and Pierre Curie, who discovered radium in 1898.

Ci Symbol for curie

Decontamination The removal of radioactive contaminants from surfaces or equipment, as by cleaning and washing with chemicals.

Disintegration Process of spontaneous breakdown of a nucleus of an atom resulting in the emission of a particle and/or a photon. The rate of disintegration of a quantity of any radioactive nuclide is the product of the number of atoms present and a disintegration or decay constant characteristic of the nuclide concerned.

D.O.T. Department of Transportation

Dose A quantity (total or accumulated) of ionizing (or nuclear) radiation absorbed. The term "dose" is often used in the sense of the exposure dose, expressed in roentgens which is a measure of the total amount of ionization that the quantity of radiation could produce in air. This should be distinguished from the absorbed dose, given in rep or rad, which represents the energy absorbed from the radiation per gram of specified body tissue. Further, the biological dose, in rem, is a measure of the biological effectiveness of the radiation exposure.

Dose Rate As a general rule, the amount of ionizing (or nuclear) radiation to which an individual would be exposed or which he would receive per unit of time. It is usually expressed as roentgens, rad, or rem per hour, or in multiples or submultiples of these units, such as milliroentgens per hour. The dose rate is commonly used to indicate the level of radioactivity in a contaminated area.

Element A pure substance which cannot be broken down into a simpler substance by a chemical change or reaction, but which will disintegrate into simpler particles by physical decomposition when they are exposed to drastic bombardments with high-energy particles.

Fission The process whereby the nucleus of a particular heavy element splits into two (generally) nuclei of lighter elements, with the release of substantial amounts of energy. The most important fissionable materials are uranium-235 and plutonium-239.

Fission Products The nuclei (fission fragments) formed by the fission of heavy elements, plus the nuclides formed by the fission fragments' radioactive decay.

FRC Federal Radiation Council

Fusion (Thermonuclear reaction) A nuclear reaction characterized by joining together of light nuclei to form heavier nuclei, the energy for the reactions being provided by kinetic energy derived from violent thermal agitation of particles at very high temperatures. If the colliding particles are properly chosen and the agitation is violent enough, there will be a release of energy from the reaction. The energy of the stars is believed to be derived from such.

Gamma Rays (or radiation) Electromagnetic radiations of high energy originating in atomic nuclei and accompanying many nuclear reactions; e.g., fission, radioactivity, and neutron capture. Physically, gamma rays are identical with X-rays of high energy, the only essential difference being that the X-rays do not originate from atomic nuclei but are produced in other ways.

Half-Life, Biological The time required for the body to eliminate half of the material taken into the body by natural biological means.

Half-Life, Effective The time required for a radioactive element fixed in the tissues of an animal body to be diminished 50 per cent as a result of the combined action of radioactive decay and biological elimination. It is related to radioactive half-life (T_r) and biological half-life (T_b) by the equation:

$$T = \frac{T_b \times T_r}{T_b + T_r}$$ Abgreviation: T_{eff}

Half-Life, Radioactive Time required for a radioactive substance to lose 50 percent of its activity by decay.

Health Physics A term in common use for that branch of radiological science dealing with the protection of personnel from harmful effects of ionizing radiation.

ICRP International Committee on Radiological Protection.

Ionization The process of adding one or more electrons to, or removing one or more electrons from, atoms or molecules, thereby creating ions. High temperature electrical discharges or nuclear radiations can cause ionization.

Isotopes Forms of the same element having identical chemical properties but differing in their atomic masses (due to different number of neutrons in their respective nuclei) and in their nuclear properties; e.g., radioactivity, fission, etc. For example, hydrogen has three isotopes, with masses of one, two and three atomic mass units. ^{2}H and ^{3}H are commonly called deuterium and tritium respectively. The first two of these are stable (nonradioactive), but the third (tritium) is a radioactive isotope. Other examples are the common isotopes of uranium, with masses of 235 and 238 units, respectively, which are radioactive, emitting alpha particles, but their half lives are different. Further, uranium-235 is fissionable by neutrons of all energies, but uranium-238 will undergo fission only with neutrons of high energy.

keV An abbreviation for kilo-electron-volt. The symbol for 1000 electron volts.

Microcurie A one-millionth part of a curie.

Millirem A one-thousandth part of a rem.

Milliroentgen A one-thousandth part of a roentgen.

Moderator A material, such as ordinary water, heavy water or graphite, used in a reactor to slow down high-velocity neutrons, thus increasing the likelihood of further fission.

Monitoring Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination present in an occupied region, as a safety measure, for purposes for health protection. Area Monitoring: Routine monitoring of the level of radiation or of radioactive contamination of any particular area, building, room or equipment. Usage in some laboratories or operations distinguishes between routine monitoring and survey activities. Personnel Monitoring: Monitoring any part of an individual, his breath or excretions, or any part of his clothing.

