Ref. 55

ALBUQUERQUE OPERATIONS OFFICE
ENVIRONMENT, SAFETY AND HEALTH DIVISION
ENVIRONMENTAL PROGRAMS BRANCH

COMPREHENSIVE ENVIRONMENTAL ASSESSMENT AND RESPONSE PROGRAM

PHASE I:
INSTALLATION ASSESSMENT
MOUND

NOT FOR PUBLIC DISSEMINATION

May contain unclassified controlled nuclear information subject to Section 148 of the AEA, as amended (42 USC 2168). Approval by the Department of Energy prior to release is required.

April 1986

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Department of Energy
Albuquerque Operations Office
P. O. Box 5400
Albuquerque, New Mexico 87115

MAY 1 7 1986

Mr. Thomas A. Winston
District Chief
Southwest District Office
Ohio Environmental Protection Agency
7 East Fourth Street
Dayton, Ohio 45402-2086

Dear Mr. Winston:

Transmitted herewith is one copy of the Department of Energy (DOE), Albuquerque Operations Office (AL), Comprehensive Environmental Assessment and Response Program (CEARP), Draft Phase 1 Report for Mound. This report represents the initial stage of an assessment of our status at Mound with respect to applicable environmental regulations. While it is broad in scope, to be most useful to this office and to the Department, the program emphasizes the discovery and remedy of any existing or potential environmental threats. As such, it is designed to also fulfill the requirements of the DOE Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Order 5480.14, and the EPA draft guidance to Federal facilities for CERCLA preliminary investigations.

The document is labeled as a draft in order to be responsive to any additional guidance from DOE Headquarters on the manner of constructing a report of this type. Although the format of the report may change, the basic technical content of the report is valid.

It is important to note the document necessarily contains information that is subject to the restrictions of Section 148 of the Atomic Energy Act. The maps, which contain information subject to this Section, are so labeled. Incorrect references to this Section have been crossed out and initialed. Regrettably, time constraints on review and release of this report did not allow printing of clean copies. Should you wish to release any portion of this document, which has been labeled as subject to Section 148, please contact Mr. J. A. Morley, Area Manager of the Dayton Area Office to initiate the approval process.

Sincerely,

R. G. Romatowski

R. G. Romatowski
Manager

Enclosure

OhioEPA

State Of Ohio Environmental Protection Agency

Southwest District Office
7 East Fourth Street; Dayton, Ohio 45402-2086

(513) 449-6357

Richard F. Celeste, Governor

July 22, 1986

Mr. David Ingle
DOE, Mound Facility
P.O. Box 66
Miamisburg, Ohio 45342

Dear Mr. Ingle:

Mr. Jack Van Kley of the Ohio Attorney General Office has authorized me to reply directly to you with Ohio EPA's comments on the Draft Phase I CEARP report for Mound. Mr. Roger Hannahs, Unregulated Sites Coordinator from the Central Office, Ms Julie Grzyb, Industrial Wastewater Group Leader and Scott Shane, Hazardous Waste Investigator have provided me with their comments.

In general, we think the CEARP can potentially be a framework for a comprehensive environmental review of the Mound facility. However, we feel that the State of Ohio needs a more active role than reviewing summary findings and reports in order to achieve an understanding of how conclusions were reached. For that reason, we would like to review and comment on all work plans, sampling plans, reports, recommendations, etc. proposed by DOE or their consultants for both the CEARP and the SFMP.

Additionally, we have the more specific comments which follow. We have limited these to the technical items in Section V.

Section V, Page V-1. Please provide a copy of the Site Survey Program report "Radiological Characterization of Mound" when it becomes available.

Please provide additional information on the Surplus Facilities Management Program. We are particularly interested in clean-up objectives and standards, schedules for remedial action, risk assessments, criteria for setting clean-up priorities, etc. We find this especially important in view of the extensive attention that Category III sites will receive under the SFMP.

Sections V.A.1.b. and V.A.1.c. In light of the environmental releases in these areas, we are unclear why the Canal area and the BVA are not scheduled for evaluation under CEARP. We are confused because the site Survey Program and SFMP activities will be evaluated under CEARP.

Sections V.A.2.a thru V.A.2.f. We are unable to find any information in our files regarding these sites and we agree that no future actions are warranted for those sites where only polonium-210 was handled and for the Unit II site where only scrap explosives were burned. We can infer, however, that longer-lived radioisotopes were handled at Unit I. What type of activities occurred at Unit I and what has led to the conclusion that no disposal occurred there?

Section V.B.5.a. We agree that noncontact cooling water should be recycled. However, small volume users should be routed to the WWTP rather than to the discharge point.

Section V.B.5.b. Please forward a copy of the "MRC Drainage Master Plan" to Kendra Dearth of the Southwest District Office.

Section V.B.7.A. Please comment on the validity of quoting analytical results of filtered water samples from the GMR in light of the suspended solids exceptions to the NPDES permit and the known and/or suspected soil contamination in areas D, G, I and areas 1, 4, 4a, 8, 11, 14, 15, 17, etc. We expect that filtering the surface water samples will bias the analytical results for radionuclides.

Section V.B.8. We agree that a hydrogeologic investigation of the BVA would assist in establishing a more effective monitoring network for surface and groundwater. However, we feel that to be most effective, this investigation also address past environmental releases including the tritium release and the plutonium-238 spill. We would prefer a computer model that would be able to reliably predict the movement of the tritium plume, duration of pumping, etc. Such a computer model could incorporate a soils study and be predictive of rates of plutonium migration through soils. We will be available to discuss these items in more detail.

Table V.1. Area B. We agree that the landfill should be subject to CEARP Phase II and we would like an opportunity to comment on the scoping or work.

Area C. We agree that further work is necessary. Please provide details of the "CEARP Phase I supplemental reconnaissance field study."

Area D. We agree that further action is necessary. Please provide details of the SFMP remedial action for Area D and the other Category 1 areas where further actions are planned.

Area J. What analytical information is available for plutonium and thorium in this area? Are suspended solids in the run-off being monitored for plutonium and thorium.

Table V.2. We agree that no further actions are warranted at the paint shop, powerhouse, Bldg. 61 and Bldg. G if these findings are supported by visual inspections at the facility. However, we do not agree that no further actions are warranted at the WD Bldg. Please provide details of the leak detection system, analytical results of the tank and surrounding soils, tests of tank integrity, etc.

Table V.3. Please provide further information on all areas discussed including Site Survey, Program results, timetables, analytical data, risk assessments, etc.

We will be available to discuss the details of our concerns if you have any questions.

Sincerely,

Thomas M. Ontko

Thomas M. Ontko
Unregulated Sites Group Leader
Solid & Hazardous Waste Management Unit

TMO/dkp

cc: Jack Van Kley, AGO

inter-office communication

Distribution date: May 6, 1986

from: TMO Tom Ontko, Unregulated Hazardous Waste Sites Group Leader, SWDO

subject: Monsanto - Mound CEARP Phase I report

DOE has completed Phase I of the Comprehensive Environmental Assessment and Response Program (CEARP) for the Monsanto Mound Facility in Miamisburg. We have scheduled a one hour meeting at 10:00 a.m. on May 28, 1986, in Room 602a of Central Office so that DOE can present their study to all involved Agency programs at the same time. Dave Ingle informed me that the CEARP is about 50% CERCLA issues but that it also addresses hazardous waste and RCRA, Clean Water Act, Air programs, radiation releases, etc.

I am directing this IOC to SWDO unit supervisors so that they can forward it to the appropriate staff. Please also inform any interested parties in your respective Divisions of this meeting. Please see me if you have any questions.

/lal

DISTRIBUTION: Jim Simpson
Dave Strayer
Steve Severyn
Jim Sumner
Don Marshall
Graham Mitchell
Tom Winston

cc: Roger Hannahs, DSHWM, CO
Scott Shane, SWDO
Bob Quillen, ODH
Jim Crawford, SWDO
Jack Van Kley, AAG

Department of Energy
Albuquerque Operations
Dayton Area Office
P.O. Box 66
Miamisburg, Ohio 45342

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Questions about this Notice should be directed to Carl W. Huntington, Monsanto Research Corporation, (513) 865-3401.

ALBUQUERQUE OPERATIONS OFFICE
ENVIRONMENT, SAFETY AND HEALTH DIVISION
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COMPREHENSIVE ENVIRONMENTAL ASSESSMENT AND RESPONSE PROGRAM

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April 1986

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EXECUTIVE SUMMARY

The U.S. Department of Energy (USDOE) Mound site has been evaluated under Phase I of the Comprehensive Environmental Assessment and Response Program (CEARP) with respect to inactive waste disposal sites, accidentally contaminated sites, current waste management practices, existing and potential surface and ground water contamination, and compliance with applicable federal, state, and local environmental regulations. A major thrust of CEARP is to determine whether waste disposal practices followed in the past prior to recognition of potential environmental hazards and/or the passage of environmental legislation have resulted in environmental problems that require remedial action today. This Phase I CEARP report provides documentation for Phase I of the USDOE Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Order 5480.14 and the following U.S. Environmental Protection Agency (USEPA) CERCLA preremedial activities: (1) Federal Facility Site Discovery and Identification Findings (FFSDIF) (notification of newly discovered sites, including negative findings notification), (2) Preliminary Assessment (PA), (3) Site Inspection (SI) [CEARP Preliminary SI (PSI)], and (4) Hazard Ranking System (HRS) evaluation.

The Phase I CEARP report findings are based on a records search, open literature survey, interviews with Monsanto Research Corporation employees, preliminary assessments, and site inspections. Therefore, the report is unavoidably subject to some uncertainty. Situations in which there is uncertainty regarding actual risk to public health and safety and the environment will be further studied through field studies and data collection during CEARP Phase II (Confirmation).

Potential sites identified during CEARP Phase I are presented in Table EX-I. As appropriate, the results for the potential sites are summarized based on a negative, positive, or uncertain finding for the following USEPA CERCLA elements: (1) FFSDIF and (2) PA, SI (CEARP PSI), and HRS evaluation. Area B, the Mound landfill, is the only site with a positive FFSDIF/PA/SI finding. The HRS Migration Mode Score for area B is 13. Sites with HRS Migration Mode Scores greater than 28.5 are listed on the National Priorities List (NPL) by USEPA. None of the potential sites identified at Mound are recommended for additional action under USEPA CERCLA.

However, some of the sites do or potentially could exceed USDOE remedial action criteria/guidelines and/or potentially could pose regulatory concerns and are recommended for future action as specified in Table EX-1 under USDOE, but not USEPA CERCLA. Additionally, remedial action (CEARP Phase IV) has been or is currently being planned/conducted at several such sites.

Compliance with appropriate environmental statutes at Mound has generally been good. The areas identified in Phase I for further evaluation are (1) the Buried Valley Aquifer to develop a thorough understanding of this important groundwater resource; (2) inactive disposal sites and contaminated sites to determine the potential availability of hazardous substances to be released to the environment; (3) hydrologic monitoring programs to ensure their capability to detect hazardous substances in ground and/or surface water; (4) NPDES-related facilities, which may require upgrading to ensure continued compliance with National Pollutant Discharge Elimination System (NPDES) discharge limits; (5) storm and sanitary drain systems to identify upgrading requirements; and (6) existing oil storage facilities to identify modification and relocation requirements.

Table EX-1. Potential CERCLA Sites Identified During CEARP Phase I

Site	USDOE CEARP Phase I: FFSDIF/PA/PSI[a] Finding	USDOE CEARP Phase I: HRS[b] Score	Planned Future Action: USEPA CERCLA Program Element	Planned Future Action: USDOE CEARP/CERCLA Order Phase
Category 1[c]				
Area A	Negative	NA[d]	None	None
Area B	Positive	13	None	Confirmation (Phase II)
Area C	Uncertain	NE[e]	None	Installation Assessment (Supplemental Phase I)
Area D	NA	NA	None	Remedial Action (Phase IV)
Area E	Negative	NA	None	None
Area F	Negative	NA	None	None
Area G	NA	NA	None	Remedial Action (Phase IV)
Area H	Negative	NA	None	None
Area I	Uncertain	NE	None	Installation Assessment (Supplemental Phase I)
Area J	Negative	NA	None	None
Category 2[f]				
Paint Shop	Negative	NA	None	None
Powerhouse	Negative	NA	None	None
WD Bldg	Negative	NA	None	None
Bldg 61	Negative	NA	None	None
Bldg G	Negative	NA	None	None
Category 3[g]				
Area 1	NA	NA	None	Remedial Action (Phase IV)
Area 2	Negative	NA	None	None
Area 3	NA	NA	None	Remedial Action (Phase IV)
Area 4	NA	NA	None	Remedial Action (Phase IV)

Table EX-1 (cont)

Site	USDOE CEARP Phase I FFSDIF/PA/PSI[a] Finding	USDOE CEARP Phase I HRS[b] Score	Planned Future Action USEPA CERCLA Program Element	Planned Future Action USDOE CEARP/CERCLA Order Phase
Area 4a	NA	NA	None	Remedial Action (Phase IV)
Area 5	NA	NA	None	Remedial Action (Phase IV)
Area 6	Negative	NA	None	None
Area 7	NA	NA	None	Remedial Action (Phase IV)
Area 8	NA	NA	None	Remedial Action (Phase IV)
Area 9	NA	NA	None	Remedial Action (Phase IV)
Area 10	Negative	NA	None	None
Area 11	NA	NA	None	Remedial Action (Phase IV)
Area 12	NA	NA	None	Remedial Action (Phase IV)
Area 13	NA	NA	None	None
Area 14	NA	NA	None	Remedial Action (Phase IV)
Area 15	NA	NA	None	Remedial Action (Phase IV)
Area 16	NA	NA	None	Remedial Action (Phase IV)
Area 17	NA	NA	None	Remedial Action (Phase IV)
Area 18	Negative	NA	None	None
Area 19	NA	NA	None	Remedial Action (Phase IV)
Tritium in the Buried Valley Aquifer	NA	NA	None	Compliance and Verification (Phase V)
Plutonium in the Miami-Erie Canal	NA	NA	None	Compliance and Verification (Phase V)

Table EX-1 (cont)

Site	USDOE CEARP Phase I		Planned Future Action	
	FFSDIF/PA/PSI[a] Finding	HRS[b] Score	USEPA CERCLA Program Element	USDOE CEARP/CERCLA Order Phase
Historical Monsanto Facilities				
Unit I	Negative	NA	None	None
Unit II	Negative	NA	None	None
Unit III	Negative	NA	None	None
Unit IV	Negative	NA	None	None
Warehouse	Negative	NA	None	None
Marion	Negative	NA	None	None

[a]Federal Facility Site Discovery and Identification Findings/Preliminary Assessments/Preliminary Site Inspections.
[b]USEPA Hazard Ranking System.
[c]Category 1--Areas that potentially could have received oils or hazardous substances.
[d]Not applicable.
[e]Not evaluated.
[f]Category 2--Areas that because of past activities had potential for leaks and spills of oils and hazardous substances.
[g]Category 3--Previously identified radioactivity contaminated areas.

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5/22/86

I. INTRODUCTION

I.A. Background

U.S. Department of Energy (USDOE) facilities operate under a policy of full compliance with applicable environmental regulations while conducting their missions. The USDOE Albuquerque Operations Office (AL) initiated the Comprehensive Environmental Assessment and Response Program (CEARP) in mid-1984 to help fulfill that commitment at installations within the AL complex. CEARP will also assist USDOE in setting environmental priorities and will help provide justification for funding to carry out enhancements of existing programs or remedial actions where required. Implementation of CEARP will be realized by combined forces of AL, individual USDOE area offices, USDOE prime contractors, Los Alamos National Laboratory, and other assistance as found to be necessary.

I.B. Authority

Authority to implement CEARP is primarily derived from the following USDOE and AL orders:

* Comprehensive Environmental Response, Compensation, and Liability Act Program (USDOE 5480.14)
* Hazardous, Toxic, and Radioactive Mixed Waste Management (USDOE 5480.2 and AL 5480.2)
* Prevention, Control, and Abatement of Environmental Pollution (Ch. XII of USDOE 5480.1 and AL 5480.1)
* Environmental Protection, Safety, and Health Protection Information Reporting Requirements (USDOE 5484.1 and AL 5484.1)
* Implementation of the National Environmental Policy Act (USDOE 5440.1C and AL 5440.1B)

Federal and state regulations with particular importance to Monsanto Research Corporation (MRC) operations at Mound are discussed in Sec. IV.

I.C. Purpose and Scope

CEARP is a phased program to identify, assess, and correct existing or potential environmental problems. The review covers the major environmental regulations such as

the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), Resource Conservation and Recovery Act (RCRA), National Environmental Policy Act (NEPA), Clean Air Act (CAA), Clean Water Act (CWA), Safe Drinking Water Act (SDWA), Toxic Substances Control Act (TSCA), and Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), with emphasis on CERCLA and RCRA. Past, current, and future practices to handle and dispose of hazardous substances, as defined under CERCLA, are evaluated. In addition, environmental pollution control requirements and environmental monitoring programs for hazardous substances are evaluated for both adequate understanding of pathways and regulatory compliance.

I.D. Methodology

CEARP is being implemented in five phases, which exactly parallel USDOE CERCLA Order 5480.14. Additionally, the U.S. Environmental Protection Agency (USEPA) has prepared guidance for federal facilities to carry out their responsibilities under CERCLA. The USEPA has outlined its plans and intentions in a series of program elements that are organized in a somewhat different fashion but constitute the same basic approach as CEARP (Federal Facilities Program Manual for Implementing CERCLA Responsibilities of Federal Agencies, final draft). The five CEARP phases are linked as indicated in Fig. I.1. CEARP includes a review of the major federal environmental regulations. The review serves two primary purposes: (1) determines compliance with environmental regulations and (2) evaluates the interaction of CERCLA with other environmental regulations, for example, releases permitted under the CWA or CAA and releases exceeding reportable quantities under CERCLA, or RCRA-related remedial activities and CERCLA-related remedial activities. The purposes of individual CEARP phases are as follows.

I.D.1. Phase I - Assessment of the Installation. Phase I objectives are to determine present compliance with environmental laws and to ascertain the magnitude of potential environmental concerns. Where insufficient data exist to accomplish this, the additional information necessary to complete the evaluation will be identified. The CEARP Phase I report will provide documentation for Phase I of the USDOE CERCLA Order 5480.14 and for the following USEPA CERCLA preremedial activities: (1) Federal Facility Site Discovery and Identification Findings (FFSDIF) (notification of newly discovered sites, including notification of negative findings), (2) Preliminary Assessment (PA), (3) Site Inspection (SI), and (4) Hazard Ranking System (HRS) evaluation (see Sec.

I.E.8., The Hazard Ranking System). Sites at Mound are indicated for no further action when CEARP findings indicate (1) negative findings for the CERCLA FFSDIF process (e.g., potential sites that are found not to exist or spills that were removed in the past through remedial action), or (2) sites initially requiring notification for the FFSDIF process, but are later found to pose no threat of release under USDOE CERCLA for the USEPA CERCLA PA process (e.g., potential sites where the hazardous substance initially identified because of its stability no longer persists in the environment). Consequently, sites at Mound that no longer pose a release threat are not included in the USEPA HRS and USDOE Modified HRS (MHRS). This procedure is consistent with the guidance provided to federal facilities by USEPA (Federal Facility Program Manual for Implementing CERCLA Responsibilities of Federal Agencies, final draft) (Fig. I.2.).

Sites requiring HRS evaluation are scored as follows: (1) nonradioactive sites are scored with the USEPA HRS and (2) radioactive sites are scored with the USEPA HRS and the USDOE MHRS. Sites meeting USEPA criteria for being listed on the National Priorities List (NPL) are recommended for future action under USDOE CERCLA Program Phase II to quantify the potential migration problem. This approach is consistent with USEPA CERCLA. Sites that do not meet USEPA criteria to be listed on the NPL but exceed other applicable USDOE remedial action criteria/guidelines (e.g., guidelines for the USDOE Surplus Facilities Management Program) and/or sites posing potential regulatory compliance concerns (e.g., RCRA-related remedial activities) are recommended for future action under CEARP. No further action is recommended for sites not meeting these criteria.

I.D.2. Phase II - Confirmation. Phase II objectives are to (1) obtain additional information identified as necessary during Phase I, (2) complete an environmental evaluation to confirm the presence or absence of potential environmental concerns identified in Phase I, and (3) plan and carry out measurement and sampling programs as required to understand potential sources of contaminants and potential environmental pathways. Confirmed problems will be assessed for health or environmental risk as a basis for setting priorities for remedial action or other follow-up actions. The CEARP Phase II reports will provide documentation for Phase II of the USDOE CERCLA Order (CEARP Phase IIA Monitoring Plan and CEARP Phase IIB Site Characterization) and for two USEPA CERCLA remedial planning program elements (Remedial Investigation Sampling Plan and Remedial Investigation).

I.D.3. Phase III - Technological Assessment. Phase III objectives are to develop plans for remedial actions or enhancements of existing programs by proposing and assessing alternative technologies and approaches to eliminate or control environmental problems identified as needing correction in CEARP Phase II. The evaluation will include assessing the effectiveness of technology; impacts on health, safety, and the environment; and cost-benefit analysis, where appropriate. Phase III reports will include identifying or developing appropriate criteria and performing any evaluation of environmental impact required by NEPA. CEARP Phase III reports will provide documentation for Phase III of USDOE CERCLA and for two remedial planning program elements of USEPA CERCLA (i.e., Feasibility Study and Remedial Action Selection).

I.D.4. Phase IV - Remedial Action. Phase IV objectives are to implement recommended site-specific remedial measures identified in Phase III, which could include engineering design and construction to remedy or control environmental problems. CEARP Phase IV will encompass requirements of USDOE CERCLA Order (Phase IV) and remedial implementation program elements of USEPA CERCLA (Design and Action).

I.D.5. Phase V - Compliance and Verification. Phase V objectives are to (1) verify and document the adequacy of remedial actions carried out in Phase IV, and (2) identify and plan for any continuing monitoring requirements needed to demonstrate control of migration or adequately recognize future concerns. CEARP Phase V will encompass requirements of USDOE CERCLA Order Phase V and USEPA Final Site Inspection/Closeout and Monitoring.

I.E. Phase I Implementation

CEARP Phase I was carried out at Mound as a number of tasks. These tasks were performed by personnel of the Los Alamos National Laboratory Environmental Surveillance Group and MRC (Mound operating contractor).

I.E.1. Records Search and Literature Survey. During the Mound records search and open literature survey, existing documents in the following categories were reviewed and evaluated by Los Alamos personnel:

- environmental documents
- development or management plans
- environmental monitoring reports
- federal/state/local permits
- operational records/documents
- safety analysis documents
- standard operating procedures
- appraisals, audits, inspections
- contingency/emergency plans
- special/topical studies or reports
- history and mission documents
- accident/incident investigation reports

Information acquired during the records search and literature survey that is directly related to CEARP is included and referenced as appropriate in this CEARP Phase I report. A listing of documents surveyed during the review process is provided in App. E. This listing is representative of documents reviewed. In addition, the appropriate CEARP-related Mound internal files were reviewed, including Mound Loss Prevention and Environmental Control (LP&EC) documentation. Appropriate AL CEARP-related files for Mound were also reviewed.

I.E.2. Employee Interviews. MRC employees (former and current) identified as possibly having knowledge relevant to CEARP were screened to determine who would be interviewed. More than 20 MRC employees familiar with or having had responsibility for past and current management practices for hazardous substances, facility operations (e.g., processes that generated solid and liquid hazardous substances), or who might know about past leaks or spills of hazardous substances were identified during the screening process. These individuals were interviewed during the official review process to identify undocumented incidents or management practices that could have resulted in environmental concerns. Information from the interview process covers the complete history of MRC at Mound and other MRC Mound-related facilities. Those interviewed included 4 employees, 1946-1949; 13 employees, 1950-1959; 24 employees, 1960-1969; 24 employees, 1970-1979; and 24 employees, 1980-1985). Current and past professionals in Operational Safety at Mound (e.g., Technical Services, Industrial Hygiene, Health Physics Operations, and Environment) were interviewed as well as those in Production, Product and Process Development, Advanced Devices, Engineering, Facilities Engineering, Nuclear Operations, Nuclear Technology, and Technology Application and Development. A two-person team from Los Alamos National Laboratory conducted the interviews during the week of Feb. 11, 1985. The interview notes were compiled and returned to the person interviewed for verification. The information from the interview process is included (as appropriate) in this CEARP Phase I report. However, names,

positions, and period of position performance have been omitted to preserve their anonymity and ensure compliance with employee protection requirements of CERCLA (Section 110 of CERCLA).

Information collected represents individual recollections of events and conditions over an extended period of time, some of it as far back as four decades. This information was accepted at face value as an indicator of potential environmental concerns but cannot be taken as documented proof of environmental perturbations. However, any event or condition mentioned that had and/or has potential to release hazardous substances into the environment provided the basis for a recommendation that at least some confirmatory data be collected under CEARP Phase II. This approach ensures that suspect sites are characterized and that potential sources for release of hazardous substances are not overlooked. The intent is to have definitive documentation by the end of CEARP Phase II confirming the presence or absence of any environmental concerns.

I.E.3. Evaluation of Waste Management. Present and past management practices for hazardous substances were reviewed and evaluated. Information for this process was gathered during the CEARP records search and literature survey, employee interviews, and investigation of current operations at Mound.

I.E.4. Identification of Contaminated Areas. Sites that were contaminated or are suspected of being contaminated as a result of current or past practices, including leaks and spills, were identified. Information for this process was gathered during the CEARP records search and literature survey, employee interviews, and investigation of current operations at Mound.

I.E.5. Evaluation of Compliance with Environmental Regulations. An evaluation of compliance with applicable environmental standards and regulations, including USDOE orders and internal guidelines, was conducted. Special emphasis was placed on those regulations that interface with CERCLA (e.g., CWA or CAA permitted releases and exceeding CERCLA reportable quantities).

I.E.6. Preliminary Physical Survey. Preliminary physical surveys of Mound were conducted during 1984 and 1985 to validate observations from the CEARP document

search and interviews and to identify other signs of environmental stress or facility features that might indicate a potential for environmental concerns.

I.E.7. Pathway Evaluation. A preliminary evaluation of potential migration pathways for hazardous substances was made.

I.E.8. The Hazard Ranking System (HRS). The HRS is used by USEPA to establish a National Priorities List (NPL) of facilities for initial attention under CERCLA. Effective Feb. 18, 1986 federal sites meeting criteria for listing on the NPL can be listed there.

The USEPA HRS, however, does not discriminate among different radioisotopes relative to their potential risk at potential CERCLA sites. Therefore, USDOE developed the modified HRS (MHRS) which is a conceptually minor modification/addition to the HRS. The MHRS permits a better assessment of existing radiological risks. Therefore, potentially radioactive sites requiring HRS evaluation are scored with USDOE's MHRS and EPA's HRS; and non-radioactive sites requiring HRS evaluation scored with USEPA's HRS.

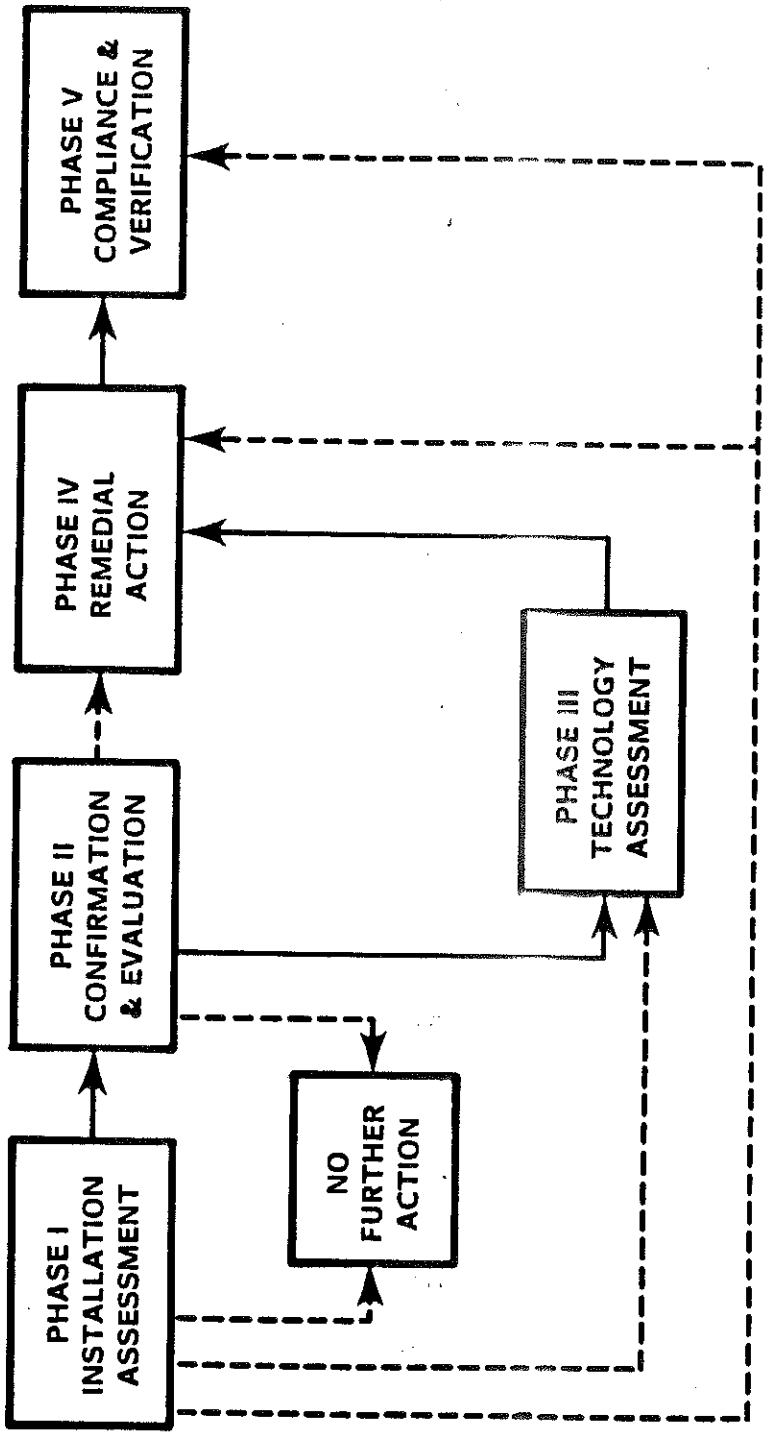

Figure I.1. CEARP Decision Flow Chart.

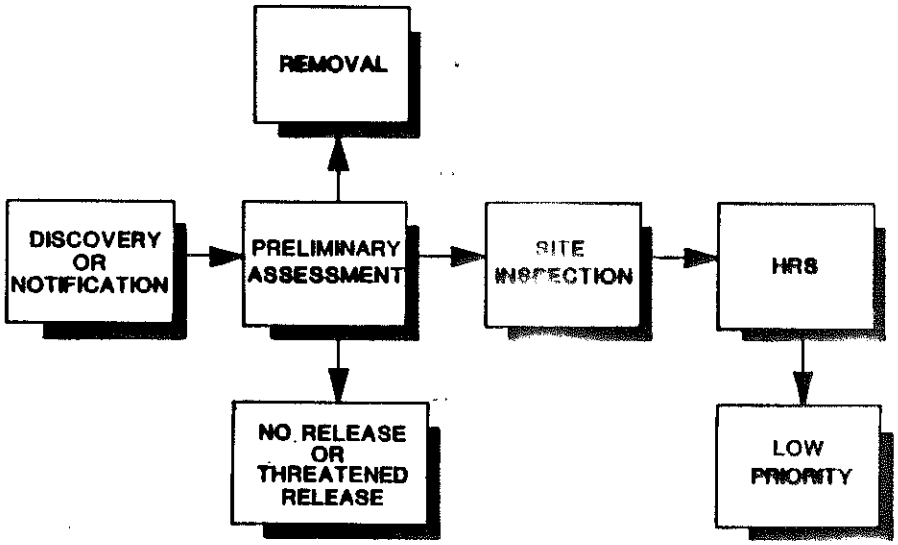

Figure I.2. Initial Phases of Federal Agency-Lead Superfund Response Activities and Events.

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II. DESCRIPTION OF THE MOUND INSTALLATION

II.A. Location and Physical Description

Mound is located on a 306-acre site in southern Montgomery County in southwestern Ohio, at the southern boundary of Miamisburg and 0.6 mi due east of the Great Miami River (Fig. II.1. and Fig. II.2.). The site is 10 mi south-southwest of Dayton, Ohio, and 31 mi north-northeast of Cincinnati, Ohio. Several photographs of Mound are provided in Appendix B.

The predominant geographical feature in the five-county region surrounding Mound is the Great Miami River, which flows from northeast to southwest through Miamisburg. The river valley is highly industrialized. The remainder of the region is predominantly farmland, dotted with light industry and small communities.

Mound is situated on 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 (the original Mound site), and the more recently acquired property to the south. Most of the buildings are located on the northwest high area (Fig. II.3.). A smaller group of buildings is located on the southeast high area, and several buildings are located in the valley and on the valley slopes. A detailed discussion of the Mound environs can be found in the Final Environmental Impact Statement for Mound (USDOE 1979).

The present site plan (Fig. II.4.) shows the layout of all facilities, including new construction. The usages for present facilities are presented in Table II.1. The utilities and support services are identified in Fig. II.5.

Buildings on the northwest hill include administrative offices, machine tool and maintenance shops, nuclear and advanced device production and development facilities, cafeteria, library, powerhouse, and other utilities (Monsanto Research Corporation 1985).

Buildings in the valley area include explosive production and test firing facilities, explosive storage bunkers, isotope separation facilities, waste disposal operations, sanitary treatment facilities, warehouses, and offices. Construction sites are available west of the test firing area.

The southeast SM Hill or PP area (Fig. III.1.) of the original Mound site is occupied by Building 50 and the old plutonium processing facilities. The area south of the PP area is flat and is the largest area available for construction on the original site.

The proposed site development plan for Mound is presented in Fig. II.6. A detailed discussion of the plan can be found in "The Mound Site Development and Facilities Utilization Master Plan" (Monsanto Research Corporation 1985).

II.B. Former Use

The original Mound site was used for agrarian purposes prior to the establishment of Mound.

II.C. Organization

MRC operates Mound, a government-owned facility of USDOE at Miamisburg, Ohio. Mound is an integral part of the USDOE AL complex. MRC is the sole contractor involved in waste generation and waste management activities at Mound.

II.D. Mission

Mound is an integrated research, development, and production facility performing work in support of USDOE weapons and energy programs, with emphasis on explosives and nuclear technology (Monsanto Research Corporation 1985).

The weapons program missions include process development, production engineering, manufacturing and surveillance of detonators, explosive timers, explosive actuated transducers, explosive pellets, nuclear components, and specific testing equipment.

The main function at Mound is to manufacture nonnuclear components and tritium-containing components for nuclear weapons. Its major objectives are as follows:

* Manufacture detonators, explosive timers, explosive-actuated transducers and switches, explosive pellets for the nuclear weapons program, firesets, and pyrotechnic actuators.

* Develop and manufacture small heat sources for the national defense program.

* Manufacture tritium components for nuclear weapons applications.

* Perform surveillance and quality assurance on explosive detonators and radioactive components received from other USDOE sites.

* Develop materials and processes for potential future manufacturing of components and explosive-actuated mechanisms containing chemical explosives.

* Develop tritium processes and materials for possible future production.

* Recover and purify tritium generated by tritium operations at various USDOE sites.

* Develop and fabricate components for a variety of radioisotopic heat sources fueled with ^{238}Pu having thermal outputs ranging from 0.2 watt to several thousand watts; assemble and test radioisotopic thermoelectric generators; and act as lead laboratory for heat source programs supporting the national space programs.

* Manage procurement of ordnance materials for weapons programs.

* Separate, purify, and market stable (nonradioactive) isotopes including the noble gases, sulfur, chlorine, and bromine, and market the isotopes of carbon, nitrogen, and oxygen.

* Conduct 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.

* Develop and implement methods to decommission and decontaminate radioactive facilities.

II.E. Demographics

The Mound site is mainly within the southern city limits of Miamisburg in Montgomery County, Ohio, an extensively urbanized county dominated by the Dayton metropolitan area (Monsanto Research Corporation 1985). It is situated about 10 mi south-southwest of the Dayton city limits (Fig. II.7.).

The 1980 census populations of Miamisburg, Dayton, and Montgomery Counties were 15,300, 199,540, and 571,700, respectively. Local urban populations are presented in Fig. II.7. There is no large seasonal variation in population for the local area surrounding Mound.

Miamisburg is mostly a residential community, with some supportive commercial facilities and limited industrial development. Most of the residential, commercial, and industrial development within a 5-mi radius of the site is concentrated on the Great Miami River flood plain. The adjacent upland areas are used primarily for residences and agriculture. Agricultural land within a 5-mi radial area around the site is used primarily for corn and soybean production and for livestock grazing. Most of the residential development on the upland areas is relatively new in comparison with development on the flood plain. It is likely that most future development in the area will occur on the upland areas.

Miamisburg has 13 parks and 4 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 the 68-ft high Indian mound (Miamisburg Mound), which is located 380 ft east-southeast of the site boundary. The Miamisburg Mound is the only historic landmark in the immediate vicinity of Mound. Within 1 mi of the facility, other recreational areas extensively used in summer include the municipal swimming pool, Harmon Athletic Field, and Library Park.

The major body of water in the Mound vicinity is the Great Miami River, which is approximately 150 to 200 ft wide. The Great Miami River is not used for commercial barge traffic or commercial fishing, but some pleasure boating and sport fishing do occur, usually during the summer.

Principal surface and groundwater users within the Great Miami River basin are depicted in Fig. III.4.). No municipal system in this basin uses surface water for a public water supply below the Mound effluent discharge. Both surface and subsurface 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 (USDOE 1979).

There are no large lakes within a 5-mi radius of the site. Several fishing ponds are located 3.5 mi north-northeast 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 site. The City of Miamisburg has maintained two very small recreation ponds in a small park in this area. During 1978, Miamisburg converted one of the small ponds into a solar pond to heat water for the municipal swimming pool. The city may expand this park area along the west boundary of the site.

Additional discussion of the Mound environs can be found in the Final Environmental Impact Statement for Mound (USDOE 1979).

II.F. Important Site Characteristics

Mound is located in an urbanized area, making accidental releases of hazardous substances, past and current, a sensitive issue to the immediate population. Earlier releases of tritium and plutonium at Mound were made public by MRC, and there has been routine annual reporting of environmental information. There has been no adverse public reaction to such announcements. The tritium releases have resulted in monitoring and pumping local groundwater supplies to ensure that tritium concentrations are within the national interim primary drinking water standard (20 nCi/L)(40 CFR 141). The Buried Valley Aquifer, a major water source for the region, trends along the Great Miami River and extends eastward beneath the valley that bisects Mound (see Sec. III.C.2.b.).

II.G. History of Monsanto Facilities

Mound originated as a technical organization in 1943 when Monsanto Company was requested to accept responsibility for determining the chemical and metallurgical properties of polonium as a project (Dayton Project) of the Manhattan Engineering District. This work was conducted at several satellite units of Monsanto's Central Research Department in the Dayton, Ohio area. Former Monsanto facilities and their respective missions are identified in Table II.2. In 1946 a 182-acre tract adjacent to Miamisburg was selected for a permanent facility. Work at the satellite units was consolidated at Mound in 1948.

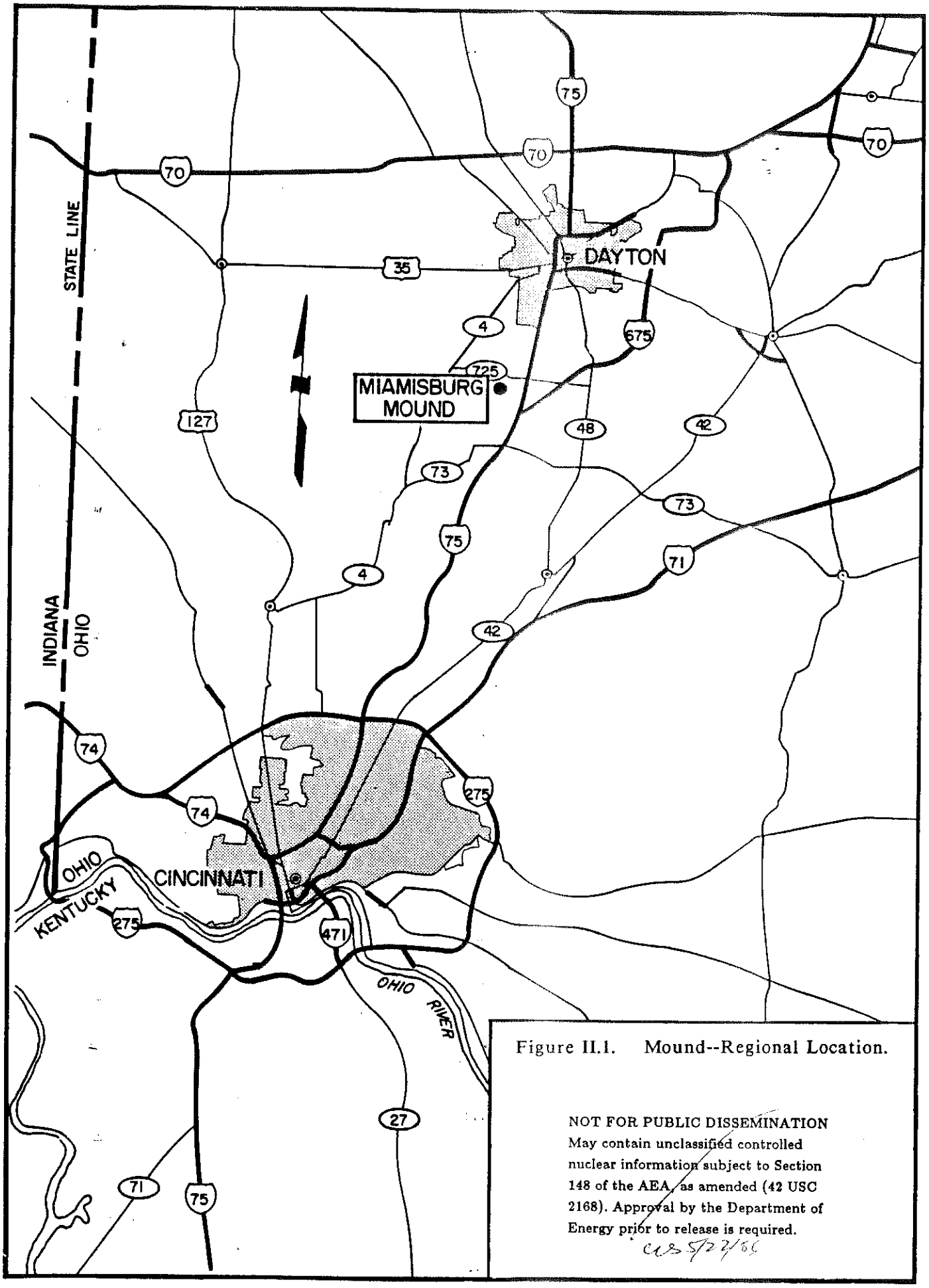

Figure II.1. Mound--Regional Location.

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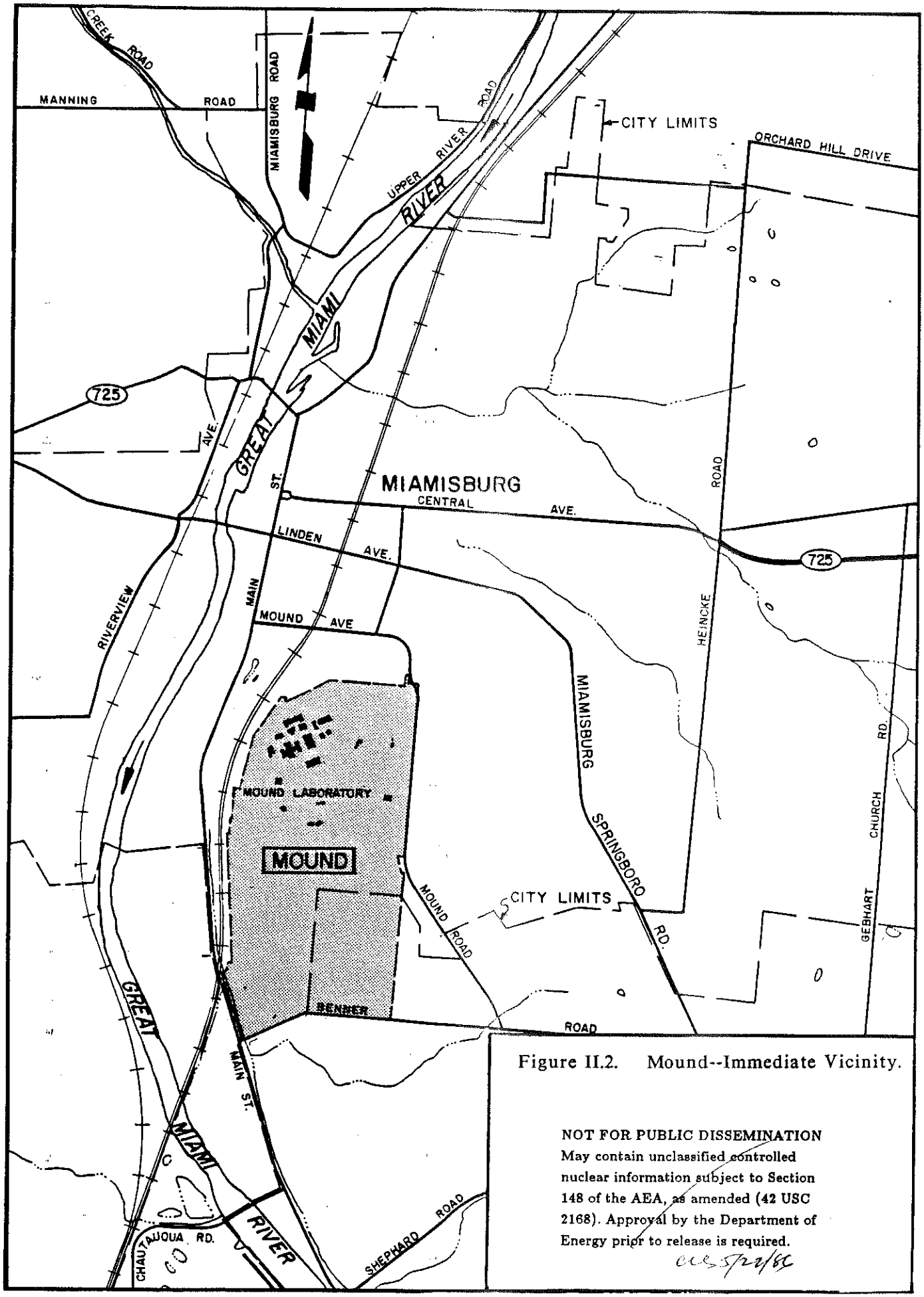

Figure II.2. Mound--Immediate Vicinity.

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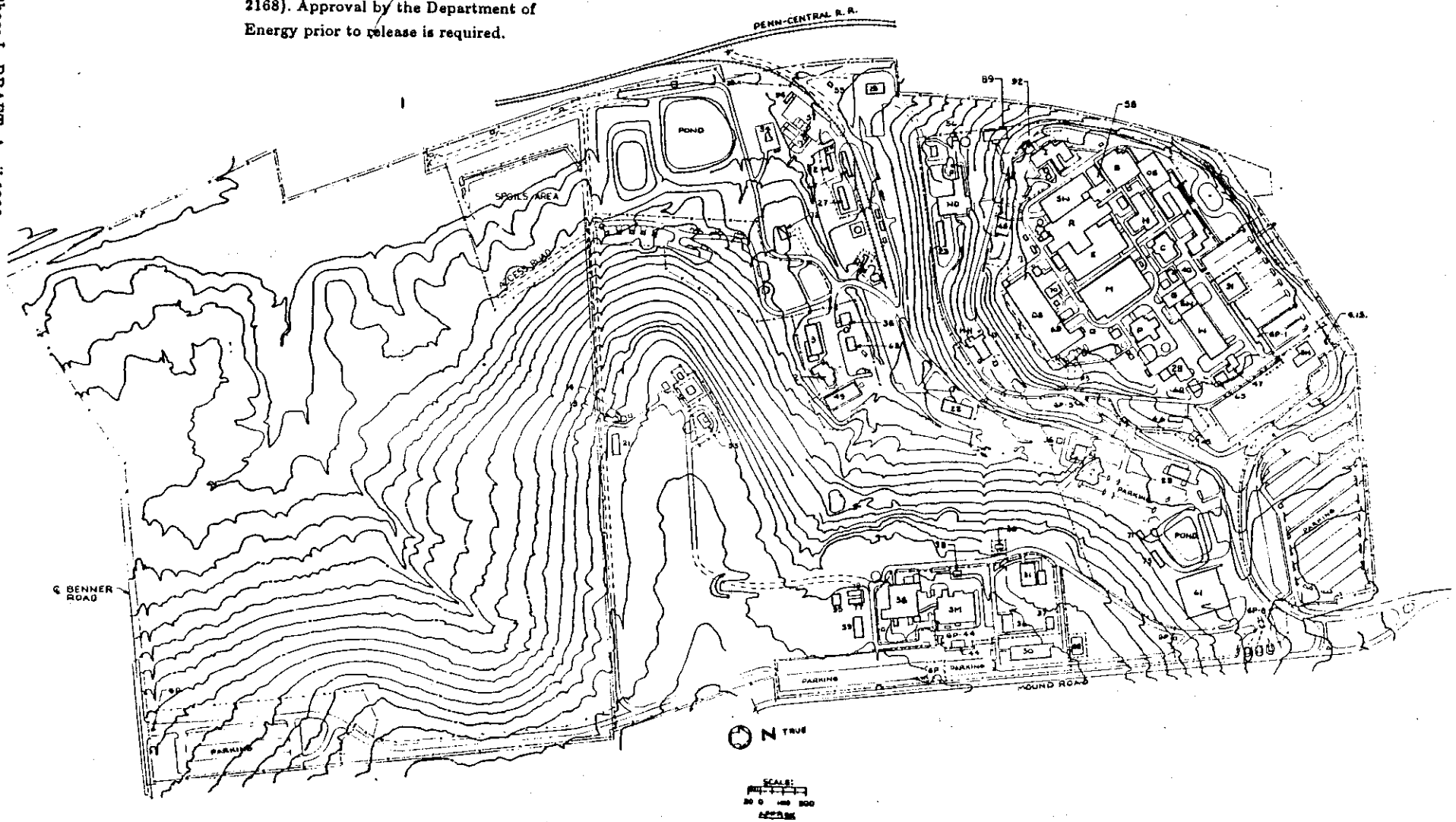

Figure II.3. Mound--Site Topography.

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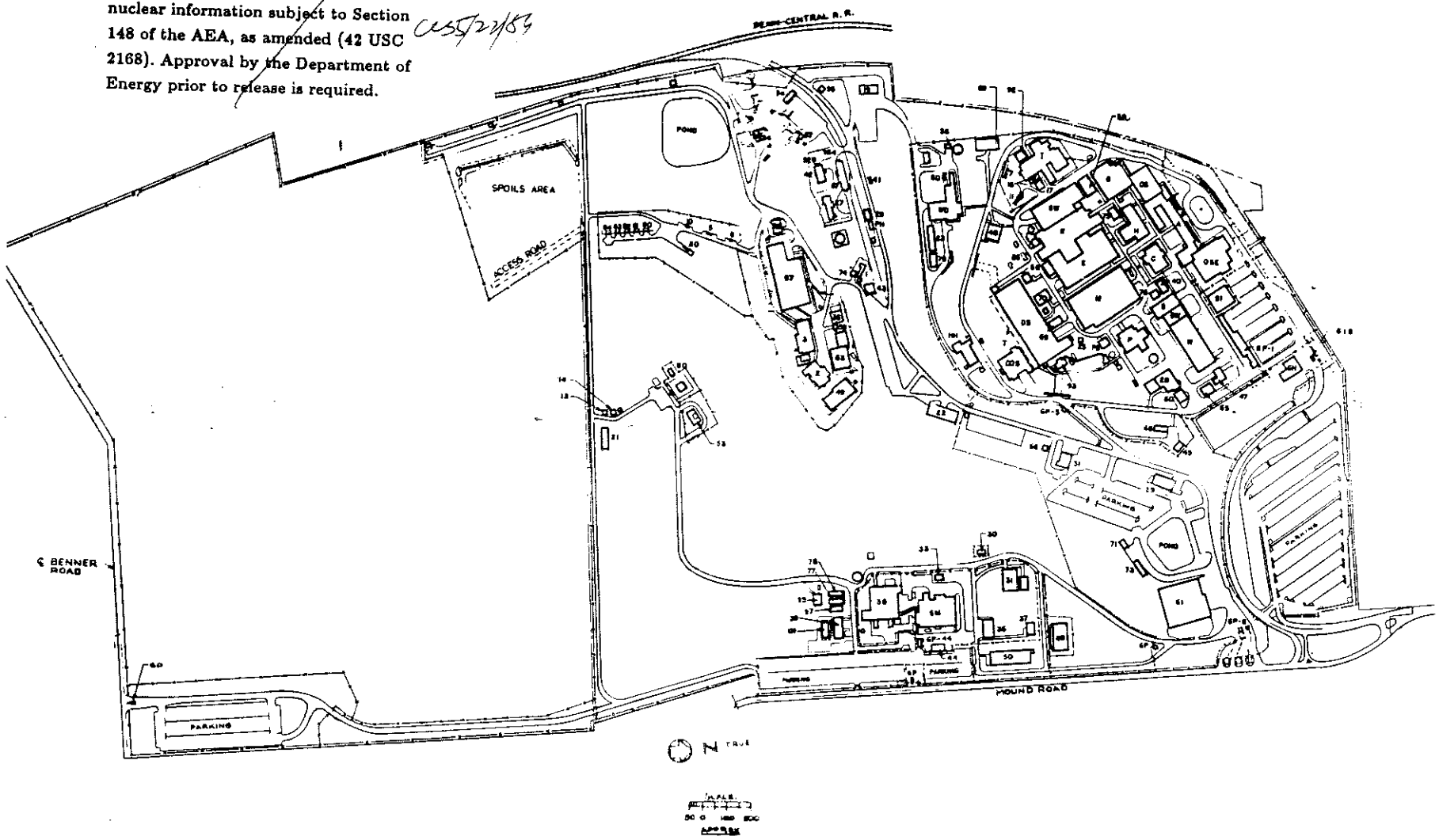

Figure II.4. Mound--Site Plan (1985).

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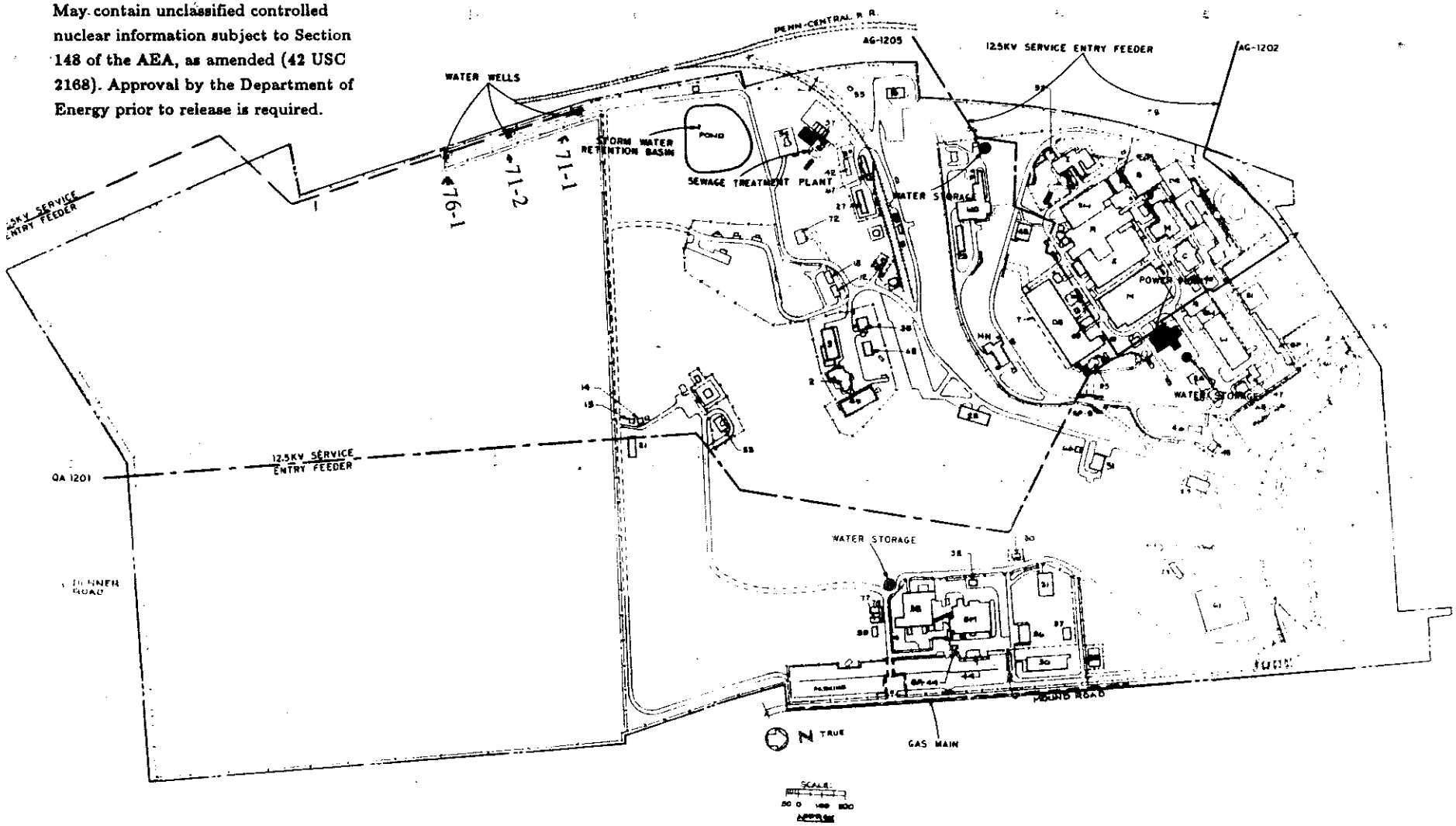

Figure II.5. Mound Utility Locations.

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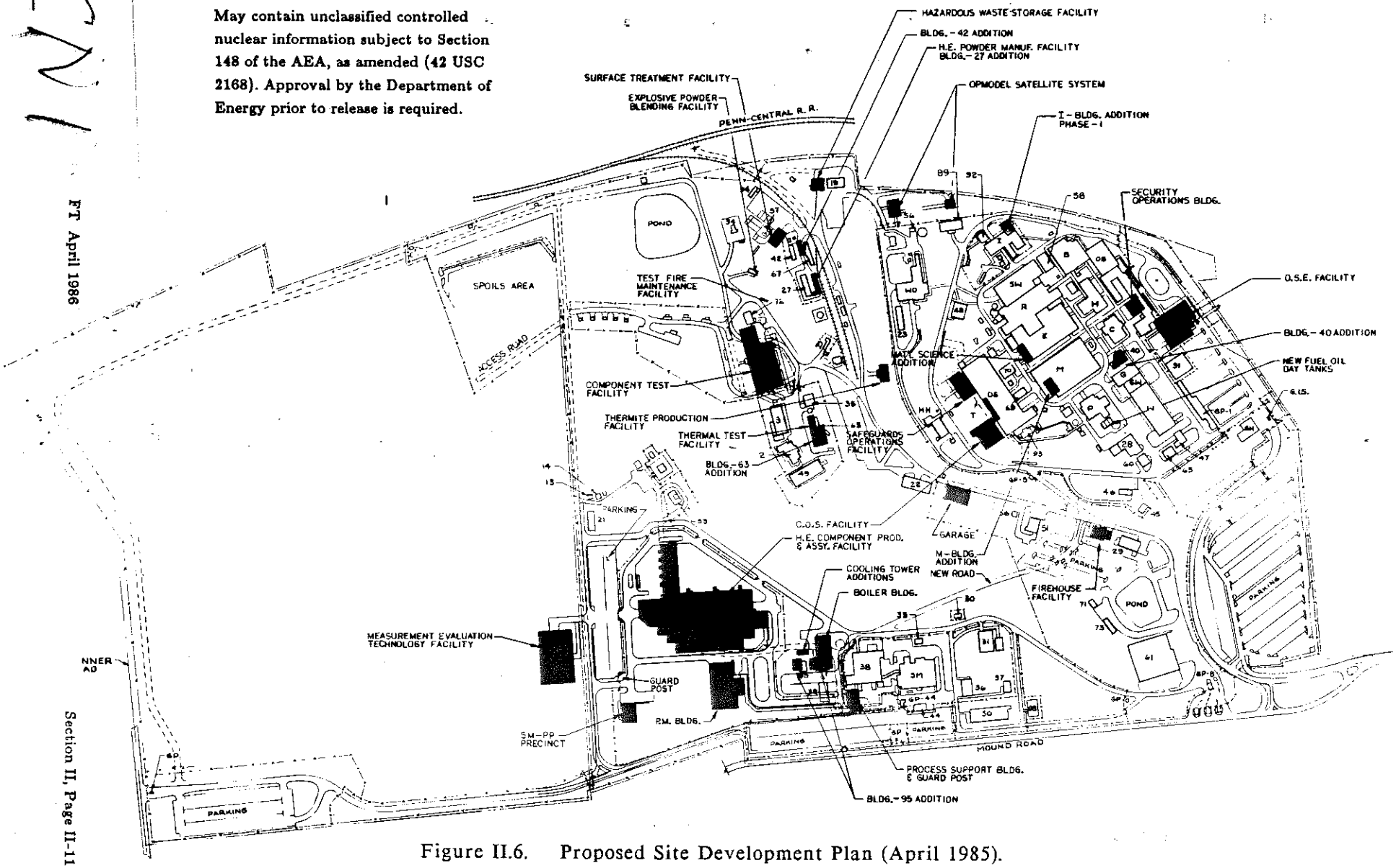

Figure II.6. Proposed Site Development Plan (April 1985).

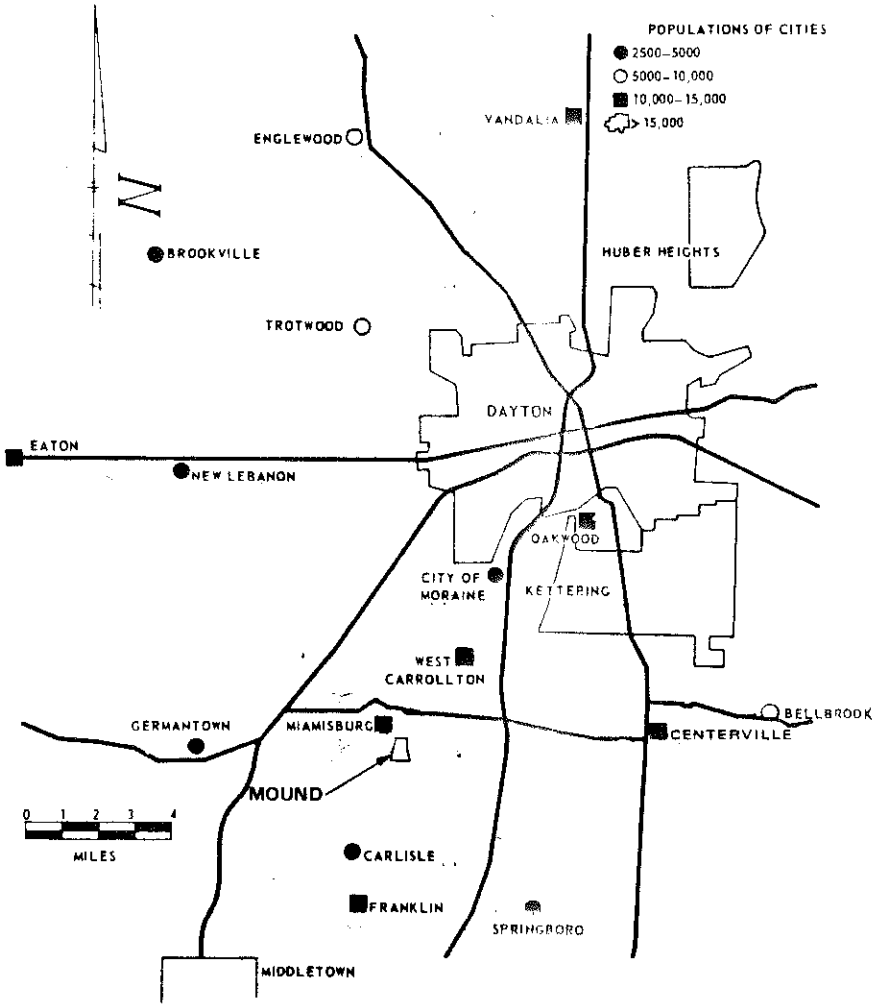

Figure II.7. Populations of Urban Areas Near Mound.

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Table II.1. Usage for Present Mound Facilities

Building	Current (1982) Use
A	Offices - Director of Laboratory, Administrative Services, Engineering, Advanced Devices, Personnel, Finance, Medical
B	Advanced Devices Inert Production
C	Cafeteria
DS	Development/Standards
E	Analytical Services/Advanced Devices Production
E Ad'n	Offices, Advanced Devices/CAD System
G	Garage
GH	Visitor Control
GH44	Guard House at SM/PP
G-P1	Guard Post No. 1/Firing Range
GW	Bonded Stores (Advanced Devices Production)
H	Laundry, Environmental Laboratories, Credit Union, Change Rooms
H-H	Isotope Separation
I	High Explosive (H.E.) Production
M	Machine Shops, Electronics Shop, Trades Shops, Maintenance Offices, and Conference Room
OS	Offices - Engineering, DOE, Nuclear Operations, Management Information, CAD, Central Computer Facility
P	Power House - Central Steam, Brine, Compressed Air, and Breathing Air
PS	Paint Shop
R	Nuclear Operations Laboratories, Offices, Library
SD	Sanitary Disposal (Abandoned)
SM	Nuclear Operations Office/Standby
SW	Nuclear Operations, Tritium Development and Recovery
T	Nuclear Operations and Advanced Devices Laboratories, Machine Shop, Administrative Services
W	Warehouse, Trades
WD	Radioactive Waste Disposal
1,2,3, 35,49, 59,63	Test Fire Operation
17	Warehouse
18	Storage
19	Salvage and Sales
21	Raw Material Storage (Cotter)
22	Storage Warehouse
23	Waste Material Staging Area
24	Water Treatment
25	Weather Station
26	Maintenance Shop

Table II.1 (cont)

Building	Current (1982) Use
27	Advanced Devices Programs
28	Ceramic Production
29	Advanced Devices Plastics
30	R&D - Hydropyrolysis
31	Contaminated TRU Waste Storage
33	SM Area Maintenance Shop
34	Emergency Brigade Training
36	Nuclear Operations - Fossil Fuels Development
37	Adhesive Formulation
38	Nuclear Operations Programs and Decontamination and Decommissioning
40	Graphics (Office Services)
42	High Explosive Production
43	Advanced Devices Development
44	Cafeteria - SM Area
45	Neutron Standards
46	Weld Development
47	Fire Station
48	Surveillance
50	Heat Source Loading and Environmental Testing
51	Pilot Scale Test Facility
57	Sanitary Sewage Disposal
58	Filter Bank
61	Warehouse
62	Aqueous Liquid Waste Handling
63	Surveillance
65	Office
66	Offices
67	Energetic Material Support
68	Decontamination and Decommissioning Staging Area
69	Offices
70	Offices
72	Waste Chemical Storage
75	QC Engineering
76	Tool/Gauge Machining
77	D&D Support, Engineering, and Health Physics
78	D&D Support, Nuclear Operations, and Safety
79	Offices
88	Offices
90	Incinerator (Detonators)
90	Detonator Retort
91	Offices
92	Training Facility
93	Offices
94	Materials Compatibility
95	SM Chiller Plant

Table II.2 Former Monsanto Facilities in the Dayton Area

Site Designation	Location and Mission
Unit I	Location--Monsanto Central Research Department Facilities, 1515 Nicholas Road, Dayton, Ohio
	Mission--The Dayton Project was organized and recruitment initiated at Unit I
Unit II	Location--Monsanto Rocket Propellant work off Betty Lane; site adjacent to present St. Henry Church on Ohio 741; north of Dayton Mall
	Mission--Dayton Project activities were not conducted at Unit II, which was operated independently as a production facility of rocket propellent
Unit III	Location--Bonebrake Theological Seminary, 1601 West First Street, Dayton, Ohio
	Mission--Unit III was used as the polonium research facility
Unit IV	Location--Runnymede Playhouse at Dixon Avenue and Runnymede Road in Oakwood, Ohio
	Mission--Unit IV was used as the polonium separation production facility
Warehouse	Location--Old warehouse at Third Street and Sears Street, Dayton, Ohio
	Mission--The warehouse was used for analysis of environmental monitoring samples, bioassay samples from project personnel, and preliminary biological studies on the effect of polonium on laboratory animals
Marion	Location--Duplicate production facility located in Marion, Ohio
	Mission--Marion was a standby facility for the Mound Laboratory T Building, but was never operated. Radioactive materials were never introduced to the facility

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III. ENVIRONMENTAL SUMMARY

The topography at Mound is characterized by bedrock bluffs overlooking the Great Miami River. The rugged topography is a remnant of glacial erosion, in which glacial outwash channels form gravel-filled valleys and the remaining bedrock highs form hills, bluffs, and uplands. Runoff from precipitation and snowmelt is moderately rapid; rainfall generally runs off the relatively impermeable bedrock surfaces (where fracturing is not extensive) into stream channels. A fairly humid temperate climate has produced a woods environment in those areas that are not managed for other purposes.

III.A. Meteorology

Southwestern Ohio, where Mound is located, has a continental climate characteristic of the north-central region of the United States. Summers are warm and humid and winters are moderately cold. On the average, daily summer temperatures range from $62^{o}F$ to $85^{o}F$ and daily winter temperatures range from $22^{o}F$ to $37^{o}F$. The average relative humidity is 71%.

Precipitation is distributed throughout each season of the year, totaling 40 in/yr. Snowfall averages approximately 27 in/yr. The average net precipitation is approximately 6 in and the 1-yr, 24-h rainfall is approximately 2.5 in.

Thunderstorms and tornadoes are the principal types of severe weather affecting the area. On the average, thunderstorms are recorded on 39 days per year at Dayton. In an area of approximately 4,800 mi^2 centered near Mound, 31 tornadoes were recorded over a period from 1953 to 1972 (USDOE 1979). The 100-yr return period wind speed for the Mound Facility is a straight wind of 80 mph (Coates 1984).

III.B. Geology

Mound is located on an area of relatively flat lying basement rocks of Precambrian Age on the eastern portion of the "Cincinnati Arch." These basement Precambrian granites are overlain by about 2,600 ft of limestones, shales, some dolomite, and thin sandstone (USDOE 1979).

The original Mound site is divided into two hilltop areas by a small valley that trends to the southwest (Fig. III.1.). The core of the hills consists of limestones and shales

of Ordovician Age. These limestones and shales were deposited in a marine environment. The upper surfaces of these Paleozoic rocks have been eroded and modified by glaciation, the most recent stage being the Wisconsin. Glacial action produced thin phase glacial till and glacial outwash in the immediate vicinity of Mound.

The thin phase forms a thin veneer over limestones and shales that form high areas such as the two hilltop areas and slopes of the valley at Mound (Fig. III.2. and Fig. III.3.). The thin phase is generally less than 20 ft thick and is a mixture of gravels, sands, silts, and clay. It covers most of the upland areas and is the predominant outcrop within Mound. The thin phase is not an aquifer.

The Buried Valley Aquifer (BVA) is a glacial outwash formation, which serves as a major aquifer in the region (Fig. III.2.). Glacial outwash is composed of stratified deposits of gravel, sand, silt, and clay. The BVA varies in thickness and is up to 130 ft thick in an area adjacent to Mound.

III.C. Hydrology

III.C.1. Regional Surface Water. Mound lies within the Great Miami River drainage basin, which covers a significant portion of southern Ohio and small segments of southeast Indiana (Fig. III.4.) The drainage area at Miamisburg, 1 mi upstream from Mound, is 2,711 mi^2. Since the installation of a flood control system in 1921, the maximum flow recorded at Miamisburg was 61,800 cfs in January 1959. The maximum daily measured discharge was 55,600 cfs (1959) and the minimum daily average discharge was 148 cfs (1925).

A flow duration curve for discharge records at Miamisburg over the period 1931 to 1960 is presented in Fig. III.5. The mean flow (expected to occur 50% of the time) is 1,050 cfs. The normal pool elevation of the river in the vicinity of Mound is controlled by the Hutchings Station Dam [680 ft mean sea level (MSL)], which is located about 1.5 mi downstream.

III.C.2. Mound's Surface Water. Onsite surface waters consist of two man-made ponds and a stream. The stream subdivides the original Mound site into two areas, the Main Hill and the SM Hill (Fig. III.6.). The stream watershed is primarily within Mound. The stream channel is located along a buried glacial outwash channel. The

alluvium underlying the stream channel is relatively permeable and allows flow in the channel to infiltrate the shallow aquifer.

Surface runoff from the SM Hill is collected in an asphalt-lined pond, which is located in the upper reach of the stream watershed. Water from the asphalt-lined pond is discharged to the stream.

Near the western boundary of Mound, the streamflow is diverted into a series of interconnected concrete retention basins prior to discharge from Mound. The stream can be diverted to an overflow pond if desired (Fig. III.1.).

After leaving the western boundary of Mound, the stream flows west under the Penn Central railroad tracks through two concrete box culverts. The stream course direction then turns south, paralleling the railroad tracks, following the course of the old Miami-Erie Canal. The stream discharges into the Great Miami River about 1 mi downstream from where it exits the western boundary of Mound.

III.C.3. Groundwater. Aquifers capable of domestic, municipal, or industrial supply in the Mound area include bedrock (low-yield Paleozoic Rocks) and glacial outwash deposits (moderate to high-yield gravels). Thin phase glacial till does not have the storage capacity or permeability to be an aquifer.

III.C.3.a. Bedrock Aquifers. The thin phase of glacial till acts as a low permeability barrier to the recharge of underlying limestones and shales. Water is stored and transmitted through the upper zones of the limestones where surficial weathering has locally opened fractures and bedding planes. The limestones and shales are relatively impermeable. The upper 20 ft have a permeability range of 1 to 10 gpd/ft^2, but below this the bedrock permeability ranges from impermeable to 0.2 gpd/ft^2 (USDOE 1979). Wells drilled into the limestones and shales usually do not yield more than 5 to 10 gpm and many wells fail to yield sufficient quantities of water to become producing wells (Spieker 1968).

A test boring at an elevation of 855 ft MSL near the northeast corner of the Operational Support Building (OS Bldg, Fig. II.4.) penetrated 481 ft of alternating layers of shale, claystone, and limestones. The hole bottomed at an elevation of 374 ft MSL, about 296 ft below the bottom of the Great Miami River. The BVA was not encountered during the test boring (Monsanto Research Corporation 1979).

Small seeps occur on the hillsides where glacial till thins over limestone and shale bedrock. These seeps are the direct result of precipitation and are, for the most part, seasonal and dependent on rainfall. Formation borings have encountered similar water in the base of the glacial till and upper part of the limestones and shales.

Thirty-seven test borings were made in the recently acquired property south of the original Mound site (Bowser and Morner 1983). The borings were made through the thin phase glacial till into the top of the limestones and shales. The BVA was not encountered during boring. Of the 37 borings, water was encountered in only 3, although others reported increased moisture near the contact between the glacial till and limestone and shale. The water resulted from infiltration of precipitation with water recharge occurring during early spring and late fall (Bowser and Morner 1983). Water in the base of the glacial till or the top bedrock aquifer is not a source of water supply for domestic or municipal use because of low yield and small storage capacity.

III.C.3.b. Buried Valley Aquifer. The BVA, consisting of sand and gravel outwash deposits, trends along the Great Miami River and extends eastward beneath the valley that bisects Mound (Fig. III.7.).

The BVA within Mound is thickest along the western boundary of Mound and ranges from 42 to 64 ft (Dames and Moore 1976A). The BVA thickens westward to about 130 ft near the eastern edge of the Great Miami River (Dames and Moore 1976B). This east/west section of the BVA is divided by a silt and clay layer into an upper and lower aquifer (Fig. III.8.).

Under normal conditions in the Mound area (no groundwater withdrawal from BVA), the normal direction of groundwater flow is from the BVA to the river. Aquifer recharge occurs from precipitation infiltrating directly through the glacial outwash moving as underflow into the aquifer along the contact between the glacial till and bedrock along the valley walls. The component of movement is also generally down gradient in the direction of surface water flow.

Three wells that furnish the water supply to Mound are located along the western site boundary (i.e., 71-1, 71-2, and 76-1 in Fig. II.5.). The wells are completed in the upper section of the BVA. The yield from the wells ranges from 450 to 550 gpm. Pumping of

the Mound supply wells can produce a cone of depression, which results in recharge from the Great Miami River (Dames and Moore 1976A).

MRC has conducted investigations to reduce the concentration of tritium in the BVA in order to meet the national interim primary drinking water standard of 20 nCi/L (40 CFR 141) (see Sec. V.A.1.b. for additional detail). The tritium in the aquifer was a result of operations at Mound (USDOE 1979). The pumping of water from the aquifer with subsequent discharge to the Great Miami River has achieved this goal (Dames and Moore 1976A, 1976B, 1978; Styron 1983a).

These investigations included pumping Miamisburg City Well 2, which is located near the western boundary of Mound just north of the Mound water supply wells. Results of the pumping indicated a hydrologic barrier to the east reflecting the increased drawdown against the impermeable shales and limestones along the valley wall. The transmissivity for this area ranged from 60 X 10^3 to 100 X 10^3 gpd/ft. Westward from the pumped well toward the Great Miami River, the transmissivity ranged from 130 X 10^3 to 170 X 10^3 gpd/ft.

The BVA west of Mound is estimated to be capable of producing 15 X 10^6 to 20 X 10^6 gal of groundwater per day per mile of river reach (USDOE 1979). The total volume of the BVA is estimated at 2.5 X 10^9 gal. In perspective, the 24-day aquifer test in 1976 removed about 17 X 10^6 gal, whereas continued pumping in the tritium removal program had by 1983 removed 1.6 X 10^9 gal. The high permeability of the aquifer and large amounts of recharge from the river have resulted in no significant water level declines in the area adjacent to Mound.

III.D. Water Quality

No municipal system in the Great Miami River basin uses surface water for a public water supply below the Mound effluent discharge. Principal users are identified in Sec. II.E. Mound effluent discharges are discussed in Sec. IV.D.

Water quality data are available from the Mound water supply wells, which represent the BVA. The BVA supplies the Miamisburg wells and other municipal water supplies. Data exist for selected constituents in the list of both primary and secondary drinking water standards of the USEPA. The water supply meets the national primary

drinking water standards (40 CFR 141). The water is very hard; total dissolved solids tend to exceed the 500 mg/L secondary standard limit.

III.E. Air Quality

MRC operations are considered to be a minor air pollution source in the greater Miamisburg area. According to the Regional Air Pollution Control Authority (RAPCA), MRC operations are in compliance with state and federal air pollution regulations. RAPCA administers these regulations for the Ohio Environmental Protection Agency (Ohio EPA) in a six county region, which includes Montgomery County. Montgomery County is currently in a status of nonattainment for ozone and total suspended particulates. MRC operations are not considered to be a cause of the nonattainment. Discussion of Mound's atmospheric releases is presented in Sec. IV.C.

III.F. Ecology

Mound is located in the Eastern Deciduous Forest Province in the transition zone between the beech-maple forest and oak-hickory forest plant associations (Bailey 1978). Much of the site has been altered through construction and use, however, heavily wooded areas do remain on and near Mound. These wooded areas support fauna characteristics of the forest/plant association. It has been concluded that the probability of threatened and endangered species occurring at Mound is extremely remote (USDOE 1979). Additional information can be found in the Final Environmental Impact Statement for Mound (USDOE 1979).

III.G. Sensitive Environments

Sensitive environments include wetlands and critical habitats for threatened and endangered species. There are no known sensitive environments being impacted by MRC operations. However, a small undeveloped area (southwestern corner of Mound) is located within the 100-yr flood plain.

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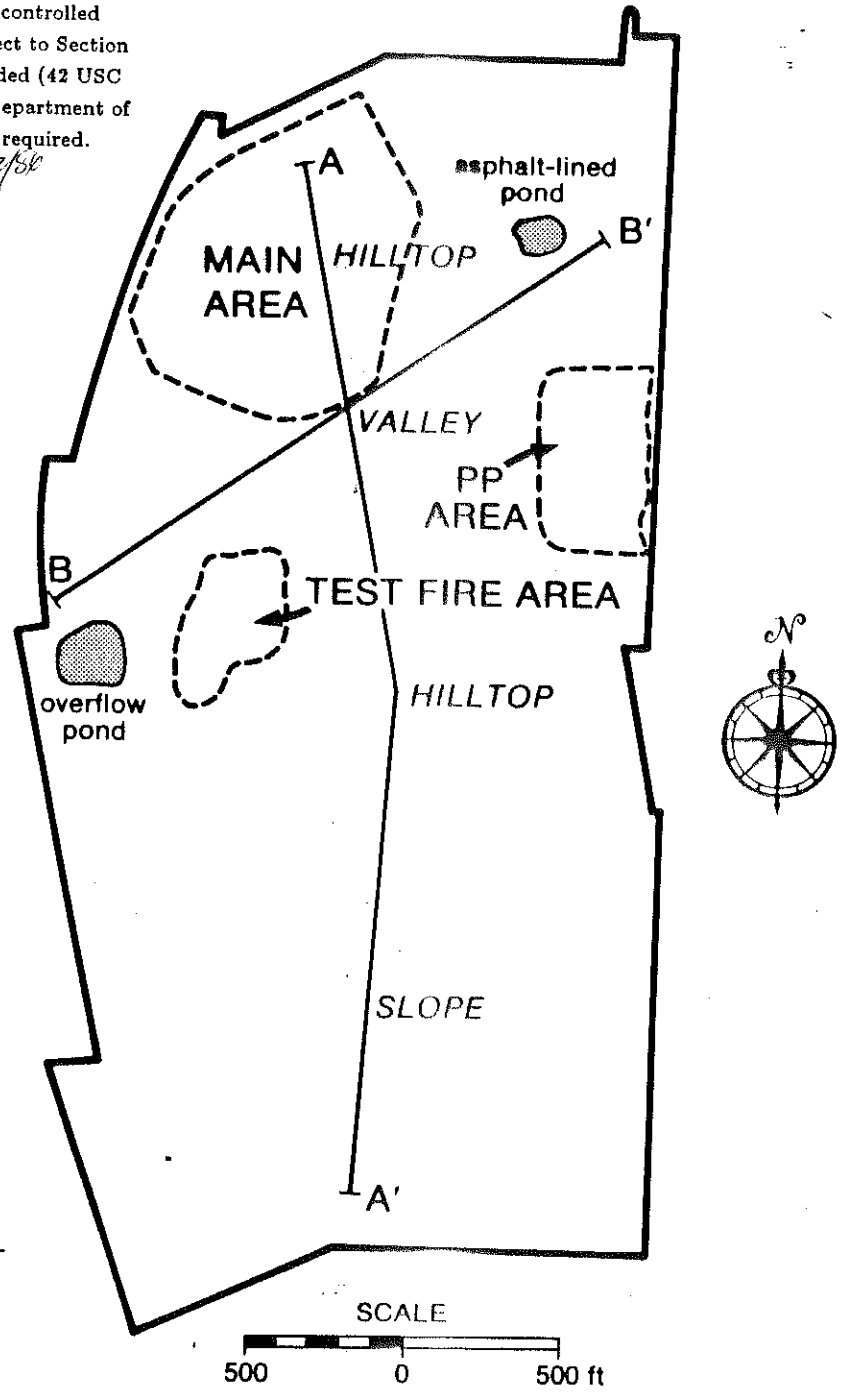

Figure III.1. Mound Facility--Geologic Section Lines.

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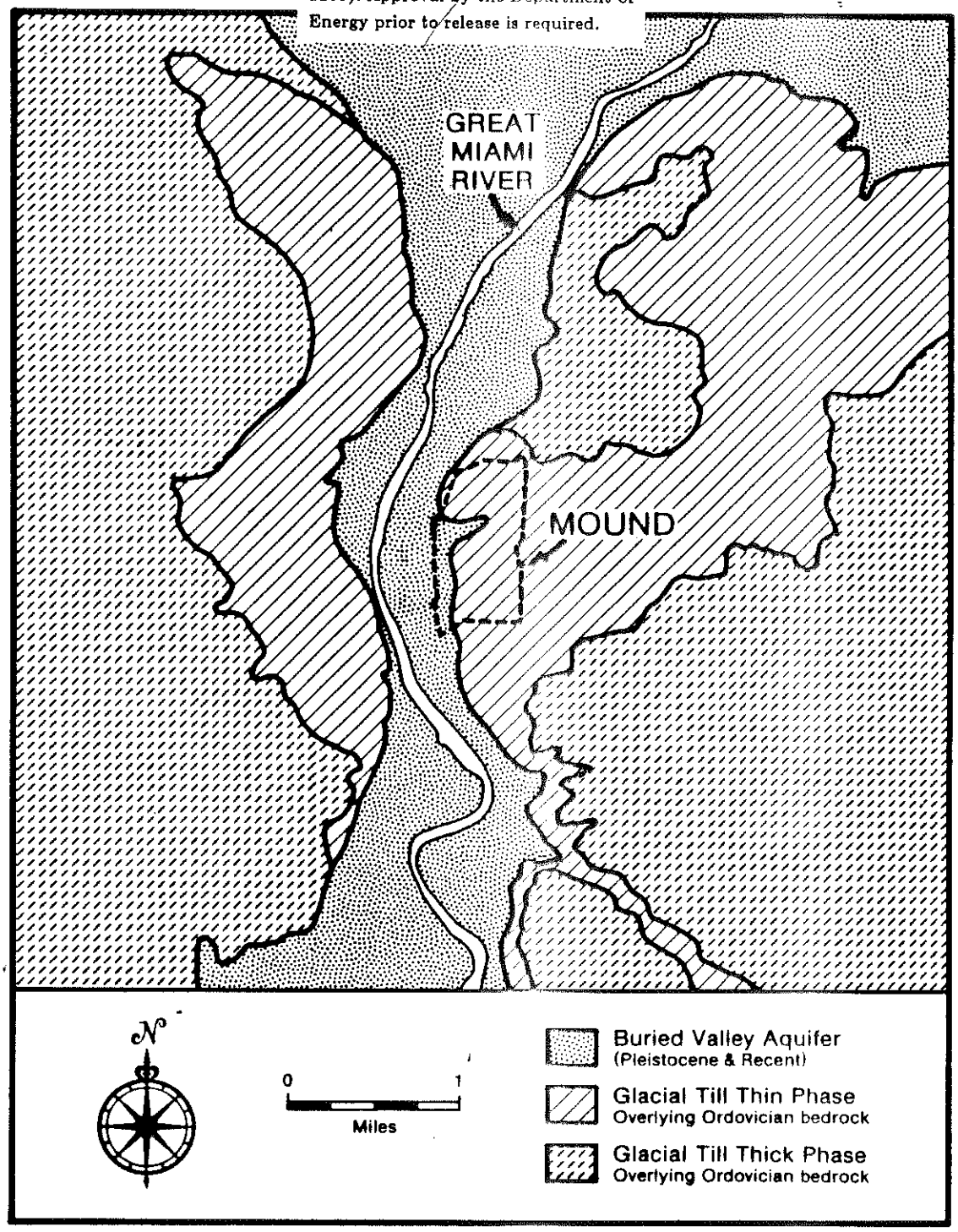

Figure III.2. Mound Area Geology.

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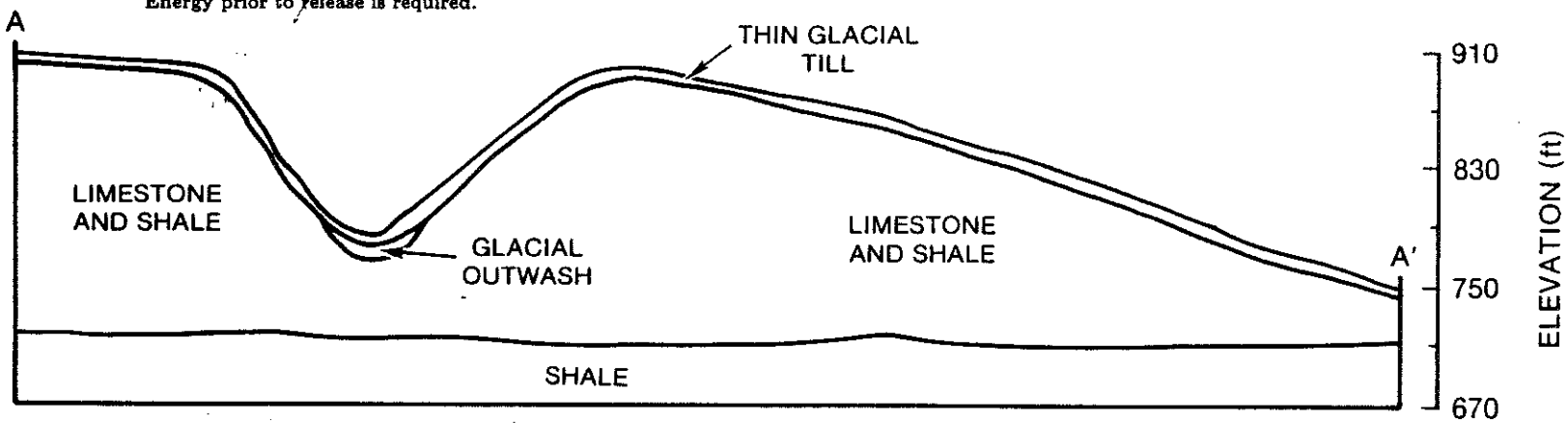

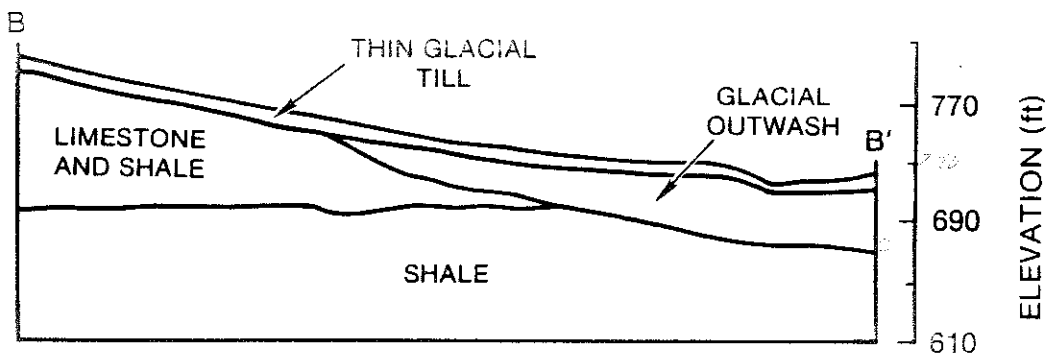

Figure III.3. Generalized Geologic Sections through Mound (see Fig. III.1. for location of geologic section lines).

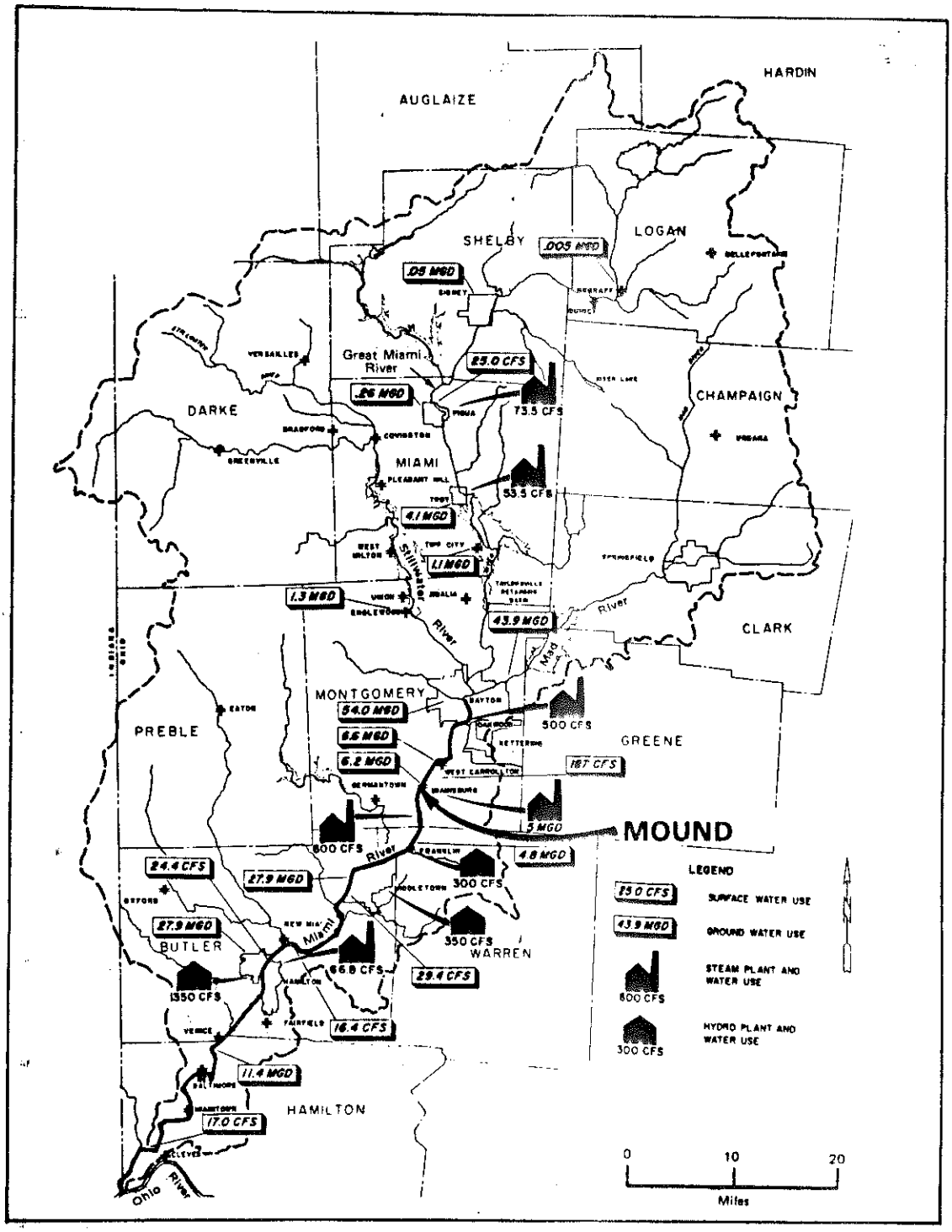

Figure III.4. Major Hydrologic Features of the Area.

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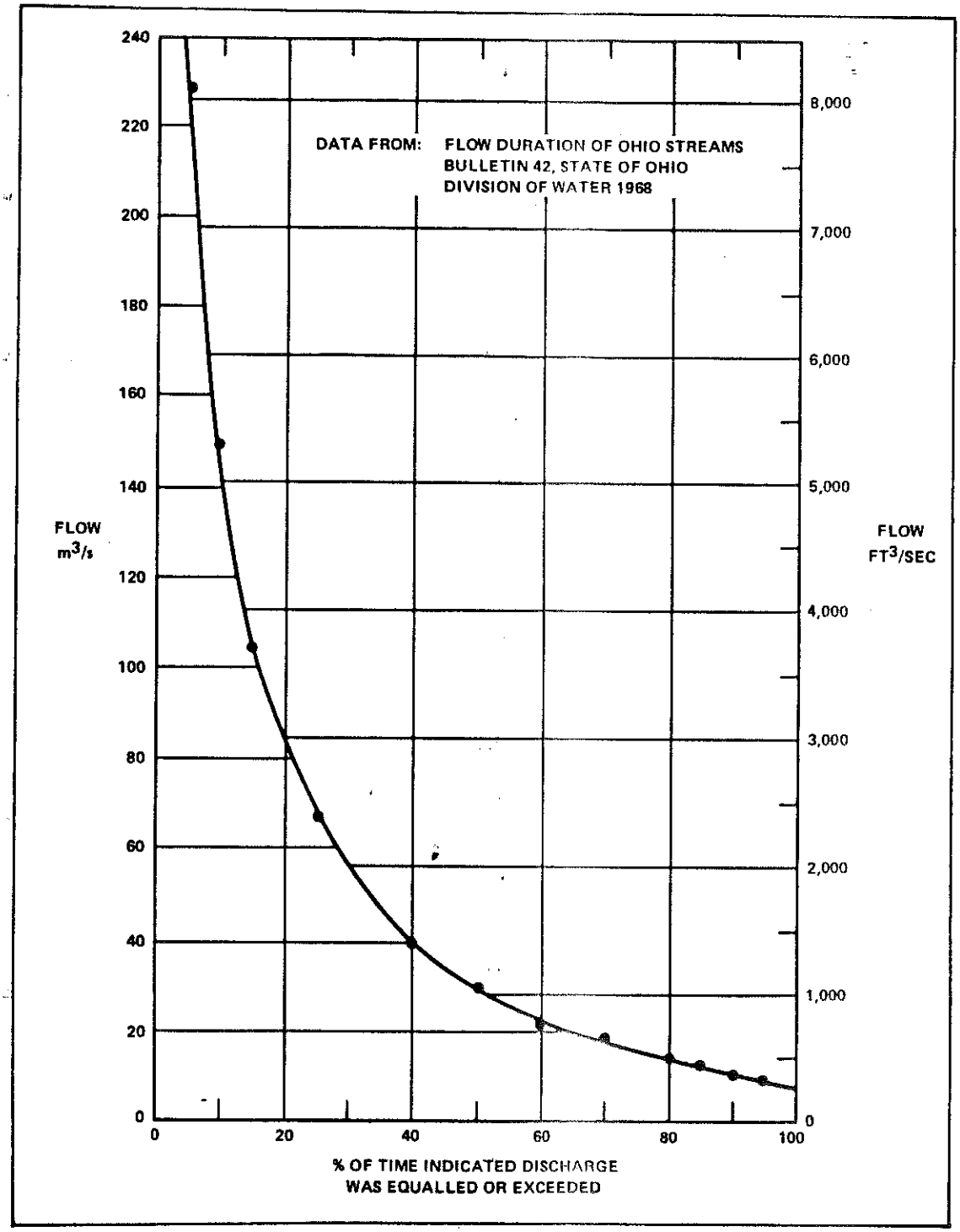

Figure III.5. Flow Duration Curve at Miamisburg, Ohio.

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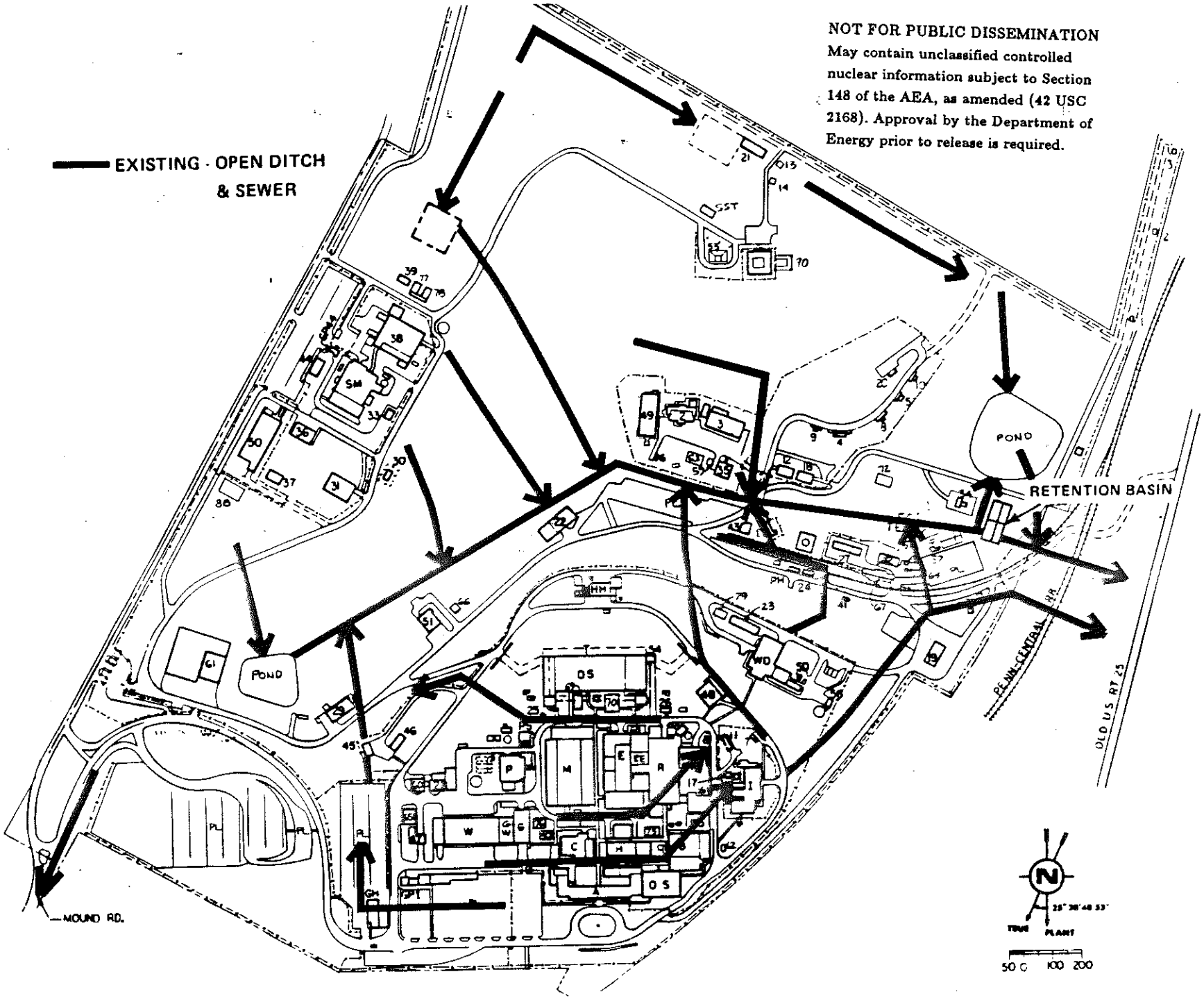

Figure III.6. Major Drain... --Open Ditch and Sewer.

UCNI

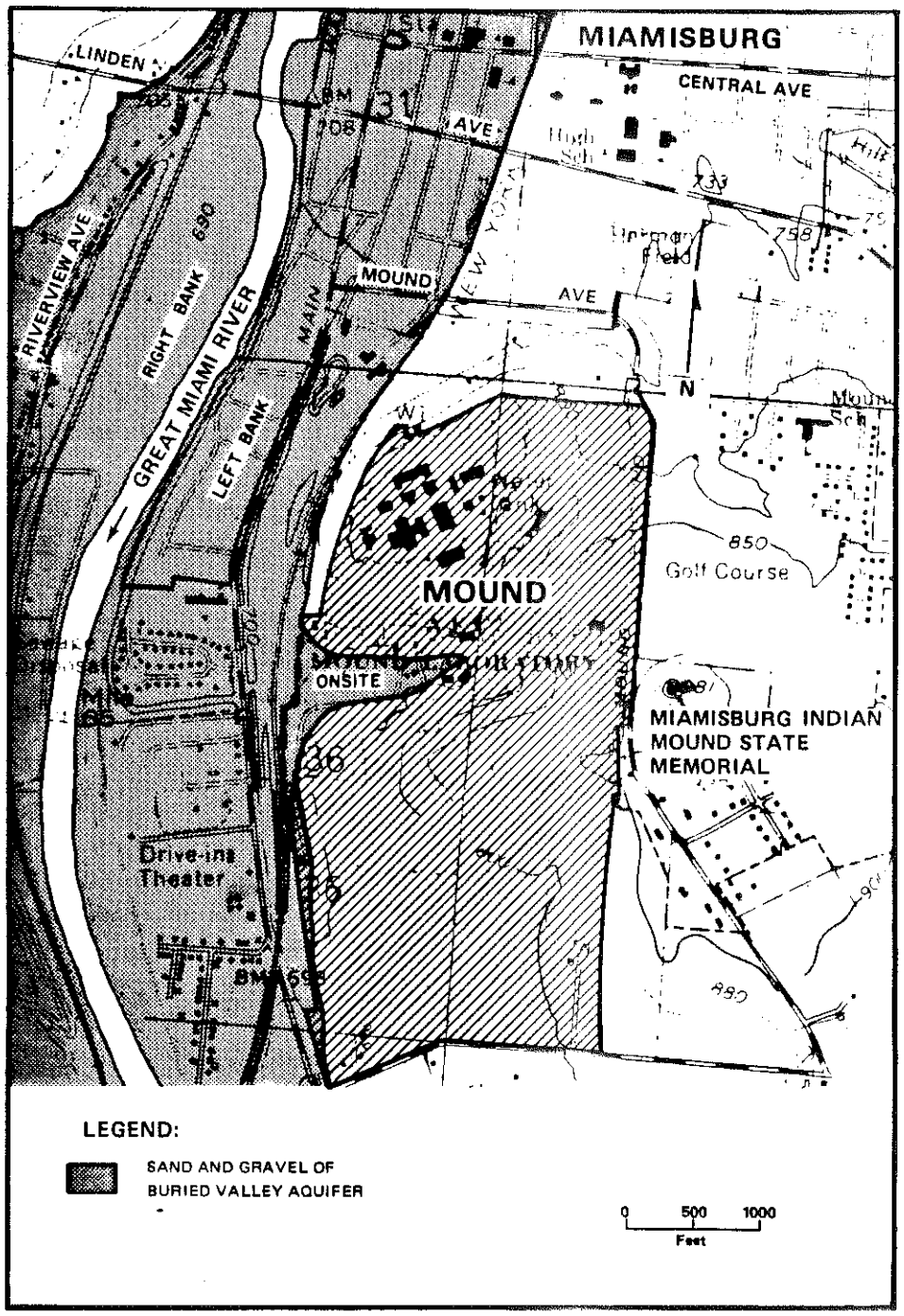

Figure III.7. Buried Valley Aquifer.

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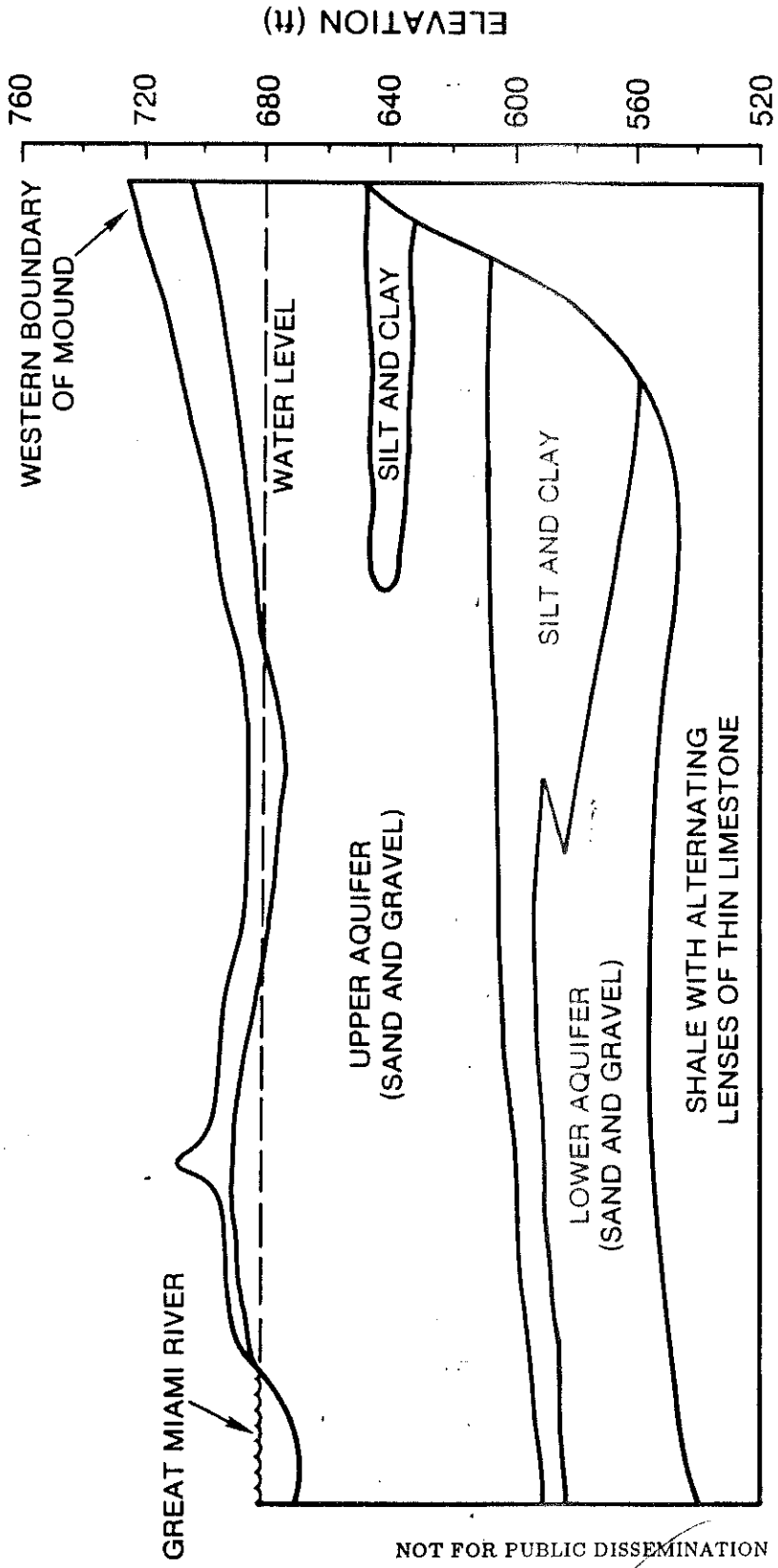

Figure III.8. Geologic Section Showing Upper and Lower Sand and Gravel Aquifer in Glacial Outwash.

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IV. ENVIRONMENTAL LAWS APPLICABLE TO MOUND

USDOE, its predecessors, and operating contractors were in operation long before the present environmental laws were enacted. During this time, USDOE, its predecessors, and contractors were guided by internal guidelines and standards and the Atomic Energy Act of 1954 with regard to pollution and radiation control.

Presently, USDOE and its operating contractors are guided by the existing applicable environmental laws and USDOE orders. Mound's compliance with the environmental laws that apply to its facility is discussed below:

IV.A. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

Current CERCLA regulations address inactive waste sites from the standpoint of hazardous substances. Sites are given a numerical Hazard Ranking System (HRS) score based on various site and waste characteristics. Sites with a HRS Migration Mode Score above the value of 28.5 are included on the National Priorities List (NPL) for cleanup. Although federal facilities are not currently included on the NPL, several have been evaluated by the USEPA, and changes in CERCLA regulations to permit inclusion of federal sites on the NPL were effective Feb. 18, 1986. The USEPA HRS Migration Mode Score for Mound area B is presented in Sec. V.A.1.d. and Appendix D.

Additionally, CERCLA requires reporting releases of hazardous substances from facilities that exceed reportable quantities as specified in 40 CFR 302. There have been no known releases of hazardous substances exceeding reportable quantities from Mound (Friedman 1985, Interviews 1985).

However, on Nov. 4, 1985, Ohio sent USDOE, MRC, and the Monsanto Company a 60-day demand letter demanding payment of $63,000,000 for a 1969 spill of plutonium-238, which Ohio interprets as a release under CERCLA.

CERCLA did not exist in 1969. Nevertheless, the Mound facility undertook immediate remedial action at the spill site. Moreover the subsequent studies and monitoring conducted by the MRC in conjunction with the State of Ohio for the past 16 years indicate that there is not a current or future threat to health or the environment as a result of this spill and that no further remedial action for this site is warranted or

necessary. Currently USDOE and the State of Ohio are attempting to resolve the matter. (See also Sec. V.A.1.c.)

USDOE also has special procedures for handling emergencies, which are detailed in "Emergency Preparedness System-Response to Fires, Explosions or Releases of Oils, Hazardous Substances and Hazardous Wastes" (Metcalf and Janowiecki 1984).

CERCLA also required that nonpermitted RCRA hazardous waste sites be reported to the USEPA by June 9, 1981. USDOE reported the Mound site landfill to USEPA Region V by the required date.

IV.B. Resource Conservation and Recovery Act (RCRA)

MRC is a generator of RCRA-regulated hazardous waste. Because hazardous wastes are stored and treated, MRC/USDOE were required to prepare an RCRA Part A application. USDOE submitted RCRA notification form 8700-12 to the USEPA Region V on Aug. 15, 1980. On Apr. 9, 1981, USDOE sent a photocopy of the USEPA Part A to the Ohio EPA in response to a notice that a photocopy of the federal permit application would be considered a valid Ohio application. The Ohio EPA acknowledged receipt of the USDOE Part A permit application and requested additional information, which was provided. USDOE also submitted a revised Part A application to the State of Ohio in November 1984 and additional versions in January, March, and May 1985. The compounds identified in these permit applications and their method of process treatment for 1985 are presented in Table IV.1.

IV.C. Clean Air Act (CAA)

Nonradioactive atmospheric releases and emission standards, regulated under CAA, are summarized in Table IV.2. (Carfagno and Farmer 1985). Atmospheric releases from Mound are regulated by the Regional Air Pollution Control Authority (RAPCA).

USDOE routinely notifies RAPCA prior to conducting explosives burning or fire fighter training. RAPCA no longer requires a permit for the paint shop, which is under RAPCA registration status, and fume hood releases do not require permits under CAA.

Asbestos operations and radionuclide releases at Mound are regulated by the CAA under National Emission Standards for Hazardous Air Pollutants (NESHAPS). USDOE

also notifies RAPCA of demolition operations involving the removal of friable asbestos and reports to RAPCA the occasional production of plastic detonator caps using asbestos filler.

MRC has an extensive monitoring program for radioactive releases (Appendix C, Monitoring Programs). Moreover, MRC/USDOE have a commitment to maintain radiation exposure to levels as low as reasonably achievable (ALARA).

IV.D. Clean Water Act (CWA)

The State of Ohio's water quality standards were approved by the USEPA on May 14, 1975. These standards were last amended Jan. 4, 1985, and became effective Apr. 4, 1985. Water quality standards may serve as the basis not only for imposing effluent limitations on point source dischargers but also for establishing controls on nonpoint sources under water quality management plans.

Region V of the USEPA initially issued a discharge permit under the National Pollutant Discharge Elimination System (NPDES) regulations covering liquid effluent streams at Mound in June 1975. The NPDES permit was renewed during December 1980 by Region V. The State of Ohio (Ohio EPA) subsequently received authority from USEPA to monitor USDOE NPDES permits in July 1983. USDOE applied for renewal of the permit, which was due to expire June 1984, during March 1984. USDOE application for renewal automatically extended the expiration date of the permit until negotiations were completed with the Ohio EPA for renewal of the permit. The new permit was issued Sept. 30, 1985.

The NPDES-regulated discharges are monitored at the four stations identified in Table IV.3.). The discharge limitations for each effluent stream are presented in Table IV.4. MRC will modify its NPDES permits as necessary.

Special procedures for handling emergencies are detailed in "Emergency Preparedness System-Response to Fires, Explosions or Releases of Oils, Hazardous Substances and Hazardous Wastes" (Metcalf and Janowiecki 1984). Appropriate federal, state, and local authorities were notified of the release of approximately 10 gal of No. 2 fuel oil, which occurred on Aug. 18, 1983. The fuel oil was released into the Mound drainage system and resulted in a minor oil sheen, approximately one-quarter mi downriver from the Mound outfall.

MRC operations do not discharge into a publicly owned treatment works (POTW) and are not subject to general pretreatment regulations for existing and new sources of pollution.

IV.E. Toxic Substances Control Act (TSCA)

TSCA establishes a list of chemicals defined as toxic, for which manufacture, use, storage, handling, and disposition are regulated. TSCA-regulated polychlorinated biphenyls (PCBs) are used at Mound. Monthly inspections are made for PCB leaks and spills (Monsanto Research Corporation 1984). PCB wastes are contained, marked, stored temporarily, and inspected monthly as required by PCB Marking and Disposal Regulations. PCB management records are kept as required. Special procedures for handling PCB emergencies are detailed in "Emergency Preparedness System-Response to Fires, Explosions or Releases of Oils, Hazardous Substances and Hazardous Wastes," Appendix B (Metcalf and Janowiecki 1984).

On occasion MRC also produces plastic detonator caps using asbestos filler, also regulated under TSCA. MRC reports this occasional use of asbestos filler to the USEPA.

IV.F. Safe Drinking Water Act (SDWA)

Drinking water supplies at Mound are obtained from onsite wells. The water supply system is categorized by the Ohio EPA as a major, noncommunity public water supply system. Applicable regulations require sampling and analysis for total coliform once per calendar quarter with submission of reports to the Ohio EPA. Results to date have shown that the water supply does not contain coliform bacteria.

In addition to these requirements, a self-imposed program including the following is maintained:

* Sampling and analysis for total coliform on a monthly basis at approximately eight locations.

* Analysis of raw well water for heavy metals on a quarterly basis.

* Weekly analysis for tritium in raw well water and at several internal use points on a weekly basis.

* All other analyses required for community systems, including priority pollutants, have been completed at least once on the well water system.

All of these analyses were within the national interim drinking water standards (40 CFR 141).

Disposal of hazardous wastes through underground injection is regulated through the SWDA. MRC does not dispose of hazardous wastes through onsite underground injection.

IV.G. Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

MRC has established guidelines for pesticide and herbicide usage and storage that will ensure compliance with USDOE Order 5480.1 Ch. XII, which provides assurance that pest control programs for USDOE operations are conducted safely and in accordance with requirements of Executive Order 11870, Environmental Safeguards on Activities for Animal Damage Control on Federal Lands, and FIFRA, as amended. FIFRA-registered compounds are applied by outside licensed contractors.

IV.H. National Environmental Policy Act (NEPA)

MRC has established guidelines (i.e., Sec. 2.3 of the Loss Prevention and Environmental Control Technical Manual MD-10193, Issue 1, January 1984) for NEPA documentation to ensure compliance with NEPA and USDOE Order 5440.1C (Implementation of the National Environmental Policy Act). The NEPA evaluation process is initiated with preparation of an action description memorandum (ADM) and concluded with NEPA documentation (i.e., memo to file, environmental assessment, or environmental impact statement) consistent with USDOE guidance for implementation of NEPA. Additionally, MRC guidance for preparing an ADM includes provisions for evaluating historic and national landmarks, floodplains/wetlands, and endangered and threatened species as appropriate.

Table IV.1

Management of RCRA-Regulated Wastes

EPA Hazard Waste No.	Estimated Annual Quantity of Waste (lb/yr)	Process Treatment Code
D001	66,000	S01
F001	(included with D001)	S01
F003	(included with D001)	S01
F005	(included with D001)	S01
D002	18,000	S01
F007	(included with D002)	S01
F009	(included with D002)	S01
D003	4000	T04,T03
D004	300	S01
D005	300	S01
D006	1500	S01
D006	25	T03
D007	500	S01
D008	2000	S01
D009	12,000	S01
D010	100	S01
D011	20,000	S01
F002	15,000	S01
F003	20,000	S01
F004	300	S01
F005	5000	S01
F007	1000	S01
F008	1000	S01
F009	1000	S01
U003	2400	T03
U009	400	T03
U037	400	T03
U158	1500	S01
U211	400	T03
Misc.	50,000	S01

D001--A solid waste that exhibits the characteristic of ignitability, but is not listed as a hazardous waste in Subpart D.

F001--The following spent halogenated solvents used in degreasing: tetrachloroethylene, trichloroethylene, methylene chloride, 1,1,1-trichloroethane, carbon tetrachloride, and chlorinated fluorocarbons; and sludges from the recovery of these solvents in degreasing operations.

Table IV.1 (cont)

F003--The following spent nonhalogenated solvents: xylene, acetone, ethyl acetate, ethyl benzene, ethyl ether, methyl isobuyl ketone, n-butyl alcohol, cyclohexanone, and methanol; and the still bottoms from the recovery of these solvents.

F005--The following spent nonhalogenated solvents: toluene, methyl ethyl ketone, carbon disulfide, isobutanol, and pyridine: and the still bottoms from the recovery of these solvents.

D002--A solid waste that exhibits the characteristic of corrosivity, but is not listed as a hazardous waste in Subpart D.

F007--Spent cyanide plating bath solutions from electroplating operations.

F009--Spent stripping and cleaning bath solutions from electroplating operations where cyanides are used in the process.

D003--A solid waste that exhibits the characteristic of reactivity, but is not listed as a hazardous waste in Subpart D.

D004--Arsenic.

D005--Barium.

D006--Cadmium.

D007--Chromium.

D008--Lead.

D009--Mercury.

D010--Selenium.

D011--Silver.

F002--The following spent halogenated solvents: tetrachloroethylene, methylene chloride, trichloroethylene, 1,1,1-trichloroethane, chlorobenzene, 1,1,2-trichloro-1,2,2-trifluoroethane, orthodichlorobenzene, and trichlorofluoromethane; and the still bottoms from the recovery of these solvents.

F004--The following spent nonhalogenated solvents: cresols and cresylic acid, and nitrobenzene; and the still bottoms from the recovery of these solvents.

F008--Plating bath sludges from the bottom of plating baths from electroplating operations where cyanides are used in the process.

U003--Acetonitrile

U009--Acrylonitrile

Table IV.1 (cont)

U037--Benzene, chloro-

U158--4,4'-Methylenebis (2-chloroaniline)

U211--Carbon tetrachloride

S01--Storage container

T03--Treatment incinerator. (Explosives are treated in an incinerator on an occasional as-needed basis; estimated annual quantity: 300 lbs; process capacity: 12 lbs per burn.)

A "cyclone incinerator" and a "glass melter" are developmental units used for hazardous waste treatment. The incinerator includes a single-stage cyclonic combustion chamber, a wet off-gas treatment system, and a high-efficiency filter. The glass melter includes a refractory chamber with molten glass over which waste is burned, a wet off-gas treatment system, and a high efficiency filter. Each unit has a design capacity of 50 lbs/h of organic waste.

T04--Treatment/Other. (Open burning of explosive-contaminated waste is conducted on an occasional as-needed basis; estimated annual quantity: 1,000 lbs; process capacity: 40 lbs per day. Detonators and pellets are treated in a retort (propane fired kiln) on an occasional as-needed basis; estimated annual quantity: 2,000 lbs; process capacity 0.33 lb per 30 seconds.)

Misc.--Periodic lab wastes, primarily having D001, D002, D003, and EP toxicity characteristics, but also including listed wastes in small quantities. The mix and quantity is dependent upon program requirements.

Table IV.2

Nonradioactive Atmospheric Emissions 1984

Emission Source	Pollutant	Emission	Emission Standard[a]	% of Standard
Powerhouse	Particulates	0.013 lb/10^6 Btu Input	0.2 lb/10^6 Btu	6.5
Powerhouse	Sulfur Oxides	0.005 lb/10^6 Btu Input	1.6 lb/10^6 Btu	0.31
Paint Shop	Organics	0.5 lb/day	40 lb/day	1.3
Explosives Burning	Particulates	8.2 lb	NA[b]	NA[b]
Fire Fighter Training	Particulates	35 lb	NA[b]	NA[b]

[a]Ohio EPA Air Pollution Regulations 3745-17-01 through 3745-17-13 and 3745-21-01 through 3745-21-08.
[b]NA--not applicable.

Table IV.4

NPDES Permit Limits

Parameter	Units	NPDES Permit Limits Maximum[a]	NPDES Permit Limits Monthly Average
Discharge 001-A			
Flow rate[b]	MGD	---[c]	---[c]
pH	pH units	9.0	---[c]
Biochem. O_2 demand	mg/L	15	10.0
Suspended solids	mg/L	30	15
Fecal coliform (summer only)	MPN/100 mL	2000	1000
Total Residual Chlorine (summer only)	mg/L	0.5	---[c]
Discharge 001-B			
Flow rate	MGD	---[c]	---[c]
pH	pH units	9.0	---[c]
Suspended solids	mg/L	45	30
Grease and oil	mg/L	10	---[c]
Chemical O_2 demand	mg/L	---[c]	---[c]
Discharge 001-C			
Cyanide	mg/L	1.0	0.65
Chromium	mg/L	0.5	---[c]
Cadmium	mg/L	0.1	---[c]
Nickel	mg/L	0.5	---[c]
Copper	mg/L	0.5	---[c]
Toxic Organics	mg/L	2.13[d]	---[c]
Discharge 002			
Flow rate	MGD	---[c]	---[c]
pH	pH units	9.0	---[c]
Suspended solids	mg/L	45	30

[a]pH has a minimum limit of 6.5 and a maximum limit of 9.0.
[b]Includes flow from Discharge 001-C. The maximum flow from 001-C is approximately 2,000 gal/day.
[c]No limit applicable.
[d]Guideline-based limitation.

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May contain unclassified controlled nuclear information subject to Section 148 of the AEA, as amended (42 USC 2168). Approval by the Department of Energy prior to release is required.
UB 4/22/86

V. FINDINGS AND PLANNED FUTURE ACTIONS

V.A. Potential CERCLA Sites -- Inactive or Former Disposal Facilities/Activities/Spills and Leaks

Potential CERCLA sites identified during CEARP Phase I (the equivalent of USDOE CERCLA Order Phase I) are presented in Sec. V.A.1., and Sec. V.A.2. The CEARP findings, as appropriate, are presented based on a negative, positive, or uncertain finding for the following USEPA CERCLA program elements: (1) Federal Facilities Site Discovery and Identification Findings (FFSDIF) and (2) Preliminary Assessments (PA), Site Inspections (SI) [SI in CEARP is a preliminary SI (PSI)], and Hazard Ranking System (HRS) evaluation.

V.A.1. Mound.

V.A.1.a. Inactive Isolated Sites at Mound. Based on a detailed records search, including interviews with MRC employees and PSI, inactive sites at Mound were placed into three categories: (1) areas that potentially could have received oils or hazardous substances; (2) areas that because of past activities had potential for leaks and spills of oil and hazardous substances, and (3) previously identified radioactively contaminated areas. Findings for categories 1 and 2 are presented in Fig. V.1.; Table V.1.; and Table V.2.

Twenty isolated areas were previously identified on the original Mound site as being contaminated with radioactive materials (Fig. V.2.; Table V.3.) (Monsanto Research Corporation 1985). These areas are primarily associated with past operational mishaps and equipment failures and were decontaminated under guidelines in existence at the time using the best available technology. Guidelines have become more restrictive since the early 1970s. The isolated contaminated areas have been evaluated as part of the MRC Site Survey Program, which was initiated in 1982. Survey results will be published under the title, "Radiological Characterization of Mound," and should be available by the fourth quarter of FY86. Information gathered by this survey and evaluation provided the basis for estimating the cost, timing, and method for removing or stabilizing contaminated soil on site (if required). Sites potentially requiring remedial action have been submitted under the Site Survey Program or to the USDOE Surplus Facilities Management Program (SFMP). Objectives of SFMP include:

* Provide for surveillance and maintenance of surplus radioactively contaminated USDOE facilities awaiting decommissioning, in order to meet all applicable USDOE standards; to protect public and on-site personnel health and safety; and to reduce potential environmental hazards to as low as reasonably achievable.

* Implement a structured decommissioning program to accomplish disposition of all present and future surplus USDOE-owned facilities under the responsibility of the USDOE Division of Remedial Action Projects (DRAP) and Office of Defense Waste and Byproducts Management (DWBM).

* Conduct financial estimating, budgetary management, integrated planning and scheduling, facility-specific engineering, and technology development to support cost effective docommissioning activities on a long-term basis.

Planned Future Actions: Category 1 areas B, C, and I (Fig. V.1.; Table V.1.) require additional investigation under CEARP Phases I and II. None of the areas in category 2 (Table V.2.) require additional investigation under CEARP. The category 3 areas (Fig. V.2.; Table V.3.) based on the detailed records search, including interviews with MRC employees, do not contain nonradioactive hazardous substances. Action on the category 3 areas has been completed, is being taken, or will be taken as indicated in Table V.3. under SFMP. Due to the status of SFMP activities (i.e., CEARP Phase IV) a CERCLA finding under FFSDIF, PA, and PSI; and HRS and MHRS scoring are not appropriate for these sites.

Planned Future Actions: Results of the MRC Site Survey Program and SFMP activities will be evaluated under CEARP.

V.A.1.b. Tritium in the Buried Valley Aquifer. Prior to 1970, tritiated waste liquids were collected in sumps, assayed for tritium concentrations, diluted to less than applicable concentration guides, and released to the Great Miami River via the site drainage ditch and a remnant of the Miami-Erie Canal. This activity resulted in elevated tritium levels in the BVA. Tritium remains in the BVA, and MRC monitors and conducts remedial pumping actions to keep BVA water in compliance with the USEPA interim drinking water standard for tritium (20 nCi/L) (40 CFR 141) (Styron 1981, 1983A&B). Due to the status of MRC activities (i.e., CEARP Phase V) a CERCLA finding under FFSDIF, PA, and PSI; and HRS and MHRS scoring are not appropriate.

Planned Future Actions: MRC will continue to monitor tritium levels in the BVA and conduct remedial pumping actions to keep BVA water in compliance with the drinking water standard.

V.A.1.c. Plutonium in the Miami-Erie Canal. Residual ^{238}Pu remains in the Miami-Erie Canal, connected ponds, and associated waterways as a result of past activities at Mound, primarily from the rupture of a process waste line. An extensive investigation of the situation was conducted in the 1970s with the finding that the ^{238}Pu is not a health hazard. Follow-up studies have continued to confirm the original finding (USDOE 1979). MRC monitors for potential ^{238}Pu in air and drinking water to confirm that there is no health hazard. Due to the status of MRC activities (i.e., CEARP Phase V) a CERCLA finding under FFSDIF, PA, and PSI; and HRS and MHRS scoring are not appropriate.

Planned Future Actions: MRC will continue to monitor for potential ^{238}Pu in air and drinking water to confirm that the residual plutonium does not pose a health risk.

V.A.1.d. Hazard Ranking System (HRS) and Modified HRS (MHRS) Scores. The HRS is applied to those CERCLA sites with positive findings for the CERCLA FFSDIF, PA, and PSI (see App. D). The HRS is applied to category 1 area B (App. D). Area B is an engineered landfill (Fig. V.3.). The landfill system could contain up to 1,000 ft^3 of nonradioactive hazardous substances. Based on the detailed records search, including interviews with MRC employees, it appears that insignificant quantities of nonradiological hazardous substances remain outside of the engineered landfill. Radioactive materials were not placed in the landfill. No releases from the landfill are known to have occurred. The resulting HRS Migration Mode Score is 13. Areas C and I potentially contain small quantities of hazardous substances, however, no releases from these areas have been detected. There is not sufficient information to calculate a HRS Migration Mode scores for areas C and I. The MHRS is not applied to any sites at Mound.

V.A.2. Former Monsanto Facilities. Waste management activities at former Monsanto facilities, which are summarized below, are based on Meyer (1979) and the CEARP Phase I MRC staff interviews (Interviews 1985). Additional discussion of the former Monsanto facilities is presented in Sec. II.B. and Table II.2.

V.A.2.a. Unit I. In the Dayton Project, polonium was not produced at Unit I. Various research projects were undertaken that involved radioisotopes. This work was done on behalf of the Atomic Energy Commission (AEC), and Oak Ridge National Laboratory took possession of and responsibility for all packaged nuclear waste from the Unit I site. There is no evidence of onsite disposal. The CERCLA Finding for Unit I is negative for FFSDIF, PA, and PSI; therefore, HRS and MHRS Migration Mode Scores are not calculated.

Planned Future Actions: No future action is warranted at Unit 1.

V.A.2.b. Unit II. Dayton Project activities were not conducted at Unit II. Scrap explosives were combusted onsite. No fuel wastes, refuse or other waste materials were ever buried onsite. Radioactive materials were not handled at Unit II. The CERCLA Finding for Unit II is negative for FFSDIF, PA, and PSI; therefore, HRS and MHRS Migration Mode Scores are not calculated.

Planned Future Action: No future action is warranted at Unit II.

V.A.2.c. Unit III. Radioactive wastes generated at Unit III were ultimately packaged according to U.S. Department of Transportation (DOT) regulations and shipped on government vehicles to Oak Ridge National Laboratory for onsite burial. The principal isotope involved was ^{210}Po, which has a physical half-life of 138 days. No materials were buried onsite at Unit III, sent to city landfills, or other disposal facilities.

All operations ceased at Unit III in 1948. The facilities and site were completely decontaminated and turned over to the Dayton Board of Education, the site owner. The CERCLA Finding for Unit III is negative for FFSDIF, PA, and PSI; therefore, HRS and MHRS Migration Mode Scores are not calculated.

Planned Future Action: No further action is warranted at Unit III.

V.A.2.d. Unit IV. Radioactive wastes were managed the same as at Unit III. The principal isotope was ^{210}Po. All operations at Unit IV were ceased and transferred to Mound Laboratory late in 1948. By spring 1950, all radioactively contaminated Unit IV structures, services, and utilities were removed, packaged and shipped to Oak Ridge for disposal. Clean fill dirt replaced the excavated soil and the site was landscaped and returned to the original owner. The CERCLA Finding for Unit IV is negative

for FFSDIF, PA, and PSI; therefore, HRS and MHRS Migration Mode Scores are not calculated.

Planned Future Action: No further action is warranted at Unit IV.

V.A.2.e. Warehouse. Operations were limited to trace quantities of ^{210}Po from the analysis of environmental monitoring samples, bioassay samples from the project personnel and preliminary biological studies on the effect of polonium on laboratory animals. To the best of current knowledge, samples, waste materials, and plated copper disc from the polonium analyses were discarded into the general warehouse wastes because the amount and concentration of polonium was so small. Warehouse operations, including equipment, were transferred to Mound Laboratory in 1948-1949. The area was decontaminated and returned to the building manager to rent to other clients. The CERCLA Finding for the Warehouse is negative for FFSDIF, PA, and PSI; therefore, HRS and MHRS Migration Mode Scores are not calculated.

Planned Future Action: No further action is warranted at the Warehouse.

V.A.2.f. Marion. The facility at Marion, Ohio, never became operational and no hazardous substances, including radioactive materials, were ever used at the facility. By the mid 1950s, all process equipment, instrumentation, and supplies were transferred to Mound. The facility was turned over to the GSA for other possible government use or sale. The CERCLA Finding for Marion is negative for FFSDIF, PA, and PSI; therefore, a HRS Migration Mode Score is not calculated.

Planned Future Actions: No further action is warranted at Marion.

V.A.2.g. Hazard Ranking System (HRS) and Modified HRS (MHRS). The HRS and MHRS are not applied to the former Monsanto facilities because the CERCLA findings for FFSDIF, PA, and PSI are negative for the facilities.

V.A.3. Summary of Planned Future Actions for Potential CERCLA Sites. Potential sites identified during CEARP Phase I (the equivalent of USDOE CERCLA Order 5480.14 Phase I) are presented in Table V.4. As appropriate, the results for the potential sites are summarized based on a negative, positive, or uncertain finding for the following USEPA CERCLA program elements: (1) FFSDIF and (2) PA, SI [CEARP preliminary SI (PSI)], and HRS evaluation.

Those sites with negative findings for the FFSDIF, PA, and PSI processes are dropped from further consideration under CEARP and other CERCLA reporting requirements. Area B, the Mound landfill, is the only site with a positive FFSDIF/PA/SI finding that is evaluated using the HRS. The HRS Migration Mode Score for area B is 13. Sites with HRS Migration Mode scores greater than 28.5 are listed on the National Priorities List (NPL) by USEPA. None of the potential sites identified at Mound are recommended for additional action under USEPA CERCLA. Additionally, sites not meeting USEPA criteria for listing on the NPL but exceeding USDOE remedial action criteria/guidelines (e.g., guidelines for the USDOE Surplus Facilities Management Program) and/or sites posing potential regulatory compliance concerns (e.g., RCRA-related remedial activities) are recommended for future action under USDOE, but not USEPA CERCLA. Due to uncertainty, Category 1 areas C and I are retained for supplemental CEARP Phase I investigation. Additionally, remedial action has been or is currently being planned/conducted at several sites under the Site Survey Program and SFMP.

V.B. Potential Environmental Concerns -- Management of Hazardous Substances/ Oils and Environmental Surveillance

V.B.1. Process Review. Environmental residuals generated as a result of activities at Mound are managed as contained waste streams (e.g., hazardous, radioactive, radioactive mixed, or sanitary sludge), recycled (e.g., wood and metal), or released to the environment at permitted levels (e.g., NPDES discharge limits). The focus of the process review is management of oils and hazardous substances. Environmental releases are discussed under Operational Emissions and Environmental Monitoring, Sec. V.B.7.

Categories of hazardous waste generated at Mound, the processes generating them, and their management are listed in Fig. V.4. and Table V.5. (Monsanto Research Corporation 1984). The waste categories include organic solvents; photoprocessing wastes; waste oils, paint wastes, and plating bath wastes; and radioactive mixed wastes. The waste management locations for hazardous wastes are identified in Fig. V.5. A detailed breakdown of the RCRA-regulated materials is presented in Table IV.1. Radioactive wastes are managed as required by USDOE. There are no active onsite waste disposal activities/facilities at Mound. MRC has formerly utilized and currently utilizes commercial contractors for treatment/disposal of nonradioactive hazardous substances. During 1984, 60 spent electric

storage (lead-acid) batteries, each weighing approximately 150 lbs, were returned to the manufacturer for reuse/recovery instead of being sent for disposal.

Efforts are continuing to reduce the volume of nonradioactive waste requiring off-site disposal by investigating the feasibility of sending some spent solvents for recycling, and reclaiming silver from photoprocessing wastes. The use of the onsite cyclone incinerator and glass melter is also being investigated to enhance waste volume reduction.

V.B.2. Existing Oil Storage Facilities. Number 2 fuel oil (backup supply for powerhouse) is stored in a 300,000-gal oil storage tank located just east of Building 27. In the event of an accident, the fuel storage tank could release No. 2 fuel oil into the environment (i.e., escape the diked containment area and flow down the stream channel to the Great Miami River). Recent USDOE AL audits have pointed out that a serious impact could result if a major spill were to occur. Because of the age of the fuel storage tank facility, the risk is considered high for such an occurrence. This risk is compounded by inadequate diking, which is incapable of containing 150% of the entire contents of the tank, and the containment liner requires continuing maintenance. The storage tank is also within an explosive storage area clearance ring. Additionally, other holding tanks for No. 2 fuel oil are located underground near the powerhouse and cannot be adequately monitored for leaks to the environment. A study is being conducted by MRC to evaluate relocation options for existing oil storage facilities. Tentative relocation sites have been identified.

Planned Future Actions: The oil storage facilities will be relocated. A containment dike will be placed around the relocated above-ground oil storage tank to contain the maximum accidental release. Additionally, the underground fuel oil holding tanks near the powerhouse will be placed above ground. The oil storage facilities will be constructed and operated in compliance with existing CWA (40 CFR 110 and 112) requirements and DOE Order 5480.1 Ch. XII Prevention, Control, and Abatement of Environmental Pollution.

V.B.3. Existing Waste Treatment and Disposal Facilities/Systems.

V.B.3.a. Sanitary Waste Treatment Facility. The activated sludge sanitary waste treatment facility that serves Mound has a capacity of 130,000 gal/day.

Treatment consists of aeration, sludge digestion, clarification, and chlorination. After processing, the sanitary sludge is air dried and packaged for offsite disposal. The sludge contains radionuclides, but does not have RCRA listed hazardous waste or hazardous waste characteristics. The sludge is being managed as a radioactive waste and shipped to an offiste USDOE disposal loction.

Sanitary waste treatment facility effluent discharges are discussed under the Clean Water Act, Sec. IV.D., and Operational Emissions and Environmental Monitoring, Sec. V.B.7.

Planned Future Actions: MRC will continue to manage the sanitary sudge as a radioactive waste.

V.B.3.b. Storm Runoff Treatment. Storm runoff at Mound is treated by settling suspended solids in the asphalt-lined pond, overflow pond, and a series of concrete basins to help ensure compliance with NPDES discharge limits. NPDES permit exceptions for total suspended solids due to storm runoff have been reported as required by the permit. Storm runoff discharges are discussed under the Clean Water Act, Sec. IV.D. and Operational Emissions and Environmental Monitoring, Sec. V.B.7.

The asphalt-lined pond is a storm water retention basin located between the Main Hill and the SM Hill (Fig. III.6.). The pond collects storm water runoff from the SM Hill. The pond also collects noncontact single-pass cooling water. Water from the pond is discharged to the onsite stream through a buried culvert. The pond was dredged in 1983 and the dredged material was shipped offsite for disposal as low-level radioactive waste.

The 5-million gal overflow pond, lined with a minimum of 3 ft of compacted clay, was constructed to hold a combination of runoff and effluents before release to the stream and the Great Miami River. The pond is located near the western boundary of Mound (Fig. III.6.). The pond is designed to store a 5-day supply should a spill or storm necessitate containment. The pond also functions as a sediment trap. The pond has never been dredged. Recent evaluation of the sediment retention capacity indicates no need to dredge at this time.

Near the western boundary of Mound, onsite streamflow is diverted through a series of interconnected concrete retention basins that regulate the rate and quality of discharge. During periods when the capacity of the concrete basins is exceeded, the stream-

flow is diverted into the overflow pond. The retention basins were dredged once and the dredged material deposited near the SM water tower. Evaluation of this deposited material is included under the Site Survey Program (Sec. V.A.1.a.).

Planned Future Actions: Storm runoff treatment will be upgraded as described under Upgrade Storm and Sanitary Sewer Drainage Systems, Sec. V.B.5.b.

V.B.3.c. Thermal Treatment of Explosive Wastes. Solid wastes from explosives operations are destroyed by thermal treatment (i.e., incineration, retorting, and open burning) (Monsanto Research Corporation 1984). The controlled access thermal treatment site is located in a remote area of the facility (Building 53 area). Wastes consist of small amounts of mild detonating fuse, 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. Classified wastes resulting from destructive testing and burning explosive devices are drummed and transported off-site for disposal.

Planned Future Actions: Explosive wastes will continue to be thermally treated as indicated in the RCRA Part A permit application (Sec. IV.B., RCRA).

V.B.3.d. Management of Liquid Wastes from Pyrotechnic Operations. Small quantities (<10 gal/yr) of wastes from pyrotechnic material operations are drummed and stored.

Planned Future Actions: MRC is studying methods for long-term management of this waste stream. The pyrotechnic wastes will be managed by MRC as appropriate under RCRA (40 CFR 265).

V.B.3.e. Management of Explosive Manufacturing Liquors. Limited quantities (approx. 1,000 gal/yr) of industrial liquors with dissolved explosives (the principal process liquid is acetone) are generated. These industrial liquors are drummed and stored. The explosive manufacturing liquor wastes are being managed by MRC as appropriate under RCRA (40 CFR 265).

Planned Future Actions: MRC is studying more efficient methods for long-term management of this waste stream.

V.B.3.f. Construction Soil Disposal Area. MRC placed into operation the first cell of a new construction soil disposal area during the first quarter of FY 85 (Fig. II.6., spoils area). The soil disposal area is planned to consist of three cells, with a capacity for handling the disposal of about 350,000 yd^3 of uncontaminated construction soil.

Planned Future Action: MRC will place cells 2 and 3 into operation as funding levels allow. MRC will operate the new construction soil disposal area in accordance with good engineering practice.

V.B.3.g. Radioactive Waste Management. Radioactive wastes, both liquid and solid, are managed as either transuranic or low-level wastes (Monsanto Research Corporation 1984). Transuranic solids are packaged (liquids are immobilized prior to packaging) in the process areas and shipped in Department of Transportation approved drums to a USDOE facility for retrievable storage.

Low-level (alpha-contaminated liquid) wastes are either piped or transported by tank truck to the waste disposal building. The wastes are treated with ferric sulfate, calcium chloride, activated charcoal, and sodium hydroxide (pH adjustment), then precipitated in a clariflocculator. The sludge from this operation containing the radioactive contaminants is solidified in cement and shipped to an offsite USDOE radioactive burial ground. The waste has been tested for EP (extraction procedure) toxicity and was determined not to exhibit EP toxicity. Further liquid treatment may involve filtration through a sand filter and a column of bone char. Treated liquids are analyzed and, if they meet release guidelines of USDOE Orders 5480.1A - Environmental Protection, Safety, and Health Protection Program for USDOE Operations and 5484.1 - Environmental Protection, Safety, and Health Protection Reporting Requirements, effluents are pumped to the river via a closed pipeline. Low-level tritium contaminated liquids are piped to the waste disposal building. They are mixed with cement and a diatomaceous earth absorbent in 55-gal steel drums prior to offsite shipment. Low-level solid wastes are compacted as necessary and drummed for shipment. All low-level wastes are shipped to an offsite USDOE facility for disposal. During FY 84, the total quantity of radioactive waste shipped offsite was 112,800 ft^3 (i.e., 20,000 ft^3 tritium contaminated waste; 2,900 ft^3 transuranic waste; and 89,900 ft^3 nontransuranic alpha waste).

Planned Future Actions: Radioactive waste will continue to be managed by MRC as required under existing regulations and USDOE Orders 5480.2 - Hazardous, Toxic, and Radioactive Mixed Waste Management and 5820.2 - Radioactive Waste Management.

V.B.4. Existing Hazardous Waste Storage Facilities. Hazardous wastes, excluding radioactive wastes, currently managed at Mound are listed in Table V.5. (Monsanto Research Corporation 1984, 1985). Waste management locations are shown in Fig. V.5. Building 72 at Mound is the principal onsite hazardous waste storage facility for consolidating containerized waste prior to offsite shipment. Building 72 is operated in compliance with RCRA interim status requirements.

Building 72 is a steel-roofed open-sided structure, 40 X 60 ft, containing four rectangular diked areas with a concrete base. These diked areas are used for segregating incompatible materials. Fire extinguishers, a portable eyewash unit, protective clothing, and various tools are located at the facility. Overhead explosion-proof lighting is provided, and electrical explosion-proof outlets are available. Signs are posted warning that only authorized personnel are allowed in the storage facility. The area is also fenced.

Three of the dike areas, each approximately 13 X 40 ft, have concrete bases sloped slightly downward toward the east. Containers of waste are stored inside these diked areas. Each area can hold approximately seventy 55-gal drums of waste with aisle space. Because of the sloped base, the concrete dike around each area varies in height above the base from 6 in on the west to 15 in on the east. The sloped base is intended to drain and remove liquids resulting from leaks, spills, or precipitation and to minimize contact of containers with accumulated liquids. The diked areas are intended to contain leaks, spills, and accumulated precipitation until the collected material is detected and removed. The fourth area, with a total area of 20 X 40 ft, contains a level base and a sump pit surrounded by a diked area, 9 X 24 ft. It can be used for containerized storage if needed, but it is intended primarily for use in transferring waste from a defective container to one in good condition, preparing waste containers for offsite shipment, and performing related activities.

A gravel surface access exists from the service roadway to the container storage facility. Drums of waste can be moved into and out of the facility using conventional fork lifts.

Leakage from any drums stored in a diked area and any influx of rain water will collect in the low end of the diked area and can be removed by portable pump and properly disposed of.

Accidental reactions between ignitable or reactive wastes are prevented primarily by segregating the wastes in closed containers and drums during all phases of handling, storage and disposal, and by protecting the waste from sources of ignition such as open flames, cutting and welding, hot surfaces, heat, sparks, spontaneous ignition, and radiant heat. Smoking and open flames are prohibited in those areas where ignitable or reactive waste may be present or handled.

Waste PCBs are stored primarily in a diked secure vault near P-Building (power plant) that meets the requirements of 40 CFR 761 (see Sec. V.B.6.c., Other Nonradioactive Liquid Wastes, for additional discussion of PCBs).

Planned Future Actions: Building 72, the principal existing storage facility for containerized hazardous waste, will be upgraded and relocated in 1985-1986. The upgrading will include the installation of (1) partial side walls around the perimeter to keep out precipitation, (2) floor grating over all of the dike areas to allow elevated drum storage above the base and to simplify the detection of leaky containers, (3) an overhead hoist to expedite moving and positioning containerized waste within the facility, and (4) fencing to improve the security of the facility.

V.B.5. Proposed Waste Treatment and Disposal Systems/Facilities. MRC has proposed to remove single-pass noncontact cooling water from the storm drainage system and to upgrade storm and sanitary sewer drainage systems. A detailed discussion of these proposals can be found in the Monsanto Research Corporation Conceptual Design Report for Environment, Safety and Health Upgrades, February 1985, which has been submitted for inclusion in the FY 87 budget.

V.B.5.a. Separate Single-Pass Noncontact Cooling Water from Storm System. The current NPDES suspended-solids limits for the main drainage ditch are restrictive in order to control the quality of process cooling water discharged into the Great Miami River. Because of this, permit compliance during storm runoff has been difficult. Almost all of the suspended solid exceptions during 1984 were not caused by operational discharges but were related to construction/maintenance activities and/or storm runoff.

By separating noncontact process water from storm runoff, the main drainage channel would carry minimal flow except during storms and the expected future NPDES limitations could be easily met, bringing Mound into compliance.

The removal of noncontact process cooling water will be accomplished by placing the five major users of single-pass cooling water on closed-loop cooling water systems. This system will account for the removal of approximately 400,000 gal per day of current discharge. The remaining small volume users throughout Mound will be combined in a process water piping system and piped to the discharge point or handled on small closed-loop package coolers.

Planned Future Actions: MRC will separate the process water from the storm system, where appropriate.

V.B.5.b. Upgrade Storm and Sanitary Sewer Drainage Systems. The 30 plus years of operation of Mound without a major upgrade of the sanitary and storm sewer system, coupled with facility additions over this same time that have added significantly to the load on these systems, has been brought into sharp focus by recent concerns over environmental pollution. A 2-yr study by Eastern Utilities Specialists, Inc., conducted through the Utilities Systems Study Program, was recently completed and pointed to the need for major repairs to the sewer systems in order to limit contaminant discharge due to leakage and infiltration. One repair was completed as a result of this study. This repair consisted of inserting a plastic liner into the existing sewer line between the site boundary and the Great Miami River. This eliminated the potential for leakage from the discharge line to infiltrate the ground and underlying aquifer.

In addition, several modifications to the storm sewer system are required in order to control the volume of suspended solids in the storm runoff that discharges into the Great Miami River. These modifications are identified in the MRC Drainage Master Plan. MRC is operating under an NPDES Permit limitation for this discharge.

Planned Future Actions: MRC will continue to pursue upgrading the storm and sanitary sewer drainage systems.

V.B.6. Commercial Nonradioactive Hazardous Waste Disposal Recycling Pfactices. Major nonradioactive wastes that are commercially disposed of can be grouped into the following categories; photoprocessing, solvent, other nonradioactive liquids, and

nonradioactive solid waste (Monsanto Research Corporation 1984). Laboratory chemical wastes (approx. 1,500 lb/yr) also are produced. Most of these wastes contain constituents regulated under RCRA.

V.B.6.a. Photoprocessing Wastes. Spent fixer solution (approx. 600 gal/yr) is collected and stored onsite for future recovery of silver using a recently acquired electrolytic recovery unit. The remaining photoprocessing waste solutions including developers, stop, bleaches, rinses, etc. (approx. 600 gal/yr) are collected for onsite storage prior to transfer to an USEPA-permitted vendor for transport and treatment/disposal.

V.B.6.b. Solvent Wastes. Operations at Mound, excluding those required for processing explosives (see V.B.3.d.), use approximately 5,400 gal of organic solvents annually (Monsanto Research Corporation 1984). The most widely used organic solvents are acetone, methylene chloride, methanol, ethanol, isopropanol, trichloroethylene, and chlorinated fluorocarbons. Solvent discharges occur to the atmosphere through fume hood operations and to the sanitary treatment facility. Used solvents are accumulated for disposal mostly in 2- or 5-gal safety cans and 55-gal drums. A USEPA-permitted waste disposal firm disposes of these wastes by incineration.

V.B.6.c. Other Nonradioactive Liquid Wastes. Waste oils (automotive, hydraulic, pump), (estimated 3,900 gal/yr), discarded excess paints and thinners (estimated 330 gal/yr), and waste corrosive solutions (estimated 290 gal/yr) are collected and disposed of by an USEPA-permitted vendor (Monsanto Research Corporation 1984). Disposal services for spent plating-bath solutions of chromic acid, cadmium cyanide, nickel sulfate, nickel chloride, electroless nickel, black oxide, and copper cyanide are handled by an USEPA-permitted vendor. First rinse and cleanup waste from the preparation of fresh plating baths are used onsite in new bath makeup.

Waste polychlorinated biphenyl (PCB) sources include transformers located throughout the facility, capacitors, fluorescent light ballasts, storage cans, microwave ovens, and electronic equipment. Less than 0.08 lb of PCB wastes are stored onsite; this waste is stored according to regulation and will be sent to an USEPA-approved disposal site after 10 to 25 lb have been accumulated.

V.B.6.d. Nonradioactive Nonhazardous Solid Wastes. Waste wood and metals are segregated on the plant site and sold periodically to salvage dealers. The

was 0.3 X 10^{-9} mCi/mL, which is 2% of the interim drinking water standard. Drinking water from private wells is also analyzed for tritium. The average concentrations of tritium for all private well locations was 6.02 X 10^{-9} mCi/mL, which is 30% of the standard.

V.B.7.b. Atmospheric. The primary source of nonradioactive airborne emissions at Mound is the steam power plant (Carfagno and Farmer 1985). This plant is normally fueled with natural gas, but has the capability to burn fuel oil. During unusually cold weather, if the natural gas supply to Mound is interrupted, fuel oil with <1% sulfur content is burned. Approximately 53,000 gal of fuel oil was burned during 1984.

Radionuclides in particulate form are removed from process air effluents by HEPA filters (Carfagno and Farmer 1985). Air effluents are filtered first at their point of origin (i.e., glove boxes) and then just before reaching the stack, where they are released. The filtering system at the stack consists of two banks of HEPA filters in series, each bank having a collection efficiency of 99.95%. The quantity of ^{238}Pu discharged to the atmosphere during 1984 was 0.0065 mCi. The quantity of tritium discharged to the atmosphere during 1984 was 3,430 Ci. These quantities are in compliance with USDOE operating orders.

Results of the atmospheric environmental monitoring program demonstrate compliance with atmospheric release of radioactive materials under USDOE operating orders. However, procedures must be developed to document compliance with CAA NESHAPS requirements for radioactive materials (40 CFR 61).

Given the volume of hazardous substances used at Mound on an annual basis, the potential for release of hazardous substances, other than radioactive materials, is not sufficiently large to require implementation of an atmospheric monitoring program for these substances.

Planned Future Actions: Planned future actions relative to potential hydrologic and atmospheric releases are presented in Table V.6. Major actions are required by MRC to ensure compliance with CWA NPDES effluent limitations. Additionally, releases of hazardous substances to the environment, which exceed reportable quantities as specified in 40 CFR 302, are to be reported under CERCLA.

collection and disposal of nonhazardous waste (trash) is contracted to a commercial landfill company (GSX Waste Services of Ohio) whose operation is licensed by Montgomery County and approved by the Ohio EPA. Mound trash is picked up daily and transported to the local sanitary landfill.

Planned Future Actions: MRC will continue to manage nonradioactive hazardous and nonhazardous wastes as required by RCRA (e.g., 40 CFR 260, 261, 262, 264, and 265).

V.B.7. Operational Emissions and Environmental Monitoring. Environmentally regulated emissions at Mound are grouped into two categories: hydrologic (surface waters) and atmospheric. Details of the MRC environmental monitoring programs for these emissions are presented in Appendix C. The environmental monitoring findings are published in an annual monitoring report (Carfagno and Farmer 1984, 1985).

V.B.7.a. Hydrologic. There currently are four NPDES-regulated discharges at Mound (Table IV.3.). The NPDES discharge limits are presented in Table IV.4. During 1983 a total of 1,402 NPDES analyses were performed for the four NPDES monitoring stations (Carfagno and Farmer 1984). Effluent parameters exceeded their maximum values 32 times and their monthly averages 13 times. The increased suspended-solids content from storm runoff after rain and snow precipitation was responsible for 31 total suspended-solids exceptions.

During 1984 a similar trend was observed. A total of 1,468 NPDES analyses were performed. Effluent parameters exceeded their maximum values 58 times and their monthly averages 23 times. Increased suspended-solids content resulting from construction and storm runoff was responsible for 62 of the exceptions (Carfagno and Farmer 1985).

Surface waters are monitored for release of radioactive materials from Mound. The average incremental concentration of ^{238}Pu, tritium, and $^{233,234,238}U$ in the Great Miami River were 1.1 X 10^{-15} mCi/mL [0.00006% of the USDOE Radioactivity Concentration Guide (RCG)], 0.04 X 10^{-9} mCi/L (0.004% of the RCG), and 0.22 X 10^{-13} mCi/L (0.01% of the RCG), respectively. The total amounts of ^{238}Pu, tritium, and $^{233,234}U$ discharged to the Great Miami River during 1984 were 1.34 mCi, 8.47 Ci, and 0.47 mCi, respectively (Carfagno and Farmer 1985).

Drinking water from communities in the surrounding area is sampled and analyzed quarterly for tritium. The average concentration of tritium for all locations during 1984

A comprehensive hydrologic environmental monitoring program will be developed and implemented by MRC based on results of the geohydrologic investigation (Sec. V.B.8., Important Site Characteristics) and the location of sources of potential contamination of ground and surface water by hazardous substances (Sect. V.A., Potential CERCLA Sites--Former Disposal Facilities/Activities/Spills and Leaks) as required by USDOE Order 5480.14 - Comprehensive Environmental Response, Compensation, and Liability Act Program.

V.B.8. Important Site Characteristics. The Buried Valley Aquifer (BVA) in the immediate Mound area is an important water resource. The aquifer system is not completely understood in terms of recharge and movement away from Mound. Oils or hazardous substances (Sec. V.A.) and leakage from the storm and sanitary sewer drainage system (Sec. V.B.5.) could potentially contribute to contamination of the BVA. Although there are no known drinking water problems (Sec. V.B.7.a.), the proximity of MRC operations to this important water supply necessitates a thorough understanding of the aquifer system.

Planned Future Actions: A geohydrological investigation of the aquifer system in the immediate vicinity of Mound will be conducted under CEARP. This investigation will supplement existing geohydrological understanding of the location, direction and rate of movement, and recharge and discharge of the aquifer system. The investigation will result in sufficient knowledge of the aquifer systems such that a ground and surface water monitoring network can be established (Sec. V.B.7., Operational Emissions and Environmental Monitoring,) to detect potential releases of hazardous substances from activities at Mound.

V.B.9. Sensitive Environments. The southwestern portion of Mound is located within the 100-yr floodplain.

Planned Future Actions: Activities at Mound within the 100-yr flood plain will continue to comply with Executive Order 11988--Floodplain Management and USDOE Compliance with Floodplain/Wetlands Environmental Review Requirements (44 FR 12594, Mar. 7, 1979).

V.B.10. Weed, Pest, and Ice Control. The normal maintenance of the grounds within Mound includes the use of fertilizer and herbicides plus the use of ice-removal material during winter months. The general purpose fertilizer is a 13(nitrogen)-13(phosphorus)-13(potassium) formulation. MRC uses 200 to 300 lb of herbicide for weed control.

Urea is used for ice removal and control on sidewalks. MRC uses approximately 2.5 tons of urea during an average winter. Commercial-grade rock salt is used for ice control of streets, roadways, and parking lots. Approximately 300 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.

Planned Future Actions: MRC will continue to comply with USDOE Order 5480.1 Chapter XII - Prevention, Control, and Abatement of Environmental Pollution when conducting weed and pest control.

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May contain unclassified controlled nuclear information subject to Section 148 of the AEA, as amended (42 USC 2168). Approval by the Department of Energy prior to release is required.
CUS 5/22/86

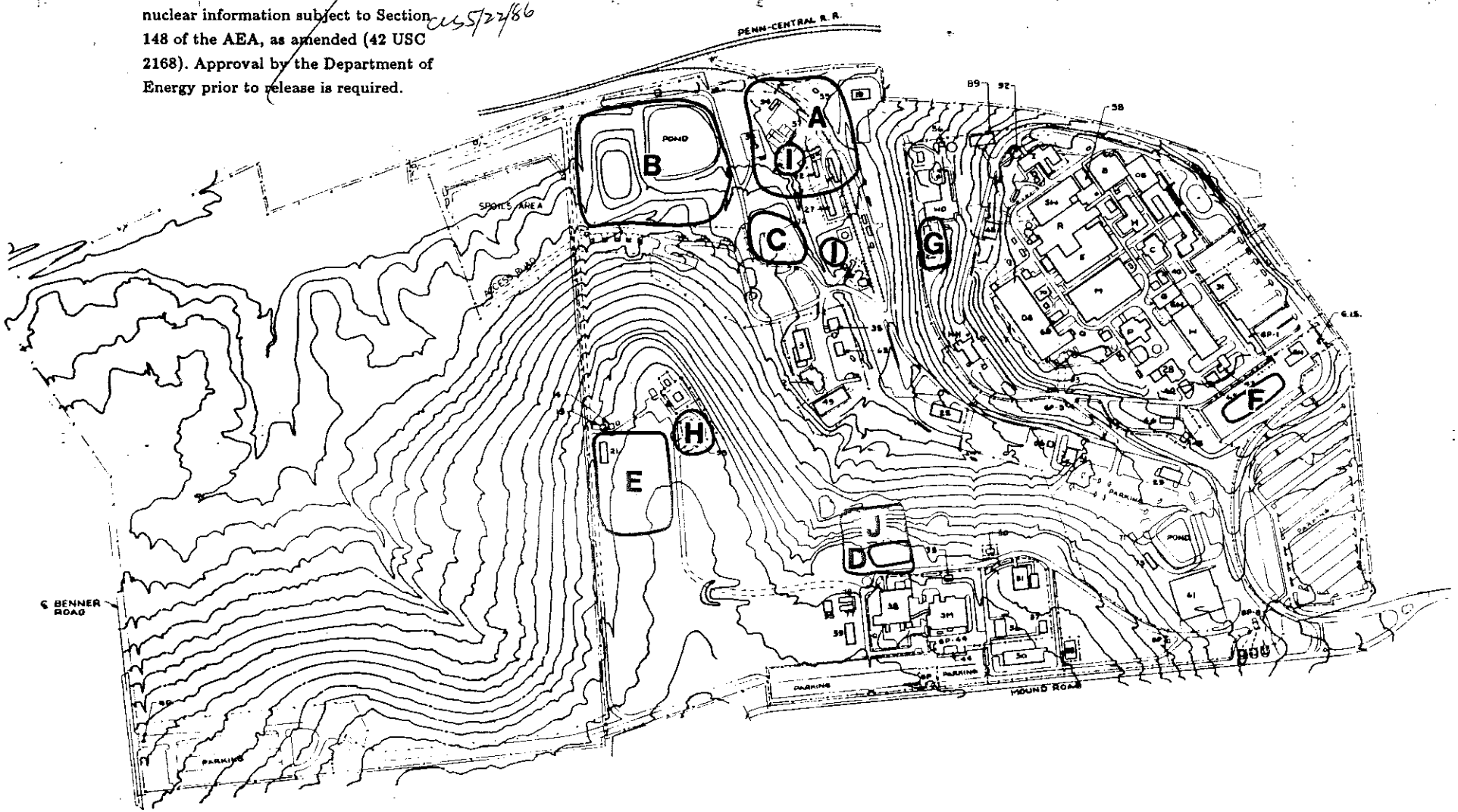

Figure V.1. Areas Potentially Contaminated with Hazardous Substances.

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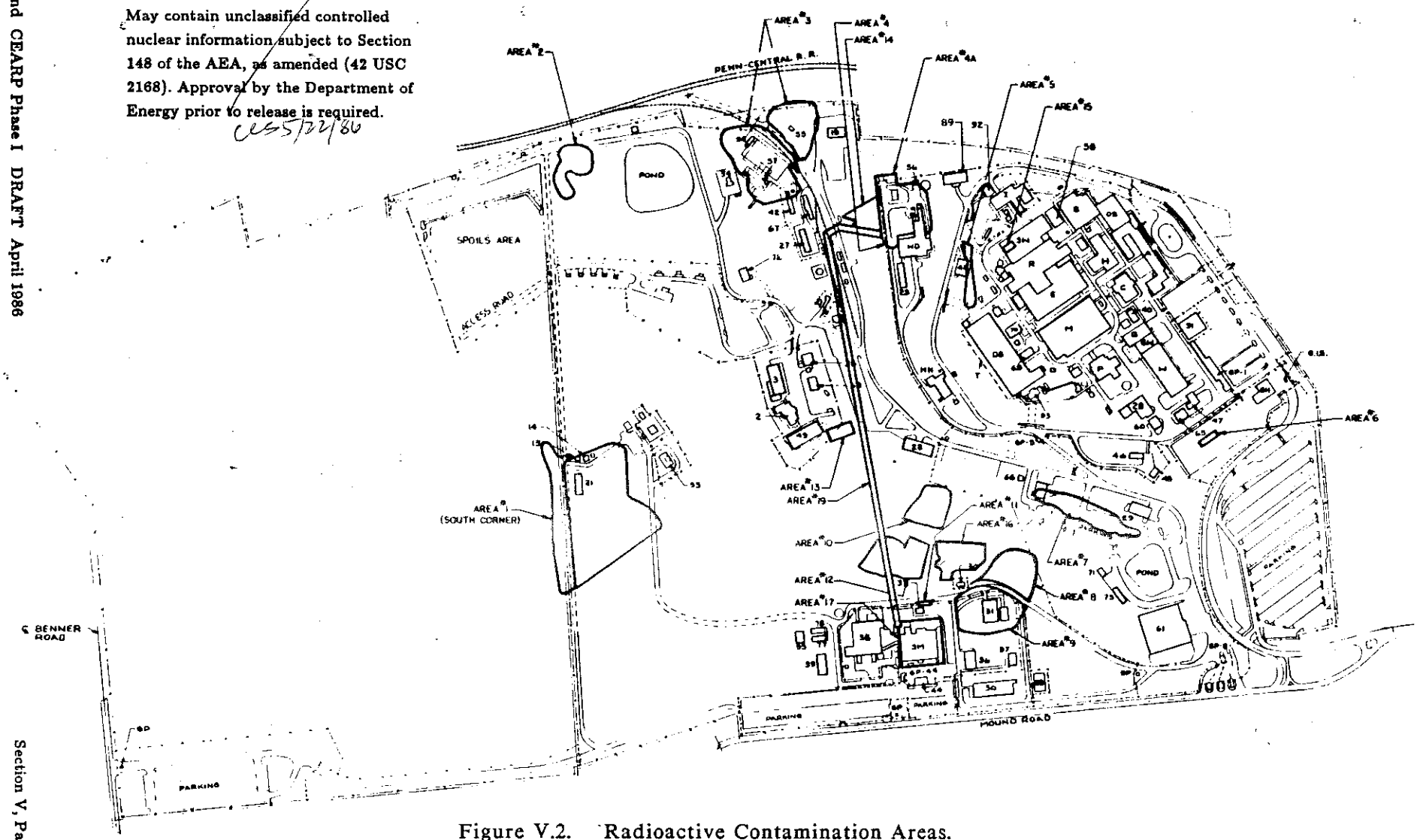

Figure V.2. Radioactive Contamination Areas.

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nuclear information subject to Section
148 of the AEA, as amended (42 USC
2168). Approval by the Department of
Energy prior to release is required.

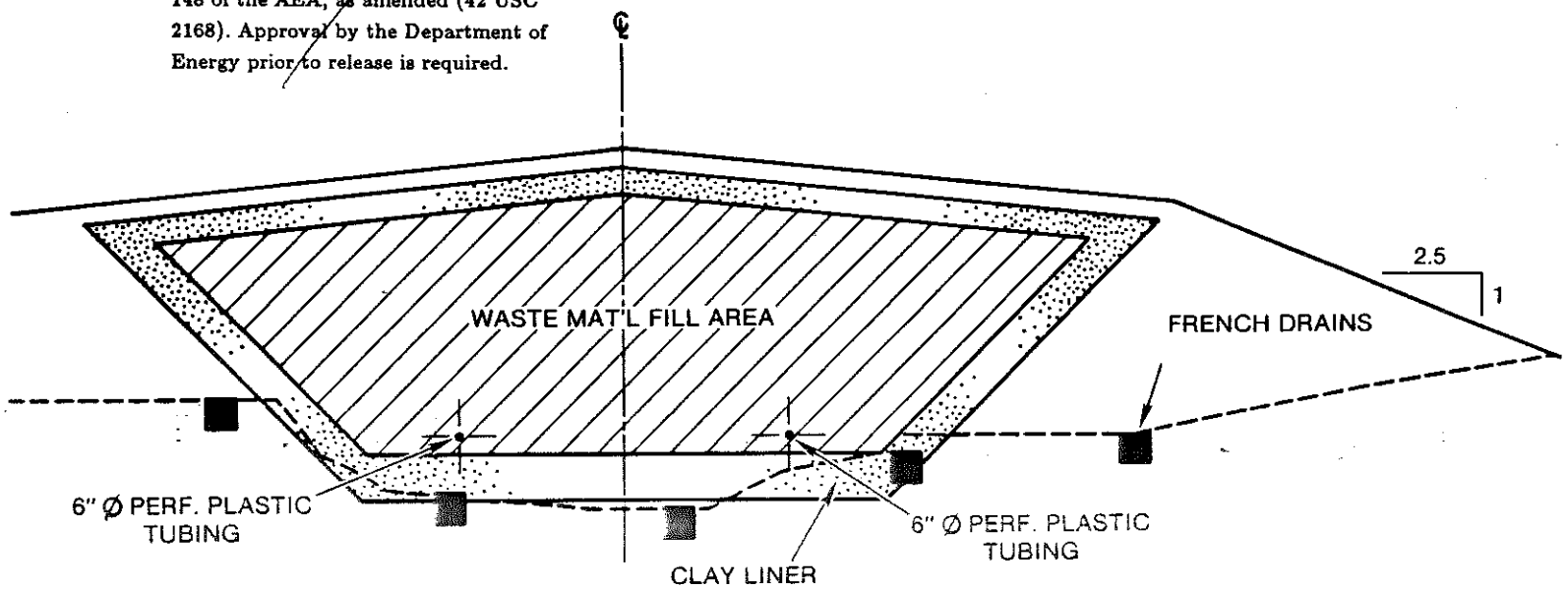

Figure V.3. Schematic of Site Landfill (Category 1 Area B).

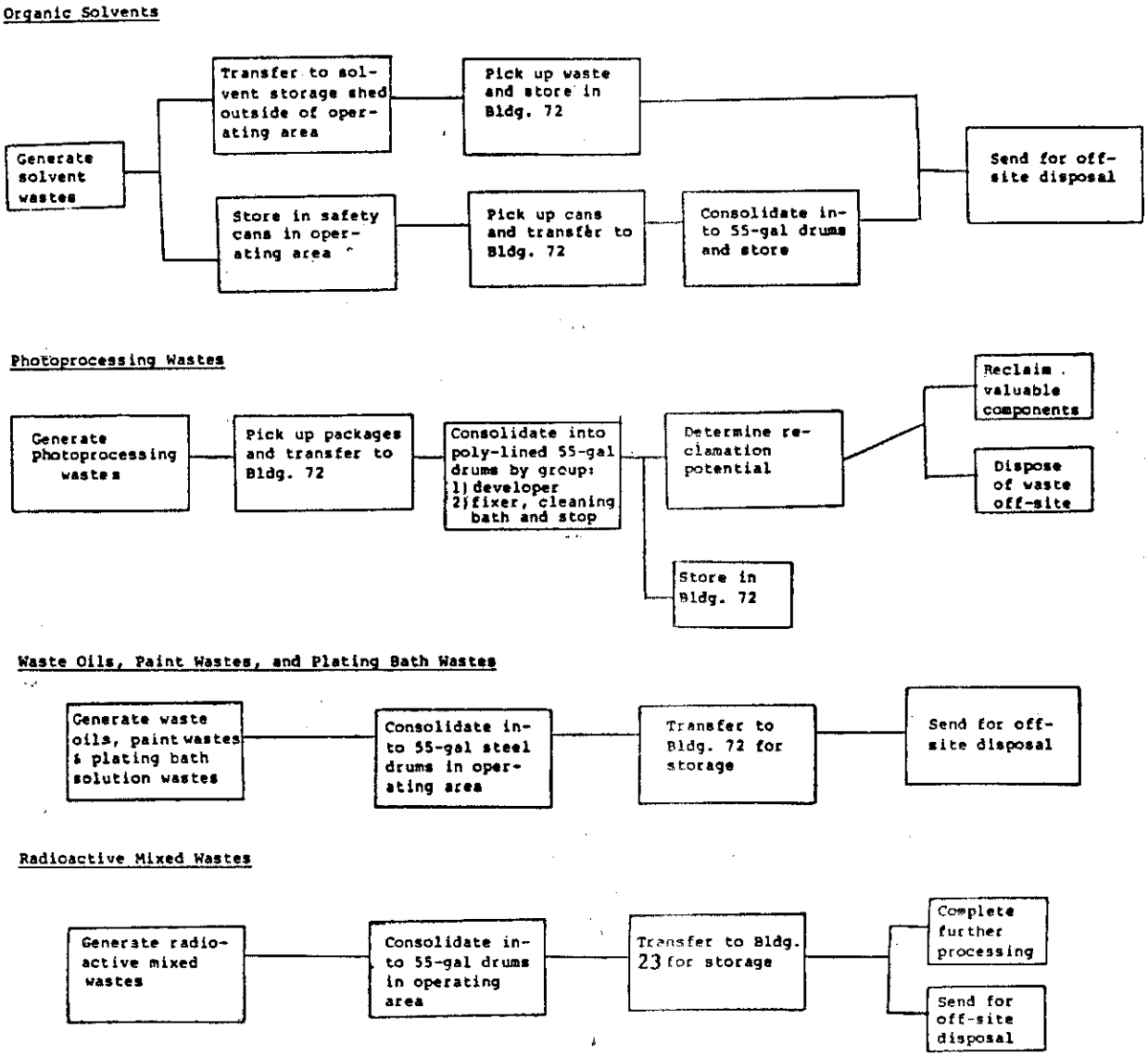

Figure V.4. Waste Management Schemes for Hazardous Waste Streams.

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CLS 5/22/86

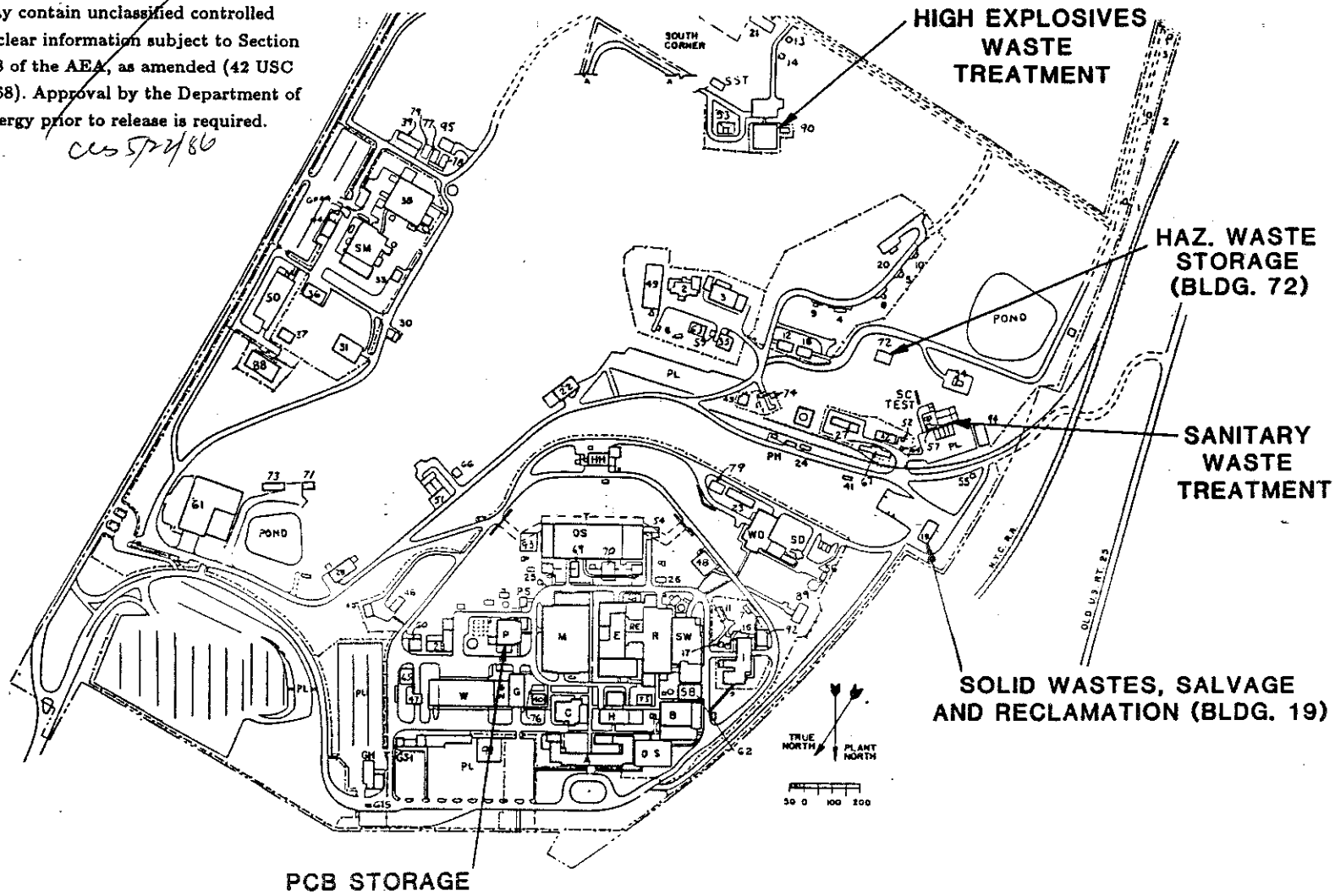

Figure V.5. Waste Managment Locations for Hazardous Wastes.

Table V.1

Planned Future Actions for Category 1
Areas Potentially Contaminated with Oils or Hazardous Substances

Area[a]	Planned Future Actions (PFA)
A	Construction soil material from Bldg T was used as fill material (approx. 17 ft^3) in the area of the sanitary treatment facility. No known hazardous substances were disposed of in this area. (Interviews 1985.) CERCLA Finding--Negative for Federal Facility Site Discovery and Identification Findings (FFSDIF), Preliminary Assessment (PA), and Preliminary Site Inspection (PSI); therefore, a HRS Migration Mode Score is not calculated. PFA--No further action is warranted.
B	Landfill operations were initiated when operations started at Mound in 1948 and ceased in the mid 1970s. Landfilled wastes included general refuse, construction materials, solvents, paints, photoprocessing solutions, and plating bath solutions. Radioactive materials were not landfilled. Many of the wastes were destroyed by burning at the time of landfilling. During construction of the overflow pond in 1978, these residual wastes were encountered. The wastes were compacted and confined in a large, sealed landfill in accordance with existing chemical landfill technology (Fig. V-3). Mound notified USEPA Region V on June 9, 1981 of the site as required under CERCLA. The materials are enclosed in a clay liner with provisions for monitoring of leachate. The volume of the landfill enclosure, including overflow pond fill, is 100,000 yd^3. It is estimated that the landfill enclosure may contain 1,000 ft^3 of hazardous substances. There may be residual hazardous substances that were not included in the clay-lined landfill; and landfilled residuals may exist under part of the overflow pond. However, based on the detailed records search, it appears that the probability of significant quantities of hazardous substances existing outside the landfill is remote. Potential exists for ground water contamination due to leakage from the landfill enclosure and movement of hazardous substances not enclosed in the landfill. The current ground water monitoring program may not detect potential movement of hazardous substances and oils away from the landfill area. (Interviews 1985; Monsanto Research Corporation 1985.) CERCLA Finding--Positive for FFSDIF, PA, and PSI; HRS Migration Mode Score 13 (Appendix D). PFA--Area B will be surveyed to determine the extent of contamination of oils and hazardous substances outside the landfill. The leachate monitoring system will be evaluated. Additionally, the potential outside the landfill for ground water contamination from unconfined oils and hazardous substances is being evaluated. Based on results of these CEARP Phase II studies, appropriate action will be taken.

[a]location of designated areas shown in Figure V-1.

Table V.1 (cont)

Area	Planned Future Actions (PFA)
C	Area C was a stagnant water area of about 150 ft in diameter. Lithium containers, probably containing residual lithium carbonate, were dumped in this area during the mid 1950s. Other wastes may have also been dumped in this area, however, the quantity of hazardous substances, if any, would have been limited. It appears that fill has been added to the area. An old warehouse was also located in this area. There is not sufficient information to make a definitive statement on the existence of hazardous substances at area C. (Interviews 1985.) CERCLA Finding--Positive for FFSDIF, PA, and PSI; however, there is not sufficient information to calculate a HRS Migration Mode Score. PFA--A CEARP Phase I supplemental reconnaissance field study will be conducted to determine the presence of hazardous substances and potential for ground water contamination. Based on the results of this study, appropriate action will be taken.
D	Area D served as the leach bed for plutonium operations in PP Bldg. The leach bed received caustic or acidic solutions with plutonium contamination. Residual hazardous substances in the leach bed are probably limited to radioactive contamination. The area is being evaluated under the Site Survey Program. (Interviews 1985; Site Survey Program 1985.) Due to the status of activities (i.e., CEARP Phase IV) a CERCLA finding under FFSDIF, PA, and PSI; and HRS and MHRS scoring are not appropriate for this site. PFA--Area D was submitted to and accepted by the USDOE Surplus Facilities Management Program (SFMP). SFMP remedial action is scheduled.
E	A single contractor waste oil dumping event (<5 gal) occurred in area E. Oil contaminated soil was removed and disposed at a USDOE disposal facility. (Interviews 1985.) CERCLA Finding--Negative for FFSDIF, PA, and PSI; therefore, a HRS Migration Mode Score is not calculated. PFA--No further action is warranted.
F	During 1963 a chromium plating bath (110 gal) was treated with sodium bisulfide and dumped in a trench at area F. The area is currently covered with an asphalt parking lot and the small amount residual chromium does not pose a health hazard. Additionally, the amount of material dumped is substantially below the 24 hour reportable quantity of 1,000 lbs for chromium. (Interviews 1985.) CERCLA Finding--Negative for FFSDIF, PA, and PSI; therefore, a HRS Migration Mode Score is not calculated. PFA--No further action is warranted.

Table V.1 (cont)

Area	Planned Future Actions (PFA)
G	Area G contains plutonium contamination from spilling a solution containing plutonium and is being evaluated under the Site Survey Program. (Interviews 1985; Site Survey Program 1985.) Due to the status of activities (i.e., CEARP Phase IV) a CERCLA Finding under FFSDIF, PA, and PSI; and HRS and MHRS scoring are not appropriate for this site. PFA--Area G has been submitted to USDOE SFMP for remedial action. Further funding is anticipated.
H	Small quantities of wastes from pyrotechnic material operations were dissolved in water and filtered; the filtrate was poured onto the ground for treatment by natural weathering processes (hydrolysis) in the thermal treatment area (Monsanto Research Corporation 1983). Historically the waste stream was less than 10 gal/yr. The waste stream in 1984 consisted of approx 5 gal of liquid, which consisted mostly of detergent with small amounts of solvents (primarily acetone) and trace amounts of reacted pyrotechnic material. Treatment by natural weathering process is no longer practiced. The primary hazardous substance (i.e., acetone) is not stable in the environment and any residual trace substances do not pose a health hazard. Additionally, the amount of acetone treated annually was substantially below the 24-hour reportable quantity of 5,000 lbs. (Interviews 1985; Monsanto Research Corporation 1983.) CERCLA Finding--Negative for FFSDIF, PA, and PSI; therefore, a HRS Migration Mode Score is not calculated. PFA--No further action is warranted.
I	Manufacturing operations involving explosives produced limited quantities of industrial liquors with dissolved explosives; the principal process liquid was acetone. Waste liquors (approx. 1,000 gal/yr) containing very small amounts of dissolved explosives (ppm range) were piped to concrete-lined filtering basins and then to an open retaining/settling basin or a leach bed for biodegradation treatment (Monsanto Research Corporation 1983). The concrete-lined basins were dredged every 3 to 4 years and the sludge destroyed by thermal treatment. Filters used at the basins were also destroyed by thermal treatment. Treatment by biodegradation is no longer practiced. The primary hazardous substance (i.e., acetone) and trace quantities of explosives are not stable in the environment. Additionally, the amount of acetone treated annually was roughly equivalent to the CERCLA 24-hour reportable quantity of 5,000 lbs. Residual trace substances probably do not pose a health hazard. (Interviews 1985; Monsanto Research Corporation 1983.) CERCLA Finding--Positive for FFSDIF, PA, and PSI; however, there is not sufficient information to calculate a HRS Migration Mode score. PFA--A CEARP Phase I supplemental reconnaissance field study will be conducted to determine the presence of hazardous substances and potential for ground water contamination. Based on results of this study, appropriate action will be taken.

Table V.1 (cont)

Area	Planned Future Actions (PFA)
J	The hillside slope west of Building 38 has been used for placement of construction spoil since the early 1950s (Monsanto Research Corporation 1985). Construction residues (including excavated soil, chunks of concrete, pipes of various sizes and types, metal banding, plumbing fixtures, roofing materials, etc.) have been discarded and bulldozed over the hillside in a random, uncompacted fashion. At the present time, this site encompasses a surface area of approximately four acres. The volume of the spoils material exceeds 100,000 yd^3. The detailed records search, including interviews with Mound employees, failed to confirm that persistent hazardous substances might be present in the construction spoils area with the possible exception of plutonium and thorium (see Table V.1, area D and Table V.3, area 12). During recent years, the site has been expanded to such an extent that the capacity of the area is being exceeded resulting in spoil pile instability and excessive erosion. Two engineering programs were completed to: (1) assess the stability of the construction material disposal area and concepts for disposal of construction spoil, and (2) eliminate the excessive discharge of suspended solids from the hillside. (Interviews 1985; Monsanto Research Corporation 1985.) CERCLA Finding--Negative for FFSDIF, PA, and PSI; therefore, a HRS Migration Mode Score is not calculated. PFA--The two ongoing engineering programs for management of construction spoil and stabilization of the construction material disposal area will be implemented by MRC.

Table V.2

Planned Future Actions for Category 2
Areas with Potential for Leaks and Spills of Oils or Hazardous Substances

Area	Planned Future Actions (PFA)
Paint Shop	The local area around the paint shop could have been contaminated as a result of leaks and spills or as a result of dumping. Paint shop wastes were disposed in the Mound area B landfill prior to disposal offsite by a commercial vendor and no major spills or leaks have been reported. Therefore, there should not be sufficient residual contamination of hazardous substances to pose an environmental problem in the paint shop area. (Interviews 1985.) CERCLA Finding--Negative for Federal Facility Site Discovery and Identification Findings (FFSDIF), Preliminary Assessment (PA), and Preliminary Site Inspection (PSI); therefore, a HRS Migration Mode Score is not calculated. PFA--No further action is warranted.
Powerhouse	The area around the powerhouse could be contaminated as the result of oil spills. No major leaks or spills have been reported in the powerhouse area that would result in sufficient residual contamination of oil to pose an environmental problem. (Interviews 1985.) CERCLA Finding--Negative for FFSDIF, PA, and PSI; therefore, a HRS Migration Mode Score is not calculated. PFA--No further action is warranted.
WD Bldg.	The four underground steel holding tanks for radioactive wastes have been subject to corrosion. The tanks have been recoated with epoxy. No major leaks have been reported in the holding tanks for radioactive wastes and their repair on several occasions has ensured that any slow undetectable leaks would have been repaired without significant losses. (Interviews 1985.) CERCLA Finding--Negative for FFSDIF, PA, and PSI; therefore, HRS and MHRS Migration Mode Scores are not calculated. PFA--No further action is warranted.
Bldg. 61	The Bldg. 61 area was the old heavy equipment area and could have been a spot for dumping waste oil. Dumping of waste oil has not been reported in the Bldg. 61 area and standard operating procedure was to dispose of waste oil in the Mound area B landfill prior to disposal/recycle offsite by a commercial vendor. Additionally, no major spills have been reported in the Bldg. 61 area. Therefore, the likelihood of residual oils in concentrations sufficient to pose environmental problems is remote. (Interviews 1985.) CERCLA Finding--Negative for FFSDIF, PA, and PSI; therefore, a HRS Migration Mode Score is not calculated. PFA--No further action is warranted.

Table V.2 (cont)

Area	Planned Future Actions (PFA)
Bldg. G	Garage work is done at Bldg. G and the local area might be contaminated as a result of these activities. Dumping of waste oil has not been reported in the Bldg. G area and prior to utilizing an offsite vendor the standard operating procedure was to dispose of waste oil in the Mound area B landfill. Additionally, no major spills have been reported in Bldg. G. Therefore, the likelihood of residual oils in concentrations sufficient to pose environmental problems is remote. (Interviews 1985.) CERCLA Finding--Negative for FFSDIF, PA, and PSI; therefore, a HRS Migration Mode Score is not calculated. PFA--No further action is warranted.

Table V.3

Planned Future Actions for Category 3
Areas Potentially Contaminated with Radioactive Materials

Area[a]	Isotopes	Planned Future Actions (PFA)
1	^{232}Th	1964, 1973. Bulk transfer of thorium from drums to storage basin (Bldg.21). 1965, 1973. Area cleaned up and backfilled with clean soil. Area approximately 136,000 ft^2.
	^{238}Pu	1969. Staged waste drum leaked. Majority of area cleaned up and backfilled. Drainage to the south from this area remains contaminated. Area approximately 10,000 ft^2.
		PFA--Area 1 was submitted to and accepted by the USDOE Surplus Facilities Management Program (SFMP). Future funding for remedial action is anticipated under SFMP.
2	^{210}Po ^{238}Pu	1965. Disposed of sand contaminated with polonium. Sand resulted from cleaning of metal framework of WD Bldg. sand filters. (Polonium has decayed out.) Area approximately 15,000ft^2.
		PFA--Based on findings of the Site Survey Program, no further action is warranted.
3	^{232}Th	1965. Storage and redrumming area cleaned and the area backfilled with clean soil. Area approximately 69,000 ft^2.
		PFA--Area 3 is being submitted under the Site Survey Program for remedial action.
4	^{210}Po ^{60}Co	1965. Waste Disposal Building influent tanks overflowed. Sewage sludge disposal drying pits were also contaminated. (Polonium has decayed out, leaving residual ^{60}Co).
		PFA--Area 4 was submitted to and accepted by SFMP. Future funding for remedial action is anticipated under SFMP.

[a]Location of Designated areas shown in Fig. V-2.