NCRP National Committee on Radiation Protection and Measurement.

Neutron A neutral particle (i.e., with no electrical charge) present in all atomic nuclei, except those of ordinary (or light) hydrogen. Its rest mass is 1.00893 amu, which is approximately the same as ordinary hydrogen. Neutrons are used to initiate the fission process and are produced by both fission and fusion reactions.

Nuclear Fission A special type of nuclear transformation characterized by the splitting of a nucleus into at least two other nuclei and the release of a relatively large amount of energy when compared to that of a fusion reaction. Two or three neutrons are usually released during this type of transformation.

Nuclear Weapons A collective term for atomic bombs and hydrogen bombs. Any weapons based on a nuclear explosive.

Nuclide A general term referring to any nuclear species, both stable (about 270) and unstable (about 500), of the chemical elements.

Organ Organized group of tissues having one or more definite functions to perform in an animal body.

Person Rem This is a unit of collective dose equivalent and is a term used when the radiation exposure involves the whole body of the exposed persons and equals the sum of the exposures (dose commitment) of all the people in the group specified. For example, if there are 1 million people in the 50-mile radius and each person receives a dose commitment of 0.1 mrem, the annual dose commitment would equal 100 person rem. The larger the population involved, the larger the person rem value becomes.

Plutonium-238 (Symbol, ^{238}Pu) A heavy, radioactive "man-made" metallic element with atomic number 94. This isotope is produced by the irradiation of neptunium-237 in a nuclear reactor. Plutonium-238 has a half-life of 87.4 years. This is in contrast to plutonium-239, with a half-life of 24,390 years, that is produced by the irradiation of uranium-238 in a nuclear reactor.

Primary Explosive An explosive that is sensitive to friction, blows, shock, or heat.

Quality Factor The linear-energy-transfer-dependent factor by which absorbed doses are multiplied to obtain a quantity that expresses - on a common scale for all ionizing radiations - the effectiveness of the absorbed dose.

Rad (Acronym for radiation absorbed dose). The basic unit of absorbed dose of ionizing radiation. A dose of one rad means the absorption of 100 ergs of radiation energy per gram of absorbing material.

Radiation 1. The emission and propagation of energy through matter or space by means of electromagnetic disturbances which display both wavelike and particle-like behavior; in this context the "particles" are known as photons. 2. The energy so propagated through space or through a material medium as waves.

The term has been extended to include streams of fast-moving particles (alpha and beta particles, free neutrons, cosmic radiation, etc.). Nuclear radiation is that emitted from atomic nuclei in various nuclear reactions, including alpha, beta and gamma radiation and neutrons.

Radioactivity The spontaneous decay or disintegration of an unstable atomic nucleus, usually accompanied by the emission of ionizing radiation.

Radioactivity Concentration Guide See RCG

Radionuclide A radioactive nuclide.

RCG Radioactivity Concentration Guide is the concentration of radioactivity in the environmental pathways, such as air and water, which is determined to result in radiation dose commitments to particular human organs or the whole body equal to the radiation protection standard applicable to the specific organs or the whole body. (Formerly called Maximum Permissible Concentration)

Raffinate A liquid product resulting from extraction of a liquid with a solvent; also, the less soluble residue that remains after extraction.

Rem An abbreviation for the term, "Roentgen Equivalent Man (or Mammal)." A unit of biological dose of radiation where the number of rem of radiation is equal to the number of rad absorbed multiplied by the quality factor of the given radiation (for a specified effect).

Roentgen A unit of exposure to ionizing radiation. It is that amount of gamma or X-rays required to produce ions carrying 1 electrostatic unit of electrical charge (either positive or negative) in 1 cubic centimeter of dry air under standard conditions. Named after Wilhelm Roentgen, German scientist who discovered X-rays in 1895.

Roentgen Equivalent, Man The quantity of ionizing radiation of any type which, when absorbed by man or other mammal, produces a physiological effect equivalent to that produced by the absorption of 1 roentgen of X-rays or gamma rays.

Sealed Source Radioactive material that is encased in and is to be used in a container in a manner intended to prevent leakage of the radioactive material.

Shielding Material used to absorb radiation from a source and thus protect individuals from exposure to radiation.

Source Discrete amount of radioactive material or radiation producing equipment.

Tritide A chemical compound in which hydrogen (^{1}H) is replaced by its isotope tritium (^{3}H).

Tritium (Symbol, ^{3}H) A radioactive isotope of hydrogen with two neutrons and one proton in the nucleus.

Waste, Radioactive Normally applied to dry waste material containing non-recoverable quantities of radioactive material released by Nuclear Operations for offsite disposal by burial.

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