Table V.3 (cont)

Area[a]	Isotopes	Planned Future Actions (PFA)
4A	^{210}Po ^{238}Pu	1965. Sewage sludge disposal drying pits were contaminated when radioactive waste line broke in Area 5. (Polonium has decayed out --trace plutonium still remains.) Combined area approximately 25,000 ft^2. PFA--Area 4A was submitted to and accepted by SFMP. Future funding for remedial action is anticipated under SFMP.
5	^{210}Po ^{60}Co	1969. Radioactive waste line broke. (Maximum reading was 500 d/m/100 cm^2.)(Polonium has decayed out, leaving residual ^{60}Co.) Area approximately 6,800 ft^2. PFA--Area 5 is being submitted under the Site Survey Program for remedial action.
6	^{210}Po	1964. Disposed of sand contaminated with polonium. Sand resulted from cleaning of metal framework of WD Bldg. sand filters. (Polonium has decayed out.) Area approximately 2,100 ft^2. PFA--Based on findings of the Site Survey Program, no further action is warranted.
7	^{232}Th ^{226}Ra ^{227}Ac ^{228}Th ^{210}Po	1954-1965. Buried empty thorium drums: ^{226}Ra, ^{227}Ac, and ^{228}Th contaminated dirt from SW Cave area; also ^{210}Po contaminated E-31 ventilation exhaust system from T-Bldg. (Polonium has decayed out.) Area approximately 22,000ft^2. PFA--Area 7 is being submitted under the Site Survey Program for remedial action.
8	^{232}Th	1965. Subsurface contaminated dirt from areas 9 and 1. Area approximately 25,000 ft^2. PFA--Area 8 is being submitted under the Site Survey Program for remedial action.

Table V.3 (cont)

Area[a]	Isotopes	Planned Future Actions (PFA)
9	^{232}Th	1965. Thorium storage and redrumming area cleaned up and backfilled with clean soil. Area approximately 40,000 ft^2. PFA--Area 9 is being submitted under the Site Survey Program for remedial action.
10	^{210}Po	1950. Polonium contaminated concrete from Unit 4 Dayton operations. (Polonium has decayed out). Area approximately 13,000 ft^2. PFA--No further action is warranted.
11	^{238}Pu	Prior to 1965. Area was contaminated from SM Bldg. operations. No estimate available for quantity of activity or affected volume. The recent analysis of surface scrapings indicate some degree of contamination. PFA--Area 11 was submitted to and accepted by SFMP. SFMP-funded remedial action is underway.
12	^{232}Th	1965. Subsurface contaminated dirt from Area 1. Area approximately 19,000 ft^2. PFA--Area 12 is being submitted under the Site Survey Program for remedial action.
13	^{210}Po	1950. Polonium-contaminated wood from Unit 4 Dayton operations burned. (Polonium has decayed out to nondetectable levels.) Area approximately 9,000 ft^2. PFA--No further action is warranted.

Table V.3 (cont)

Area[a]	Isotopes	Planned Future Actions (PFA)
14	^{238}Pu	1969. Radioactive waste line from SM to WD Bldg. broke. Grossly contaminated soil (964 ft^3), removed and shipped to NECO for burial. Area backfilled with clean soil. In August 1974, action to remove all hillside surface soil containing significant levels of contamination was started. Approximately 2,700 ft of soil were removed containing an estimated 35 curies. The area was backfilled with clean dirt and sodded. The soil was shipped to Idaho for retrievable storage. PFA--Area 14 was submitted to and accepted by SFMP. SFMP-funded remedial action is underway.
15	^{226}Ra ^{227}Ac ^{228}Th	1958-1960. Steel crane, tracks, and shielding panels for SW Bldg. Old Room 219 cave are contained under new concrete floor. Area approximately 1,000 ft^2. PFA--Area 15 was submitted to and accepted by SFMP. Remedial action is planned but not yet scheduled.
16	^{238}Pu	1960-1965. Sanitary-sewage septic tank and leach basin for SM Bldg. Core samples will be obtained to determine whether any contamination exists. Area approximately 15,500 ft^2. PFA--Area 16 was submitted to and accepted by SFMP. SFMP-funded remedial action is underway.
17	^{238}Pu	1960-1970. Area under and immediately surrounding SM Building. The contamination is largely the result of activity located beneath the concrete floor of the "hot" side and the previous utilization of low risk tanks outside SM. Area approximately 40,000 ft^2. PFA--Area 17 was submitted to and accepted by SFMP. SFMP-funded remedial action is underway.

Table V.3 (cont)

Area[a]	Isotopes	Planned Future Actions (PFA)
18	^{238}Pu	1971-1974. Sanitary sludge from drying beds used as cover for certain sections of landfill. Subsequent investigations revealed that this material may have been contaminated. Approximately 3,200 ft^3 spread over an area of 60,000 ft^2. This material was packaged and shipped offsite for disposal. PFA--No further action is warranted.
19	^{238}Pu	Area 19 represents a 1-1/2 in underground line and a 2-in underground line that were formerly used to transfer low level and higher level ^{238}Pu contaminated liquid waste from the SM-PP area to WD Bldg. for processing. PFA--Area 19 was submitted to and accepted by SFMP. SFMP remedial action is underway.

Table V.4. Potential CERCLA Sites Identified During CEARP Phase I

Site	USDOE CEARP Phase I: FFSDIF/PA/PSI[a] Finding	USDOE CEARP Phase I: HRS[b] Score	Planned Future Action: USEPA CERCLA Program Element	Planned Future Action: USDOE CEARP/CERCLA Order Phase
Category 1[c]				
Area A	Negative	NA[d]	None	None
Area B	Positive	13	None	Confirmation (Phase II)
Area C	Uncertain	NE[e]	None	Installation Assessment (Supplemental Phase I)
Area D	Positive	NA	None	Remedial Action (Phase IV)
Area E	Negative	NA	None	None
Area F	Negative	NA	None	None
Area G	Positive	NA	None	Remedial Action (Phase IV)
Area H	Negative	NA	None	None
Area I	Uncertain	NE	None	Installation Assessment (Supplemental Phase I)
Area J	Negative	NA	None	None
Category 2[f]				
Paint Shop	Negative	NA	None	None
Powerhouse	Negative	NA	None	None
WD Bldg	Negative	NA	None	None
Bldg 61	Negative	NA	None	None
Bldg G	Negative	NA	None	None
Category 3[g]				
Area 1	NA	NA	None	Remedial Action (Phase IV)
Area 2	Negative	NA	None	None
Area 3	NA	NA	None	Remedial Action (Phase IV)
Area 4	NA	NA	None	Remedial Action (Phase IV)

Table V.4 (cont)

Site	USDOE CEARP Phase I		Planned Future Action	
	FFSDIF/PA/PSI[a] Finding	HRS[b] Score	USEPA CERCLA Program Element	USDOE CEARP/CERCLA Order Phase
Area 4a	NA	NA	None	Remedial Action (Phase IV)
Area 5	NA	NA	None	Remedial Action (Phase IV)
Area 6	Negative	NA	None	None
Area 7	NA	NA	None	Remedial Action (Phase IV)
Area 8	NA	NA	None	Remedial Action (Phase IV)
Area 9	NA	NA	None	Remedial Action (Phase IV)
Area 10	Negative	NA	None	None
Area 11	NA	NA	None	Remedial Action (Phase IV)
Area 12	NA	NA	None	Remedial Action (Phase IV)
Area 13	NA	NA	None	None
Area 14	NA	NA	None	Remedial Action (Phase IV)
Area 15	NA	NA	None	Remedial Action (Phase IV)
Area 16	NA	NA	None	Remedial Action (Phase IV)
Area 17	NA	NA	None	Remedial Action (Phase IV)
Area 18	Negative	NA	None	None
Area 19	NA	NA	None	Remedial Action (Phase IV)
Tritium in the Buried Valley Aquifer[h]	NA	NA	None	Compliance and Verification (Phase V)
Plutonium in the Miami-Erie Canal[i]	NA	NA	None	Compliance and Verification (Phase V)

Table V.4 (cont)

Site	USDOE CEARP Phase I		Planned Future Action	
	FFSDIF/PA/PSI[a] Finding	HRS[b] Score	USEPA CERCLA Program Element	USDOE CEARP/CERCLA Order Phase
Historical Monsanto Facilities[j]				
Unit I	Negative	NA	None	None
Unit II	Negative	NA	None	None
Unit III	Negative	NA	None	None
Unit IV	Negative	NA	None	None
Warehouse	Negative	NA	None	None
Marion	Negative	NA	None	None

[a]Federal Facility Site Discovery and Identification Findings/Preliminary Assessments/Preliminary Site Inspections.
[b]USEPA Hazard Ranking System (for HRS scoring details see Appendix D).
[c]Category 1 (see Section V.A.1.a; Table V.1).
[d]Not Applicable.
[e]Not Evaluated.
[f]Category 2 (see Section V.A.1.a; Table V.2).
[g]Category 3 (see Section V.A.1.a; Table V.3).
[h]See Section V.A.1.b.
[i]See Section V.A.1.c.
[j]See Section V.A.2.

Table V.5

Management of Hazardous Substances and Oils Generated at Mound

Waste Description	Process/Source	Annual Quantity FY-83	Annual Quantity FY-84	Waste Handling
Organic solvents such as acetone, isopropanol, methanol, ethanol, trichloroethylene, and chlorinated fluorocarbons	Various cleaning operations excluding those required for processing explosives	3994 gal	4300 gal	Drums and Safety Cans; picked up weekly; can contents emptied into drums; wastes stored in Bldg. 72 prior to offsite disposal (3 to 24 months residence time)
Waste oils	Machining operations, hydraulic systems, pump oils, used motor oil	1879 gal	3900 gal	Consolidated in 55-gal drums at operating area, and stored in Bldg. 72 for offsite disposal (3 to 24 months residence time)
Discarded excess paints and thinners	Paint shop, outdated paint, cleaning solutions from paint operations	215 gal	330 gal	Consolidated in 55-gal drums at operating area, and stored in Bldg. 72 for offsite disposal (3 to 24 months residence time)
Waste corrosive solutions	Plating operations and other sources	50 gal	290 gal	Consolidated in drums at operating area, and stored in Bldg. 72 for offsite disposal (3 to 24 months) residence time)
Spent plating-bath solutions of chromic acid, cadmium cyanide, nickel sulfate, nickel chloride, electroless nickel, black oxide, and copper cyanide	Plating shop	83 gal	640 gal	Consolidated in drums at operating area, and stored in Bldg. 72 for offsite disposal (3 to 24 months residence time)
EP toxic wastes and polymeric wastes	Various processes	---	620	Picked up weekly and stored in Bldg. 72 prior to offsite disposal (3 to 24 months residence time)

Table V.5 (cont)

Waste Description	Process/Source	Annual Quantity FY-83	Annual Quantity FY-84	Waste Handling
Waste PCBs	From transformers, capacitors, storage cans, microwave ovens, and electronic equipment; also bulk waste from various site operations	0	0	Stored in marked cans or drums, labelled and placed in dikes and covered vaults or controlled storage facility near P-Building (12 months residence time)
Photoprocessing wastes such as spent fixer solution, developers, stop, bleaches and rinses	From various functional groups including Product Development and Environmental Testing, Manuals and Procedure, Drawing Control, General Analytical, ADP Operations, Photography, Industrial Radiography, and Medical Radiography	539 gal	1200 gal	Picked up weekly, consolidated into polyethylene-lined 55-gal drums and stored in Bldg. 72 prior to offsite disposal (3 too 124 months residence time)
Explosive wastes consisting of small amounts of mild detonating fuse (MDF), pyrotechnic materials, rejected components containing small amounts of explosives, and operational wastes such as tissue and cardboard that have been contaminated with explosives or pyrotechnics; also bulk high explosives/pyrotechnics	Generated in production areas throughout facility	770 lb	800 lb	Stored in magazines; small quantities are destroyed by incineration, retorting, and open burning in remote area (24 months residence time)
Radioactive mixed wastes	Biomedical assay	825 gal[a]	2100 gal[b]	Managed per DOE 5480.2 and 5820.2 (3 years residence time)

Table V.5 (cont)

Waste Description	Process/Source	Annual Quantity FY-83	Annual Quantity FY-84	Waste Handling
Laboratory wastes consisting of solvents; flammable corrosive, toxic liquids and solids	Lab R&D and analytical work	900 lb	1500 lb	Packed in steel container with vermiculite prior to offsite incineration or landfilling (3 to 24 months residence time)

[a]Includes ninety-four 55-gal drums of scintillation vials, plus packaging material; pending analyses may show some of these materials to be nonradioactive.
[b]Includes One-hundred and sixteen 55-gal drums of scintillation vials plus packaging materials.

Table V.6

Planned Future Actions for Potential Emissions

Potential Emissions	Planned Future Actions
Hydrologic	
NPDES discharges	Continued compliance with CWA NPDES reporting requirements. The following projects will be implemented to ensure TSS NPDES compliance (1) stabilization of the construction material disposal area (area J, Table V.1), (2) upgrade storm and sanitary sewer drainage systems (Section V.B.3), and (3) separate process water from storm system (Section V.B.5).
Atmospheric	
Powerhouse	Continued compliance with RAPCA requirements.
Paint shop	Continued compliance with RAPCA requirements for organic releases.
Explosives thermal	Continued compliance with RAPCA requirements.
Fire fighter training	Continued compliance with RAPCA notification requirements.
Plastic manufacturing	Continued compliance with CAA NESHAPS reporting requirements for asbestos.
Demolition and renovation of facilities containing asbestos	Continued compliance with CAA NESHAPS requirements.
Radionuclides	Comply with CAA NESHAPS reporting requirements (40 CFR 61, effective May 1985).

Table V.6 (cont)

Potential Emissions	Planned Future Actions
Environment Hazardous substances	Releases of hazardous substances to the environment will be reported as required under CERCLA (40 CFR 302). All concurrent releases of the same substance from a particular facility into the environment must be aggregated to determine if the reportable quantity has been exceeded.

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VI. REFERENCES

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APPENDIX A - PROFESSIONAL QUALIFICATIONS OF INSTALLATION ASSESSMENT TEAM

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CES 5/22/84

BECKER, Naomi M.
- Hydrologist
- Registered Professional Engineer (New Mexico)
- Los Alamos National Laboratory
- B.S. 1974, Geological Science, University of Illinois
- M.S. 1978, Civil and Environmental Engineering, University of Wisconsin, Madison
- Years of Professional Experience: 11
- CEARP Responsibilities: Geology, Hydrology, Water Quality

DEWART, Jean
- Meteorologist
- Los Alamos National Laboratory
- B.S. 1976, Atmospheric Science, University of Washington
- M.S. 1978, Atmospheric Science, Colorado State University
- Years of Professional Experience: 9
- CEARP Responsibilities: Meteorology

FERENBAUGH, Roger W.
- Chemical Engineer, Ecologist
- Los Alamos National Laboratory
- B.Ch.E. 1963, Chemical Engineering, University of Virginia
- M.S. 1965, Chemical Engineering, Rice University
- Ph.D. 1974, Plant Ecology, University of Montana
- Years of Professional Experience: 16
- CEARP Responsibilities: Team Leader, Process Review, Pathway Analysis

NOCHUMSON, David H.
- Environmental Engineer
- Los Alamos National Laboratory
- B.S. 1970, Chemical Engineering, Rutgers University
- M.S. 1972, Environmental Engineering, Harvard University
- Ph.D. 1978, Environmental Engineering, Harvard University
- Years of Professional Experience: 9
- CEARP Responsibilities: Air Quality

PURTYMUN, William D.
Geohydrologist
Registered Professional Geologist (California)
Los Alamos National Laboratory
B.S. 1958, Geology, University of New Mexico
Years of Professional Experience: 27
CEARP Responsibilities: Geology
Hydrology
Water Quality

REA, Kenneth H.
Terrestrial Ecologist
Los Alamos National Laboratory
B.S. 1969, Wildlife Science, New Mexico State University
M.S. 1972, Range Science, New Mexico State University
Ph.D. 1976, Range Ecology, Utah State University
Years of Professional Experience: 16
CEARP Responsibilities: Team Leader
Interviewer
Pathway Analysis

STOKER, Alan K.
Environmental Engineer
Los Alamos National Laboratory
B.S. 1965, Physics, Occidental College
M.S. 1974, Environmental Engineering, Stanford University
Engineer 1975, Environmental Engineering, Stanford University
Years of Professional Experience: 13
CEARP Responsibilities: Reviewer

VOCKE, Robert W.
Aquatic Biologist, Environmental Scientist
Los Alamos National Laboratory
B.S. 1972, Fisheries and Wildlife Biology, Iowa State University
M.S. 1974, Botany, Iowa State University
Ph.D. 1978, Water Resources, Iowa State University
Years of Professional Experience: 10
CEARP Responsibilities: Project Leader and Manager
Team Leader
Pathway Analysis

APPENDIX B

PHOTOGRAPHS

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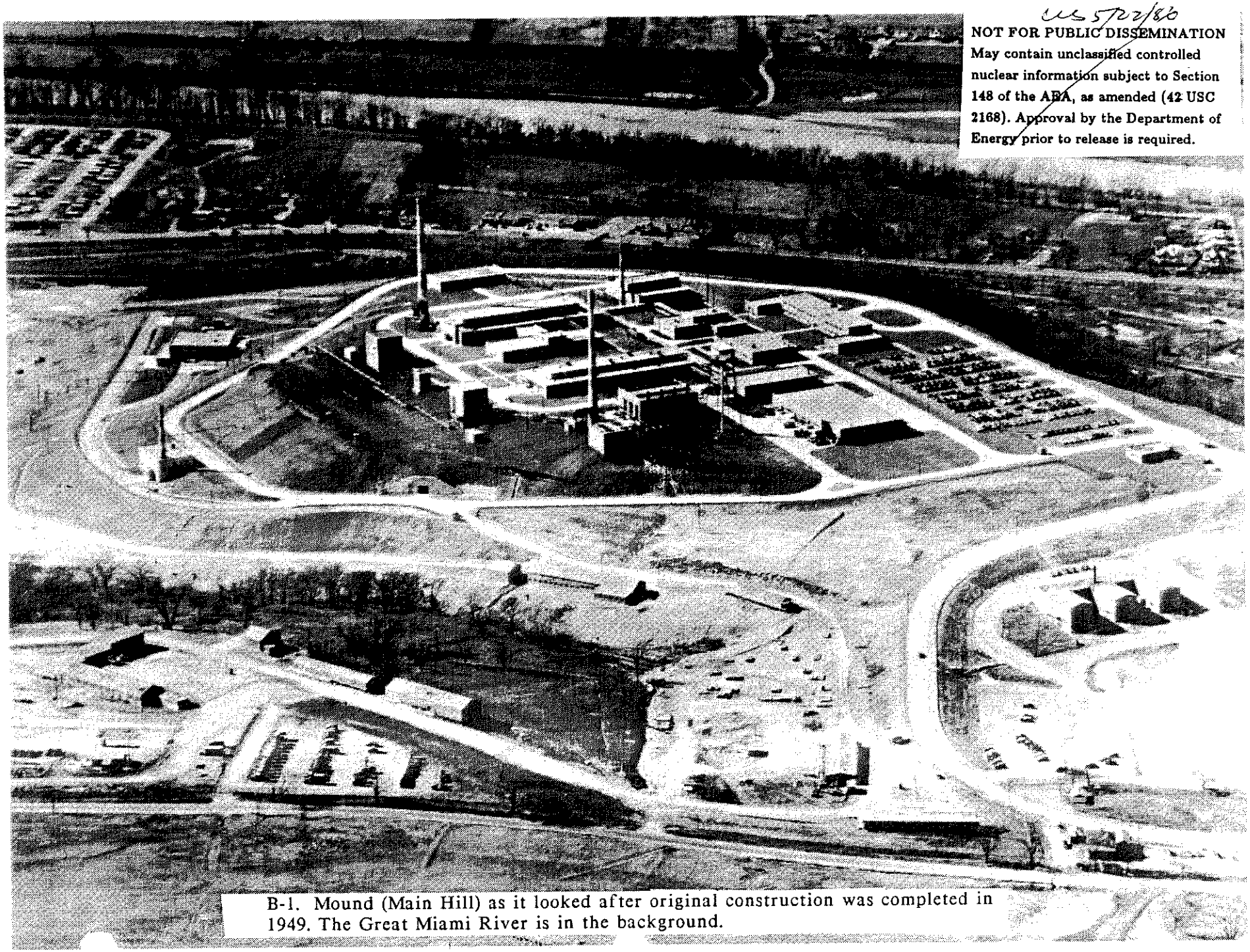

B-1. Mound (Main Hill) as it looked after original construction was completed in 1949. The Great Miami River is in the background.

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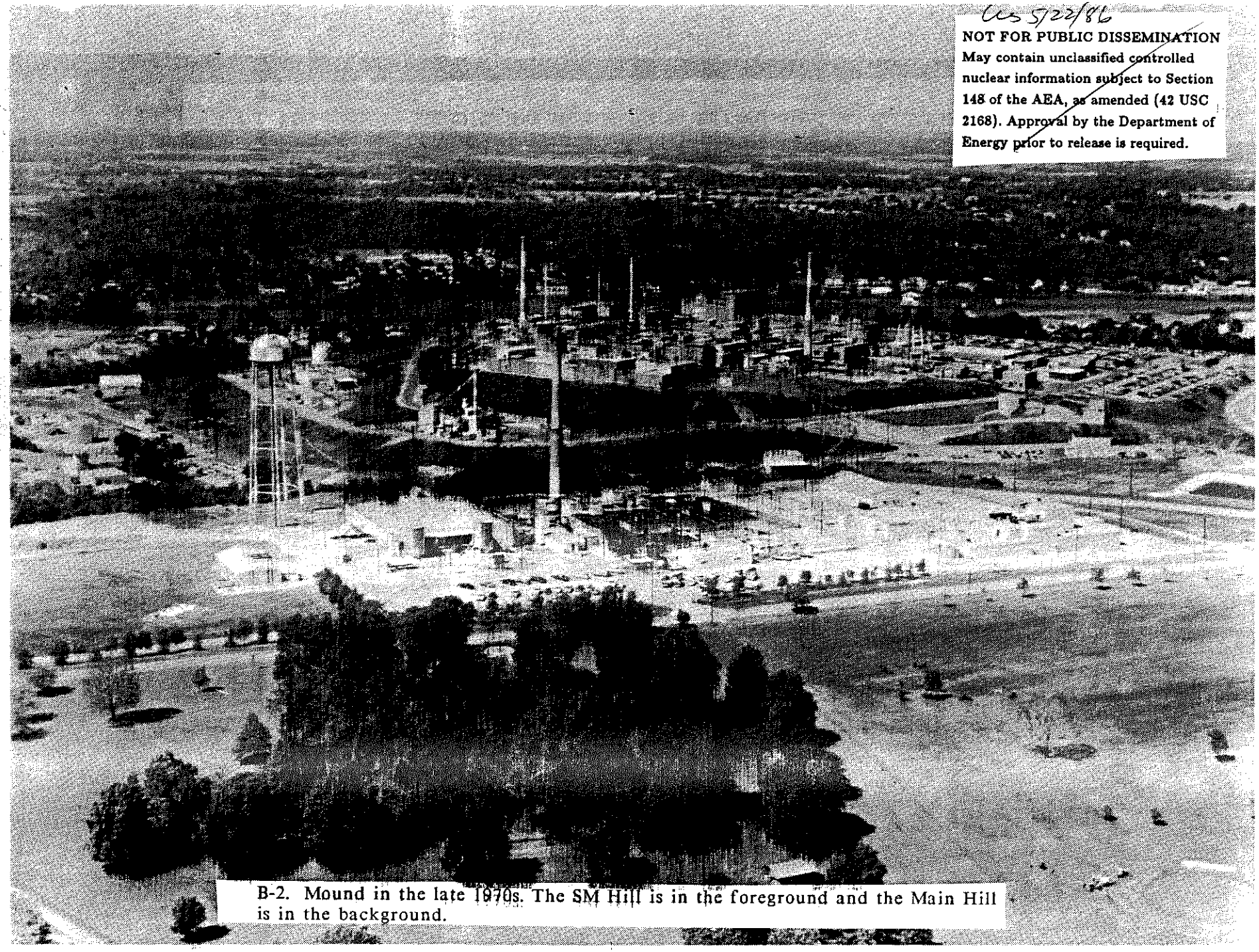

B-2. Mound in the late 1970s. The SM Hill is in the foreground and the Main Hill is in the background.

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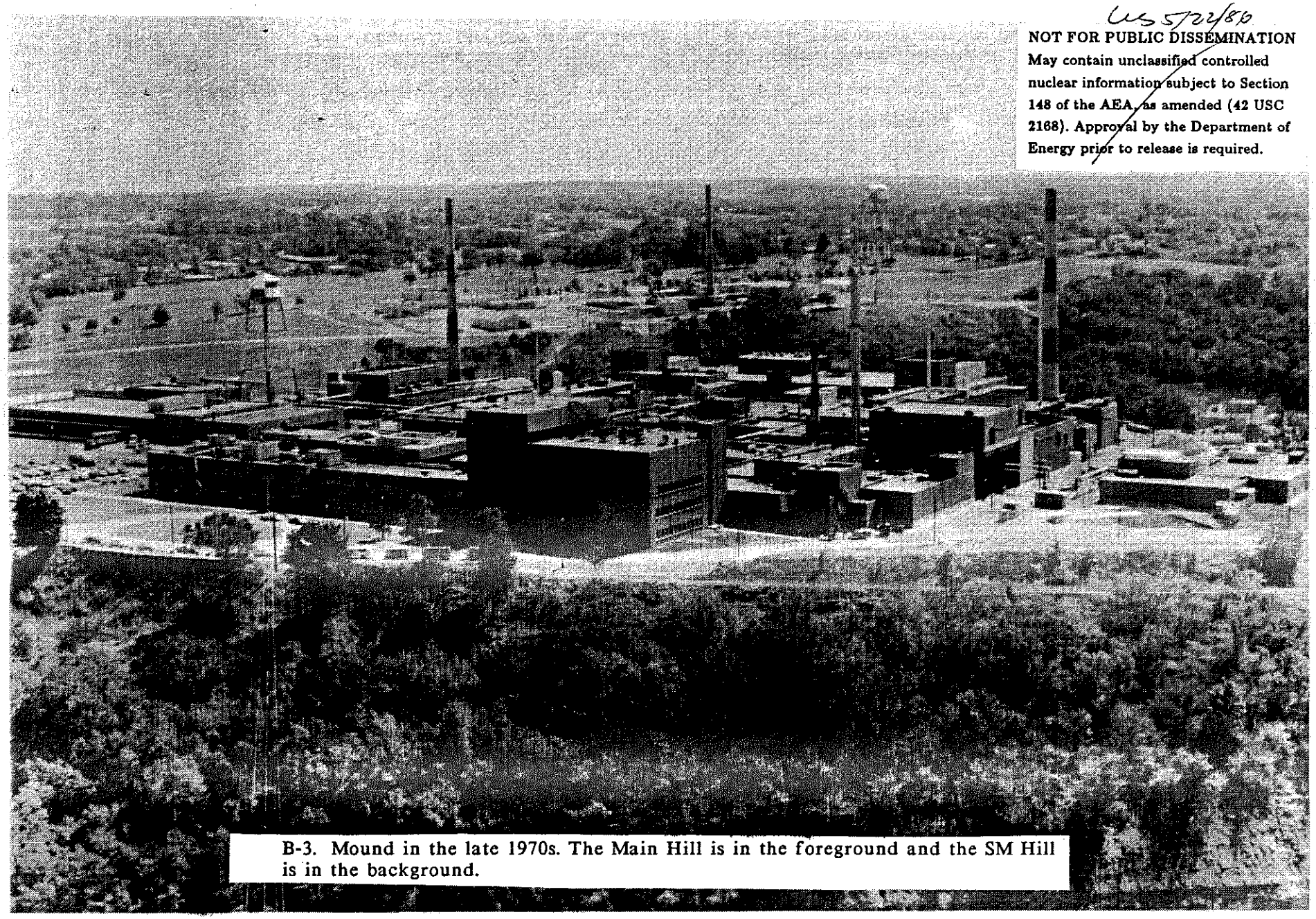
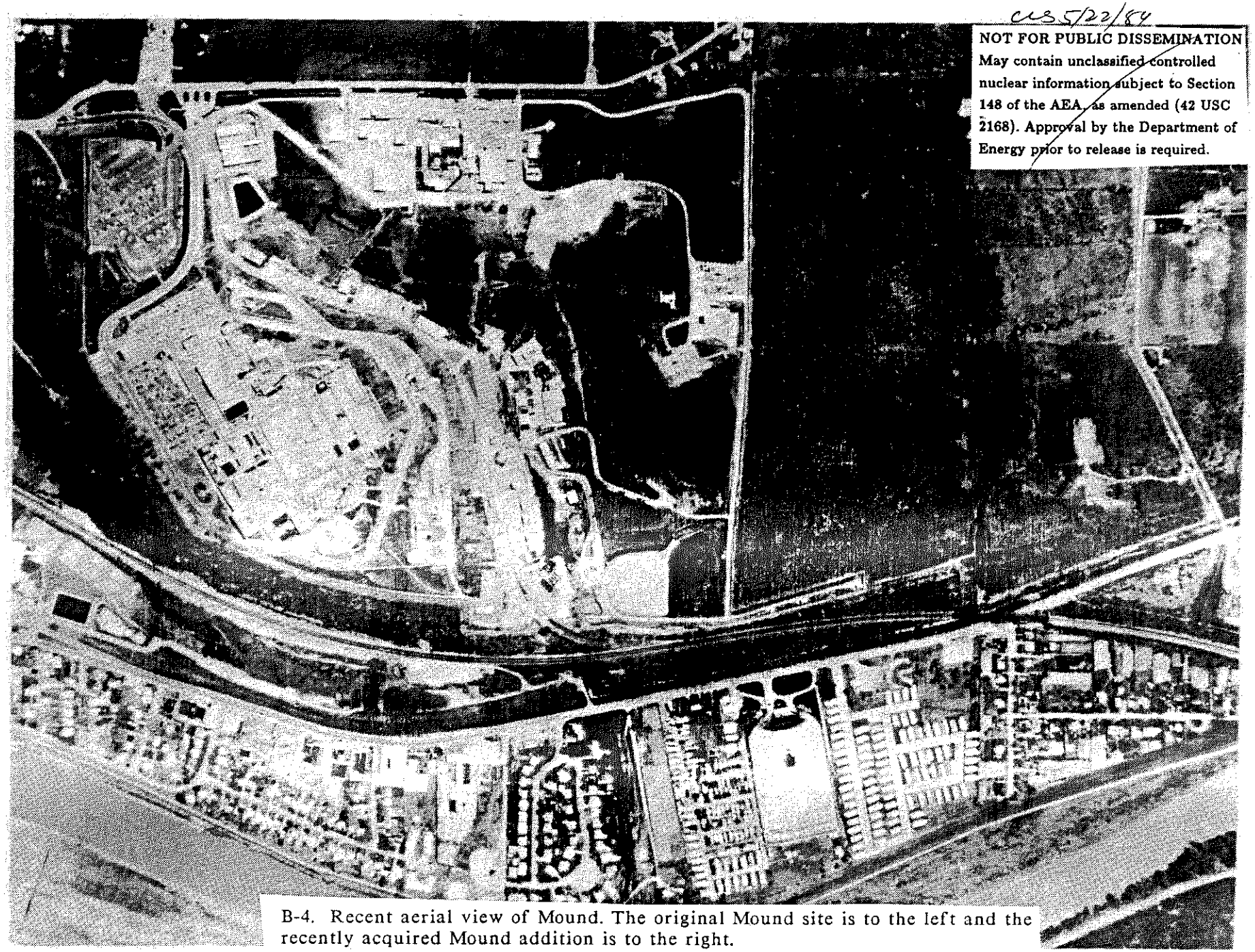


B-3. Mound in the late 1970s. The Main Hill is in the foreground and the SM Hill is in the background.



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B-4. Recent aerial view of Mound. The original Mound site is to the left and the recently acquired Mound addition is to the right.

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APPENDIX C

MONITORING PROGRAMS

The MRC Environmental Control Program has been in operation since work began at Mound in 1949. A summary of the current monitoring program is presented in Table C.I. These monitoring activities include the collection of air, water, foodstuff, soil, and sediment samples out to a distance of 28 mi around the facility. Samples are analyzed for potentially toxic pollutants, including radioisotopes handled at Mound. Data obtained by the environmental monitoring program are used to ensure that operations at Mound are conducted so that emissions comply with applicable emission and environmental standards and to provide a local background or base line for comparison in the event of an accidental release.

A comprehensive, unclassified environmental monitoring report is issued annually. These annual reports contain details on the MRC quality assurance program, sampling techniques, analytical techniques, and results. A summary report is distributed to individuals in political and administrative positions within the general area.

C.I. Quality Assurance

An essential part of the quality control program is the analysis of reference samples from a reliable outside laboratory. During 1984, MRC analyzed samples from the USDOE Environmental Measurements Laboratory (EML) for trace radionuclides. MRC also participated in the 1984 USEPA Quality Assurance Program for Water Analysis, and in a Monsanto Company quality control program for 1984.

C.II. Nonradioactive

Region V of the USEPA has issued a NPDES discharge permit for liquid effluent streams at Mound. MRC is required to characterize its effluent water by analyzing samples collected at four onsite locations (Table IV.3.). A 24-h composite, flow proportional sample, and grab sample are collected from discharges 001-A, 001-B, and 002. An 8-h composite, time proportional sample is collected from discharge 001-C. Monitoring the flow from one well (i.e., discharge 003) that is periodically pumped as a part of the Potable Water Standards Project is also required (Styron 1983).

Mound's drinking water supply is categorized by Ohio EPA as a major, noncommunity public water supply system. The MRC sampling program is discussed in Section IV.F., Safe Drinking Water Act.

C.III Radioactive

C.III.1. Water. Water sampling locations along the banks of the Great Miami River were selected according to guidelines recommended by the USEPA. The locations, shown in Fig. C.1. provide samples that are representative of river water after adequate mixing of effluent from Mound has occurred. Water samples are collected and filtered in the field at these locations 5 days per week, and analyzed for ^{238}Pu and tritium. Water samples for quarterly analyses are obtained by compositing daily samples. Weekly samples are analyzed for tritium. Uranium-233, 234, and 238 are also monitored at the river water sampling locations. Seven offsite surface water locations are sampled quarterly for plutonium and tritium (Fig. C.1.). Drinking water from communities in the surrounding area is sampled and analyzed quarterly for tritium. Drinking water from private wells is also analyzed for tritium (Fig. C.1.). Three private wells and Miamisburg city water are sampled and analyzed quarterly for ^{238}Pu.

C.III.2. Air. In 1984, the offsite air-sampling network consisted of 15 continuously operating air-sampling stations used for sampling both tritium oxide and plutonium (Fig. C.2.). Ten sampling stations are located within a 1 mi radius of Mound, and four samplers are located in or near population centers. The remaining sampler (No. 119) is approximately 28 mi from Mound in the prevailing wind direction. This sampler receives no measurable contribution from operations at Mound and serves as a base line sample for computing environmental levels.

Two types of samples are collected at each sampling station. A particulate sample from a high-volume air sampler is collected for ^{238}Pu analysis. A sample from a bubbler-type sampler is collected for tritium oxide analysis. Plutonium-238 analyses are performed on a monthly composite for three sampling locations (Nos. 122, 123, and 124), and on quarterly composites for the other offsite locations.

An onsite network consisting of five continuous, high-volume air samplers is used to monitor air quality (Fig. C.3.).

C.III.3. Biota and Sediment. Samples of plants and animals are collected to determine whether there is significant uptake and concentration of radionuclides by biota. Samples are collected in Miamisburg, Centerville, and Bellbrook. Centerville and Bellbrook are in the prevailing wind direction from Mound at a distance of 5 mi and 10 mi, respectively. Fish are collected in the Great Miami River. Sediment samples are collected from the river and surface water sample locations shown in Fig. C.1.

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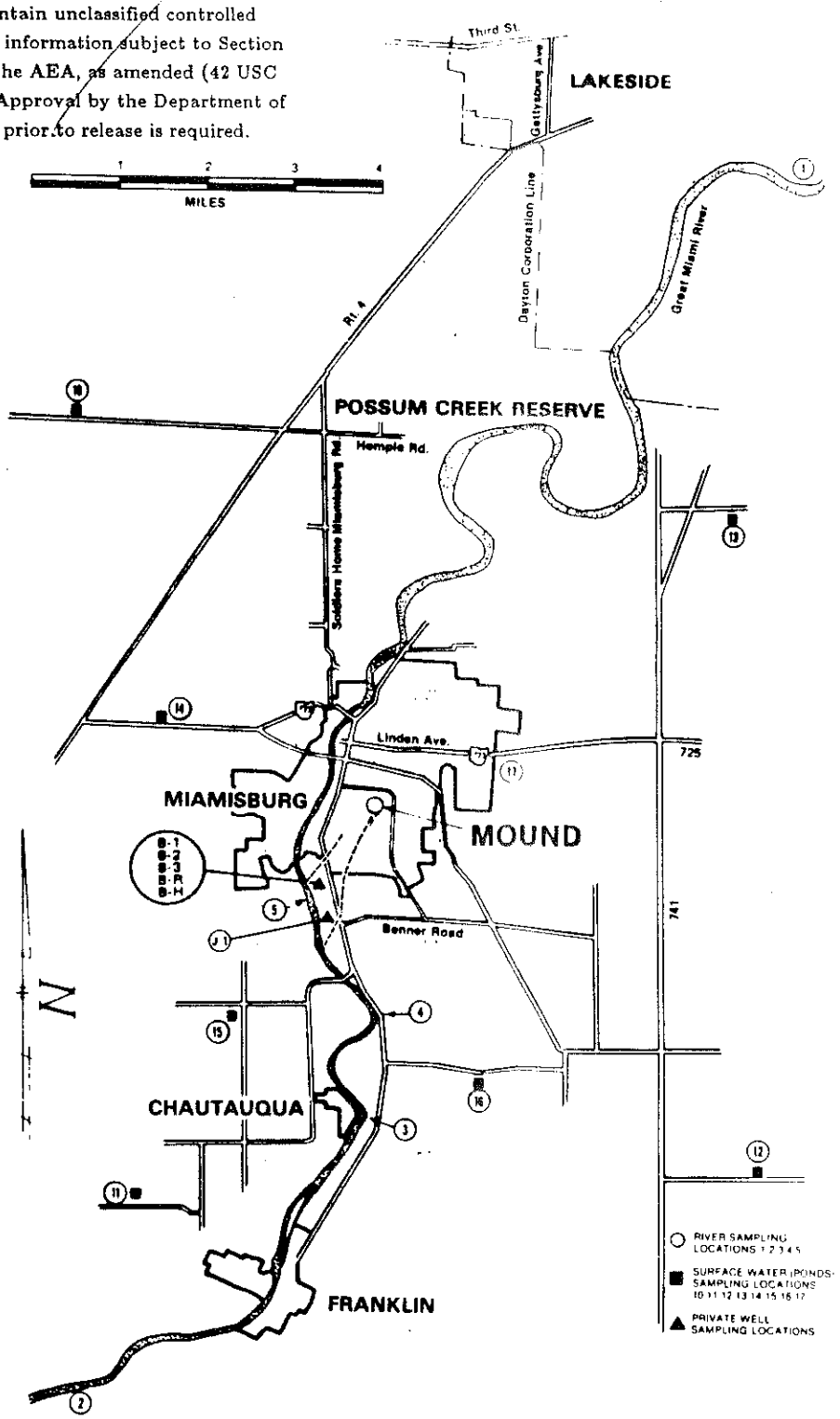

Figure C.1. Offsite Water Sampling Locations.

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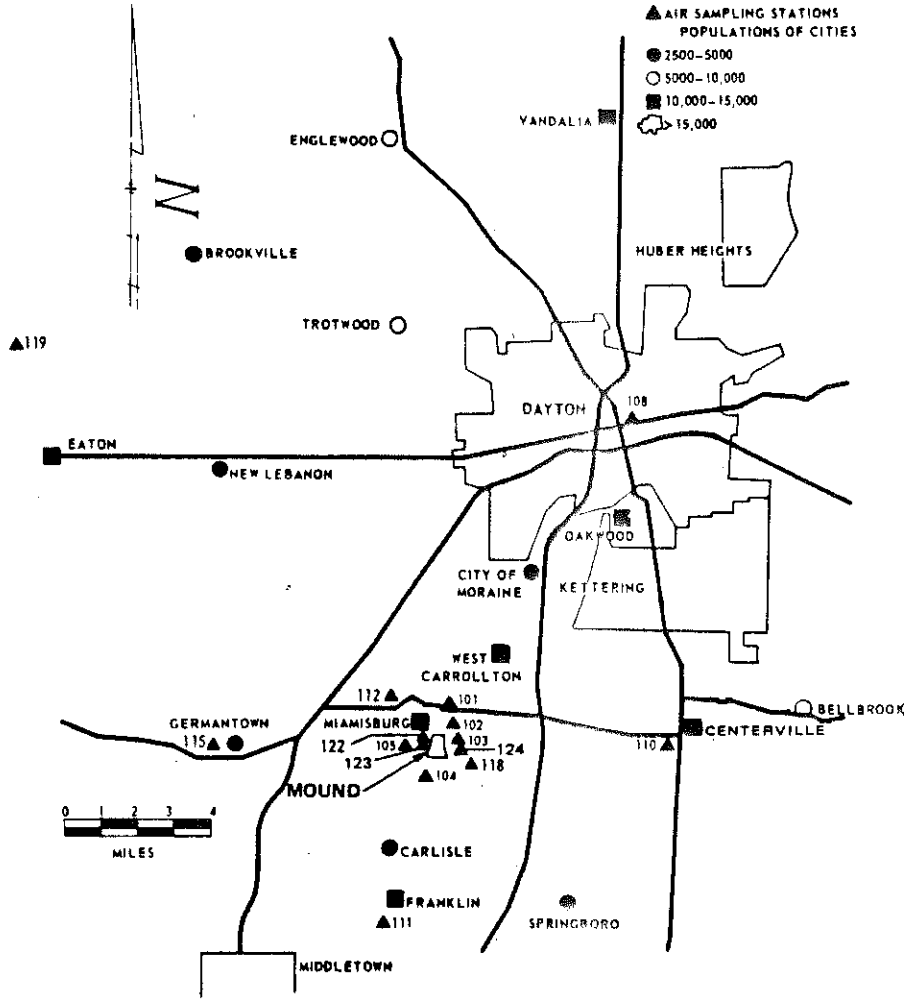

Figure C.2. Offsite Air Sampling Locations.

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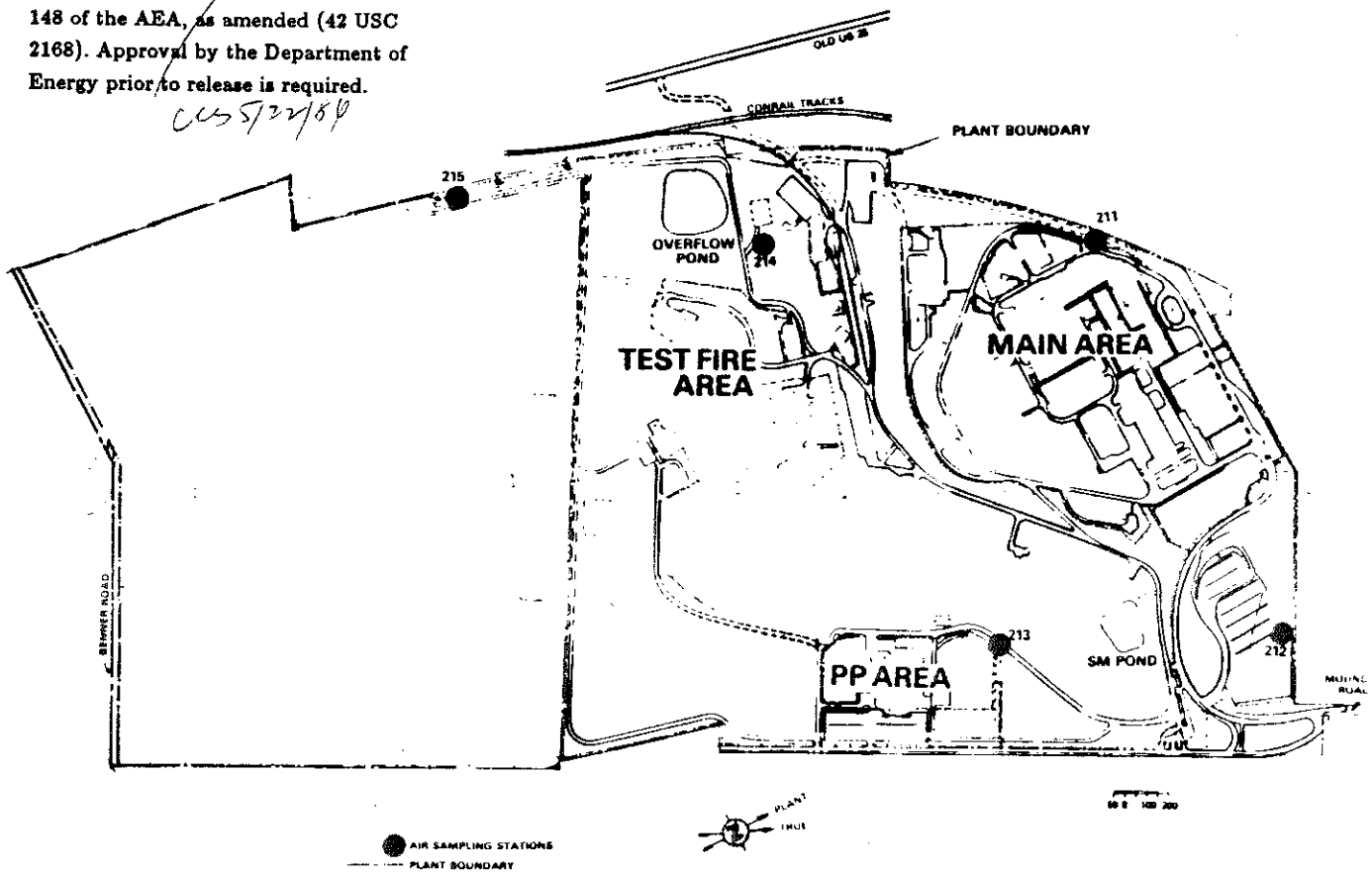

Figure C.3. Onsite Air Sampling Locations.

Table C.1

MRC Environmental Monitoring Program

	Sampling Frequency	Parameter Measured
Air Surveillance		
Offsite		
15 locations	Weekly	HTO, Pu, particulate
Onsite		
5 locations	Weekly	HTO, Pu, particulate
Stack Emission		
15 locations	Daily	HT, HTO, Pu, U
Water Surveillance--Offsite		
River		
5 locations	Daily	HTO, Pu, U
Pond		
7 locations	Monthly	HTO, Pu, U
Municipal Drinking Water		
12 locations	Quarterly	HTO, Pu
Well Water		
5 locations	Monthly	HTO, Pu
Water Surveillance--Onsite		
Effluent Water		
3 locations	Daily	Flow, suspended solids, BOD_5, fecal coliform, pH, oil and grease, COD, residual chlorine, dissolved solids, cyanide, chromium, cadmium, nickel copper, HTO, Pu, U
Sediment Surveillance--Offsite		
River		
5 locations	Quarterly	Pu
Pond		
7 locations	Quarterly	Pu
Vegetation and Foodstuff Surveillance		
Vegetation		
3 locations	Semiannually	HTO, Pu
Foodstuffs		
3 locations	Annually	HTO, Pu
Environmental Level Surveillance		
Four Mediums		
6 locations	Quarterly	HTO, Pu

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APPENDIX D

HAZARD RANKING SYSTEM SCORE FOR MOUND

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) (P.L. 95-510) requires federal agencies to identify to the USEPA inactive sites under their control that may be sources of environmental contaminants. Such sites could include inactive waste disposal sites, facilities, or other locations that were contaminated by hazardous waste in the past. As one means of establishing the relative importance of such sites, the USEPA promulgated the Hazard Ranking System (HRS) as Appendix A of 40 CFR 300. The relative ranking of sites at various installations can serve to highlight particular problems or suggest priorities for further investigation.

The HRS was designed by the USEPA to be used to "evaluate the relative potential of uncontrolled hazardous substance facilities to cause health or safety problems, or ecological or environmental damage," (Sec. 1.0, 40 CFR 300, App. A). The following excerpts from the regulation indicate some of the limitations of the system:

"The HRS is a means for applying uniform technical judgment regarding the potential hazards presented by a facility relative to other facilities. It does not address the feasibility, desirability or degree of cleanup required."

"The HRS does not quantify the probability of harm from a facility or the magnitude of the harm that could result, although the factors have been selected in order to approximate both those elements of risk. It is a procedure for ranking facilities in terms of the potential threat they pose..."

The HRS assigns three hazard mode scores to a site. These include: (1) a migration mode score that reflects the potential for harm to humans or the environment from migration of a hazardous substance by either ground water, surface water, or air pathways; (2) a fire/explosion score that reflects the potential for harm from substances that can explode or cause fires; and (3) a direct contact mode score that reflects the potential for harm from direct contact with hazardous substances at the site. The score for each mode is obtained by evaluating a series of factors that characterize the potential of the facility to cause harm. Each factor receives a numerical value according to a predetermined

scale; the factor values are weighted and combined to yield final scores according to set rules. The migration score was used by the USEPA in establishing the National Priorities List of facilities in the private sector for initial attention under CERCLA. The fire and explosion and direct contact mode scores are intended by the USEPA to identify facilities requiring emergency action.

The migration mode score is a composite of the separate scores for each of the three migration routes: groundwater, surface water, and air. Each migration route score is calculated by multiplying selected factors for route characteristics, containment, waste characteristics, and potentially affected targets to arrive at a value on a normalized 0 to 100 scale. The overall migration mode score is the root mean square of the three route scores, which emphasizes the highest scoring route, and is also on a 0 to 100 scale. Higher scores are expected to indicate a greater potential for problems. However, as suggested by the acknowledged limitations, the migration mode scores are useful principally for ranking sites for priority of follow-up actions and do not quantify risk.

The HRS is applied to the Mound landfill (category 1 area B--the site landfill), which has the potential to contain significant quantities of nonradiological hazardous substances (Table D.1.). The Mound landfill is discussed in Section V.A., Potential CERCLA Sites--Inactive or Former Disposal Facilities/Activities/Spills and Leaks. The Migration Mode Scores for the landfill is 13.

Table D.1. HRS Migration Mode Scores for Mound Site Landfill

FACILITY NAME: Mound -- Landfill

FIELD OFFICE: Dayton Area Office

EPA REGION: V / Chicago, IL

PERSON(S) IN CHARGE OF SITE: James A. Morley, Area Manager
U.S. Department of Energy

NAME OF REVIEWER: Robert W. Vocke DATE: December 20, 1985

GENERAL DESCRIPTION OF THE FACILITY:

(For example: landfill, surface impoundment, pile, container; types of hazardous substances; location of the facility; contamination route of major concern; types of information needed for rating; agency action, etc.)

Landfilled wastes were enclosed in a clay liner with provisions for monitoring leachate. It is estimated that the landfill may contain 1,000 ft3 of hazardous substances (e.g., solvents, photoprocessing solutions, and plating bath solutions). Radioactive materials were not placed in the enclosure. No releases have been detected. Landfilled residuals do not pose potential problems for direct contact or fire and explosion and are not further evaluated for these parameters. [See Sec. V.A.1.a (category 1 area B), and Table V.1.]

SCORES:	CHEMICAL	RADIOACTIVE	MAXIMUM
Sm =	12.85	0.00	12.85
Sgw =	22.22	0.00	22.22
Ssw =	0.00	0.00	0.00
Sa =	0.00	0.00	0.00
Sfe =	0.00	0.00	0.00
Sdc =	0.00	0.00	0.00

Table D-1 (cont)

GROUNDWATER ROUTE WORKSHEET Site: Mound -- Landfill

RATING FACTOR	VALUE RANGE	SEL VAL	MULTI-PLIER	SCORE	MAX. SCORE	REF. SEC.	REFERENCES FOR EACH ASSIGNED SCORE
1. OBSERVED RELEASE	0 45	0	1	0	45	3.1	No observed release (Friedman 1985, personal communication).
If Observed Release is Given a Score of 45, Proceed to Line 4							
If Observed Release is Given a Score of 0, Proceed to Line 2							
2. ROUTE CHARACTERISTICS						3.2	
A. Depth to Aquifer of Concern	0 1 2 3	3	2	6	6		<20 ft (Dames and Moore 1976A, Figure 21 Piezometric Surface).
B. Net Precipitation	0 1 2 3	2	1	2	3		Approx 6" (USDOE 1979, page 2-61; USEPA 1984, page 13).
C. Permeability of the Unsaturated Zone	0 1 2 3	2	1	2	3		Thin phase glacial till (USDOE 1979, page 2-40, 2-43).
D. Physical State	0 1 2 3	3	1	3	3		Assumed to contain some liquid (Interviews 1985; Monsanto Research Corporation 1984, page 6-6).
TOTAL ROUTE CHARACTERISTICS SCORE				13	15		
3. CONTAINMENT	0 1 2 3	1	1	1	3	3.3	Clay liner and leachate collection system (Monsanto Research Corporation 1984; Section V, Figure V.3, page V-22).
4. WASTE CHARACTERISTICS						3.4	
Chemical							
A. Toxicity/Persistence	0 3 6 9 12 15 18	18	1	18	18		Assumed to include at least some persistent organic solvents; quantity assumed to be no more than 1,000 cubic ft (Interviews 1985).
B. Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	2	1	2	8		
Radioactive							
A. Maximum Observed	0 1 3 7 11 15 21 26	NE	1	0	26		No radioactive substances present (Interviews 1985).
B. Maximum Potential	0 1 3 7 11 15 21 26	NE	1	0	26		
TOTAL WASTE CHARACTERISTICS SCORE							
CHEMICAL				20	26		
RADIOACTIVE				0	26		
5. TARGETS						3.5	
A. Ground Water Use	0 1 2 3	3	3	9	9		Wells <3 mi (USDOE 1979, page 2-56, 2-60).
B. Distance to Nearest Well/Population Served	0 4 6 8 10 12 16 18 20 24 30 32 35 40	40	1	40	40		Distance <2,000 ft (USDOE 1979, page 2-60). Population >10,000 (USDOE 1979, page 2-30).
TOTAL TARGETS SCORE				49	49		

6. CALCULATION

If Line 1 is 45, Multiply 1 x 4 x 5

If Line 1 is 0, Multiply 2 x 3 x 4 x 5

CHEMICAL	12740	57330
RADIOACTIVE	0	57330

7. NORMALIZATION

Divide Line 6 by 57330 and Multiply by 100

CHEMICAL Sgw =	22.22	100.00
RADIOACTIVE Sgw =	0.00	100.00
MAXIMUM Sgw =	22.22	100.00

NOTE: NE means not evaluated.

Table D-1 (cont)

SURFACE WATER ROUTE WORKSHEET Site: Mound -- Landfill

RATING FACTOR	VALUE / RANGE	SEL VAL	MULTI-PLIER	SCORE	MAX. SCORE	REF. SEC.	REFERENCES FOR EACH ASSIGNED SCORE
1. OBSERVED RELEASE	0 45	0	1	0	45	4.1	No observed release (Friedman 1985, personal communication).
If Observed Release is Given a Value of 45, Proceed to Line 4							
If Observed Release is Given a Value of 0, Proceed to Line 2							
2. ROUTE CHARACTERISTICS						4.2	
A. Facility Slope and Intervening Terrain	0 1 2 3	3	1	3	3		Slope >8% (Monsanto Research Corporation 1984, figure 6.0).
B. 1-yr. 24-hr. Rainfall	0 1 2 3	2	1	2	3		2.5" (USEPA 1984, page 33).
C. Distance to Nearest Surface Water	0 1 2 3	3	2	6	6		<1,000 ft [The Mound discharge is a perennial offsite stream (Friedman 1985, personal communication).]
D. Physical State	0 1 2 3	3	1	3	3		Assumed to contain some liquid (Interviews 1985; Monsanto Research Corporation 1984, page 6-6).
TOTAL ROUTE CHARACTERISTICS SCORE				14	15		
3. CONTAINMENT	0 1 2 3	0	1	0	3	4.3	Adequate landfill cover assumed from construction description (Monsanto Research Corporation 1985;
4. WASTE CHARACTERISTICS						4.4	Sec. V, Figure V.3, page V-22).
Chemical							
A. Toxicity/Persistence	0 3 6 9 12 15 18	18	1	18	18		Assumed to include at least some persistent organic solvents; quantity assumed to be no more than 1,000 cubic ft (Interviews 1985).
B. Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	2	1	2	8		
Radioactive							
A. Maximum Observed	0 1 3 7 11 15 21 26 NE		1	0	26		No radioactive substances present (Interviews 1985).
B. Maximum Potential	0 1 3 7 11 15 21 26 NE		1	0	26		
TOTAL WASTE CHARACTERISTICS SCORE							
CHEMICAL				20	26		
RADIOACTIVE				0	26		
5. TARGETS						4.5	
A. Surface Water Use	0 1 2 3	2	3	6	9		Recreation uses <3 mi (USDOE 1979, page 2-53).
B. Distance to Sensitive Environment	0 1 2 3	0	2	0	6		No wetlands or critical habitat (USDOE 1979, page 2-68).
C. Population Served/ Distance to Water Intake Downstream	0 4 6 8 10 12 16 18 20 24 30 32 35 40	0	1	0	40		No population served having intake <3 mi (USDOE 1979, page 2-53).
TOTAL TARGETS SCORE				6	55		
6. CALCULATION							
If Line 1 is 45, Multiply 1 x 4 x 5					64350		
If Line 1 is 0, Multiply 2 x 3 x 4 x 5							
CHEMICAL				0			
RADIOACTIVE				0			
7. NORMALIZATION							
Divide Line 6 by 64350 and Multiply by 100							
CHEMICAL Ssw =				0.00	100.00		NOTE: NE means not evaluated.
RADIOACTIVE Ssw =				0.00	100.00		
MAXIMUM Ssw =				0.00	100.00		

Table D-1 (cont)

AIR ROUTE WORK SHEET Site: Mound -- Landfill

RATING FACTOR	-----VALUE----- -----RANGE-----	SEL VAL	MULTI-PLIER	SCORE	MAX. SCORE	REF. SEC.	REFERENCES FOR EACH ASSIGNED SCORE
1. OBSERVED RELEASE	0 45	NE	1	0	45	5.1	
Date and Location:							
Sampling Protocol:							
If Line 1 is 0, the Sa = 0. Enter on Line 5							
If Line 1 is 45, Then Proceed to Line 2.							
2. WASTE CHARACTERISTICS						5.2	
Chemical							
A. Reactivity and Incompatibility	0 1 2 3	NE	1	0	3		
B. Toxicity	0 1 2 3	NE	3	0	9		
C. Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	NE	1	0	8		
Radioactive	0 2 5 8 12 16 20	NE	1	0	20		
TOTAL WASTE CHARACTERISTICS SCORE							
CHEMICAL				0	20		
RADIOACTIVE				0	20		
3. TARGETS							
A. Population Within 4-Mile Radius	0 9 12 15 18 21 24 27 30	NE	1	0	30		
B. Distance to Sensitive Environment	0 1 2 3	NE	2	0	6		
C. Land Use	0 1 2 3	NE	1	0	3		
TOTAL TARGETS SCORE				0	39		
4. CALCULATION							
Multiply 1 x 2 x 3							
		CHEMICAL		0	35100		
		RADIOACTIVE		0	35100		
5. NORMALIZATION							
Divide Line 4 by 35100 and Multiply by 100							
		CHEMICAL Sa =		0.00	100.00		NOTE: NE means Not Evaluated.
		RADIOACTIVE Sa =		0.00	100.00		
		MAXIMUM Sa =		0.00	100.00		

SUMMARY CALCULATION OF TOTAL MIGRATION SCORE

		CHEMICAL	RADIOACTIVE	
Ground Water Route	(Sgw)	22.22	0.00	
Surface Water Route	(Ssw)	0.00	0.00	
Air Route	(Sa)	0.00	0.00	
Sum of Squares		493.83	0.00	
Square Root of Sum		22.22	0.00	
TOTAL MIGRATION SCORE	(Sm)	12.85	0.00	Square Root of Sum Divided by 1.73

Table D-1 (cont)

DIRECT CONTACT WORKSHEET Site: Mound -- Landfill

RATING FACTOR	VALUE RANGE	SEL VAL	MULTI-PLIER	SCORE	MAX. SCORE	REF. SEC.	REFERENCES FOR EACH ASSIGNED SCORE
1. OBSERVED INCIDENT	0 45	NE	1	0	45	8.1	
If Observed Incident is Given a Score of 45, Proceed to Line 4							
If Observed Incident is Given a Score of 0, Proceed to Line 2							
2. ACCESSIBILITY	0 1 2 3	NE	1	0	3	8.2	
3. CONTAINMENT	0 15	NE	1	0	15	8.3	
4. WASTE CHARACTERISTICS							
Chemical Toxicity	0 1 2 3	NE	5	0	15	8.4	
Radioactive	0 1 2 4 6 9 12 15	NE	1	0	15		
5. TARGETS							
A. Population Within a 1-Mile Radius	0 1 2 3 4 5	NE	4	0	20	8.5	
B. Distance to a Critical Habitat	0 1 2 3	NE	4	0	12		
TOTAL TARGETS SCORE				0	32		

6. CALCULATION

If Line 1 is 45, Multiply 1 x 4 x 5

If Line 1 is 0, Multiply 2 x 3 x 4 x 5

CHEMICAL	0	21600
RADIOACTIVE	0	21600

7. NORMALIZATION

Divide Line 6 by 21600 and Multiply by 100

CHEMICAL Sdc =	0.00	100.00
RADIOACTIVE Sdc =	0.00	100.00
MAXIMUM Sdc =	0.00	100.00

NOTE: NE means Not Evaluated.

Table D-1 (cont)

FIRE AND EXPLOSION WORKSHEET Site: Mound -- Landfill

RATING FACTOR	-----VALUE----- -----RANGE-----	SEL VAL	MULTI-PLIER	SCORE	MAX. SCORE	REF. SEC.	REFERENCES FOR EACH ASSIGNED SCORE
1. OBSERVED RELEASE	1 3	NE	1	0	3	7.1	
2. WASTE CHARACTERISTICS						7.2	
A. Direct Evidence	0 3	NE	1	0	3		
B. Ignitability	0 1 2 3	NE	1	0	3		
C. Reactivity	0 1 2 3	NE	1	0	3		
D. Incompatibility	0 1 2 3	NE	1	0	3		
E. Waste Quantity							
Chemical	0 1 2 3 4 5 6 7 8	NE	1	0	8		
Radioactive	0 1 2 3 5 6 8	NE	1	0	8		
TOTAL WASTE CHARACTERISTICS SCORE							
CHEMICAL				0	20		
RADIOACTIVE				0	20		
3. TARGETS						7.3	
A. Distance to Nearest Population	0 1 2 3 4 5	NE	1	0	5		
B. Distance to Nearest Building	0 1 2 3	NE	1	0	3		
C. Distance to Sensitive Environment	0 1 2 3	NE	1	0	3		
D. Land Use	0 1 2 3	NE	1	0	3		
E. Population Within 2-Mile Radius	0 1 2 3 4 5	NE	1	0	5		
F. Buildings Within 2-Mile Radius	0 1 2 3 4 5	NE	1	0	5		
TOTAL TARGETS SCORE				0	24		
4. CALCULATION							
Multiply 1 x 2 x 3							
		CHEMICAL		0	1440		
		RADIOACTIVE		0	1440		
5. NORMALIZATION							
Divide Line 4 by 1440 and Multiply by 100							
CHEMICAL Sfe =				0.00	100.00		NOTE: NE means Not Evaluated.
RADIOACTIVE Sfe =				0.00	100.00		
MAXIMUM Sfe =				0.00	100.00		

NOT FOR PUBLIC DISSEMINATION
May contain unclassified controlled nuclear information subject to Section 148 of the AEA, as amended (42 USC 2168). Approval by the Department of Energy prior to release is required.
WSS 2/22/86

APPENDIX E

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Ref. 56

RECEIVED
APR 29 1986
REGIONAL AIR POLLUTION CONTROL AGENCY

Department of Energy
Albuquerque Operations
Dayton Area Office
P.O. Box 66
Miamisburg, Ohio 45342

April 24, 1986

Larry F. Kertcher
Chief, Air Compliance Branch
Air Management Division
U. S. Environmental Protection Agency
Region V
230 South Dearborn Street
Chicago, Illinois 60604

Dear Mr. Kertcher:

We are providing the attached information in response to your request dated February 24, 1986. A copy of the information has been provided to Mr. Charles Taylor (OEPA) per your request. Additionally, a copy is being provided Ms. Donna Lee, Regional Air Pollution Control Agency (RAPCA), Dayton, Ohio.

If you have any questions, please contact D. S. Ingle at (513) 865-3597 or on FTS 774-3597.

Sincerely,

James A. Morley

James A. Morley
Area Manager

Attachments: a/s

cc:
C. M. Taylor, OEPA, w/attach.
D. Lee, RAPCA, w/attach.
R. Neff, MRC, w/o attach.
M. G. Wilson, AL/OCC, w/attach.
C. Soden, AL/ES&HD, w/attach.

AIR POLLUTION CONTROL INFORMATION

1. A report describing the operation and maintenance procedures used to maintain the facility's air pollution control devices.

2. A list and description of all the types of air pollution control devices used to control toxic or radioactive air pollutant releases into the atmosphere during the facility's operations.

The air pollution control devices for stacks at Mound are basically designed for plutonium and tritium. All exhaust systems for these radioactive processing areas have emergency, diesel powered, electrical power. The plutonium system generally consists of two stages of high efficiency particulate air (HEPA) filters. Pressure drop readings are taken weekly and based on these readings the filters in the filter banks are changed.

The tritium systems are more involved than those of plutonium. There are basically two types of systems, the effluent recovery system (ERS) and the emergency containment system (ECS).

The ERS involves oxidizing tritium in the exhaust gas stream to HTO on a hot (~550°C) catalyst bed. The HTO is trapped on an absorber bed and subsequently baked off as tritiated water. This tritiated water is then mixed with cement and shipped for burial. The ERS system is provided with emergency power and backup air pressure for the air actuated valves in the event of a power outage. Routine maintenance is provided and spare parts are on hand for efficient repair in the event of a system malfunction.

The emergency containment system (ECS) is an automatically actuated room air processing system developed by Mound that is designed to remove tritium from room air if primary and secondary containment systems should ever fail.

The system consists of: 1) a 1000 cfm turbine which transports room air through the system, 2) an electric preheater to heat the air stream to 175°C (350°F) before it enters the catalyst bed, 3) the reactor, which contains the precious metal catalyst where the oxidation

of elemental tritium occurs to meet the design goal of 99.9% conversion, 4) a shell and tube aftercooler which reduces the temperature of the air stream exiting the reactor to 20°C (70°F), and 5) two stainless steel exchange beds connected in parallel, each containing 1700 kg (3800 lb) of alumina pellets saturated with water.

In the event of an accidental release of tritium in a room, the ECS is automatically activated by tritium monitors located in the room exhaust duct. Quick-acting pneumatic valves close off the normal supply and exhaust air ducts and divert the room air through the ECS and back into the room where the release occurred, until the tritium concentration in the room air is returned to a safe operating level.

The tritium oxide generated in the ECS reactor is captured and contained on the saturated alumina in the two exchange beds. The ECS is designed to provide the oxidation and absorption capacities for a single pass decontamination factor of 1000:1 in a 1000 cfm (30 m^3/min) air flow containing concentrations as high as 1 Ci/m^3 before a defined breakthrough of 100 µCi/m^3 occurs. Each bed has the capacity to trap 18,000 Ci, which is equivalent to approximately 10 hr of operation.

In addition, major parts of the system are on a preventative maintenance schedule and are serviced regularly. Interim monitors are checked regularly by health physics personnel. Spare parts for critical components are also kept on hand.

All emission points for radionuclides except Building 41 and Trailer 15 are outfitted with real time monitors and alarms as well as sample collection systems which are used for quantification of radionuclide emissions.

There are no air pollution devices at Mound's powerhouse which generates steam primarily for heating. The boilers are fueled with natural gas with #2 fuel oil as a backup.

The operation at Building 29 for the preparation of asbestos filled DAP (diallyl phthallate) is an intermittent operation. The exhaust system for the operation has two control devices, a high efficiency

filter and a bag house. Because of the intermittent nature of the operation, these control systems are checked prior to start-up.

3. A map showing the location of the facility's air pollution point sources.

   A map showing the location of Mound's air pollution point sources is included as Attachment A.

4. A report of the amounts of all toxic or radioactive air pollutants released to the atmosphere from operation of the facility during the period January 1, 1984 thru December 31, 1985. Radioactive constituents should be reported by activity in curies or submultiples thereof (microcuries, picocuries, etc.).

5. Identify the operation which produced the releases, the release points of the emissions and the specific composition, particle sizes and amounts of releases.

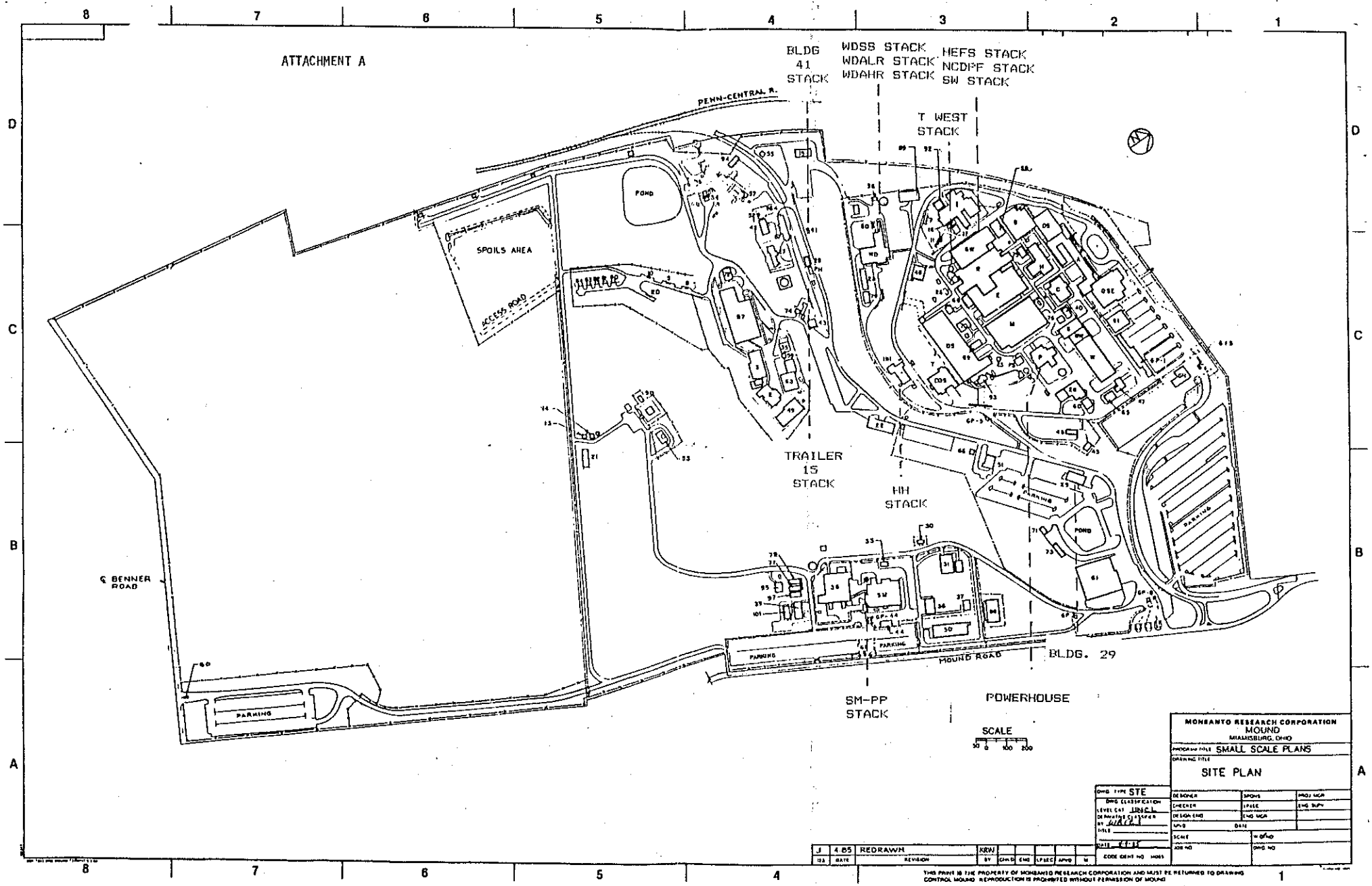
   Attachment B includes a description of the emission points, the operation which generates the emission and the quantity of the pollutant released from Mound from January 1, 1984 through December 31, 1985. The particle sizes and solubility for plutonium-238 stack releases are not available.

6. A copy of the Mound Plant Environmental Emergency Plan (EEP) concerning the release of toxic or radioactive air pollutants. If not included in the EEP, submit any information used to designate emergency action levels, the conditions required for designation of each level, and reporting requirements to designated parties, including time frames for reporting.

   A copy of the Mound Emergency Environmental Protection Plan is included as Attachment C.

7. Information regarding the frequency that the emergency response plan is tested to assure the Mound Facility preparedness for a toxic or radioactive release.

   Mound's Environmental Protection Plan was exercised three times during 1985. Future plans call for one exercise per year.


ATTACHMENT A
BLDG 41 STACK
WDSS STACK
WDALR STACK
WDAHR STACK
HEFS STACK
NCDPF STACK
SW STACK
T WEST STACK
PENN-CENTRAL R.
POND
SPOILS AREA
ACCESS ROAD
TRAILER 15 STACK
HH STACK
PARKING
℄ BENNER ROAD
MOUND ROAD
BLDG. 29
SM-PP STACK
POWERHOUSE
SCALE
MONSANTO RESEARCH CORPORATION
MOUND
MIAMISBURG, OHIO
SMALL SCALE PLANS
SITE PLAN
STE
J 4-85 REDRAWN KRW
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ATTACHMENT B

STACK	OPERATIONS GENERATING EMISSIONS	POLLUTANT	QUANTITY RELEASED 1/1/84 - 12/31/85
HH	Recovery of He-3 contaminated with H-3.	tritium (oxide) tritium (elemental)	5.1 Ci 4.6 Ci
SH-PP	Decontamination and demolition and other plutonium activities.	plutonium-238	6.4 x 10^-6 Ci
T-WEST	Decontamination and demolition, other plutonium activities, and tritium processing.	plutonium-238 tritium (oxide) tritium (elemental)	7.3 x 10^-7 Ci 11 Ci 11.3 Ci
SW	Analysis of tritium containing materials.	plutonium-238 tritium (oxide) tritium (elemental)	6.6 x 10^-8 Ci 29.6 Ci 133.5 Ci
NCDPF	Development of nuclear components.	tritium (oxide) tritium (elemental)	573 Ci 266 Ci
HEFS	Nuclear component related activities.	plutonium-238 tritium (oxide) tritium (elemental)	7.1 x 10^-8 Ci 3410 Ci 3790 Ci
WDSS	Solidification of radioactive contaminated sludge.	plutonium-238	8.1 x 10^-8 Ci
WDALR	Disposal of radioactive waste.	plutonium-238	3.8 x 10^-6 Ci
WDAHR	Disposal of radioactive waste.	plutonium-238	1 x 10^-7 Ci
BLDG. 41	Pumping of contaminated waste.	plutonium-238	1.4 x 10^-8 Ci
TRAILER 15	Contaminated soil screening.	plutonium-238	3.8 x 10^-7 Ci
POWERHOUSE	Steam generation.	particulates sulfur oxides	4587 lb. 2370 lb.
BLDG. 29	Preparation of asbestos filled DAP.	asbestos	No visible emission

PURPOSE

The purpose of this manual is to assign environmental responsibilities, provide advice and technical guidance, and establish the procedures for monitoring to minimize the effect to the general public resulting from an accidental acute release of radioactive or other toxic materials to the local environment.

REFERENCES

MD-10135, Mound Emergency Preparedness System Master Plan.

MD-10149, Oil & Hazardous Substances Spill Plan.

DOE Order 5484.2, Unusual Occurrence Reporting System.

DOE Order 5484.1, Ch. XVIII, Effluent and Environmental Monitoring and Reporting.

DOE Order 5480.1, Ch. XI, Requirements for Radiation Protection.

SCOPE

The plan is for all toxic materials but deals mainly with release of radioactive materials and provides guidance in such matters as Criteria for Activation, Initial Monitoring Plan, Survey of Contaminated Area, Acceptable Contamination Levels, Extent of Public Exposure, Analytical Methods, Protective Action Guides for acute releases to air, water or soil with particular attention given to the timing and relative priorities of actions to be taken.

DEFINITIONS

- Protective Action Guide - The projected absorbed dose from ionizing radiation to individuals in the general population that warrants protective action following a contaminating event.
- Protective Action - A short-term action that will avert most of the radiation exposure that would otherwise occur to the general public.

- Critical Organ - The organ whose damage by radiation results in the greatest damage to the body.

GUIDELINES AND PROTECTIVE ACTION - GENERAL

The avoidance of human exposure during the period immediately following a sudden release of radioactive material over a short period of time is not feasible by measures based on environmental monitoring. The recommendation (should a local acute contaminating event take place) is that protective action should be taken to avoid most of the exposure to ionizing radiation or other toxic materials that would occur from future inhalation or ingestion of radioactive or other toxic materials. A decision to implement protective action involves a comparison of the risk due to radiation or toxic materials exposure with the undesirable features or impact of the contemplated protective action on the population involved.

The projected radiation dose should be used as a basis for implementation of a proposed protective action for radioactive material releases only if it is expected that most of the projected dose will be averted by such actions. (See pages 12 through 16 for specific guides and protective actions.)

RESPONSIBILITIES

It is the responsibility of the Environmental Section to guide and coordinate off-site environmental surveys, sample collection, sample analyses, provide data and technical guidance.

ACTIVATION OF ENVIRONMENTAL PROTECTION PLAN

This plan could be activated under the following conditions: explosion, fires, loss of building or storage containment, criticality incident, accidental release of radioactive or toxic materials via liquid effluent waste or stacks; and all verified appearances of "high" levels of radioactive concentrations greater than the Protective Action Guides or for toxic materials in the local environment, natural disasters, etc.

- Activation of the Environmental Protection Plan During Normal Working Hours.
  - The Environmental Manager or his alternate will implement the plan as appropriate. The Manager, Operational Safety will be notified of the situation.

- If the Level I Control Center has not already been activated, it will be activated at this time. The Communications manager will be alerted to the situation at this time.

- Activation of the Environmental Protection Plan during Off-Duty Hours

  - The Duty Officer activates the Level I Emergency Control Center upon notification of an environmental release.

  - The Environmental Manager or his alternate is notified and directs the implementation of the plan. The Manager, Operational Safety and the Communications Manager will be alerted to the situation at this time.

- Activation of the Level II Control Center and Dissemination of Information.

  - The Manager, Operational Safety or the Level I Commander will recommend activation of the Level II Control Center at anytime there is cause to believe the off-site portion of this plan should be implemented and/or protective action guidelines may be exceeded off-site.

  - The Environmental Manager will keep the activated control center (I or II) informed of the results of on-site and off-site data collection. He will advise the control center, in advance, giving actions required in implementing the plan that could have significant implications to the population off site.

  - The contact with and dissemination of information to off-site agencies during the implementation of this plan will be approved by the Director, Mound. The dissemination of information to off-site agencies will be made with the assistance of the communications manager and in coordination with the Dayton Area DOE Office. Appropriate off-site agencies will be contacted prior to implementation of off-site actions specified in this plan.

Before activation of any off-site emergency procedures, as much of the following information as possible is obtained by the Environmental Manager:

- Nature of the release - radionuclide, solubility of radionuclide if possible, amount and how released.
- Time of Release - important so that the meterorological conditions at the time of the release can be related to the release.
- Predicted Local Airborne Concentration Isopleths from the Atmospheric Release Advisory Capability System (ARAC) if a Stack Release.
- Predicted Concentration of Radionuclide in water if a Release by Water Effluents.
- Duration of release - The time period in which radioactive material is being released to the environment; if release is extended, the meteorological condition or water flow conditions for the entire period should be considered.
- Personnel available - place all appropriate Environmental personnel on standby alert and advise the Emergency Control Center which is activated or the Manager, Operational Safety if neither control center is activated.
- Equipment and vehicles available - check for available laboratory or personal autos in the event they may be needed.

If the decision is made in the Emergency Control Center that the potential for an offsite emergency exists. The Environmental Manager activates the program as follows:

Procedure - Stack Releases

- Activates the Regional Atmospheric Release Advisory Capability (ARAC) System through Livermore, California.
- Alerts either Mound Environmental Personnel or the Montgomery County Combined General Health District to the need for sample collection from offsite ambient air samplers.
- Determine preliminary dose estimates from concentrations predicted by ARAC.
- Alerts the Health Physics Operations Manager that local offsite environmental survey capabilities may be needed.

- Informs the Health Physics Operation Personnel responding to the area of maximum concentration/deposition as predicted by ARAC, what environmental media should be sampled and returned to the Mound Environmental Laboratory Analyses.

NOTE: If supplemental portable air monitoring is needed during a stack release in addition to ARAC dispersion estimates and offsite ambient air sample data from Mound's environmental samplers, it must be promptly initiated due to rapid dispersion.

The Health Physics Operations Personnel who respond to the area should proceed as follows:

- If any significant concentrations of deposited radioactivity are located, the Emergency Control Center should be notified for additional needed personnel at the contaminated area.

Plutonium - 238

- Establish the boundary of soil and vegetation contamination above 10,000 d/m/cm^2 using alpha survey meters according to the following table for plutonium-238:

TABLE 2

EBERLINE COMPANY ALPHA SURVEY METER (PAC) READINGS FROM VARIOUS SURFACES

EQUIVALENT TO 10,000 d/m/cm^2

SURFACE	PAC READING (c/m)	EQUIVALENT
Soil	120,000	10,000 d/m/cm^2
Concrete	140,000	10,000 d/m/cm^2
Plywood	170,000	10,000 d/m/cm^2

The degree of the contamination is to be more precisely determined by surface soil scrapings and vegetation samples returned to the Environmental Laboratory in E Building for analysis.

Set up portable staplex air samplers for 15 minute samples as follows:

- Downwind from the area of highest surface contamination.
- Upwind for a baseline sample.

Limit people access to the area with a surface reading 10,000 d/m/cm^2

- In areas where ground contamination is greater than 60,000 d/m/cm^2, a suitable sample of the population should be considered for whole body counting.
- Pu-238 released to the environment will present primarily an internal radiation hazard to the population. It should be emphasized strongly that any amount of plutonium deposition on the surface constitutes a minimum hazard as long as it remains deposited. The actual hazard to persons living or working in a contaminated area is directly dependent on the amount of contamination which is resuspended and inhaled. The inhalation hazard is best determined by air sampling.

Take nasal wipes of a representative number of people in the contaminated area. (If possible, obtain name, address and/or other identification for possible follow-up urine sampling.)

Estimate the number of people exposed in the 10,000 d/m/cm^2 area.

Return all survey data and field samples to the Environmental Laboratory in E Building for analysis and evaluation.

NOTE: It is of the utmost importance that precautions be taken to prevent possible contamination of the analytical laboratory by high level samples.

TABLE 3

RAPID LABORATORY ANALYSIS OF pu-238

SAMPLE	METHOD	SENSITIVITY	ANALYTICAL TIME	COUNTING TIME
Filter Paper 200 ft^3 Air	Ashing, Acid Leach, direct deposition, gas flow proportional counting.	4×10^{-14}uci/ml	2 hrs	10 min.
Water 3 cc	Direct deposition, gas flow proportional counting.	7×10^{-8}uci/ml	1 hr	10 min.
NASAL Swabs	Acid Leach, Direct deposition, gas flow proportional counting.	2×10^{-7}uci	1 hr	10 min.
Soil	Dry, Acid Leach, direct deposition, gas flow proportional counting.	2×10^{-7}uci	2 hrs	10 min.
Vegetation	Dry, Acid Leach, direct deposition, gas flow proportional counting.	2×10^{-7}uci	2 hrs	10 min.

Tritium (oxide)

Field surveys for tritium is not as simple as for plutonium-238. If predicted condition warrent field surveys, then the following actions can be taken:

- Tritium oxide air samples may be taken by bubbling air through a solution of water and ethylene glycol by small aquarium pumps both upwind and downwind from the suspect deposition area.

- Collect vegetation samples in plastic bags.

- Collect water samples, if available, from area.
- Collect urine samples, if warranted, from a representative number of people in the area.
- Return all samples to the environmental laboratory in E Building for analyses.
- Tritium oxide samples can be analyzed very rapidly with the exception of vegetation.

The Environmental Manager evaluates all available results and calculates the percent of the Protective Action Guide (see page 12) based on intake through inhalation and/or ingestion and reports to the Emergency Control Center.

RELEASE TO SURFACE WATERS

Plutonium-238 or Tritium (oxide)

The Environmental Manager immediately sends environmental personnel to sample Mound's effluent release points, the Great Miami River, and the drinking water of downstream communities. Arrangements, if appropriate, will be made to restrict the flow of effluent water from Mound.

- The pathway of possible radiation exposure to the public in the period immediately following a release would be through ingestion of contaminated water; however, no downstream communities on the Great Miami River uses the river as a source of drinking water.
- For plutonium-238, the amount of deep leaching into the soil and into the water table would be small, since soil acts as a good absorption medium to minimize plutonium in ground water.

The Environmental personnel collects samples at regular intervals and returns them to the Environmental Laboratory immediately for analysis. For analysis time, sensitivity, etc., see Table 3.

The Environmental Manager calculates the percent Protection Action Guide (see page 12) in drinking water and reports to the Emergency Control Center.

RELEASE TO SOIL (SPILLS, ETC)

Plutonium-238 or Tritium (oxide)

The Health Physics Operations Personnel locate the surface contamination by appropriate survey methods.

Set up air samplers:

- Subsequent monitoring of the surface layers of the soil and of nearby surface waters and vegetation over an extended period of time may be required.

Return samples and data to the Environmental Laboratory for analysis. For time and sensitivity of analysis, see Table 3. The Environmental Manager calculates percent of Protective Action Guide (see page 12) and reports to the Emergency Control Center.

RELEASES TO AIR, WATER OR SOIL - OTHER

Fission Products Release

- Since the release of fission products to the environment from Mound Laboratory would occur only in a criticality type incident (which is a remote possibility) and, in such a case only very small amounts would be released; it will be dealt with only briefly.

The Health Physics operations personnel monitor the environment as described previously under plutonium releases to air, water and soil, except that portable off-site surveys will be done for beta-gamma activity and air sampling will include a charcoal trap for collection of iodine - 131.

The Environmental manager evaluates the Environmental data and reports to the Emergency Control Center.

Non-Radioactive, Toxic Materials

- The release of large amounts of non-radioactive toxic chemicals to the environment from Mound Laboratory is minimal since large amounts are not used or produced at Mound, therefore, this type of emergency will not be described in detail; however, our procedure would, in general, be the same as that for radioactive materials in that samples would be analyzed to determine the hazard and actions.

- Also, see MD-10149, Mound Oil & Hazardous Substances Spill Plan for additional procedure.

PROTECTIVE ACTION GUIDES

The protective action guide (PAG's) developed for Mound were based on the protective action guide values found in the EPA's "Manual of Protective Action Guides and Protective Actions for Nuclear incidents, September, 1975." The derived protective action guides (PAG's) for plutonium-238 and tritium for the general population are shown below:

RADIONUCLIDE	PROJECTED DOSE REM(a)
Plutonium-238	5 - 25
Tritium	1 - 5

(a) The lower value should be used unless local constraints make the lower value impractical.

At this point some clarification is needed concerning the PAG's for Mound. The projected dose listed for plutonium-238 in rem is converted to projected dose commitment due to the especially longer biological effect from plutonium-238. In order to determine derived estimated uptake quantities for each respective PAG, inhalation and ingestion pathways for tritium and plutonium-238 were considered. Due to the quick response times needed for decisive protective actions, it was decided to use the radionuclide forms which were more restrictive. The more restrictive form of tritium is tritium oxide and the soluble form of plutonium-238 were used in developing the uptake guides for each respective PAG. Since the more restrictive forms of the radionuclide in question were used, and considering certain local constraints in potential evacuation situations, it is prudent to set the PAG's at each upper range. It is generally concluded that quick response decisions will be necessary and overreaction based on conservative values may be more detrimental than the potential emergency conditions. Listed below are derived protective action guidelines (PAG's) and the respective acute intake values for each radionuclide:

TABLE 4

PROTECTIVE ACTION GUIDELINES (PAG's)

TRITIUM (OXIDE)

Receptor	Pathwork	Critical Organ	Acute Intake (uci)	PAG (Rem)
General population	Inhalation	Whole body	8.4×10^4	5
	Ingestion	Whole body	8.4×10^4	5

Plutonium-238

Receptor	Pathwork	Critical Organ	Acute Intake (uci)	PAG (Rem)
General population	Inhalation	Bone surfaces	0.003	25*
	Ingestion	Bone surfaces	28.6	25*

*70 Year Dose Commitment

Percent of Protective Action Guide Calculation

The percent of the Protective Action Guide is calculated as follows:

1. Inhalation of conatamihated air

$$\%PAG = \frac{(\text{Intake [cc]}) \times (\text{Concentration in air [uci/cc]} \times 100}{\text{PAG (uci)}}$$

where,
(Intake per 24 hour day = 2×10^7 cc of air)

NOTE: For tritium oxide, the (% PAG) should be multiplied by two to compensate for an equal estimated absorption by skin.

2. Ingestion of contaminated drinking water

$$\%PAG = \frac{(\text{Intake [cc]}) \times (\text{Concentration in drinking water [uci/cc]} \times 100}{\text{PAG (uci)}}$$

where,
(Intake per 24 hour day = 2.2×10^3 cc of water)

PROTECTIVE ACTIONS

If protective actions are necessary, the actions will be determined in the Emergency Control Center. At this point, the appropriate contacts will be made with offsite authorities. (See Annex B for names and phone numbers)

The following actions are recommended relative to factors of the protective action guidelines. All actions considered should weigh the impact on the community with the benefit from dose reduction.

LEVEL (PAG)	AIR
<1	None
>1	News broadcast to seek shelter indoors
	Consider possible evacuation
	Limit access to area

LEVEL (PAG)	DRINKING WATER
<1	None
>1	News broadcast to restrict the intake of drinking water and avoid contact with Miami River water. Recommend drinking bottled water Limit access to area.

At this point longer term responses should be decided among Mound's management, local officials, and State and Federal officials. Due to the variability of conditions, no exact responses can be predicted here, however, some generalities can be noted. Illustrated below are general actions, both protective and restorative as presented by the EPA.

EXPOSURE PATHWAYS AND APPROPRIATE RESPONSES

- Exposure from airborne materials

Protective Actions	Restorative Actions
-Evacuation -Shelter -Prophylaxis - protect or treat disease -Respiratory Protection -Clothing -Control Access	-Stop Protective Actions -Reentry -Decontamination -Control Foods

- Exposure from foodstuffs and water

Protective Actions	Restorative Actions
-Reserves -Alternate Source -Decontamination -Diversion -Destruction	-Stop Protective Actions

. Exposure from contaminated property or equipment

Protective Actions	Restorative Actions
-Evacuation -Control Acess	-Stop Protective Action -Decontamination -Reentry

For exposures greater than the annual recommended limit (uncontrolled conditions) but less than the Protective Action Guide; the immediate action would be to increase surveillance to provide reliable data concerning: (1) level of intake, (2) size of population exposed, and (3) effectiveness of control actions.

SURFACE CONTAMINATION

Should high levels of ground contamination warrant protective action against resuspension, cleanup must be accomplished in the first few weeks to significantly reduce the burden. Most plutonium-contaminated surfaces can be restored and returned to normal use through the application of appropriate decontamination methods by properly trained personnel.

The actual removal of alpha contamination over a large area is obviously extremely difficult and probably of questionable value unless practically all of the involved area can be handled the same way. (See Table 5)

A potential health problem could exist in an area where the protective action guides have been exceeded. This situation, however, must be evaluated with great care. Evaluations such as family residence time, individual working time, and special precautions will be made on a case by case basis. These evaluation topics can scarcely be answered before the fact.

TABLE 5

PERCENT EFFICIENCIES FOR VAIROUS HARD SURFACE DECONTAMINATION METHODS

Material	Vacuum	High pressure water	High pressure water with scrub	High pressure water and detergent	High pressure water and detergent with scrub	Sand blasting	Steam clean
	Method (% efficiency)						
Glass	98	99	97	100	99	100	97
Stucco	48	97	95	95	99	100	27
Painted wood	99	98	96	99	99	100	91
Unpainted wood	36	85	93	99	95	99	85
Aluminum	89	99	97	99	100	98	84
Plate steel	93	97	94	100	98	99	91
Asbestos shingles	61	99	98	96	99	100	63
Unpainted wood Shingles	61	97	90	95	97	99	71
Brick	29	99	99	99	99	97	
Tar Paper	55	98	95	95	96	99	52
Corrugated galvanized roofing	69	99	97	99	99	100	85
Highway asphalt	32	99	96	99	99	99	44
Highway asphalt (10 ft.^{2})	72	92	94	98	96	92	22
Sealed asphalt	71	98	90	100	99	99	84
Sealed asphalt (10 ft. ^{2})	64	90	82	96	97	90	48
Steel trowel concrete	74	98	--	96	99	100	--
Steel trowel concrete (10 ft ^{2})	--	78	97	---	98	98	27
Wood float concrete	--	98	92	100	97	100	65
Wood float concrete (10 ft. ^{2})	56	97	--	98	98	98	85
Average of all surfaces	66	96	94	98	98	98	67

TABLE 6

LAND AREA FIXATION AND/OR DECONTAMINATION EFFICIENCIES

Method for Ground Decontamination	Activity Present Mean Initial (dpm/m^2)	Mean Final (dpm/m^2)	Efficiency Percent
Plowing	8200	140	98
Oil	4200	80	98
Scrape	580	25	85
Water (0.3 in. and Scrape	1400	100	95
Oil (RC-0 road oil)	1000	100	89
Flooding with water (1.0 in.)	1600	225	85
Water-$FeCl_3$ solution (0.3 in.)	4000	630	84
Disking	3000	730	76

APPLICABLE REFERENCES

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7. Gutherie, C. E., Nichols, J. P. "Theoretical Possibilities and sequences of Major Accidents in U^{233} and Pu-239 Fuel Fabrication and Radioisotope Processing Plants" ORNL Report No. 3441.

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9. Recommendations of the Internation Commission and Radiological Protection, ICRP Publication II, 1959.

10. "Manual of Protective Action Guide and Protective Actions for Nuclear Incidents," EPA 520/1-75-001, September, 1975, Environmental Protection Agency.

ANNEX A - CONTACT LIST

MANAGER, OPERATIONAL SAFETY:

R. A. Neff — Mound Extension - 3928
Home Telephone - 885-7076

ENVIRONMENTAL MANAGER:

C. S. Friedman — Mound Extension - 4541
Home Telephone - 837-2504

ALTERNATE: Supervisor, Environmental Laboratories

D. G. Carfagno — Mound Extension - 3931
Home Telephone - 433-6886

ALTERNATE: Supervisor, Environmental Evaluation

C. T. Bishop — Mound Extension - 3927
Home Telephone - 433-0284

ANNEX B - OUTSIDE AGENCIES

Miami Valley Disaster Services Authority		433-2651
Ohio State Disaster Services Agency (FTS) 572-6081		614-889-7150
Montgomery County Combined General Health District		225-9381
City Managers	Centerville	885-7411
	Franklin	746-9921
	Miamisburg	866-3303
	West Carrollton	859-5181
USAF Medical Center - Wright Patterson AFB		257-2968 or 257-2969 Commar
Post 257-1110		

Other Off-Site Agencies are listed in the Emergency Call List, Emergency Planning System Manual MD-10144.

Ref. 57

KHD

Department of Energy
Albuquerque Operations
Dayton Area Office
P.O. Box 66
Miamisburg, Ohio 45342

Mr. Robert Phelps
Division of Industrial Wastewater
State of Ohio Environmental Protection Agency
361 East Broad Street
P. O. Box 1049
Columbus, Ohio 43216

Dear Mr. Phelps:

RE: Reporting and Testing Requirements for Recirculating Water or Non-Contact Cooling Water Systems Additives

In accordance with the provisions of NPDES Permit No. 1I00005*BD, we are providing the attached information concerning referenced additives. If you need additional information, please contact D. S. Ingle, (513) 865-3597.

Sincerely,

James A. Morley
Area Manager

Attachment: a/s

cc: K. Dearth, OEPA, w/attach.
R. Neff, MRC, w/o attach.
C. Friedman, MRC, w/o attach.

RECEIVED
MAY 15 1986
Environmental Protection Agency
SOUTHWEST DISTRICT

COOLING TOWER ADDITIVES

1. ANCO Algaecide No. 1, Anderson Chemical Company (EPA Registration No. 3931-3).

2. 55 mg/l of 2-benzyl-4-chlorophenol added once a week.

3. 9.1 - 9.3

4. Trace to 45 mg/l.

5. Aqueous solution of 19.85% 2-benzyl-4-chlorophenol and sodium hydroxide.

6. Initially a maximum of 55 mg/l continually decreasing with time until next weekly addition.

7. At maximum load during summer season approximately 0.1 MGD, a typical range would be 0.01 to 0.030 MGD.

8. Seven day, once-in-ten year low-flow 218 CFS, 90% flow 380 CFS.

9. Maximum of 95^{0}F under normal operation.

10. 9.1 - 9.3

11. Only information available LD_{50} = 5 g/kg (rat).

COOLING TOWER ADDITIVES

1. Siltex - Anderson Chemical Company
2. 261 ppm

COOLING TOWER ADDITIVES

1. ANCO Microbicide 77, Anderson Chemical Company (EPA Registration No. 3931-7).
2. 1.1 ppm 5-chloro-2-methyl-4-isothiazolin-3-one

   0.3 ppm 2-methyl-4-isothiazolin-3-one

   added once a week
3. 9.1 - 9.3
4. Trace to 45 mg/l.
5. 1.15% by weight 5-chloro-2-methyl-4-isothiazolin-3-one

   0.35% by weight 2-methyl-4-isothiazolin-3-one
6. Initially a maximum of 1.1 ppm and 0.3 ppm of each active ingredient continually decreasing with time until next weekly addition.
7. At maximum load during summer season approximately 0.1 MGD, a typical range would be 0.01 to 0.030 MGD.
8. Seven day, once-in-ten year low-flow 218 CFS, 90% flow 380 CFS.
9. Maximum of $95^{o}F$ under normal operation.
10. 9.1 - 9.3
11. Only information available TLV = 0.1 mg/m^3.

COOLING TOWER ADDITIVES

1. Cooling Water Treatment - CSA - Anderson Chemical Company
2. 10 - 25 ppm
3. 9.1 - 9.3
4. Trace to 45 mg/l.
5. Aqueous solution of organo-phosphonate, triazol, polyacrylate.
6. Initially a maximum of 10-25 ppm continuously decreasing with time until next weekly addition.
7. At maximum load during summer season approximately 0.1 MGD, a typical range would be 0.01 to 0.030 MGD.
8. Seven day, once-in-ten year low-flow 218 CFS, 90% flow 380 CFS.
9. Maximum of $95^{o}F$ under normal operation.
10. 9.1 - 9.3
11. No information available. Product does not contain any hazardous ingredients or known or potential carcinogens.

BOILER WATER ADDITIVES

1. NALCO 2549 Ball Oxygen Scavenger
2. 40-60 ppm
3. 8.2
4. Trace to 45 mg/l.
5. Sodium sulfite, sodium carbonate, sodium lignosulfate and cobalt sulfate.
6. Initially a maximum of 60 ppm continually decreasing with time until next weekly addition.
7. Approximately 0.002 MGD.
8. Seven day, once-in-ten year low-flow 218 CFS, 90% flow 380 CFS.
9. $208^{o}F$
10. 10
11. No toxicity studies performed on this product.

BOILER WATER ADDITIVES

1. NALCO 2554 Inhibitor

2. 75 ppm

3. 8 to 9

4. Trace to 45 mg/l.

5. Morpholine 1-10%

   Cyclohexylamine 10-20%

6. Initially a maximum of 75 ppm continually decreasing with time until next weekly addition.

7. Approximately 0.002 MGD.

8. Seven day, once-in-ten year low-flow 218 CFS, 90% flow 380 CFS.

9. $208^{o}F$

10. 10

11. Oral LD_{50} = 1,404 mg/kg (Albino Rats)

    Dermal LD_{50} = 2,463 mg/kg (Albino Rabbits)

BOILER WATER ADDITIVES

1. Transport - Plus - 2800

2. 200 ppm

3. 8 - 9

4. Trace to 45 mg/l.

5. Aqueous solution of an acrylamide/sodium acrylate resin, butyl ethers of polyethylene-propylene glycol, sodium hydroxide and sodium polyacrylate.

6. Initially a maximum of 200 ppm continually decreasing with time until next addition.

7. Approximately 0.002 MGD.

8. Seven day, once-in-ten year low-flow 218 CFS, 90% flow 380 CFS.

9. $208^{o}F$

10. 10

11. No toxicity studies have been performed on this product.

Ref. 58

DESCRIPTION AND SAFETY ASSESSMENT OF SITE

for

M O U N D L A B O R A T O R Y

(Study Performed by DAMES & MOORE, Consulting Engineers, under contract to Monsanto Research Corporation)

Prepared for the

U. S. ATOMIC ENERGY COMMISSION

under

U. S. Government Contract No. AT-33-1-GEN-53

by

Monsanto Research Corporation

a subsidiary of

Monsanto Company

Mound Laboratory
Miamisburg, Ohio 45342

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Text, Tables and Plates in this report are on file at:

Dames & Moore
1150 West Eighth St.
Cincinnati, Ohio 45203

1. SUMMARY

Mound Laboratory is located on 182 acres of land in southwest Ohio within the city limits of Miamisburg. The facility is situated atop a topographic high area overlooking the Great Miami River flood plain. The facility is operated by the Monsanto Research Corporation for the Atomic Energy Commission.

Mound Laboratory is located within the Dayton, Ohio urbanized fringe area, which is expected to grow substantially, as a populated north-south trending metropolitan corridor develops between the Cincinnati-Dayton areas. Over the next decade, the population of the 10-mile radial area surrounding Mound Laboratory is expected to grow approximately 18 percent. At present, there is little seasonal variation of population in Miamisburg and the immediate area surrounding the facility. There are no national or regional landmarks of significance to attract a large volume of population to this area. The largest variation of population distribution occurs on a daily basis.

Land use patterns surrounding Mound Laboratory are predominately rural-agricultural. However, as the Dayton urbanized area continues to expand, this pattern will most likely be replaced by a residential-commercial pattern.

Mound Laboratory is located within the Dayton metropolitan area. Consequently, there are numerous transportation links and industries surrounding the facility. However, because the laboratory is situated on a topographically higher area relative to the surrounding landscape, it is unlikely that a nearby transportation or industrial accident could significantly effect the operation of the facility. The operation of Mound Laboratory could most significantly be effected by an accident within the boundaries of the plant site.

The Presto Adhesive Company stores and produces the largest volume of volatile materials within five miles of Mound Laboratory. The Penn Central Railroad is the nearest major transportation link, and commercial, military and private aircraft occasionally pass over the laboratory. An accidental airplane crash at Mound Laboratory is improbable

considering past safety performance records. The only major military installation in the vicinity of the plant site is Wright-Patterson Airforce Base located approximately 12 miles to the north.

The maximum site elevation at Mound Laboratory is approximately 880 feet above mean sea level (msl) while the river is at about 683 feet msl. Some terrain elevations of 900 to 1,000 feet msl are found near the site.

The climate of the area is continental in nature, characterized by moderate extremes of heat and cold. Summers are rather warm and humid, but temperatures rarely exceed 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.

Precipitation is rather evenly distributed through the year with an annual average of about 40 inches. Snowfall averages about 27 inches per year.

Severe weather is mostly associated with heavy thunderstorms. Damaging winds, local flash flooding, and even an occasional tornado may result. Most tornadoes, however, are of limited effect having paths that are short and narrow. The frequency of general flooding in Ohio is about one in three years. Destruction from tropical cyclones is almost unknown in this area.

The interplay between synoptic scale processes and topography is minimal in this area. 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.

The possibility of flooding at the site which could remotely occur as a result of instantaneous failure of upstream dams and the maximum probable flood due to severe hydrometerological conditions was examined. The hypothetical maximum flood was analyzed for wave run-up due to wind and for stage due to down-valley surge. It is concluded that the maximum water level that could be reached by the worst conceivable combination of hydrologic conditions is below the elevation of all safety related structures at Mound Laboratory.

Groundwater supplies in the area are primarily developed in the buried valley aquifer which follows the course of the Great Miami River Valley, adjacent to the site. Small groundwater supplies are available from bedrock and glacial till in the upland areas. The buried valley aquifer is 100 to 200 feet thick in the vicinity of Miamisburg and

provides a source of water which is tapped by public, industrial and private wells. Three wells tap this aquifer on the site and provide water to Mound Laboratory.

The dilution and dispersion characteristics of the environment were examined to provide an evaluation of the acceptance of effluents. The Great Miami River is the principal drainage course adjacent to Mound Laboratory and has a mean discharge of 1,050 cubic feet per second. During drought periods, a low flow discharge of 212 cubic feet per second would be available for dilution. In the groundwater environment, effluents are estimated to move at a maximum rate of about seven feet per day. Most major well fields adjacent to the site are physically separated from Mound Laboratory by the Great Miami River which acts as a recharge barrier. Groundwater in the vicinity of Mound Laboratory is continuously being monitored for quality.

A detailed geologic study was conducted to evaluate site geology and aseismic design parameters. Six test borings were drilled on the site and a seismic exploration program was performed. Laboratory and field testing programs were conducted to aid with the evaluation.

Mound Laboratory is founded upon horizontally bedded, Ordovician Age bedrock of the Richmond Group; 3400 feet of Ordovician and Cambrian Age sedimentary rock overlie Precambrian granitic basement rocks. The site is located on the eastern portion of the Indiana-Ohio Platform which is included within the Central Stable Tectonic Province. A thin layer of Pleistocene Age glacial till and outwash overlie bedrock at portions of the site. No evidence of bedrock folding, faulting or solution activity is suggested in the area. All safety related buildings are designed to maintain an adequate factor of safety and are founded on bedrock.

No active faults within 200 miles of the site have been identified. The closest center of earthquake activity is located about 35 miles north of Mound Laboratory near Anna, Ohio. The cause of this seismic activity is believed to be associated with thermal stress concentrated around a Precambrian rock body which is identified by an aeromagnetic anomaly. Other earthquake mechanisms suggested for the region include adjustment along faults, isostatic rebound from glaciation and fluid withdrawal from petroleum reservoirs.

In consideration of seismic activity in the Anna area and other locations, an engineering evaluation was made for the seismic response of structures at Mound Laboratory.

2. INTRODUCTION

This report is a description and safety assessment of the site at Mound Laboratory, an AEC facility operated by Monsanto Research Corporation. This study was made as part of the requirement for safety analysis reports for AEC facilities. Monsanto Research Corporation is preparing individual safety analysis reports as required for each operating facility at the site. Because the site itself is small (182 acres), a single, thorough analysis of the entire site was judged the best approach to the objective.

Mound Laboratory is located in southwest Ohio in southern Montgomery County, within the city limits of Miamisburg. It is situated atop a hill overlooking the adjacent Great Miami River Floodplain. The 182 acre plant site is bisected by a deep valley. Most of the facility's buildings are located atop the two adjacent topographic highs.

Dames & Moore was retained by the Monsanto Research Corporation (MRC) to prepare the "Description and Safety Assessment" of the Mound Laboratory site. The information presented in this report pertaining to the operation of Mound Laboratory was supplied by MRC. Information pertaining to the surrounding environment was obtained by literature reviews, field surveys, and interviews with various public and private agencies and individuals. The general areas of study included in this report are:

1. Geography and Demography This section identifies the plant's site location and interrelationship with the surrounding land use and the present and projected population.

2. Nearby Industrial, Transportation and Military Facilities This section identifies the various potential hazardous situations which may arise from accidents at nearby industrial, transportation and military facilities, and evaluates the possible impact generated on Mound Laboratory.

3. Meteorology This section describes the meteorological conditions which surround Mound Laboratory. An evaluation is made of the local severe weather conditions and the impact of the facility on the local meteorology.

4. Hydrology

   Surface Water - This subsection describes local surface water characteristics, and the possible impact of severe hydrologic conditions on the facility. An estimate of the environmental acceptability of effluents is also made.

   Ground Water - The various aquifers underlying the site area and their groundwater potential are discussed in this subsection. The ability of the local groundwater regime to dilute an accidental release of radioactive effluents is also evaluated.

5. Geology and Seismology This section describes basic geologic, tectonic and seismic data, vibratory ground motion and site stability. A detailed field study included six test borings, and both surface and downhole geophysical investigations. All drilling, pressure testing and some laboratory testing was performed by Bowser-Morner Testing Laboratories, Inc., of Dayton, Ohio. Construction records and previous soils investigations were made available by both Monsanto Research Corporation and Bowser-Morner Testing Laboratories. All available data, both published and unpublished, was evaluated to form the basis of this report. Earthquake design criteria and analyses of geologic stability are given for the site.

In this report tables and illustrations are grouped at the end of each section.

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3. GEOGRAPHY & DEMOGRAPHY

3.1. SITE LOCATION

The Mound Laboratory is located on 182 acres of land in southern Montgomery County in southwest Ohio, within the southern boundary of the Miamisburg City Limits (Plate 3.1-1). The exact location is 39° 37' 42" north latitude and 84° 17' 15" west longitude. The Universal Transverse Mercator Coordinates are 4,389,800 m.N. and 733,200 m.E.

The Mound Laboratory site is 10 miles south-southwest of Dayton, Ohio and 31 miles north-northeast of Cincinnati, Ohio. It is 0.58 miles due east of the Great Miami River and 0.82 miles south-southeast from the center of the Linden Avenue Bridge, which crosses the Great Miami River at Miamisburg.

There are presently no large lakes in the vicinity of the site. Two man-made ponds lie 650 feet north-northwest of the site adjacent to the abandoned Miamisburg Power & Light Company. Several other small ponds are found in the vicinity of the site, primarily as a result of sand and gravel quarry excavations.

The two predominant geographical features in the vicinity of the site are: the Great Miami River, which flows from northeast to southwest through Miamisburg, and the ancient burial mound in Miamisburg Mound State Memorial Park. The mound is located 380 feet east-southeast of the site and rises approximately 68 feet above the ground surface, providing an excellent view of the site from a public overlook on top of the mound.

3.2. SITE DESCRIPTION

Plate 3.2-1 illustrates the general plan of the Mound Laboratory, the relative distances between buildings, and the distances of buildings to boundaries of the site. Hereafter, the area enclosed by site boundaries is referred to

as the "exclusion area." The Atomic Energy Commission owns and controls the facilities and operations within this exclusion area.

The northern boundary of the site is approximately 0.13 miles south of Mound Avenue, which becomes Mound Road that curves near the entrance to the plant and runs adjacent to the eastern boundary of the site. The southern boundary of the site lies adjacent to a subdivided 127 acre open space area. This space is enclosed by Benner Road which is approximately 2,000 feet south of the site boundary. Tracks of the Penn Central Railroad roughly parallel the western boundary of the Mound Laboratory, at distances ranging from approximately 50 feet to 200 feet west of the site boundary. The Great Miami River ranges between 1,500 to 2,000 feet west of the plant boundary.

Mound Laboratory is situated upon a topographic high area overlooking the Great Miami River and the river plain area to the west. The relief between the river and the laboratory site is 190 feet. Relief on the property site is 170 feet, with two higher areas being divided by a WNW-SSE trending valley. Most of the buildings are located atop the northwest topographic high area, but a smaller group of buildings lie atop the southeast topographic high area.

3.2.1. Exclusion Area Control

The exclusion area has been defined as the area enclosed by the boundaries of the plant site. There are presently no operations conducted on the plant site which are unrelated to the operation of the facility. The exclusion area is well secured against outside intrusion and movement of operational personnel employed by the Mound Laboratory is regulated. Chain link fencing with attached barbed wire surrounds the facility; all entrances to security areas are controlled by guards. Entrances to the other fenced areas can be closed.

Should an emergency situation arise on the site, there is a system of documented emergency plans for the entire Mound Laboratory. This Emergency Planning System is maintained by a Coordinator, Emergency Planning, who is responsible for readiness training related to the system and for assuring that all plans are kept up to date. In addition to general procedures that apply to all areas of the plant, there are detailed shut-down procedures for every room in every building of the plant.

3.2.2. Boundaries for Establishing Effluent Release Limits

The plant property lines are defined in Section 3.2, and distances between the property line and the Great Miami River are discussed. In this section, the distances from plant effluent release points to the property line are defined.

There are presently two effluent release points for liquid wastes generated on the plant site (Plate 3.2-1). Both points are located on the western property line.

Liquid discharge point A is 320 feet west of the center of the Sewage Disposal Building (SD) and approximately 1800 feet east of the release point on the Great Miami River. The release point is Mile 65 on the Great Miami River, referenced on the Miamisburg, Ohio, 7-1/2 minute U.S.G.S. topographic map quadrangle. Liquid effluents discharged at this point originate from Building B Cooling Tower, the Sanitary Sewage Disposal Building (Bldg. SD) and the Radioactive Waste Disposal Building (Bldg. WD). Radioactive wastes are chemically removed from the waste liquid before discharge and sanitary wastes are processed in the SD building prior to release. This discharge system utilizes 10-inch diameter subsurface drainage pipe on-site, and 12 inch diameter subsurface drainage pipe off-site.

Liquid discharge point B is approximately 290 feet south of discharge point A, and 1,750 feet east of reference point Mile 65 on the Great Miami River. (Plate 3.2-1). This system is composed of an open brick drainage ditch which originates from the southwest area of the site. The liquid effluents are waters gathered in storm sewers and cooling units located in the Powerhouse (Bldg. P). This drainage system forks just west of the Penn Central Railroad tracks. The north-trending fork flows parallel to the site boundary at a distance of approximately 600 feet and terminates in two recreation ponds situated behind the abandoned Miamisburg Power & Light Company plant. The south-southwest-trending fork parallels the Penn Central Railroad tracks to their intersection with a bridge over the Great Miami River. The liquid effluent is discharged into the river at this point, (Plate 3.2-1), 1,200 feet north-northwest of Mile 64, referenced on the Franklin, Ohio, 7-1/2 minute U.S.G.S. topographic map quadrangle.

There are presently 14 air effluent release stacks located on the plant site, (Plate 3.2-1). Five of these stacks are constructed of brick and the remainder are constructed of metal. Three of the brick stacks are large structures, with a height of over 150 feet each. These stacks are located adjacent to P Building (Powerhouse building), SW Building (Development,

Disassembly & Recovery Building) and the SM Building, (Special Metallurgical Building).

With the exception of the three metal stacks on P Bldg. and the stack on the incinerator (Bldg. #51), all stacks are used to ventilate various buildings on the site.

3.3. POPULATION AND POPULATION DISTRIBUTION

Population figures presented in this report are based upon 1970 census data. Data from three states, 28 counties, three Standard Metropolitan Statistical Areas (SMSAs)*, numerous Minor Civil Divisions (MCDs)** and census tracts have been used as the basis for this report.

3.3.1. Population Within Ten Miles

Concentric circles were drawn 1, 2, 3, 4, 5 and 10 miles from the center of Mound Laboratory. The circles were divided into 22-1/2 degree segments with each segment centered on one of the 16 cardinal compass points. A total of 96 different sectors were thus formed by the intersection of the concentric circles and the radial lines.

The procedure used to derive and assign the 1970 population to each of the 96 sectors within the population rose is described below.

(1) The ten mile radial area surrounding Mound Laboratory presently lies within three Standard Metropolitan Statistical Areas (hereafter referred to as SMSAs):

1. Dayton, Ohio SMSA
2. Hamilton-Middletown, Ohio SMSA
3. Cincinnati, Ohio SMSA

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* A general definition of an SMSA is a county or group of contiguous counties which contains at least one city of 50,000 or more inhabitants. There are presently 247 designated SMSAs in the United States and Puerto Rico.

**A Minor Civil Division (MCD) is commonly used synonymously with the word township or, an unorganized subdivision of a county.

(2) These three SMSAs were subdivided into hundreds of component census tracts. The boundaries of all the census tracts lying within the ten mile radial area were then drawn on assembled adjoining 7-1/2 minute U.S.G.S. topographic map sheets. The following 7-1/2 minute U.S.G.S. topographic quadrangle maps were used in this population study:

Bellbrook Quadrangle (1965)

Waynesville Quadrangle (1968)

Oregonia Quadrangle (1968)

Lebanon Quadrangle (1966)

Monroe Quadrangle (1965)

Trenton Quadrangle (1966)

Middletown Quadrangle (1970)

Franklin Quadrangle (1965)

Springboro Quadrangle (1965)

Farmersville Quadrangle (1960)

Miamisburg Quadrangle (1965)

Dayton South Quadrangle (1965)

Dayton North Quadrangle (1965)

Trotwood Quadrangle (1965)

Brookville Quadrangle (1961)

(3) The areal percent of each census tract lying within a particular sector of the population rose was then calculated. Assuming an even distribution of population, this percentage was then multiplied by the known 1970 population of that census tract. This procedure was repeated for each census tract lying within a particular sector until a total population for that sector was obtained. (Plate 3.3.1-1).

One limitation of this procedure is that the smaller sector areas often receive population figures which are disproportionate to their actual population. For example, a 0 to 1 mile radial sector may fall on the uninhabitable slope of a large hill. But since it contains an areal proportion equal to an adjacent sector, both sectors are assigned equivalent populations because they both lie within the same census

tract. This effect generally decreases proportionately as the size of the sector increases. Also, in a metropolitan or metropolitan fringe area, the adverse trends tend to be minimal.

It must also be noted that for some cases, a small areal proportion of a census tract was found to lie within a sector. If no houses were shown on topographic maps in these small areas, a proportional allotment of the total census tract population was not assigned to the sector. When this procedure was implemented, subsequent field surveys were conducted to verify the results.

- Population Projections (0-10 Miles) Population projections for the 0-10 mile radial area were made for each of five decades to the year 2020. The procedure used was derived from suggestions made by the Miami Valley Regional Planning Commission (MVRPC).

The 0-10 mile radial area lies within a four county planning area controlled in part by the Ohio-Kentucky-Indiana Regional Planning Authority (OKI) (Warren and Butler Counties) and in part by the MVPRC (Montgomery and Greene Counties). OKI has made population projections for Warren and Butler Counties to the year 1990 and MVRPC has made population projections for Montgomery and Greene Counties to the year 2020. Therefore, in order to have projections for all four counties to the year 2020, OKI population projections for Warren and Butler Counties were extended linearly for three decades. The per decade percent change in population was then calculated for the four counties to the year 2020, and these percentages were multiplied by their respective 1970 sector populations. Where two counties were found to lie within one sector, their populations were multiplied by their respective growth rates. This procedure was repeated for each sector until the entire population rose for each decade was compiled. Plate 3.3.1-2 through Plate 3.3.1-6 illustrate the projected population figures for 1980, 1990, 2000, 2010 and 2020.

This procedure was used for two reasons. First, population projections for all of the individual census tracts lying within the 10 mile radial area were not available. Had these projections been available, a proportioning of these figures would have provided the most accurate measure of projecting population for the small sector areas. The other method would have been to multiply the present sector populations by a projected statewide growth rate. This method would have been less accurate than the procedure implemented in this report because the larger scale tends to distort local figures.

The linear projection method used to obtain population figures for Warren and Butler Counties tends to give higher population figures than might otherwise be expected. Recent trends have indicated that population growth rates are declining. If these trends persist over the next decade(s), the projection figures presented in this report may be abnormally high. However, it is likely that this area will continue to become more urbanized as the Cincinnati-Dayton-Middletown metropolitan fringe areas tend to merge together. This effect is likely to reduce the present agricultural and open space areas surrounding these urban areas by residential replacement and reduce or reverse the declining population trend. Cumulative per decade population figures are indicated for each one mile radius up to 10 miles from the site on Plates 3.3.1-1 through 3.3.1-6.

3.3.2. Population Between 10 and 50 Miles

Concentric circles were drawn at 10 mile intervals from the center of the laboratory site out to a 50-mile radial distance at a scale of 1" = 10 miles. Radial lines were drawn on this map by the same technique used in Section 3.3.1. Sixty-four different sectors were thus formed, ranging in size from 59 square miles to 177 square miles.

Minor Civil Divisions (MCDs) were used as the basis for determining the present population between 10 and 50 miles. MCDs were used in place of the census tract units used in the 0-10 mile study since census tract information was not available for all of the spatially larger 10-50 mile area. The larger sector areas found between 10 and 50 miles often encompassed five or six MCDs, and rarely less than four.

The 1970 population data for the MCDs were allocated to the sectors assuming an equal distribution throughout the MCD. The percentage of each MCD within a sector was calculated. This percentage was multiplied by the MCD populations to obtain the population within a sector. The sum of these computations for each sector yielded its 1970 population. The results are shown on Plate 3.3.2-1.

- Population Projections (10-50 Miles) Population projections for sectors lying between 10 and 50 miles were made on a per decade basis to the year 2020. The following procedure was used: the projected per decade county growth rate was multiplied by the proportioned MCD population lying within the individual sectors. These proportioned MCD figures were then added to yield a total sector population. This procedure was repeated until each sector of the population rose was assigned a projected population figure for each of the ensuing decades. The results are shown in

Plates 3.3.2-2 through 3.3.2-6.

Of the 28 counties lying within 50 miles of the site, only the five counties of the Miami Valley Regional Planning Commission had population projections available to the year 2020. Ten other counties had population projections available to the year 1990, while 13 counties had no projections at all, (Table 3.3.2-1). The following procedures were used to project county populations to the year 2020: for those counties which maintained population projections to the year 1990, their population was graphically recorded for a 30-year period prior to this date. Their 2000, 2010 and 2020 population was then extrapolated from a linear extension of this projected growth. Per decade growth rates were calculated from these linear extensions.

For those counties which maintained no population projections whatsoever, the following procedure was used to obtain projected per decade growth rates: the population change between 1940, 1950 and 1960 was graphically recorded and a linear extension of these trends was projected to the year 2020. The per decade growth change was then calculated from this extrapolated projection.

If present growth trends continue, the projected figures may result in abnormally high estimates. It is quite likely, however, that the population of this area will continue to increase, particularly along the corridor between Cincinnati, Dayton and Middletown, Ohio. Cumulative population figures within 50 miles of Mound Laboratory are listed on Plates 3.3.2-1 through 3.3.2-6.

3.3.3. Low Population Zone

The boundaries of the low population zone were determined in conference with the Monsanto Research Corporation. The boundary is defined as the exclusion area, described in Section 3.2. The population of the low population zone is described in Section 3.3.4.

3.3.4. Transient Population

There is no large seasonal variation in population for the local area surrounding Mound Laboratory. There are no major parks, major landmarks, or tourist attractions which would draw a significant seasonal transient population to the area. The resident population of Miamisburg remains relatively constant throughout the year.

Daily variations in the population do occur on the site and in the immediate Miamisburg area. There are approximately

1800 employees working within the low population zone within the site boundary from 7:00 a.m. to 5:00 p.m. during the five-day work week. Most of these employees are concentrated on the northwest area of the site where a variety of operational activities occur. Approximately 200 employees work within the exclusion area on Saturdays and 25 on Sundays and at night. Periods of the heaviest vehicular traffic on, and immediately adjacent to the site occur between 7:00 and 8:00 a.m. and 4:00 and 5:00 p.m. (Table 3.3.4-1).

3.3.4.1. Local Traffic The heaviest volumes of local Miamisburg traffic are concentrated on three thoroughfares: (1) The Dayton-Cincinnati Pike, located 0.4 miles west of Mound Laboratory; (2) State Route 725, located 0.9 miles to the north of the lab and, (3) Interstate 75, located three miles to the east of the lab. Comparative traffic volumes found on these roads and the other local Miamisburg roads (shown on the 1971 traffic flow map of the areawide T.O.P.I.C.S. plan) indicate that primary traffic flow is entering or leaving Miamisburg on a daily basis. Most of this volume is between Miamisburg and the Dayton urbanized area and is associated with the local working force being employed in the metropolitan area. Assuming a normal working day, it is likely that the highest concentrations of population surrounding Mound Laboratory will occur during the non-working hours.

3.3.5. Population Center

The population center nearest Mound Laboratory is Dayton, Ohio, at a distance of ten miles from the facility. However, the Mound Laboratory plant site is located entirely within the city limits of Miamisburg. The 1970 population of Miamisburg was 14,797. Projections for 1975 and 1980 are 19,000 and 24,500, respectively. (Dayton Chamber of Commerce) These projection figures are likely to be too high if based upon the recent trend of declining school enrollment. (School enrollment often directly reflects population growth trends).

3.3.6. Public Facilities and Institutions

In this section, public facilities, including schools, hospitals, prisons and parks, are identified and located and their transient or permanent populations discussed.

3.3.6.1. Public Facilities and Institutions in Miamisburg Miamisburg school children are concentrated in nine local schools on weekdays during the school year. Class hours vary, but most students are in session from 8:25 a.m.

to 2:55 p.m. during the day. The school nearest Mound Laboratory is Mound Elementary located 0.6 miles east-northeast of the site. Its total enrollment and staff presently number 834. Locations and enrollment of all Miamisburg schools are presented in Table 3.3.6.1-1.

There are presently 34 churches in Miamisburg. Their peak attendance hours are on Sunday morning and most of the congregations number less than 200 people. However, there are a few larger congregations. The largest, Our Lady of Good Hope, is 0.8 miles north of Mound Laboratory and has a total of about 1,000 people attending all Sunday services.

The present Miamisburg jail is 1.0 mile north of Mound Laboratory and has a maximum capacity of eight. However, in April 1973 it will be replaced by a new community complex with facilities for 18 people, (Table 3.3.6.2-6).

Miamisburg has 13 parks and four playgrounds. Mound Golf Course and Mound Park, directly east of Mound Laboratory across Mound Road are heavily used during favorable weather. Within one mile of Mound Laboratory, other recreational areas extensively used in summer include the municipal swimming pool, Harmon Field and Library Park. Pertinent data on these facilities are given in Table 3.3.6.1-2.

3.3.6.2. Public Facilities and Institutions within a Ten Mile Radius of Mound Laboratory, Excluding Miamisburg

Within ten miles of Mound Laboratory, excluding Miamisburg, there are 95 public schools, 13 private schools and three colleges or universities. Their locations, enrollments and hours in session are given in Tables 3.3.6.2-1, 3.3.5.2-2 and 3.3.6.2-3.

There are six hospitals within ten miles of the site, (Table 3.3.6.2-4). The largest public hospital is Miami Valley Hospital, 9.7 miles northeast of Mound Laboratory. It has 679 beds and 1,649 employees. The closest hospital is the Charles F. Kettering Memorial Hospital located 6.9 miles northeast of the site. It has 413 beds and 1,186 employees.

Table 3.3.6.2-5 presents locations and facilities of two nursing homes and a county welfare home within ten miles of the site.

Five smaller jails are within a ten mile radius of Mound Laboratory and two larger jails are just beyond this radius, (Table 3.3.6.2-6). The Dayton Correction Farm, 7.0 miles north-northeast of the site, normally has 110 to 200 inmates, but has facilities for 275.

Excluding Miamisburg, there are 52 parks and 31 playgrounds, affording a wide variety of recreational activities and facilities. The most extensive programs are offered by the Kettering Parks and Recreation Division and the Montgomery County Recreation and Parks Department. Several smaller communities closer to Miamisburg also provide organized recreation. See Table 3.3.6.2-7 for locations of recreational areas and their facilities.

3.4. USES OF ADJACENT LANDS AND WATERS

The present land use configuration for a two country (Warren and Montgomery), five mile radial area surrounding Mound Laboratory, is based upon field surveys, topographic map examinations, and land use data supplied by the Miami Valley Regional Planning Commission and, the Ohio-Kentucky-Indiana Regional Planning Authority. (Table 3.4-1). Both planning organizations have compiled extensive land use data for the study area. The land use in Warren and Montgomery Counties is summarized in Table 3.4-1.

Mound Laboratory is located within the southern city limits of Miamisburg. Miamisburg is primarily a residential community, with some supportive commercial facilities and minimal industrial development. Traffic density counts* indicate that a large volume of the local and surrounding population migrates to and from the city daily. The majority of this traffic is flowing to and from the urbanized Dayton area.

As Plate 3.4-1 indicates, most of the residential, commercial and industrial development within a five mile radius of the site is concentrated on the low-lying Miami River Flood Plain (listings and locations of local industries are found in Section 4.2). 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.

Agricultural land within the five mile radial area is primarily used for corn and soybean production and for livestock grazing. In 1970, 74 percent of Montgomery County was listed as agricultural or vacant land; 84 percent of Warren County was similarly classified (OKI and MVRPC). Table 3.4-2 indicates the principal food crops grown, the acreage devoted to their production and the relative yield per acre.

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* Obtained from the Miami Valley Regional Planning Commission

The nearest land to the Mound Laboratory capable of supporting dairy cows is the Marjorie S. Penrod property situated adjacent to the southern boundary of the Mound facility. Eight feeder cows presently graze on the Penrod property.

A total of 212 dairy cows and heifers* were observed by field surveys within a five mile radius of the site. Most of these cows are classified Grade A; that is, cows supplying non-commercial dairying operations. The total number of dairy cows reported in Montgomery County for December, 1971, was 95 cows (60 non-commercial and 35 commercial). The total number of dairy cows reported in Warren County for the same period was 66 cows (48 non-commercial and 18 commercial). (Houghton, U.S.D.A.).

As Table 3.4-3 indicates, there has been a continued drop in the total number of heifers and dairy cows over the past decade in Warren and Montgomery Counties. This trend reflects the general decline in heifers and dairy cows throughout the entire State of Ohio. This trend is expected to continue in this area because of: (1) financial deficits experienced by the dairy farmer, (2) the full-time commitment required to operate a dairy farm, and (3) the continuing growth of the Cincinnati-Dayton urbanized area. (Houghton, U.S.D.A.)

There are no large lakes within a five mile radius of the site. Two ponds, approximately 2,000 feet northwest of the site, are used by local inhabitants for recreational purposes. These ponds are fed by water effluents released from the Mound Laboratory. Several small fishing ponds are located 3-1/2 miles north-northeast of the facility in inactive gravel pits.

The major water body in the vicinity of the plant site is the Great Miami River. It is approximately 150 to 200 feet wide in this area. There is presently no commercial barge traffic or commercial fishing. However, some pleasure boating and sport-fishing does occur, primarily during the summer.

There are no recent comprehensive surveys of fish species and populations found in the Great Miami River near Miamisburg.** The Miami Conservancy District has recently conducted a survey, but the results are not yet available for publication. However, some fish which may be found in the vicinity of the

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* A heifer is a young cow that has not had a calf and therefore does not as yet give milk.

**Dunhill, Miami Conservancy District

Mound Laboratory are: silver shiners, rainbow darters, eastern banded darters, northern rockbass, catfish, minnows, and gar.

3.5. ARCHEOLOGICAL SITES

The Laboratory site is immediately to the west of the Great Miamisburg Mound, a prehistoric Indian earthwork. To determine whether any sites of archeological importance might be situated on AEC 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 on the plant property. He expressed interest in examining the ground south of PP Building and southwest of Buildings 2 and 3 during the earliest stage of excavation if construction should be done in either area.

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Table 3.3.2-1 Available population projections for counties within a 50 mile radius of Mound Laboratory

State	No Projections Available	Projections Available to 1990	Projections Available to 2020
OHIO	Brown Co.	Clermont Co.	Montgomery Co.
	Highland Co.	Hamilton Co.	Preble Co.
	Clinton Co.	Butler Co.	Green Co.
	Fayette Co.	Logan Co.	Miami Co.
	Clark Co.	Champaign Co.	Darke Co.
	Madison Co.	Warren Co.	
	Shelby Co.		
INDIANA	Ripley Co.	Dearborn Co.	
	Fayette Co.		
	Franklin Co.		
	Wayne Co.		
	Union Co.		
	Randolph Co.		
KENTUCKY		Campbell Co.	
		Kenton Co.	
		Boone Co.	

Table 3.3.4-1 Vehicular traffic volume at the intersection of Mound Road and Mound Laboratory entrance during hours of greatest traffic on Wednesday, 4 August 1971

Time Interval	Vehicles Entering Site	Vehicles Leaving Site
0700 - 0715	187	5
0715 - 0730	207	10
0730 - 0745	184	12
0745 - 0800	209	19
1600 - 1615	18	241
1615 - 1630	14	213
1630 - 1645	11	283
1645 - 1700	9	100

Table 3.3.6.1-1 Locations and enrollments of public and parochial schools of Miamisburg, Ohio

Name and Address	Grades Incl.	Distance and Direction from Mound Laboratory	1972 Enrollment	Certified Staff	Hours in Session
La Veta Bauer Elementary 6951 Springboro Pk.	K-6	3.5 mi. ENE	666	29	9:30-4:00
H. V. Bear Elementary 545 School St.	K-6	0.9 mi. WNW	458	19	8:25-2:55
Kinder Elementary 536 E. Central Ave.	K-5	0.9 mi. NNE	361	18	8:25-2:55
Mark Twain Elementary 822 N. 9th St.	K-6	1.5 mi. NNE	473	22	8:25-2:55
Mound Elementary 1108 Range Ave.	K-6	0.6 mi. ENE	805	29	9:00-3:30
Anna K. Wantz Jr. High S. 7th St.	6-8	0.8 mi. NNE	867	39	8:25-2:55
Miamisburg Jr. High 6th St. at Linden Ave.	9	0.7 mi. NNE	420	79	8:25-2:55
Miamisburg Sr. High 1860 Belvo Road	10-12	>1.2 mi. E	1,140	79	7:40-2:20
Our Lady of Good Hope 24 S. 3rd St.	1-8	0.8 mi. N	171	11	9:00-3:15
		Totals:	5,357	246	

Table 3.3.6.1-2 Parks and recreational facilities in Miamisburg, Ohio

Name and Address	Distance and Direction from Mound Laboratory	Acreage	Usage/special facilities or programs
Beachler Field 9th Street	1.2 mi. NNE	12	Mound Laboratory baseball league Monday evenings
Community Park 1st Street	0.3 mi. NNW	27	--
Groby Field	--	4	--
Harmon Field 7th St. and Linden Ave.	0.6 mi. NE	3	Tennis courts, track meets, Wednesday evenings in summer
Library Park 5th St. and Central Ave.	0.8 mi. N-NNE	4	Extensively used for concerts, art sales, etc. during summer weekends
Mary Frances Park	--	1/2	--
Mound Golf Course Mound Ave.	0.4 mi. E-ENE	58	--
Mound State Memorial Park Mound Ave.	0.4 mi. ESE	5	--
Play Farm 6th Street	1.0 mi. ENE	3/4	--
S.T.P. Field Main Street	0.4 mi. W	35	--

Table 3.3.6.1-2 (Continued

Name and Address	Distance and Direction from Mound Laboratory	Acreage	Usage/special facilities or programs
Swimming Pool 1st St. and Mound Ave.	0.4 mi. NNW	1	
Sycamore Trails Park Heinecke Rd. and S.R. 725	1.4 mi. ENE	33	
Westover Park Riverview Ave.	0.7 mi. WNW	6	

Playground facilities are available at:

Bear School
Mound School - See Table 3.3.6.1-1 for addresses and locations with respect to Mound Laboratory
Marktwain School

Miamisburg Center - 2nd St. and Central Ave.

Table 3.3.6.2-1 Locations and enrollments of public schools within 10 miles of Mound Laboratory, excluding Miamisburg, Ohio

Name and Address	Grades Included	Distance and Direction from Mound Laboratory	1972 Enrollment	Certificated Staff	Hours in Session
Carlisle Local Schools (Carlisle, Ohio 45005)					
Carlisle Primary 310 Jamaica Rd.	K-3	3.7 mi. SSW	795	34	9:35-2:55
Carlisle Intermediate 100 Jamaica Rd.	4-6	3.3 mi. SW	654	25	7:45-1:55
Carlisle Jr. High 720 Fairview Dr.	7-9	3.6 mi. SSW	628	38	9:00-3:25
Carlisle Sr. High 250 Jamaica Rd.	10-12	3.4 mi. SW	540	42	8:25-2:25
		Total	2,617	139	
Centerville City Schools (Centerville, Ohio 45459)					
W. A. Driscoll Elementary 5767 Marshall Rd.		7.7 mi. ENE	Indiv.enroll. statistics not avail.	No info. avail.	8:25-2:30
Dr. John Hole Elementary 180 W. Whipp Rd.		6.7 mi. ENE			8:25-2:30
Normandy Elementary 401 Normandy Ridge Rd.		6.2 mi. E			8:25-2:30
C. L. Stingley Elementary 95 Linden Dr.		7.1 mi. E			8:25-2:30

Table 3.3.6.2-1 (Continued)

Name and Address	Grades Included	Distance and Direction from Mound Laboratory	1972 Enrollment	Certificated Staff	Hours in Session
Village South Elementary 6450 Marshall Rd.		7.6 mi. ENE			8:25-2:30
Ida A. Weller Elementary 9600 Sheehan Rd.		6.7 mi. ESE			8:25-2:30
Enrollment total for Elementary Schools			3,608		
Hithergreen Middle School 5900 Hithergreen Dr.		7.5 mi. ENE			9:00-3:30
Tower Heights Middle School 95 North Johanna Dr.		7.2 mi. E			9:00-3:30
Hadley E. Watts Middle School 7056 McEwen Rd.		5.5 mi. E			9:00-3:30
Enrollment total for Middle Schools			1,889		
Centerville High Magsig Bldg. 192 W. Franklin St.		6.5 mi. E	2,197		3 shifts: 7:10-2:00 8:35-2:55 9:30-3:50
		Total	7.594		

1980 projected enrollment for Centerville City Schools - 9,681 students

Table 3.3.6.2-1 (Continued)

Name and Address	Grades Included	Distance and Direction from Mound Laboratory	1972 Enrollment	Certificated Staff	Hours in Session
Clear Creek School District (Springboro, Ohio)					
Clear Creek 750 S. Main	4-6	5.9 mi. SSE	598		9:00-3:30
Jonathan Wright 40 Florence Dr.	K-3	5.9 mi. SSE	528		9:00-3:30
Springboro High 705 S. Main	7-12	6.2 mi. SSE	1,048		8:00-2:30
		Total	2,174		
Total certificated staff	96				
Total non-certificated staff	43				
	139				

Table 3.3.6.2-1 (Continued)

Name and Address	Grades Included	Distance and Direction from Mound Laboratory	1971 Enrollment	Certificated Staff (1972)	Hours in Session
Dayton Public Schools (Dayton, Ohio)					
Jane Addams 35 Victory Drive	K-8, Sp.Ed.*	8.3 mi N	540	24	8:15-2:15
Francis G. Carlson 807 S. Gettysburg	K-8	7.6 mi. NNE	575	27	8:15-2:15
Drexel 143 Miller	K-8, Sp.Ed.	8.2 mi. N	602	24	8:15-2:15
Edison 228 N. Broadway	PreK-5, SpEd.	9.7 mi. NNE	557	25	8:15-2:15
Gardendale 1733 N. Gettysburg	K-8	9.9 mi. N	517	25	8:45-2:45
G. A. Greene 503 Edison	PreK-5, Sp.Ed.	9.5 mi. NNE	533	24	8:15-2:15
Highview 2101 McArthur	K-8, Sp.Ed.	7.2 mi. NNE	671	27	8:15-2:15
Irving 355 Cincinnati	PreK-5, Sp.Ed.	9.3 mil NNE	701	27	8:15-2:15
Jackson Elementary 317 Abbey	4-8, Sp.Ed.	8.4 mi. NNE	725	37	8:15-2:15

Table 3.3.6.2-1 (Continued)

Name and Address	Grades Included	Distance and Direction from Mound Laboratory	1971 Enrollment	Certificated Staff (1972)	Hours in Session
Jackson Primary 3201 McCall	K-3	8.5 mil NNE	538	17	8:15-2:15
MacFarlane Middle 215 S. Summit	6-8, Sp.Ed.	9.3 mi. NNE	919	46	8:15-2:15
Horace Mann 715 Krebs	K-8	9.6 mi. NE	284	12	8:15-2:15
McNary Park Elementary 2400 Hoover	K-5, Sp.Ed.	9.6 mi. NNE	394	17	8:15-2:15
Miami Chapel 1600 Miami Chapel	3-5, Sp.Ed.	8.2 mi. NNE	354	19	8:15-2:15
Patterson Elementary 258 Wyoming	K-8	9.8 mi. NE	580	48	8:15-2:15
Louise Troy 1665 Richley	K-3	8.1 mi. NNE	592	23	8:15-2:15
Weaver 2000 Howell	PreK-5, Sp.Ed.	9.0 mi. NNE	872	35	8:15-2:15
Westwood 3410 Hoover	K-8, Sp.Ed.	9.3 mi. NNE	1,264	57	8:15-2:15
Whittier 721 Miami Chapel	6-8, Sp.Ed.	8.7 mi. NNE	749	35	8:15-2:15

Table 3.3.6.2-1 (Continued)

Name and Address	Grades Included	Distance and Direction from Mound Laboratory	1971 Enrollment	Certificated Staff (1972)	Hours in Session
Wogaman 2716 Germantown	K-8, Sp.Ed.	8.0 mi. NNE	946	43	8:15-2:15
Dunbar High 2222 Richley	9-12, Sp.Ed.	7.8 mi. NNE	1,366	74	8:00-3:00
Roosevelt High 2013 W. Third	9-12, Sp.Ed.	9.2 mi. NNE	1,695	78	8:00-3:00
Nettie Lee Roth High 4535 Hoover	9-12, Sp.Ed.	9.3 mi. N	1,193	62	8:00-3:00
		Total	17,169	806	

* Special Education

Table 3.3.6.2-1 (Continued)

Name and Address	Grades Included	Distance and Direction from Mound Laboratory	1972 Enrollment	Certificated Staff	Hours in Session
	Franklin City Schools (Franklin, Ohio 45005)				
Hampton Bennett 130 E. Sixth St.	6-7	5.3 mi. S	629	28	8:30-2:40
Central 121 E. Second St.	Primary-Intermediate	4.8 mi. S	218	12	8:30-2:40
Laura Farrell Park Ave.	Primary-Intermediate	4.7 mi. SSW	329	14	8:30-2:40
Gerke Sherman Dr.	Primary-Intermediate	5.0 mi. S	425	17	8:30-2:40
Hunter School Red Lion & Blue Ball Rd.	Primary-Intermediate	5.9 mi. S	458	17	8:30-2:40
Pennyroyal Pennyroyal	Primary-Intermediate	3.5 mi. S	365	17	8:30-2:40
Schenck Arlington Ave.	Primary-Intermediate	4.2 mi. S	332	12	8:30-2:40
Anthony Wayne 16 Farm Ave.	Primary-Intermediate	5.4 mi. SSW	388	18	8:30-2:40
Franklin Jr. High 136 E. Sixth St.	8-9	5.0 mi. S	826	37	8:15-3:15
Franklin Sr. High 750 E. Fourth St.	10-12	5.4 mi. S	1,010	52	8:15-3:15
		Total	4,980	224	

Table 3.3.6.2-1 (Continued

Name and Address	Grades Included	Distance and Direction from Mound Laboratory	1972 Enrollment	Certificated Staff	Hours in Session
Jefferson Township School (Dayton, Ohio)					
Blairwood Elementary 1241 Blairwood Ave.	K-2	6.9 mi. N	609	22	8:45-3:15
Jefferson Elementary 2989 S. Union Rd.	5-6	5.2 mi. NNW	417	18	8:45-3:15
Radcliffe Elementary 120 Knox Ave.	3-4	8.0 mi. N	377	18	8:45-3:15
Jefferson Jr. High 2989 S. Union Rd.	7-9	5.2 mi. NNW	686	33	7:55-2:30
Jefferson Sr. High 2701 S. Union Rd.	10-12	5.2 mi. NNW	540	33	7:55-2:30
		Total	2,629	124	

Table 3.3.6.2-1 (Continued)

Name and Address	Grades Incl.	Distance and Direction from Mound Laboratory	1972 Enroll.	Predicted 1973-74 Enroll.	Certificated Staff (1972)	Hours in Session
		Kettering City Schools (Kettering, Ohio)				
Beavertown 2700 Wilmington Pk.	K-6	9.4 mi. NE	590	571	No info. available	8:45-2:55
Croftshire 4901 Croftshire Rd.	K-6	8.8 mi. ENE	532	539	--	8:45-2:55
G. L. Ernst 4555 Marshall Rd.	K-6	8.2 mi. ENE	490	454	--	8:45-2:55
J. M. Holt 1545 Sacramento Ave.	K-6	8.0 mi. NE	153	162	--	8:45-2:55
Meadow Lawn 2250 E. Stroop Rd.	K-6	9.6 mi. ENE	416	400	--	8:45-2:55
Moraine Meadows 2600 Holman Ave.	K-6	6.4 mi. ENE	315	360	--	8:45-2:55
Oak Creek 2316 Springmill Rd.	K-6	9.1 mi. ENE	571	526	--	8:45-2:55
Oakview 4001 Ackerman Blvd.	K-6	8.1 mi. ENE	526	525	--	8:45-2:55
Orchard Park 600 E. Dorothy Lane	K-6	8.5 mi. NE	473	460	--	8:45-2:55

Table 3.3.6.2-1 (Continued)

Name and Address	Grades Incl.	Distance and Direction from Mound Laboratory	1972 Enroll.	Predicted 1973-74 Enroll.	Certificated Staff (1972)	Hours in Session
J. E. Prass 2601 Parklawn Dr.	K-6	9.7 mi. ENE	681	640	--	8:45-2:55
Southdale 1200 W. Dorothy Lane	K-6	7.2 mi. NE	626	583	--	8:45-2:55
D.L. Barnes Jr. High 3700 Far HIlls Ave.	7-9	7.8 mi. NE	890	871	--	8:35-3:21
J. F. Kennedy 5030 Polen Dr.	7-9	8.8 mi. ENE	901	923	--	8:35-3:21
Van Buren 3775 Shroyer Rd.	7-9	7.9 mi. NE	877	855	--	8:35-3:21
Fairmont West High	10-12	8.1 mi. NE	1,880	1,946	--	8:09-2:55
		Total	9,921	9,815		

Table 3.3.6.2-1 (Continued)

Name and Address	Grades Incl.	Distance and Direction from Mound Laboratory	1972 Enroll.	Predicted 1973-74 Enroll.	1972 Staff (certificated + non-teaching)	Hours in Session
Middletown City Schools (Middletown, Ohio 45042)						
Creekview Elementary 301 Loretta Dr.	K-5	9.0 mi. SSW	478	457	26	9:10-3:55
Jefferson Elementary Charles & Jefferson St.	K-5	9.2 mi. SW	374	424	23	8:30-3:15
Lincoln Elementary 2402 E. Central Ave.	K-5	9.8 mi. SSW	336	245	20	8:45-3:30
Maple Park Elementary Tytus & Illinois	K-5	8.3 mi. SW	365	352	26	9:10-3:55
Rosedale Elementary 4601 Sophie Ave.	K-6	8.5 mi. SSW	219	210	16	9:10-3:55
Spring Hill Elementary 2101 Brell Dr.	K-5	7.4 mi. SSW	197	169	16	9:10-3:55
Wildwood Elementary Wildwood Road	K-6	8.5 mi. SSW	240	220	16	9:10-3:55
Wilson Elementary 106 S. Highview Rd.	K-6	9.3 mi. SSW	296	275	21	9:10-3:55
Manchester Middle School 4420 Manchester Rd.	7-9	8.0 mi. SSW	667	641	48	9:10-3:55
Roosevelt Middle School 2701 E. Central Ave.	7-9	9.5 mi. SSW	760	766	56	9:10-3:55
		Total	3,932	3,759	268	

Table 3.3.6.2-1 (Continued)

Name and Address	Grades Included	Distance and Direction from Mound Laboratory	1972 Enrollment	Staff (certificated + non-teaching)	Hours in Session
	Oakwood Public Schools (Oakwood, Ohio 45419)				
Harman Avenue 735 Harman Ave.	K-6	8.8 mi. NE	461	31	8:40-3:10
Smith 1701 Shafor	K-6	8.6 mi. NE	476	34	8:40-3:10
Oakwood High 1200 Far Hills Dr.	7-12	8.8 mi. NE	1,037	80	8:15-3:15
		Total	1,974	145	
	Poast Town School (Butler County, Ohio)				
				Certificated Staff	
Poast Town School 6600 Trenton-Franklin Rd. Middletown, Ohio	K-4	7.6 mi. SW	840	32	8:15-3:30

Table 3.3.6.2-1 (Continued)

Name and Address	Distance and Direction from Mound Laboratory	1972 Enrollment	Staff (certificated + non-teaching)
	Valley View Local Schools		
Farmersville Elementary 202 Jackson St. Farmersville, O. 45325	8.6 mi. WNW	363	27
Germantown Elementary 110 Comstock St. Germantown, O. 45327	4.7 mi. W	810	56
Valley View Middle 64 Comstock St. Germantown, O. 45327	4.6 mi. W	585	34
Valley View High R.R. 2, Box 337 D Germantown, O. 45327	> 4.6 mi. W	623	61
	Total	2,381	178

Table 3.3.6.2-1 (Continued)

Name and Address	Grades Included	Distance and Direction from Mound Laboratory	1972 Enroll-ment	Certifi-cated Staff	Hours in Session
West Carrollton City Schools (West Carrollton, Ohio 45449)					
C. F. Holliday 4100 S. Dixie	K-6	8.1 mi. NE	806	30	8:00-2:00
Frank Nicholas 3846 Vance	K-6	5.0 mi. NNE	269	12	8:00-2:00
Harry Russell 123 Elementary Dr.	K-6	3.3 mi. NE	758	29	8:00-2:00
Walter Shade 510 E. Pease	K-6	3.9 Mi. NE-NNE	700	30	8:40-2:40
Valley Hills 5995 Student	K-6	4.2 mi. NE	764	31	8:40-2:40
West Carrollton Jr. High 20 Cedar	8-9	3.8 mi. NE-NNE	874	45	8:35-3:05
West Carrollton Sr. High 5833 Student	7, 10-12	4.2 mi. NE	1,649	87	7th grade-2 shifts 7:10-12:25 12:35-5:50 10-12 grades 7:50-2:20
		Total	5,820	264	

Table 3.3.6.2-2 Location and enrollments of private schools within 10 miles of Mound Laboratory, excluding Miamisburg

Name and address	Grades Included	Distance and Direction from Mound Laboratory	1972 Enrollment	Staff (certificated + non-teaching)	Hours in Session
Archbishop Alter High 940 E. David Dayton, O. 45429	9-12	8.1 mi. ENE	1,224	55	--
Fenwick High 3800 Manchester Rd. Middletown, O. 45042	-	8.1 mi. SSW	393	23	--
Holy Angels 223 L St. Dayton, O. 45409	2-8	9.4 mi. NE	243	11	--
Incarnation Far Hills & Williamsburg Lane Centefville, O. 45459	2-8	6.8 mi. E	406	16	--
Miami Valley (NP) 5151 Denise Dr. Washington Twp., O. 45429	K-11	4.9 mi. ENE	302	47	8:30-3:10 M,T,Th & F 8:30-1:30 W
Resurrection 138 Gramont Dayton, O. 45417	1-8	9.1 mi. NNE	216	11	--
St. Agnes Superior & St. Agnes Dayton, O.	1-8	10.0 NNE	203	10	--

Table 3.3.6.2-2 (Continued)

Name and Address	Grades Included	Distance and Direction from Mound Laboratory	1972 Enrollment	Staff (certificated + non-teaching)	Hours in Session
St. Albert the Great 104 W. Dorothy Lane Dayton, O.	1-8	8.1 mi. NE	650	32	--
St. Charles Borromeo 4600 Ackerman Blvd. Dayton, O. 45429	4-8	7.9 mi. ENE	627	26	--
St. Henry's 6666 Springboro Pk. Dayton, O. 45449	2-8	3.9 mi. ENE	291	14	--
St. James 700 Heck Dayton, O.	1-8	8.6 mi. NNE	171	14	--
St. Mary's 3917 Central Middletown, O. 45042	1-8	9.1 mi. SSW	258	11	--
Spring Valley Academy (NP) 943 E. Spring Valley Rd. Centerville, O.	1-12	E	390	30	8:15-3:15
		Total	5,374	300	

(NP) = Non-parochial private school

Table 3.3.6.2-3 Locations and enrollments of colleges and universities within 10 miles of Mound Laboratory

Name and address	Distance and Direction from Mound Laboratory	1972 Enrollment	Staff (teaching + non-teaching)	Hours in Session
Miami University-Middletown Middletown, O.	8.2 mi. SSW	1,872	90	8:00 a.m.-10:00 p.m.
St. Leonard's College 8100 Clyo Rd. Centerville, O.	8.1 mi. E	50	18	Boarding school
University of Dayton 300 College Park Dayton, O.	9.6 mi. NE	8,275* (2,500 live on campus)	1,600	7:00 a.m.-11:00 p.m.

*Projected enrollment: Sep. '73 - 7,900
'74 - 7,700
'75 - 7,550
'76 - 7,725
'77 - 8,500

Table 3.3.6.2-4 Location and maximum capacities of medical facilities within 10 miles of Mound Laboratory*

Name and Address	Distance and Direction and Mound Laboratory	Number Beds	Employees
Dayton Children's Psychiatric Hospital 141 Firewood Dr. Dayton, O. 45430	9.7 mi. NE	84	-
Charles F. Kettering Memorial Hospital 3535 Southern Dayton, O. 45429	6.9 mi. NE	413	1,186
Miami-Valley Hospital 1 Wyoming Dayton, O 45409	9.7 mi. NE	679	1,649
Middletown Hospital 105 McKnight Dr. Middletown, O.	9.6 mi. SSW	500	885
St. Elizabeth Hospital 601 Miami Blvd., West Dayton, O. 45408	9.4 mi. NNE	490	1,380
Veteran's Administration Center 400 W. Third St. Dayton, O. 45428	7.5 mi. NNE	732	1,324
	Total	2,898	6,424

* Each of the above medical institutions was contacted during the course of this study to provide the listed statistical information

Table 3.3.6.2-5 Locations and maximum capacities of nursing and rest homes within 10 miles of Mound Laboratory*

Name and Address	Distance and Direction from Mound Laboratory	Maximum Capacity	Employees
Bethany Village Home 6451 Far Hills Centerville, O.	7.0 mi. E	102 (rest home) 126 (nursing home)	150 (including part-time)
Montgomery County Home 601 Infirmary Rd. Dayton, O.	7.3 mi. N	112	66
Montgomery County Nursing Home 601 Infirmary Rd. Dayton, O.	7.3 mi. N	150	122

* Each of the above institutions was contacted during the course of this study to provide the statistical information listed in this table.

Table 3.3.6.2-6 Locations and maximum capacities of jails and correctional institutions within 10.4 miles of Mound Laboratory*

Name and Address	Distance and Direction from Mound Laboratory	Maximum Capacity	Average Capacity
Dayton City Jail 335 W. Third St. Dayton, O. 45402	10.4 mi. NNE	175	50-70
Dayton Correction Farm 1613 S. Gettysburg Dayton, O. 45408	7.0 mi. NNE	275	110-200
Miamisburg City Jail 109 E. Central Miamisburg, O. 45342	1.0 mi. N	8**	3-6
Middletown City Jail City Building Middletown, O.	10.0 mi. SW	40 men 8 women	30-40 men 5-8 women
Montgomery County Jail 330 W. Second St. Dayton, O. 45402	10.4 mi. NNE	250	150
Moraine City Jail 4200 Dryden Rd. Dayton, O. 45439	6.5 mi. NNE	4	--
Oakwood City Jail 30 Park Avenue Dayton, O. 45419	8.5 mi. NE	4	--
West Carrollton City Jail 41 E. Central West Carrollton, O. 45449	3.5 mi. NNE	4	3-4

* Each of the above institutions was contacted during the course of this study.

**A new Miamisburg jail is scheduled for completion in April 1973 and will have a maximum capacity of 18.

Table 3.3.6.2-7 Parks and recreational facilities within 10 miles of Mound Laboratory, excluding Miamisburg, Ohio

Name and Address	Distance and Direction from Mound Laboratory	Acreage	Usage/special facilities or programs
Centerville-Washington Township Park District (Centerville, Ohio 45459)			
Black Oak Road Clyo & Centerville Station Rd.	8.6 mi. E		
Black Oak East Park Centerville Station Rd. & Wilmington Pk.	9.2 mi. E		
Concept Park near E. Spring Valley Rd.	7.3 mi. E	6	1,620 people/yr. use areas for baseball, basketball, football, ice skating and soccer
Donnybrook Park W. Whipp Rd.	7 mi. ENE		
Grant Park Normandy Lane & Bellbrook Rd.	6.0 mi. E	55	Life Science Center, 4,250 students/yr. visited nature center; 360 people/yr. use areas for ice skating
Green Park Saddlewood Ave.	6.2 mi. ENE	5	1,710 people/yr. use areas for baseball, football, ice skating and soccer
Iron Horse Park E. Whipp Rd.	8.1 mi. ENE		
Manor Park near Marshall Rd.	8.5 mi. ENE		

Table 3.3.6.2-7 (Continued)

Name and Address	Distance and Direction from Mound Laboratory	Acreage	Usage/special facilities or programs
Oak Creek South Park S.R. 725	5.9 mi. E		
Old Lane Park Mark Dale Dr.	6.5 mi. ENE		1,105 people/yr. use areas for baseball, football and soccer
Pleasant Hill Park Clyo Rd.	7.8 mi. E		
Rahn Park Rahn Rd.	6.9 mi. ENE		
Red Coach Park near Marshall Rd.	8.3 mi. ENE	5	1,150 people/yr. use area for baseball, football and soccer
Rosewood Park between Paragon & Sheehan Rd.	7.6 mi. ESE		
Sugar Valley Park Clyo & E. Spring Valley Rd.	8.7 mi. E		
Village South Park Far Hills Ave. & E. Whipp Rd.	7.7 mi. E	10.5	5,400 people/yr. use tennis courts; 910 people/yr. use area for baseball and soccer
Western Park Yankee St. & W. Spring Valley Rd.	5.2 mi. E.		
Woodbourne Green Park Main St. & W. Whipp Rd.	6.4 mi. ENE		

Table 3.3.6.2-7 (Continued)

Name and Address	Distance and Direction from Mound Laboratory	Acreage	Usage/special facilities or programs
Yankee Park Yankee St.	4.8 mi. E	26	13,002 people/yr. use areas for baseball; 4,800 people/yr. use areas for soccer
Franklin Parks (Franklin, Ohio 45005)			
Franklin Community Park between 4th & 6th Sts.	5.3 mi. S	60	2,000 people/day visit park from early June to September; 2,000-3500 people attend football games on Friday evenings in fall; 200-500 people attend football games on Monday and Thursday evenings in fall
Playground facilities are available at:			
Gerhe School Schenck School Anthony Wayne School Harmon Field Lanecrest Playground	See Table 3.3.6.2-1 for addresses and locations with respect to Mound Laboratory		Combined usage of these 5 playgrounds is about 1,000 children/day

Table 3.3.6.2-7 (Continued)

Name and Address	Distance and Direction from Mound Laboratory	Acreage	Usage/special facilities or programs
	Kettering Parks and Recreation		
Croftshire Park 4901 Croftshire	8.8 mi. ENE		Approximately 100 children/day use playground facilities during summer
Dorothy Lane Park 150 W. Dorothy Lane	8.1 mi. NE		Approximately 100 children/day use playground facilities during summer
Ernst Park 4555 Marshall	8.2 mi. ENE		500 people/day during summer
Glaser Park 1851 Doris	9.4 mi. ENE		
Hills and Dales Patterson Rd.	8.1 mi. NE		
Kantner Park 1512 Brownleigh	9.2 mi. ENE		Approximately 100 children/day use playground facilities during summer
Kettering Pool 1320 E. Stroop Rd.	8.6 mi. ENE		60,000 people/summer
Kennedy Park 5030 Polen	9.0 mi. ENE		
Rose E. Miller 3201 Marshall	9.0 mi. ENE closed		
Oak Creek Park 2316 Springmill	9.1 mi. ENE		Approximately 100 children/day use playground facilities during summer

Table 3.3.6.2-7 (Continued)

Name and Address	Distance and Direction from Mound Laboratory	Acreage	Usage/special facilities or programs
Pondview Park 2320 Pondview	9.2 mi. E		
Tait Road Park 3750 Tait Road	6.6 mi. NE		
Wenzler Park 3535 Sharewood	8.6 mi. ENE		Approximately 100 children/day use playground facilities during summer

Playground facilities are available at:

D. L. Barnes School Beavertown School Fairmont West School J. M. Holt School * Meadow Lawn School Oakview School * Orchard Park School J. E. Prass School * Southdale School	See Table 3.3.6.2-1 for addresses and locations with respect to Mound Laboratory

* Playground facilities used by approximately 100 children/day during summer

Table 3.3.6.2-7 (Continued)

Name and Address	Distance and Direction from Mound Laboratory	Acreage	Usage/special facilities or programs
	Middletown City Parks		
Gardner Park Tytus & Catalpa	9.4 mi. SW	7.2	
Jacot Park Terri Moore Circle	9.3 mi. SSW	17.5	
Miami Park Miami & Fleming	9.4 mi. SW	3.2	
Sherman Park Sherman & Wayne	9.9 mi. SSW	very small	
Sunset Park Belmont & Milton St.	9.4 mi. SSW	15.2	Swimming pool, tennis courts; 13,595 people used facilities during June 1972
	Montgomery County Recreation and Parks Department		
Carillon Park E. River Rd. Dayton, Ohio	8.2 mi. NE-NNE		
Cox Arboretum 6733 Springboro Pk. Centerville, Ohio	3.5 mi. ENE	164	
Germantown Park Walnut & Warren Germantown, Ohio	W		100 children/day use playground facilities during summer

Table 3.3.6.2-7 (Continued)

Name and Address	Distance and Direction from Mound Laboratory Acreage	Usage/special facilities or programs
Orchardly Park 399 Wonderly Ave. Dayton, Ohio	8.5 mi. NE	100 children/day use playground facilities during summer
Possum Creek Reserve Soldiers Home Rd. West Carrollton, Ohio	6.7 mi. N-NNE	
Richardson Playground Bluecrest Avenue Dayton, Ohio	7.8 mi. N	100 children/day use playground facilities during summer
Shafor Park 115 Patterson Rd. Dayton, Ohio	9.1 mi. N	100 children/day use playground facilities during summer
Waldruhe Park Springboro Pk. Centerville, Ohio	3.8 mi. ESE	

*Playground facilities are also available at:
La Veta Bauer School - See Table 3.3.6.1-1 for address and location with respect to Mound Laboratory

Blairwood School Drexel Playground Farmersville Elementary Dr. John Hole School	Jefferson School Normandy School Radcliffe School Tower Heights School	See Table 3.3.6.2-1 for addresses and locations with respect to Mound Laboratory

*100 children/day use these playground facilities during summer

Table 3.3.6.2-7 (Continued)

Name and Address	Distance and Direction from Mound Laboratory	Acreage	Usage/special facilities or programs
	Moraine City Parks		
Ahola Park		12	
Cadillac Park		1.5	
Ora Everts Park		10	
C. F. Holliday Park 4100 S. Dixie West Carrollton, O.	8.1 mi. NE	2.5	
Janco Park		5	
Moraine Meadows Park 2600 Holman Ave. Kettering	6.4 mi. ENE		
Moraine Recreation Park		40	
Frank Nicholas Park 3846 Vance West Carrollton, O.		7	Extensively used for baseball
Taylor Park		2	

Table 3.3.6.2-7 (Continued)

Name and Address	Distance and Direction from Mound Laboratory	Acreage	Usage/special facilities or programs
	West Carrollton City Parks		
Grantwood Park Grantwood Drive		Small neighborhood park	
Harmon Field Miami Ave.	3.8 mi. NNE	8	
Lake Forest Lake Forest Dr.	2.3 mi. NE	Small neighborhood park	
Orchard Hill Park Orchard Hill Dr. (to be opened in May 1973)	2.8 mi. NE	23	Pool, picnic table, tennis courts - probably will be used by several thousand people/yr.
Weidner Park		2.5	

Table 3.4-1 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

Table 3.4-2 Acreage and yield of principal food crops for Montgomery and Warren Counties*

County	Food Crop	Acreage	Yield (in bushels/acre)
Montgomery	Soybeans	22,900	35
	Corn**	40,500	83
	Wheat	10,500	45
	Oats	2,200	49
	All hay	11,400	1.65
Warren	Soybeans	25,000	31
	Corn**	31,800	80
	Wheat	6,500	41
	Oats	1,700	47
	All hay	15,800	1.60

* Figures based on 1971 preliminary estimates by the United States Department of Agriculture, Statistical Reporting Service

**Corn for grain

Table 3.4-3 Milk cows & heifers, two years and older

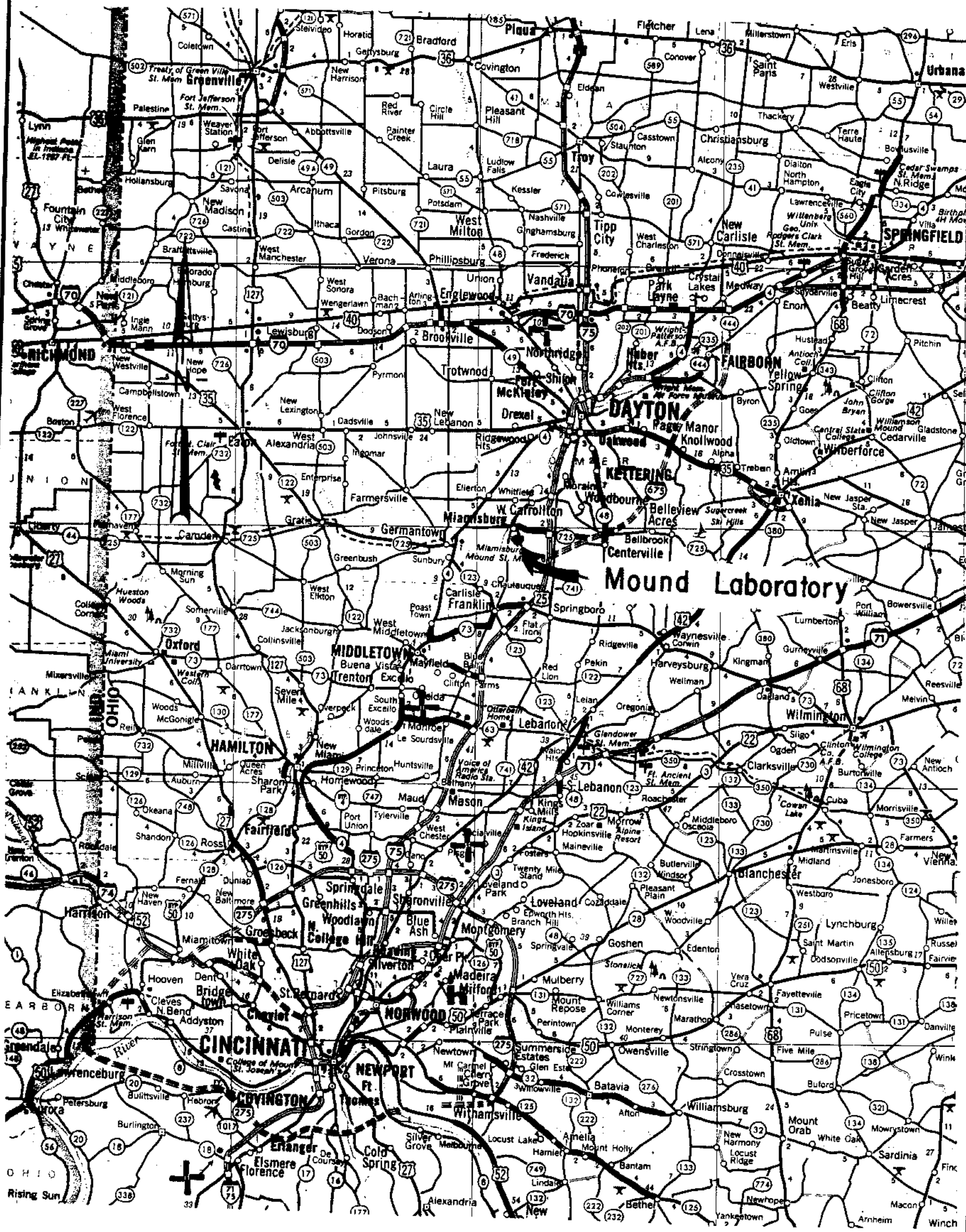
County	1960	1961	1962	1963	1964	1965	1970	1971	1972
Montgomery	6100	5800	5600	5300	5000	4500	2900	2600	2500
Warren	6600	6200	6000	5500	5200	4800	2800	2700	2600

REVISIONS BY ______ DATE ______

FILE ______

BY ______ DATE ______
CHECKED BY ______

946.7 (REV. 6-61)



Scale: One inch: approximately 9.7 miles

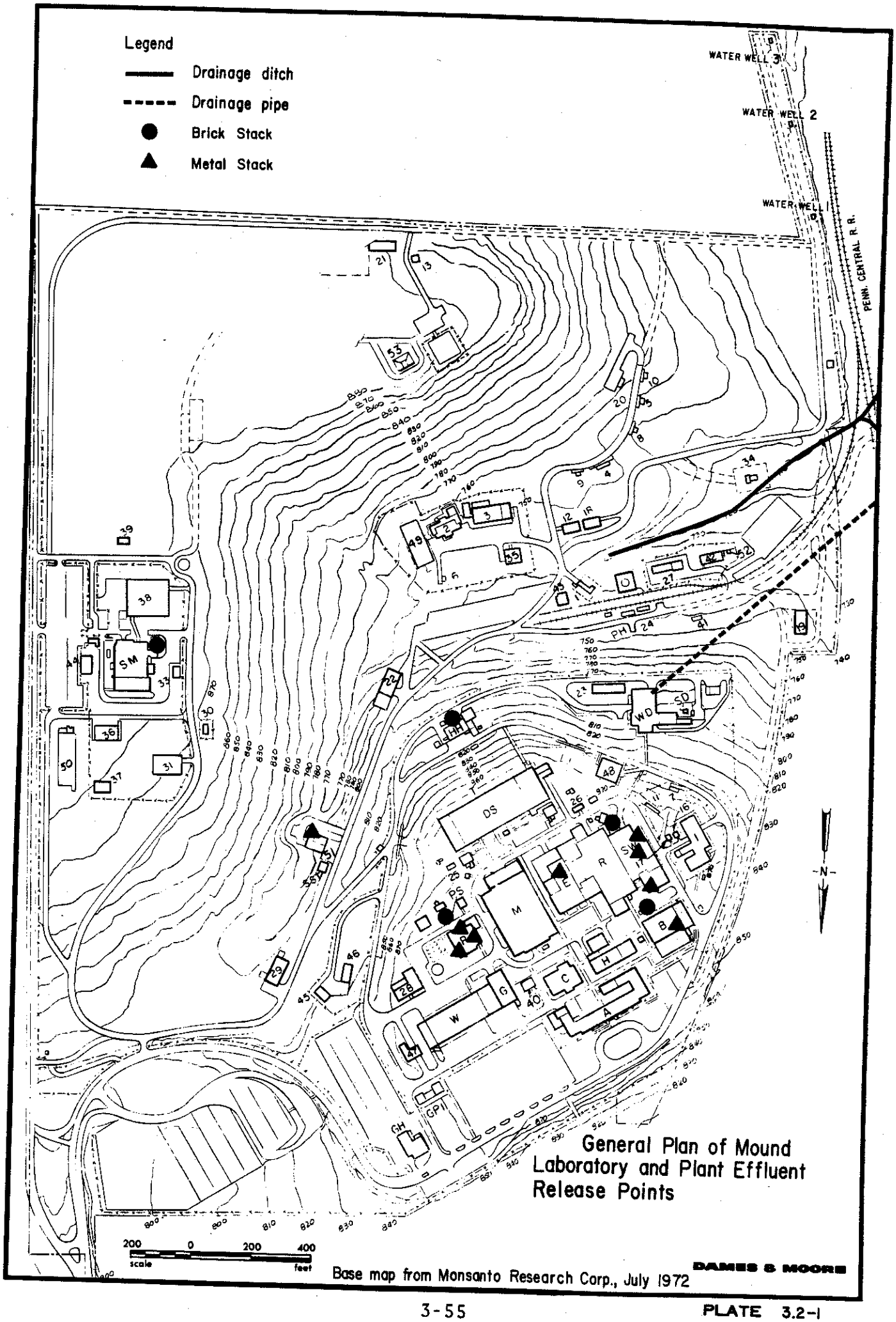
miles: 0 5 10 20
inches: 0 1 2

Site Location Map

Adapted from Sohio Road Map

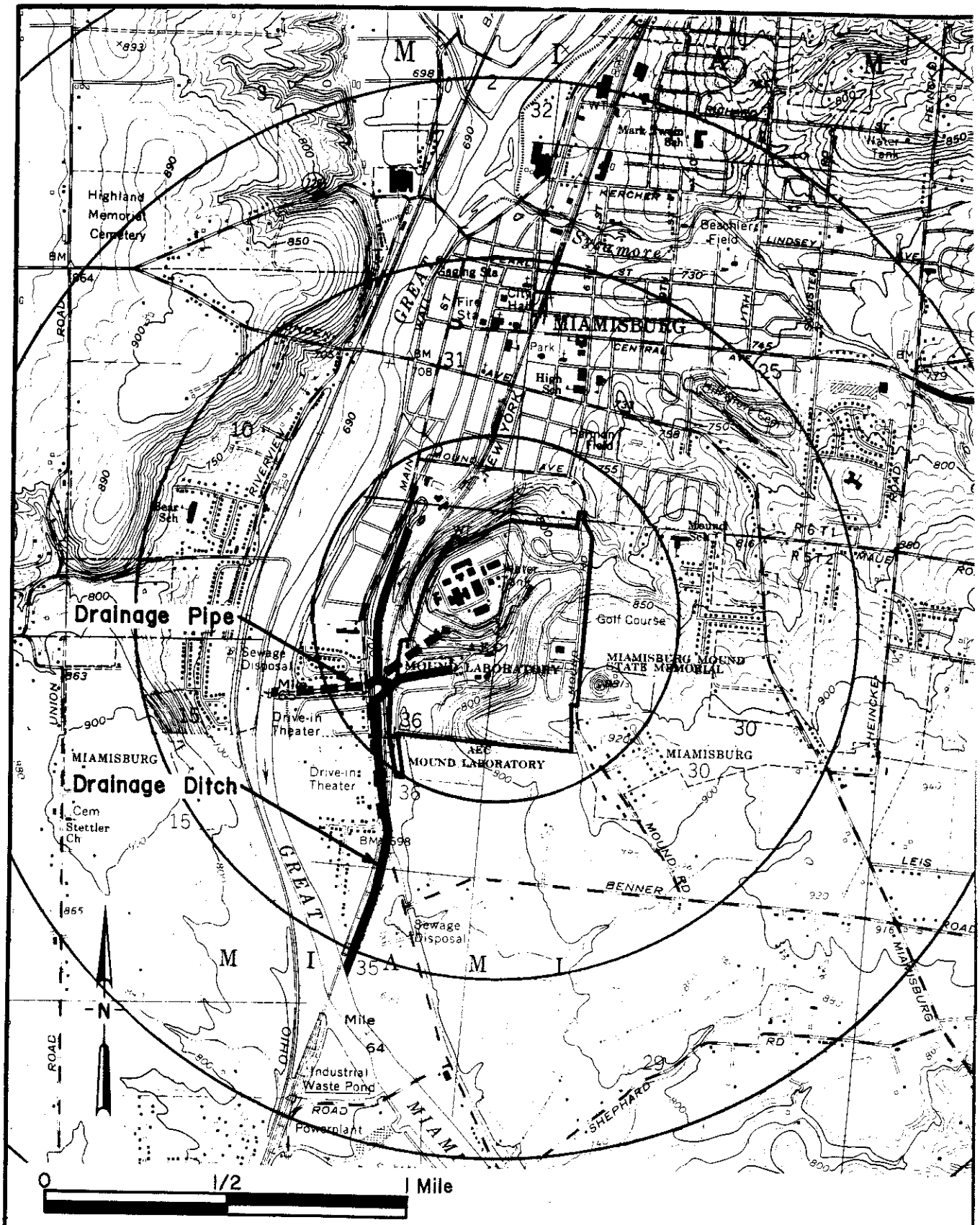
DAMES & MOORE

PLATE 3.1-1



General Plan of Mound Laboratory and Plant Effluent Release Points

PLATE 3.2-1



Plant Effluent Release Points

Circles on 1/2 Mile Radii from Center of Site

Adapted from U.S.G.S. Topographic Map

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PLATE 3.2-1a

REVISIONS BY _____ DATE _____

FILE _____

BY G.W.K. DATE 3/23

CHECKED BY _____

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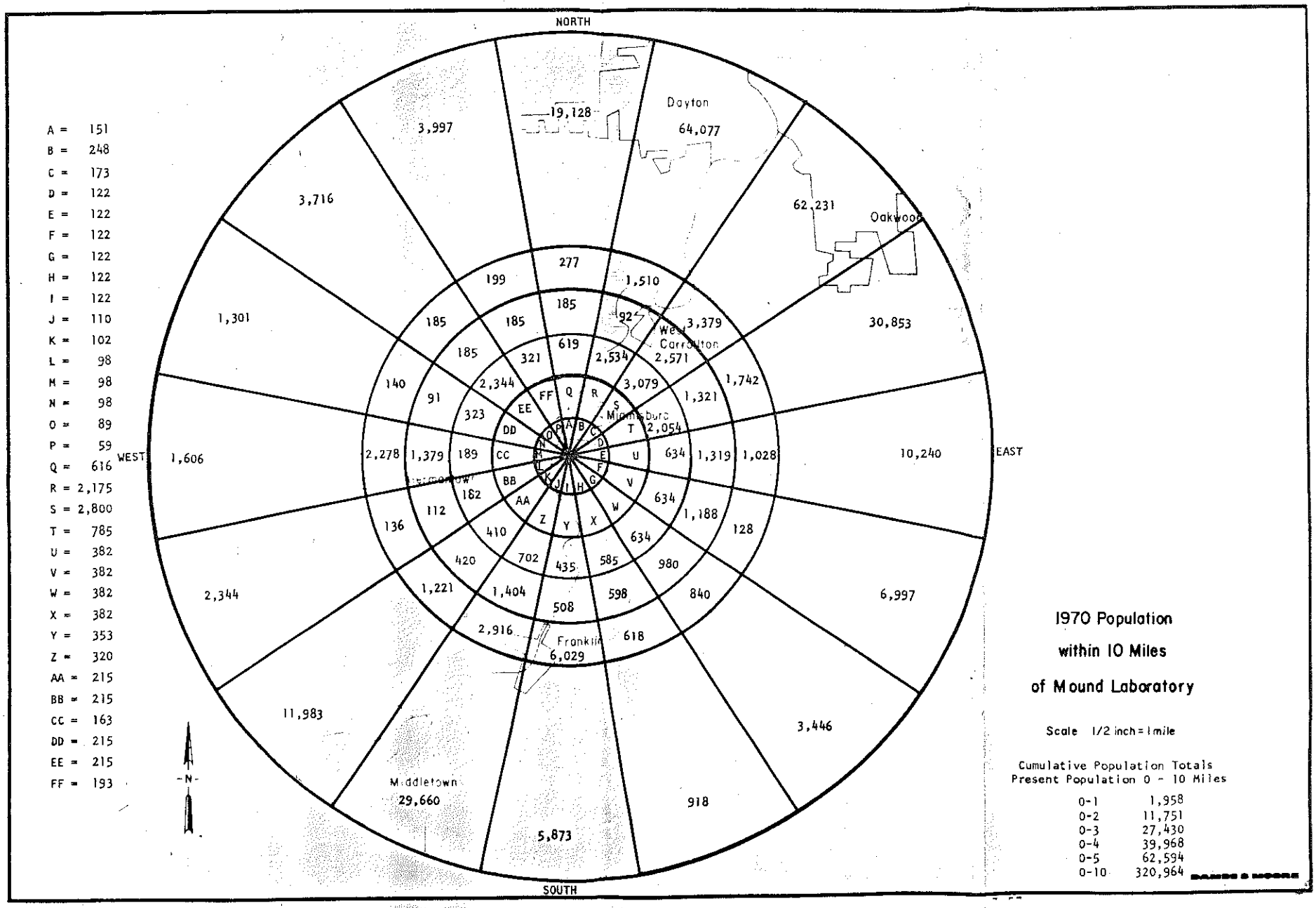
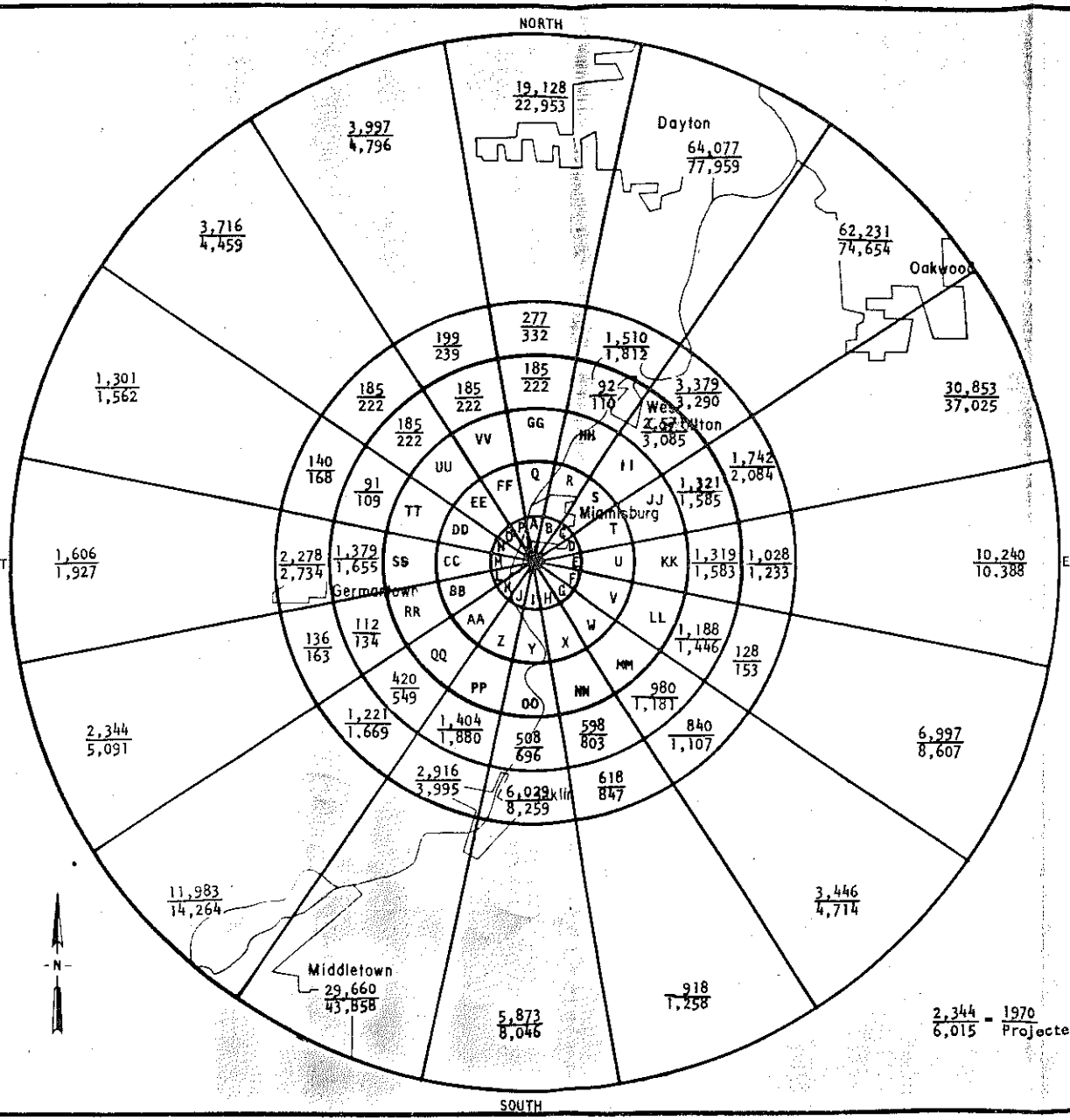

NORTH
SOUTH
WEST
EAST
Dayton
64,077
19,128
3,997
3,716
1,301
1,606
2,344
11,983
Middletown
29,660
5,873
918
3,446
6,997
10,240
30,853
62,231
Oakwood
Franklin
6,029
West Carrollton
Miamisburg
Germantown
277
199
185
185
185
185
92
619
321
2,534
2,571
3,379
1,510
140
91
323
2,344
3,079
1,321
1,742
2,278
1,379
189
2,054
634
1,319
1,028
136
112
182
410
634
1,188
128
420
702
435
585
980
1,221
1,404
508
598
840
2,916
618
N
A = 151
B = 248
C = 173
D = 122
E = 122
F = 122
G = 122
H = 122
I = 122
J = 110
K = 102
L = 98
M = 98
N = 98
O = 89
P = 59
Q = 616
R = 2,175
S = 2,800
T = 785
U = 382
V = 382
W = 382
X = 382
Y = 353
Z = 320
AA = 215
BB = 215
CC = 163
DD = 215
EE = 215
FF = 193
1970 Population
within 10 Miles
of Mound Laboratory
Scale 1/2 inch = 1 mile
Cumulative Population Totals
Present Population 0 - 10 Miles
0-1 1,958
0-2 11,751
0-3 27,430
0-4 39,968
0-5 62,594
0-10 320,964

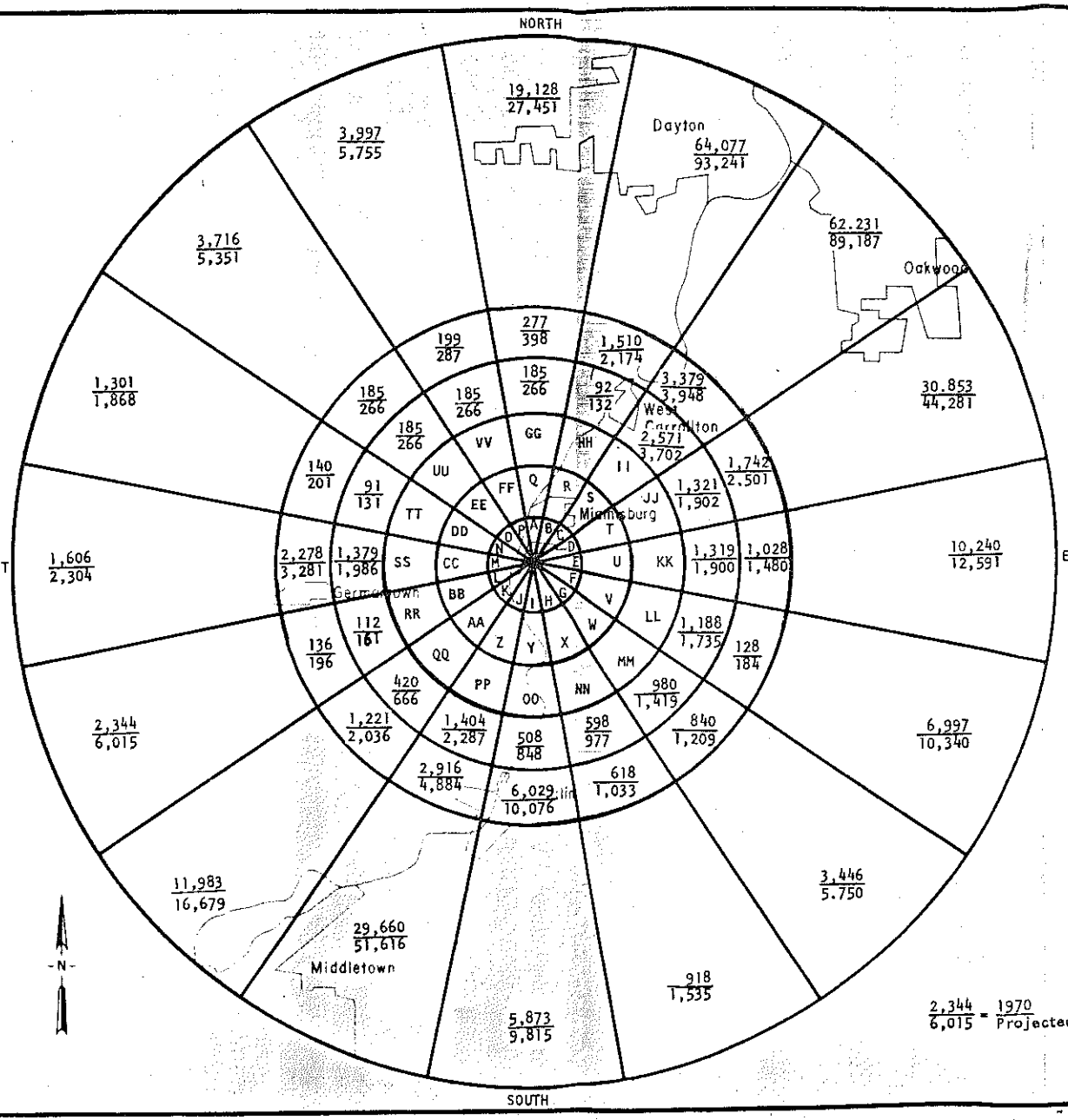


Projected 1980 Population
within 10 Miles
of Mound Laboratory

Scale 1/2 inch = 1 mile

Cumulative Population Totals
1980 Population 0 - 10 Miles

0-1	2,336
0-2	14,010
0-3	32,909
0-4	48,391
0-5	76,698
0-10	398,259



A = 151/217
B = 248/358
C = 173/249
D = 122/175
E = 122/175
F = 122/175
G = 122/175
H = 122/175
I = 122/175
J = 110/158
K = 102/146
L = 98/140
M = 98/140
N = 98/140
O = 89/128
P = 59/85
Q = 616/888
R = 2,175/3,132
S = 2,800/4,070
T = 785/1,131
U = 382/550
V = 382/550
W = 382/550

X = 382/550
Y = 353/508
Z = 320/331
AA = 215/309
BB = 215/309
CC = 163/235
DD = 215/309
EE = 215/309
FF = 193/309
GG = 619/890
HH = 2,534/3,650
II = 3,079/4,433

JJ = 2,054/2,958
KK = 634/913
LL = 634/913
MM = 634/913
NN = 585/858
OO = 435/652
PP = 702/1,075
QQ = 410/590
RR = 182/262
SS = 189/272
TT = 323/466
UU = 2,344/3,376
VV = 321/462

2,344 / 6,015 = 1970 / Projected

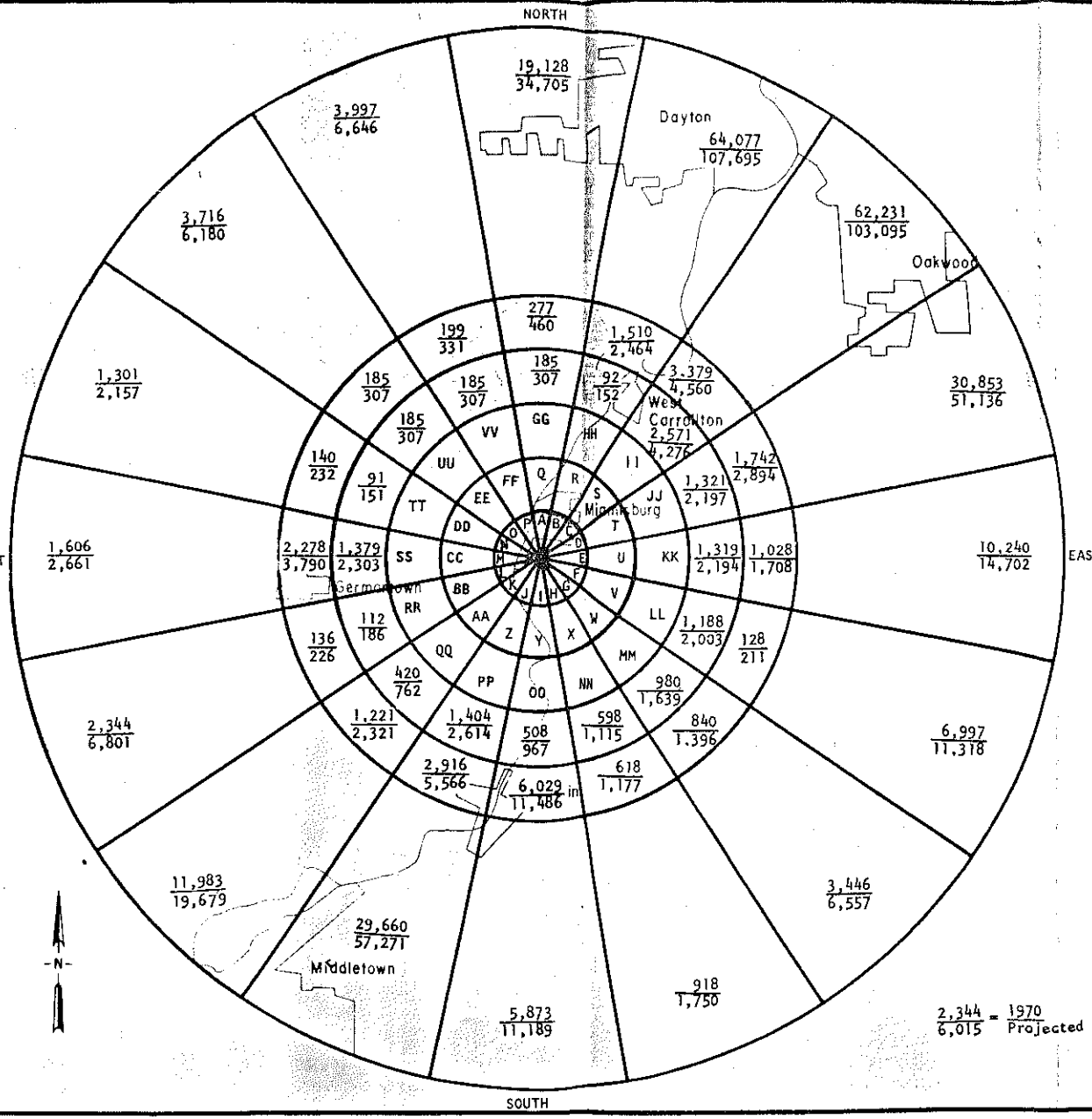
Projected 1990 Population within 10 Miles of Mound Laboratory

Scale 1/2 inch = 1 mile

Cumulative Population Totals
1990 Population 0 - 10 Miles

0-1	2,811
0-2	16,851
0-3	39,534
0-4	58,178
0-5	93,332
0-10	477,111

DAMES & MOORE



A = 151/250
B = 248/413
C = 173/287
D = 122/202
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F = 122/202
G = 122/202
H = 122/202
I = 122/202
J = 110/183
K = 102/169
L = 98/161
M = 98/161
N = 98/161
O = 89/148
P = 59/99
Q = 616/2,225
R = 2,175/3,618
S = 2,800/4,503
T = 785/1,307
U = 382/635
V = 382/635
W = 382/635

X = 382/635
Y = 353/587
Z = 320/382
AA = 215/357
BB = 215/357
CC = 163/271
DD = 215/357
EE = 215/357
FF = 193/357
GG = 619/1,028
HH = 2,534/4,216
II = 3,079/5,119

JJ = 2,054/3,417
KK = 634/1,055
LL = 634/1,055
MM = 634/1,055
NN = 585/990
OO = 435/750
PP = 702/1,233
QQ = 410/681
RR = 182/302
SS = 189/314
TT = 323/538
UU = 2,344/3,899
VV = 321/533

2,344 / 6,015 = 1970 / Projected

Projected 2000 Population within 10 Miles of Mound Laboratory

Scale 1/2 inch = 1 mile

Cumulative Population Totals
2000 Population 0 - 10 Miles

0-1	3,244
0-2	20,462
0-3	46,647
0-4	68,127
0-5	107,256
1-10	550,798

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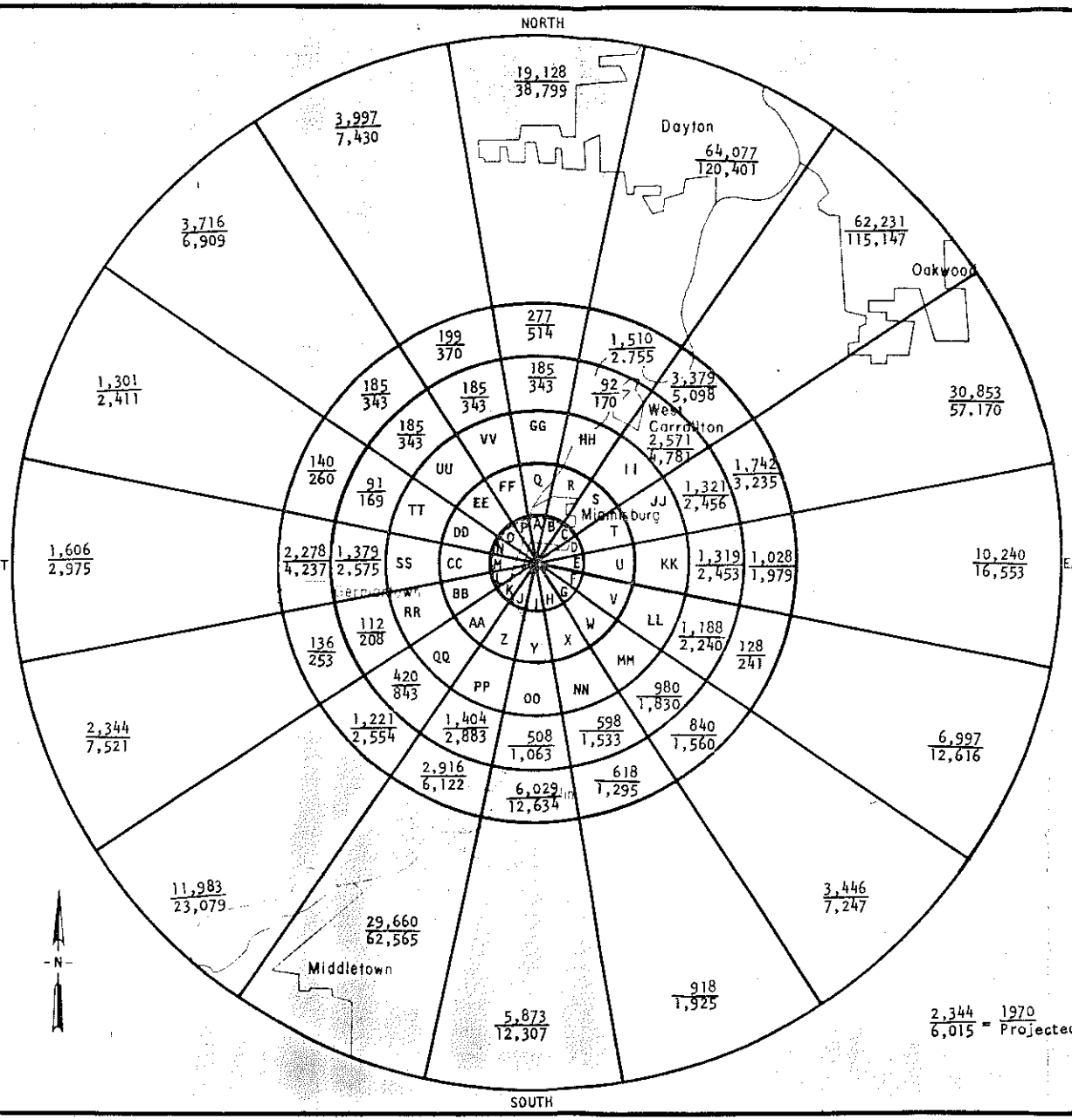


A = 151/280
B = 248/461
C = 173/321
D = 122/226
E = 122/226
F = 122/226
G = 122/226
H = 122/226
I = 122/226
J = 110/205
K = 102/189
L = 98/180
M = 98/180
N = 98/180
O = 89/165
P = 59/111
Q = 616/2,487
R = 2,175/4,045
S = 2,800/5,259
T = 785/1,462
U = 382/710
V = 382/710
W = 382/710

X = 382/710
Y = 353/656
Z = 320/427
AA = 215/399
BB = 215/399
CC = 163/303
DD = 215/399
EE = 215/399
FF = 193/399
GG = 619/1,149
HH = 2,534/4,708
II = 3,079/5,724

JJ = 2,054/3,821
KK = 634/1,179
LL = 634/1,179
MM = 634/1,179
NN = 585/1,106
OO = 435/835
PP = 702/1,368
QQ = 410/762
RR = 182/328
SS = 189/351
TT = 323/592
UU = 2,344/4,369
VV = 321/596

Projected 2010 Population within 10 Miles of Mound Laboratory

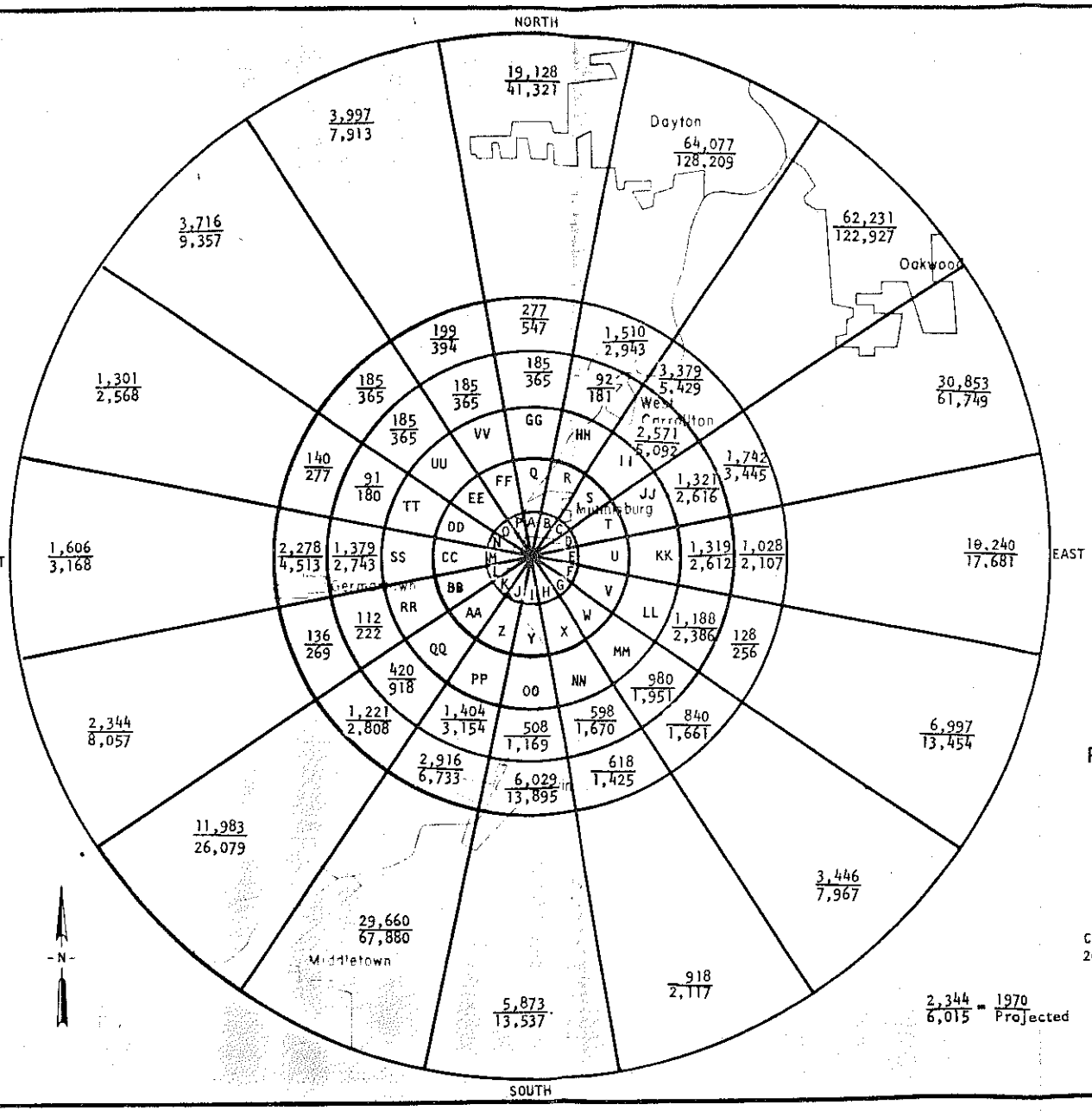
Scale 1/2 inch = 1 mile

2,344 / 6,015 = 1970 Projected

Cumulative Population Totals
2010 Population 0 - 10 Miles

0-1	3,628
0-2	23,102
0-3	52,348
0-4	76,581
0-5	120,031
0-10	615,086

DAMES & MOORE



A = 151/298
B = 248/491
C = 173/341
D = 122/240
E = 122/240
F = 122/240
G = 122/240
H = 122/240
I = 122/240
J = 110/219
K = 102/201
L = 98/192
M = 98/192
N = 98/192
O = 89/176
P = 59/119
Q = 616/2,648
R = 2,175/4,308
S = 2,800/5,596
T = 785/1,557
U = 382/756
V = 382/756
W = 382/756

X = 382/756
Y = 353/698
Z = 320/455
AA = 215/425
BB = 215/425
CC = 163/323
DD = 215/425
EE = 215/425
FF = 193/425
GG = 619/1,224
HH = 2,534/5,014
II = 3,079/5,451

JJ = 2,054/4,120
KK = 634/1,256
LL = 634/1,256
MM = 634/1,256
NN = 585/1,179
OO = 435/897
PP = 702/1,480
QQ = 410/812
RR = 182/359
SS = 189/374
TT = 323/641
UU = 2,344/4,654
VV = 321/635

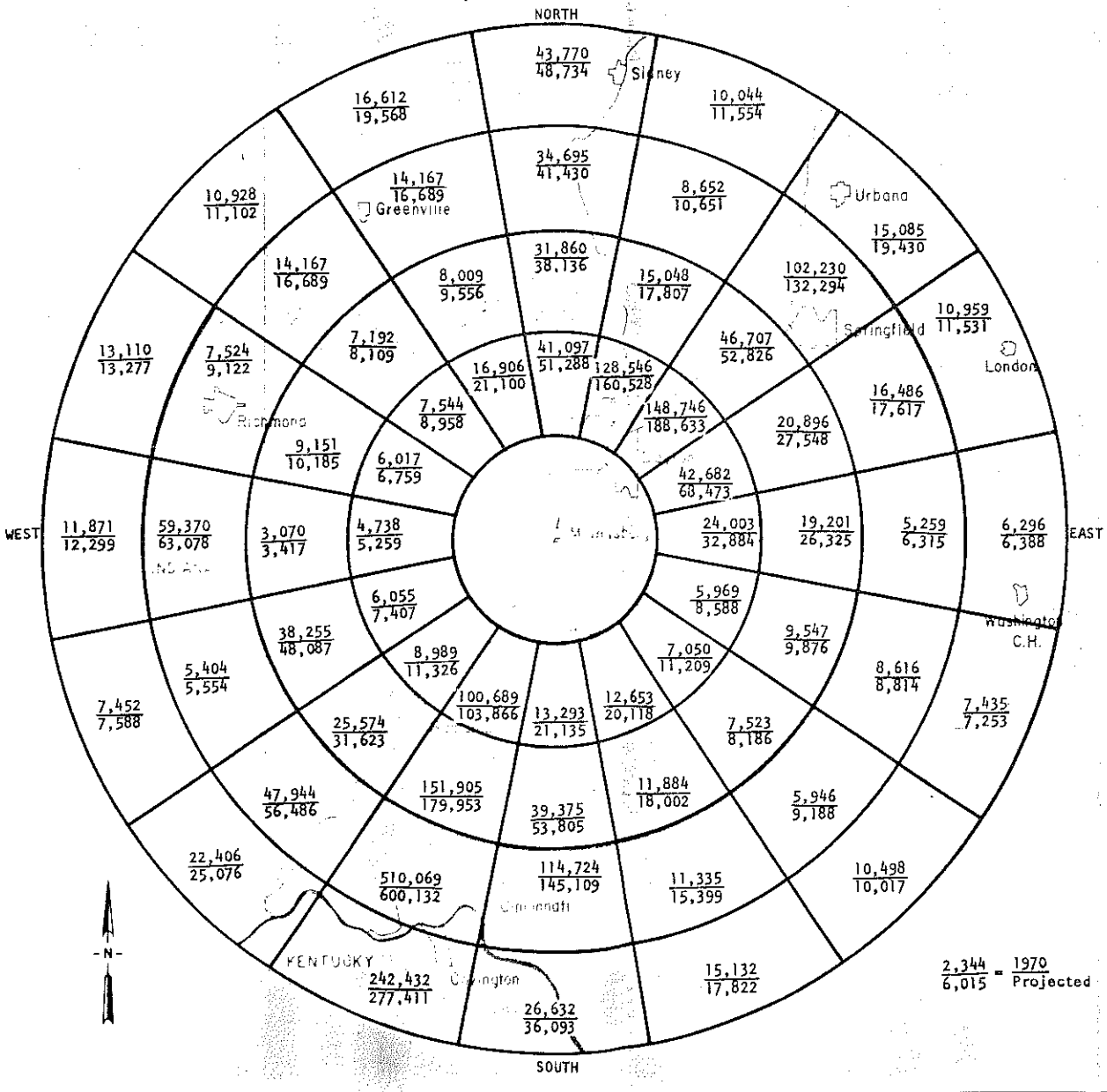
2,344/6,015 = 1970 Projected

Projected 2020 Population within 10 Miles of Mound Laboratory

Scale 1/2 inch = 1 mile

Cumulative Population Totals
2020 Population 0 - 10 Miles

0-1	3,861
0-2	24,595
0-3	55,203
0-4	81,192
0-5	128,259
0-10	662,243



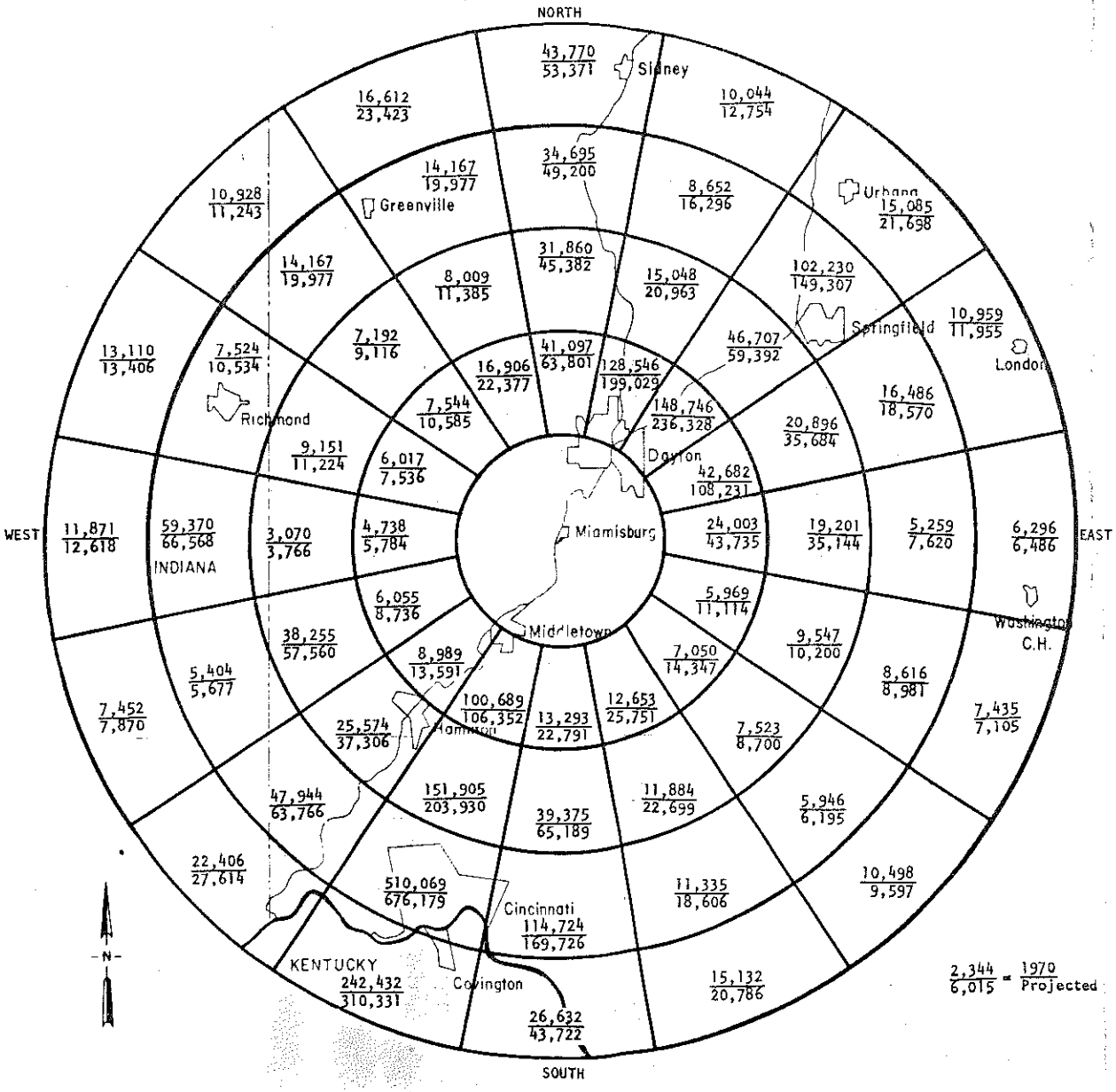
Projected 1980 Population within 50 Miles of Mound Laboratory

Scale 1 inch = 10 miles

Cumulative Population Totals
1980 Population 0 - 50 Miles

0-20	1,125,790
0-30	1,669,231
0-40	2,823,798
0-50	3,358,941

DAMES & MOORE



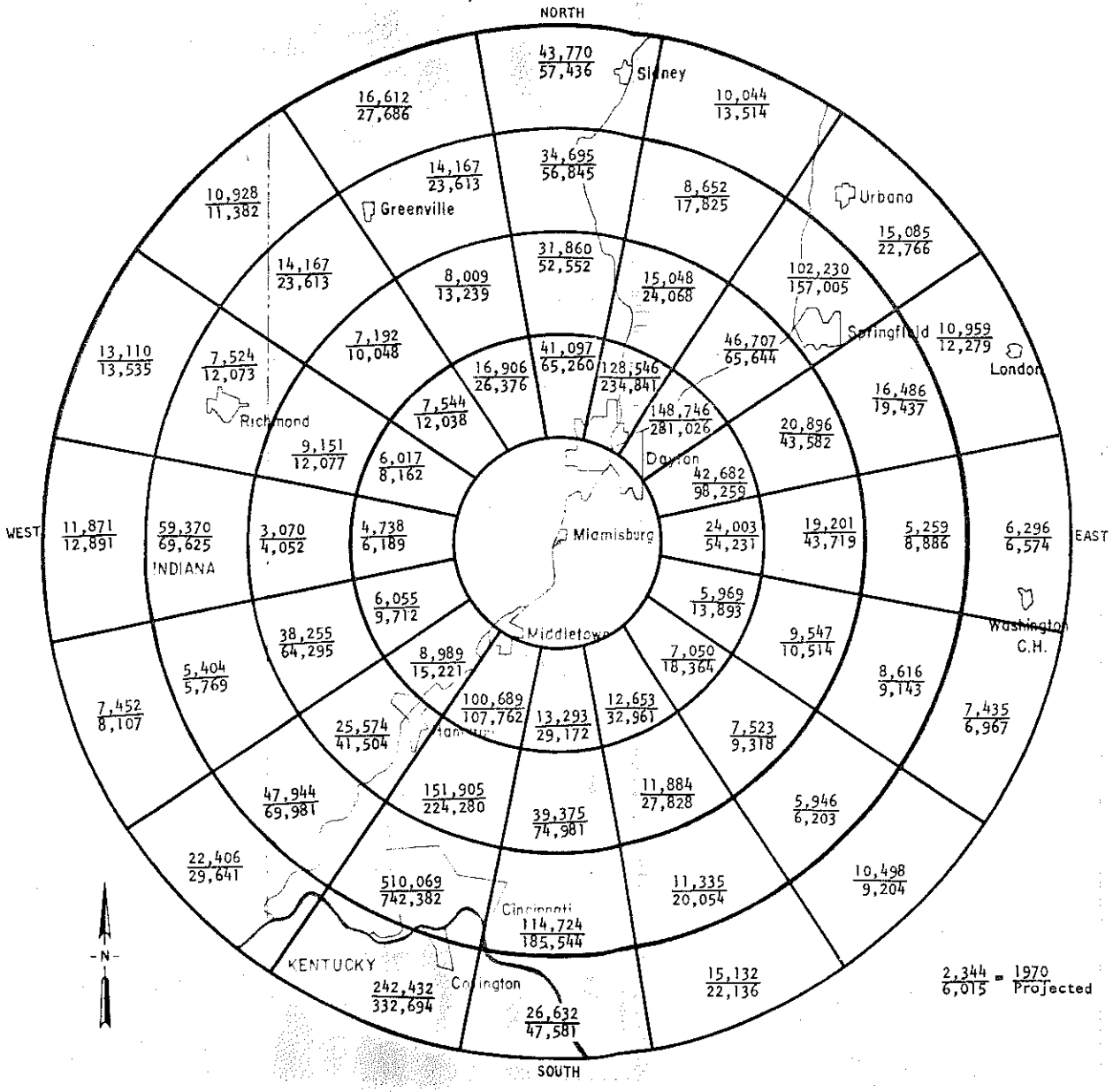
Projected 1990 Population within 50 Miles of Mound Laboratory

Scale 1 inch = 10 miles

Cumulative Population Totals
1990 Population 0 - 50 Miles

0-20	1,377,199
0-30	2,014,839
0-40	3,322,018
0-50	3,915,997

DAMES & MOORE



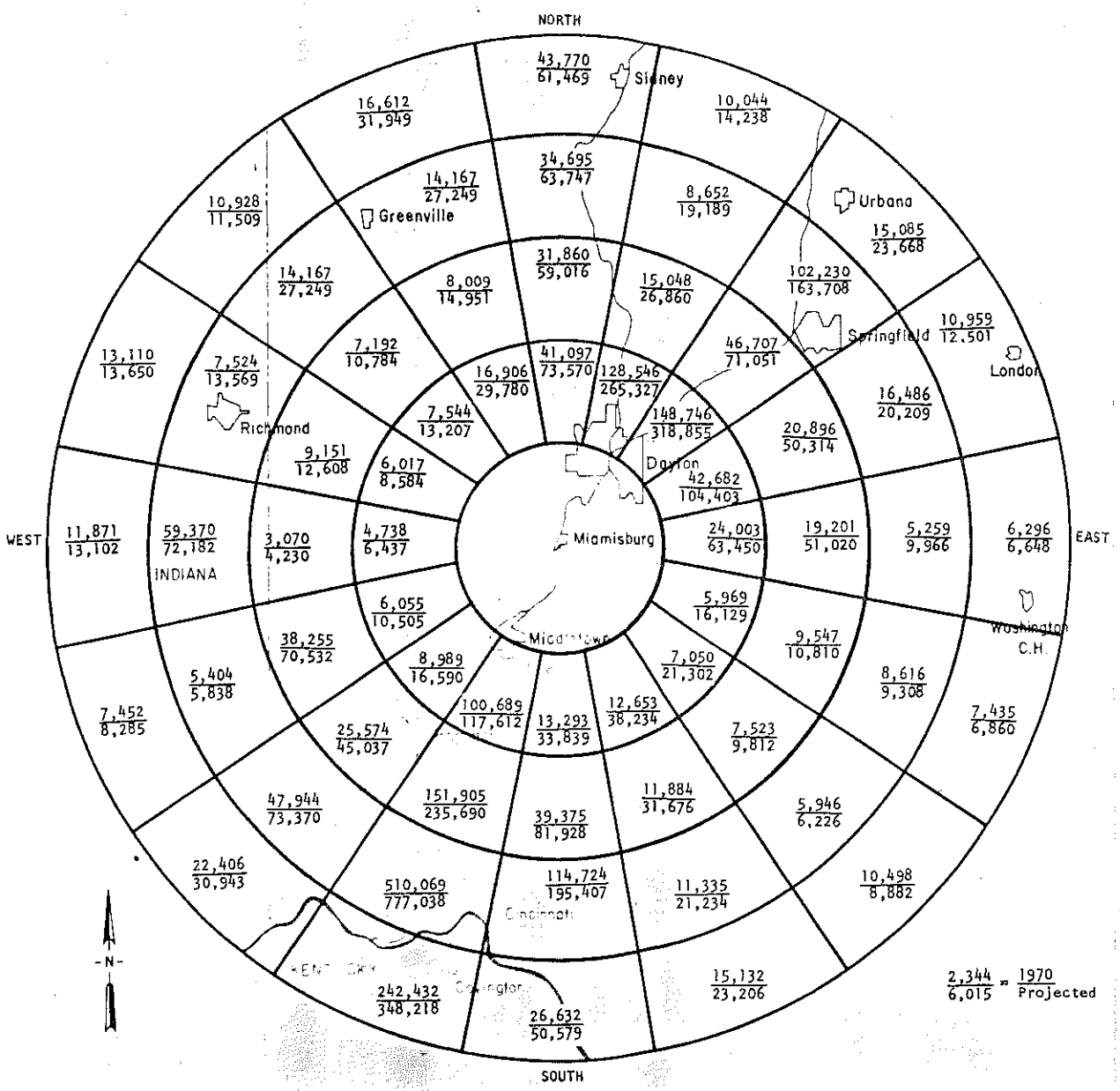
Projected 2000 Population within 50 Miles of Mound Laboratory

Scale 1 inch = 10 miles

Cumulative Population Totals
2000 Population 0 - 50 Miles

0-20	1,564,265
0-30	2,285,966
0-40	3,713,964
0-50	4,348,357

BAKER & MOORE



2,344 / 6,015 = 1970 / Projected

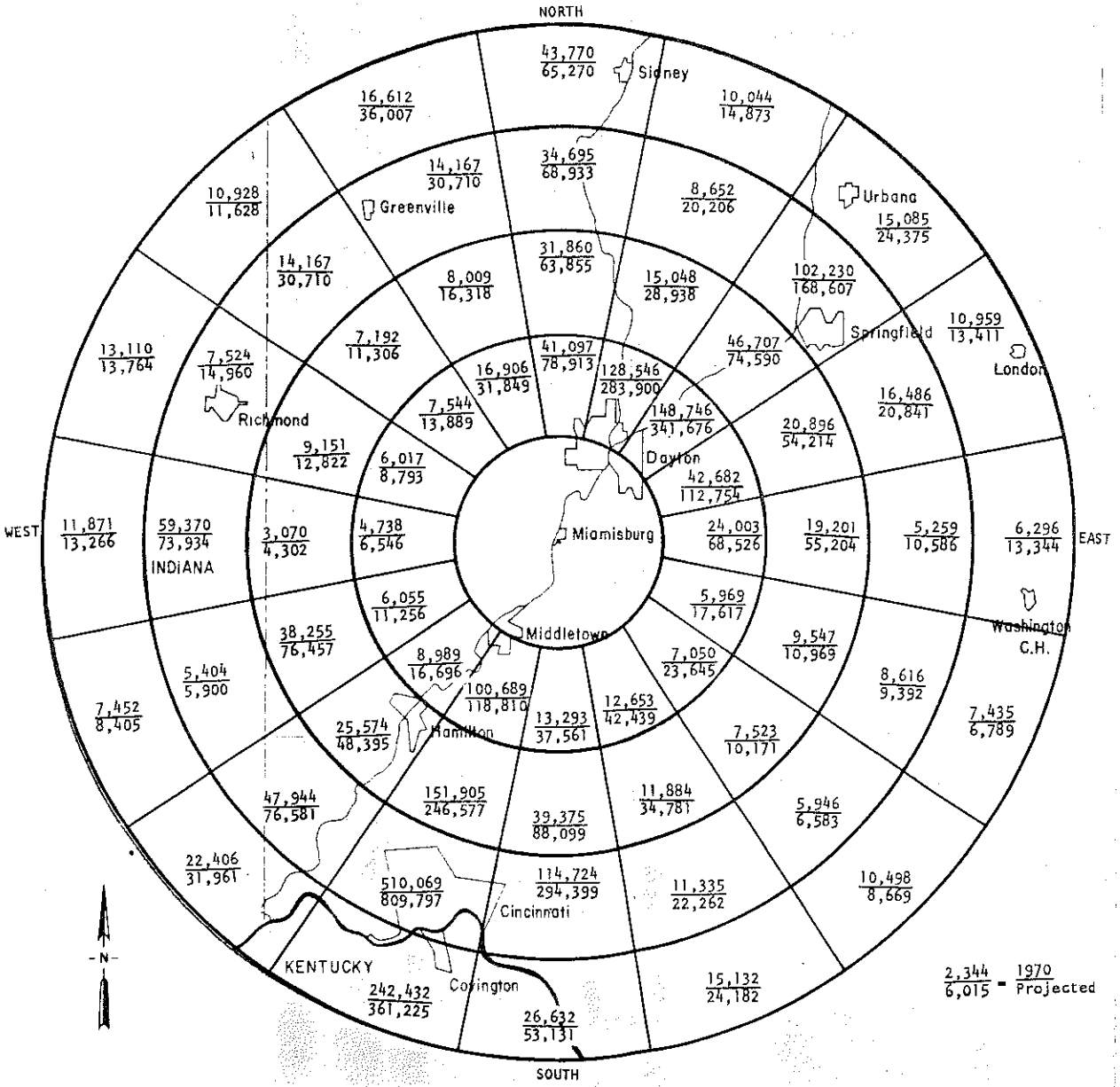
Projected 2010 Population within 50 Miles of Mound Laboratory

Scale 1 inch = 10 miles

Cumulative Population Totals
2010 Population 0 - 50 Miles

0-20	1,752,910
0-30	2,539,229
0-40	4,044,718
0-50	4,710,425

BAINES & MOORE



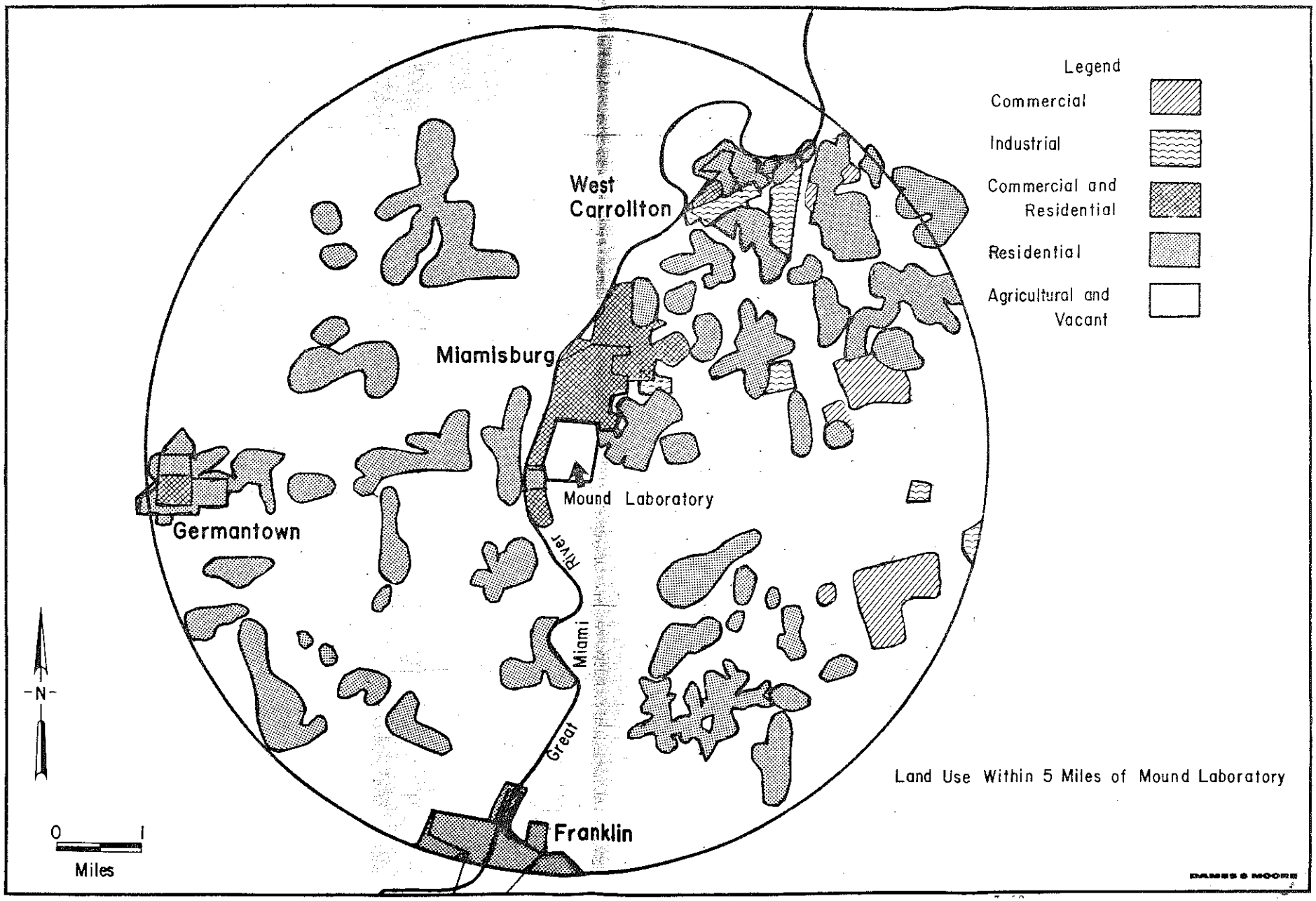
Projected 2020 Population within 50 Miles of Mound Laboratory

Scale 1 inch = 10 miles

Cumulative Population Totals
2020 Population 0 - 50 Miles

0-20	1,877,113
0-30	2,714,111
0-40	4,378,512
0-50	5,078,812

BAKER & MOORE



Land Use Within 5 Miles of Mound Laboratory

FILE 5627-002
BY JEG, GWP DATE 1-73
CHECKED BY F.W.E. DATE 9-73

466.12 (4-64)

4. NEARBY INDUSTRIAL, TRANSPORTATION AND MILITARY FACILITIES

The purpose of this section is to describe the Mound Laboratory facility location in relation to industrial, transportation and military operations in the vicinity of the site.

4.1. LOCATIONS AND ROUTES

Three maps are included (Plates 4.1-1, 4.1-2 and 4.1-3) in this section. Plate 4.1-1 shows all manufacturing plants, pipelines, storage facilities, and transportation routes within five miles of the site. Plate 4.1-2 illustrates all military bases, major transportation routes and airports within 50 miles of the site. Plate 4.1-3 shows flight path routes within 50 miles of the site for all aircraft. As Plates 4.1-1 and 4.1-2 indicate, there are presently no chemical plants, storage facilities, military bases, missile sites, government installations, or military firing ranges within five miles of the Mound Laboratory facility. One significant government facility and one military installation are located within 50 miles of the site. Wright-Patterson Air Force Base is 12 miles north-northeast and DESC (Defense Electronics Supply Center) is nine miles northeast of the site.

4.1.1. Nearby Airplane Low-Level Flight and Landing Patterns

4.1.1.1. Commercial Flights Mound Laboratory is located five miles east-southeast of Victor Airway* 47, which is an in-bound flight path to the Greater Cincinnati Airport from the north-northeast (Plate 4.1-3). The outer perimeter of this Victor Airway is generally one mile north-northwest of the site. The minimum altitude of commercial traffic on this flight path is 3,000 feet and generally greater than 7,000 feet. Mound Laboratory is situated within the limits of controlled airspace areas. The average daily volume of

*Victor Airways are federally controlled airspace flight corridors.

commercial traffic is estimated at 60 planes, with peak traffic volumes occurring between 7:00 a.m. and 7:00 p.m. The weight of a commercial jetliner varies greatly according to the model, but estimates are approximately 400,000 pounds.* Average minimum ground speed in the vicinity of Mound Laboratory is 200 m.p.h. for commercial aircraft taking off or landing. This figure varies with the type and altitude of the plane.

There are no east-west Victor Airways within ten miles of the site. Victor Airways and major airports within 50 miles of the site are shown on Plate 4.1-3.

4.1.1.2. Private Flights Very little data are maintained on private flights. Information presented in this subsection is based on estimates supplied by local FAA and airport officials.

Mound Laboratory is located within an FAA controlled airspace area. Private aircraft entering this zone are required to follow FAA commands pertaining to altitude, speed and direction. No plane is permitted to fly below 700' altitude unless taking off or landing.

Three airports surrounding Mound Laboratory serve private aircraft: Montgomery County Airport, South Dayton Airport, and Dahio Airport. Cox Municipal Airport lies 16 miles north but primarily serves commercial aircraft. The Middletown Airport lies nine miles southwest but generally serves aircraft flying between Middletown, and the Cincinnati-Dayton airports.

Montgomery County Airport reported that no planes approaching their field normally fly over the Mound Laboratory. However, if a plane approaching or taking off would fly directly over the laboratory, the minimum altitude would be 800 feet. Ground speed could vary greatly, but generally would not be less than 40 m.p.h. or more than 200 m.p.h. Montgomery County Airport officials reported that most private pilots know the location of Mound Laboratory well, and use the facility as a reference point. An average of 80 to 90 airplanes use Montgomery County Airport each day.

South Dayton Airport officials reported that aircraft approaching the field from the south or west would fly over Miamisburg. No figures were given on the altitude or ground speed of these craft, but it is assumed they are similar to those supplied by Montgomery County Airport. An average of

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*Average of the maximum take-off weights for the Boeing 707, 727, and 747.

50 aircraft takeoff or land there daily.

No data were available from Dahio Airport.

All three airports reported that the number of private flights originating or landing at their fields varied with prevailing meteorologic conditions.

4.1.1.3. Military Flights Mound Laboratory is approximately 15 miles from the Wright-Patterson Air Force Base runways, and is rather removed from normal military takeoff and landing traffic patterns. "However, there are occasions when aircraft making instrument approaches on runway 05 would fly directly over the Mound Laboratory," (Captain James R. Bowman, USAF, Deputy Chief, Office of Information). These aircraft would normally be approaching the airfield from the Cincinnati area. "Other aircraft landing on runway 05 would normally be given vectors which would turn them about 5 to 10 miles short of the Mound Laboratory Area. Approximately 1,250 overflights per year would be a reasonable estimate," (Bowman), of military traffic passing over Mound Laboratory and landing at Wright-Patterson Airfield. Takeoffs would not take aircraft into this area.

Figures are not maintained for overflights other than takeoffs or landings, and the variety of aircraft frequenting Wright-Patterson includes nearly every airplane in the Air Force inventory.

4.2. DESCRIPTION OF PRODUCTS MANUFACTURED, TRANSPORTED OR STORED IN THE AREA SURROUNDING MOUND LABORATORY

4.2.1. Products Stored or Manufactured within Five Miles

Table 4.2.1-1 and Plate 4.1-1 show the distances and compass directions of all manufacturing plants and their stored products within five miles of Mound Laboratory. Twenty-one manufacturing plants are located within this area. The Presto Adhesive Company is the only producer of volatile products. The Presto plant has a normal in-process chemical inventory of about 100 55-gallon drums of hydrocarbon solvent base coatings.

The eight paper products industries manufacture or store large quantities of combustible materials. Some of the foundries and machine tool companies store combustible liquid solvents, but in very small quantities.

Miamisburg fire officials consider the Presto Adhesive Company to be the only local producer of highly volatile materials.

4.2.2. Products Stored or Manufactured by Mound Laboratory

4.2.2.1. Explosive Materials Approximately 4,400 pounds of Class A explosives are received, stored, used for manufacturing and then shipped as manufactured parts each year. All received materials are shipped in compliance with the appropriate requirements and specifications authorized by the I.C.C. Materials are stored until needed in magazines designed in compliance with Ordinance Safety Manual AMCR 385-244. The magazines are safety inspected and certified yearly by the State of Ohio. All outgoing shipments of manufactured parts are made in approved shipping containers and under conditions of shipment which comply with appropriate I.C.C. regulations. (MRC, 1973).

4.2.2.2. Radioactive Materials Plutonium-238 containing 20 percent plutonium-239, and uranium-233 isotopes are handled at Mound Laboratory in kilogram quantities. The following isotopes are handled in lesser quantities: tritium, polonium-210, radium, thorium-229, thorium-230, protactinium-231, uranium-234, and natural uranium. There is also approximately 1650 tons of processed monazite sand, containing 45 percent thorium, stored at the Laboratory; plans are being made to sell this material and remove it from the site. The processes that use these isotopes and the handling procedures are discussed in detail in the Final Safety Analysis Reports for the individual buildings.

All explosive and radioactive materials are received by truck shipment. All manufactured items, both explosive and

radioactive, are shipped by truck. Shipments of radioactive wastes to burial sites are transported approximately 80 percent by truck and 20 percent by rail. Time of day for dispatch of either manufactured or waste materials is random during normal working hours for the shipping department, (8:00 a.m. to 5:00 p.m.), Monday through Friday.

4.2.3. Products Transported in the Area Surrounding Mound Laboratory

Mound Laboratory and the Presto Adhesive Company store, manufacture and transport the largest amounts of potentially hazardous materials within a five mile radial area. A description of materials transported to and from Mound Laboratory was included in Section 4.2.2. The Presto Adhesive Company regularly transports volatile adhesive liquids by truck to the Monarch Marking Company for manufacturing.

A wide variety of potentially hazardous materials are shipped on the nearby rail and road links by other firms.

The dual Penn Central Railroad tracks, 200 feet west of Mound Laboratory form the major rail link between Cincinnati and Dayton. Approximately 25 trains use this route daily, some transporting chemicals, volatiles and potentially explosive materials. Penn Central could not supply figures to show quantities of hazardous materials shipped, but restrictions and regulations of the Department of Transportation and the I.C.C. are strictly adhered to during transportation.

Interstate 75 lies three miles east of Mound Laboratory and is a major north-south thoroughfare; a variety of potentially hazardous materials are shipped on this road in normal commercial operations.

4.3. Evaluations

Evaluations made in this subsection are based upon information found in 4.1. through 4.2.3.

4.3.1. The Effects of Explosion of Chemicals, Flammable Gases, and Munitions

The handling of potentially hazardous materials at Mound Laboratory is evaluated in detail in the Safety Analysis Report for each process.

The nearest large natural gas transmission pipeline is 2.1 miles northeast of Mound Laboratory (Plate 4.1-1). This pipeline is 8 inches in diameter and carries a maximum* of 500,000 cubic feet of natural gas per hour at 100 P.S.I. and 32°F. According to the Dayton Power & Light Company, the maximum explosive impact generated by an accidental release would not

affect Mound Laboratory. The 8 inch natural gas pipeline leading onto the Mound Laboratory site carries a maximum* of 195,000 cubic feet of gas per hour. It could create a low magnitude explosive impact on the southeast area of the facility if an accidental release of gas and subsequent explosion followed.

Within five miles of Mound Laboratory there are no active stone quarries or mining operations which use or store munitions, nor are there any military or civilian munitions storage areas.

The Class A explosives stored by Mound Laboratory are kept in certified and inspected magazines.

4.3.2. The Potential Effects and Probabilities of Fires in Adjacent Oil and Gasoline Plants or Storage Facilities, Adjacent Industries, Brush and Forest Fires and from Transportation Incidents

No significant petroleum processing or storage facilities are within five miles of Mound Laboratory. The Presto Adhesive Company is the only potential industrial fire hazard within this area (Table 4.2.1-1). If the plant were totally destroyed by fire, it is unlikely that there would be a significant impact on Mound Laboratory. The nearest facility building is 1,300 feet southeast of Presto Adhesive, and approximately 130 feet higher in elevation. The steep bluff separating the two plants would absorb a maximum potential explosive shock, and the large open space area separating the bluff from laboratory buildings would act as a fire break.

The potential of brush or forest fires on or adjacent to Mound Laboratory is minimal. There is a limited area of trees and brush on the eastern hillside of the valley bisecting the plant site. Any potential grass fire could be readily extinguished by the plant's fire fighting equipment. The adjacent areas are typically urban or developed, with limited forested land. Some trees and brush grow on the property's northwest perimeter; however, it is anticipated that a maximum intensity fire would have a low magnitude impact because of a relatively low density of ground cover and the distance from facility buildings.

The most potentially significant site of a transportation accident is the dual Penn Central Railroad tracks 200 feet west of the site. Although shipments of hazardous materials

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*The figures quoted are the maximum quantities of gas which can be carried in the pipelines at the temperature and pressure given.

follow Department of Transportation and I.C.C. safety requirements, a train derailment could create a potentially hazardous situation. A high magnitude explosion on these tracks could create an impact on the northwest buildings complex. The 130 foot bluffs separating the railroad tracks from the facility would absorb much of the explosive impact. Possibly, buildings closest to the bluff may receive some superficial damage from the air blast generated by a large explosion.

Strict safety precautions are implemented for the handling and processing of on-site toxic gases. These hazards are discussed in the process Safety Analysis Reports.

Toxic gases generated by the nearby foundries, including carbon dioxide and sulphur dioxide, are insignificant and do not affect any critical facility components.

Toxic gas release by nearby railroad accidents are not expected to create a significant impact. The facility's relatively higher elevation would minimize the effect of heavy gases (chlorine, bromine, iodine) which would tend to settle in low lying areas.

4.3.3. The Effect of Possible Aircraft Impacts on the Facility

The location of nearby airports and low level flight landing paths were discussed in subsection 4.1.2. Various personnel from the surrounding airports (including airport managers and FAA officials) were requested to give their opinion of the probability of a plane crashing into Mound Laboratory, given its position relative to nearby landing approaches and flight paths. The unanimous response was that the probability is almost zero. Three reasons given are:

1. Elevation of the plant relative to normal flight and approach altitudes.

2. Plant site position relative to the center of major Victor Airways.

3. General lack of past accidents or near accidents in the immediate Mound Laboratory vicinity.

Between 1964 and 1971, 11 airplane accidents occurred within five miles of the Mound Laboratory. (Reported by the National Transportation Safety Board). Four of these accidents occurred at Miamisburg, and no injuries were reported. Two minor injuries were reported for the 11 accidents.

Common aircraft specifications are included in Table 4.3.3-1. It is concluded that the possibility of an accident resulting from aircraft impact is extremely remote.

REFERENCES CITED

United States Department of Commerce, 1972, Cincinnati Sectional Aeronautical Chart: Washington, D. C.

Jane's, 1972, All The World's Aircraft: London Samson, Low, Marston & Company, Ltd.

_____, 1970, Traffic Survey Report: Ohio Department of Highways

PERSONS AND AGENCIES CONTACTED

Airport Manager, Montgomery County Airport, Dayton, Ohio

Airport Supervisor, South Dayton Airport, Dayton, Ohio

Aplund, (Mr.), Dayton Power & Light Company, Miamisburg, Ohio

Secretary, Atlas Tool & Die, Germantown, Ohio

Ed Benson, Penn Central Railroad, Dayton, Ohio

Robert Benson, Monsanto Research Corporation, Miamisburg, Ohio

Secretary, Bergstrom Paper Co., West Carrollton, Ohio

James R. Bowman, Captain, Department of the Air Force, Office of Information, Wright-Patterson Air Force Base, Ohio

Childers, (Mr.), Federal Highway Administration, Bureau of Motor Carrier Safety, Cincinnati, Ohio

John L. Crawford, National Transportation Safety Board, (Bureau of Aviation Safety), Department of Transportation, Washington, D. C.

Workman, Dayton Steel & Foundry Co.Warehouse, Miamisburg, Ohio

Secretary, Dayton Sure Grip & Shore, Miamisburg, Ohio

Secretary, R. L. Drake Co., Miamisburg, Ohio

Secretary, Dupp's, Germantown, Ohio

Federal Aviation Administration, Air Traffic Control Tower, Greater Cincinnati Airport, Cincinnati, Ohio

Federal Aviation Administration, Airport Traffic Control Tower, James M. Cox, Dayton Municipal Airport, Vandalia, Ohio

Federal Railroad Administration, Bureau of Railroad Safety, Cincinnati, Ohio

Robert Ford, Monsanto Research Corporation, Miamisburg, Ohio

Salesman, Gross Brothers, Inc., Miamisburg, Ohio

Secretary, Interstate Folding Box Company, Miamisburg, Ohio

Secretary, Janesville Products, Franklin, Ohio

Art Jonas, Monarch Marking Company and Presto Adhesive Co., Miamisburg, Ohio

Secretary, Karrolton Envelope, Miamisburg, Ohio

Menker, Captain, Miamisburg Fire Department, Miamisburg, Ohio

Secretary, Miami Valley Industries, Franklin, Ohio

Workman, Miami Valley Paper Company, Franklin, Ohio

Secretary-Receptionist, Miami Foundry, Miamisburg, Ohio

Secretary, Miller Tool & Die Company, Miamisburg, Ohio

Secretary, Osborne Container Company, Miamisburg, Ohio

Secretary, Oxford Paper Company, West Carrollton, Ohio

Dale Rop, (Inspector on Duty), Flight Service Station, Lunken Airport, Cincinnati, Ohio

Roth, (Mr)., Dayton Power & Light, Dayton, Ohio

Secretary, St. Regis (Howard Division), Franklin, Ohio

Secretary, White Villa Foods, West Carrollton, Ohio

Table 4.2.1-1 Manufacturing plants within five miles of Mound Laboratory

Plant Name	Distance and Direction from Mound Laboratory	Products Manufactured	Volatile or Explosive Material Stored or Manufactured
Presto Adhesive Paper Co.	0.4 mi. NNW	Glues and Adhesives	Yes
Gross Brothers, Inc.	0.4 mi. NNW	Vinyl Adhesives	No
Miami Foundry	1.3 mi. N	Iron and Steel	No
Dayton Steel Foundry Co. Warehouse	1.5 mi. N	Steel Warehouse	No
Interstate Folding Box Co.	1.5 mi. N	Paper Boxes	No
Osborne Container Co.	1.6 mi. N	Paper Containers	No
Miller Tool & Die	1.6 mi. N	Tool and Dies	No
R. L. Drake Co.	1.4 mi. N	Radio Equipment	No
Dayton Sure Grip & Shore	1.5 mi. N	Cement Producgs	No
Karrolton Envelope	1.3 mi. NNW	Paper Envelopes	No
Janesville Products	4.8 mi. SSW	Felt	No
Miami Valley Ind.	4.8 mi. SSW	Paper Products	No
Miami Valley Paper	4.8 mi. SSW	Paper Products	No
Hollywood Hedstadt	4.3 mi. SSW		No

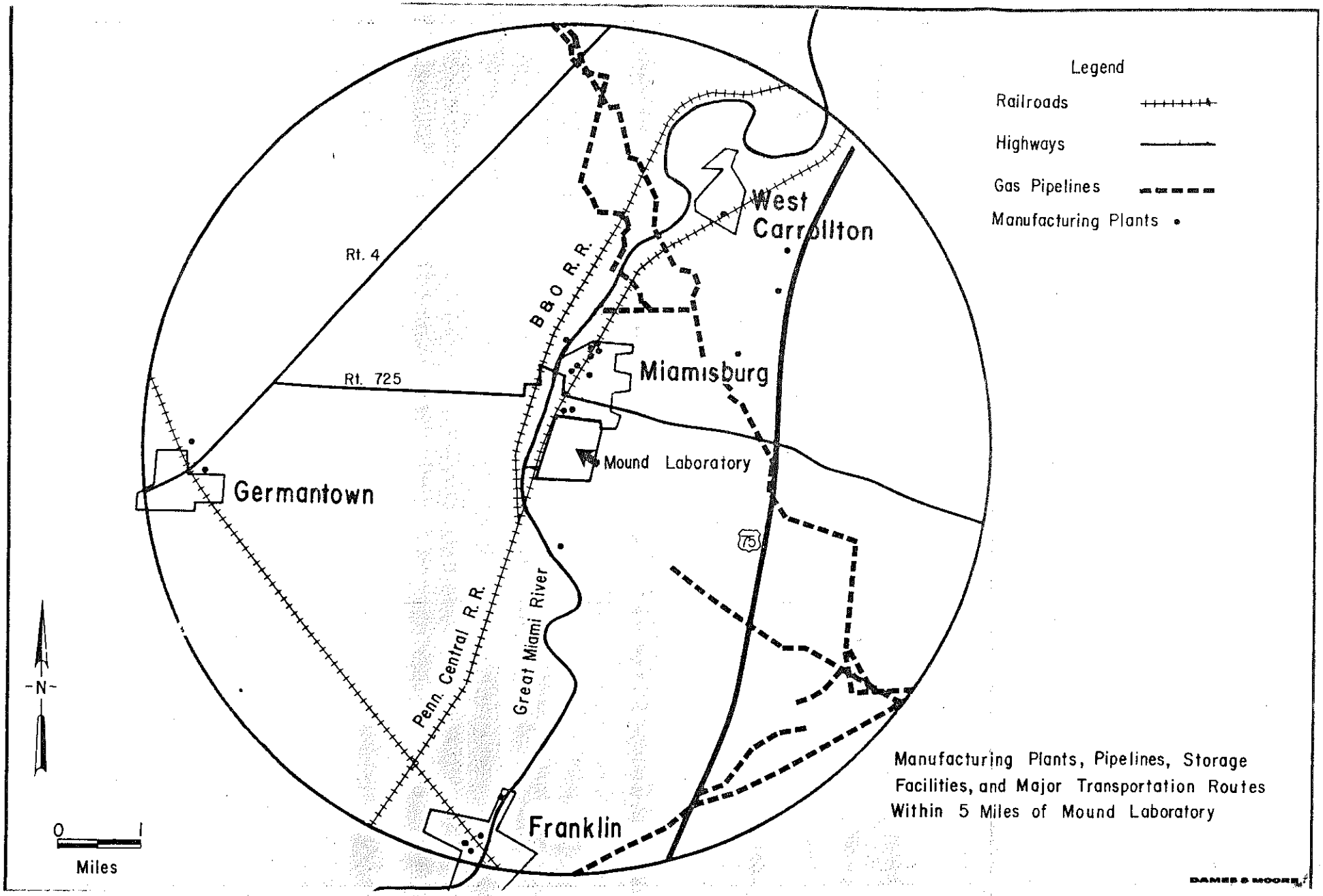
Table 4.2.1-1 (Continued)

Plant Name	Distance and Direction from Mound Laboratory	Products Manufactured	Volatile or Explosive Material Stored or Manufactured
St. Regis, (Howard Div.)	4.3 mi. SSW	Paper Products	No
Dupp's	4.2 mi. W	Iron and Steel Products	No
Atlas Tool and Die	4.2 mi. W	Tools and Dies	No
Monarch Marking	2.6 mi. ENE	Adhesive Products	No
White Villa	3.7 mi. NE	Food Products	No
Bergstrom Paper Co.	4.0 mi. NE	Paper Products	No
Oxford Paper Co.	3.3 mi. NE	Paper Products	No
Dayton Power & Light	1.5 mi. SSW	Electrical Power	No

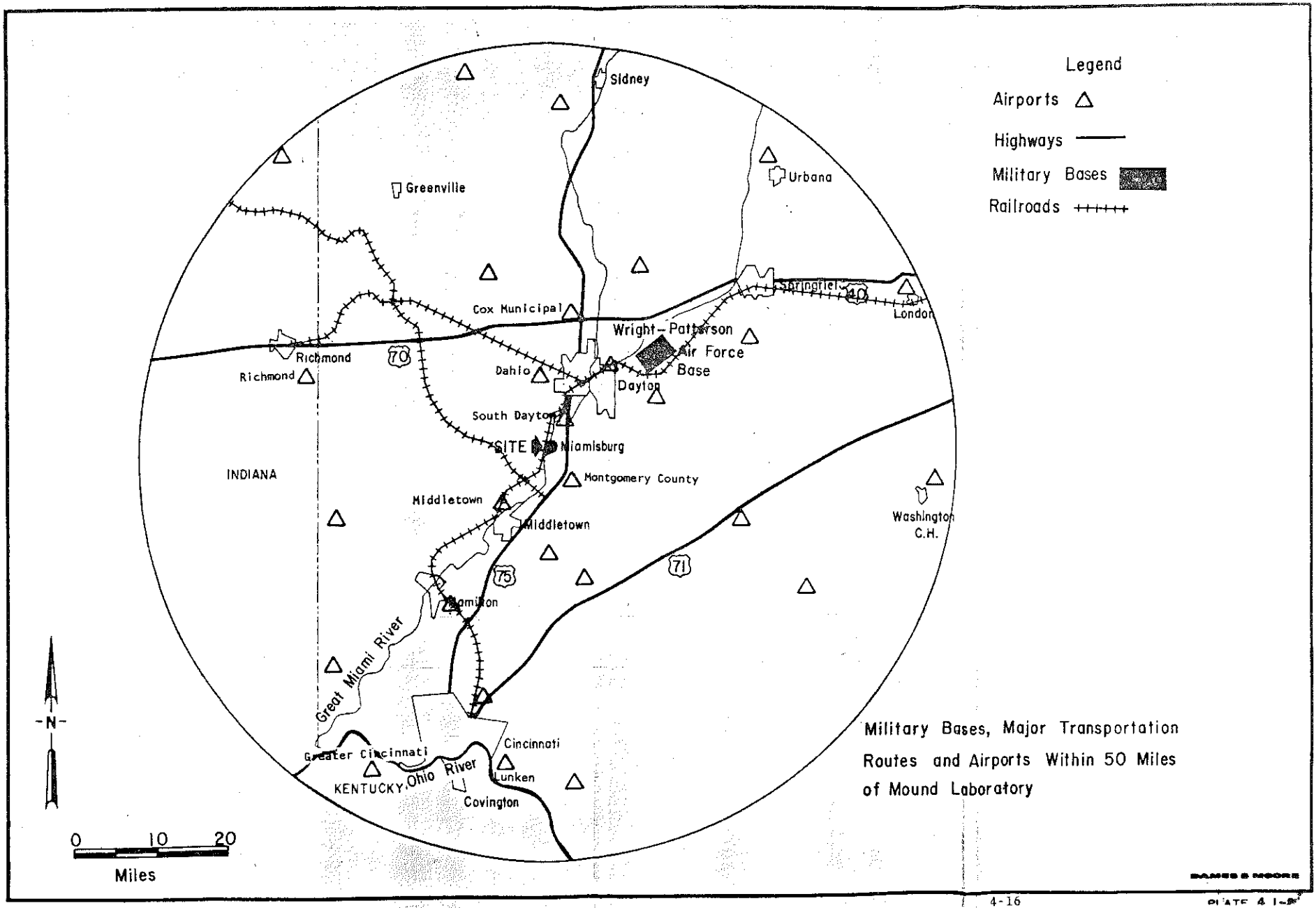
Table 4.3.3-1 Common Aircraft Specifications*

Model	Maximum T-O Weight	Max. Ground Speed (@ Max. T-O Weight)	Fuel Capacity (Maximum)
Beechcraft Bonanza (G33)	3,300 lbs.	224 MPH	44 gals.
Beechcraft King (Air Model C 90)	10,100 lbs.	287 MPH	384 gals.
Boeing 707	333,600 lbs.	600 MPH	23,855 gals.
Boeing 727	≅ 160,000 lbs.	632 MPH	2,520 gals.
Boeing 747	710,000 lbs.	595 MPH	47,210 gals.
Cessna (210 Centurion 1)	3,800 lbs.	200 MPH	90 gals.
Cessna (Citation 500 Series)	10,350 lbs.	330 MPH	--

*From Jane's, All the World's Aircraft (1972)

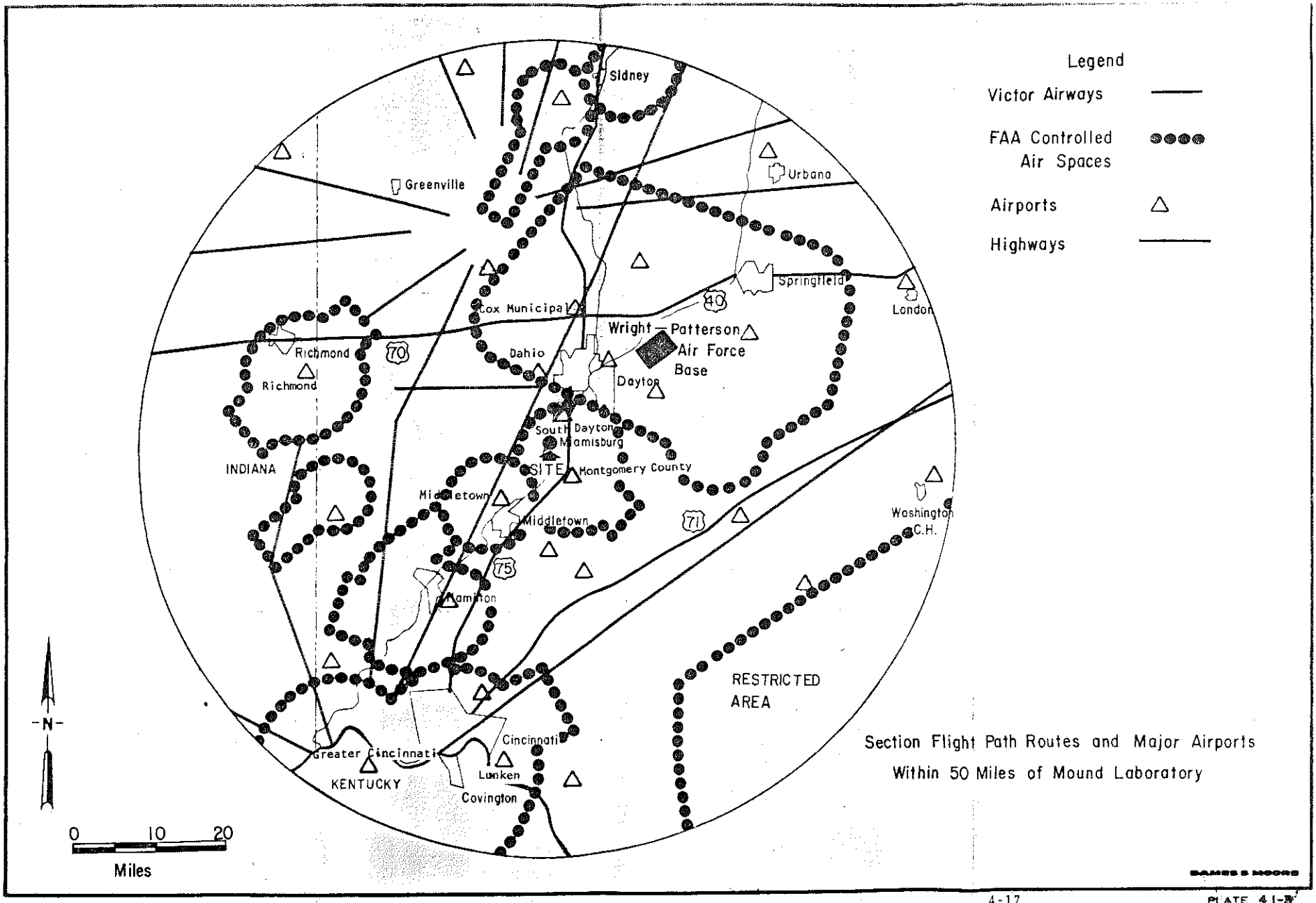


Manufacturing Plants, Pipelines, Storage Facilities, and Major Transportation Routes Within 5 Miles of Mound Laboratory



Military Bases, Major Transportation Routes and Airports Within 50 Miles of Mound Laboratory

PLATE 4 1-5



Section Flight Path Routes and Major Airports Within 50 Miles of Mound Laboratory

PLATE 4 1-3

5. METEOROLOGY

5.1. REGIONAL METEOROLOGY

5.1.1. Data Sources

Sources used in the preparation of the regional meteorology include:

5.1.1-A "Climatic Summary of the United States - Supplement for 1951 through 1960 - Ohio." U.S. Department of Commerce, Weather Bureau, Washington, D.C., 1964.

5.1.1-B Hershfield, David M. - "Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years" U.S. Government Printing Office, Washington, D.C., May 1961.

5.1.1-C "Maximum Recorded United States Point Rainfall for 5 Minutes to 24 Hours at 296 First Order Stations." Technical Paper No. 2, U.S. Weather Bureau, Washington, D.C., 1963.

5.1.1-D "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 10,000 Square Miles and Duration of 6, 12, 24 and 48 Hours." Hydrometeorological Report No. 33, Washington, D.C., April 1956.

5.1.1-E "Climates of the States, Ohio." U.S. Department of Commerce, Weather Bureau, Washington, D.C., December 1959.

5.1.1-F "Local Climatological Data, Dayton, Ohio." U.S. Department of Commerce, ESSA, Environmental Data Service, 1971.

5.1.1-G "Local Climatological Data, Cincinnati, Ohio." U.S. Department of Commerce, ESSA, Environmental Data Service, 1968.

5.1.1-H Visher, Stephen S. - "Climatic Atlas of the United States." Harvard University Press, Cambridge, Massachusetts, 1966.

5.1.1.I Private Communication with Dr. Jerry M. Davis, Ohio State Climatologist, January 1973.

5.1.1-J Thom, H.C.S. - "Tornado Probabilities." Monthly Weather Review, October-December 1963.

5.1.1-K Cry, George W. - "Effects of Tropical Cyclone Rainfall on the Distribution of Precipitation over the Eastern and Southern United States." ESSA Professional Paper 1, U.S. Department of Commerce, Washington, D. C., June 1967.

5.1.1-L Thom, H.C.S. - "New Distributions of Extreme Winds in the United States." Journal of the Structural Division, Proceedings of the ASCE, July 1968.

5.1.1-M Holzworth, George C. - "Mixing Heights, Wind Speeds and Potential for Urban Air Pollution Throughout the Contiguous United States." Environmental Protection Agency, Research Triangle Park, North Carolina, January 1972.

5.1.2. General Climate

Mound Laboratory is located within the city limits of Miamisburg, Ohio, and adjacent to the Great Miami River. The maximum site elevation is approximately 880 feet above mean sea level (msl) while the river is at about 683 feet msl. Some terrain elevations of 900 to 1,000 feet msl are found near the site.

The climate of the area is continental in nature, characterized by moderate extremes of heat and cold. Summers are rather warm and humid, but temperatures rarely exceed 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.

Precipitation is rather evenly distributed through the year with an annual average of about 40 inches. Snowfall averages about 27 inches per year. (Data source 5.1.1-A).

Severe weather is mostly associated with heavy thunderstorms. Damaging winds, local flash flooding, and even an occasional tornado may result. Most tornadoes, however, are of limited effect having paths that are short and narrow. The

frequency of general flooding in Ohio is about one in three years. Destruction from tropical cyclones is almost unknown in this area.

The interplay between synoptic scale processes and topography is minimal in this area. 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.

5.1.3. Severe Weather

This section is concerned with conditions which represent wide deviations from the general climate such as the intensity and frequency of occurrence of heavy precipitation, hail, ice storms, thunderstorms, tornadoes, strong winds, and high air pollution potential.

5.1.3.1. Precipitation Estimated rainfall maxima (inches) for the region are:

	Return Period (years)						
Duration	1	2	5	10	25	50	100
30 min.	0.87	1.07	1.30	1.50	1.75	1.90	2.15
1 hr.	1.10	1.33	1.68	1.90	2.20	2.45	2.80
2 hr.	1.40	1.60	2.00	2.30	2.60	2.95	3.25
3 hr.	1.47	1.75	2.17	2.50	2.95	3.17	3.50
6 hr.	1.80	2.05	2.60	3.00	3.35	3.80	4.05
12 hr.	2.10	2.50	3.00	3.50	4.00	4.35	4.95
24 hr.	2.45	2.85	3.50	4.00	4.60	5.00	5.50

(Data source 5.1.1-B)

The maximum recorded rainfalls (inches for various durations at Dayton and Cincinnati are:

Duration	Dayton	Cincinnati
5 min.	0.57	0.81
10 min.	0.92	1.45
15 min.	1.22	1.92
30 min.	1.75	2.57
60 min.	2.31	2.63
2 hr.	3.14	2.85
3 hr.	3.16	3.29
6 hr.	3.50	3.76
12 hr.	3.65	4.28
24 hr.	4.56	5.22

(Data source 5.1.1-C)

Extreme snowfalls (inches) for representative stations in the area are:

Period	Abbe Observatory Cincinnati (42 Yrs.)	Cincinnati Airport (21 Yrs.)	Dayton Airport (57 Yrs.)
24 hrs.	11.0	9.8	11.3
Calendar Mo.	20.2	15.3	24.4
Season	-	46.0	54.7
JAN	20.2	15.3	24.4
FEB	11.6	13.3	15.2
MAR	13.0	13.0	13.8
APR	5.2	3.3	4.3
MAY	Trace	Trace	0.5
JUN	0	0	0
JUL	0	0	0
AUG	0	0	0
SEP	0	0	0
OCT	4.7	1.7	2.8
NOV	8.9	12.1	12.7
DEC	16.3	12.5	15.6

(Data source 5.1.1-E, F, G)

5.1.3.2. Hail The most commonly reported hailstones are 1/2- to 3/4-inch in diameter and cause little or no property damage. However, much larger stones are associated with the more severe thunderstorms. Hard hail of one inch diameter and larger, that does not shatter on impact, will cause heavy damage to roofs, pit thin steel surfaces such as automobiles, and may break windows. Larger hail breaks window panes, occasionally shatters automobile windshields, and has been known to puncture automobile roofs.

Essentially, all of Ohio is subject to damaging hailstones at one time or another. 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 (less than one) for the region occurs during the month of April. (Data source 5.1.1-H).

5.1.3.3. Ice Storms Ice storms attributed to precipitation in the form of freezing rain and/or sleet occur occasionally in the region. One or two short periods of freezing rain or sleet will be experienced each season; however, these 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 average about once every four or five years and can

be quite damaging to utility lines and trees, as well as being a serious traffic hazard. (Data source 5.1.1-I).

5.1.3.4 Thunderstorms In this area the maximum frequency of thunderstorms occurs in the summer season, generally peaking in July. The wintertime minimum is reached in December.

The annual distributions of thunderstorms for Dayton, Cincinnati and Abbe Observatory area are:

Month	Mean Number of Thunderstorm-Days per Month		
	Dayton (26 Yrs.)	Cincinnati (21 Yrs.)	Abbe Observatory (42 Yrs).
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	5
OCT	2	1	2
NOV	1	1	1
DEC	<1	<1	<1

(Data sources 5.1.1-E, F, G)

5.1.3.5. Tornadoes From 1953 through 1972 a total of 31 tornadoes occurred in a 1° square centered near Mound Laboratory. This gives an annual frequency of 1.55.

The probability of a tornado hitting a point is:

$$P = (2.8209)\ \bar{t}/A$$

where A is the area in square-miles of a 1° square centered on the point, and $\bar{t}$ is the mean annual frequency of tornadoes in the area, (Data source 5.1.1-J). For the Mound Laboratory site, $\bar{t}$ is 1.55 and A is approximately 3,680 square miles.

Thus, $P = (2.8209)1.55/3680 = .00119$

The return period, the reciprocal of P, is:

$1/P = 1/.00119 = 840$ years.

Therefore the probability of a tornado hitting the site in any given year is .00119 with a return frequency of once every 840 years.

A map showing the approximate positions of tornado damage in Ohio over the ten year period from 1953 - 1972 is presented on Plate 5.1-1.

5.1.3.6 Hurricanes Tropical cyclones, including hurricanes, lose strength as they move inland and the greatest concern is possible damage from winds, or flooding due to excessive rainfall. The extremes for winds and rainfall presented elsewhere include hurricane effects. The chronology of tropical cyclones that affected Ohio, 1931-60, follows:

Year	Cyclone's Life	Force*
1932	Aug. 25-Sep. 3	T
1932	Sep. 18-21	T
1934	Jun. 4-21	T
1938	Sep. 10-22	T
1939	Aug. 7-20	T
1941	Sep. 16-25	T
1945	Sep. 11-20	T
1948	Sep. 1-6	T
1949	Aug. 23-31	T
1950	Aug. 20-Sep. 1	T
1950	Sep. 1-9	T
1952	Aug. 18-Sep. 2	T
1954	Oct. 5-18	T
1955	Aug. 3-14	T
1955	Aug. 7-21	T
1957	Jun. 25-28	T
1959	Sep. 20-Oct. 2	T
1960	Jun. 22-28	T
1960	Sep. 14-17	T

*T indicates less than hurricane force winds in Ohio (Data source 5.1.1-K).

5.1.3.7. Extreme Winds Estimated extreme winds at 30 feet above ground for the general area are:

Return Period (Years)	Fastest Mile* (miles per hour)
200	98
100	88
50	79
20	70
10	64
5	57
2	49

(Data source 5.1.1-L)

*The fastest mile is the highest wind speed lasting for any time interval during which a length of air one mile long passes a wind instrument.

5.1.3.8. Air Pollution Potential In January 1972 Holzworth published a study (Data source 5.1.1-M), on mixing heights, wind speeds, and potential for urban air pollution throughout the contiguous United States. Surface and upper air data from the National Weather Service Station at Dayton, Ohio, were included in the analyses made for this study. The data covered the five-year period 1960 through 1964.

The mixing height (or depth) as used in the study is defined as the height above the surface through which relatively vigorous vertical mixing occurs. The morning mixing height was calculated as that existing around the morning commuter rush hours. The afternoon mixing height may be considered to coincide approximately with the usual mid-afternoon minimum concentration of slow-reacting urban pollutants.

Wind speeds for both morning and afternoon were computed as arithmetic averages of speeds observed at the surface and aloft within the mixing layer.

The following table shows mean mixing heights and wind speeds as calculated for Dayton, Ohio:

	Morning		Afternoon	
Season	Mixing Height (Meters)	Wind Speed (mps)	Mixing Height (Meters)	Wind Speed (mps)
Winter	557	7.1	836	7.9
Spring	555	6.6	1670	8.0
Summer	375	4.0	1685	5.5
Autumn	417	5.0	1346	6.5
Annual	476	5.7	1384	7.0

The above data show that, on the average, the greatest air pollution potential (lowest mixing height and lowest wind speed) occurs on summer mornings.

In his study Holzworth also used a mathematical model to compute the average normalized concentration ($\bar{X}/\bar{Q}$) (i.e., the concentration (X) averaged over a city and normalized for uniform average area emission rate ($\bar{Q}$), as a function of mixing height (H), wind speed (U), and along-wind distance (S) across the city). The assumptions used in his model are not applicable to point source emissions but some of his results are shown below as a qualitative indication of the diffusion characteristics of the laboratory site area:

$\bar{X}/\bar{Q}$ VALUES FOR 10 KM* CITY AS CALCULATED FOR DAYTON, OHIO

Season	Median Morning (Sec m^{-1})	Median Afternoon (Sec m^{-1})	Upper Decile Morning (Sec m^{-1})	Upper Decile Afternoon (Sec m^{-1})
Winter	10	9	19	11
Spring	10	9	19	10
Summer	13	10	48	11
Autumn	14	10	45	11
Annual	11	9	25	11

*Refers to along-wind distance across the city.

East of the Rocky Mountains the annual median concentration for 10 km cities vary between only 9 and 13 sec m^{-1} in the morning. Annually, the median afternoon $\bar{X}/\bar{Q}$ values for a 10 km city are for the most part not much smaller than the values for morning and they are practically uniform, being either 9 or 10 sec m^{-1}.

The persistence of high meteorological potential for air pollution is indicated by a parameter called episode-days by Holzworth.

Tables 5.1.3.8-1 through 5.1.3.8-4 are seasonal tables that give the numbers of episodes of specified meteorological conditions on a seasonal basis during a five-year period (1960-64) at Dayton, Ohio. For these tables, A, B, C, D, E, F, G specify the upper limits of the mixing depths as 250, 500, 750, 1000, 15000, 2000, 3000 meters. In the next column the numbers 2, 4, 6, 8 for each mixing depty (or mixing height) specify the upper limits of the vertically averaged speed as 2.0, 4.0, 6.0, 8.0 mps. The column headings across the top 2, 3, 4, ..., 41, are the number of consecutive computations during which the meteorological conditions occurred. The column at the end gives the total number of times that the condition occurred without regard to their being consecutive or not. As an example, Table 5.1.3.8-1 states that during the winter season for a mixing depth of 500 meters (B), there were seven cases where the wind speed was 4 m/sec. or less and this condition persisted for two consecutive days. This occurred for three consecutive days on three occasions and on one occasion for four consecutive days.

Episodes of low mixing height and low wind speed are classified according to upper limits of mixing height and wind speed as shown in this matrix:

WIND SPEED (mps)	Mixing Height (meters) A 250	B 500	C 750	D 1000	E 1500	F 2000	G 3000
2							
4							
6							
8							

(See Tables 5.1.3.8-1 through 4)

Episodes lasting at least three days mean that the conditions were satisfied in at least seven consecutive computation times, respectively (e.g., morning of day one, to afternoon of day one, to morning of day two, etc.). A precipitation event terminated an episode and was not counted as part of the episode.

5.2. LOCAL METEOROLOGY

5.2.1. Data Sources

Sources used in the preparation of the local meteorology include:

5.2.1-A "Wind Distribution by Pasquill Stability Classes Based on 8 Obs/Day. Station: Dayton, Ohio." U.S. Department of Commerce, ESSA, Environmental Data Service, National Weather Records Center, Asheville, North Carolina, July 1970.

5.2.1-B "Climates of the States, Ohio." U.S. Department of Commerce, Weather Bureau, Washington, D.C., December 1959.

5.2.1-C "Climatic Summary of the United States - Supplement for 1951 Through 1960 - Ohio." U.S. Department of Commerce, Weather Bureau, Washington, D.C., 1964.

5.2.1-D "Extremes of Snowfall - Cities." Weatherwise, Volume 23, No. 6, December 1970.

5.2.1-E "Local Climatological Data, Greater Cincinnati Airport." U.S. Department of Commerce, ESSA, Washington, D.C., 1968.

5.2.1-F "Local Climatological Data, Dayton, Ohio." U.S. Department of Commerce, ESSA, Washington, D.C., 1969.

5.2.2. Normal and Extreme Values of Meteorological Parameters

At present, very limited meteorological observational data exist for the Mound Laboratory site, and only precipitation data exists for the Miamisburg area. Therefore, data from proximal locations have been used to estimate or indicate normals and extremes that may be expected at the site.

5.2.2.1. Winds The surface wind flow at Dayton has two distinct maxima from the directions west and south. Percentage frequencies of surface wind from each wind sector (22.5°) on an annual basis at Dayton, based on the years 1965-1969, are shown in Table 5.2.2.1-1. Seasonal frequencies are shown in Tables 5.2.2.1-2 through 5.2.2.1-5. Tables 5.2.2.1-1 through 5.2.2.1-5 give the frequency of occurrence of surface winds by direction (sector) and speed. These tables could be used to determine prevailing wind directions. (Data source 5.2.1-A).

The "Fastest Miles" on record at Dayton and Cincinnati's Abbe Observatory for each month are as follows, (Fastest Mile is defined in Section 5.1.3.7):

Month	Dayton (43 Years)	Abbe Observatory (36 Years)
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

(Data source 5.2.1-B)

5.2.2.2. Temperatures The estimated monthly average daily maximum and minimum temperatures and extreme maximum and minimum values are as follows:

Month	DEGREES FAHRENHEIT 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

(The above values are based on 20 years of record at Dayton Municipal Airport and 29-30 years of record at Hamilton Water Works South.) (Data source 5.2.1-C).

5.2.2.3. Humidity Estimated average relative humidity (%) for four different times of day at the site are:

Month	HOUR (EST) 01	07	13	19
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

(The above values are estimated from 18 years of record at Cincinnati's Abbe Observatory and 17 to 43 years of record at Dayton Municipal Airport).

(Data source 5.2.1-B).

Monthly average dewpoints for Miamisburg were estimated based on monthly temperatures and monthly average relative humidities which were obtained from the above tables. The dewpoint values (^{o}F) are as follows:

JAN	24.9	JUL	64.3
FEB	25.5	AUG	63.7
MAR	31.3	SEP	56.6
APR	41.8	OCT	46.5
MAY	51.9	NOV	34.2
JUN	61.8	DEC	26.1

5.2.2.4. Precipitation Monthly precipitation normals and the mean number of days with precipitation equal to or greater than 0.5 inches at Miamisburg are presented below:

Month	Normal (Inches) (a)	No. of Days ≥0.5 Ins. (b)
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

(a) Based on 30 years of record
(b) Based on 10 years of record

(Data source 5.2.1-C)

Monthly extremes of precipitation on record at Miamisburg, Dayton Municipal Airport, and Cincinnati's Abbe Observatory are (inches):

Month	Miamisburg (10 Years)	Dayton (43 Years)	Abbe (42 Years)
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

(Data sources 5.2.1-B, C)

The snow and sleet season runs from November through April with a trace (T) reported in several other months. The average monthly totals for Miamisburg for the period of record (21 years) are given below (in inches):

JAN	6.3	JUL	T
FEB	4.7	AUG	0
MAR	4.8	SEP	0
APR	0.3	OCT	T
MAY	T	NOV	2.3
JUN	T	DEC	6.8

ANNUAL 25.2

(Data source 5.2.1-C)

Extremes of snowfall (inches) observed near the Mound Laboratory site are:

	Dayton (1883-1970)	Cincinnati (1871-1970)
24 Hours:	11.3	11.0
Single Storm:	11.3	11.0
Calendar Month:	31.6	21.4
Season:	54.7	40.4
Maximum Depth:	18.0	13.7

(Data source 5.2.1-D)

5.2.2.5. Fog Heavy fog is defined as that fog which reduces visibility to 1/4-mile or less. Heavy fog frequencies for Dayton Municipal Airport and Greater Cincinnati Airport are:

Month	Number of Days Dayton	Cincinnati
JAN	4	2
FEB	3	2
MAR	2	2
APR	1	*
MAY	1	1
JUN	1	*
JUL	1	2
AUG	2	2
SEP	1	3
OCT	1	1
NOV	2	2
DEC	3	1
ANNUAL	22	19

*Less than 1/2.

(Based on 26 years of record at Dayton and five years of record at Cincinnati). (Data sources 5.2.1-E, F).

5.2.2.6. Atmospheric Stability In this section wind direction and speed data are presented in relative frequency distributions by stability classes for each season and annually for Dayton, Ohio. Stability classes used are based on Pasquill's class structure (see Journal of Applied Meteorology, February 1964), as follows:

Pasquill Stability Class	Identified in Tables as	Definition
1	A	Extremely Unstable
2	B	Unstable
3	C	Slightly Unstable
4	D	Neutral
5, 6, 7	E	Slight Stable to Extremely Stable

Tables 5.2.2.6-1 through 5.2.2.6-25 contain the wind/stability data. They give the frequency of occurrence of surface winds by direction, speed, and stability class. These tables could be used to make X/Q calculations. The data in these tables were developed from observations taken from January 1965 through December 1969. The tables are self-explanatory except that the calm values have been

distributed in the 0-3 speed category based on the number of observations in speed categories 0-3 and 4-6. (Data source 5.2.1-A).

5.2.3. Potential Influence of the Plant and its Facilities on Local Meteorology

It must be recognized that while data in the previous section are considered representative of local meteorology, the stations from which the data were derived are, in some cases, as much as 45 miles distant from the site. Consequently, departures from the normal and extreme values given above are expected.

Potential modifications of the local meteorology at the laboratory site, resulting from the existence and operations of the laboratory, are recognized, but believed to be minimal. The laboratory buildings and ancillary structures are expected to have some small influence on the local flow of air; specifically, mechanical turbulence is expected downwind of the laboratory in the lower layers. Also, expected to be of minor influence is a modification of the radiative properties of the site area.

Since there are no large cooling systems associated with the laboratory, any changes to the local temperature and humidity regimes are expected to be minimal and unmeasurable. The effluent from the incinerator stack may add additional condensation nuclei to the downwind regions which could result in some additional cloudiness and precipitations. This effect, if it exists, is expected to be so minute as to be undetectable by routine observational methods.

5.2.4. Topographical Description

A map showing topographic features for a five mile radius surrounding the plant site is shown in Plate 5.2.4-1. The sixteen topographic cross sections as indexed on Plate 5.2.4-1 are presented on Plates 5.2.4-2 through 5.2.4-5. They will be used in conjunction with Mound Laboratory data for evaluating atmospheric diffusion.

5.3. ON-SITE METEOROLOGY

A complete program has begun for the accumulation of on-site meteorological data. A weather station will automatically record data. The data will be used to refine diffusion models for atmospheric dispersion of airborne effluents. Upon accumulation of a full year's data, the on-site meteorology will be analyzed, and that information will be added to this report.

Table 5.1.3.8-1 Frequency of episode-days at high meteorological potential during winter at Dayton, Ohio

STA	S	Mix Depth Mtrs	Avg Wind Spd Thru Mix Dpt Mps	Frequency of Episodes: Number of Consecutive Computations - Equal to or Greater than 2	3	4	5	6	7	8	9	10	11	13	15	17	19	21	25	31	41	TOT
93815	1	(A) 250	2																			8
			4	4																		58
			6	6																		82
			8	9	1																	96
		(B) 500	2																			15
			4	7	3	1																85
			6	15	7	4	1	1														140
			8	25	13	7	2	1														184
		(C) 750	2	3																		24
			4	12	5	1	1	1	1	1	1	1	1	1								115
			6	32	15	6	3	2	1	1	1	1	1	1								201
			8	52	24	15	9	3	1	1	1	1	1	1	1							271
		(D) 1,000	2	3																		26
			4	19	7	3	2	1	1	1	1	1	1									130
			6	39	19	10	8	5	3	2	2	2	2	1								228
			8	61	32	18	13	8	5	3	3	2	2	1	1							319
		(E) 1,500	2	3																		28
			4	24	8	3	2	1	1	1	1	1	1									147
			6	51	25	11	8	6	3	2	2	2	2	1								251
			8	77	42	23	15	8	6	4	3	2	2	1	1							351
		(F) 2,000	2	3																		28
			4	25	8	3	2	1	1	1	1	1	1									144
			6	54	26	11	8	6	3	2	2	2	2	1								255
			8	81	43	23	15	8	6	4	3	2	2	1	1							357
		(G) 3,000	2	3																		28
			4	25	8	3	2	1	1	1	1	1	1									144
			6	54	26	11	8	6	3	2	2	2	2	1								255
			3	81	44	24	15	8	6	4	3	2	2	1	1							358

Table 5.1.3.8-2 Frequency of episode-days at high meteorological potential during spring at Dayton, Ohio

STA	S	Mix Depth Mtrs	Avg Wind Spd Thru Mix Dpt Mps	2	3	4	5	6	7	8	9	10	11	13	15	17	19	21	25	31	41	TOT
93815	2	(A) 250	2																			18
			4																			60
			6	1																		110
			8	1																		124
		(B) 500	2																			23
			4																			76
			6	3																		148
			8	5																		188
		(C) 750	2																			25
			4	3																		91
			6	11	1																	178
			8	18	3																	240
		(D) 1,000	2																			26
			4	6	3																	99
			6	17	6	1																204
			8	31	13	2																280
		(E) 1,500	2	1																		28
			4	12	5	1																115
			6	46	16	8	1															253
			8	71	39	19	9	3	1													357
		(F) 2,000	2	2	1																	30
			4	18	7	1																125
			6	70	30	10	3	1	1													286
			8	97	55	28	13	5	4	2	2	1	1									402
		(G) 3,000	2	4	2																	36
			4	26	10	3	2	2	1													139
			6	75	37	20	10	7	4	3	1	1										315
			8	100	65	41	25	17	10	5	4	2	2									443

Table 5.1.3.8-3 Frequency of episode-days at high meteorological potential during summer at Dayton, Ohio

STA	S	Mix Depth Mtrs	Avg Wind Spd Thru Mix Dpt Mps	2	3	4	5	6	7	8	9	10	11	13	15	17	19	21	25	31	41	TOT
93815	3	(A) 250	2																			69
			4	1																		173
			6	1																		194
			8	1																		198
		(B) 500	2	1																		90
			4	3	1																	230
			6	5	2																	294
			8	8	2																	315
		(C) 750	2	2																		93
			4	5	1																	248
			6	10	5	1	1															335
			8	17	5	1	1															371
		(D) 1,000	2	2																		94
			4	6	1																	255
			6	14	6	1	1															352
			8	26	9	1	1															397
		(E) 1,500	2	3	1	1	1	1														103
			4	30	18	4	2	1														292
			6	68	51	12	6	2														432
			8	85	67	20	14	5	2	1	1											499
		(F) 2,000	2	13	6	2	2	1														114
			4	67	49	20	11	5	3	2												357
			6	94	79	47	34	18	17	9	6	4	1	1								530
			8	100	84	57	50	33	27	17	12	7	5	4	1	1	1	1				621
		(G) 3,000	2	17	8	2	2	1														118
			4	77	59	38	26	13	9	7	5	2	2	1								404
			6	94	85	63	50	35	31	22	18	15	10	5	2	2						598
			8	92	80	69	61	49	42	33	27	22	28	12	8	7	5	4	1			709

Table 5.1.3.8-4 Frequency of episode-days at high meteorological potential during autumn at Dayton, Ohio

STA	S	Mix Depth Mtrs	Avg Wind Spd Thru Mix Dpt Mps	2	3	4	5	6	7	8	9	10	11	13	15	17	19	21	25	31	41	TOT
93815	4	(A) 250	2																			64
			4																			174
			6																			211
			8																			216
		(B) 500	2																			69
			4	2	1																	203
			6	8	7																	263
			8	12	8	1	1	1	1													292
		(C) 750	2																			71
			4	6	4																	215
			6	19	13	1	1															294
			8	28	17	4	4	1	1													340
		(D) 1,000	2																			74
			4	14	8	1																230
			6	34	21	8	5	2	1													329
			8	54	31	14	9	2	2	1	1	1	1	1	1	1	1	1				392
		(E) 1,500	2	7	2																	84
			4	43	25	10	4															274
			6	76	55	28	19	8	6	3	1											411
			8	90	70	40	32	21	17	9	5	3	3	1	1	1	1	1				503
		(F) 2,000	2	11	6																	88
			4	59	40	16	10	3	2	1												304
			6	86	66	50	40	22	18	12	8	6	4	2								475
			8	93	76	60	52	37	28	20	17	15	11	8	4	4	3	3	2			590
		(G) 3,000	2	12	7																	89
			4	61	43	18	11	4	3	2	1	1	1									311
			6	84	66	50	40	25	22	17	13	12	9	5	1							493
			8	89	74	59	51	40	33	24	21	19	15	12	7	5	5	5	3	1		617

Table 5.2.2.1-1 Dayton, Ohio annual surface wind direction and speed, relative frequencies

Annual

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.006475	0.017950	0.018841	0.014525	0.001781	0.000069	0.059640
NNE	0.004759	0.015621	0.013154	0.007879	0.000548	0.000274	0.042235
NE	0.003486	0.010825	0.011099	0.004316	0.000206	0.000000	0.029931
ENE	0.003404	0.015552	0.014456	0.005070	0.000274	0.000000	0.038756
E	0.004963	0.022609	0.021376	0.007673	0.000137	0.000000	0.056758
ESE	0.004009	0.015621	0.013634	0.005755	0.000274	0.000000	0.039293
SE	0.004948	0.024048	0.020534	0.005549	0.000069	0.000000	0.055167
SSE	0.004764	0.020485	0.016169	0.007673	0.000206	0.000000	0.049297
S	0.007582	0.031378	0.046588	0.035489	0.005136	0.000411	0.126587
SSW	0.004167	0.018909	0.036859	0.030202	0.005491	0.000411	0.096110
SW	0.004553	0.018224	0.023774	0.017265	0.002672	0.000754	0.067241
WSW	0.004148	0.016306	0.018567	0.018970	0.004796	0.000822	0.063917
W	0.008214	0.029323	0.037202	0.039305	0.006440	0.001370	0.122355
WNW	0.003753	0.015278	0.019526	0.018772	0.001918	0.000069	0.059316
NW	0.004031	0.014250	0.017059	0.009797	0.000685	0.000000	0.045823
NNW	0.004437	0.016991	0.015347	0.009866	0.001165	0.000069	0.047874
TOTAL	0.077692	0.303370	0.344204	0.238695	0.031790	0.004248	

TOTAL RELATIVE FREQUENCY OF OBSERVATIONS = 1.000000

TOTAL RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE = 0.032612

Table 5.2.2.1-2 Dayton, Ohio winter surface wind direction and speed, relative frequencies

SEA-DJF

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.005700	0.013056	0.017222	0.016667	0.002778	0.000278	0.055700
NNE	0.003558	0.012778	0.012500	0.008056	0.001111	0.001111	0.039113
NE	0.003335	0.010278	0.006333	0.003056	0.000000	0.000000	0.025002
ENE	0.002452	0.010556	0.011111	0.005556	0.000278	0.000000	0.029952
E	0.003775	0.018611	0.023611	0.010833	0.000000	0.000000	0.056830
ESE	0.002625	0.012500	0.013611	0.010000	0.000278	0.000000	0.039014
SE	0.004355	0.018333	0.021944	0.008056	0.000278	0.000000	0.052966
SSE	0.001520	0.010278	0.016944	0.008889	0.000556	0.000000	0.039187
S	0.003639	0.024444	0.046111	0.046944	0.009444	0.000833	0.131467
SSW	0.002150	0.010556	0.034722	0.034167	0.011667	0.000556	0.093816
SW	0.001649	0.008333	0.018056	0.015000	0.001111	0.000833	0.044983
WSW	0.003736	0.011944	0.016944	0.027778	0.006667	0.002222	0.069341
W	0.006967	0.023889	0.054167	0.066389	0.010000	0.002500	0.163911
WNW	0.002570	0.015278	0.024444	0.031111	0.003333	0.000000	0.076737
NW	0.002015	0.015833	0.013333	0.010000	0.000833	0.000000	0.042015
NNW	0.002909	0.008889	0.015000	0.012778	0.001389	0.000000	0.040965
TOTAL	0.053056	0.225555	0.348055	0.315278	0.049722	0.008333	

TOTAL RELATIVE FREQUENCY OF OBSERVATIONS = 1.000000

TOTAL RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE = 0.022778

Table 5.2.2.1-3 Dayton, Ohio spring surface wind direction and speed, relative frequencies

SEA-MAM

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.004269	0.014134	0.026094	0.018211	0.003262	0.000000	0.065971
NNE	0.003036	0.017668	0.017396	0.012503	0.000272	0.000000	0.050875
NE	0.002245	0.008970	0.014134	0.005980	0.000815	0.000000	0.032144
ENE	0.002639	0.015765	0.019571	0.005980	0.000272	0.000000	0.044226
E	0.002954	0.021201	0.025550	0.011688	0.000544	0.000000	0.061937
ESE	0.001760	0.015493	0.019571	0.008970	0.000815	0.000000	0.046609
SE	0.003021	0.017396	0.026094	0.008970	0.000000	0.000000	0.055481
SSE	0.003434	0.019571	0.016852	0.011416	0.000000	0.000000	0.051273
S	0.004537	0.014755	0.043490	0.038325	0.005980	0.000272	0.111360
SSW	0.001827	0.011688	0.031258	0.030443	0.005164	0.001087	0.081463
SW	0.001930	0.013591	0.019299	0.020114	0.004349	0.001631	0.060921
WSW	0.002402	0.011688	0.017124	0.015765	0.007067	0.000544	0.054591
W	0.005364	0.023104	0.032340	0.040500	0.011144	0.002175	0.114633
WNW	0.002942	0.016037	0.018211	0.019642	0.002718	0.000272	0.060023
NW	0.002591	0.014950	0.023640	0.013319	0.000815	0.000000	0.055323
NNW	0.002607	0.015222	0.019571	0.013047	0.002718	0.000000	0.053164
TOTAL	0.047567	0.255232	0.370209	0.275074	0.045936	0.005980	

TOTAL RELATIVE FREQUENCY OF OBSERVATIONS = 1.000000

TOTAL RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE = 0.016581

Table 5.2.2.1-4 Dayton, Ohio summer surface wind direction and speed, relative frequencies

SEA-JJA

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.008269	0.024185	0.019565	0.011685	0.000272	0.000000	0.063975
NNE	0.006134	0.018207	0.017120	0.007065	0.000543	0.000000	0.049068
NE	0.004072	0.015761	0.015217	0.004076	0.000000	0.000000	0.039126
ENE	0.004717	0.019022	0.017663	0.005978	0.000000	0.000000	0.047381
E	0.005165	0.026087	0.017935	0.004076	0.000000	0.000000	0.053262
ESE	0.004315	0.015217	0.007880	0.001630	0.000000	0.000000	0.029043
SE	0.006453	0.026902	0.009239	0.000543	0.000000	0.000000	0.043138
SSE	0.006630	0.023370	0.012226	0.002174	0.000000	0.000000	0.044452
S	0.011813	0.043478	0.043750	0.015217	0.000000	0.000000	0.114259
SSW	0.007057	0.032609	0.046467	0.023370	0.002174	0.000000	0.111676
SW	0.009060	0.032609	0.039402	0.019837	0.002446	0.000000	0.103153
WSW	0.006079	0.023370	0.022826	0.016304	0.001359	0.000272	0.070209
W	0.012210	0.035870	0.025000	0.015761	0.000272	0.000272	0.089384
WNW	0.004459	0.016576	0.014946	0.005435	0.000543	0.000000	0.041959
NW	0.005846	0.015489	0.017120	0.004348	0.000272	0.000000	0.043074
NNW	0.007111	0.027446	0.015489	0.005978	0.000543	0.000272	0.056840
TOTAL	0.109239	0.396195	0.341847	0.143478	0.009424	0.000815	

TOTAL RELATIVE FREQUENCY OF OBSERVATIONS = 1.000000

TOTAL RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE = 0.048370

Table 5.2.2.1-5 Dayton, Ohio autumn surface wind direction and speed, relative frequencies

SEA-SON

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.007691	0.020346	0.012373	0.011548	0.000825	0.000000	0.052783
NNE	0.006061	0.013748	0.005499	0.003849	0.000275	0.000000	0.029432
NE	0.004246	0.008249	0.006599	0.004124	0.000000	0.000000	0.023218
ENE	0.003646	0.016772	0.009348	0.002750	0.000550	0.000000	0.033065
E	0.007833	0.024471	0.018422	0.004124	0.000000	0.000000	0.054850
ESE	0.007267	0.019247	0.013473	0.002475	0.000000	0.000000	0.042461
SE	0.006074	0.033544	0.025021	0.004674	0.000000	0.000000	0.069313
SSE	0.007366	0.023595	0.018697	0.008249	0.000275	0.000000	0.062181
S	0.010602	0.038768	0.053056	0.041763	0.005224	0.000550	0.150002
SSW	0.005692	0.020621	0.034919	0.033269	0.003024	0.000000	0.097726
SW	0.005929	0.018147	0.018147	0.014023	0.002750	0.000550	0.059544
WSW	0.004405	0.018147	0.017322	0.016222	0.004124	0.000275	0.060495
W	0.008297	0.034369	0.037658	0.037119	0.004399	0.000550	0.122401
WNW	0.004783	0.013198	0.020621	0.018972	0.001100	0.000000	0.058673
NW	0.005429	0.010723	0.014023	0.011548	0.000825	0.000000	0.042547
NNW	0.005111	0.016222	0.011273	0.007699	0.000000	0.000000	0.040304
TOTAL	0.100632	0.335166	0.316469	0.222436	0.023371	0.001925	

TOTAL RELATIVE FREQUENCY OF OBSERVATIONS = 1.000000

TOTAL RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE = 0.042618

Table 5.2.2.6-1 Dayton, Ohio winter surface wind direction and speed, relative frequencies for "A" stability

SEA-DJF

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.000017	0.000000	0.000000	0.000000	0.000000	0.000000	0.000017
NNE	0.000017	0.000000	0.000000	0.000000	0.000000	0.000000	0.000017
NE	0.000017	0.000000	0.000000	0.000000	0.000000	0.000000	0.000017
ENE	0.000017	0.000000	0.000000	0.000000	0.000000	0.000000	0.000017
E	0.000017	0.000000	0.000000	0.000000	0.000000	0.000000	0.000017
ESE	0.000017	0.000000	0.000000	0.000000	0.000000	0.000000	0.000017
SE	0.000017	0.000000	0.000000	0.000000	0.000000	0.000000	0.000017
SSE	0.000017	0.000000	0.000000	0.000000	0.000000	0.000000	0.000017
S	0.000017	0.000000	0.000000	0.000000	0.000000	0.000000	0.000017
SSW	0.000017	0.000000	0.000000	0.000000	0.000000	0.000000	0.000017
SW	0.000017	0.000000	0.000000	0.000000	0.000000	0.000000	0.000017
WSW	0.000017	0.000000	0.000000	0.000000	0.000000	0.000000	0.000017
W	0.000017	0.000000	0.000000	0.000000	0.000000	0.000000	0.000017
WNW	0.000017	0.000000	0.000000	0.000000	0.000000	0.000000	0.000017
NW	0.000017	0.000000	0.000000	0.000000	0.000000	0.000000	0.000017
NNW	0.000017	0.000000	0.000000	0.000000	0.000000	0.000000	0.000017
TOTAL	0.000278	0.000000	0.000000	0.000000	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF A STABILITY = 0.000276

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH A STABILITY = 0.000278

Table 5.2.2.6-2 Dayton, Ohio winter surface wind direction and speed, relative frequencies for "B" stability

SEA-DJF

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.001389	0.000278	0.000000	0.000000	0.000000	0.000000	0.001667
NNE	0.000556	0.000278	0.000000	0.000000	0.000000	0.000000	0.000833
NE	0.000417	0.000000	0.000278	0.000000	0.000000	0.000000	0.000694
ENE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	0.000833	0.000000	0.000000	0.000000	0.000000	0.000000	0.000833
ESE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SE	0.000139	0.000278	0.000000	0.000000	0.000000	0.000000	0.000417
SSE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
S	0.000139	0.000278	0.000000	0.000000	0.000000	0.000000	0.000417
SSW	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SW	0.000417	0.000000	0.000000	0.000000	0.000000	0.000000	0.000417
WSW	0.000417	0.000000	0.000000	0.000000	0.000000	0.000000	0.000417
W	0.000417	0.000000	0.000278	0.000000	0.000000	0.000000	0.000694
WNW	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NW	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NNW	0.000000	0.000000	0.000278	0.000000	0.000000	0.000000	0.000278
TOTAL	0.004722	0.001111	0.000833	0.000000	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF B STABILITY = 0.006667

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH B STABILITY = 0.001944

Table 5.2.2.6-3 Dayton, Ohio winter surface wind direction and speed, relative frequencies for "C" stability

SEA-DJF

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.000403	0.001667	0.001667	0.000000	0.000000	0.000000	0.003737
NNE	0.000054	0.000833	0.000833	0.000278	0.000000	0.000000	0.001998
NE	0.000609	0.000278	0.000833	0.000000	0.000000	0.000000	0.001720
ENE	0.000314	0.000278	0.000833	0.000000	0.000000	0.000000	0.001425
E	0.000036	0.000556	0.001111	0.000000	0.000000	0.000000	0.001703
ESE	0.000090	0.001389	0.000278	0.000000	0.000000	0.000000	0.001756
SE	0.000018	0.000278	0.000833	0.000000	0.000000	0.000000	0.001127
SSE	0.000054	0.000833	0.000278	0.000000	0.000000	0.000000	0.001165
S	0.000054	0.000833	0.002222	0.000000	0.000000	0.000000	0.003109
SSW	0.000090	0.001389	0.002778	0.000556	0.000000	0.000000	0.004812
SW	0.000072	0.001111	0.000833	0.000000	0.000000	0.000000	0.002016
WSW	0.000090	0.001389	0.000556	0.000278	0.000000	0.000000	0.002312
W	0.000365	0.001389	0.003333	0.000000	0.000000	0.000000	0.005106
WNW	0.000108	0.001667	0.001944	0.000000	0.000000	0.000000	0.003719
NW	0.000054	0.000833	0.001389	0.000000	0.000000	0.000000	0.002276
NNW	0.000072	0.001111	0.002500	0.000000	0.000000	0.000000	0.003683
TOTAL	0.002500	0.015833	0.022222	0.001111	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF C STABILITY = 0.041667

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH C STABILITY = 0.001111

Table 5.2.2.6-4 Dayton, Ohio winter surface wind direction and speed, relative frequencies for "D" stability

SEA-DJF

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.001498	0.004722	0.013056	0.016667	0.002778	0.000278	0.038998
NNE	0.000942	0.005278	0.010833	0.007778	0.001111	0.001111	0.027053
NE	0.000424	0.005389	0.005278	0.003056	0.000000	0.000000	0.015146
ENE	0.000665	0.005556	0.008611	0.005556	0.000278	0.000000	0.020665
E	0.001292	0.010556	0.020000	0.010833	0.000000	0.000000	0.042681
ESE	0.001034	0.006667	0.012778	0.010000	0.000278	0.000000	0.030757
SE	0.001441	0.008333	0.019167	0.008056	0.000278	0.000000	0.037275
SSE	0.000591	0.004444	0.015000	0.008889	0.000556	0.000000	0.029490
S	0.000941	0.009722	0.033333	0.046944	0.009444	0.000833	0.101219
SSW	0.000239	0.003611	0.023056	0.033611	0.011667	0.000556	0.072739
SW	0.000480	0.002778	0.013056	0.015000	0.001111	0.000833	0.033258
WSW	0.001202	0.004722	0.010556	0.027500	0.006667	0.002222	0.052848
W	0.001552	0.010000	0.032222	0.066389	0.010000	0.002500	0.122653
WNW	0.000942	0.005278	0.015278	0.031111	0.003333	0.000000	0.055942
NW	0.000663	0.005833	0.008889	0.010000	0.000833	0.000000	0.026239
NNW	0.001073	0.002778	0.008611	0.012778	0.001389	0.000000	0.026623
TOTAL	0.015000	0.096667	0.249722	0.314166	0.049722	0.008333	

RELATIVE FREQUENCY OF OCCURRENCE OF D STABILITY = 0.733611

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH D STABILITY = 0.006944

Table 5.2.2.6-5 Dayton, Ohio winter surface wind direction and speed, relative frequencies for "E" stability

SEA-DJF

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.002746	0.006389	0.002500	0.000000	0.000000	0.000000	0.011635
NNE	0.002137	0.006389	0.000833	0.000000	0.000000	0.000000	0.009359
NE	0.001870	0.003611	0.001944	0.000000	0.000000	0.000000	0.007425
ENE	0.001369	0.004722	0.001667	0.000000	0.000000	0.000000	0.007756
E	0.001635	0.007500	0.002500	0.000000	0.000000	0.000000	0.011635
ESE	0.001341	0.004444	0.000556	0.000000	0.000000	0.000000	0.006341
SE	0.002735	0.009444	0.001944	0.000000	0.000000	0.000000	0.014124
SSE	0.000785	0.005000	0.001667	0.000000	0.000000	0.000000	0.007452
S	0.002527	0.013611	0.010556	0.000000	0.000000	0.000000	0.026694
SSW	0.001752	0.005556	0.008889	0.000000	0.000000	0.000000	0.016197
SW	0.000732	0.004444	0.004167	0.000000	0.000000	0.000000	0.009343
WSW	0.002083	0.005833	0.005833	0.000000	0.000000	0.000000	0.013750
W	0.004551	0.012500	0.018333	0.000000	0.000000	0.000000	0.035383
WNW	0.001410	0.008333	0.007222	0.000000	0.000000	0.000000	0.016965
NW	0.001186	0.007167	0.003056	0.000000	0.000000	0.000000	0.013408
NNW	0.001699	0.005000	0.003611	0.000000	0.000000	0.000000	0.010310
TOTAL	0.030556	0.111944	0.073278	0.000000	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF E STABILITY = 0.217778

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH E STABILITY = 0.012500

Table 5.2.2.6-6 Dayton, Ohio spring surface wind direction and speed, relative frequencies for "A" stability

SEA-MAM

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NNE	0.000770	0.000000	0.000000	0.000000	0.000000	0.000000	0.000770
NE	0.000113	0.000272	0.000000	0.000000	0.000000	0.000000	0.000385
ENE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	0.000498	0.000272	0.000000	0.000000	0.000000	0.000000	0.000770
ESE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SSE	0.000498	0.000272	0.000000	0.000000	0.000000	0.000000	0.000770
S	0.000770	0.000000	0.000000	0.000000	0.000000	0.000000	0.000770
SSW	0.000227	0.000544	0.000000	0.000000	0.000000	0.000000	0.000770
SW	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
WSW	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
W	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
WNW	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NW	0.000113	0.000272	0.000000	0.000000	0.000000	0.000000	0.000385
NNW	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
TOTAL	0.002990	0.001631	0.000000	0.000000	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF A STABILITY = 0.004621

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH A STABILITY = 0.001359

Table 5.2.2.6-7 Dayton, Ohio spring surface wind direction and speed, relative frequencies for "B" stability

SEA-MAM

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.000919	0.001359	0.000544	0.000000	0.000000	0.000000	0.002822
NNE	0.000634	0.001359	0.000272	0.000000	0.000000	0.000000	0.002265
NE	0.000298	0.000272	0.001087	0.000000	0.000000	0.000000	0.001657
ENE	0.000026	0.000544	0.001087	0.000000	0.000000	0.000000	0.001657
E	0.000375	0.001903	0.000815	0.000000	0.000000	0.000000	0.003093
ESE	0.000091	0.001903	0.001087	0.000000	0.000000	0.000000	0.003081
SE	0.000066	0.002446	0.001359	0.000000	0.000000	0.000000	0.004471
SSE	0.000958	0.002175	0.000000	0.000000	0.000000	0.000000	0.003132
S	0.000091	0.001903	0.001631	0.000000	0.000000	0.000000	0.003624
SSW	0.000013	0.000272	0.000272	0.000000	0.000000	0.000000	0.000557
SW	0.000324	0.000815	0.000544	0.000000	0.000000	0.000000	0.001683
WSW	0.000620	0.000544	0.000815	0.000000	0.000000	0.000000	0.002239
W	0.000958	0.002175	0.001903	0.000000	0.000000	0.000000	0.005035
WNW	0.000647	0.001631	0.000544	0.000000	0.000000	0.000000	0.002822
NW	0.000919	0.001359	0.000815	0.000000	0.000000	0.000000	0.003093
NNW	0.000337	0.001087	0.000544	0.000000	0.000000	0.000000	0.001967
TOTAL	0.008154	0.021745	0.013319	0.000000	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF B STABILITY = 0.043218

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH B STABILITY = 0.001359

Table 5.2.2.6-8 Dayton, Ohio spring surface wind direction and speed, relative frequencies for "C" stability

SEA-MAM

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.000379	0.001631	0.002446	0.000815	0.000000	0.000000	0.005272
NNE	0.000046	0.000815	0.001087	0.000272	0.000000	0.000000	0.002220
NE	0.000574	0.000000	0.001631	0.000544	0.000000	0.000000	0.002749
ENE	0.000061	0.001087	0.002446	0.001087	0.000000	0.000000	0.004682
E	0.000061	0.001087	0.004077	0.000544	0.000000	0.000000	0.005769
ESE	0.000333	0.000815	0.004621	0.000272	0.000000	0.000000	0.006041
SE	0.000346	0.001087	0.002718	0.001087	0.000000	0.000000	0.005241
SSE	0.000318	0.000544	0.002990	0.000272	0.000000	0.000000	0.004123
S	0.000348	0.001087	0.005154	0.001631	0.000272	0.000000	0.008503
SSW	0.000061	0.001087	0.003262	0.001087	0.000000	0.000000	0.005498
SW	0.000092	0.001631	0.005706	0.001087	0.000544	0.000000	0.009062
WSW	0.000107	0.001903	0.002175	0.001631	0.000272	0.000000	0.006087
W	0.000077	0.001359	0.007067	0.000815	0.000000	0.000272	0.009590
WNW	0.000318	0.000544	0.003805	0.000544	0.000000	0.000000	0.005210
NW	0.000046	0.000815	0.001631	0.000272	0.000000	0.000000	0.002764
NNW	0.000092	0.001631	0.001631	0.000544	0.000000	0.000000	0.003897
TOTAL	0.003262	0.017124	0.052460	0.012503	0.001087	0.000272	

RELATIVE FREQUENCY OF OCCURRENCE OF C STABILITY = 0.086708

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH C STABILITY = 0.001087

Table 5.2.2.6-9 Dayton, Ohio spring surface wind direction and speed, relative frequencies for "D" stability

SEA-MAM

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.001249	0.005960	0.017124	0.017396	0.003262	0.000000	0.045011
NNE	0.000433	0.006795	0.013047	0.012232	0.000272	0.000000	0.032779
NE	0.000631	0.003262	0.008426	0.005436	0.000815	0.000000	0.018570
ENE	0.000409	0.005708	0.010601	0.004893	0.000272	0.000000	0.021882
E	0.000409	0.005708	0.016309	0.011144	0.000544	0.000000	0.034113
ESE	0.000624	0.002990	0.010873	0.008693	0.000815	0.000000	0.024000
SE	0.000636	0.004349	0.018211	0.007883	0.000000	0.000000	0.031099
SSE	0.000099	0.004349	0.010873	0.011144	0.000000	0.000000	0.026465
S	0.000371	0.004077	0.026909	0.036695	0.005708	0.000272	0.074033
SSW	0.000643	0.003805	0.016581	0.029356	0.005164	0.001087	0.056637
SW	0.000624	0.002990	0.008426	0.019027	0.003805	0.001631	0.036504
WSW	0.000378	0.004349	0.008426	0.014134	0.006795	0.000544	0.034626
W	0.001268	0.006795	0.015493	0.039605	0.011144	0.001903	0.076238
WNW	0.000433	0.006795	0.006970	0.019299	0.002713	0.000272	0.035487
NW	0.000353	0.003262	0.013222	0.013047	0.000815	0.000000	0.032693
NNW	0.000662	0.004621	0.013319	0.012503	0.002718	0.000000	0.033823
TOTAL	0.009242	0.075836	0.218809	0.262571	0.044849	0.005708	

RELATIVE FREQUENCY OF OCCURRENCE OF D STABILITY = 0.617015

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH D STABILITY = 0.001903

Table 5.2.2.6-10 Dayton, Ohio spring surface wind direction and speed, relative frequencies for "E" stability

SEA-MAM

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.001535	0.005164	0.005980	0.000000	0.000000	0.000000	0.012679
NNE	0.001205	0.003698	0.002990	0.000000	0.000000	0.000000	0.012893
NE	0.000661	0.005164	0.002990	0.000000	0.000000	0.000000	0.009815
ENE	0.002059	0.008426	0.005436	0.000000	0.000000	0.000000	0.015922
E	0.001749	0.012232	0.004349	0.000000	0.000000	0.000000	0.018330
ESE	0.000700	0.007785	0.002990	0.000000	0.000000	0.000000	0.013475
SE	0.001263	0.009513	0.003805	0.000000	0.000000	0.000000	0.014582
SSE	0.001749	0.012232	0.002990	0.000000	0.000000	0.000000	0.016971
S	0.003166	0.011688	0.009765	0.000000	0.000000	0.000000	0.024640
SSW	0.001010	0.005980	0.011144	0.000000	0.000000	0.000000	0.018135
SW	0.000875	0.008154	0.004621	0.000000	0.000000	0.000000	0.013650
WSW	0.000933	0.004693	0.005708	0.000000	0.000000	0.000000	0.011333
W	0.002953	0.012775	0.007883	0.000000	0.000000	0.000000	0.023611
WNW	0.001379	0.007067	0.004893	0.000000	0.000000	0.000000	0.013339
NW	0.001244	0.009242	0.005980	0.000000	0.000000	0.000000	0.016465
NNW	0.001438	0.007883	0.004077	0.000000	0.000000	0.000000	0.013398
TOTAL	0.023920	0.138896	0.083621	0.000000	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF E STABILITY = 0.248437

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH E STABILITY = 0.010873

Table 5.2.2.6-11 Dayton, Ohio summer surface wind direction and speed, relative frequencies for "A" stability

SEA-JJA

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.000133	0.000543	0.000000	0.000000	0.000000	0.000000	0.000676
NNE	0.000066	0.000272	0.000000	0.000000	0.000000	0.000000	0.000338
NE	0.000404	0.000272	0.000000	0.000000	0.000000	0.000000	0.000676
ENE	0.000404	0.000272	0.000000	0.000000	0.000000	0.000000	0.000676
E	0.001007	0.001359	0.000000	0.000000	0.000000	0.000000	0.002366
ESE	0.000066	0.000272	0.000000	0.000000	0.000000	0.000000	0.000338
SE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SSE	0.000066	0.000272	0.000000	0.000000	0.000000	0.000000	0.000338
S	0.000809	0.000543	0.000000	0.000000	0.000000	0.000000	0.001352
SSW	0.000133	0.000543	0.000000	0.000000	0.000000	0.000000	0.000676
SW	0.000133	0.000543	0.000000	0.000000	0.000000	0.000000	0.000676
WSW	0.000603	0.001087	0.000000	0.000000	0.000000	0.000000	0.001690
W	0.000404	0.000272	0.000000	0.000000	0.000000	0.000000	0.000676
WNW	0.000066	0.000272	0.000000	0.000000	0.000000	0.000000	0.000338
NW	0.000875	0.000815	0.000000	0.000000	0.000000	0.000000	0.001690
NNW	0.001020	0.000272	0.000000	0.000000	0.000000	0.000000	0.001352
TOTAL	0.006250	0.007609	0.000000	0.000000	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF A STABILITY = 0.013859

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH A STABILITY = 0.002717

Table 5.2.2.6-12 Dayton, Ohio summer surface wind direction and speed, relative frequencies for "B" stability

SEA-JJA

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.001084	0.004620	0.002174	0.000000	0.000000	0.000000	0.007877
NNE	0.001533	0.002174	0.002174	0.000000	0.000000	0.000000	0.005881
NE	0.000433	0.002989	0.001630	0.000000	0.000000	0.000000	0.005052
ENE	0.001587	0.003261	0.001902	0.000000	0.000000	0.000000	0.006750
E	0.000540	0.005163	0.001359	0.000000	0.000000	0.000000	0.007062
ESE	0.000705	0.002717	0.000543	0.000000	0.000000	0.000000	0.003965
SE	0.000161	0.003261	0.000815	0.000000	0.000000	0.000000	0.004237
SSE	0.000651	0.001630	0.000815	0.000000	0.000000	0.000000	0.003096
S	0.002442	0.003261	0.002446	0.000000	0.000000	0.000000	0.008149
SSW	0.000785	0.004348	0.002989	0.000000	0.000000	0.000000	0.008122
SW	0.001587	0.003261	0.005163	0.000000	0.000000	0.000000	0.010011
WSW	0.000161	0.003261	0.002446	0.000000	0.000000	0.000000	0.005868
W	0.001899	0.003804	0.004348	0.000000	0.000000	0.000000	0.010051
WNW	0.001017	0.003261	0.002174	0.000000	0.000000	0.000000	0.006451
NW	0.000664	0.001902	0.002446	0.000000	0.000000	0.000000	0.005012
NNW	0.000513	0.004620	0.002717	0.000000	0.000000	0.000000	0.007850
TOTAL	0.015761	0.053533	0.036141	0.000000	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF B STABILITY = 0.105435

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH B STABILITY = 0.003261

Table 5.2.2.6-13 Dayton, Ohio summer surface wind direction and speed, relative frequencies for "C" stability

SEA-JJA

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.000343	0.001902	0.005435	0.002174	0.000000	0.000000	0.010354
NNE	0.000538	0.001902	0.002446	0.001630	0.000000	0.000000	0.006516
NE	0.000233	0.001902	0.001902	0.001087	0.000000	0.000000	0.005124
ENE	0.000199	0.001630	0.006250	0.002174	0.000000	0.000000	0.010254
E	0.000637	0.002717	0.005978	0.000815	0.000000	0.000000	0.010148
ESE	0.001181	0.002174	0.002446	0.000000	0.000000	0.000000	0.005800
SE	0.000976	0.002989	0.002717	0.000000	0.000000	0.000000	0.006682
SSE	0.000637	0.002717	0.001902	0.000543	0.000000	0.000000	0.005800
S	0.001513	0.004891	0.007337	0.001359	0.000000	0.000000	0.015100
SSW	0.000942	0.002717	0.012772	0.001902	0.000000	0.000000	0.018334
SW	0.000604	0.002446	0.012772	0.002446	0.000543	0.000000	0.018811
WSW	0.001691	0.001359	0.009511	0.002174	0.000000	0.000000	0.014735
W	0.002733	0.004891	0.007337	0.001902	0.000272	0.000000	0.017135
WNW	0.000504	0.001630	0.005435	0.000543	0.000000	0.000000	0.008113
NW	0.000604	0.002446	0.003533	0.000000	0.000000	0.000000	0.006582
NNW	0.001109	0.004076	0.004076	0.000815	0.000000	0.000000	0.010076
TOTAL	0.014946	0.042391	0.091848	0.019565	0.000815	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF C STABILITY = 0.169565

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH C STABILITY = 0.006250

Table 5.2.2.6-14 Dayton, Ohio summer surface wind direction and speed, relative frequencies for "D" stability

SEA-JJA

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.000449	0.005707	0.008424	0.009511	0.000272	0.000000	0.024362
NNE	0.000416	0.004620	0.009511	0.005435	0.000543	0.000000	0.020525
NE	0.000664	0.003533	0.007065	0.002939	0.000000	0.000000	0.014251
ENE	0.000096	0.003261	0.007065	0.003804	0.000000	0.000000	0.014227
E	0.000121	0.004076	0.006522	0.003261	0.000000	0.000000	0.013979
ESE	0.000952	0.003804	0.004620	0.001630	0.000000	0.000000	0.011006
SE	0.000728	0.005707	0.004348	0.000543	0.000000	0.000000	0.011325
SSE	0.000505	0.007609	0.008152	0.001630	0.000000	0.000000	0.017896
S	0.001376	0.008696	0.027174	0.013859	0.000000	0.000000	0.051104
SSW	0.000281	0.009511	0.022826	0.021467	0.002174	0.000000	0.055259
SW	0.000313	0.007880	0.014946	0.017391	0.001902	0.000000	0.042832
WSW	0.000416	0.004620	0.007880	0.014130	0.001359	0.000272	0.028677
W	0.001096	0.008696	0.011413	0.013859	0.000000	0.000272	0.035336
WNW	0.000416	0.004620	0.004348	0.004891	0.000543	0.000000	0.014819
NW	0.000960	0.004076	0.007609	0.004348	0.000272	0.000000	0.017264
NNW	0.000249	0.008424	0.005978	0.005163	0.000543	0.000272	0.020630
TOTAL	0.009239	0.094037	0.157880	0.123913	0.007609	0.000815	

RELATIVE FREQUENCY OF OCCURRENCE OF D STABILITY = 0.394293

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH D STABILITY = 0.002989

Table 5.2.2.6-15 Dayton, Ohio summer surface wind direction and speed, relative frequencies for "E" stability

SEA-JJA

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.003708	0.011413	0.003533	0.000000	0.000000	0.000000	0.020654
NNE	0.003524	0.009239	0.002939	0.000000	0.000000	0.000000	0.015752
NE	0.002274	0.007065	0.004620	0.000000	0.000000	0.000000	0.013959
ENE	0.002477	0.010598	0.002446	0.000000	0.000000	0.000000	0.015520
E	0.003105	0.012772	0.004076	0.000000	0.000000	0.000000	0.019952
ESE	0.001221	0.006250	0.000272	0.000000	0.000000	0.000000	0.007743
SE	0.004666	0.014946	0.001359	0.000000	0.000000	0.000000	0.020971
SSE	0.004735	0.011141	0.001359	0.000000	0.000000	0.000000	0.017235
S	0.005977	0.026087	0.006793	0.000000	0.000000	0.000000	0.038857
SSW	0.004745	0.015489	0.007880	0.000000	0.000000	0.000000	0.028115
SW	0.006114	0.018478	0.006522	0.000000	0.000000	0.000000	0.031114
WSW	0.003455	0.013043	0.002939	0.000000	0.000000	0.000000	0.019488
W	0.006075	0.018207	0.001902	0.000000	0.000000	0.000000	0.026184
WNW	0.002234	0.005793	0.002939	0.000000	0.000000	0.000000	0.012017
NW	0.002778	0.006250	0.003533	0.000000	0.000000	0.000000	0.012560
NNW	0.003954	0.010054	0.002717	0.000000	0.000000	0.000000	0.016726
TOTAL	0.063043	0.197826	0.055978	0.000000	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF E STABILITY = 0.316848

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH E STABILITY = 0.033152

Table 5.2.2.6-16 Dayton, Ohio autumn surface wind direction and speed, relative frequencies for "A" stability

SEA-SON

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.000120	0.000000	0.000000	0.000000	0.000000	0.000000	0.000120
NNE	0.000120	0.000000	0.000000	0.000000	0.000000	0.000000	0.000120
NE	0.000120	0.000000	0.000000	0.000000	0.000000	0.000000	0.000120
ENE	0.000120	0.000000	0.000000	0.000000	0.000000	0.000000	0.000120
E	0.000120	0.000000	0.000000	0.000000	0.000000	0.000000	0.000120
ESE	0.000120	0.000000	0.000000	0.000000	0.000000	0.000000	0.000120
SE	0.000120	0.000000	0.000000	0.000000	0.000000	0.000000	0.000120
SSE	0.000120	0.000000	0.000000	0.000000	0.000000	0.000000	0.000120
S	0.000120	0.000000	0.000000	0.000000	0.000000	0.000000	0.000120
SSW	0.000120	0.000000	0.000000	0.000000	0.000000	0.000000	0.000120
SW	0.000120	0.000000	0.000000	0.000000	0.000000	0.000000	0.000120
WSW	0.000120	0.000000	0.000000	0.000000	0.000000	0.000000	0.000120
W	0.000120	0.000000	0.000000	0.000000	0.000000	0.000000	0.000120
WNW	0.000120	0.000000	0.000000	0.000000	0.000000	0.000000	0.000120
NW	0.000120	0.000000	0.000000	0.000000	0.000000	0.000000	0.000120
NNW	0.000120	0.000000	0.000000	0.000000	0.000000	0.000000	0.000120
TOTAL	0.001925	0.000000	0.000000	0.000000	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF A STABILITY = 0.001925

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH A STABILITY = 0.001925

Table 5.2.2.6-17 Dayton, Ohio autumn surface wind direction and speed, relative frequencies for "B" stability

SEA-SON

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.000348	0.001100	0.000000	0.000000	0.000000	0.000000	0.001448
NNE	0.000623	0.000825	0.000000	0.000000	0.000000	0.000000	0.001448
NE	0.000898	0.000550	0.000000	0.000000	0.000000	0.000000	0.001448
ENE	0.000883	0.000275	0.000275	0.000000	0.000000	0.000000	0.001433
E	0.000942	0.001375	0.000825	0.000000	0.000000	0.000000	0.003141
ESE	0.000652	0.001375	0.000825	0.000000	0.000000	0.000000	0.002852
SE	0.000956	0.001650	0.000000	0.000000	0.000000	0.000000	0.002606
SSE	0.000044	0.000825	0.000550	0.000000	0.000000	0.000000	0.001419
S	0.001550	0.001925	0.000825	0.000000	0.000000	0.000000	0.004300
SSW	0.000652	0.001375	0.000550	0.000000	0.000000	0.000000	0.002577
SW	0.001217	0.001100	0.000000	0.000000	0.000000	0.000000	0.002317
WSW	0.000088	0.001650	0.000550	0.000000	0.000000	0.000000	0.002287
W	0.000942	0.001375	0.001100	0.000000	0.000000	0.000000	0.003416
WNW	0.000594	0.000275	0.000000	0.000000	0.000000	0.000000	0.000869
NW	0.000319	0.000550	0.000275	0.000000	0.000000	0.000000	0.001144
NNW	0.000015	0.000275	0.000000	0.000000	0.000000	0.000000	0.000290
TOTAL	0.010723	0.016497	0.005774	0.000000	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF B STABILITY = 0.032994

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH B STABILITY = 0.001375

Table 5.2.2.6-18 Dayton, Ohio autumn surface wind direction and speed, relative frequencies for "C" stability

SEA-SON

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.000026	0.001100	0.001100	0.000275	0.000000	0.000000	0.002500
NNE	0.000039	0.001650	0.001100	0.000000	0.000000	0.000000	0.002788
NE	0.000006	0.000275	0.000825	0.000000	0.000000	0.000000	0.001106
ENE	0.000032	0.001375	0.001100	0.000000	0.000000	0.000000	0.002507
E	0.000052	0.002200	0.004949	0.000000	0.000000	0.000000	0.007201
ESE	0.000026	0.001100	0.001650	0.000000	0.000000	0.000000	0.002775
SE	0.000065	0.002750	0.003574	0.000000	0.000000	0.000000	0.006389
SSE	0.000333	0.002200	0.002475	0.000275	0.000000	0.000000	0.005282
S	0.000084	0.003574	0.008249	0.001100	0.000000	0.000000	0.013007
SSW	0.000045	0.001925	0.004124	0.001100	0.000000	0.000000	0.007194
SW	0.000006	0.000275	0.002750	0.000000	0.000000	0.000000	0.003031
WSW	0.000013	0.000550	0.002475	0.000275	0.000000	0.000000	0.003312
W	0.000039	0.001650	0.003574	0.000275	0.000000	0.000000	0.005538
WNW	0.000013	0.000550	0.003024	0.000550	0.000000	0.000000	0.004137
NW	0.000013	0.000550	0.001925	0.000275	0.000000	0.000000	0.002762
NNW	0.000207	0.001100	0.001100	0.000275	0.000000	0.000000	0.002682
TOTAL	0.001100	0.022021	0.043922	0.004399	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF C STABILITY = 0.072312

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH C STABILITY = 0.000550

Table 5.2.2.6-19 Dayton, Ohio autumn surface wind direction and speed, relative frequencies for "D" stability

SEA-SON

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.002383	0.007149	0.003524	0.011273	0.000825	0.000000	0.030153
NNE	0.001283	0.004674	0.003574	0.003849	0.000275	0.000000	0.013656
NE	0.001123	0.002750	0.004399	0.004124	0.000000	0.000000	0.012396
ENE	0.000573	0.003299	0.005774	0.002750	0.000550	0.000000	0.012746
E	0.001501	0.004674	0.009073	0.004124	0.000000	0.000000	0.019453
ESE	0.001169	0.003299	0.007699	0.002475	0.000000	0.000000	0.014941
SE	0.000458	0.005499	0.015397	0.004674	0.000000	0.000000	0.026029
SSE	0.001398	0.006049	0.012648	0.007974	0.000275	0.000000	0.028343
S	0.001764	0.006874	0.030249	0.040693	0.005224	0.000550	0.085349
SSW	0.001329	0.005224	0.019247	0.032169	0.003024	0.000000	0.060993
SW	0.001627	0.005224	0.012098	0.014023	0.002750	0.000550	0.036271
WSW	0.001741	0.006599	0.010448	0.015947	0.004124	0.000275	0.039135
W	0.002314	0.013473	0.022546	0.036544	0.004399	0.000550	0.080125
WNW	0.000733	0.005224	0.013748	0.018422	0.001100	0.000000	0.039226
NW	0.002131	0.004124	0.007699	0.011273	0.000825	0.000000	0.026052
NNW	0.001214	0.007424	0.008249	0.007424	0.000000	0.000000	0.024310
TOTAL	0.022821	0.091559	0.191366	0.218037	0.023371	0.001925	

RELATIVE FREQUENCY OF OCCURRENCE OF D STABILITY = 0.549079

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH D STABILITY = 0.008798

Table 5.2.2.6-20 Dayton, Ohio autumn surface wind direction and speed, relative frequencies for "E" stability

SEA-SON

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.004787	0.010998	0.002750	0.000000	0.000000	0.000000	0.018535
NNE	0.003925	0.006599	0.000825	0.000000	0.000000	0.000000	0.011349
NE	0.002135	0.004674	0.001375	0.000000	0.000000	0.000000	0.008184
ENE	0.002105	0.011823	0.002200	0.000000	0.000000	0.000000	0.016128
E	0.005135	0.016222	0.003574	0.000000	0.000000	0.000000	0.024931
ESE	0.005408	0.013473	0.003299	0.000000	0.000000	0.000000	0.022180
SE	0.004520	0.023646	0.006049	0.000000	0.000000	0.000000	0.034215
SSE	0.005549	0.019522	0.003024	0.000000	0.000000	0.000000	0.028096
S	0.007033	0.026395	0.013748	0.000000	0.000000	0.000000	0.047176
SSW	0.003668	0.012098	0.010998	0.000000	0.000000	0.000000	0.026784
SW	0.002999	0.011548	0.003299	0.000000	0.000000	0.000000	0.017847
WSW	0.002413	0.009348	0.003849	0.000000	0.000000	0.000000	0.015611
W	0.004723	0.017872	0.010448	0.000000	0.000000	0.000000	0.033043
WNW	0.003375	0.007149	0.003849	0.000000	0.000000	0.000000	0.014373
NW	0.002858	0.005499	0.004124	0.000000	0.000000	0.000000	0.012481
NNW	0.003409	0.007424	0.001925	0.000000	0.000000	0.000000	0.012758
TOTAL	0.064064	0.204289	0.075337	0.000000	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF E STABILITY = 0.343690

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH E STABILITY = 0.029970

Table 5.2.2.6-21 Dayton, Ohio annual surface wind direction and speed, relative frequencies for "A" stability

Annual

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.000059	0.000137	0.000000	0.000000	0.000000	0.000000	0.000196
NNE	0.000226	0.000069	0.000000	0.000000	0.000000	0.000000	0.000295
NE	0.000158	0.000137	0.000000	0.000000	0.000000	0.000000	0.000295
ENE	0.000128	0.000059	0.000000	0.000000	0.000000	0.000000	0.000196
E	0.000473	0.000411	0.000000	0.000000	0.000000	0.000000	0.000884
ESE	0.000030	0.000069	0.000000	0.000000	0.000000	0.000000	0.000098
SE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SSE	0.000158	0.000137	0.000000	0.000000	0.000000	0.000000	0.000295
S	0.000452	0.000137	0.000000	0.000000	0.000000	0.000000	0.000589
SSW	0.000119	0.000274	0.000000	0.000000	0.000000	0.000000	0.000393
SW	0.000059	0.000137	0.000000	0.000000	0.000000	0.000000	0.000196
WSW	0.000217	0.000274	0.000000	0.000000	0.000000	0.000000	0.000491
W	0.000128	0.000069	0.000000	0.000000	0.000000	0.000000	0.000196
WNW	0.000030	0.000069	0.000000	0.000000	0.000000	0.000000	0.000098
NW	0.000315	0.000274	0.000000	0.000000	0.000000	0.000000	0.000589
NNW	0.000324	0.000069	0.000000	0.000000	0.000000	0.000000	0.000393
TOTAL	0.002877	0.002329	0.000000	0.000000	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF A STABILITY = 0.005207

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH A STABILITY = 0.001576

Table 5.2.2.6-22 Dayton, Ohio annual surface wind direction and speed, relative frequencies for "B" stability

Annual

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.000646	0.001850	0.000635	0.000000	0.000000	0.000000	0.003131
NNE	0.000003	0.001165	0.000617	0.000000	0.000000	0.000000	0.002584
NE	0.000498	0.000959	0.000754	0.000000	0.000000	0.000000	0.002211
ENE	0.000646	0.001028	0.000822	0.000000	0.000000	0.000000	0.002498
E	0.000645	0.002124	0.000754	0.000000	0.000000	0.000000	0.003523
ESE	0.000387	0.001507	0.000617	0.000000	0.000000	0.000000	0.002511
SE	0.000406	0.001918	0.000549	0.000000	0.000000	0.000000	0.002873
SSE	0.000438	0.001165	0.000343	0.000000	0.000000	0.000000	0.001946
S	0.001065	0.001850	0.001233	0.000000	0.000000	0.000000	0.004148
SSW	0.000387	0.001507	0.000959	0.000000	0.000000	0.000000	0.002854
SW	0.000864	0.001302	0.001439	0.000000	0.000000	0.000000	0.003625
WSW	0.000379	0.001370	0.000959	0.000000	0.000000	0.000000	0.002708
W	0.001065	0.001850	0.001918	0.000000	0.000000	0.000000	0.004833
WNW	0.000593	0.001302	0.000685	0.000000	0.000000	0.000000	0.002580
NW	0.000498	0.000959	0.000891	0.000000	0.000000	0.000000	0.002348
NNW	0.000242	0.001507	0.000891	0.000000	0.000000	0.000000	0.002640
TOTAL	0.009866	0.023363	0.014113	0.000000	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF B STABILITY = 0.047342

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH B STABILITY = 0.001987

Table 5.2.2.6-23 Dayton, Ohio annual surface wind direction and speed, relative frequencies for "C" stability

Annual

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.000424	0.001576	0.002672	0.000822	0.000000	0.000000	0.005494
NNE	0.000180	0.001302	0.001370	0.000548	0.000000	0.000000	0.003400
NE	0.000346	0.000617	0.001302	0.000411	0.000000	0.000000	0.002676
ENE	0.000163	0.001096	0.002672	0.000822	0.000000	0.000000	0.004753
E	0.000206	0.001644	0.004042	0.000343	0.000000	0.000000	0.006237
ESE	0.000408	0.001370	0.002201	0.000069	0.000000	0.000000	0.004107
SE	0.000367	0.001781	0.002406	0.000274	0.000000	0.000000	0.004829
SSE	0.000350	0.001576	0.001918	0.000274	0.000000	0.000000	0.004118
S	0.000508	0.002603	0.005755	0.001026	0.000069	0.000000	0.009763
SSW	0.000393	0.001781	0.005755	0.001165	0.000000	0.000000	0.008994
SW	0.000185	0.001370	0.005549	0.000891	0.000274	0.000000	0.008270
WSW	0.000476	0.001302	0.003700	0.001096	0.000069	0.000000	0.006642
W	0.000782	0.002329	0.005344	0.000754	0.000069	0.000069	0.009346
WNW	0.000237	0.001096	0.003563	0.000411	0.000000	0.000000	0.005307
NW	0.000159	0.001165	0.002124	0.000137	0.000000	0.000000	0.003594
NNW	0.000384	0.001987	0.002329	0.000411	0.000000	0.000000	0.005111
TOTAL	0.005481	0.024596	0.052023	0.009455	0.000480	0.000069	

RELATIVE FREQUENCY OF OCCURRENCE OF C STABILITY = 0.092902

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH C STABILITY = 0.002261

Table 5.2.2.6-24 Dayton, Ohio annual surface wind direction and speed, relative frequencies for "D" stability

Annual

Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.001388	0.005492	0.011784	0.013702	0.001781	0.000069	0.034017
NNE	0.000783	0.005344	0.009249	0.007331	0.000548	0.000274	0.023529
NE	0.000712	0.003974	0.006303	0.003905	0.000206	0.000000	0.015099
ENE	0.000448	0.004453	0.008016	0.004248	0.000274	0.000000	0.017439
E	0.000830	0.006235	0.012949	0.007331	0.000137	0.000000	0.027481
ESE	0.000939	0.004179	0.008975	0.005686	0.000274	0.000000	0.020053
SE	0.000815	0.005961	0.014250	0.005275	0.000069	0.000000	0.026370
SSE	0.000653	0.005618	0.011647	0.007399	0.000206	0.000000	0.025523
S	0.001103	0.007331	0.029392	0.034461	0.005070	0.000411	0.077760
SSW	0.000650	0.005549	0.020417	0.029118	0.005481	0.000411	0.061625
SW	0.000823	0.004727	0.012127	0.016374	0.002398	0.000754	0.037203
WSW	0.000913	0.005070	0.009318	0.017832	0.004727	0.000822	0.038732
W	0.001516	0.009729	0.020346	0.039052	0.006372	0.001302	0.078318
WNW	0.000646	0.005481	0.010551	0.018361	0.001918	0.000069	0.037026
NW	0.001018	0.004316	0.009546	0.009660	0.000685	0.000000	0.025545
NNW	0.000808	0.005824	0.009044	0.007455	0.001165	0.000069	0.026363
TOTAL	0.014045	0.089862	0.204234	0.229241	0.031310	0.004179	

RELATIVE FREQUENCY OF OCCURRENCE OF D STABILITY = 0.572691

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH D STABILITY = 0.005138

Table 5.2.2.6-25 Dayton, Ohio annual surface wind direction and speed, relative frequencies for "E" stability

Annual

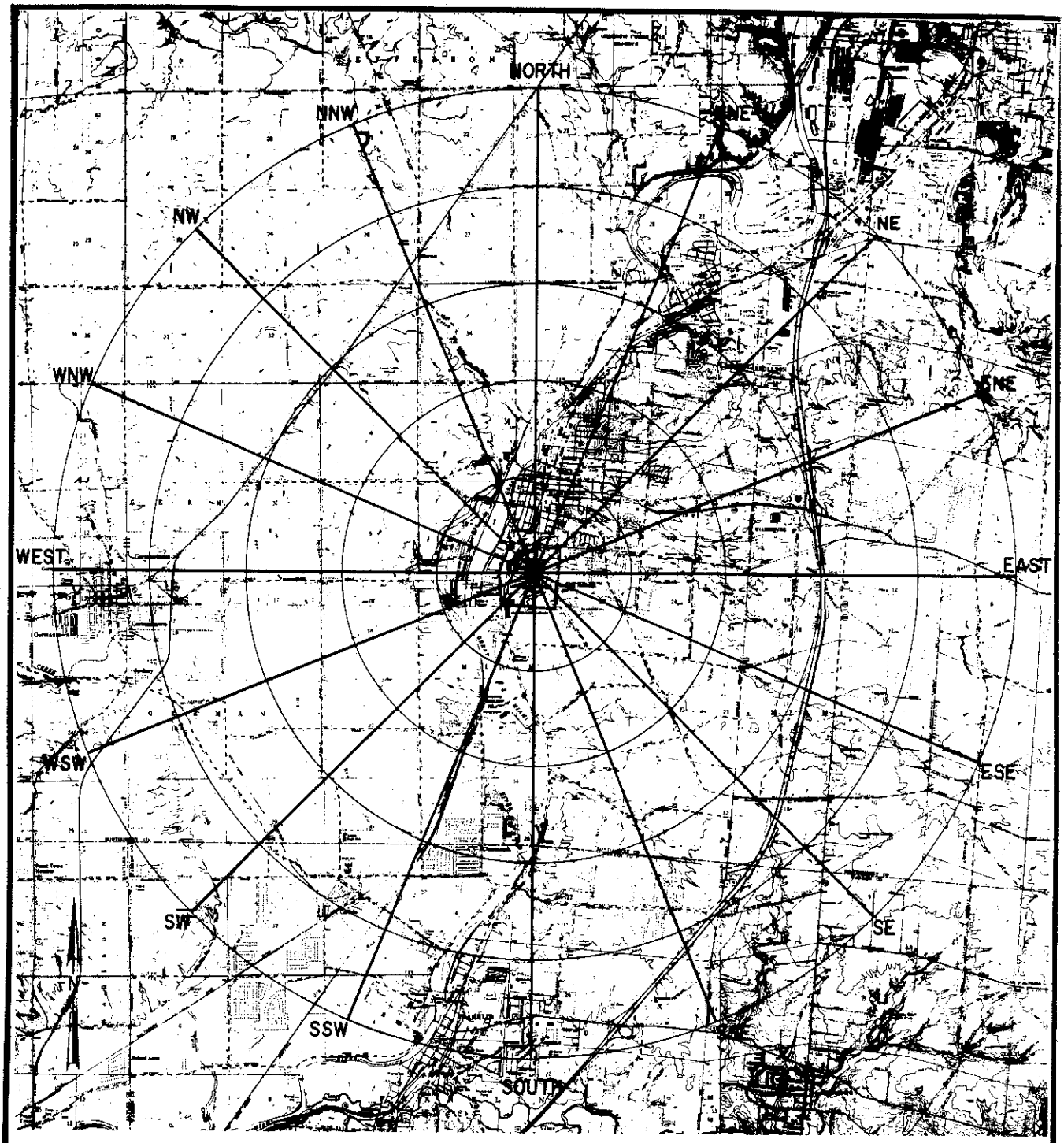
Station-Dayton, Ohio 65-69

Relative Frequency Distribution
Speed (Kts)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.003658	0.008495	0.003700	0.000000	0.000000	0.000000	0.015853
NNE	0.002730	0.007742	0.001918	0.000000	0.000000	0.000000	0.012390
NE	0.001741	0.005138	0.002740	0.000000	0.000000	0.000000	0.009620
ENE	0.002024	0.008907	0.002946	0.000000	0.000000	0.000000	0.013876
E	0.002939	0.012195	0.003631	0.000000	0.000000	0.000000	0.018764
ESE	0.002206	0.004495	0.001781	0.000000	0.000000	0.000000	0.012482
SE	0.003269	0.014388	0.003289	0.000000	0.000000	0.000000	0.020945
SSE	0.003221	0.011990	0.002261	0.000000	0.000000	0.000000	0.017472
S	0.004620	0.019457	0.010208	0.000000	0.000000	0.000000	0.034286
SSW	0.002738	0.009797	0.009729	0.000000	0.000000	0.000000	0.022264
SW	0.002612	0.010688	0.004659	0.000000	0.000000	0.000000	0.017959
WSW	0.002182	0.008290	0.004590	0.000000	0.000000	0.000000	0.015062
W	0.004603	0.015347	0.009592	0.000000	0.000000	0.000000	0.029542
WNW	0.002147	0.007331	0.004727	0.000000	0.000000	0.000000	0.014205
NW	0.002095	0.007536	0.004179	0.000000	0.000000	0.000000	0.013810
NNW	0.002638	0.007605	0.003083	0.000000	0.000000	0.000000	0.013326
TOTAL	0.045423	0.163401	0.073034	0.000000	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF E STABILITY = 0.281858

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH E STABILITY = 0.021650



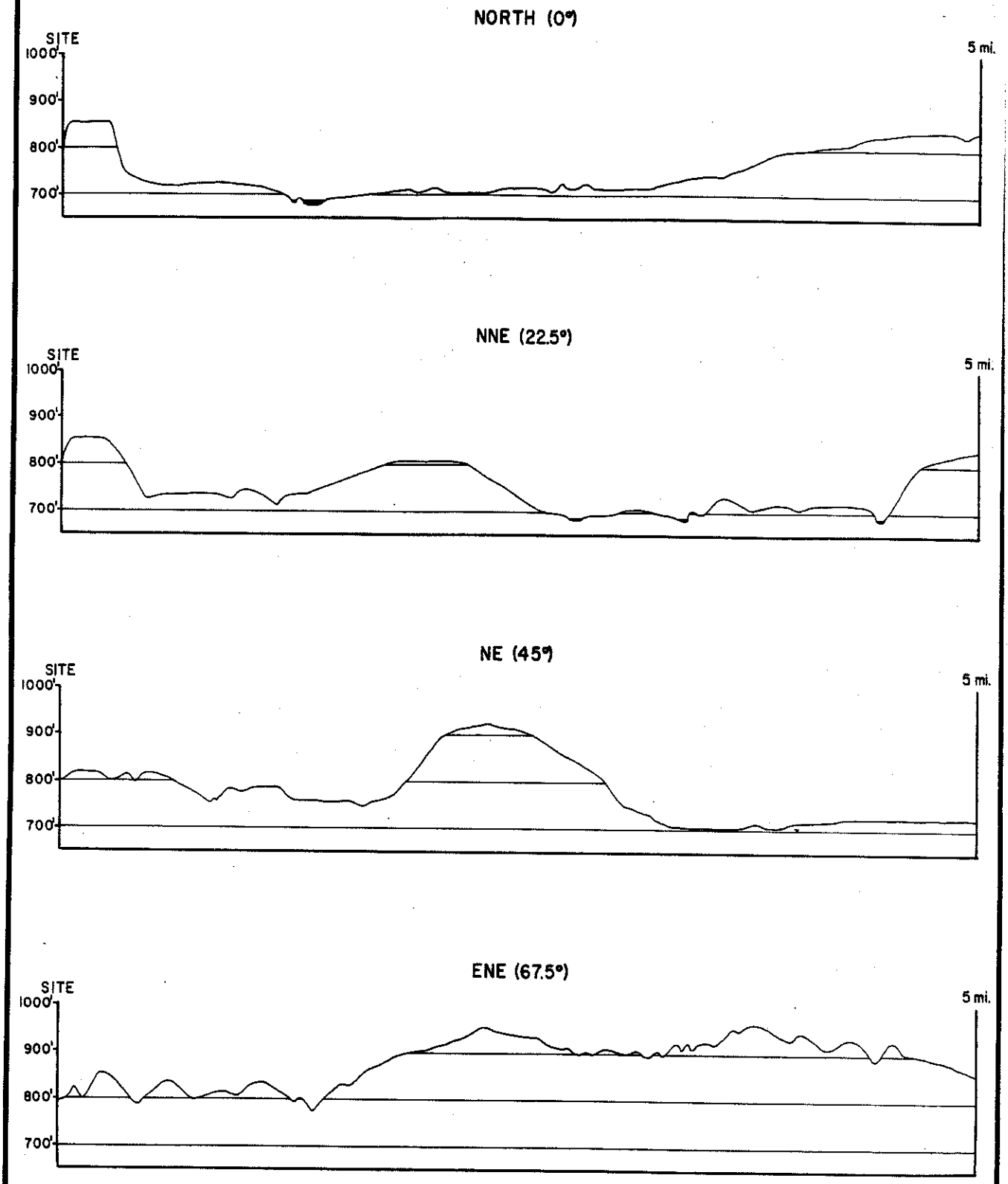
Map Showing Topographic Features and Index to Topographic Cross Sections.

0 1 2 Miles

Circles on 1 Mile Radii from Center of Site.

Adapted from U.S.G.S. 7 1/2 minute Topographic Maps, 1965.

DAMES & MOORE



TOPOGRAPHIC CROSS SECTIONS

0°–67.5°

0 0.5 1.0 MILE

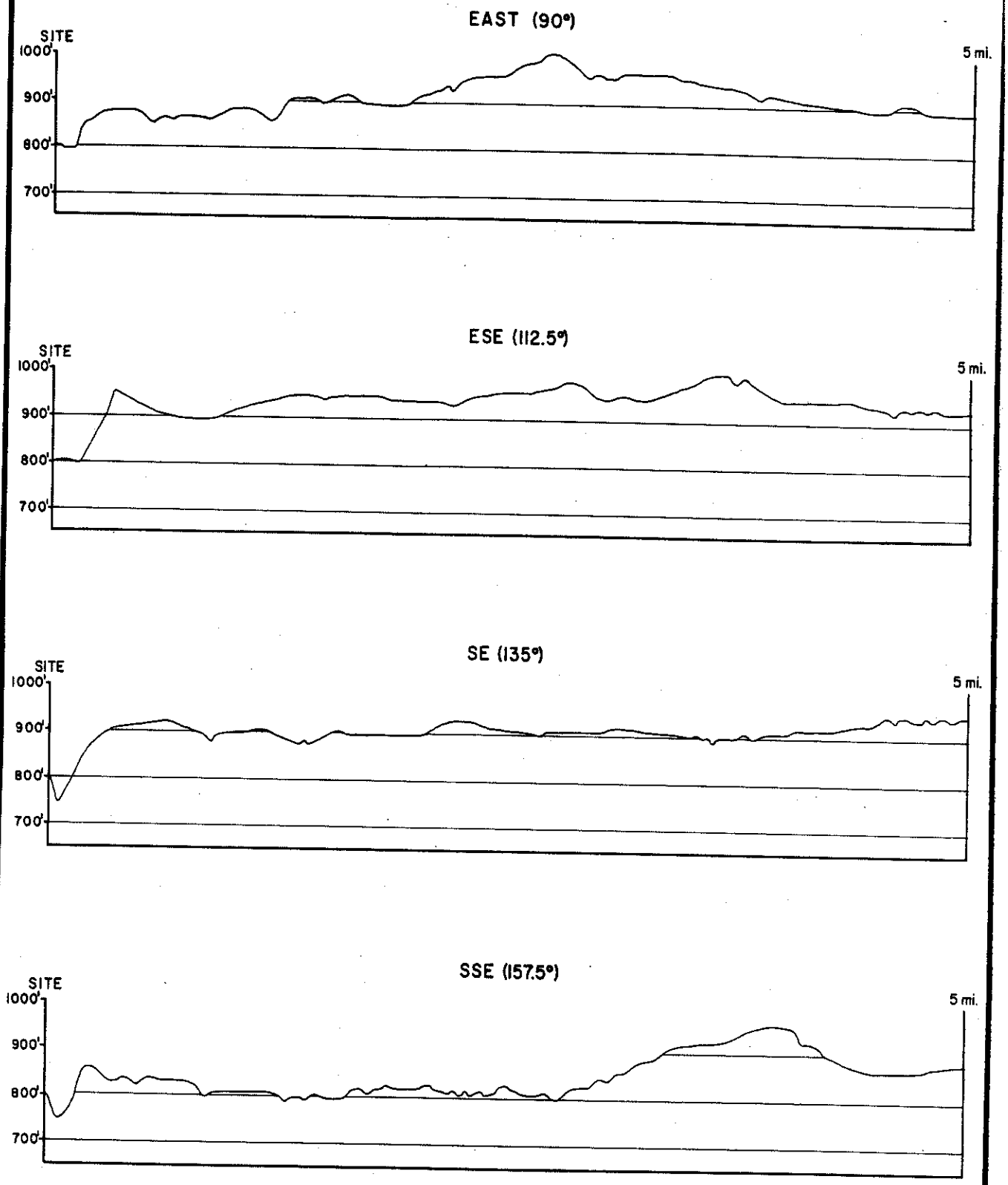
VERTICAL EXAGGERATION: 13.3X

DAMES & MOORE

REVISIONS
BY ____ DATE ____
BY ____ DATE ____
PLATE ____ OF ____

FILE 5827-002
BY Gray DATE 4/12/72
CHECKED BY ____ DATE ____

486.10 (4-64)



TOPOGRAPHIC CROSS SECTIONS

90°–157.5°

0 0.5 1.0 MILE

VERTICAL EXAGGERATION: 13.3X

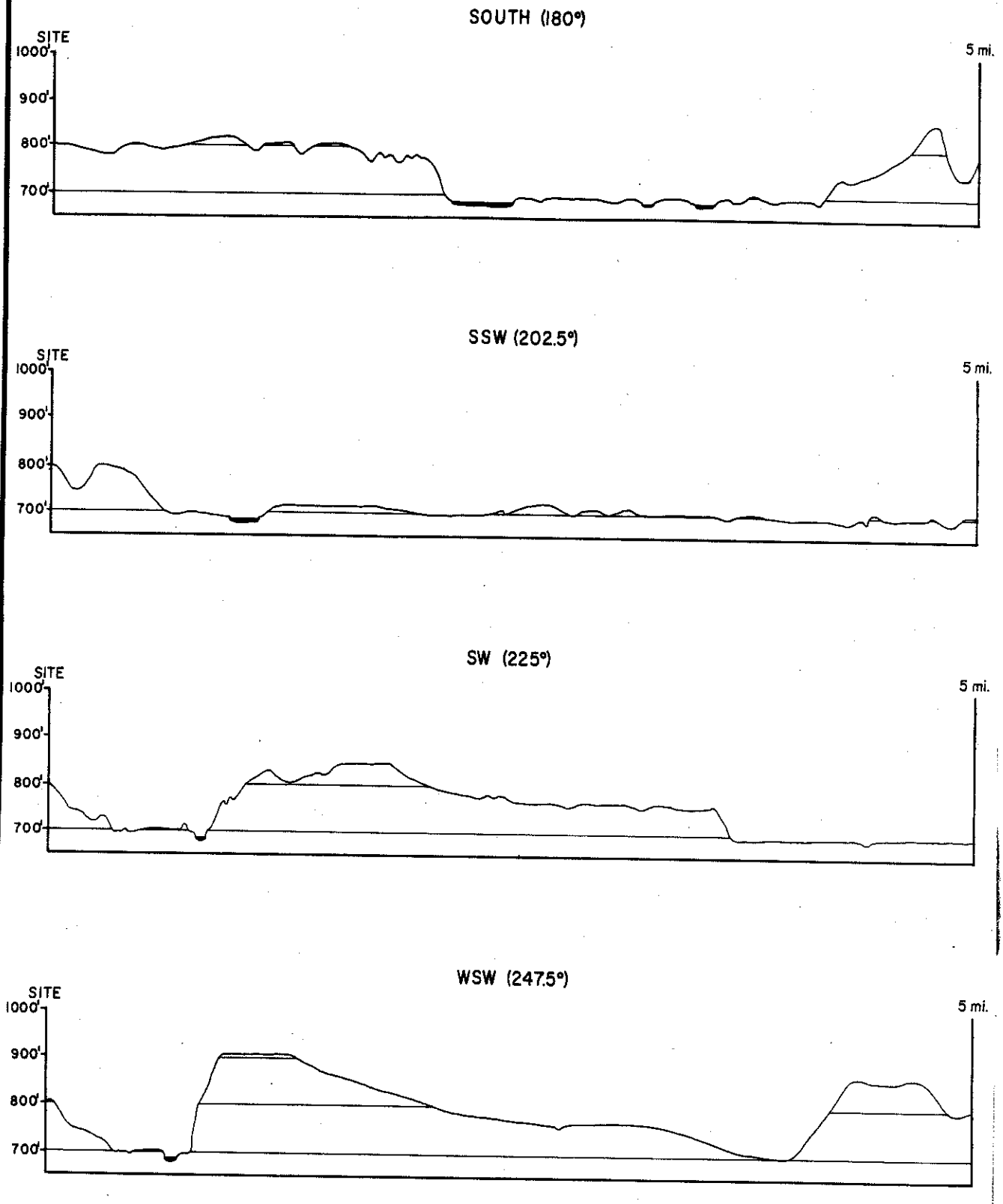
DAMES & MOORE

REVISIONS
BY ____ DATE ____
BY ____ DATE ____
PLATE ____ OF ____

FILE 5627-002
BY G. May DATE 12-27-72
CHECKED BY ____ DATE ____

466.10 (4-64)

PLATE 5.2.4-3



TOPOGRAPHIC CROSS SECTIONS

180°–247.5°

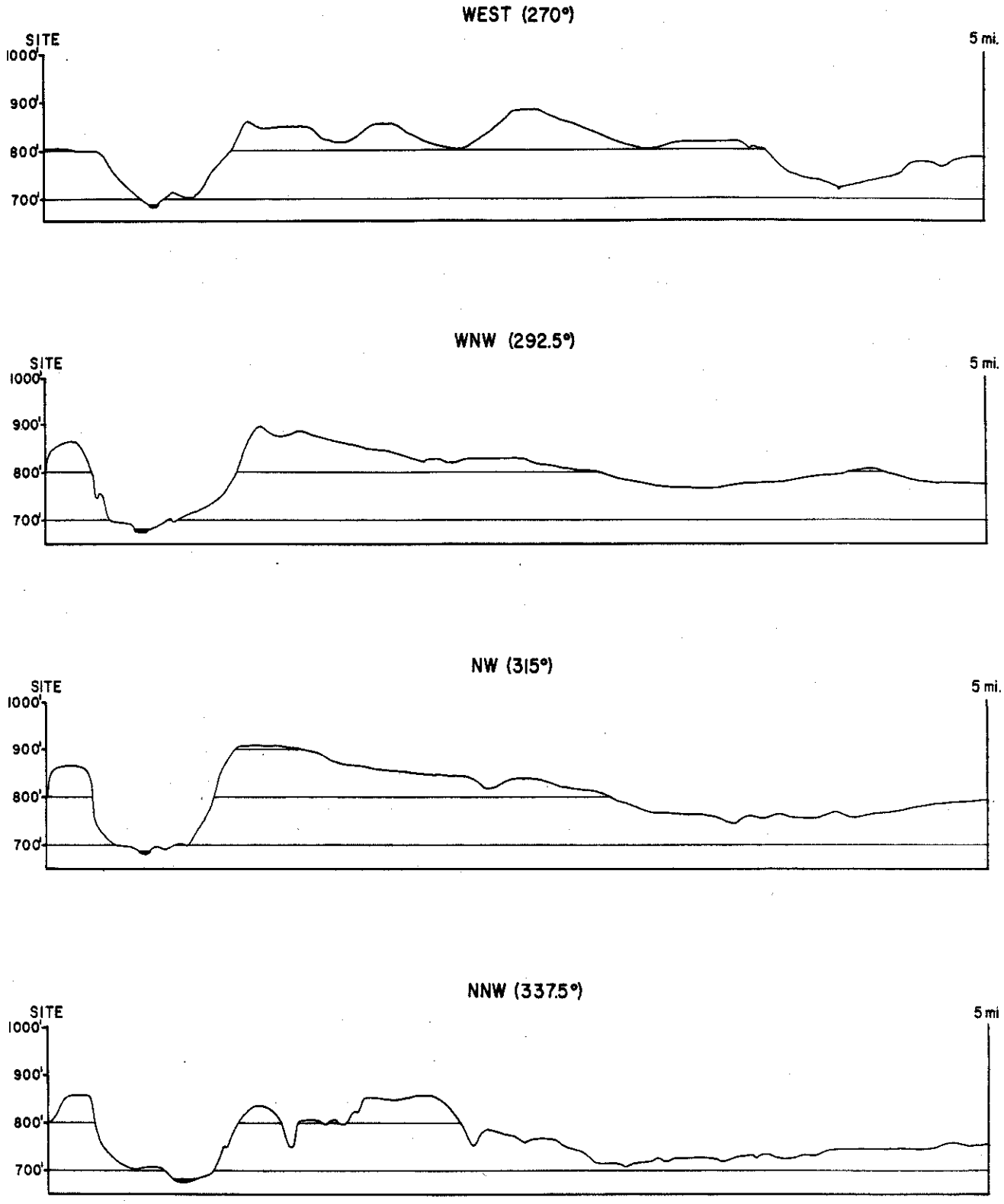
0 0.5 1.0 MILE

VERTICAL EXAGGERATION: 13.3X

DAMES & MOORE

REVISIONS BY DATE BY DATE PLATE OF

FILE 5627-002 BY DATE 12-27-72 CHECKED BY DATE



TOPOGRAPHIC CROSS SECTIONS

270°–337.5°

0 0.5 1.0 MILE

VERTICAL EXAGGERATION: 13.3X

DAMES & MOORE

REVISIONS BY DATE BY DATE PLATE OF

FILE 5617-002 BY Guy DATE 12/17/82 CHECKED BY DATE

6. HYDROLOGY

6.1. SURFACE WATER

6.1.1. Introduction

This section presents a hydrologic engineering appraisal of the maximum water levels that could occur under the most severe hydrometeorological and upstream dam failure conditions at Mound Laboratory. Because Mound Laboratory does not utilize large volumes of process or cooling water and due to the topography of the site as discussed below, the surface water hydrology has been evaluated in substantially less detail than that suggested in the Safety Analysis Report Guidelines for Nuclear Power Plants, (U.S.A.E.C. Oct. 1972). This reduced level of effort was consistent with discussions held prior to developing the scope of work with Monsanto Research Corporation. The data base used in this analysis was developed from interviews and literature research from various agencies and companies that worked or are now working on the hydrology of the Great Miami River Basin.

6.1.2. Site and Facilities

Mound Laboratory is located on the east bank of the Great Miami River in southwestern Ohio in Miamisburg just south of Dayton, Ohio. Major hydrologic features of the area and their relation to the laboratory are shown on Plate 6.1.2-1. The relationship between the topography of the site and the Great Miami River is shown on Plate 6.1.2-2. The Mound Laboratory site elevation (El.) varies from a minimum of El. 710 at the western boundary adjacent to the Penn Central Railroad spur to a maximum elevation of about 880 feet at the Plutonium Processing Building (PP). Most of the site is well above El. 800 feet with the typical non-flood stage of the Great Miami River at El. 682. The normal pool elevation is controlled by the Hutchings Station dam about 1.5 miles downstream from the site with a dam crest El. 680. The river bottom in the site vicinity is at El. 670. The safety

related buildings and the detailed site topography are indicated on Plate 6.3-6. It should be noted that the Radioactive Waste Disposal Building is located at El. 790 which is the lowest Category I building on the site. (Category I buildings are those in which significant quantities of radioactive material are processed or handled outside of shipping containers or encapsulation systems. Category I also includes buildings in which there is the potential for release of radioactive material from a containment system).

There are no perennial streams on the site. The site is bisected by a deep valley as shown on Plate 6.3-6. The drainage basin contributory to this valley is generally limited to the site area, being about 200 acres in extent. Therefore, because of the small drainage basin and the steep gradients, runoff through site drainage features will not have an impact on the safety related structures.

The Great Miami River Basin is not subjected to seiches or excessive surges and associated wave action caused by hurricanes or tsunamies. The maximum water levels that could occur are caused by either the Probable Maximum Flood (PMF) or a flood wave resulting from a dam failure upstream from the site. These conditions were examined.

The conclusion of the hydrologic assessment is that the safety related elevation for the Mound Laboratory site, including the highest water level with associated wave runup is calculated to be El. 727. This was estimated by assuming the extremely remote possibility of complete failure of Huffman Dam upstream from the site. For the Probable Maximum Flood, the maximum stage at the site was calculated to be El. 710. It must be stressed that the postulated Huffman Dam failure on Mad River, as shown on Plate 6.1.2-1, is an extremely remote condition 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 (MCD).

6.1.3. Flood History

Flow in the Great Miami River at the site originates from three major and two minor sub-drainage systems. The three major stream systems are: 1) Stillwater River, 676 square miles; 2) Great Miami River above Stillwater River, 1,175 square miles, and 3) Mad River, 657 square miles. The minor sub-drainage systems are: 1) Bear Creek drainage area, 53 square miles and 2) Wolf Creek, 70 square miles. Other small stream systems such as Holes Creek contribute 80 square miles of drainage area. Total drainage area of the Great Miami River at Miamisburg is 2,711 square miles, (Cross, 1967).

The site is only about one mile downstream from the Miamisburg gage (U.S.G.S. No. 3-2715). The discharge at the gage is assumed to be the same as at the site because the drainage basin areas are essentially equal. (See Plate 6.1.6-2).

Before construction of the large flood water retarding basins as detailed in Section 6.1.4. and shown on Plate 6.1.2-1, considerable flooding occurred throughout the Great Miami River Basin. A summary of the discharges at Miamisburg for the highest floods on record since 1913, as estimated or measured are given in Table 6.1.3-1.

Stream gage data has been obtained above Miamisburg at Dayton since 1866. The gaging station at Miamisburg was established in 1916. The greatest flood of record occurred in 1913. The flood was later estimated to be 257,000 cfs at Miamisburg. After the 1913 flood, the Miami Conservancy District (MCD) was formed to investigate and develop a flood control system to protect population centers in the upper Great Miami River Valley. Since construction of the retarding basins in 1921, floods on the Great Miami River have been greatly reduced with a maximum flow of 61,800 cfs occurring at Miamisburg in January, 1959. Damage associated with such flooding has been confined to tributaries and developed areas lying in the flood plain since development of the flood control system. (Cross, 1959).

Under controlled discharge conditions, the following flow conditions have been observed at the Miamisburg gage, (Cross, 1968):

Maximum daily average discharge - 55,600 cfs, 1/23/1959

Minimum daily average discharge - 148 cfs, 9/7/1925.

6.1.4. Reservoir Description

Design statistics of the four flood water retarding basins shown on Plate 6.1.2-1 above the site are listed in Table 6.1.4-1. Low dams of inconsequential effect to this analysis are also located along the river. These low dams are used for various purposes and do not have a significant influence on maximum water levels at Mound Laboratory due to their crest elevations.

The Buck Creek Reservoir is under construction and will be completed in 1973. It is located east of Springfield, Ohio, 7.3 miles above the confluence of Buck Creek with the Mad River, (see Figure 6.1.2-1). For flood control protection, the 72-foot high dam and reservoir will reduce flooding at

Springfield, Ohio and reduce flood stages at downstream points in the Mad River basin above Huffman Dam. Approximately 32,900 acre feeet (AF) will be available for flood storage during the winter season out of the total reservoir capacity of 63,700 AF. Flood control capacity after the winter season extending into summer will be 26,800 AF, (Corps of Engineers, 1971).

6.1.5. Probable Maximum Precipitation (PMP)

6.1.5.1. Background The Miami Conservancy District has reviewed the maximum or greatest average depth of rainfall versus periods of time for maximum storms occurring in the United States. The storm of March, 1913 was responsible for the greatest precipitation on record in many areas of the Great Miami River Basin, with precipitation ranging from 8.94 to 11.74 inches over a four day period. After extensive investigation of storms in the eastern United States it was concluded that the March, 1913 storm produced one of the greatest historical floods in the Miami Valley. Using the precipitation records of the 1913 storm, the MCD based their flood protection works on a design flood runoff approximately 40 percent greater than the 1913 flood. This design flood was estimated by the MCD to be 15 to 20 percent above the greatest possible flood that will ever occur in the northern part of the Miami River Basin over a 300 to 400 year period. (Engineering Staff of the District, 1917).

In 1964, the Miami Conservancy District issued a restudy of the official plan, using computer techniques and additional data developed during the previous ten years. (MCD - Part 1, 11, 1964, Part 111, 1967). The basin under study was divided above Hamilton, Ohio, into thirty subareas, varying in size from 36 to 339 square miles. Use of the five MCD retarding basins was also taken into consideration for flood routing. The maximum precipitation data was also reviewed as part of the study, including seven storms of record for the period from 1913 to 1963, to determine the reliability of the basin mathematical model, utilizing a high speed digital computer.

6.1.5.2. Development of Probable Maximum Precipitation (PMP) No studies have been made to date using modern criteria that will directly yield the Probable Maximum Flood for the Great Miami River Basin. Extensive studies by the MCD as well as the Louisville District, US Army Corps of Engineers of the Standard Project Flood (SPF) have been made for the basin, however. The development of the PMP for use in the Probable Maximum Flood Computation for the Mound Laboratory site would require a very large number of storms arranged geographically in many locations and orientations with attempts at maximizing the total amount of precipitation. It was felt that such a study would require far more

effort than would be justified. It was therefore decided to utilize the Standard Project Storm (SPS) precipitation which has been adequately defined (MCD, 1964) and to apply the recommended factor to the SPS to develop the Probable Maximum Precipitation (PMP). The recommended relationship between the SPS and the PMP is two times the SPS and is equivalent to the PMP as defined by the US Army Corps of Engineers, (Corps of Engineers, 1952).

The SPS isohyetals were applied to the Great Miami River Basin with the storm centered on the basin at a location approximately 20 miles north of the Mound Laboratory site near Union, Ohio on the Stillwater River above Englewood Dam. The SPS isohyetals were then doubled, converting them to PMP isohyetals, as shown on Plate 6.1.5-1. The rainfall excess values were computed and applied to each of the 30 basin subareas. A summary of the rainfall distribution and excess values for each six-hour rainfall period, for each subarea is presented in Table 6.1.5-1. The procedure used in developing the average rainfall period, for each subarea consisted of using the average rainfall between the isohyetals superimposed on the subarea. This average rainfall was then distributed in time according to the US Army Corps of Engineers criteria, (Corps of Engineers, 1952). Evapotranspiration and infiltration losses were estimated as follows:

a) The first 1.6 inches of rain is lost;

b) Thereafter, 0.05 inches per hour is lost.

These parameters were essentially the same as those applied by the MCD in their basin work and were confirmed in discussions with the Louisville District Corps of Engineers.

The resulting rainfall excess values for each basin were used to generate hydrographs that were routed through the drainage basin, including the retarding reservoirs. The results are summarized in Table 6.1.5-1. It should be noted that all of the retarding basins contained the flood below the top of the dam crest with the resulting maximum discharge of 238,000 cfs at the Mound Laboratory plant site, as discussed below.

6.1.5.3 Runoff Model The MCD has developed a flood routing model for the 3,639 square mile Great Miami River Drainage Basin above Hamilton, Ohio. This model was utilized to estimate the PMF. The model consists of 30 unit hydrographs with 23 channel-routing reaches and simulates eight retarding reservoirs, four of which are above the site. A six-hour routing period is utilized which is consistent with the storm rainfall excess intervals previously described. The model has been tested for the highest floods on record.

The mathematical model yields reliable results that have been verified by measured high-water flood marks. The basic components of the mathematical simulation model consists of the following:

1) Unit hydrographs -- The Great Miami River Basin above Hamilton, Ohio is divided into 30 subareas which vary from 36 to 330 square miles, as shown on Plate 6.1.5-1. Six-hour unit hydrographs were developed by using stream flow records where possible, or synthetic methods were good flow data were lacking.

2) Reservoir Routing -- The five MCD retarding basins and three state lakes are represented in the model. (See Plate 6.1.2-1 for the location of these features). A direct step method is used to route the flood through the reservoirs.

3) Channel Routing -- The Muskingum Routing Method is utilized for the 23 channel reaches contained within the mathematical model. The routing coefficients were developed by trial and error and computations from plots of discharge vs. storage (Doyle & Thomas, 1964).

The model has been verified by reproducing six floods that have occurred since 1922. In addition, the maximum flood record, March 1913, was reproduced by eliminating the retarding basin system from the model. It is concluded therefore, that the MCD model reliably reproduces the relationship between recorded high-water marks and associated discharges utilizing simulated hydrometeorological events.

6.1.6. Probable Maximum Flood (PMF)

The US Army Corps of Engineers defines the Probable Maximum Flood as, "Estimates of hypothetical flood characteristics (peak discharge, volume and hydrograph shape) that are considered to be the most severe reasonably possible at a particular location, based on relatively comprehensive hydrometeorological analysis of critical runoff-producing precipitation (and snow melt if pertinent) and hydrologic factors favorable for maximum flood runoff." (Corps of Engineers, 1966). An additional definition that indicates the remoteness of a PMF is "the estimated flood that would result if all the factors that contribute to the operation of flood were to reach their most critical value that could occur concurrently. The PMF is the estimate of the boundary between possible floods and impossible floods. The objective

therefore is to obtain a flood that has a chance of occurrence of zero for a time period of infinity." (Koelzer, 1964).

Based on the data and assumptions outlined in Sections 6.1.5.2, 6.1.5.3, the PMF at the site was calculated to be 238,000 cfs. It is of significance to note that the standard project flood as defined by the US Army Corps of Engineers at the Mound Laboratory site is 120,000 cfs or approximately 50 percent of the PMF. This is consistent with the generally accepted criteria (U.S.A.E.C., 1972), applied to the relationship between the Standard Project Flood and the PMF.

The discharge at Miamisburg for the 1913 storm without regulation in the basin, was estimated by the MCD at 257,000 cfs. The corresponding stage for this event at the site is El. 710.3. When the 1913 storm occurred flood protection works were very limited. After 1913 retarding basins and extensive levees were constructed. In the area of the site the elevation of these levee tops is approximately El. 708. Utilizing the backwater profiles computed by the US Army Corps of Engineers, Louisville District, and the highwater marks for the 1913 flood, the PMF of 238,000 cfs yields stage elevation of 710.0 feet at the site. Plate 6.1.6-1 shows the stage discharge relationship for the Miamisburg gage. Table 6.1.6-1 summarizes the 1913 flood, the SPF and the PMF statistics. Backwater curves for the 10, 20 and 250 year (SPF) events are shown on Plate 6.1.6-2.

The PMF starting point was computed on the basis that average August hydrologic factors existed in the Great Miami River Drainage basin. Therefore, the average flow of 750 cfs for August at Dayton, Ohio was used as the base flow for the PMF calculation after proration over the entire watershed.

6.1.7. Upstream Dam Failure

As indicated in the foregoing sections, the upper reach of the Great Miami River drainage basin, above Miamisburg, is controlled by a series of dams and retarding basins. (Plate 6.1.2-1). These are the Englewood Dam, Lockington Dam, Taylorsville Dam, Huffman Dam and the Buck Creek Reservoir which is presently under construction. Details on each of these flood control projects are presented in Section 6.1.4.

Dam failure for each of these dams was analyzed since failure during a period of high runoff would have a major impact on water levels at the site.

The worst possible condition was assumed to have occurred:

that of complete and instantaneous rupture leaving no flow obstruction in the channel downstream of the removed dam. It must be emphasized that this condition is extremely remote and is postulated to provide the maximum possible surge height at the site. The height of the flood wave would be 0.44 (Henderson, 1968) of the upstream water depth at the dam, and the velocity of the flood wave or surge moving downstream would be:

$$V = 2/3 \sqrt{gy_o}$$

where, V = Initial Wave Velocity

g = 32.2 feet/second/second

y_o = Depth of water behind the dam

At the time of failure each reservoir was assumed to be filled to the spillway crest elevation. It was further conservatively assumed that the resulting surge crest was not attenuated by longitudinal spreading. The following relationship was used to route surges from failure of the Englewood, Taylorsville and Huffman Dams downstream to Miamisburg, (Henderson, 1968):

$$\frac{\Delta Y_2}{\Delta Y_1} = \frac{2b}{b_1 + b_2}$$

where,

ΔY_1 = Initial surge height

ΔY_2 = Surge height after a fairly abrupt change of river section

b_1 = River width at initial surge height

b_2 = River width at changed section

The above relationship assumes a rectangular channel and is applicable to both large channel section changes and river branching. As the surge approaches a major channel area increase or junction, it will continue to travel through the channel but with diminished intensity because of the increased cross-sectional area. The transition region then becomes filled with water of depth intermediate between the two depths related above. The result is that a negative wave is reflected back into the channel from which the surge originated. At a change of cross-section the surge will increase in height if the change is a constriction, or reduce in

height if it is an expansion. Each surge was routed downstream from the ruptured dam to Miamisburg.

The results of these computations are presented in Table 6.1.7-1. For this analysis, each dam failure was assumed to be coincident with the 250 year flood, which is equivalent to the Standard Project Flood on the Great Miami River, as analyzed by the US Army Corps of Engineers. In order to be conservative, computational techniques did not include frictional and transitional losses which would reduce the surge crest. These losses might be significant since a flood wave traveling at velocities approaching those calculated at the dam would subject the riverbed to major erosion resulting in reducing the computed surge crest elevation at the site.

Failure of the Buck Creek Dam would create a surge down the Mad River and into the Huffman Retarding Basin. The 15-foot freeboard available above the spillway crest elevation at the Huffman Dam will provide about 138,000 acre-feet of storage, which is considerably more than the total maximum storage of about 64,000 acre-feet in the Buck Creek Reservoir. The initial surge height from Buck Creek Reservoir of 29.5 feet would be diminished to less than the 15-foot Huffman Dam freeboard, and the dam would not be overtopped. Thus the Huffman Dam would not fail in domino fashion due to failure of the Buck Creek Dam and would create no significant surge at Miamisburg.

Similarly, a failure of the Lockington Dam would not cause failure of the downstream Taylorsville Dam since the available 19-foot freeboard above the Taylorsville Dam spillway level would contain the total surge.

Coincident failure of all of these dams or multiple combinations of failure have not been considered since the probability of this type of occurrence is so unreasonably remote as to preclude the rational need for examination.

The maximum computed surge height at the Mound Laboratory site resulted from the complete instantaneous removal of the Huffman Dam. This condition resulted in a high water elevation of 719.3, to which the wave runup effects must be added. Elevation of the Radioactive Waste Disposal facility is the lowest Category I structure which is at elevation 790 feet.

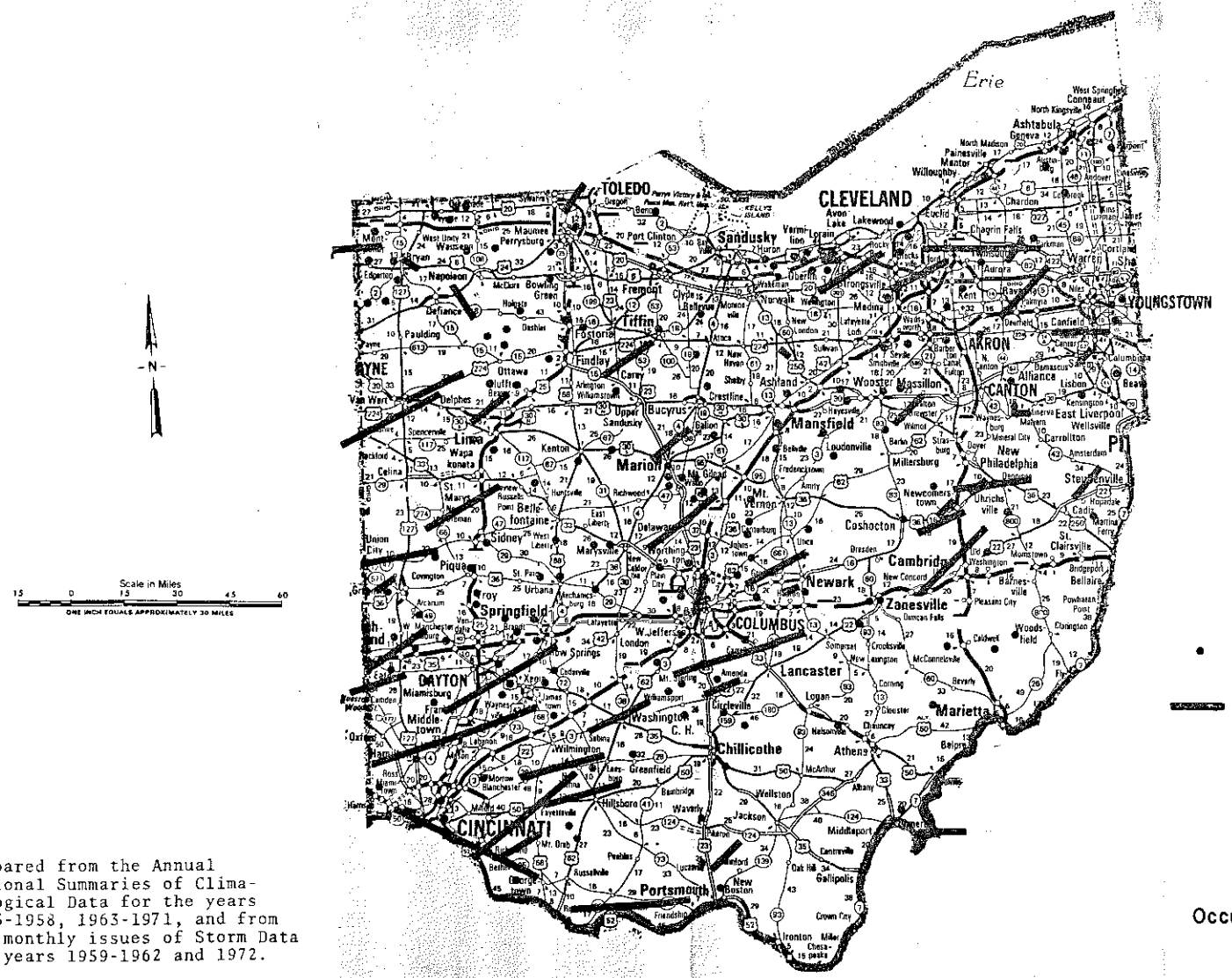
6.1.8. Wind Generated Wave Effects at Site

The maximum flood stages developed for the Probable Maximum Flood (PMF) and Dam Failure condition were described in the

preceding Sections 6.1.6. and 6.1.7. Since the Huffman Dam failure condition yields the highest stage of El. 719.3, only this elevation is considered for wave runup effects. The effect of cross-stream wind and waves must be added to the maximum surge height elevation to determine the maximum site water level. The fetch was computed to be 3,000 feet. The average depth over the fetch in the flood plain at the maximum stage would be about 30 feet resulting in a shallow wave condition. Using the maximum recorded wind velocity by the National Weather Service at the Dayton, Ohio airport of 78 mph in June, 1950, (Monsanto, 1972) as occurring over the fetch, the wind setup at the site would be approximately 0.1 feet. The significant wave height would be 3.5 feet as measured from the wave crest to trough, (Corps of Engineers, 1966). Therefore, the maximum still water elevation at the wave top for the site would be El. 719.3 plus 0.1 feet equals 719.4 feet. To the maximum water levels the effect of runup on the plant site must be added. The runup was computed on the basis of the existing site grade in front of the Radioactive Waste Disposal Building of about one vertical to two horizontal with grass as the ground cover using the above wave length. This computation results in a wave runup of approximately 8.1 feet vertically. Therefore, the total maximum design water elevation at the site, including runup, would be El. 727.5 as computed above.

6.1.9. Ice Flooding

Formation of ice jams with consequent flooding is not a problem on the Great Miami River. However, ice jams in tributary streams during winter associated with a high runoff has resulted in damage along the tributaries. Due to the wide channel and levee configurations at Miamisburg, it is unlikely that damming of the main channel at bridges would cause an appreciable rise in water elevation. The Probable Maximum Flood is considered to occur in August without associated potential for ice formation.



Legend

- Damage area 2 miles or less
- Damage area greater than 2 miles (with approx. length shown)

Occurrence of Tornadoes in Ohio
1953-1972

Prepared from the Annual National Summaries of Climatological Data for the years 1953-1958, 1963-1971, and from the monthly issues of Storm Data for years 1959-1962 and 1972.

Base map adapted from American Automobile Association highway map, Fall 1972.

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466.12 (4-64)

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6.2. ENVIRONMENTAL ACCEPTANCE OF EFFLUENTS

6.2.1. Introduction

This section describes the ability of the environment to dilute and disperse radioactive waste effluents discharged from the Mound Laboratory waste disposal facilities to the Great Miami River. Other aspects of environmental acceptance of normal and accidental releases of effluents for a full range of operating conditions are described in Sections 6.3.2. and 6.3.3.

6.2.2. Mound Laboratory Waste Disposal System

Existing low-level liquid radioactive wastes are discharged from the Waste Disposal Building through a monitored holding tank and a pipeline to the Great Miami River at approximate River Mile 65. This low-level waste meets federal guidelines (Monsanto Research Corporation, 1972).

Additional sanitary waste is discharged through the same line to the Great Miami River. The sanitary waste is monitored for inadvertent radioactive material content before treatment. Effluent discharged from the sanitary treatment system is monitored to meet local, state and federal water quality criteria, (Monsanto Research Corporation, 1972).

The radioactive waste disposal facilities for holding and monitoring the effluents before and after treatment, negate the possibility of a normal or accidental discharge to the environment that exceeds present guidelines and regulations. In the improbable event of a discharge that exceeds these water quality guidelines, such as a tank rupture, dilution and dispersion of the discharge is available through the flow of the Great Miami River.

6.2.3. River Water Use

Upstream use of the surface water system, formed by the Great Miami and tributary streams, would affect the quantity and quality of water available for dilution and dispersion of accidental discharges. Downstream of the site, surface and groundwater use by industries and municipalities could be affected if dispersion or dilution of an accidental discharge were inadequate to lower the concentration of radionuclides to meet water quality standards. Principal surface and groundwater users within the basin during prior years are depicted in Plate 6.2.3-1.

No municipal system uses surface water for a public water supply below the Mound Laboratory effluent discharge point at River Mile 65. Both surface and subsurface 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 circulating 585 cfs (Wolman, et al., 1957).

6.2.4. Flow Duration and Augmentation

The ability of the environment to dilute and disperse effluents depends upon the flow characteristics of the stream. This subsection describes the average flow rates of the Great Miami River and the studies to modify the flow rates for increasing demands to meet water quality and water use requirements for future years. A flow duration curve, Plate 6.2.4-1, has been constructed from available data covering the years from 1931 to 1960 at the Miamisburg gaging station (Cross, 1968). This curve depicts the discharge at the site that can normally be expected to be equalled or exceeded and serves as an index of drought flow conditions, (Cross, 1959). Using the 95 percent time coordinate, 310 cfs discharge past the effluent point can normally be expected for dilution of an accidental or normal discharge. The mean flow at Miamisburg is located at coordinate 50 percent or 1050 cfs. Plate 6.2.4-2 illustrates the available flow at Miamisburg under severe drought conditions and under conditions of a proposed flow augmentation utilizing the Englewood Retarding Basin for controlled discharge. During severe drought, flow to be expected over a seven day period once in 20 years, is about 180 cfs. Flow augmentation would provide an additional 400 cfs for dilution purposes. The low design flow at Miamisburg designated by the MCD is 212 cfs.

6.2.5. Dilution and Dispersion of Radioactive Releases

Radioactive waste effluent introduced through a normal or an improbable accidental release to the Great Miami River will be subjected to a number of dilution and dispersion mechanisms. The rate of dispersion and dilution within this environment primarily depends upon the flow rate of the river during the periods of radioactive waste release and the downstream dams and water users. The existence of O.H. Hutching Power Station and dam approximately 1.5 miles downstream would tend to promote dispersion of contaminants within the river body due to turbulence created by the station's circulating water pumps and the dam crest.

The minimum instantaneous low-flow of record was 148 cfs on

September 7, 1925. The likelihood of an accident occurring at the same time as the instantaneous low-flow of record is highly remote. A more reasonable estimate of the minimum water available for dilution can be made utilizing a consecutive day low-flow average as is the accepted practice for sewage treatment plant design. At the site this value is assumed to be the same as that used by the MCD or 212 cfs.

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6.3. GROUNDWATER

6.3.1. Description and On-Site Use

6.3.1.1. Regional Aquifers The site is within the Till Plains Section of the Central Lowlands Physiographic Province (Fenneman, 1938).

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 100 to 200 feet of Pleistocene sand, gravel and fine-grained till, and form the principal aquifer in the area.

In the upland areas, bedrock wells yield small quantities of poor quality water for private homes and farms. These wells are generally shallow and depend upon drainage from weathered cracks as their source.

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 summary of the hydrologic characteristics of geologic units in the vicinity of the site is presented in the following paragraphs. A detailed description of the geologic formations is presented in Sections 7.1. and 7.2. A map showing hydrogeologic environments for a radius of 2-1/2 miles from the site is shown on Plate 6.3-1.

Paleozoic Bedrock Aquifers

Maysville and Richmond Groups (Ordovician Age) Rocks of the Maysville and Richmond Groups are the oldest exposed rocks in Montgomery County (Norris, 1948) and form the principal bedrock type in the vicinity of the site. These rocks are composed primarily of shale interbedded with thin layers of dense limestone.

Water is stored and transmitted primarily through upper zones where surficial weathering has locally opened fractures and bedding planes. Weathered pyrite commonly occurs in the water bearing zones, and produces a high concentration of sulphur and iron compounds in the groundwater.

Wells drilled into rocks of the Maysville and Richmond Groups usually do not yield more than 5-10 gallons per minute (gpm); many wells are total failures (Spieker, 1968). Significantly higher yields (40 and 120 gpm) have been reported at two

locations in Jefferson Township, north of the site. Transmissivity coefficients for successful wells ranging from 62 to 428 gallons per day per foot (gpd/ft) have been reported. Specific capacities for these wells range from 0.26 to 2.50 gallons per minute per foot (gpm/ft) of drawdown, (Norris, 1948).

Recharge is principally derived from direct infiltration of precipitation. Glacial till overlying the bedrock in most areas acts to limit available recharge by retarding vertical percolation.

No fresh water aquifers exist below the upper zones of the Ordovician group. Salinity increases rapidly with depth because of low permeability which prevents replacement of connate water with meteoric water. A map showing the lowest approximate elevation of potable groundwater is presented on Plate 6.3-2.

Brassfield and Niagara Formations (Silurian Age) Rocks of the Brassfield and Niagara formations are exposed at higher elevations in the northern portion of Montgomery County. In the vicinity of the site, rocks of Silurian age are found only on topographic highs above an elevation of 950 feet. These rocks are primarily composed of massive limestones and dolomites.

Water is stored and transmitted through fractures and bedding planes which have been enlarged through solution activity. A significant "spring horizon" or seepage zone exists where these rocks are in contact over the shaley Ordovician rocks.

Wells drilled into rocks of the Brassfield and Niagara formations usually yield 5 to 14 gpm, though occasionally yield over 100 gpm, (Norris, 1948). Because of the topographic position of this aquifer, recharge must come primarily from direct infiltration of precipitation and is somewhat limited by the presence of glacial till which overlies most of the region. The yield of individual wells is extremely variable due to the inherent nature of carbonate aquifers, which transmit water through fractures and solution channels.

Reported transmissivity coefficients for wells in the Silurian Aquifer range from 52 to 2,790 gpd/ft. Specific capacities for these wells ranges from 0.29 to 2.85 gpm/ft of drawdown, (Norris, 1948).

Pleistocene Unconsolidated Aquifers

Valley Fill Outwash Deposits Outwash or "Valley Train" deposits of sand and gravel were emplaced by torrential glacial melt water streams which occupied pre-glacial

river valleys. They usually contain zones of relatively impermeable glacial till which may or may not be aerially extensive. The Valley Fill outwash deposits range from 100 to 200 feet in thickness and essentially follow the same course as the present day Great Miami River and its major tributaries.

Buried Valley outwash deposits which trend along the course of the Great Miami River form the most important aquifer in the area. Where induced stream infiltration is available, individual wells can yield as much as 2000 to 3000 gpm, (Spieker, 1968). Transmissivity coefficients for the aquifer usually range between 100,000 and 500,000 gpd/ft. Industrial wells adjacent to the site have specific capacities ranging from 73 to 218 gpm/ft of drawdown. Specific capacities as high as 1360 gpm/ft of drawdown have been reported for a well at Chatauqua, about 1-1/2 miles south of the site, (Norris, 1948).

Where aerially extensive layers of clay rich till prevent induced stream infiltration, or where surface streams are located too far away to form a hydraulic connection, individual wells yield from 100 to 1000 gpm, (Spieker, 1968).

The permeability of water-bearing sand and gravel zones has been computed from field pumping tests. For aquifers in the Dayton area, north of the site, typical values range from 1000 to 3000 gpd/sq ft, (Norris & Spieker, 1966).

Recharge to the aquifer is available from three major sources:

1) Directly from infiltration of precipitation on the flood plain.

2) Leakage along valley walls at the bedrock-outwash contact.

3) Induced infiltration caused by hydraulic sinks due to pumping.

Under natural conditions (no groundwater withdrawal) the natural direction of flow is from the aquifer to the stream, (Spieker, 1968). Recharge is primarily derived directly from precipitation and by leakage from valley walls. This source of recharge is sufficient in quantity to balance withdrawals of low capacity wells, but is not sufficient to supply high capacity well fields such as those at West Carrollton, about four miles north of the site. Under these conditions, groundwater levels experience continuous declines. (See Plate 6.3-3).

Where wells are hydraulically connected to streams, water is

recharged to the aquifer by means of induced infiltration. Under these conditions, water levels in the aquifer stabilize and the volume of water added to the aquifer by induced stream infiltration is approximately equal to the yield of the well, (Spieker, 1968).

Glacial Till - Thin Phase (Less than 20 ft thick) Ground moraine or glacial till is a heterogeneous mixture of gravel, sand, silt and clay. It covers most of the upland area and portions of outwash in the Buried Valley deposits.

Dug wells completed in upland glacial tills ordinarily yield from 2 to 10 gpm, (Norris, 1948). Coefficients of transmissivity range from 82 to 3,700 gpd/ft and specific capacities range from 0.23 to 2.88 gpm/ft of drawdown. Recharge is dependent upon direct infiltration from precipitation.

Glacial till is also interbedded with valley fill outwash deposits and acts as a low permeability barrier. Although not a continuous blanket in most areas, interbedded till horizons restrict recharge from stream infiltration, valley walls and precipitation. The average vertical permeability of interbedded till zones has been determined to be on the order of 0.1 gpd/sq ft, (Norris & Spieker, 1966).

Glacial Till - Thick Phase (Greater than 20 ft thick) Ground moraine and end moraine is similar in character to glacial till, thin phase, except the greater thickness of till may contain stringers, and irregular bodies of sand and gravel. Well yields are variable, depending upon the nature of sand and gravel lenses penetrated. Water supplies are generally adequate for farm or domestic requirements, (Norris, 1948).

Upland Outwash Deposits Thick, extensive deposits of permeable glacial outwash are usually overlain by till 5 to 70 feet thick. Water supplies from the underlying sands and gravels are described as "abundant", (Norris, 1948). Recharge is limited by the low permeability cap of glacial till and is primarily dependent upon direct infiltration of precipitation.

Kames and Kame Moraine These deposits form topographic highs composed of permeable sand and gravel, usually resting upon a relatively impermeable layer of glacial till or bedrock. They are not important aquifers because the water table is usually below the level of these deposits. No deposits of this type are known to exist within five miles of the site.

6.3.1.2. Local Aquifers

Bedrock Aquifers Most of the site is located on limestone and shale bedrock belonging to the Richmond Group. A thin layer of glacial till caps most of the hilltop areas. The waterbearing properties of this formation have been described in paragraph 6.3.1.1.

An examination of Well Log and Drilling Reports provided by the State of Ohio, Department of Natural Resources, Division of Water has revealed that most local wells drilled into bedrock range in depth from 40 to 100 feet, and yield groundwater at rates of about 1 to 6 gpm. Occasional well yields of up to 20 gpm have been reported. The deepest well in the vicinity of Mound Laboratory is 215 feet deep and yields approximately 3-1/2 gpm.

Because of the very low water transmission characteristics of the Richmond Group rocks, the Ordovician aquifer is considered to be locally insignificant as a water source.

Valley Fill Outwash Aquifer The Buried Valley immediately west of Mound Laboratory, below an elevation of approximately 710 feet, is the major aquifer adjacent to the site. The water-bearing properties of this formation are described in paragraph 6.3.1.1.

Within limits of the property, the maximum known thickness of the aquifer is about 70 feet at the extreme southwest corner of the site, (Earth Science Laboratories, Inc., 1961). The aquifer reaches a maximum thickness of about 150 feet near the river channel and is oriented in a north-south direction, in coincidence with the course of the Great Miami River, (Watkins & Spieker, 1971). Recharge by induced stream infiltration is available, although the sand and gravel aquifer at this location may contain aerially extensive inter-stratified layers of clayey till. Storage coefficients generally range from 0.2 to 0.0002, depending upon the degree of confinement, (Spieker, 1968). In consideration of recharge and hydraulic transmission properties of the aquifer, the Buried Valley west of the site is estimated to be capable of producing 15 to 20 million gallons per day (MGD) of groundwater per linear mile of valley, (Dames & Moore, 1972).

Four high capacity wells exist along the western border of the property. Three of these wells belong to Monsanto Research Corporation and provide a source of water supply for the Mound Laboratory. A fourth well located north of the other three belongs to the City of Miamisburg and is a source of public water supply. Locations of Monsanto wells are

shown in Plate 6.3-6. A summary of production data for these wells is presented in Table 6.3.1-1.

Hydrologic conditions adjacent to the site are highly variable, as demonstrated by the character of existing wells in the area. It has been suggested that groundwater withdrawn from wells adjacent to the site is at least partially replenished by induced stream infiltration from the Great Miami River, located about 1700 feet west of the well field, (Fred H. Klaer & Assoc., 1969). However, direct recharge from precipitation and leakage from the valley wall east of the well field probably make up the major source of recharge. Several residents who live on the Great Miami River flood plain adjacent to the site have reported that water levels in their wells are significantly more responsive to precipitation than to river stage.

The direction of groundwater flow is generally toward the south, following the downstream course of the Great Miami River. The average groundwater gradient in October, 1964 was about five feet per mile, (Spieker, 1968). A map showing groundwater gradients is presented in Plate 6.3-4, "Piezometric Levels in the Buried Valley Aquifer, October, 1964." Groundwater levels experience local reversals in areas of heavy pumpage, as indicated by closed contours on the piezometric map. Such reversals in groundwater gradient are expected to increase in both number, magnitude and aerial extent as regional groundwater development increases in the future.

Most of the communities north of Miamisburg must rely on induced stream infiltration in order to achieve sufficient well yields. Well fields in the vicinity of West Carrollton and Moraine currently do not have adequate recharge available to balance groundwater withdrawals and therefore, are experiencing severe water level declines, such as illustrated in Plate 6.3-3. The town of West Carrollton is planning to relieve the problem by drilling additional wells close to the Great Miami River where induced recharge is available. The aquifer in the vicinity of Moraine is tapped by several industrial and municipal users and is being overpumped at a rate of about 12 MGD, (Moulenbelt & Seifert, 1972). Recharge lagoons are being planned in order to direct a sufficient quantity of river water into the ground to balance withdrawal rates.

The City of Dayton, located about twelve miles northeast of the site, is also undergoing large-scale depletion of groundwater resources because of overpumping. At least 458 private, municipal and industrial water wells have been cataloged in the Dayton area, (Norris & Spieker, 1966). Water is being artificially recharged to the aquifer; however, a more

extensive program of artificial recharge is required to balance groundwater withdrawals in the area. The change in water levels at selected observation wells in the Dayton area over a ten-year period is illustrated in Table 6.3.1-2.

Although the Buried Valley aquifer is generally over-developed 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 piezometric gradient is reversed south of the City of West Carrollton. At Miamisburg, the natural groundwater gradient is toward the south and is not influenced by pumping except locally near individual wells fields.

The annual variation in groundwater levels is illustrated on Plate 6.3-5 by the hydrograph of Observation Well MT-49, (Kaser & Harstine, 1965). The Observation Well is located about one mile west of West Carrollton and about three miles north of the site.

The average annual fluctuation is about six feet, although the long-term trends show the effects of groundwater depletion which tends to exaggerate the annual changes. Local residents near the site report annual water level changes of about 3 or 4 feet, based upon casual, intermittent inspection of their wells.

6.3.1.3. On-Site Use

Water Sources Water supply for Mound Laboratory is obtained from three high-capacity wells located on a property leg that extends off the southwest corner of the site, (see Plate 6.3-6). Each of the wells is pumped intermittently at the following rates:

Well No. 1	450-500 gpm.
Well No. 2	500-550 gpm.
Well No. 3	500-550 gpm.

Present water usage at the facility ranges from 500 to 900 gpm. The estimated maximum capacity of the water system is 1100 gpm. A reserve water supply having a capacity of 1000 gpm is available from the City of Miamisburg. This reserve supply is not used by the facility, but is available in case of emergency.

Water Storage and Treatment Facilities Two water towers are used at Mound Laboratory, as shown on Plate 6.3-6.

The water tower adjacent to "P" Building has a total capacity of 100,000 gallons. The normal operating capacity is 50,000 gallons and the emergency fire capacity is 50,000 gallons.

A second water tower located adjacent to Building 38 has a total capacity of 250,000 gallons. The normal operating capacity is 125,000 gallons and the emergency fire capacity is 125,000 gallons.

In addition to the towers, a 350,000 gallon capacity ground level tank is located near the Waste Disposal Bldg. This tank is used only as additional fire protection reserve.

Five water softener units are used, each having a rated capacity of 250 gallons per minute. Total hardness is reduced from approximately 300-500 ppm to 0-10 ppm. Three of the water softening units are located in "P" Building. The other two units are located in Building 24.

Plans for Conservation of Water Resources A 350-ton cooling tower and chiller system project was budgeted for FY 1972 and is underway as part of a system to recirculate water used to cool heat exchangers in laboratories. When put into operation, it is anticipated that this recirculation will reduce water usage by 150 gpm. This concept of using recirculated water will also be extended to other areas whenever feasible. A program designed to provide data necessary to manage plant water resources is currently underway. Water meters are being installed for buildings which are the major users of water.

6.3.2 Sources

6.3.2.1. Present and Future Regional Use

Public and Industrial Users There are six major public water supplies and numerous industrial users within a five mile radius of Mound Laboratory. A map showing the locations of public water supply wells and distribution areas for municipal water service is shown on Plate 6.3-7. A tabulation of current and projected water demands is presented in Table 6.3.2-1, and a map showing municipal groundwater use in 1969 is presented on Plate 6.3-8.

Groundwater supply wells and hydraulic conditions for all municipal users within five miles of Mound Laboratory are discussed in the following paragraphs. The only industrial user discussed is the Dayton Power & Light Company, Hutching Generating Station, because it is the only major industrial facility located downstream and within five miles of the site. No industrial groundwater users located north (upstream) of the site are considered in this report because they are

isolated from Mound Laboratory by hydraulic barriers.

For reference in discussions which follow, Mound Laboratory is located opposite River Mile 65. This Mile Post system is referenced to the junction with the Ohio River as River Mile 0.0, and is presented on topographic maps published by the U.S. Geological Survey.

Miamisburg The City of Miamisburg owns ten water wells, but only four are in use. The six abandoned wells do not meet criteria for public health standards and are not intended for any future use. City Well No. 2 is located on the east side of the Great Miami River, immediately west of the Mound Laboratory site. City Wells, No. 8, 9 and 10 are located on the west side of the river immediately south of the Linden Avenue bridge, upstream from the Mound Laboratory site. The city plans to drill one or two additional wells immediately north of the Linden Avenue bridge in the near future. The operation of Wells No. 8 and No. 9 support the city's normal water requirements. Wells No. 2 and No. 10 are used for periods of peak demand, particularly fire fighting.

Because of the relative locations of the wells to the Great Miami River and to the site, the only well owned by the City of Miamisburg that could be immediately affected by Mound Laboratory is City Well No. 2. All other operational city wells, both existing and planned, are separated from the site by the Great Miami River, and by a minimum straight-line distance of at least one-half mile from the laboratory.

The small stream which drains the laboratory site divides at the foot of the hill. The south-flowing portion follows the railroad tracks until it empties into the Great Miami River at the railroad bridge downstream of the site. The north-flowing portion empties into two small recreation ponds approximately one-half mile north of the site. If a contaminant borne by the stream is allowed to be carried into these ponds, it may be possible that the contaminant would enter the aquifer and be drawn toward the City of Miamisburg Wells No. 8, 9 and 10.

Groundwater gradients and aquifer coefficients between the small recreation ponds and the active city well field are not known in sufficient detail to predict dilution and groundwater movement rates. However, the Great Miami River acts as a partial recharge barrier and would add to the probable dilution by perhaps two orders of magnitude by means of induced stream infiltration. Groundwater gradients between the small recreation ponds and the active well field can also be reversed by pumping the abandoned Miamisburg Power Station wells which surround the small recreation

ponds if the main city water supplies appear to be endangered.

West Carrollton The City of West Carrollton owns four operational water wells. All of these wells are located far enough away from the Great Miami River so that they do not invite induced stream infiltration. As a result of over-pumping, water levels in these wells are experiencing an accelerating rate of decline. In order to deal with this problem, the City of West Carrollton is planning to construct a high capacity well (2000 gpm) near the river at approximately River Mile 71.5.

All of the existing and planned wells operated by the City of West Carrollton are upstream of the Mound Laboratory site by a minimum straight-line distance of three miles, and are separated from the facility by hydraulic barriers.

Montgomery County Sanitary District The Montgomery County Sanitary District operates three well fields in the Greater Moraine area. The Miami Shores well field is located on the west bank of the Great Miami River, opposite the mouth of Holes Creek. The Dryden Road well field is located on the east bank of the Great Miami River on both sides of Holes Creek. The Lamme Road well field is located almost one mile east of the Great Miami River in the vicinity of Holiday School. The closest well field to the site is the Miami Shores field opposite River Mile 72-1/2, which is a straight-line distance of over four miles from Mound Laboratory.

All of the well fields serving the district are isolated from the site by physical and hydraulic barriers. Although groundwater resources are currently over-developed due to heavy industrial use as well as municipal use, recharge lagoons are either planned or under construction. Because the area is far enough upstream, it is not anticipated that any activity at Mound Laboratory could affect any of the Montgomery County well fields.

Hutching Power Station The O.H. Hutching Station owned by Dayton Power & Light Company operates six high-capacity (1,500 gpm) wells, ranging in depth from 126 to 177 feet. The wells are all located on the west side of the Great Miami River at about River Mile 63-1/2. The closest well is a minimum straight-line distance of about one mile from Mound Laboratory.

Wells at the O.H. Hutching Power Station are physically separated from the site by the Great Miami River, which acts as a partial recharge barrier. However, it is conceivable that a contaminant entering the aquifer at the site could

be attracted by the cone of depression at the well field, because the rate of pumping is relatively great in relation to the ability of the river bed to provide infiltration to the aquifer. This is indicated by closed piezometric contours which extend east of the river as shown on Plate 6.3-4.

Hydrogeological conditions between wells at the power station and the site are not known in sufficient detail to permit accurate prediction of flow rates through the aquifer or diffusion characteristics. The wells at the power station do induce stream infiltration as a major portion of their yield. It is therefore reasonable to assume that any contaminant which is transmitted through the aquifer between the site and the well field would be substantially diluted with recharged water by probably two orders of magnitude.

Although the transmissivity coefficients between the site and the well field are relatively high, the piezometric gradient between the two locations is very low and is somewhat responsive to the local pumping demands in well fields between them. Under the worst conditions, using a coefficient of permeability equal to 3000 gpd/sq ft, and a hydraulic gradient of 10 feet per mile, the calculated rate of groundwater movement through the aquifer would be about 0.76 feet per day. It has been estimated that groundwater moves at a rate of up to seven feet per day in outwash deposits at the Mad River Buried Valley near Dayton, under the influence of natural piezometric gradients, (Norris & Spieker, 1961). Assuming that a groundwater movement rate of seven feet per day near the site is possible, it would take over two years for a contaminant introduced to the aquifer at the site to reach the Hutching Station well field.

The well field is dependent upon induced stream infiltration from the Great Miami River in order to maintain yield and is therefore susceptible to contamination carried by the river. Contamination would be introduced to the aquifer at the point which the Great Miami River intersects the zone of influence due to pumping. The probable danger would be dependent upon toxicity and dilution at the point of entry to the aquifer. The rate of groundwater movement at two very high-capacity (15 MGD) collector wells near Hamilton, Ohio has been calculated at about 13 feet per day, (Norris & Spieker, 1961). The wells at Hutching Power Station are all located a minimum distance of 300 feet from the Great Miami River. Using these rates and distances as conservative estimates of actual conditions, a river-borne contaminant could be expected to reach the well field in about 23 days.

Springboro Water District The Springboro Water District owns four water wells. Two are located in the City of Springboro on the east side of a south-flowing branch of

Clear Creek. Two additional wells are located on the west side of the Great Miami River, opposite the terminus of Pennyroyal Road on the east bank of the river.

The two wells located within the city limits of Springboro are isolated from the site by a drainage divide and a minimum straight-line distance of over 5-1/2 miles. Therefore, operation of the Mound Laboratory would have no effect on these water supply wells.

The two wells located on the west bank of the Great Miami River, approximately at River Mile 61-1/2, would probably not be affected by the introduction of a contaminant into the aquifer at the site. This conclusion is based upon the fact that the Great Miami River separates the well field from the site by acting as a recharge barrier between them. A hydraulic sink provided by the Hutching Power Station well field, 1-1/2 miles north of the Springboro water wells, would provide additional hydraulic insulation against direct transmission of a contaminant through the aquifer. Also, the minimum straight-line distance between the Springboro wells and the site is 2-3/4 miles, which is very long in comparison to the maximum aquifer thickness of 200 feet.

Franklin The City of Franklin owns eight water wells. Seven are located on the west side of the Great Miami River at approximately River Mile 59.5. One additional well is located on the east side of the river at about River Mile 60.0. The closest well is a straight-line distance from the site of over four miles.

It is unlikely that the well field at Franklin could be affected by a contaminant introduced into the aquifer at Mound Laboratory because of the distance from the site and discontinuities in the aquifer body between the two points. However, it is very likely that a contaminant carried by the Great Miami River could affect the well field, since induced stream infiltration is required to maintain well yields. The anticipated danger resulting from a particular river-borne contaminant would have to be evaluated upon the basis of dilution and toxicity at the point on the river opposite to the zone of influence of the well field.

Germantown The city owns four water wells located on the north side of town, and on the west side of Twin Creek. The well field is hydraulically isolated from the Mound Laboratory site by a drainage divide and a straight-line distance of over four miles. Therefore, the operation of Mound Laboratory would have no affect on this well field.

Private Users A map showing the locations of private water wells near Mound Laboratory is presented on Plate 6.3-9

and is referenced to Table 6.3.2-2 for more detailed information. Areas designated as Zones A & B on Plate 6.3-9 are located on the west side of the Great Miami River and are therefore hydraulically isolated from Mound Laboratory. Areas D & E are being rapidly converted to city water supplies. Most of the wells in these two areas provide very limited yields and are usually abandoned by the owner as soon as hook-up with city water supplies are completed.

The only zone in the vicinity of Mound Laboratory, highly dependent upon well water, is Area C. Most local residents who live on the flood plain below Mound Laboratory still depend on wells as their source of water supply. A 12-inch diameter water line extends from the southern city limits of Miamisburg along Cincinnati Pike (which is the southern extension of Main Street in Miamisburg) to the sewage disposal plant, approximately one-half mile south of Mound Laboratory. Currently, the Ideal Mobile Home Park has the only tie into this water line. All other residences on the flood plain still rely totally upon well water.

Well water supplies in Zone C are readily available from the granular deposits of the Great Miami River flood plain. These wells are relatively inexpensive to maintain in comparison to the cost of hooking up to the city water pipeline. It is therefore expected that wells will continue to provide a major source of water supply in this area.

6.3.2.2. Site Conditions The site is topographically divided into two hilltop areas by a small intermittent stream which flows south and west. The upland bedrock plateaus northwest and southeast of the small stream are occupied by most of the major laboratory structures. Below an elevation of about 760 feet, bedrock and glacial till become buried by glacial outwash and till deposits. These deposits reach a maximum thickness of about 70 feet near Monsanto Water Well No. 3, at the extreme southern end of the property.

The three wells which supply water to the plant are drilled into, and receive water from, glacial outwash deposits. A landfill containing cardboard, paper, wood, machine shop wastes, plating room wastes and other miscellaneous materials, including laboratory and cafeteria wastes, is located in the zone of glacial soil, several hundred feet northeast of Well No. 1. (Fred H. Klaer & Asso., January, 1971). 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, (Fred H. Klaer & Asso., October 1971). The consultant detected an anomalous variation in the hardness and chloride content of the well water and concluded that the contaminant probably entered the aquifer by induced infiltration from the small stream which

drains the property. The source of hardness and chloride contamination was believed to have been the backwash from Zeolite water softeners.

Too little is presently known of the detailed site geology to permit complete delineation of on-site areas which offer possible routes of groundwater contamination. It is not unlikely however, that the entire site area containing glacial deposits could offer a possible route into the aquifer.

Unless proven otherwise by additional site investigations, it should be assumed that any contaminant which may be carried by water can enter the major Buried Valley aquifer at the site either by direct infiltration through the glacial outwash deposits below an approximate elevation of 760 feet, or by leakage from the bedrock valley walls which enter the outwash deposits. The bedrock hills which support most of the laboratory buildings may be considered as being virtually impermeable because of lithology and horizontal bedding structure.

6.3.3. Environmental Acceptance of Effluents

The following paragraphs present an evaluation of the dilution and dispersion characteristics of the groundwater environment with respect to existing users and future users.

It has been shown in the preceding section that fluid contaminants could enter the groundwater environment at the site. A small stream which provides storm, groundwater and cooling water drainage from the site follows the course of the Penn Central Railroad tracks in a southerly direction, and empties into the Great Miami River where the railroad bridge crosses the river at River Mile 64.2. This small stream flows along the flood plain for a distance of about one mile between the site and its junction with the Great Miami River, and is probably subjected to induced infiltration by several private water wells along the way. Therefore, water from this stream could be introduced into the groundwater environment at any point along its path.

Below River Mile 62.4, any contamination carried by the small stream which drains the site would be diluted by several orders of magnitude by the Great Miami River. The actual degree of dilution would depend upon the relative flow rates between the stream and the river. Mixing would occur the most quickly when the river stage is high due to an increase in turbulence. Riverborne contaminants could enter the aquifer at any downstream location which is subjected to the influence of induced stream infiltration caused by the

pumping of wells.

A concentration of streamborne contamination would pass a particular downstream well field faster and would be more thoroughly diluted if released during a period of high river stage. At low river stage, a wave of contamination would pass more slowly and would be diluted less; however, a low-permeability silt layer which forms along the riverbottom during low flow period (Moulenbelt & Seifert, 1972) would significantly inhibit infiltration to the aquifer. Therefore a wave of contamination released into the Great Miami River would be of similar impact to downstream well fields during both high and low river stages.

The first major downstream well field would be the Hutching Power Station, followed by the Springboro Municipal Well Field and the Franklin Municipal Well Field. A more detailed description of these well fields and their hydraulic relationship with Mound Laboratory has been presented in Section 6.3.2.1 of this report.

One branch of the small stream which drains the site also flows north from the point at which the drainage enters the flood plain and feeds two small recreation ponds about 2000 feet north of the laboratory. These ponds depend upon this stream for maintaining their water levels and it is assumed that they contribute to aquifer recharge. The quality of groundwater on the flood plain adjacent to this stream, and particularly in the vicinity of the ponds appears to be partially controlled by the quality of surface water carried by the drainage system.

Locally, a contaminant that entered the aquifer at the site could be directed toward the cones of depression created by the operation of wells located within and immediately west of the site boundary. While in the groundwater environment, the flow characteristic would be laminar, and diffusion by mixing would therefore be minimal. Underground flow would take place mainly in zones of high permeability rather than in the vicinity of low permeability till layers. Thus, attenuation of a contaminant during passage through the aquifer by adsorption on ion exchangeable clay minerals would be small.

Groundwater gradients and aquifer coefficients west of the small recreation ponds are not known in sufficient detail to predict dilution and groundwater movement rates. However, the Great Miami River acts as a partial recharge barrier and would add to the probable dilution by perhaps two orders of magnitude by means of induced stream infiltration. Groundwater gradients between the small recreation ponds and the active well field can also be reversed by pumping the

abandoned Miamisburg Power Station wells which surround the small recreation ponds should it become necessary.

If a contaminant were to enter a well, it would be mixed with non-contaminated water drawn from other sectors of the aquifer. The probably degree of dilution as a result of mixing in the well is unknown but is not expected to exceed about one order of magnitude of the maximum concentration of the contaminant.

Private homes that obtain water from bedrock wells, or from alluvial deposits in hydraulically isolated drainage systems, would not be affected by fluid contamination originating from Mound Laboratory.

6.3.4. Groundwater Monitoring Program

Varions public and private water supplies are monitored on a regular basis according to the following schedule.

1. Municipal water supplies in the area are sampled and analyzed quarterly.

2. All three Mound Laboratory wells are sampled and analyzed weekly for tritiated water, monthly for nonradioactive parameters such as dissolved solids and chlorides, quarterly for plutonium and semi-annually for fifteen heavy metals.

The Miami Conservancy district is undertaking a groundwater quality monitoring study under the sponsorship of Monsanto Research Corporation. The scope of the monitoring program is as follows:

1. Representative water samples will be obtained from bedrock aquifers, buried valley aquifers, and water supplies developed in upland glacial till out to a distance of five miles in all four quadrants surrounding Mound Laboratory. Samples are to be obtained quarterly. All public water supplies falling within the five-mile radius are included as sampling points.

2. In order to obtain information on possible subsoil transport of contaminants of interest, a limited number of sites within the five-mile radius surrounding Mound Laboratory will be equipped with pressure-vacuum lysimeters to obtain water samples from the unsaturated soils in the area of the sampling wells. Sampling is to be performed semiannually. Specific sites included are the City of Miamisburg Well No. 2

near the Mound Laboratory west boundary, the O. H. Hutchings power station wells and the Mound Laboratory well field.

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PERSONS AND AGENCIES CONTACTED

Paul M. Plummer, December 15, 1972, The Miami Conservancy District, Dayton, Ohio

Table 6.1.3-1 Peak stages and discharges

Great Miami River at Miamisburg, Ohio			
Water Year	Date	Gage Height (feet)	Discharge (cfs)
1913	Mar. 28, 1913	-	a257,000
1917	Mar. 14, 1917	11.6	30,500
1920	Apr. 21, 1920	16.8	51,800
1929	Feb. 27, 1929	16.5	55,000
1930	Jan. 10, 1939	16.16	50,800
1933	May 15, 1933	16.13	51,800
1959	Jan. 21, 1959	20.65	61,800

a. Computed by Miami Conservancy District

Location - Lat 39°38'45", long 84°17'20", 600 ft downstream from bridge on State Highway 725 at Miamisburg, Montgomery County, and 0.3 mile downstream from mouth of Bear Creek.

Drainage Area - 2,718 sq mi. At site used 1916-20, 2,780 sq mi; at site used 1924-35, 2,719 sq mi.

Gage - Nonrecording prior to Oct. 1, 1924; recording thereafter. At site 6.7 miles downstream at different datum May 16, 1916 to Sep. 30, 1929. At site 2.2 miles downstream at datum 677.06 ft. above mean sea level Aug. 29, 1924, to Sep. 30, 1935. Datum of gage is 678.60 ft. above sea level, adjustment of 1912. The 1929 adjustment lowered the gage elevation to 678.35.

Stage-discharge relation - Defined by current-meter measurements below 46,000 cfs, 1917-20; below 43,000 cfs, 1925-35; and below 59,800 cfs, 1953-61.

Bankfull stage - 22 ft.

Remarks - Flow regulated by four retarding basins (combined capacity, 735,000 acre-ft) since 1921. Base data furnished by Miami Conservancy District. Only annual peaks are shown.

Table 6.1.3-1 (Continued)

Reference - Geological Survey Water Supply Paper 1675 Magnitude and Frequency of Floods in the U.S. Part 3-A, Ohio River 1965.

Table 6.1.4-1 Data pertaining to dams and appurtenances

	Englewood Dam	Lockington Dam	Taylorsville Dam	Huffman Dam
Drainage area above dam, square miles	651	255	1,133	671
Average elevation bed of river, feet above sea level	768	876	759	777
Average elevation valley floor, feet above sea level	782	885	770	785
Elevation of spillway crest, feet above sea level	876	938	818	835
Elevation of top of dam, feet above sea level	892.5	954	837	850
Maximum height of dam above valley floor, feet	110.5	69	67	65
Length of crest of dam, feet	4,716	6,400	2,980	3,340
Thickness of dam at average elevation of valley floor, feet	739	409	397	385
Number of conduits	2	2	4	3
Length of each outlet conduit, feet	709	46	40	40
Vertical diameter of permanent outlet conduits, feet	10.5	9.2	19.2	16.3
Maximum width of outlet conduits, feet	13	9	15	15
Combined sectional area of permanent outlet conduits, square feet	217	158	1,118	705
Elevation of conduit invert at entrance	772	876	760	777
Length of spillway crest, feet	100	72	132	100
Volume of earth in dams, cubic yards	3,500,000	1,135,000	1,235,000	1,655,000
Volume of concrete in dams and appurtenances, cubic yards	36,800	38,000	48,000	40,000
Storage capacity to spillway crest, acre feet	312,000	70,000	186,000	167,000
Area in basin below elevation of spillway crest, acres	7,930	4,020	11,000	9,180
Outflow through conduits with water level at spillway crest, second feet	12,000	8,800	53,600	35,000
Velocity of outflow with water level at spillway crest, feet per second	55	56	48	50

Ref: Hydraulics of the Miami Flood Control Project, MCD Tech. Rpt. VII.

Table 6.1.5-1 Great Miami River Drainage Basin - Distribution of the probable maximum precipitation

SUB-BASIN NO.	SUB-BASIN NAME	DRAINAGE AREA (Sq. Miles)	RAINFALL EXCESS (After Losses) SIX-HOUR PERIODS IN INCHES																TOTAL R. E. (inches)
1	Indian Lake	109	0	0	0	0	0	.46	.46	.46	1.36	3.5	6.5	1.8	0	0	0	0	14.54
2	Brokengehalas	38	0	0	0	0	0	.5	.5	.5	1.5	3.7	6.9	1.9	.1	.02	.02	.02	15.66
3	Stone Creek	59	0	0	0	0	0	.5	.5	.5	1.5	2.7	6.9	1.9	.1	.02	.02	.02	15.66
4	Sidney Local	339	0	0	0	0	0	.5	.5	.5	1.6	3.9	7.2	2.1	0	0	0	0	16.3
5	Loramie Lake	79	0	0	0	0	0	.5	.5	.5	1.4	3.6	6.7	1.9	0	0	0	0	15.1
6	Lockington Local	182	0	0	0	0	0	.5	.5	.5	1.5	3.7	6.9	1.9	.1	.02	.02	.02	15.66
7	Piqua Local	36	0	0	0	0	.1	.6	.6	.6	1.9	4.4	8.2	2.3	.1	.1	.1	.1	19.1
8	Troy Local	66	0	0	0	0	.3	.8	.8	.8	2.1	5.1	9.5	2.7	.1	.1	.1	.1	22.5
9	Tipp City Local	53	0	0	0	0	.3	.8	.8	.8	2.2	5.4	9.9	2.9	.1	.1	.1	.1	23.5
10	Lost Creek	55	0	0	0	0	.2	.7	.7	.7	2.0	4.9	9.2	2.6	.1	.1	.1	.1	21.4
11	Taylorsville Local	139	0	0	0	0	.1	.6	.6	.6	1.9	4.4	8.2	2.3	.1	.1	.1	.1	19.1
12	Urbana	157	0	0	0	0	0	.46	.46	.46	1.36	3.5	6.5	1.8	0	0	0	0	14.54
13	Buck Creek Dam Site	85	0	0	0	0	.2	.4	.4	1.4	1.3	3.2	6.1	1.8	0	0	0	0	13.4
14	Springfield Local	243	0	0	0	0	0	.46	.46	.46	1.36	3.5	6.5	1.8	0	0	0	0	14.54
15	Huffman Local	147	0	0	0	0	0	.5	.5	.5	1.5	3.7	6.9	1.9	.1	.02	.02	.02	15.66
16	Bradford	195	0	0	0	0	0	.2	.4	.4	1.3	3.5	6.4	1.8	0	0	0	0	14.0
17	Covington Local	243	0	0	0	0	0	.46	.46	.46	1.36	3.5	6.5	1.8	0	0	0	0	14.54
18	Pleasant Hill Local	64	0	0	0	0	.1	.6	.6	.6	1.6	3.9	7.3	2.1	0	0	0	0	16.8
19	Englewood Local	144	0	0	0	0	.1	.6	.6	.6	1.9	4.4	8.2	2.3	.1	.1	.1	.1	19.1
20	Dayton Local	80	0	0	0	0	.1	.6	.6	.6	1.9	4.4	8.2	2.3	.1	.1	.1	.1	19.1
21	Wolf Creek	70	0	0	0	0	.2	.7	.7	.7	2.0	4.9	9.2	2.6	.1	.1	.1	.1	21.4
22	Miamisburg	135	0	0	0	0	.1	.6	.6	.6	1.6	3.9	7.3	2.1	0	0	0	0	16.8
23	Franklin Local	67	0	0	0	0	0	.2	.4	.4	1.3	3.5	6.4	1.8	0	0	0	0	14.0
24	Ingomar	198	0	0	0	0	.1	.6	.6	.6	1.9	4.4	8.2	2.3	.1	.1	.1	.1	19.1
25	Germantown Local	77	0	0	0	0	.1	.6	.6	.6	1.9	4.4	8.2	2.3	.1	.1	.1	.1	19.1
26	Middletown Local	167	0	0	0	0	0	.5	.5	.5	1.5	3.7	6.9	1.9	.1	.02	.02	.02	15.66
27	Acton Lake	102	0	0	0	0	0	.2	.4	.4	1.3	3.2	6.1	1.8	0	0	0	0	13.4
28	Collinsville	121	0	0	0	0	.1	.6	.6	.6	1.7	4.2	7.8	2.2	0	0	0	0	17.8
29	Talawanda Local	88	0	0	0	0	0	.5	.5	.5	1.5	3.7	6.9	1.9	.1	.02	.02	.02	15.66
30	Hamilton Local	168	0	0	0	0	0	.46	.46	.46	1.36	3.5	6.5	1.8	0	0	0	0	14.54

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6.2. ENVIRONMENTAL ACCEPTANCE OF EFFLUENTS

6.2.1. Introduction

This section describes the ability of the environment to dilute and disperse radioactive waste effluents discharged from the Mound Laboratory waste disposal facilities to the Great Miami River. Other aspects of environmental acceptance of normal and accidental releases of effluents for a full range of operating conditions are described in Sections 6.3.2. and 6.3.3.

6.2.2. Mound Laboratory Waste Disposal System

Existing low-level liquid radioactive wastes are discharged from the Waste Disposal Building through a monitored holding tank and a pipeline to the Great Miami River at approximate River Mile 65. This low-level waste meets federal guidelines (Monsanto Research Corporation, 1972).

Additional sanitary waste is discharged through the same line to the Great Miami River. The sanitary waste is monitored for inadvertent radioactive material content before treatment. Effluent discharged from the sanitary treatment system is monitored to meet local, state and federal water quality criteria, (Monsanto Research Corporation, 1972).

The radioactive waste disposal facilities for holding and monitoring the effluents before and after treatment, negate the possibility of a normal or accidental discharge to the environment that exceeds present guidelines and regulations. In the improbable event of a discharge that exceeds these water quality guidelines, such as a tank rupture, dilution and dispersion of the discharge is available through the flow of the Great Miami River.

6.2.3. River Water Use

Upstream use of the surface water system, formed by the Great Miami and tributary streams, would affect the quantity and quality of water available for dilution and dispersion of accidental discharges. Downstream of the site, surface and groundwater use by industries and municipalities could be affected if dispersion or dilution of an accidental discharge were inadequate to lower the concentration of radionuclides to meet water quality standards. Principal surface and groundwater users within the basin during prior years are depicted in Plate 6.2.3-1.

No municipal system uses surface water for a public water supply below the Mound Laboratory effluent discharge point at River Mile 65. Both surface and subsurface 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 circulating 585 cfs (Wolman, et al., 1957).

6.2.4. Flow Duration and Augmentation

The ability of the environment to dilute and disperse effluents depends upon the flow characteristics of the stream. This subsection describes the average flow rates of the Great Miami River and the studies to modify the flow rates for increasing demands to meet water quality and water use requirements for future years. A flow duration curve, Plate 6.2.4-1, has been constructed from available data covering the years from 1931 to 1960 at the Miamisburg gaging station (Cross, 1968). This curve depicts the discharge at the site that can normally be expected to be equalled or exceeded and serves as an index of drought flow conditions, (Cross, 1959). Using the 95 percent time coordinate, 310 cfs discharge past the effluent point can normally be expected for dilution of an accidental or normal discharge. The mean flow at Miamisburg is located at coordinate 50 percent or 1050 cfs. Plate 6.2.4-2 illustrates the available flow at Miamisburg under severe drought conditions and under conditions of a proposed flow augmentation utilizing the Englewood Retarding Basin for controlled discharge. During severe drought, flow to be expected over a seven day period once in 20 years, is about 180 cfs. Flow augmentation would provide an additional 400 cfs for dilution purposes. The low design flow at Miamisburg designated by the MCD is 212 cfs.

6.2.5. Dilution and Dispersion of Radioactive Releases

Radioactive waste effluent introduced through a normal or an improbable accidental release to the Great Miami River will be subjected to a number of dilution and dispersion mechanisms. The rate of dispersion and dilution within this environment primarily depends upon the flow rate of the river during the periods of radioactive waste release and the downstream dams and water users. The existence of O.H. Hutching Power Station and dam approximately 1.5 miles downstream would tend to promote dispersion of contaminants within the river body due to turbulence created by the station's circulating water pumps and the dam crest.

The minimum instantaneous low-flow of record was 148 cfs on

September 7, 1925. The likelihood of an accident occurring at the same time as the instantaneous low-flow of record is highly remote. A more reasonable estimate of the minimum water available for dilution can be made utilizing a consecutive day low-flow average as is the accepted practice for sewage treatment plant design. At the site this value is assumed to be the same as that used by the MCD or 212 cfs.

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6.3. GROUNDWATER

6.3.1. Description and On-Site Use

6.3.1.1. Regional Aquifers The site is within the Till Plains Section of the Central Lowlands Physiographic Province (Fenneman, 1938).

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 100 to 200 feet of Pleistocene sand, gravel and fine-grained till, and form the principal aquifer in the area.

In the upland areas, bedrock wells yield small quantities of poor quality water for private homes and farms. These wells are generally shallow and depend upon drainage from weathered cracks as their source.

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 summary of the hydrologic characteristics of geologic units in the vicinity of the site is presented in the following paragraphs. A detailed description of the geologic formations is presented in Sections 7.1. and 7.2. A map showing hydrogeologic environments for a radius of 2-1/2 miles from the site is shown on Plate 6.3-1.

Paleozoic Bedrock Aquifers

Maysville and Richmond Groups (Ordovician Age) Rocks of the Maysville and Richmond Groups are the oldest exposed rocks in Montgomery County (Norris, 1948) and form the principal bedrock type in the vicinity of the site. These rocks are composed primarily of shale interbedded with thin layers of dense limestone.

Water is stored and transmitted primarily through upper zones where surficial weathering has locally opened fractures and bedding planes. Weathered pyrite commonly occurs in the water bearing zones, and produces a high concentration of sulphur and iron compounds in the groundwater.

Wells drilled into rocks of the Maysville and Richmond Groups usually do not yield more than 5-10 gallons per minute (gpm); many wells are total failures (Spieker, 1968). Significantly higher yields (40 and 120 gpm) have been reported at two

locations in Jefferson Township, north of the site. Transmissivity coefficients for successful wells ranging from 62 to 428 gallons per day per foot (gpd/ft) have been reported. Specific capacities for these wells range from 0.26 to 2.50 gallons per minute per foot (gpm/ft) of drawdown, (Norris, 1948).

Recharge is principally derived from direct infiltration of precipitation. Glacial till overlying the bedrock in most areas acts to limit available recharge by retarding vertical percolation.

No fresh water aquifers exist below the upper zones of the Ordovician group. Salinity increases rapidly with depth because of low permeability which prevents replacement of connate water with meteoric water. A map showing the lowest approximate elevation of potable groundwater is presented on Plate 6.3-2.

Brassfield and Niagara Formations (Silurian Age) Rocks of the Brassfield and Niagara formations are exposed at higher elevations in the northern portion of Montgomery County. In the vicinity of the site, rocks of Silurian age are found only on topographic highs above an elevation of 950 feet. These rocks are primarily composed of massive limestones and dolomites.

Water is stored and transmitted through fractures and bedding planes which have been enlarged through solution activity. A significant "spring horizon" or seepage zone exists where these rocks are in contact over the shaley Ordovician rocks.

Wells drilled into rocks of the Brassfield and Niagara formations usually yield 5 to 14 gpm, though occasionally yield over 100 gpm, (Norris, 1948). Because of the topographic position of this aquifer, recharge must come primarily from direct infiltration of precipitation and is somewhat limited by the presence of glacial till which overlies most of the region. The yield of individual wells is extremely variable due to the inherent nature of carbonate aquifers, which transmit water through fractures and solution channels.

Reported transmissivity coefficients for wells in the Silurian Aquifer range from 52 to 2,790 gpd/ft. Specific capacities for these wells ranges from 0.29 to 2.85 gpm/ft of drawdown, (Norris, 1948).

Pleistocene Unconsolidated Aquifers

Valley Fill Outwash Deposits Outwash or "Valley Train" deposits of sand and gravel were emplaced by torrential glacial melt water streams which occupied pre-glacial

river valleys. They usually contain zones of relatively impermeable glacial till which may or may not be aerially extensive. The Valley Fill outwash deposits range from 100 to 200 feet in thickness and essentially follow the same course as the present day Great Miami River and its major tributaries.

Buried Valley outwash deposits which trend along the course of the Great Miami River form the most important aquifer in the area. Where induced stream infiltration is available, individual wells can yield as much as 2000 to 3000 gpm, (Spieker, 1968). Transmissivity coefficients for the aquifer usually range between 100,000 and 500,000 gpd/ft. Industrial wells adjacent to the site have specific capacities ranging from 73 to 218 gpm/ft of drawdown. Specific capacities as high as 1360 gpm/ft of drawdown have been reported for a well at Chatauqua, about 1-1/2 miles south of the site, (Norris, 1948).

Where aerially extensive layers of clay rich till prevent induced stream infiltration, or where surface streams are located too far away to form a hydraulic connection, individual wells yield from 100 to 1000 gpm, (Spieker, 1968).

The permeability of water-bearing sand and gravel zones has been computed from field pumping tests. For aquifers in the Dayton area, north of the site, typical values range from 1000 to 3000 gpd/sq ft, (Norris & Spieker, 1966).

Recharge to the aquifer is available from three major sources:

1) Directly from infiltration of precipitation on the flood plain.

2) Leakage along valley walls at the bedrock-outwash contact.

3) Induced infiltration caused by hydraulic sinks due to pumping.

Under natural conditions (no groundwater withdrawal) the natural direction of flow is from the aquifer to the stream, (Spieker, 1968). Recharge is primarily derived directly from precipitation and by leakage from valley walls. This source of recharge is sufficient in quantity to balance withdrawals of low capacity wells, but is not sufficient to supply high capacity well fields such as those at West Carrollton, about four miles north of the site. Under these conditions, groundwater levels experience continuous declines. (See Plate 6.3-3).

Where wells are hydraulically connected to streams, water is

recharged to the aquifer by means of induced infiltration. Under these conditions, water levels in the aquifer stabilize and the volume of water added to the aquifer by induced stream infiltration is approximately equal to the yield of the well, (Spieker, 1968).

Glacial Till - Thin Phase (Less than 20 ft thick) Ground moraine or glacial till is a heterogeneous mixture of gravel, sand, silt and clay. It covers most of the upland area and portions of outwash in the Buried Valley deposits.

Dug wells completed in upland glacial tills ordinarily yield from 2 to 10 gpm, (Norris, 1948). Coefficients of transmissivity range from 82 to 3,700 gpd/ft and specific capacities range from 0.23 to 2.88 gpm/ft of drawdown. Recharge is dependent upon direct infiltration from precipitation.

Glacial till is also interbedded with valley fill outwash deposits and acts as a low permeability barrier. Although not a continuous blanket in most areas, interbedded till horizons restrict recharge from stream infiltration, valley walls and precipitation. The average vertical permeability of interbedded till zones has been determined to be on the order of 0.1 gpd/sq ft, (Norris & Spieker, 1966).

Glacial Till - Thick Phase (Greater than 20 ft thick) Ground moraine and end moraine is similar in character to glacial till, thin phase, except the greater thickness of till may contain stringers, and irregular bodies of sand and gravel. Well yields are variable, depending upon the nature of sand and gravel lenses penetrated. Water supplies are generally adequate for farm or domestic requirements, (Norris, 1948).

Upland Outwash Deposits Thick, extensive deposits of permeable glacial outwash are usually overlain by till 5 to 70 feet thick. Water supplies from the underlying sands and gravels are described as "abundant", (Norris, 1948). Recharge is limited by the low permeability cap of glacial till and is primarily dependent upon direct infiltration of precipitation.

Kames and Kame Moraine These deposits form topographic highs composed of permeable sand and gravel, usually resting upon a relatively impermeable layer of glacial till or bedrock. They are not important aquifers because the water table is usually below the level of these deposits. No deposits of this type are known to exist within five miles of the site.

6.3.1.2. Local Aquifers

Bedrock Aquifers Most of the site is located on limestone and shale bedrock belonging to the Richmond Group. A thin layer of glacial till caps most of the hilltop areas. The waterbearing properties of this formation have been described in paragraph 6.3.1.1.

An examination of Well Log and Drilling Reports provided by the State of Ohio, Department of Natural Resources, Division of Water has revealed that most local wells drilled into bedrock range in depth from 40 to 100 feet, and yield groundwater at rates of about 1 to 6 gpm. Occasional well yields of up to 20 gpm have been reported. The deepest well in the vicinity of Mound Laboratory is 215 feet deep and yields approximately 3-1/2 gpm.

Because of the very low water transmission characteristics of the Richmond Group rocks, the Ordovician aquifer is considered to be locally insignificant as a water source.

Valley Fill Outwash Aquifer The Buried Valley immediately west of Mound Laboratory, below an elevation of approximately 710 feet, is the major aquifer adjacent to the site. The water-bearing properties of this formation are described in paragraph 6.3.1.1.

Within limits of the property, the maximum known thickness of the aquifer is about 70 feet at the extreme southwest corner of the site, (Earth Science Laboratories, Inc., 1961). The aquifer reaches a maximum thickness of about 150 feet near the river channel and is oriented in a north-south direction, in coincidence with the course of the Great Miami River, (Watkins & Spieker, 1971). Recharge by induced stream infiltration is available, although the sand and gravel aquifer at this location may contain aerially extensive inter-stratified layers of clayey till. Storage coefficients generally range from 0.2 to 0.0002, depending upon the degree of confinement, (Spieker, 1968). In consideration of recharge and hydraulic transmission properties of the aquifer, the Buried Valley west of the site is estimated to be capable of producing 15 to 20 million gallons per day (MGD) of groundwater per linear mile of valley, (Dames & Moore, 1972).

Four high capacity wells exist along the western border of the property. Three of these wells belong to Monsanto Research Corporation and provide a source of water supply for the Mound Laboratory. A fourth well located north of the other three belongs to the City of Miamisburg and is a source of public water supply. Locations of Monsanto wells are

shown in Plate 6.3-6. A summary of production data for these wells is presented in Table 6.3.1-1.

Hydrologic conditions adjacent to the site are highly variable, as demonstrated by the character of existing wells in the area. It has been suggested that groundwater withdrawn from wells adjacent to the site is at least partially replenished by induced stream infiltration from the Great Miami River, located about 1700 feet west of the well field, (Fred H. Klaer & Assoc., 1969). However, direct recharge from precipitation and leakage from the valley wall east of the well field probably make up the major source of recharge. Several residents who live on the Great Miami River flood plain adjacent to the site have reported that water levels in their wells are significantly more responsive to precipitation than to river stage.

The direction of groundwater flow is generally toward the south, following the downstream course of the Great Miami River. The average groundwater gradient in October, 1964 was about five feet per mile, (Spieker, 1968). A map showing groundwater gradients is presented in Plate 6.3-4, "Piezometric Levels in the Buried Valley Aquifer, October, 1964." Groundwater levels experience local reversals in areas of heavy pumpage, as indicated by closed contours on the piezometric map. Such reversals in groundwater gradient are expected to increase in both number, magnitude and aerial extent as regional groundwater development increases in the future.

Most of the communities north of Miamisburg must rely on induced stream infiltration in order to achieve sufficient well yields. Well fields in the vicinity of West Carrollton and Moraine currently do not have adequate recharge available to balance groundwater withdrawals and therefore, are experiencing severe water level declines, such as illustrated in Plate 6.3-3. The town of West Carrollton is planning to relieve the problem by drilling additional wells close to the Great Miami River where induced recharge is available. The aquifer in the vicinity of Moraine is tapped by several industrial and municipal users and is being overpumped at a rate of about 12 MGD, (Moulenbelt & Seifert, 1972). Recharge lagoons are being planned in order to direct a sufficient quantity of river water into the ground to balance withdrawal rates.

The City of Dayton, located about twelve miles northeast of the site, is also undergoing large-scale depletion of groundwater resources because of overpumping. At least 458 private, municipal and industrial water wells have been cataloged in the Dayton area, (Norris & Spieker, 1966). Water is being artificially recharged to the aquifer; however, a more

extensive program of artificial recharge is required to balance groundwater withdrawals in the area. The change in water levels at selected observation wells in the Dayton area over a ten-year period is illustrated in Table 6.3.1-2.

Although the Buried Valley aquifer is generally over-developed 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 piezometric gradient is reversed south of the City of West Carrollton. At Miamisburg, the natural groundwater gradient is toward the south and is not influenced by pumping except locally near individual wells fields.

The annual variation in groundwater levels is illustrated on Plate 6.3-5 by the hydrograph of Observation Well MT-49, (Kaser & Harstine, 1965). The Observation Well is located about one mile west of West Carrollton and about three miles north of the site.

The average annual fluctuation is about six feet, although the long-term trends show the effects of groundwater depletion which tends to exaggerate the annual changes. Local residents near the site report annual water level changes of about 3 or 4 feet, based upon casual, intermittent inspection of their wells.

6.3.1.3. On-Site Use

Water Sources Water supply for Mound Laboratory is obtained from three high-capacity wells located on a property leg that extends off the southwest corner of the site, (see Plate 6.3-6). Each of the wells is pumped intermittently at the following rates:

Well No. 1	450-500 gpm.
Well No. 2	500-550 gpm.
Well No. 3	500-550 gpm.

Present water usage at the facility ranges from 500 to 900 gpm. The estimated maximum capacity of the water system is 1100 gpm. A reserve water supply having a capacity of 1000 gpm is available from the City of Miamisburg. This reserve supply is not used by the facility, but is available in case of emergency.

Water Storage and Treatment Facilities Two water towers are used at Mound Laboratory, as shown on Plate 6.3-6.

The water tower adjacent to "P" Building has a total capacity of 100,000 gallons. The normal operating capacity is 50,000 gallons and the emergency fire capacity is 50,000 gallons.

A second water tower located adjacent to Building 38 has a total capacity of 250,000 gallons. The normal operating capacity is 125,000 gallons and the emergency fire capacity is 125,000 gallons.

In addition to the towers, a 350,000 gallon capacity ground level tank is located near the Waste Disposal Bldg. This tank is used only as additional fire protection reserve.

Five water softener units are used, each having a rated capacity of 250 gallons per minute. Total hardness is reduced from approximately 300-500 ppm to 0-10 ppm. Three of the water softening units are located in "P" Building. The other two units are located in Building 24.

Plans for Conservation of Water Resources A 350-ton cooling tower and chiller system project was budgeted for FY 1972 and is underway as part of a system to recirculate water used to cool heat exchangers in laboratories. When put into operation, it is anticipated that this recirculation will reduce water usage by 150 gpm. This concept of using recirculated water will also be extended to other areas whenever feasible. A program designed to provide data necessary to manage plant water resources is currently underway. Water meters are being installed for buildings which are the major users of water.

6.3.2 Sources

6.3.2.1. Present and Future Regional Use

Public and Industrial Users There are six major public water supplies and numerous industrial users within a five mile radius of Mound Laboratory. A map showing the locations of public water supply wells and distribution areas for municipal water service is shown on Plate 6.3-7. A tabulation of current and projected water demands is presented in Table 6.3.2-1, and a map showing municipal groundwater use in 1969 is presented on Plate 6.3-8.

Groundwater supply wells and hydraulic conditions for all municipal users within five miles of Mound Laboratory are discussed in the following paragraphs. The only industrial user discussed is the Dayton Power & Light Company, Hutching Generating Station, because it is the only major industrial facility located downstream and within five miles of the site. No industrial groundwater users located north (upstream) of the site are considered in this report because they are

isolated from Mound Laboratory by hydraulic barriers.

For reference in discussions which follow, Mound Laboratory is located opposite River Mile 65. This Mile Post system is referenced to the junction with the Ohio River as River Mile 0.0, and is presented on topographic maps published by the U.S. Geological Survey.

Miamisburg The City of Miamisburg owns ten water wells, but only four are in use. The six abandoned wells do not meet criteria for public health standards and are not intended for any future use. City Well No. 2 is located on the east side of the Great Miami River, immediately west of the Mound Laboratory site. City Wells, No. 8, 9 and 10 are located on the west side of the river immediately south of the Linden Avenue bridge, upstream from the Mound Laboratory site. The city plans to drill one or two additional wells immediately north of the Linden Avenue bridge in the near future. The operation of Wells No. 8 and No. 9 support the city's normal water requirements. Wells No. 2 and No. 10 are used for periods of peak demand, particularly fire fighting.

Because of the relative locations of the wells to the Great Miami River and to the site, the only well owned by the City of Miamisburg that could be immediately affected by Mound Laboratory is City Well No. 2. All other operational city wells, both existing and planned, are separated from the site by the Great Miami River, and by a minimum straight-line distance of at least one-half mile from the laboratory.

The small stream which drains the laboratory site divides at the foot of the hill. The south-flowing portion follows the railroad tracks until it empties into the Great Miami River at the railroad bridge downstream of the site. The north-flowing portion empties into two small recreation ponds approximately one-half mile north of the site. If a contaminant borne by the stream is allowed to be carried into these ponds, it may be possible that the contaminant would enter the aquifer and be drawn toward the City of Miamisburg Wells No. 8, 9 and 10.

Groundwater gradients and aquifer coefficients between the small recreation ponds and the active city well field are not known in sufficient detail to predict dilution and groundwater movement rates. However, the Great Miami River acts as a partial recharge barrier and would add to the probable dilution by perhaps two orders of magnitude by means of induced stream infiltration. Groundwater gradients between the small recreation ponds and the active well field can also be reversed by pumping the abandoned Miamisburg Power Station wells which surround the small recreation

ponds if the main city water supplies appear to be endangered.

West Carrollton The City of West Carrollton owns four operational water wells. All of these wells are located far enough away from the Great Miami River so that they do not invite induced stream infiltration. As a result of over-pumping, water levels in these wells are experiencing an accelerating rate of decline. In order to deal with this problem, the City of West Carrollton is planning to construct a high capacity well (2000 gpm) near the river at approximately River Mile 71.5.

All of the existing and planned wells operated by the City of West Carrollton are upstream of the Mound Laboratory site by a minimum straight-line distance of three miles, and are separated from the facility by hydraulic barriers.

Montgomery County Sanitary District The Montgomery County Sanitary District operates three well fields in the Greater Moraine area. The Miami Shores well field is located on the west bank of the Great Miami River, opposite the mouth of Holes Creek. The Dryden Road well field is located on the east bank of the Great Miami River on both sides of Holes Creek. The Lamme Road well field is located almost one mile east of the Great Miami River in the vicinity of Holiday School. The closest well field to the site is the Miami Shores field opposite River Mile 72-1/2, which is a straight-line distance of over four miles from Mound Laboratory.

All of the well fields serving the district are isolated from the site by physical and hydraulic barriers. Although groundwater resources are currently over-developed due to heavy industrial use as well as municipal use, recharge lagoons are either planned or under construction. Because the area is far enough upstream, it is not anticipated that any activity at Mound Laboratory could affect any of the Montgomery County well fields.

Hutching Power Station The O.H. Hutching Station owned by Dayton Power & Light Company operates six high-capacity (1,500 gpm) wells, ranging in depth from 126 to 177 feet. The wells are all located on the west side of the Great Miami River at about River Mile 63-1/2. The closest well is a minimum straight-line distance of about one mile from Mound Laboratory.

Wells at the O.H. Hutching Power Station are physically separated from the site by the Great Miami River, which acts as a partial recharge barrier. However, it is conceivable that a contaminant entering the aquifer at the site could

be attracted by the cone of depression at the well field, because the rate of pumping is relatively great in relation to the ability of the river bed to provide infiltration to the aquifer. This is indicated by closed piezometric contours which extend east of the river as shown on Plate 6.3-4.

Hydrogeological conditions between wells at the power station and the site are not known in sufficient detail to permit accurate prediction of flow rates through the aquifer or diffusion characteristics. The wells at the power station do induce stream infiltration as a major portion of their yield. It is therefore reasonable to assume that any contaminant which is transmitted through the aquifer between the site and the well field would be substantially diluted with recharged water by probably two orders of magnitude.

Although the transmissivity coefficients between the site and the well field are relatively high, the piezometric gradient between the two locations is very low and is somewhat responsive to the local pumping demands in well fields between them. Under the worst conditions, using a coefficient of permeability equal to 3000 gpd/sq ft, and a hydraulic gradient of 10 feet per mile, the calculated rate of groundwater movement through the aquifer would be about 0.76 feet per day. It has been estimated that groundwater moves at a rate of up to seven feet per day in outwash deposits at the Mad River Buried Valley near Dayton, under the influence of natural piezometric gradients, (Norris & Spieker, 1961). Assuming that a groundwater movement rate of seven feet per day near the site is possible, it would take over two years for a contaminant introduced to the aquifer at the site to reach the Hutching Station well field.

The well field is dependent upon induced stream infiltration from the Great Miami River in order to maintain yield and is therefore susceptible to contamination carried by the river. Contamination would be introduced to the aquifer at the point which the Great Miami River intersects the zone of influence due to pumping. The probable danger would be dependent upon toxicity and dilution at the point of entry to the aquifer. The rate of groundwater movement at two very high-capacity (15 MGD) collector wells near Hamilton, Ohio has been calculated at about 13 feet per day, (Norris & Spieker, 1961). The wells at Hutching Power Station are all located a minimum distance of 300 feet from the Great Miami River. Using these rates and distances as conservative estimates of actual conditions, a river-borne contaminant could be expected to reach the well field in about 23 days.

Springboro Water District The Springboro Water District owns four water wells. Two are located in the City of Springboro on the east side of a south-flowing branch of

Clear Creek. Two additional wells are located on the west side of the Great Miami River, opposite the terminus of Pennyroyal Road on the east bank of the river.

The two wells located within the city limits of Springboro are isolated from the site by a drainage divide and a minimum straight-line distance of over 5-1/2 miles. Therefore, operation of the Mound Laboratory would have no effect on these water supply wells.

The two wells located on the west bank of the Great Miami River, approximately at River Mile 61-1/2, would probably not be affected by the introduction of a contaminant into the aquifer at the site. This conclusion is based upon the fact that the Great Miami River separates the well field from the site by acting as a recharge barrier between them. A hydraulic sink provided by the Hutching Power Station well field, 1-1/2 miles north of the Springboro water wells, would provide additional hydraulic insulation against direct transmission of a contaminant through the aquifer. Also, the minimum straight-line distance between the Springboro wells and the site is 2-3/4 miles, which is very long in comparison to the maximum aquifer thickness of 200 feet.

Franklin The City of Franklin owns eight water wells. Seven are located on the west side of the Great Miami River at approximately River Mile 59.5. One additional well is located on the east side of the river at about River Mile 60.0. The closest well is a straight-line distance from the site of over four miles.

It is unlikely that the well field at Franklin could be affected by a contaminant introduced into the aquifer at Mound Laboratory because of the distance from the site and discontinuities in the aquifer body between the two points. However, it is very likely that a contaminant carried by the Great Miami River could affect the well field, since induced stream infiltration is required to maintain well yields. The anticipated danger resulting from a particular river-borne contaminant would have to be evaluated upon the basis of dilution and toxicity at the point on the river opposite to the zone of influence of the well field.

Germantown The city owns four water wells located on the north side of town, and on the west side of Twin Creek. The well field is hydraulically isolated from the Mound Laboratory site by a drainage divide and a straight-line distance of over four miles. Therefore, the operation of Mound Laboratory would have no affect on this well field.

Private Users A map showing the locations of private water wells near Mound Laboratory is presented on Plate 6.3-9

and is referenced to Table 6.3.2-2 for more detailed information. Areas designated as Zones A & B on Plate 6.3-9 are located on the west side of the Great Miami River and are therefore hydraulically isolated from Mound Laboratory. Areas D & E are being rapidly converted to city water supplies. Most of the wells in these two areas provide very limited yields and are usually abandoned by the owner as soon as hook-up with city water supplies are completed.

The only zone in the vicinity of Mound Laboratory, highly dependent upon well water, is Area C. Most local residents who live on the flood plain below Mound Laboratory still depend on wells as their source of water supply. A 12-inch diameter water line extends from the southern city limits of Miamisburg along Cincinnati Pike (which is the southern extension of Main Street in Miamisburg) to the sewage disposal plant, approximately one-half mile south of Mound Laboratory. Currently, the Ideal Mobile Home Park has the only tie into this water line. All other residences on the flood plain still rely totally upon well water.

Well water supplies in Zone C are readily available from the granular deposits of the Great Miami River flood plain. These wells are relatively inexpensive to maintain in comparison to the cost of hooking up to the city water pipeline. It is therefore expected that wells will continue to provide a major source of water supply in this area.

6.3.2.2. Site Conditions The site is topographically divided into two hilltop areas by a small intermittent stream which flows south and west. The upland bedrock plateaus northwest and southeast of the small stream are occupied by most of the major laboratory structures. Below an elevation of about 760 feet, bedrock and glacial till become buried by glacial outwash and till deposits. These deposits reach a maximum thickness of about 70 feet near Monsanto Water Well No. 3, at the extreme southern end of the property.

The three wells which supply water to the plant are drilled into, and receive water from, glacial outwash deposits. A landfill containing cardboard, paper, wood, machine shop wastes, plating room wastes and other miscellaneous materials, including laboratory and cafeteria wastes, is located in the zone of glacial soil, several hundred feet northeast of Well No. 1. (Fred H. Klaer & Asso., January, 1971). 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, (Fred H. Klaer & Asso., October 1971). The consultant detected an anomalous variation in the hardness and chloride content of the well water and concluded that the contaminant probably entered the aquifer by induced infiltration from the small stream which

drains the property. The source of hardness and chloride contamination was believed to have been the backwash from Zeolite water softeners.

Too little is presently known of the detailed site geology to permit complete delineation of on-site areas which offer possible routes of groundwater contamination. It is not unlikely however, that the entire site area containing glacial deposits could offer a possible route into the aquifer.

Unless proven otherwise by additional site investigations, it should be assumed that any contaminant which may be carried by water can enter the major Buried Valley aquifer at the site either by direct infiltration through the glacial outwash deposits below an approximate elevation of 760 feet, or by leakage from the bedrock valley walls which enter the outwash deposits. The bedrock hills which support most of the laboratory buildings may be considered as being virtually impermeable because of lithology and horizontal bedding structure.

6.3.3. Environmental Acceptance of Effluents

The following paragraphs present an evaluation of the dilution and dispersion characteristics of the groundwater environment with respect to existing users and future users.

It has been shown in the preceding section that fluid contaminants could enter the groundwater environment at the site. A small stream which provides storm, groundwater and cooling water drainage from the site follows the course of the Penn Central Railroad tracks in a southerly direction, and empties into the Great Miami River where the railroad bridge crosses the river at River Mile 64.2. This small stream flows along the flood plain for a distance of about one mile between the site and its junction with the Great Miami River, and is probably subjected to induced infiltration by several private water wells along the way. Therefore, water from this stream could be introduced into the groundwater environment at any point along its path.

Below River Mile 62.4, any contamination carried by the small stream which drains the site would be diluted by several orders of magnitude by the Great Miami River. The actual degree of dilution would depend upon the relative flow rates between the stream and the river. Mixing would occur the most quickly when the river stage is high due to an increase in turbulence. Riverborne contaminants could enter the aquifer at any downstream location which is subjected to the influence of induced stream infiltration caused by the

pumping of wells.

A concentration of streamborne contamination would pass a particular downstream well field faster and would be more thoroughly diluted if released during a period of high river stage. At low river stage, a wave of contamination would pass more slowly and would be diluted less; however, a low-permeability silt layer which forms along the riverbottom during low flow period (Moulenbelt & Seifert, 1972) would significantly inhibit infiltration to the aquifer. Therefore a wave of contamination released into the Great Miami River would be of similar impact to downstream well fields during both high and low river stages.

The first major downstream well field would be the Hutching Power Station, followed by the Springboro Municipal Well Field and the Franklin Municipal Well Field. A more detailed description of these well fields and their hydraulic relationship with Mound Laboratory has been presented in Section 6.3.2.1 of this report.

One branch of the small stream which drains the site also flows north from the point at which the drainage enters the flood plain and feeds two small recreation ponds about 2000 feet north of the laboratory. These ponds depend upon this stream for maintaining their water levels and it is assumed that they contribute to aquifer recharge. The quality of groundwater on the flood plain adjacent to this stream, and particularly in the vicinity of the ponds appears to be partially controlled by the quality of surface water carried by the drainage system.

Locally, a contaminant that entered the aquifer at the site could be directed toward the cones of depression created by the operation of wells located within and immediately west of the site boundary. While in the groundwater environment, the flow characteristic would be laminar, and diffusion by mixing would therefore be minimal. Underground flow would take place mainly in zones of high permeability rather than in the vicinity of low permeability till layers. Thus, attenuation of a contaminant during passage through the aquifer by adsorption on ion exchangeable clay minerals would be small.

Groundwater gradients and aquifer coefficients west of the small recreation ponds are not known in sufficient detail to predict dilution and groundwater movement rates. However, the Great Miami River acts as a partial recharge barrier and would add to the probable dilution by perhaps two orders of magnitude by means of induced stream infiltration. Groundwater gradients between the small recreation ponds and the active well field can also be reversed by pumping the

abandoned Miamisburg Power Station wells which surround the small recreation ponds should it become necessary.

If a contaminant were to enter a well, it would be mixed with non-contaminated water drawn from other sectors of the aquifer. The probably degree of dilution as a result of mixing in the well is unknown but is not expected to exceed about one order of magnitude of the maximum concentration of the contaminant.

Private homes that obtain water from bedrock wells, or from alluvial deposits in hydraulically isolated drainage systems, would not be affected by fluid contamination originating from Mound Laboratory.

6.3.4. Groundwater Monitoring Program

Varions public and private water supplies are monitored on a regular basis according to the following schedule.

1. Municipal water supplies in the area are sampled and analyzed quarterly.

2. All three Mound Laboratory wells are sampled and analyzed weekly for tritiated water, monthly for nonradioactive parameters such as dissolved solids and chlorides, quarterly for plutonium and semi-annually for fifteen heavy metals.

The Miami Conservancy district is undertaking a groundwater quality monitoring study under the sponsorship of Monsanto Research Corporation. The scope of the monitoring program is as follows:

1. Representative water samples will be obtained from bedrock aquifers, buried valley aquifers, and water supplies developed in upland glacial till out to a distance of five miles in all four quadrants surrounding Mound Laboratory. Samples are to be obtained quarterly. All public water supplies falling within the five-mile radius are included as sampling points.

2. In order to obtain information on possible subsoil transport of contaminants of interest, a limited number of sites within the five-mile radius surrounding Mound Laboratory will be equipped with pressure-vacuum lysimeters to obtain water samples from the unsaturated soils in the area of the sampling wells. Sampling is to be performed semiannually. Specific sites included are the City of Miamisburg Well No. 2

near the Mound Laboratory west boundary, the O. H. Hutchings power station wells and the Mound Laboratory well field.

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PERSONS AND AGENCIES CONTACTED

Paul M. Plummer, December 15, 1972, The Miami Conservancy District, Dayton, Ohio

Table 6.1.3-1 Peak stages and discharges

Great Miami River at Miamisburg, Ohio			
Water Year	Date	Gage Height (feet)	Discharge (cfs)
1913	Mar. 28, 1913	-	a257,000
1917	Mar. 14, 1917	11.6	30,500
1920	Apr. 21, 1920	16.8	51,800
1929	Feb. 27, 1929	16.5	55,000
1930	Jan. 10, 1939	16.16	50,800
1933	May 15, 1933	16.13	51,800
1959	Jan. 21, 1959	20.65	61,800

a. Computed by Miami Conservancy District

Location - Lat 39°38'45", long 84°17'20", 600 ft downstream from bridge on State Highway 725 at Miamisburg, Montgomery County, and 0.3 mile downstream from mouth of Bear Creek.

Drainage Area - 2,718 sq mi. At site used 1916-20, 2,780 sq mi; at site used 1924-35, 2,719 sq mi.

Gage - Nonrecording prior to Oct. 1, 1924; recording thereafter. At site 6.7 miles downstream at different datum May 16, 1916 to Sep. 30, 1929. At site 2.2 miles downstream at datum 677.06 ft. above mean sea level Aug. 29, 1924, to Sep. 30, 1935. Datum of gage is 678.60 ft. above sea level, adjustment of 1912. The 1929 adjustment lowered the gage elevation to 678.35.

Stage-discharge relation - Defined by current-meter measurements below 46,000 cfs, 1917-20; below 43,000 cfs, 1925-35; and below 59,800 cfs, 1953-61.

Bankfull stage - 22 ft.

Remarks - Flow regulated by four retarding basins (combined capacity, 735,000 acre-ft) since 1921. Base data furnished by Miami Conservancy District. Only annual peaks are shown.

Table 6.1.3-1 (Continued)

Reference - Geological Survey Water Supply Paper 1675 Magnitude and Frequency of Floods in the U.S. Part 3-A, Ohio River 1965.

Table 6.1.4-1 Data pertaining to dams and appurtenances

	Englewood Dam	Lockington Dam	Taylorsville Dam	Huffman Dam
Drainage area above dam, square miles	651	255	1,133	671
Average elevation bed of river, feet above sea level	768	876	759	777
Average elevation valley floor, feet above sea level	782	885	770	785
Elevation of spillway crest, feet above sea level	876	938	818	835
Elevation of top of dam, feet above sea level	892.5	954	837	850
Maximum height of dam above valley floor, feet	110.5	69	67	65
Length of crest of dam, feet	4,716	6,400	2,980	3,340
Thickness of dam at average elevation of valley floor, feet	739	409	397	385
Number of conduits	2	2	4	3
Length of each outlet conduit, feet	709	46	40	40
Vertical diameter of permanent outlet conduits, feet	10.5	9.2	19.2	16.3
Maximum width of outlet conduits, feet	13	9	15	15
Combined sectional area of permanent outlet conduits, square feet	217	158	1,118	705
Elevation of conduit invert at entrance	772	876	760	777
Length of spillway crest, feet	100	72	132	100
Volume of earth in dams, cubic yards	3,500,000	1,135,000	1,235,000	1,655,000
Volume of concrete in dams and appurtenances, cubic yards	36,800	38,000	48,000	40,000
Storage capacity to spillway crest, acre feet	312,000	70,000	186,000	167,000
Area in basin below elevation of spillway crest, acres	7,930	4,020	11,000	9,180
Outflow through conduits with water level at spillway crest, second feet	12,000	8,800	53,600	35,000
Velocity of outflow with water level at spillway crest, feet per second	55	56	48	50

Ref: Hydraulics of the Miami Flood Control Project, MCD Tech. Rpt. VII.

Table 6.1.5-1 Great Miami River Drainage Basin - Distribution of the probable maximum precipitation

SUB-BASIN NO.	SUB-BASIN NAME	DRAINAGE AREA (Sq. Miles)	RAINFALL EXCESS (After Losses) SIX-HOUR PERIODS IN INCHES																TOTAL R. E. (inches)
1	Indian Lake	109	0	0	0	0	0	.46	.46	.46	1.36	3.5	6.5	1.8	0	0	0	0	14.54
2	Brokengehalas	38	0	0	0	0	0	.5	.5	.5	1.5	3.7	6.9	1.9	.1	.02	.02	.02	15.66
3	Stone Creek	59	0	0	0	0	0	.5	.5	.5	1.5	2.7	6.9	1.9	.1	.02	.02	.02	15.66
4	Sidney Local	339	0	0	0	0	0	.5	.5	.5	1.6	3.9	7.2	2.1	0	0	0	0	16.3
5	Loramie Lake	79	0	0	0	0	0	.5	.5	.5	1.4	3.6	6.7	1.9	0	0	0	0	15.1
6	Lockington Local	182	0	0	0	0	0	.5	.5	.5	1.5	3.7	6.9	1.9	.1	.02	.02	.02	15.66
7	Piqua Local	36	0	0	0	0	.1	.6	.6	.6	1.9	4.4	8.2	2.3	.1	.1	.1	.1	19.1
8	Troy Local	66	0	0	0	0	.3	.8	.8	.8	2.1	5.1	9.5	2.7	.1	.1	.1	.1	22.5
9	Tipp City Local	53	0	0	0	0	.3	.8	.8	.8	2.2	5.4	9.9	2.9	.1	.1	.1	.1	23.5
10	Lost Creek	55	0	0	0	0	.2	.7	.7	.7	2.0	4.9	9.2	2.6	.1	.1	.1	.1	21.4
11	Taylorsville Local	139	0	0	0	0	.1	.6	.6	.6	1.9	4.4	8.2	2.3	.1	.1	.1	.1	19.1
12	Urbana	157	0	0	0	0	0	.46	.46	.46	1.36	3.5	6.5	1.8	0	0	0	0	14.54
13	Buck Creek Dam Site	85	0	0	0	0	.2	.4	.4	1.4	1.3	3.2	6.1	1.8	0	0	0	0	13.4
14	Springfield Local	243	0	0	0	0	0	.46	.46	.46	1.36	3.5	6.5	1.8	0	0	0	0	14.54
15	Huffman Local	147	0	0	0	0	0	.5	.5	.5	1.5	3.7	6.9	1.9	.1	.02	.02	.02	15.66
16	Bradford	195	0	0	0	0	0	.2	.4	.4	1.3	3.5	6.4	1.8	0	0	0	0	14.0
17	Covington Local	243	0	0	0	0	0	.46	.46	.46	1.36	3.5	6.5	1.8	0	0	0	0	14.54
18	Pleasant Hill Local	64	0	0	0	0	.1	.6	.6	.6	1.6	3.9	7.3	2.1	0	0	0	0	16.8
19	Englewood Local	144	0	0	0	0	.1	.6	.6	.6	1.9	4.4	8.2	2.3	.1	.1	.1	.1	19.1
20	Dayton Local	80	0	0	0	0	.1	.6	.6	.6	1.9	4.4	8.2	2.3	.1	.1	.1	.1	19.1
21	Wolf Creek	70	0	0	0	0	.2	.7	.7	.7	2.0	4.9	9.2	2.6	.1	.1	.1	.1	21.4
22	Miamisburg	135	0	0	0	0	.1	.6	.6	.6	1.6	3.9	7.3	2.1	0	0	0	0	16.8
23	Franklin Local	67	0	0	0	0	0	.2	.4	.4	1.3	3.5	6.4	1.8	0	0	0	0	14.0
24	Ingomar	198	0	0	0	0	.1	.6	.6	.6	1.9	4.4	8.2	2.3	.1	.1	.1	.1	19.1
25	Germantown Local	77	0	0	0	0	.1	.6	.6	.6	1.9	4.4	8.2	2.3	.1	.1	.1	.1	19.1
26	Middletown Local	167	0	0	0	0	0	.5	.5	.5	1.5	3.7	6.9	1.9	.1	.02	.02	.02	15.66
27	Acton Lake	102	0	0	0	0	0	.2	.4	.4	1.3	3.2	6.1	1.8	0	0	0	0	13.4
28	Collinsville	121	0	0	0	0	.1	.6	.6	.6	1.7	4.2	7.8	2.2	0	0	0	0	17.8
29	Talawanda Local	88	0	0	0	0	0	.5	.5	.5	1.5	3.7	6.9	1.9	.1	.02	.02	.02	15.66
30	Hamilton Local	168	0	0	0	0	0	.46	.46	.46	1.36	3.5	6.5	1.8	0	0	0	0	14.54

(1) Reference: Restudy of the Official Plan, Part 1, MCD, June 1964

Ref 58 (cont)

7. GEOLOGY AND SEISMOLOGY

7.1. BASIC GEOLOGY AND SEISMIC DATA

This section presents basic geologic and seismic data obtained for Mound Laboratory. The site is located immediately south of the town of Miamisburg, Ohio. The location of the site in relationship to the surrounding area is shown on Plate 7.1-1, Site Vicinity Map.

Basic geologic and seismic data for the site were developed by a program including the following:

a. research of both published and unpublished geologic and seismic data;

b. geologic reconnaissance of the site and surrounding area;

c. test borings;

d. geophysical explorations; and

e. laboratory tests.

The purpose of this program was to evaluate the site geology and aseismic design parameters.

The research program provided a history of geologic conditions which formed the region. The geologic history provides an understanding of the sedimentary environments and the tectonic activity which acted upon the area, and helps to provide an evaluation of the foundation materials at Mound Laboratory.

Test borings were used for a detailed examination of the geologic structure under Mound Laboratory and provided samples which were used for a variety of laboratory tests. The laboratory tests provided additional information which was used to evaluate stability of the site under static and dynamic (earthquake) loading. Any potential problems which could have an effect on site stability were identified and addressed.

Geophysical site investigations were conducted to examine the compressional and shear wave propagation characteristics of the soil and rock strata. This information was used to evaluate the character and geologic structure of subsurface materials, and to evaluate the possible effects of earthquake wave amplification.

All of the basic geologic and seismic data was analyzed in order to establish a correlation between geologic structure and earthquake activity. The interaction between earthquake waves and subsurface materials was examined in order to predict the stability and degree of horizontal acceleration which the site could experience during a seismic event.

7.1.1 Geologic and Seismic Research and Geologic Reconnaissance

Geologic and seismologic literature, aerial photographs, and topographic maps of the area were studied. In addition, representatives of governmental agencies, private organizations and universities were contacted to obtain available geologic and seismic data, including unpublished data. A listing of the literature references and agencies and individuals contacted is included at the end of this section.

A geologic reconnaissance of the site and surrounding area was undertaken to identify the geologic characteristics of the area. Rock exposures within the Penn Central Railroad rock cut, immediately west of the site, were examined.

7.1.2. Test Borings

Six widely spaced geologic borings were drilled at the site to determine the lithology, structure, and physical properties of the subsurface strata. The borings ranged in depth from 50 to 200 feet below the existing ground surface and were drilled at locations indicated in Plate 7.1-2, Plot Plan. The drilling was done with truck-mounted rotary wash equipment. Drilling mud and/or casing was used in the soil portion of the borings. Bedrock coring was performed with the aid of water.

Detailed descriptions of the soil and rock encountered in the borings are presented on Plates 7.1-3 through 7.1-8. The soils were classified according to the Unified Soil Classification System described on Plate 7.1-9.

Rock was cored utilizing NX double tube core barrels, which provide rock cores approximately two inches in diameter. Undisturbed soil samples suitable for laboratory testing were

obtained using a Dames & Moore Type U Sampler which is 3-1/4 inches in outside diameter and approximately 2-1/2 inches in inside diameter, as shown on Plate 7.1-11. The Dames & Moore Sampler was driven by a 300 pound hammer falling 24 inches.

Disturbed soil samples were obtained using a standard, two inch outside diameter, split-barrel sampler driven by a 140 pound hammer falling 30 inches. The blow counts were averaged over a driven distance of 12 inches to provide Standard Penetration Test values.

Selected borings were water pressure tested after they were drilled in rock. An inflatable double packer was used to isolate a ten foot section of the drill hole during each increment of the tested section. The tests normally consisted of one pressure level which was computed as 0.75 pounds per square inch (psi) per foot of depth. A maximum gage pressure of 105 psi was used.

The net applied pressure is given as: Net pressure equals gage pressure plus column pressure minus friction loss. The column pressure is equal to the depth to the upper packer or the depth to ground water, whichever is smaller, times a constant of 0.433 psi per foot of depth (hydrostatic pressure gradient).

Values of net pressure and flow rate were converted to values of permeability using a method described by the United States Department of the Interior (Bureau of Reclamation, 1963), and are presented on the boring logs.

Groundwater observations were made by utilizing three types of borehole completion methods. Borings 1 and 2 were open hole completions. Except for a few feet of soil near the surface, most of the two holes were drilled in rock which supported itself during the time that water levels were being monitored.

A section of 1-1/4 inch diameter iron pipe equipped with a four foot long well-point was installed in both borings 3 and 4. In each case, the well-point was set immediately above apparent top of bedrock.

Four inch diameter plastic casing was installed in borings 5 and 6 to the apparent top of rock. The lower 20 feet of the plastic casing was perforated with slots to facilitate communication with ground water levels.

7.1.3. Geophysical Borehole Logging

All borings were logged with the Widco Porta-Logger upon completion of drilling to aid in the identification of lithology, and to assist with stratigraphic correlation.

The geophysical logs obtained included both Gamma Ray and Single Electrode Resistance Profiles. A detailed description of the Widco Porta-Logger, including a discussion of its capabilities and limitations, is shown on Plate 7.1-12. Results of geophysical logging with the Widco Porta-Logger are shown on the boring logs, Plates 7.1-3 through 7.1-8.

Birdwell Division of Seismograph Service Corporation was contacted to run three dimensional velocity log, density log, and caliper log surveys in boreholes 1 and 2. Results of the computed "Elastic Properties Logs" are presented on Plate 7.1-13. These logs were used to supplement information obtained from the surface geophysical survey.

7.1-4. Geophysical Explorations

The following geophysical surveys were conducted at the site:

1. Seismic refraction surveys to establish the compressional wave velocities of soils and rock, and to determine depths to velocity interfaces.

2. A crosshole shear wave survey to establish the shear wave velocities of soils and rock.

3. An uphole velocity survey to further establish compressional wave velocities.

4. Ambient vibration measurements to determine the characteristics of ground motion initiated by background noise.

Locations for the above studies are shown on Plate 7.1-2, Plot Plan.

The geophysical field crew consisted of two geophysicists and a licensed powderman. The majority of the field studies were conducted at times when activity at the site was at a minimum.

7.1.4.1. Seismic Refraction Surveys Approximately 1,300 lineal feet of profiling was conducted in six seismic refraction lines. The lines were arranged in perpendicular pairs at Borings 1, 3 and 5 & 6. Orientation and exact locations are shown on Plate 7.1-2.

Two energy sources were utilized for the refraction surveys. A total of 875 feet of profiling was performed in the vicinity of Borings 5 and 6, using explosives as the energy source. A sledgehammer was used to provide energy around Borings 1 and 3.

The explosive charges consisted of DuPont Nitramon SEL detonated by means of DuPont SSS seismic electric blasting caps. The charges, ranging in size from 1/2 to 3 pounds, were placed

in drilled shot holes averaging from 8 to 15 feet in depth.

The energy released by detonation of the explosive charges was detected by vertically oriented geophones spaced at intervals that varied from 10 to 25 feet. The geophones, manufactured by Electro-Tech Labs, have a natural frequency of 14 Hertz and were fitted with either a spike or plate to assure good coupling with site materials. The energy pulses detected by the geophones were input into a Dresser SIE RA44 seismic amplifier, coupled with a Dresser SIE R6 recording oscillograph.

On profiles where explosives were not used, the instrumentation was identical to that already described. The only variation between the two techniques was a shortened spacing between geophones.

The compressional wave velocities and corresponding depths to velocity interfaces were evaluated by plotting first arrival times of seismic energy at each geophone against distance from the energy source. The time-distance plots and corresponding interpretive cross-sectional profiles for each line are presented on Plates 7.1-14 through 7.1-19. The plotted information was supplemented by several short spreads to obtain more detailed near-surface information.

The compressional wave velocities and depths to boundaries obtained by the refraction method correspond well with known information from the site as well as published velocity values from the general area. Groundwater levels obtained from the test borings indicate that both the V_1 and V_2 layers, (1650 and 3350 feet per second respectively) are above the water table. The marked change in velocity of the V_3 layer (10,000 fps) defines both the soil-rock interface and the static water level in the vicinity of Borings 5 and 6.

Seismic Lines 5 and 6 permitted interpretation of the configuration of the soil-rock interface. As can be seen on Plates 7.1-18 and 7.1-19, this interface slopes downward into the stream valley and reflects the character of part of the buried bedrock valley found at the site. In the vicinity of Borings 1 and 3, the primary information obtained was compressional wave velocities.

7.1.4.2. Crosshole Velocity Survey Two basic techniques were attempted as means of obtaining shear wave velocities by means of the crosshole method. The first technique made use of two borings (Borings 5 and 6) spaced 100 feet apart. At a distance of approximately 500 feet from Boring 6, and in line to both borings, explosive charges of one to two pounds were detonated in drilled holes.

The energy released by the explosive charges was detected by two geophones placed at the same elevation in each boring. The geophones, 3-component low frequency geophones, (Mark Products L-1-3DS), were coupled to the Dresser SIE recording system. Both geophones were raised in 10-foot intervals between each recording.

Shear wave arrivals are often masked by the relatively large amplitude motions caused by multiple reflected and refracted compressional waves and by surface waves. To help overcome this difficulty, recordings were made at both high and low gain levels at each recording depth.

The second technique employed consisted of using a horizontal sledgehammer impact against a face cut into the soil around Boring 6. Impact directions were reversed, and high and low gain levels were recorded at each depth.

The results of both techniques are presented on Plate 7.1-20. Good agreement was found between the two methods. The values presented represent an average velocity value for each seismic unit. Because of the relatively thin layer of glacial till, (approximately 50 feet) and the alternating layer nature of bedrock, no attempt was made to define the shear wave velocities any farther than is presented.

7.1.4.3. Uphole Velocity Survey An uphole velocity survey was conducted at Boring 6. Small explosive charges of one-half pound of TNT were detonated in drilled holes located around the boring. The energy released by the explosive charges was detected by a special geophone cable lowered into the boring. Geophones are spaced at 25-foot intervals along this cable. Recordings were made using the Dresser SIE recording system. Between each recording, the cable was raised in 5-foot increments to provide continuous data at 5-foot intervals up the boring.

The result of the uphole survey is presented on Plate 7.1-21. The V_2 and V_3 layers show very clearly and the V_2 - V_3 interface ties very well with boring information. The V_1, low velocity layer, was not recognized due to its thin nature.

Variations observed in compressional wave velocities obtained through different techniques, as exhibited at this site, are attributable to the non-homogeneity and anisotropic nature of the site materials. Much of the variation is due also to the sloping interface encountered between soil and rock, giving apparent rather than true velocities. The values presented reflect the most reasonable velocities for each method.

7.1.4.4. Ambient Vibration Studies Measurement of the level of ground motion due to background (ambient) vibrations were taken at all boring locations. These measurements were made during normal working hours at the site.

An oriented, 3-component VS-1200 Sprengnether engineering seismograph was used to record the ambient ground motion. The seismograph recorded motion in three modes: displacement, acceleration and velocity. In each mode, ground motion in three components (radial, vertical and transverse) was recorded.

The results of this study are presented in Table 7.1.4-1. Were no motion value is given, the measured motion was negligible.

7.1.5. Laboratory Tests

Representative soil samples and rock cores extracted from the test borings were subjected to laboratory tests to evaluate the physical characteristics of the soil and rock encountered at the site. The laboratory program included the following tests:

a. Strength Tests

   1. Unconfined compression tests on rock.

   2. Unconfined compression and triaxial compression tests on soil.

b. Dynamic Tests

   1. Dynamic properties tests on soil.

   2. Resonant column tests on soil and rock.

c. Other Physical Tests

   1. Permeability tests on rock.

   2. Permeability tests on soil.

   3. Moisture and density determinations on soil.

   4. Particle size analyses on soil.

   5. Atterberg limit tests on soil.

   6. Consolidation tests on soil.

The stratigraphic position of all samples used in the laboratory testing program is noted on the boring logs.

7.1.5.1. Strength Tests on Rock The strengths and deformation moduli of the underlying rock formations were evaluated by performing uniaxial compression tests on representative rock core samples. The tests were performed by Bowser-Morner Testing Laboratories of Dayton, Ohio.

Samples approximately four inches in height and two inches in diameter were subjected to a constant rate of axial loading of 0.05 inches per minute. Four SR-4 strain gages were mounted on the sides of the test specimens, two parallel and two perpendicular to the applied load. The stress strain curves were then used to calculate values of Young's Modulus and Poisson's Ratio under "static" loading conditions. Results of the compression tests are shown in Table 7.1.5-1.

Other selected samples approximately two inches in height and two inches in diameter were placed sideways in the compression machine and broken. The ultimate load which causes failure of the specimen parallel to the direction of loading is used to compute the tensile strength of the sample parallel to the direction of bedding. This test is described as the Brazilian Tensile Test (Obert & Duvall, 1967) and the results are shown in Table 7.1.5-2.

7.1.5.2. Strength Tests on Soil The unconfined compressive strengths of representative soil samples were measured on test specimens approximately six inches in height and 2-1/2 inches in diameter. Determinations of field moisture content and dry density were made in conjunction with each strength test. The results of these tests are presented in Table 7.1.5-3.

Additional values of unconfined compressive strengths were made available in soils and foundation reports for existing structures at Mound Laboratory. These values were measured on samples taken from shallow to moderate depths and were statistically treated to form the basis of the slope stability analysis, presented in Section 7.5. All of these test results were taken out of reports for Mound Laboratory by Bowser-Morner Testing Laboratories, Inc., of Dayton, Ohio and are presented in Table 7.1.5-4.

Triaxial unconsolidated-undrained compression tests were also performed on selected soil samples. The test results are presented in Table 7.1.5-5. The methods of performing unconfined compression and triaxial compression tests are described on Plate 7.1-22.

7.1.5.3. Dynamic Properties Tests on Soil The behavior of representative soils under dynamic loading was evaluated by conducting dynamic triaxial compression tests. The tests were performed by Dames & Moore using the method described on Plate 7.1-23. Soil samples were initially allowed to consolidate isotropically under confining pressures representative of existing in situ conditions and were then subjected to strain controlled sine wave oscillations at various strain amplitudes under undrained conditions. The modulus and damping ratio were determined at each strain level. The test results are presented in Table 7.1.5-6.

7.1.5.4. Resonant Column Tests Dynamic torsional shear (Resonant Column) tests were performed on representative soil and rock samples to evaluate the modulus of rigidity of these materials. The method of performing resonant column tests is described on Plate 7.1-24. The tests were conducted at natural moisture content and density over a range of confining pressures. The results of the resonant column tests are

presented in Table 7.1.5-7.

7.1.5.5. Permeability Tests on Rock Six shale core samples from borings 1 and 2 were selected for high pressure vertical permeability tests. The results all showed a value of vertical permeability less than 1×10^{-8} gpd/sq ft, and that a threshold pressure greater than 500 psi was required in order to start the flow of water through the rock.

The tests were performed by Geo-Engineering Laboratories, Inc., of Mt. Vernon, Illinois, and the results are presented in Table 7.1.5-8.

7.1.5.6. Permeability Tests on Soil Permeability tests were performed on undisturbed soil samples utilizing both falling head and constant head permeameters. The results are presented on Table 7.1.5-9.

7.1.5.7. Moisture and Density Determination on Soil In addition to the moisture and density determinations made in conjunction with the above tests, independent moisture and density tests were performed on other undisturbed soil samples for correlation purposes. The results of all moisture and density determinations are presented in Table 7.1.5-10.

7.1.5.8. Particle Size Analyses on Soil Particle size distributions were determined for representative soil samples to aid in classification and correlation of the physical soil properties. The particle size analyses were conducted in accordance with the American Society for Testing and Materials D422-63 standard testing procedure. The results of these tests are presented on Plates 7.1-25 through 7.1-27.

7.1.5.9. Atterberg Limit Tests on Soil Atterberg limit tests were performed (in accordance with the American Society for Testing and Materials D423-66 and D424-59 standard testing procedures) on selected samples of cohesive fine-grained soils encountered in the test borings. The Atterberg limits, consisting of the liquid limit, the plastic limit, and the resulting plasticity index were determined to facilitate classification of the soils according to the Unified Soil Classification System and for correlation purposes. The results of the Atterberg limit tests and the plasticity indices are presented in Table 7.1.5-11.

7.1.5.10. Consolidation Tests on Soil Consolidation tests were performed on representative soil samples to determine the compressibility characteristics of the soils. The method of performing consolidation tests is described on Plate 7.1-28. The results of the consolidation tests are presented on Plates 7.1-29 through 7.1-30.

7.1.6. Regional Geologic History and Stratigraphy

7.1.6.1. General The description of regional geologic history and stratigraphy provided in this subsection gives an insight into the tectonic stability and stratigraphic interrelationships of the area surrounding Mound Laboratory.

An accurate interpretation of geologic history is the result of years of cumulative effort. It is based on numerous examinations of soil and rock units in exposures, and borings with regard to lithology and fossil content. Comparisons are drawn with events observed in present day environments under the assumption that natural processes have remained comparatively constant throughout geologic time.

The geologic events which have occurred in southwest Ohio are numerous. Many different environments have existed 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. It is difficult to comprehend the vast amounts of geologic time required for these events to have taken place; nevertheless, they have existed and their history is preserved in the soil and rock units of southwest Ohio.

- Explanation of Geologic Column The geologic column included in this report (Plate 7.1-31) is a synthesis of various columns previously compiled for Ohio or the Midwest regional area.* It is intended to identify the subsurface stratigraphy underlying the area immediately surrounding southwest and south-central Ohio. More detail is provided on the lower periods of the column (Cambrian, Ordovician and Silurian) which are located within this region, than the upper periods (Devonian, Mississippian, Pennsylvanian and Permian) which have been removed by erosion.

A more detailed description of the geologic periods, their history, depositional environment and constituent stratigraphic formations is included in subsections 7.1.6.2 through 7.1.6.10. The series, group, or formational names used in this stratigraphic classification are commonly used nomenclature. In some cases where synonymous names are commonly used for the same formation, both names are provided (e.g., Eden Formation = Kope Formation).

7.1.6.2. Precambrian The Precambrian is the oldest recognized division of geologic time and its history is

*Oil and Gas Fields of Ohio, 1960; Tobin, 1961; State of Ohio, Generalized Column of Rocks in Ohio.

obscure. In southwest Ohio, Precambrian rocks lie some 2,400 to 2,700 feet below sea level. Their nature and history must be based on samples from deep wells and observations of exposures in more distant regions. Between 1912 and 1961, 38 wells have been drilled into Precambrian basal bedrock in Ohio (Summerson 1962). These borings indicate that a variety of rock types exist in this area, including fine and coarse grained igneous and metamorphic rocks.

In eastern Greene, Clinton and Fayette Counties, east of Mound Laboratory, the Precambrian rocks are composed of metamorphic amphibolites, hornfels and marble, with some evidence of igneous intrusion. North of the site, fine grained igneous trachytes and rhyolites underlie portions of Miami, Shelby and Logan Counties. Granite basement rocks have been found in Butler County, Ohio, and in Wayne County, Indiana, south and west of the site. Surface exposures of Precambrian rocks are found in the folded mountains of the Appalachian Geosyncline to the east and southeast in West Virginia and eastern Tennessee, and in the Canadian Shield to the north. The Armco deep well at Middletown, Ohio, ten miles southwest of Mound Laboratory, provided specimens of granite which are the closest observed samples of Precambrian rock in the vicinity of the site, (Plate 7.1-32).

Precambrian rocks have been dated by radioisotopic methods. The oldest known group of rocks in North America is exposed in Canada around the southern perimeter of Hudson Bay which ranges in age from 2 to 2.5 billion years old. Unmetamorphosed igneous rocks from deep well cuttings in western Ohio and eastern Indiana have been dated and range from 1.3 to 1.4 billion years old. They form the Central Province group of Precambrian rocks. Metamorphic and igneous rocks found in deep well cuttings from central and eastern Ohio range in age from 0.9 to 1.0 billion years and are believed to be a southern extension of the Grenville Province of eastern Canada. Based on both radiometric age dating and petrographic studies, an approximate line dividing the Central Province on the west and the Grenville Province on the east has been proposed (McCormick, 1961) and is shown on Plate 7.1-33.

It has been suggested (Summerson, 1962) that the intrusive and extrusive igneous rocks of the Central Province correlate with the Precambrian rocks exposed in the St. Francis Mountains of the Missouri Ozarks. This correlation is proposed on the basis of similar lithology and radioisotopic age dates.

Rocks of the Grenville Province are thought to represent a total thickness of about 20,000 feet of geosynclinal sediments (Calvert, 1964). Much of the sedimentary section

(at least 10,000 feet) evidently represents the first known carbonate shelf deposit to be found along the eastern edge of "embryonic" North America. This limestone is assumed to be of biogenic origin and probably represents deposition in shallow, open marine waters of the continental shelf. The mode of deposition would indicate a temperate climate, a continent of low relief to the west, and the existence of marine carbonate-secreting organisms during Grenville time. However, intense deformation of the Grenville orogeny erased all features of the original rock record and transformed the carbonate rocks into marble and calc-silicate hornfels. The original shales, siltstones and sandstones were likewise altered to gneisses, schists and sandstones, removing all fossil record. Tectonic forces which caused this orogeny originated from the east, causing compression of the Grenville sediments against rocks of the Central Province on the western border of the geosyncline.

After the Grenville orogeny occurred about one billion years ago, the intensely deformed Grenville mountains were above sea level and subjected to erosion until the start of the Paleozoic Era, almost one-half billion years later.

7.1.6.3. Cambrian The Cambrian division of geologic time began when the eastern margin of the North American continent slowly submerged and shallow seas transgressed onto the continental interior, covering Precambrian rocks of both the Central and Grenville Provinces. The land was devoid of vegetation. Winds as well as rivers carried large amounts of detrital sediment from the barren interior into the advancing eastern seas. The material was reworked and deposited by waves and offshore currents (Calvert, 1964).

Lower and Middle Cambrian strata are not found over broad areas of Ohio and Indiana. During this time, deposition occurred to the south and east of an Adirondack-Ozark Hinge Line (Calvert, 1964) which passes through the northern half of Kentucky. However, during late Cambrian time, the shallow seas covered most of the continental interior, and upper Cambrian strata were deposited over Ohio and Indiana.

It is believed that climatic conditions during the Cambrian in North America were similar to those of today. The shallow seas were temperate and living organisms which inhabited the waters were abundant. Their record is well preserved in the Cambrian strata.

Approximately 2,600 feet of upper Cambrian aged deposits unconformably overlie the basal Precambrian bedrock. In Ohio, the Cambrian is represented by the St. Croixan Series (Plate 7.1-31). The individual members of this series include the Mt. Simon sandstone, the Eau Claire sandstone and

dolomites, the Dresbach sandstones (with some dolomite) and the Trempleau dolomite. Deposition of the St. Croixan series was uninterrupted by periods of erosion.

St. Croixan Series

- Mt. Simon Formation This formation consists of white to yellow-gray, fine to coarse grained, poor to fairly sorted, friable sandstone. Occasional shale layers are known to be interbedded with the porous sandstones. The thickness of this formation surrounding the site area is estimated to be approximately 300 feet, based on deep boring data. The thickness of these beds is uniform in the Ohio region, (Woodward, 1961).

- Eau Claire Formation This formation consists of various lithologies. In the region surrounding Mound Laboratory, the formation is comprised of sandstone, siltstone, dolomite, and trace amounts of limestone. The color is generally white to yellow-gray. Traces of glauconite, mica, and fossils are found in the formation. The thickness of the Eau Claire is approximately 530 feet in southwest Ohio. Regionally, the formation thins to the north and east (Woodward, 1961).

- Dresbach Formation This formation consists of greenish-gray, slightly silty shale with occasional traces of limestone stringers, mica, and fossils. The thickness of the Dresbach in the vicinity of the site is approximately 50 feet. The thickness of the formation is regionally uniform.

- Trempleau Formation (Copper Ridge Formation or Lower Knox Group) This formation consists of white to yellow-gray dolomite with some siltstone stringers and traces of chert. The thickness of the Trempleau is approximately 750 feet in the vicinity of the site and remains regionally uniform throughout most of south-central Ohio (Woodward, 1961). The Trempleau marks the uppermost beds of the Cambrian.

The different rock types found in the Cambrian represent varying depositional environments and source materials. The Cambrian ended when the shallow seas retreated from the continental interior followed by a period of erosion.

7.1.6.4. Ordovician The Ordovician began when shallow seas once again transgressed the continental interior. Submergence was rapid and it is believed that the seas which covered Ohio approached from the southwest (Calvert, 1964). During the period of maximum marine transgression, most of the North American continent was inundated.

Initial deposition consisted primarily of calcareous materials followed by alternating periods of clastic and calcareous deposition, all of which comprise the Canadian Series (lower Ordovician). At the end of Canadian time a period of uplift and subsequent erosion followed.

When the land again subsided, deposits of the Champlainian series were laid unconformably atop the Canadian Series rocks, forming the Knox Unconformity. This was the first great widespread unconformity to occur in the Paleozoic. Emergence once again occurred and was followed by Cincinnatian deposition.

Deposits of the Cincinnatian series initially consisted of thick silt and mud accumulations which probably formed in shallow turbid seas. Later the seas cleared and were followed by calcareous deposition, only to be followed once again by turbid seas.

Approximately 1,300 feet of Ordovician rocks underlie the southwest Ohio area, and much of the Cincinnatian series (upper Ordovician) is exposed on a north-south trending pseudo-structural high area between Cincinnati and Dayton, believed to be the easternmost extension of the stable continental platform. This is demonstrated on the Geologic Map of Ohio, Plate 7.1-34.
In the area surrounding Mound Laboratory, the following formations comprise the subsurface Ordovician bedrock.

Canadian Series

Knox (Beekmantown) Group In Ohio, the following formations comprise the Ordovician portion of the Knox Group.

- Oneota (Rose Run or Chepultepec) Formation This formation consists of a buff colored dolomite with some oolite and cherty material. The Oneota is approximately 400 feet thick in Ohio.

- New Richmond (Longview) Formation This formation consists of light gray dolomite in the lower portion and gray sandstone in the upper beds. The New Richmond and Shakopee beds range from 0 to 600 feet in thickness in southwest Ohio.

- Shakopee (Newala) Formation This formation consists of light to dark colored, medium to finely crystalline dolomite, with traces of chert.

At the end of Canadian deposition, regional uplift and subsequent erosion removed sections of the Knox group. The total thickness of strata removed by erosion is uncertain.

However, the erosion was widespread and the group generally remained consistently thick in southwest Ohio.

Champlainian Series

- St. Peter Formation The St. Peter formation lies unconformably atop the eroded Knox (Beekmantown) surface, known as the Knox Unconformity. This formation consists of a white, fairly well sorted sandstone with traces of silt and dolomite. The formation is approximately 20 feet thick in southwest Ohio, but varies in thickness below the entire State of Ohio.

Black River Group The Black River Group overlies the St. Peter formation, and is comprised of the Glenwood and Platteville formations.

- Glenwood Formation This formation consists of gray-green interbedded shale and dolomite, with traces of pyrite. The formational thickness varies greatly throughout this region, but in southwest Ohio it is approximately 50 feet thick.

- Platteville Formation The Platteville consists of brown limestone and dolomite with two upper zones of volcanic metabentonite. In this region, the beds range in thickness from 400 to 1,000 feet thick.

The top of the Black River Group is identified by the first zone of metabentonite, known by drillers as the "Mud Cave." A second zone of metabentonite, the "Pencil Cave" is usually present 10 to 25 feet below the Mud Cave zone.

Trenton Group The Trenton Group lies conformably atop the Black River Group. The beds contain numerous shells of calcareous secreting organisms and very little clastic material. The Trenton is comprised of the Lexington (Galena) and Cynthiana (Pt. Pleasant) formations.

- Lexington (Galena) Formation The Lexington consists of brown dolomite beds overlain by brown limestone beds.

- Cynthiana (Pt. Pleasant) Formation The Cynthiana is similar to the Lexington in that the formation consists of brown dolomite beds overlain by brown limestone beds.

The Trenton Group is known by drillers as the first hard limestone series to lie below the soft Eden shales of the Cincinnatian series. In southwest Ohio, drilling logs have shown the Trenton beds to be about 50 feet thick, which is relatively thin.

Cincinnatian Series

Eden Group (Kope)

- Eden Formation This formation consists of gray shale with some lenticular zones of limestone. The Eden is approximately 200 feet thick and is the lowermost formation of the Cincinnatian series.

Maysville Group

- Fairview Formation The Fairview formation consists of gray to gray-blue shale, interbedded with fossiliferous limestone. The Fairview is approximately 110 feet thick.

- McMillan Formation The McMillan formation consists of gray to gray-blue shale and interbedded fossiliferous limestone. The McMillan is approximately 80 feet thick.

Richmond Group

- Arnheim Formation This formation consists of dark gray, calcareous, friable shales with few distinct limestone beds. The Arnheim is approximately 60 feet thick.

- Waynesville Formation The Waynesville formation consists of gray interbedded shales and limestones with numerous fossils. The Waynesville is approximately 100 feet thick.

- Liberty Formation This formation consists of gray interbedded limestone and shale layers with numerous fossils. The Liberty is approximately 30 feet thick.

- Whitewater Formation The Whitewater formation consists of blue-gray shale interbedded with limestone and numerous fossils. The Whitewater is approximately 80 feet thick. In Indiana and northern Kentucky, a broad lenticular dolomite zone, called the Saluda Formation, is known to interbed with the Whitewater. It consists of a light colored crystalline, fossiliferous dolomite.

- Elkhorn Formation (Queenston) The Elkhorn formation consists of red-gray shales and limestones with numerous fossils. The Elkhorn is approximately 60 feet thick.

7.1.6.5. Silurian Following emergence of the North American Continent at the end of the Ordovician, a long period of erosion followed. Then, at the beginning of the Silurian, shallow seas once again began to transgress the continental interior from the Gulf of Mexico area and from the northeast. The seas were evidently clear and most of the

Silurian deposition was calcareous, with very little clastic interbedding. The lands adjacent to these seas were of very low relief.

In late Silurian time, the shallow seas had retreated and the continent was emergent. However, a portion of the shallow sea became trapped in the continental interior and covered much of Ohio, as well as the present day Great Lakes area. Arid conditions turned the inland sea into a "Dead Sea", (Dunbar, 1962), forming vast deposits of salt.

Truncation of various Silurian beds (Janssens, 1967), east of the Mound Laboratory area indicates that regional subsidence was occurring in central and east-central Ohio. In southwest and south-central Ohio, the total thickness of Silurian beds is approximately 550 feet. The thickest sequence is found in eastern Ohio.

Alexandrian Series

- Brassfield Formation The Brassfield formation consists of gray to brown-red, finely crystalline, thin to thick bedded, fossiliferous limestone (Stout, 1941). Thickness of the formation varies from 20 to 70 feet.

Niagaran Series

Clinton Group

- Dayton Formation This formation consists of a bluish-gray, hard crystalline dolomite. The thickness varies from 7 to 13 feet.

- Alger Formation The Alger formation consists of bluish-gray to light green to pink to mottled, soft calcareous and ferruginous shale. The thickness varies from 40 to 90 feet (Stout, 1941).

Lockport Group

- Springfield Formation This formation consists of a buff to light brown, porous textured dolomite, which is approximately 10 feet thick.

- Cedarville Formation The Cedarville formation consists of buff to light bluish-gray, crystalline, thick-bedded dolomite. The thickness of the beds is approximately 70 feet.

Cayugan Series

Salina Group

- Greenfield Formation The Greenfield formation consists of bluish-gray to dark brown, dense dolomite which is approximately 200 feet thick. An unconformity separating the Niagaran and Cayugan series rocks is found at the base of the Greenfield.

- Tymochtee Formation This formation consists of bluish-gray to brown dolomite with some shale layers. The texture, porosity, and hardness of the Tymochtee varies greatly and the formation is approximately 150 feet thick.

7.1.6.6. Devonian The Devonian period began when shallow seas again began transgressing the continental interior following late Silurian emergence and subsequent erosion. Continental relief was low, but initial submergence was minimal. A shallow linear sea extended from Newfoundland to Mississippi and later spread inland to cover a large area of the midwest.

Fossils indicate that Devonian seas were generally warmer for a larger geographical area than present day seas. Over the North American Continent the general climate was warmer than today.

Marine and terrestrial plant life was abundant during the Devonian. The North American fossil record is well preserved in comparatively thick beds extending westward from New York into Ohio. In south-central Ohio, Devonian beds are approximately 800 feet in thickness and tend to thicken towards the north and east. The lowermost Devonian beds overlying the Silurian-Devonian unconformity are not geographically widespread in Ohio due to the differential advances of the shallow seas.

Ulsterian Series

- Columbus Formation The Columbus formation is the lowest member of Devonian strata found in southwest Ohio. It lies unconformably atop the older Silurian beds in this area and consists of light gray to light brown, massive bedded magnesian limestone and limy dolomites. The average thickness of this formation is approximately 100 feet.

Erian Series

- Delaware Formation The Delaware formation overlies the Columbus formation and consists of light to dark bluish-gray, dense, fossiliferous impure limestone. The average

thickness is 45 feet.

- Olentangy Formation The Olentangy overlies the Delaware formation and consists of "gray, siliceous, calcareous shale with plastic-like properties" (Stout, 1941). This formation is approximately 20 feet thick.

Chautauquan Series

- Ohio Formation The Ohio formation overlies the Erian Series and consists of dark brown to black carbonaceous shale with some pyrite. The beds are fissile and average approximately 600 feet in thickness.

7.1.6.7. Mississippian The North American continent slowly emerged towards the end of the Devonian period, but generally did not rise to any great extent.

At the beginning of the Mississippian period, the continental interior was low and stable, and with the exception of the Oauchita and Appalachian ranges, remained this way until late in the period. Shallow seas again transgressed the interior and reached their maximum geographical distribution before middle Mississippian time. By the end of the period, massive tectonic activity was occurring in both the Rocky Mountain area and the Appalachian province.

It is believed that climatic conditions during the North American Mississippian were generally similar to present day conditions. Climate varied with altitude and there is evidence that during this time, arid zones existed in the rain shadow of tectonic mountain belts. The massive limestone deposits in central and western North America indicate the shallow seas were warm.

Marine life was abundant in the Mississippian and the fossil record is well preserved in the strata. Terrestrial plants and animals were not as yet widespread.

Depositional environments varied greatly over widespread geographical areas. In central and western North America deposition was primarily calcareous, indicating a warm and clear environment. In eastern Ohio however, alternating sandstone and shale layers indicate a more turbid environment with large amounts of clastic source materials. The clastics originated from erosion of the young Appalachian mountains and were carried to the basin by westward flowing streams.

Kinderhook Series

- Bedford Formation This formation consists of gray

and reddish-brown shale with some locally interbedded sandstone units. In eastern Ohio, the Bedford ranges from 50 to 80 feet in thickness, and conformably overlies the Devonian Ohio formation.

- Berea Formation The Berea formation consists of white and gray hard sandstones with occasional traces of a discontinuous shale zone. The Berea ranges from 4 to 70 feet in thickness in eastern Ohio, and overlies the Bedford formation.

- Sunbury Formation The Sunbury formation consists of brownish-black, carbonaceous shale and ranges from 10 to 25 feet in thickness. The Sunbury formation overlies the Berea sandstone.

- Cuyahoga Formation This formation overlies the Sunbury shales and consists of gray to gray-black shales with localized zones of sand, sandstone and siltstone. The Cuyahoga ranges in thickness from 380 to 530 feet.

- Logan Formation The Logan formation overlies the Cuyahoga shales and consists of gray, brown to black, and black shales with localized zones of sand and sandstone. The Logan shales range in thickness from 50 to 70 feet.

- Maxville Formation The Maxville formation overlies the Logan shales and is the uppermost formation of the Mississippian Period. The Maxville consists of limestone and dolomite and ranges in thickness from 15 to 40 feet.

7.1.6.8. Pennsylvanian During the Pennsylvanian Period the North American Continent was characterized by a broad mountainous ring enclosing much of the continental interior. This interior soon became a depositional basin where large amounts of erosional materials were deposited in what often were swamp-like conditions. Marine transgression was sporadic and not as geographically widespread as in previous periods.

The climate was notably more humid and warm during the Pennsylvanian. However, it is quite likely that geographically small arid zones persisted in the rainshadow areas of the higher mountain ranges.

Terrestrial and marine faunas were abundant during the Pennsylvanian and reflect the warm subtropical climate which geographically dominated much of the earth. This period is particularly well noted for the lush vegetation which covered the landscape in an environment believed to be similar to the present day Amazon Basin. Large insects and low order animals thrived in this environment.

Depositional environments varied extensively during the Pennsylvanian. In eastern Ohio, western Pennsylvania and West Virginia, deposition consisted of alternating clastic, beach and swamp materials being laid in an orderly sequence known as cyclothems. This resulted from cyclical shallow marine transgression and basinal subsidence. The Pennsylvanian resulted in abundant coal deposits forming to the east of the Indiana-Ohio platform.

- Pottsville Group The Pottsville group unconformably lies atop the older Mississippian beds. It consists of alternating shale, coal, sandstone and marine limestone. Bedding is generally distinct. In eastern Ohio, the Pottsville is approximately 250 feet thick.

- Allegheny Group The Allegheny group overlies the Pottsville and is also composed of alternating coal, shale, sandstone and marine limestones. The Allegheny is approximately 200 feet thick in eastern Ohio.

- Conemaugh Group The Conemaugh overlies the Allegheny and consists of alternating coal, sandstone, shale and marine limestone. The Conemaugh is approximately 500 feet thick in eastern Ohio.

- Monongahela Group The Monongahela group is the uppermost Pennsylvanian strata. It consists of alternating coal, shale, sandstone and marine limestone. The Monongahela is approximately 350 feet thick in eastern Ohio.

7.1.6.9. Permian Widespread changes characterized the Permian Period and the end of the Paleozoic Era. It was a period of continental emergence when much of North America was gradually rising. Very little marine transgression occurred on the continental interior, and the Permian strata found in Ohio originated from fluvial deposition.

The Permian climate was characteristically dry and cooler. Extensive glaciation is known to have taken place over broad areas of the earth, and deserts were geographically widespread.

Terrestrial plants and lower forms of animals and insects changed drastically during the Permian. The cooling climate and increasing aridity eliminated many species which flourished during Pennsylvanian time. Marine organisms also underwent modifications. Towards the end of the Permian, marine plant and animal groups which had dominated the oceans were replaced by new groups.

The Permian depositional environment of eastern Ohio differed from previous environments because it was exclusively

non-marine. The Dunkard group was deposited by streams flowing west out of the Appalachian area onto the continental interior. As a result, many of the deposits are lenticular sandstones, shales, coal and fresh-water limestones.

Dunkard Group

- Washington Formation The Washington formation conformably overlies the Pennsylvanian Monongahela group in eastern Ohio. It consists of interbedded sandstone shale and coal beds. The Washington is approximately 175 feet thick.

- Greene Formation The Greene formation overlies the Washington and consists of sandstone, shale and some coal. The Greene is approximately 65 feet thick in eastern Ohio.

There are no Mesozoic or early Cenozoic deposits found in southwest and south-central Ohio. A long period of emergence, erosion and continental stability over most of the continental interior followed the end of the Paleozoic Era.

7.1.6.10 Quaternary During Quaternary time of the Cenozoic Era, numerous glaciers moved southward from Canada and covered all of southwest and south-central Ohio during at least one of the ice advances. Massive surficial changes took place over a widespread area of the midwest, and the pre-Pleistocene geography was altered extensively. Drainage patterns were shifted or destroyed; valleys were filled with glacial debris and a thin veneer of till was spread over the landscape.

The Pleistocene climatologic environment was cooler and drier than earlier periods of the Cenozoic and Mesozoic Era and changes in the ecosystem resulted. Conifers once again flourished in the subarctic environment and animals less adapted to the cold environment perished. The sea level was lowered approximately 300 to 400 feet while the ice ages progressed.

The most significant changes occurred when the pre-Pleistocene drainage systems were drastically altered. Prior to this period a broad peneplain extended northward in the Cincinnati region. Stream divides were of low relief and ranged from 8 to 12 miles apart trending in a north-south direction (Durrell, 1961). The first advancing ice sheet (Nebraskan) disrupted this system and established Teays drainage, which flowed northward through the Cincinnati area and then westward into the present day Mississippi Valley.

The Teays System was subsequently altered by a second ice sheet (Kansan) which moved into the midwest after the

Nebraskan ice retreated. The Teays Drainage System was disrupted by formation of the Deep Stage Drainage, which closely paralleled the present course of the Ohio River.

The third ice advance (Illinoian) brought about the last great alteration of the pre-Ohio River System, and generally formed the present day stream course. The final, Wisconsin Ice sheet, filled many of the previous north-south trending valleys, including the Great Miami River at Miamisburg, with meltwater outwash. Many of the regional stream channels were aggraded with similar outwash deposits. There have been few regional geographic changes since the retreat of Wisconsin glaciers. A map showing the glacial deposits of Ohio is presented on Plate 7.1-35.

7.1.7. Regional Physiography

Widespread areas of Ohio and Indiana are located in the Till Plains section (Plate 7.1-36) of the Central Lowland Physiographic Province (Lobeck, 1950). The area is characterized by a thin veneer of glacial till covering most of the landscape. Zones of boulders and end moraines mark temporary or permanent termination lines for Wisconsin Glaciation.

Generally, elevations increase to the north of the Ohio River and relief does not exceed several hundred feet. Slopes are low to moderate and the larger stream channels such as the Ohio River and the Great Miami River seldom have stream gradients which exceed more than one or two feet per mile. Many of the medium sized streams such as Mill Creek near Cincinnati, flow in underfit valleys* which were formed during the Pleistocene. The dendritic or branch-like regional drainage patterns do not generally reflect geologic structure or joint patterns in the bedrock.

A generalized landform map for the State of Ohio is presented on Plate 7.1-37.

* A valley whose stream appears to be too small to have eroded its present configuration.

7.1.8. Regional Structures

Mound Laboratory is located on the eastern portion of the Indiana-Ohio platform which is included within the Central Stable Province. The Indiana-Ohio platform is 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 location of Mound Laboratory in relationship to these regional structural features is shown on Plate 7.1-38, Tectonic Map.

The Indiana-Ohio platform is a nearly flat structural element occupying eastern Indiana and western Ohio for a width of 100 to 200 miles. The platform is believed to have formed due to subsidence of adjacent basin areas during Paleozoic time, and not by uplift of the platform area. Subsidence in the adjacent Appalachian basin began during deposition of the Trenton limestone (Middle Ordovician) and continued throughout the Paleozoic Era.

The term "Cincinnati Arch" has also been used to describe the apparent anticlinal outcrop pattern of the Indiana-Ohio platform in western Ohio. However, both recent and historical work has shown that the "Cincinnati Arch" possesses none of the structural features of an anticline, and is, in fact, a broad platform flanked by structural basin areas. In order to clarify this misnomer, the term "Indiana-Ohio Platform" was introduced (Green, 1957) to describe this positive structural element in proper geologic perspective.

The closest structural province adjacent to the position of Mound Laboratory 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 between the junctions of Pike, Ross, Pickaway, and Franklin Counties with Highland, Fayette and Madison Counties as shown on Plate 7.1-33. Paleozoic strata west of the hinge line dip toward the east at about 10 to 30 feet per mile. East of the hinge line, dip in the same rock sequence increases to about 40 to 70 feet per mile.

Deep-seated faulting along the hingeline between these two structural provinces has been postulated (Lockett, 1947). A series of high angle faults with vertical displacements on the order of 100 feet was found by seismic reflection methods in Madison and eastern Fayette Counties as shown in Plate 7.1-40. The faults are all parallel to the trend of the hingeline and are parallel to the strike of the Paleozoic sedimentary beds. The apparent throw of these faults increases with depth which suggests that vertical movement took place either periodically during deposition or soon after deposition of the Trenton formation (Mayhew, 1969). These

faults are apparently present only at the change in dip along the hingeline between the Indiana-Ohio platform and the Appalachian Basin. There is no reason to assume that faults of this type should exist beyond the immediate vicinity of this hingeline and therefore should not be anticipated to exist near Mound Laboratory which is at least 50 miles west of the hingeline.

A newly postulated structural feature contained entirely within the Appalachian Basin and distinctly east of the Indiana-Ohio platform (or Cincinnati Arch) is the Waverly Arch (Woodward, 1961). This structural feature is based upon apparent erosional thinning of the late Cambrian and early Ordovician sediments, primarily rocks of the Knox group. The Waverly Arch as postulated from limited deep drill hole data has a north-south axis which is located through central Ohio. Only rocks older than the Trenton Group (Middle Ordovician) show evidence of being affected by this arch. Existence of the Waverly Arch has not yet been confirmed by either seismic reflection or deep drilling data.

Sediments in the Appalachian Basin continue to thicken eastward until they are interrupted by the folded Appalachian mountain belt which runs through Pennsylvania, West Virginia and Kentucky. Paleozoic sediments reach a maximum thickness of over 12,000 feet at the front of the Appalachian Orogenic belt.

Both the Michigan and Illinois Basins are oval depressions which contain an estimated maximum thickness of 14,000 feet of Paleozoic section, and form the north and west flanks of the Indiana-Ohio platform respectively. Hingeline faults have been discovered at the junction of the Illinois basin and the Indiana-Ohio platform in similar position to those found by Mayhew at the western border of the Appalachian Basin. Hingeline faults have not yet been discovered at the boundaries of the Michigan Basin, but this probably reflects the lack of data (Rudman, et al., 1965).

The three structural basins surrounding the Indiana-Ohio platform are separated from one another by structural arches. These structural arches are poorly defined by a lack of data and their continuity is questionable.

The Illinois Basin is separated from the Michigan Basin by the Kankakee Arch. The Michigan Basin is separated from the Appalachian Basin by the Findlay Arch. These arches are occupied by several fault zones, monoclines and structural sags which probably resulted from basement tension during formation of the adjacent basins. The only such structure in Ohio is the Lucas-Monroe Monocline (or Bowling Green Fault/Monocline) which is a north-south trending feature

located on the Findlay Arch near Toledo, Ohio. Where mapped as a fault, this structure shows almost vertical displacement on the order of 200 feet (the fault plane dips about 80° toward N. 70° E.). The Bowling Green Fault is actually a fault zone since several individual fault planes are present and in places these fault lines seem to have an en echelon arrangement. This fault has been traced in the subsurface as far south as southern Hancock County (Forsyth, 1962).

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. This fault zone is marked by a semi-continuous basement scarp having apparent vertical displacements as great as 5,000 feet. Stratigraphic evidence indicates that this basement scarp was present in early Cambrian time but continued to move intermittently throughout Paleozoic time, and possibly into the Mesozoic. This fault zone has also been interpreted as a wrench fault, but conflicting conclusions as to the direction of relative movement has been presented by various investigators. The Tectonic significance represented by the 38th parallel fault zone is not well understood at this time.

The West Hickman fault zone (or "Maysville Fault") extends from the Kentucky River fault zone north to the Ohio River near southern Adams County, Ohio. It has been suggested that this fault zone is connected to the Adams County Monocline in Adams County, Ohio; extends through the Serpent Mound Cryptoexplosive structure, and continues north, following the hingeline of the Appalachian Basin (Koucky, 1972). Cryptoexplosive structures such as the Serpent Mound disturbance are interpreted as being related to movements along deep seated faults. It is believed that these disturbances are caused by volcanic gases which are generated during movement along such faults and are vented at weak points on the earth's crust. The disturbance is generally very intense, but highly localized. The Serpent Mound disturbance is the closest cryptoexplosive structure to Mound Laboratory and is located about 60 miles southeast of the site.

The postulated northern extension of the West Hickman fault zone is believed to follow the hingeline between the Indiana-Ohio platform and the Appalachian Basin, although no studies have been performed to date that would verify this conclusion. It is remotely possible that a basement connection exists between a southern extension of the Bowling Green Fault and a northern extension of the West Hickman fault zone, but such a connection is purely hypothetical at this time.

7.1.9. Regional Geophysical Anomalies

Measurements of the earth's gravity and magnetic field have been made on the ground and from the air in Ohio and surrounding areas. Radioactivity surveys have also been made from aircraft over the site area. It is the purpose of this section to interpret the significance of these data in terms of regional geologic structure and the relationship to Mound Laboratory.

7.1.9.1. Regional Gravity Anomalies Both "Free Air" and "Bouguer" gravity anomaly maps have been published for the State of Ohio (Heiskanen & Uotila, 1956) and are presented on Plates 7.1-41 and 7.1-42, respectively.

The free air gravity anomaly map presents the difference between the measured gravity field (corrected for elevation only) and the calculated gravity field, based upon the International Gravity Formula. No correction is made for density of the ground between the point of measurement and sea level datum.

The trend of the free air gravity anomaly in Montgomery County is in a NW-SE direction which is in general agreement with the trend of the eastern boundary of the Indiana-Ohio basement platform. The average gravity gradient across Montgomery County is dipping toward the southwest at a rate of about 0.9 milligals per mile. At the location of Mound Laboratory, the free air gravity anomaly is approximately zero which implies that the area is in nearly perfect isostatic equilibrium.

The Bouguer gravity anomaly map is similar to the free air anomaly map except that a correction for the density of rock between the measuring point and the datum of measurement is included as well as an elevation correction. For the Bouguer correction in Ohio, an average rock density of 2.67 grams/cm^3 was used.

The average Bouguer anomaly for the entire State of Ohio is -38 milligals which corresponds to an average elevation of 1116 feet. This closely agrees with the mean surface elevation for the State of Ohio and suggests that the entire state is in nearly complete isostatic equilibrium, (Heiskanen & Uotila, 1956). This opinion was generally confirmed by isostatic reduction of the gravity anomalies according to the Airy-Heiskanen System, (Heiskanen & Vening Meinesz, 1958). The average gravity anomaly, corresponding to an assumed thickness of the earth's crust equal to 30 kilometers, is -8 milligals.

Five major anomalies appear on the gravity maps which are represented by steep gravity gradients. Studies performed to evaluate the geological significance of these anomalies have shown that these anomalous areas are probably caused by density contrasts in the precambrian basement rocks and are not primarily related to structure or lithology of the paleozoic sediments, or to precambrian basement relief (Pincus, 1960). Detailed studies in the vicinity of the large gravity anomaly in Fayette County substantiate this conclusion (Batsche, 1963; and Tobin, 1961). Although a precambrian basement high exists in coincidence with the Fayette County Gravity High, it has been shown that a deep seated density contrast much greater than is available from the basement relief must be associated with such an anomaly.

7.1.9.2. Regional Aeromagnetic Anomalies An aeromagnetic map of the Dayton-Columbus area which includes the site area in the lower portion is presented in part on Plate 7.1-43. The survey was conducted in 1960 and was flown at a nominal height of 500 feet above the ground surface (Philbin, Long & Moore, 1965).

Large anomalies presented on aeromagnetic maps are usually due to a contrast in basement lithology and not from topography of the basement rock. While most sedimentary rock is practically non-magnetic, most igneous rock and some metamorphic rocks contain appreciable quantities of ferromagnetic minerals which influence the earth's magnetic field. These rocks remain magnetic to a depth of about 13 miles after which temperatures rise to above the Curie point geotherm and the rocks cease to be magnetic (Vacquier, et al., 1963).

The aeromagnetic map of the Dayton-Columbus area shows two distinct features. The western half of the map shows an area of relatively mild magnetic gradients while the eastern half of the map shows an area of very steep magnetic gradients. A similar pattern is expressed on the aeromagnetic map of the Findley area (Bromery & McCaslin, 1965), in the northwest portion of Ohio. The lack of basement relief in areas of high magnetic gradients has been generally confirmed upon the basis of deep drilling (Owens, 1967), and by seismic reflection surveys (Mayhew, 1969 and Tobin, 1961). Petrographic studies of precambrian rocks from deep wells (Bass, 1960; McCormick, 1961: Summerson, 1962; Engel, 1963; and Rudman, et al., 1965), have shown that a variety of igneous and metamorphic rocks underlie the paleozoic sediments in Ohio and adjoining states. These areas of magnetic relief are therefore attributed completely to the changes in rock type which possess a corresponding contrast in magnetic susceptibility.

The line shown by McCormick which divides the granitic rocks of the Central Province on the west and the younger metamorphic rocks of the Grenville Province on the east is shown on Plate 7.1-33. This line has been proposed in the same orientation, but in slightly different positions by other workers (Bass, 1960 and Rudman, et al., 1965).

The western boundary of the Grenville Series as proposed by McCormick is in very close coincidence with the boundary between areas of high and low aeromagnetic relief. The zone of high aeromagnetic gradient on the east side of the map area is believed to represent the folded orogenic belt of the Grenville Series. The zone of low aeromagnetic gradient on the west side of the map area is believed to represent the older granitic rocks of the Central Province. The occasional patches of high magnetic relief in the zone of low magnetic relief are interpreted as outliers of Grenville rocks contained within granites of the Central Province. Such anomalies probably represent basaltic intrusives which were emplaced along the geosynclinal perimeter. Magnetic susceptibility contrasts on the order of 0.1 electromagnetic c.g.s. units per cubic centimeter have been computed for these outliers as calculated from analysis of magnetic models. (Vacquier et al., 1963).

Based upon this interpretation, Mound Laboratory is located over granitic basement rocks of the Central Province and is about 18 miles west of the closest outlier of the Grenville boundary. The proximity of granitic basement rocks near the site has been confirmed at the Armco deep well site in Middletown as illustrated on Plate 7.1-32.

The town of Anna, Ohio which is associated with a history of earthquakes is also within the Central Province and is about 30 miles northwest of the contact with Grenville rocks. It is therefore believed that earthquakes in the Anna area are not related to possible remnant tectonic activity at the western Grenville boundary. A strong, positive magnetic anomaly located from 13 to 17 miles south-southeast of Anna is interpreted as a precambrian basaltic intrusive. The calculated depth of burial is equal to the elevation of surrounding basement rocks which indicates that this feature was eroded contemporaneously with the surrounding basement rocks in late precambrian time. Earthquake epicenters near the Anna area are in close coincidence with this magnetic high which suggests a possible relationship to the anomaly.

7.1.9.3. Regional Aeroradioactivity Anomalies A map showing radioactivity over the site area is presented on Plate 7.1-44. The survey was conducted in 1960 at a nominal height of 500 feet above the ground surface. The radioactive data were compensated for deviations from the 500-foot

surveying altitude, and for the cosmic ray component.

The information obtained from an aeroradioactive survey can reveal data on, 1) the surficial geology of an area, and 2) the background radioactivity of the region. Because the area is covered by glacial debris, very little geologic information is obtained from the aeroradioactivity map of the site vicinity. The following discussion by the author (Bates, 1965) provides an understanding of the significance of the survey and a conclusion regarding the geological correlations that could be made:

> "The effective area of response of the scintillation equipment at an altitude of 500 feet is that encompassed by a circle with a radius of 500 feet, and the radioactivity recorded is the average radioactivity of that area. The scintillation equipment records only pulses from gamma radiation with incident energies greater than 50 kev (thousand electron volts).
>
> "The gamma-ray flux at 500 feet above the ground has three principal sources: cosmic radiation, radionuclides in the air (mostly radon daughter products), and radionuclides in the surficial layer of the ground. The cosmic component, called the cosmic background, is determined twice daily by calibration at 2,000 feet above the ground, and is automatically subtracted from the radioactivity data during recording. The cosmic background during this survey ranged from 240 to 400 cps (counts per second) and averaged 320 cps.
>
> "The component due to radionuclides in the air at 500 feet is difficult to evaluate. It is affected by meteorological conditions, and a tenfold change in radon concentration is not unusual under conditions of extreme temperature inversion. However, if inversion conditions are avoided, the air component may be considered to be fairly uniform on a given day in a particular area, and will not mask the differences in radioactivity levels that reflect changes in the ground component.
>
> "The ground component comes from approximately the upper few inches of the ground. It consists of gamma rays from natural radionuclides, principally members of the uranium and thorium radioactive decay series and potassium-40, and fallout of radioactive nuclear fission products. The amount of fallout, if present in the survey area, must be small because of the overall low radioactivity level. Lacking any control information, the distribution of fallout is assumed to be uniform.

"Typically, aeroradioactivity data from glaciated regions give little information on the areal distribution of underlying bedrock units. The present survey is a good example of this. Only two correlations of aeroradioactivity data with bedrock geology were noted in this area. They are the linear radioactivity highs (500 to 800 cps) along the Olentangy River and Alum Creek, north of Columbus. There the basal part of the Ohio Shale is exposed along the sides of the stream valleys. The correlative of the Ohio Shale, the Chattanooga Shale, has been intensively studied in eastern Tennessee. There, the uranium content of the basal unit ranges from 0.0024 to 0.0052 percent, and the uranium content of the whole formation ranges from 0.0011 to 0.0086 percent. The radioactivity data indicate that the Ohio Shale has about the average uranium content for marine black shales but less than that of the Chattanooga Shale.

"A large area having a lower radioactivity level (200 to 500 cps) is immediately west of the center of the mapped area and extends from the southern boundary of the survey area almost to the northern boundary. This area, from Miamisburg northward, closely coincides with the interlobate area formed between the Miami and Scioto glacial lobes during late Wisconsin time. The lower radioactivity level probably is due, in part, to the large areas of sand and gravel deposited as outwash from the two glacial lobes." (Bates, 1965).

7.1.9.4. Geothermal Gradients A short distance below the surface of the ground (perhaps 10 or 20 feet) temperatures in the subsurface are usually equal to the mean annual temperature at the ground surface. In the vicinity of Mound Laboratory, rock and soil below the ground surface is at a constant temperature of about 54° Fahrenheit.

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 Laboratory 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 0.43 degrees Fahrenheit per hundred feet of depth, which is very low in comparison to the typical value for oilfields in North America of 1°F/100 feet of depth. Average values between 1.24° and 1.49°F/100 feet of depth have been published for West Virginia and Pennsylvania respectively (Birdwell, no date) which demonstrates the relative increase in geothermal gradient within the Appalachian Orogenic belt, east of the site.

7.1.10. Regional Oil and Gas Production A map showing oil and gas fields in the State of Ohio is presented on Plate 7.1-45. A graph showing oil and gas production for the map area is presented on Plate 7.1-46. The major oil producing area closest to Mound Laboratory 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. Production from this field is now mostly abandoned. (Calvert, 1964).

The Lima-Indiana Oil and Gas Field lies immediately northwest of the town of Anna, Ohio which has been the center of significant earthquake activity. A correlation between earthquake frequency and petroleum production associated with the Lima-Indiana field is presented on Plate 7.1-47. No association between earthquake activity and petroleum production is apparent from this analysis.

The closest area of petroleum production to Mound Laboratory is the Arcanum Gas pool located in Darke County, Ohio, 25 miles northwest of the site. Gas production is from the Trenton formation which is at an average depth of 1,150 feet below ground surface. The Arcanum Field was discovered in 1887 and is now depleted. Other wells which have penetrated the Trenton formation as close to Mound Laboratory as Dayton were drilled, but no shows of oil or gas have been reported.

7.1.11. Site Geology

7.1.11.1. Introduction Mound Laboratory is located atop a hill overlooking the Miami River and the city of Miamisburg in southwest Montgomery County, Ohio. Elevations of the natural land surface within the site boundaries range from 710 to 880 feet. A northeast to southwest trending stream valley divides the site into two topographic high areas, and a low area filled with glacial outwash.

During the period of investigation, a total of six borings were drilled at various locations within the site boundaries. A total of 748.5 feet of soil and rock were drilled and sampled. The deepest subsurface penetration was completed at an elevation of approximately 618 feet above sea level, (Boring 5, Plate 7.1- 7), and the deepest continuous penetrations (Borings 1 and 2, Plates 7.1-3 and 7.1-4) were 200 feet.

In addition to drilling and sampling the various soil and rock units which underlie the site, geophysical logs were taken at five borings to correlate stratigraphic horizons. Logs of deep wells in the vicinity of the site were reviewed.

The site was inspected by an experienced Dames & Moore geologist, and exposures of soil and bedrock were examined for weathering characteristics, stratigraphy, lithology and structure. Available geologic literature pertaining to the site area was researched and recognized authorities from the Ohio State Geological Survey and Miami University were consulted.

7.1.11.2. Physiographic Setting Mound Laboratory is located within a physiographic division of Ohio known as the Till Plain Section (Lobeck, 1950). The Till Plains section is a subdivision of the Central Lowland Province which covers widespread areas of adjacent Indiana and Illinois. This section is characterized by variable deposits of geographically widespread glacial till which originated during Wisconsin and Illinoian time. Evidence of earlier glacial advances are also recorded farther south of Mound Laboratory.

Mound Laboratory is situated on top of a river bluff overlooking the Great Miami River and the city of Miamisburg. This river bluff was formed by deep stage erosion in the Great Miami River Valley. Topographic relief within the site boundaries range up to 170 feet and the maximum and minimum relief between the Miami River and site is 200 and 30 feet respectively. Natural slopes on the site range up to 20 degrees from the horizontal.

7.1.11.3. Stratigraphy

- General The information presented in this section is primarily based upon six borings which were drilled within the site boundaries. Over 200 preexisting borings and nearby deep wells provided additional information. Plates 7.1-48 and 7.1-49 illustrate a geologic cross section of the upper Ordovician horizon upon which Mound Laboratory is situated. The geologic column below the upper Ordovician is extrapolated from logs of the Armco Deep Well which is the closest deep well to Mound Laboratory. The following review of subsurface stratigraphy begins with the uppermost horizon and concluded with a discussion of the basement complex.

- Quaternary Variable deposits of Pleistocene till and outwash cover much of the site area. The two topographic high areas are generally covered by a relatively thin layer (1 to 5 feet) of glacial till, composed of silt and clay with some fine gravel. The topographically lower valley is filled with a wedge of glacial outwash between the upper tills and bedrock. The thickness of deposits filling the buried valley increases as the valley approaches the Great Miami River.

- Ordovician - Cincinnatial Series The six borings drilled by Dames & Moore spanned approximately 250 feet of Cincinnatian Series rock. All of the rock core retrieved from these borings are of the Richmond Group. The sequence of formations lying within the Richmond Group is shown on Plate 7.1-31. The cores do not indicate any igneous or metamorphic rocks, nor are there any obvious indications of structural deformation. The formations are found in their correct sequence, without omission or duplication, and except for the Arnheim Formation, have thicknesses, lithologies and faunas compatible with surface exposures within the region, including Montgomery, Butler and Warren Counties, Ohio (Pope, 1973). A bedrock geology map of the site is presented on Plate 7.1-50.

The formations of the Cincinnatian Series within the Cincinnati Province, the area of outcrop in northern Kentucky, southwestern Ohio and southeastern Indiana, are conventionally defined by their faunal content. The lithology of the formations is of secondary importance in their definition and identification. Thus, the formations are in reality teilzones (the stratigraphic interval through which a particular fauna is found within a region), and not formations in the contemporary sense of being stratigraphic intervals of mappable extent defined by lithologic character alone. Workers from the U. S. Geological Survey, the Ohio State University and elsewhere have started to redefine Cincinnatian formations in the contemporary sense in Kentucky, southern Ohio and southeastern Indiana, but this work has not proceeded into the northern part of the

Cincinnati Province. Consequently, the conventional formations have not been recognized in the Miamisburg area.

The conventional formations locally have gradational boundaries owing to overlap of faunas or arbitrary boundaries caused by the lack of diagnostic fauna in short intervals of the section. Even in surface exposures, it is difficult to precisely fix the contacts between Richmond formations, but generally, these contacts can be specified to lie within short intervals of section. These faunal boundaries may or may not coincide with prominent lithologic boundaries. Thus, the thicknesses of Richmond formations in the Cincinnati Province are somewhat variable from locality to locality and from author to author.

Richmond Group

- Whitewater Formation At Mound Laboratory, the basal part of the Whitewater Formation is found at elevation 850 feet. (Plate 7.1-48). The Whitewater Formation is commonly described as being a mixture of nodular, lenticular, or lumpy medium blue-gray to light gray limestone and medium blue to gray shale. The irregular limestone masses are flattened, a few inches to a few feet across and no more than a few inches in thickness. Locally, the rock appears conglomeratic, especially toward the top of the formation. At surface exposures, only a few continuous limestone strata are evident, especially toward the base of the Whitewater Formation where the rocks grade into the even-bedded strata of the Liberty Formation.

This formation was identified by various brachiopids and the presence of corals known to be abundant in the Whitewater. The thickness of the basal Whitewater found at Mound Laboratory is compatible with known thicknesses of the formation found in other areas of the Cincinnati Province.

- Liberty Formation The Liberty formation, lying below the Whitewater formation (Plate 7.1-48), extends from elevation 849 to 821, and has a thickness of 26 to 29 feet. The Liberty formation is composed of fossiliferous, evenly bedded, medium grained, medium blue to gray limestone strata which rarely exceed 8 to 10 inches in thickness. These alternate with intervals of medium blue to gray shale which are rarely over 18 inches thick .

The Liberty formation has a large but generalized Richmondian marine fauna. Few common species are restricted to the Liberty formation, and it is often identified by faunal associations. The top of the Liberty was picked at the upper

occurrence of Thaerodonta rugosa and the bottom by a thin pyrite zone at an approximate depth of 65 feet. The lower Liberty does not appear as fossiliferous as might be expected but the thickness (26-29 feet) is comparable with previous investigations conducted in northeastern Warren County, Ohio (Pope, 1973).

- Waynesville Formation The Waynesville formation is a thick sequence of shale which underlies the Liberty formation, incorporating thin, evenly bedded limestone strata (Plate 7.1-48). The dominant rock type of the Waynesville formation is sparingly fossiliferous, bluish or greenish-gray shale, which occurs in intervals of a few inches to 8 or 10 feet in thickness. The limestone strata of this formation are less prominent and thinner than in adjacent formations. The limestone strata of the Waynesville formation are evenly bedded, rarely more than a few inches in thickness, fossiliferous, medium grained and medium to dark gray or bluish-gray in color.

The fauna of the Waynesville formation is not as diverse nor abundant as the fauna of the Whitewater or Liberty formations. The species most diagnostic of the Waynesville formation is the punctate brachiopod Onniella meeki which occurs in large numbers. The Waynesville has a thickness of 90 to 100 feet beneath Mound Laboratory, which is compatible with thicknesses of the Waynesville found in previous investigations.

- Arnheim Formation The Arnheim formation underlies the Waynesville formation (Plate 7.1-48) and is found in the lowermost sections of rock cores taken from the Mound Laboratory site. The top of the Arnheim is found at elevation 715 to 706. The base of the Arnheim and the underlying formations of the Maysville Group were not intersected by any of the borings drilled on the site. Thus, the Arnheim has a minimum thickness of approximately 85 feet beneath Mound Laboratory, which is a thickness greater than expected in this area.

The lithology of the Arnheim formation is variable. In the upper part, it is irregularly bedded, nodular or lumpy, argillaceous, medium gray to light bluish-gray limestone with irregular, poorly bedded shale intervals a few inches to 18 inches thick. Fossils are moderately common but generally fragmentary and poorly preserved. The top of the Arnheim formation is marked at some localities by a zone of abundant, dark phosphatic fossil fragments and by black to dark brown miniature fossils including abundant gastropods.

The lower Arnheim formation is also mainly a lumpy, nodular, argillaceous limestone, with some evenly bedded strata at the base, which in color may vary from dark blue, through

grays to light gray. Interbedded with the limestone nodules and uneven beds is poorly bedded, dark blue to medium gray shale. Toward the base, the shale may be more evenly bedded and gray to blue-gray in color. The lower member contains abundant fossil fragments which are usually fractured and quite abraded. Good, complete, identifiable fossils from this interval are unusual.

Rocks of the Maysville and Eden Groups underlie rocks of the Richmond Group. They are calcareous shales and are interbedded with thin layers of limestone, similar to the Richmond Group rocks.

Champlainian Series

- Trenton Group The Trenton group is the upper formation of Champlainian series strata underlying the site area. It is known as the first hard limestone underlying the Eden shales of the Cincinnatian series. The formational divisions (Cynthiana and Lexington) are not distinguished in this study.

The Trenton consists of a light gray, thickly bedded, very finely crystalline limestone with a trace of fossils and some argillaceous material. The top of the Trenton lies approximately at sea level and has a thickness of 35 feet beneath the site area.

Black River Group The top of the Black River group is separated from the Trenton by a gray-brown, soft layer of metabentonite* commonly called the "Mud Cave" by drillers. Another metabentonite lies approximately 18 feet below this layer and is commonly called the "Pencil Cave." The individual formations of the Black River group underlying Mound Laboratory are the Platteville and Glenwood. The Black River has a combined thickness of 360 feet.

- Platteville Formation This formation consists of a white to yellow-brown, very finely crystalline limestone with trace fossils, dolomitic stringers, and argillaceous material.

- Glenwood Formation This formation consists of white to yellow-brown, very finely crystalline limestone with trace shale stringers and pyrite. Some zones of argillaceous dolomite are found near the bottom of the formation.

*Metabentonite is an altered silaceous volcanic ash commonly resembling a clay. It probably originated from volcanic activity in the Appalachian Geosyncline.

- St. Peter Formation The St. Peter formation lies beneath the Glenwood formation and unconformably atop the Canadian series strata. This formation consists of a white, fine to medium grained, subangular to rounded sandstone with traces of clay and dolomite. The top of the St. Peter sandstone lies at an elevation 500 feet below sea level and has a thickness of 20 to 25 feet.

Canadian Series

Knox Group The Knox group lies immediately below the Knox unconformity. The upper formations of the Knox include the Shakopee and New Richmond formations.

- Shakopee and New Richmond Formations (Upper Knox) These formations consist of a white, finely crystalline dolomite with trace amounts of chert particles, oolite and gray-green shale. The combined thickness of the Shakopee and New Richmond formations is approximately 300 feet beneath Mound Laboratory. They begin at an elevation 550 feet below sea level.

- Oneota Formation (Rose Run) The Oneota consists of yellow-gray to gray-brown, finely crystalline (with occasional medium-coarse crystals), slightly argillaceous dolomite with trace glauconite and sandstone. The Oneota lies about 800 feet below sea level and has a thickness of approximately 100 feet beneath Mound Laboratory.

Cambrian

St. Croixan Series The St. Croixan series strata lie unconformably below the break between the Ordovician and Cambrian periods. Four formations comprise the St. Croixan series strata.

- Trempleau Formation (Copper Ridge or Lower Knox) The Trempleau formation consists of yellow-gray to light brown, very finely crystalline dolomite with some shale, traces of pyrite and glauconite. The top of the Trempleau lies at an elevation of 900 feet below sea level and has a thickness of about 750 feet.

- Franconia Formation (Dresbach) The Franconia formation consists of light gray to brown, fine to medium crystalline dolomitic sandstone with glauconite. This formation lies at elevation 1,700 feet below sea level and has a thickness of approximately 50 feet.

- Eau Claire Formation (Rome) The Eau Claire formation underlies the Franconia and consists of gray-brown dolomite with interbedded sandstone and trace red-brown siltstone.

The top of the Eau Claire Formation lies at an elevation 1,750 feet below sea level and has a thickness of 500 feet beneath Mound Laboratory.

- Mount Simon Formation The Mount Simon formation underlies the Eau Claire and lies unconformably atop the break between Paleozic and Precambrian strata. This formation consists of a white, fine to coarse grained sandstone with traces of shale. The Mount Simon lies at an elevation of 2,300 feet below sea level and has a thickness of 300 feet.

- Precambrian The rocks lying below the unconformity between the Precambrian and Paleozoic consist of gray-red to gray-brown granites of the Central Province. The top of the Precambrian rocks lie 2,600 feet below sea level beneath Mound Laboratory.

7.1.11.4 Structure Mound Laboratory is located on a stable geologic platform. To the east of this platform, the Paleozoic strata dip east to southeast into the Appalachian basin. The beds dip slightly to the west along the western margin of the platform. However, the stratigraphic attitude of beds underlying the site is nearly horizontal. The geologic record preserved in the rocks underlying Mound Laboratory indicates the area has been relatively stable since the beginning of the Paleozoic era, more than one-half billion years ago.

- Jointing An analysis of 48 joint measurements taken along the north-northeast to south-southwest trending Penn Central Railroad cut, located adjacent to the western boundary of Mound Laboratory, indicates that at least two major joint sets are present beneath the site. One set strikes in a west-northwest to east-southeast direction, and the other strikes in a north-northeast to south-southwest direction. The dip of both joint sets is vertical.

- Folding The six borings drilled on the plant site and a review of previous subsurface borings in the vicinity of Mound Laboratory did not reveal any evidence of subsurface structural folding. There is no evidence to indicate significant stratigraphic thinning in the Richmond beds. Some of the individual shale and limestone layers of the formations thin beneath the site. However, the thinning patterns are not persistent and were probably caused by the near wave base depositional environment which characterized the Upper Ordovician strata in southwest Ohio.

- Faulting An examination of rock cores and geophysical logs taken from the six borings drilled on the site did not indicate any evidence of subsurface faulting in the Upper Ordovician strata. The beds are nearly horizontal and

there is no indication of structural displacement or fault zones. There is no evidence of sub-Richmond structural displacement in the area immediately surrounding Mound Laboratory.

- Solution Activity The limestone strata which is interbedded with shale layers at the site shows no evidence of solution activity. Limestone is isolated from percolating groundwater by impermeable shale which encases the carbonate beds. No evidence of solution cavities or cavern development has been observed in any borings or outcrops in the Miamisburg area.

7.1.11.5. Ground Water Groundwater conditions at Mound Laboratory 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 upper 20 feet of bedrock is the most permeable where chemical weathering allows enlargement of cracks. Permeability of the upper 20 feet of bedrock is estimated to range from 1 to 10 gpd/ft^2. Below this depth, bedrock permeability generally ranges from 0.2 to 0.0 gpd/ft^2.

The glacial till soils which form a veneer over the entire site are composed of silt and clay with some disseminated sand and gravel. Hydraulic properties of the glacial till soils 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 0.0001 to 0.001 gpd/ft^2, although values up to 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 mostly of sand and gravel. The permeability of this zone is estimated to range from 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 on-site water supply wells draw water from this aquifer.

Water levels in the six exploratory borings are presented on Table 7.1.11-1. Water levels under Mound Laboratory are ultimately controlled by the water level of the Great Miami River which has a non-flood level at elevation 682. However groundwater under the site 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 the borings do not reflect the true static water levels, but

rather the dynamic equilibrium level between recharge and discharge at a given permeability interface for a particular date.

7.1.11.6. Foundation Considerations More than 80 existing structures are located within the exclusion area at Mound Laboratory. Most of these structures are located on the flat hilltop areas and are founded directly on bedrock. Other structures are founded on stiff glacial till which overlies bedrock.

A review of actual design bearing pressures and recommended foundation loading indicated that existing structures were conservatively designed. Recommended safe bearing pressures were never exceeded and in many cases were reduced by the designer. A tabulated summary of building foundation data is shown on Table 7.1.11-2. The apparent safety factor is the ratio of recommended bearing pressure to design bearing pressure. The actual safety factors are known only to the soils consultants who prepared the original reports and were not made available for this study. However, an analysis of ultimate bearing capacity was made from an evaluation of the test data so that actual factors of safety could be estimated.

Unconfined compressive strengths for glacial till soils ranged from 2396 to 14,537 psf. Based on the lowest test value, an ultimate bearing capacity of about 7,000 psf was calculated. For the average value of unconfined compressive strength, the ultimate bearing capacity is on the order of 18,000 psf. All structures founded on glacial till soils were designed for bearing pressures ranging between 3,000 and 6,000 psf. The average safety factor between probable ultimate bearing capacity and the design bearing capacity is estimated to be approximately three for buildings founded on glacial till soils.

The lowest unconfined compressive strength value as determined from testing the rock core was 5,650 psi which is equivalent to 813,600 psf. If a minimum rock strength of about 100,000 psf is assumed for the weakest probable rock layer (where core recovery was low and no samples could be obtained for testing) then this value would represent the ultimate bearing capacity of the bedrock foundation material. Actual design bearing capacities for buildings founded on rock range from 4,000 to 15,000 psf, but usually are within 6,000 to 7,000 psf. Based on this data, a safety factor of at least ten is estimated for structures founded on bedrock.

- Foundation Design of Safety Related Structures Within the boundary of Mound Laboratory, there are eight Category 1 structures and four other structures which could influence the integrity of Category 1 structures. Category 1

structures are defined as those structures in which significant quantities of radioactive materials are processed or handled outside of shipping containers or encapsulation systems. Category 1 structures include all buildings and pipelines in which there is the potential for release of radioactive material from a containment system.

Seven of the Category 1 structures are buildings which include units 38, 50, 21, WD, R, SW and T. The other Category 1 structure is an array of radioactive waste pipelines which connects units 38, R, and SW to unit WD. Of the four additional safety related structures, three are brick stacks and one is an elevated water tank.

Elevations in the discussions which follow refer to plant datum which is 1.143 feet higher than North American Datum as established by the U.S. Coast and Geodetic Survey. To convert plant datum to North American Datum, add 1.143 feet.

Building 38 is the plutonium processing plant. It is on the southern hill at an approximate elevation of 890 feet. Bedrock at this site lies between elevation 878-883 with soil depth ranging from seven to 12 feet. The foundation of Building 38 is in bedrock at elevations of 873-877-1/2 feet. The foundation consists of reinforced concrete continuous wall footings 2-1/2 feet wide and one foot thick on interior walls. These footings are 1-1/2 to seven feet below first floor elevation. Columns rest on square footings with different dimensions depending on their location in the building. Corner footings are four feet square and 1'-3" thick. Wall line and individual column footings are 4-1/2 feet square and 1'-8' thick or 6' square and 2'-1" thick. These footings are reinforced with steel bar and dowels. Column loads were listed as 200,000 pounds and partition wall loads as 8,000 pounds per lineal foot. Design bearing pressure used in construction of the building was 10,000 psf, and all footings are on bedrock.

Building 50 is the Alpha Fuels Environmental Test Facility. It is also located on the southern hill at an approximate elevation of 885-890 feet. Bedrock at this site ranges from elevation 875.5 to 883.9 with a soil depth of approximately 7-10 feet. The foundations of the building are in rock at elevations between 873.3 and 879.7 feet. The foundation of Building 50 consists of continuous wall footings 1'-8" to two feet wide and one foot thick. The footings are 5'-4" to 7'-9" feet below ground level. These footings are reinforced with steel bars and dowels. A recommended safe bearing pressure of 6,000 psf was used for the foundations.

Building 21 is the Thorium Sludge Storage Building. It is

located at the southern edge of the plant site on the southern hill. The site has an approximate elevation of 870 and depth of soil is thin. Foundation elevation of the structure is 868 feet which is three feet below finish grade. The foundation consists of a reinforced concrete slab 1'-4" thick set in the zone of weathered bedrock. The reinforcing steel is in a grid pattern throughout the mat and is anchored with hooks and dowels into the concrete walls. A design bearing pressure of 4,000 psf was used.

"WD" Building is the Radioactive Waste Disposal Building. It is located on the southern slope of the main complex on the northern hill of the site. Topographic elevation of the site area before construction ranged from 800-820 feet. Elevation of bedrock also varies about 20 feet, from elevation 780-800. Foundation elevations range from 773.2 to 791.5 feet at the site, with the elevation increasing northward following the slope of the bedrock. Foundations of this building are in bedrock. They consist of continuous wall footings 2'-4" to 4'-4" wide and 1.0 to 1'-3" thick. These footing sizes are dependent on wall loads within each individual section and were placed at a grade ranging from zero feet to 10'9" below final ground surface. Concrete mats 1'-0" to 1'-3" feet thick support the clariflocculators. All the foundations are reinforced with steel bar and dowels. Recommended safe bearing pressure for the rock foundations under the Solid & Liquid Waste Building was 12,000 psf. Design bearing pressure for the "WD" Building for rock was 4,000 psf.

"R" Building is the Research Building. It is located on the northern hill in the main plant complex. Topographic elevation of the site before excavation is unknown. Bedrock elevation at this site ranges between 876.5-881.0 feet. Foundations of the building were founded in rock at elevation 875.0. The foundations consist of continuous wall footings 1'-3" wide with square footings at all column locations within the outer limits of exterior walls. Square column footings were used in the exterior walls. Interior wall footings are 3.5 feet square to 4.0 feet square and 1'-3" thick. Exterior wall column footings are 2.5 feet square to 3.5 feet square and 1'-3" thick. All footings are three feet below grade and are reinforced with steel bar and dowels. The design bearing pressure was 8,000 psf.

"SW" Building is the Disassembly and Surveillance building. It is located adjacent to "R" Building. Topographic elevation before construction is unknown. Bedrock is approximately at elevation 881. Foundations of the building are founded in bedrock at elevations ranging from 872.4 to 876.4 feet. The foundations consist of continuous wall footings 1.5' wide with 0.5' extension on alternating columns

in north and south walls. Square column footings 3'-3" square and one foot thick are located beneath each column in the east-west exterior walls. Individual square footings are used for interior columns. These footings are two feet square in one wall and 3.5 feet square in the other. Depth below finished floor grade ranges from 2'-1" to 6'-1". All footings are reinforced with steel bar and dowels. A design bearing pressure of 10,000-15,000 psf was used.

"T" Building (Development and Purification of Radioactive Materials) is located southeast of "R" Building in the main complex and underlies "DS" Building. This building is almost entirely underground with the foundation elevation at 809'-6", which is one to 64 feet below bedrock elevation. The foundation of "T" Building consists of a 7'-2" thick reinforced concrete slab on rock. Design bearing pressure for the foundation is not known.

The radioactive waste pipelines connect several of the process buildings to "WD" Building for radioactive waste removal and decontamination. The longest section consists of two parallel pipelines which start at "PP" Building at elevation 875.9, go to rundown tanks at elevation 736.6, and finally enter "WD" Building at elevation 804.0. The Low Risk Alpha (L.R.A.) pipeline is two inches in diameter and the High Risk Alpha (H.R.A.) pipeline is 1-1/2 inches in diameter. Both lines are constructed of Saran polypropylene lined steel pipe having a wall thickness of 11/32 of an inch. The pipes are connected by full flange bolted joints with full gasket.

The pipelines which connect "PP" Building to "WD" Building are about 2,377 feet long and were built in 1966. The underground portion of the pipelines has a minimum earth cover of three feet which is stabilized along the sloped section by three concrete bulkheads on approximately 220-foot centers. Sections of the underground pipeline are further stabilized by concrete encasement. Above ground, the pipelines are wrapped with a four inch thickness of foamglass insulation encased in an aluminum jacket.

Additional shorter pipelines connect "R" and "SW" Buildings to "WD" Building. One is a 369-foot long Low Risk Beta (L.R.B.) pipeline, 1-1/2 inches in diameter. The L.R.B. pipeline starts at "SW" Building at elevation 874.0, and enters "WD" Building at elevation 805.7. A 2-inch diameter Low and High Risk Alpha (L.H.R.A.) pipeline also connects from "SW" Building to "WD" Building. Both the L.R.B. and L.H.R.A. lines were built in 1966, and are constructed of Saran polypropylene lined steel pipe having a wall thickness of 11/32 of an inch and full flange joints. A minimum earth cover of three feet was used to backfill the pipelines. A third pipeline, the Hot Waste Discharge (H.W.D.) pipeline

also connects "R" and "SW" Buildings to "WD" Building. This line is constructed of 8-inch vitrified clay pipe and has a minimum earth cover of five feet.

All of the Category 1 pipelines, including the L.R.A., H.R.A., L.R.B. and L.H.R.A. lines are founded on either glacial till soils or weathered bedrock. The pipeline adds a negligible surcharge weight to the foundation material such that bearing capacity is not considered to be a problem. Differential settlement between sections of pipe founded on soil and sections founded on weathered bedrock is not considered to be a problem because the surcharge weight added by the pipeline is negligible and because of the overconsolidated nature of the glacial till soils. No sections of Category 1 pipeline are located adjacent to any heavy structures founded on soil which could cause settlement in its immediate vicinity.

Stacks Number 2, 3, and 4 are located on the North Hill building complex. Stack No. 2 is 100 feet high and is north of the "R-SW" complex. Stack No. 3 is 200 feet high and is south of "SW" Building. Stack No. 4 is also 200 feet high and is south of "P" Building. Bedrock elevation in the vicinity of Stack No. 2 is approximately 875 feet; Stack No. 3, 870 feet and Stack No. 4, 870 feet. The foundations of all stacks are reinforced concrete mats founded in rock. Stack No. 2 has a 4-foot thick mat, 16 feet in diameter; Stack No. 3 has a 6-foot thick mat, 28 feet in diameter; Stack No. 4 has an 8-foot thick mat, 28 feet in diameter. A design bearing pressure of 5,000 psf was used for all stack foundations.

The 250,000 gallon elevated water storage tank is located southwest of the "PP" Building. The topographic elevation of the site is approximately 875 feet. Bedrock elevation is 868.5 to 871.8 feet. Foundations are set in rock at elevations of 868.5 to 871.75 feet. The foundations consist of a mat for each of the five structural elements of the water tank. Mats 9'-8" square at the base and 11 inches thick are located beneath each leg. Depths of the mats vary so as to reach rock. Design bearing pressure used in constructing the tank foundation was 5,000 psf.

- Liquefaction Potential Soil liquefaction is a phenomenon which may occur in loose, saturated, granular soils which are subject to vibratory (earthquake) loading. As the soil is vibrated, the pore water pressure tends to increase. As the pore water pressure approaches the confining pressure, the effective pressure between the soil grains approaches zero. When this happens, the soil loses its shear resistance and behaves as a high-density liquid.

Laboratory investigations and field observations have shown that the liquefaction potential of a soil deposit depends upon characteristics of the soil, (soil type and relative density), the initial stress conditions acting on the soil, and the intensity and duration of earthquake forces which are applied to the soil (See & Idriss, 1971). Saturated soils which are generally susceptible to liquefaction include uniformly graded, fine to medium cohesionless soils which have a low relative density (or high void ratio). Cohesive soils, bedrock, and very dense granular soils are not generally subjected to liquefaction.

An examination of soil samples obtained from the field boring program indicates that all soils which overlie bedrock at Mound Laboratory are either cohesive or extremely dense. In the lower portion of the buried valley area, a layer of dense sand and gravel exists between the overlying till and bedrock. This sand and gravel layer contains a minimum of 10 percent silt and clay binder. (See Plate 7.1-26). The overlying till is composed mostly of silt and clay, and has an average wet unit weight of about 150 pounds per cubic foot which provides a uniformly high confining pressure to the underlying sand and gravel. It is therefore concluded that the possibility of liquefaction occurring at Mound Laboratory is extremely remote. All Category 1 buildings at Mound Laboratory are founded on bedrock which is not subject to liquefaction, and is therefore not a consideration for design.

- Static and Dynamic Properties of Subsurface Materials

This section presents a general evaluation of the static and dynamic soil properties and moduli in the various soil and rock strata encountered at the site. These values are based upon:

a. a review of all available field and laboratory tests performed during this investigation;

b. a review of the geophysical surveys performed during this investigation;

c. a review of the latest available literature; and

d. a review of similar studies made recently for nuclear generating plants at other locations.

Static tests on soil samples suitable for testing, and obtained using the Dames & Moore Type U soil sampler, include strength tests, consolidation tests and moisture and density tests. Classification tests, such as particle size analyses, and Atterberg limit tests were also performed on disturbed samples.

Dynamic tests on soil and rock samples provide an estimate

of their dynamic properties which include:

a. Young's Modulus of Elasticity (E);

b. Modulus of Rigidity (G);

c. Poisson's Ratio (μ); and

d. a damping factor.

Young's Modulus (E) is defined as the ratio of axial stress per unit strain and is a measure of the stiffness of a material. The Modulus of Rigidity (G) is defined as the ratio of shear stress per unit strain and is also a measure of stiffness. Poisson's Ratio (μ) is defined as the ratio of lateral strain to longitudinal strain. E and G are related by:

$$E - 2G (1 + \mu)$$

The deformation moduli (E, G and μ) for rock, and particularly for soil, are the "effective" values which describe response of the mass to static and dynamic loading. Since the deformation moduli for rock and soil are generally strain dependent (i.e., nonlinear), the data is given for several different levels of strain.

A generalized summary of both static and dynamic moduli and damping for the subsurface materials at the site is presented in Table 7.1.11-3. The dynamic moduli of elasticity and rigidity were evaluated from the redults of geophysical measurements and laboratory tests. The static moduli of elasticity and rigidity were evaluated from the results of laboratory tests, a review of the latest available literature and a comparison of the values for similar materials at other sites.

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7.2. VIBRATORY GROUND MOTION

7.2.1. Geologic and Tectonic Background

The site is located within the Central Stable Region of North America, which is an area of relatively simple geologic structure. The region is characterized by a system of structural basins (Michigan, Illinois, and Appalachian) separated by broad, structural arches (Kankakee, Findlay, and the Indiana-Ohio platform). Numerous secondary features are superimposed on these broad structures. The site lies on the Indiana-Ohio platform ("Cincinnati Arch"), a short distance south of the confluence between the Kankakee and Findlay Arches.

Precambrian crystalline basment in the vicinity of the site is covered by about 3,400 feet of Cambrian and Ordovician sedimentary rocks. The Ordovician rocks are covered by a thin veneer of Pleistocene glacial till consisting of sandy clay and silt with gravel and cobbles.

The site area was subjected to deposition throughout the Paleozoic Era. The area was then subjected to continuous erosion until Pleistocene glaciers deposited the veneer of till. The uppermost bedrock unit at the site is the Richmond shale and interbedded limestone group of late Ordovician age. A complete discussion of the regional stratigraphy, structure and geologic history is presented in Section 7.1.

Faults have not been identified within the basement rocks or overlying sedimentary strata at the site. The closest known fault is the Maysville fault which lies about 70 miles to the southeast at its closest approach. The Maysville fault is believed to be related to the east-west trending Kentucky River fault zone, about 125 miles south of the site. Two other faults, the Bowling Green fault to the north and the Mt. Carmel fault to the southwest, also lie about 125 miles from the site. Other known faults in the area are more distant. Most faults in the region are believed to have been dormant since late Paleozoic time, at least 200 million years ago.

7.2.2. Geologic Structure

A complete description of regional structure is presented in Section 7.1.8. The most significant structural features are listed below:

- The Kentucky River fault zone, including the Maysville fault, trends generally east-west in east central Kentucky. The northeast extension of this zone (the

Maysville fault) lies about 70 miles southeast of the site.

- The Bowling Green fault trends north-south in northwestern Ohio. The closest approach of the fault is about 110 miles north of the site.

- The Mt. Carmel fault trends slightly west of north in south-central Indiana. This fault lies about 125 miles southwest of the site.

- The Rough Creek fault zone is a complex system of normal faults in western Kentucky and southern Illinois. The closest approach of this system lies about 160 miles southwest of the site.

- The Indiana-Ohio Platform trends northward through Kentucky and southwestern Ohio. A few miles north of the site it bifurcates into the northeast-trending Findlay Arch and the northwest-trending Kankakee Arch.

7.2.3. Regional Seismology

7.2.3.1. Site Behavior During Prior Earthquakes Many earthquakes have been felt at the site, some of which had origins near Anna, Ohio, 53 miles to the north. The September 20, 1931 earthquake generated Modified Mercalli (MM) Intensity* VII damage in Anna, but only Intensity IV in Miamisburg (U.S. Earthquakes, 1931). The March 2, 1937 earthquake, MM Intensity VII in Anna, was felt at a level of Intensity IV at the site. The March 9 1937 shock, Intensity VIII in Anna, generated the most severe shaking known in Miamisburg; Intensity V (BSSA V. 30, 1940). The earthquake closest to the site (10 miles north) was recorded on April 20, 1950 near Dayton. The maximum intensity was III, but it is listed as only a possible earthquake and could have been a sonic boom.

Even though many earthquakes have been felt at the site, detailed on-site studies suggest that their intensities have been insufficient to affect local surface or subsurface materials.

7.2.3.2. Earthquake History The site is located about 35 miles south of an active seismic area in western Ohio (Anna), and about 150 miles northeast of another active area in southern Illinois. Other earthquake epicenters are

*Modified Mercalli Intensity Scale of 1931 is presented on Table 7.2-1.

scattered throughout Ohio, southern Michigan, western West Virginia, western Tennessee and Kentucky. Some of the earthquakes have not been identified with a specific structure.

A list of earthquakes with epicenters located within an area bounded on the south by 36.5 degrees North latitude; on the north by 42.5 degrees North latitude; on the east by 80.5 degrees West longitude; and on the west by 89.0 degrees West longitude, is presented in Table 7.2-2. The epicenters of these shocks are plotted on Plate 7.2-1. All earthquakes within 100 miles of the site are listed, but only Intensity V and greater shocks are listed for greater distances.

Although many earthquakes probably have been felt at the site, the maximum intensity has reached V only once, and IV probably only four times during the period of historical record.

Since 1827, 14 earthquakes of Intensity V or greater have been reported within 100 miles of the site, and only 40 earthquakes of Intensity V or greater have been recorded within 200 miles. Few were of high enough intensity to cause structural damage to reasonably well-built structures. None of these shocks was greater then Intensity VIII and only seven can be considered more than minor disturbances. These earthquakes occurred in 1875 (Intensity VII), 1899 (VII), 1909 (VII), 1930 (VII), 1931 (VII), and two in 1937 (VII and VIII). The epicenter of the closest of these shocks was about 35 miles north of the site.

For the purposes of this study, the most significant earthquakes in the region were the 1937 Intensity VII-VIII and the 1931 Intensity VII earthquakes in west-central Ohio near the town of Anna. This evaluation has been made considering such factors as epicentral intensity (with regard to both damage to structures and perceptible area), distance from the site, and geologic structures (with regard to the possible relationship of geologic structures near the earthquake epicenter to structures near the site). Discussions of these earthquakes are presented below:

- The single most significant shock recorded within 200 miles of the site was the earthquake of March 9, 1937. The shock occurred near Anna, Ohio, an area which has experienced the most concentrated seismic activity within the region. This earthquake, Intensity VIII, closely followed the Intensity VII shock of March 2, 1937. Damage done by these two events was quite similar. The March 2 shock was felt over 70,000 square miles, while the March 9 event was perceptible over 150,000 square miles. The principal damage

was to chimneys and masonry buildings. Some plaster walls were cracked and some tombstones were rotated on their bases. In Miamisburg, the March 2 earthquake was felt as Intensity IV, while the March 9 shock might have reached Intensity V.

- The Intensity VII earthquake of September 20, 1931 damaged many chimneys, threw down two large cornice stones and shook plaster off some walls in the Anna area. Intensity IV shaking was reported in Dayton and Cincinnati. The Miamisburg area probably also felt Intensity IV shaking.

Three earthquakes, considered to be the largest ever to have occurred in the central and eastern United States, occurred near New Madrid, Missouri in 1811 and 1812. These shocks (Intensity IX and X) were felt over an area of 2,000,000 square miles and changed the topography over an area of 30,000 to 50,000 square miles. The structural damage resulting from these earthquakes was small only because of the lack of structures and habitation in the region. The intensities in Cincinnati were probably on the order of V or VI and in Detroit probably III or IV. The intensities at Miamisburg may have been IV or V.

7.2.3.3. Correlation of Epicenters with Geologic Structures With few exceptions, the significant earthquakes reported in the region can be associated with relatively well defined geologic structural zones. The concentrations of earthquakes nearest to the site at Anna, Ohio have been associated with a suggested structural weakness near the confluence of the Findlay and Kankakee Arches at the northern border of the Indiana-Ohio Platform (Primmer, 1972).

The shocks in southern Illinois, Indiana and Missouri have been connected with the northern terminus of the Mississippi Valley fault zone. The Rough Creek fault zone extending eastward into western Kentucky, about 160 miles from the site at its closest approach is not believed to be active. Most of the earthquakes are related to the northeast trending Mississippi Valley fault zone which extends from New Madrid, Missouri to Vincennes, Indiana. The most recent movement on the Rough Creek fault system is thought to be pre-Cretaceous but post-Pennsylvanian.

Two earthquakes near Wingsville, Kentucky and three shocks southeast of Cincinnati lie near the Maysville Fault which is connected to the Kentucky River fault zone. The age of the Maysville fault cannot be precisely determined, but it is considered to be early to middle Paleozoic. Rocks of mid-Tertiary age have not been displaced by this fault. The closest approach of this fault to the site is about

70 miles.

Five earthquakes have been recorded in the Cleveland area and are thought to be associated with extensive salt mining activity (Primmer, 1972).

The 1947 southern Michigan shock apparently is coincident with the alignment of the Tekonsha oil field and may be associated with oil field structures. Structure and faulting is inferred for the field. The validity of an Intensity VI shock in 1883 in southern Michigan has been questioned, but its location would also indicate a relation to oil field structures.

Other minor epicenters, within 200 miles of the site have not been related to any known geologic structures. The activity has been postulated to be the result of final crustal readjustment to Pleistocene glacial zone advance and retreat.

7.2.3.4. Earthquake Mechanism in the Anna Area

Several source mechanisms have been proposed for the cluster of seismic events originating in the Anna, Ohio area with tectonic forces and crustal rebound due to glacial unloading being the usual explanations. Geologic correlation with earthquake distribution in this otherwise stable platform area is weak.

Seismic activity has been confined to a limited region, whereas, both of the above mechanisms would generate exposure over a relatively large area.

An alternate, or perhaps, triggering hypothesis may be due to a concentration of thermal stress. Differential stresses are evident in the differences in radioactive age dating of the basement rocks in this and the adjacent region. Ages range from early precambrian to late precambrian. The upper mantle under old basement would be thermally colder than under the younger basement. The older portion of the mantle would be cooling off while the younger portion is still heating up. This would generate thermal stress, accumulated at the contact between old and young basement. Deep-seated thermoelastic energy released at the contact could provide the necessary seismic triggering.

Thermoelastic stresses due to differential heat flow could be concentrated around the precambrian basement rock mass identified as an aeromagnetic high which is located from 13 to 17 miles south-southeast of Anna. This rock mass could possess both a contrast in thermal conductivity and coefficient of thermal expansion with respect to the surrounding country rock. Earthquake epicenters in the Anna area

generally coincide with the location of this aeromagnetic anomaly.

Better understanding of the relationships of geology to the seismology in Central Ohio requires further study. However, present criteria depend upon existing data and its interpretation. The definition of thermal stress in the area may provide future refinement of the seismic problem.

7.2.3.5. Identification of Active Faults No known active faults occur within 200 miles of the site. Significant tectonic structures which do occur within 200 miles have been described in Sections 7.1.8. and 7.2.2.

7.2.3.6. Description of Active Faults No known active faults occur within 200 miles of the site. Although none of the faults within this area are considered active (by evidence of displacement of Quaternary material), some seismic activity has been associated with some of the structures.

The Tekonsha oil field structure, along which faulting has been postulated and to which two Intensity VI events tentatively have been correlated, trends northwest-southeast for an inferred length of 60 miles. Only limited, minor structural indications of this fault have been observed. The closest approach to the site is about 175 miles. The Mississippi Valley fault zone is tectonically active, but is farther than 200 miles from the site at its closest approach. The Rough Creek fault zone extends to about 160 miles from the site, but has not displaced Tertiary or Quaternary rocks.

7.2.3.7. Earthquakes Associated with Active Faults No faults are known to exist within 70 miles of the site. The closest earthquake to the site (about five miles) occurred in 1950. The shock was reported only as a possible earthquake and may have been due to a sonic boom from a low-flying aircraft. The next closest earthquakes are those in the Anna area. The earthquake zone is located about 35 miles north of the site. These shocks are associated with a zone of structural weakness at the confluence of three structural arches and are not related directly to the movement along faults.

7.2.4. Engineering Seismology Evaluation

7.2.4.1. Maximum Earthquake 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 at the site would be less than fifteen percent of gravity (0.15g).

A repetition of either of these historic events would result in ground motion at the site significantly less than that recommended for the Safe Shutdown Earthquake.

Small earthquakes, similar to the 1950 Intensity III event five miles north of the site, could recur. The maximum horizontal ground acceleration, at the rock surface, due to such a shock, would be less than one percent of gravity, (0.01g).

7.2.4.2. Maximum Earthquake in Same Province as Site Not Related to Structure Southwestern Ohio was shaken by an Intensity V earthquake in 1925. Several Intensity III shocks were felt in Cincinnati in 1877, 1936 and 1937. These shocks have not been associated with any known structure. If the 1925 event were to recur adjacent to the site, the maximum ground acceleration at the site would be less than five percent of gravity (0.05g).

7.2.4.3. Maximum Earthquake in Province Adjacent to Site Not Related to Structure The Appalachian Basin is located in eastern Ohio and western West Virginia. Several earthquakes have occurred southeast of Columbus in the Appalachian Basin, but have not been associated with any known structure. A repetition of the 1926 Intensity VI shock on the closest approach of the basin to the site (85 miles) would produce a maximum ground acceleration less than five percent of gravity (0.05g).

7.2.5. Seismic Design Criteria

7.2.5.1. Safe Shutdown Earthquake Category 1 structures at Mound Laboratory shall be founded on rock and shall be designed so that they can be safely shut down in the event ground accelerations at the site exceed those which are operationally tolerable. Consequently, an evaluation has been made of the degree of ground motion which is remotely possible, considering both seismic history and geologic structure. In developing the safe shutdown earthquake factor, consideration was given to the fact that there is a history of minor to moderate earthquake activity in the region which cannot be related directly to known tectonic features. Category 1 structures shall be designed for safe shutdown due to horizontal ground accelerations, at the rock surface at foundation level, of twenty percent of gravity (0.20g). These safe shutdown earthquake spectra, based on Newmark, are shown for various degrees of structural damping on Plate 7.2-2.

7.2.5.2. Operating Basis Earthquake On the basis of the seismic history of the area, the site probably will not be subjected to significant earthquake ground motion during the life of Mound Laboratory. However, Category 1 structures shall be conservatively designed to respond elastically, with no loss of function, to horizontal ground acceleration, on the rock surface at foundation level, of ten percent of gravity (0.10g). These operating basis earthquake spectra, also based on Newmark, are shown for various degrees of structural damping on Plate 7.2-3.

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7.3. SURFACE FAULTING

Based on the data contained in Section 7.1., Basic Geologic and Seismic Data, and Section 7.2., Vibratory Ground Motion, and the interpretation and conclusions from this data, there are no active faults within five miles of the site, as defined by the Atomic Energy Commission, Appendix A of 10 CFR, Part 100, November 1971.

A detailed description of the lithologic, stratigraphic and structural conditions of the site and the area surrounding the site, including its geologic history, is contained in Section 7.1.

All historically reported earthquakes within 200 miles of the site are detailed in Section 7.2.

Based on the data contained in the above mentioned subsections, surface faulting is not a factor in the design for Mound Laboratory.

7.4. STABILITY OF SUBSURFACE MATERIALS

This section presents an evaluation of the stability of the soil and rock beneath Mound Laboratory foundations during the vibratory motion associated with the Safe Shutdown Earthquake. The amount of motion that can be expected is discussed in Section 7.2.4., Engineering Seismology Evaluation. The following evaluation is based on a review of available literature, field and laboratory tests, and the geophysical surveys conducted during this investigation.

7.4.1. Regional Subsidence or Uplift

The site as shown on Plate 7.1-38, is located on the eastern flank of the Indiana-Ohio platform. It is in a region which can be described as a structural high. Analysis of regional geological and geophysical data indicates that the earth's crust is stable in this area.

7.4.2. Site Stability

The two hilltop areas which provide foundation support to most of the buildings at Mound Laboratory are composed of shale and limestone bedrock overlain by a thin mantle of glacial till. These overlie a thick sedimentary sequence of shale, dolomite, limestone and sandstone which rest on precambrian basement rocks. The buildings located below elevation 760 are underlain by dense glacial soils which are supported by the same sequence of sedimentary rocks as the

hilltop areas.

There are no known faults within the site area. Subsidence due to mining activity or petroleum production is not a potential problem since no such activity is known to exist in the vicinity.

No evidence of on-site folding within the Ordovician rocks has been observed. No unrelieved bedrock stresses are anticipated since numerous joints have been formed in response to regional forces.

There is no evidence of natural cavities existing within rock formations which could result in a sudden collapse or slow subsidence of rock foundations.

Instability of the rocks because of mineralogy, lack of consolidation, attitude, structure, or undesirable response to seismic events is not considered a problem. The relatively thick layer of glacial soils below elevation 760 is not subject to liquifaction effects as discussed in Section 7.1.11.6. The foundations of all existing Category 1 structures, and other structures which influence the safety of Category 1 structures are designed to maintain an adequate factor of safety during normal operating conditions and during the Safe Shutdown Earthquake as postulated for the site.

7.5. SLOPE STABILITY

Natural slopes at Mound Laboratory range from zero to approximately 20 degrees from the horizontal. Most of these slopes are composed of surficial soil (glacial till), 1-1/2 to 22 feet thick overlying bedrock.

In order to evaluate the stability of these slopes, values of unconfined compressive strength were obtained from previous foundation reports. These values are considered to be representative of the average strength of surficial soils at the site. No measurements of the coefficient of internal friction were available from the previous reports so the analysis is based completely on the conservative assumption that cohesion equals one-half the unconfined compressive strength of the soil (i.e., $\phi = 0$). Test values of internal friction (if available) would probably be too sporadic for use in the analysis due to the extremely variable nature of the sand and gravel content in the glacial till soil samples.

The 21 values of unconfined compressive strength for samples of surficial glacial till were first analyzed statistically to remove any apparently anomalous data. The 12 values which remained within three standard deviations of the mean were

used for analysis and are presented on Table 7.5-1. Values outside of this range were discarded as being not representative or, for some reason, anomalous.

A statistical mean and standard deviation for the 12 valid strength values was then determined and used to generate a stability analysis of an infinite slope. Again for conservative design, it was assumed that the soil strength was equal to a range of values between one and two standard deviations below the mean. A value of wet unit weight equal to 150 lb/cubic foot was assumed for the soil mass.

The results of this analysis showing the range of critical slope angle and depth to bedrock for the assumed soil conditions, and the range of existing surficial soil conditions at Mound Laboratory is presented on Plate 7.5-1, Slope Stability Analysis. This graph demonstrates that natural soil slopes and depths to bedrock are less than failure conditions, assuming that the C = 1300 psf line is representative of the weakest soil mass likely to exist on the site. If the average soil strength on the site is represented by the mean value of cohesion (C - 3100 psf), then the factor of safety against a slope failure is about 2.35 for soil conditions approximated by the C = 1300 psf line.

Based on the preceding analysis, natural soil slopes at Mound Laboratory are judged to be in a stable condition. Artificial slopes composed of fill materials (both existing and future) are not included in this analysis and must be evaluated on an individual basis. No records of test data for fill materials were available for analysis of any artificial slopes which now exist at Mound Laboratory. However, all engineered backfills which were controlled during placement were compacted to a density of not less than 90 percent of maximum density as determined by the ASTM-D1557 (Modified AASHO) compaction test standard. Engineered backfills are limited to a maximum slope of 26 degrees (2:1) and are assumed to be substantially stronger than natural soil slopes.

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Table 7.1.4-1 Ambient Vibration Analysis

Location (Boring Number)	Approximate Frequency Content (Hertz)	Gain*	Ground Motion in Inches x 10^3		
			Radial	Vertical	Transverse
1	30, 36	D x 20,000	.00275	-	.0015
	30, 72	A x 200	.225	.125	.15
	30, 72	V x 2,000	.285	.125	.20
2	4.5	D x 20,000	.0045	.00125	.00525
	70 to 80	A x 200	.225	-	.15
	50 to 60	V x 2,000	.0675	.0675	.065
3	5.5, 10	D x 20,000	.005	.003	.00105
	50	A x 200	.05	-	.15
	10, 22, 60 to 70	V x 2,000	.095	.06	.125
4	29	D x 5,000	.003	.003	.005
	35, 150	A x 50	.30	.50	.80
	30, 150	V x 500	.30	.34	.48
5 & 6	4, 150	D x 20,000	.00325	.003	.004
	37.5, 150	A x 200	.10	.10	.125
	35, 75	V x 2,000	.08	.065	.1175

* D=Displacement (inches) A=Acceleration (inches/second/second) V=Velocity (inches/second)

Table 7.1.5-1 Uniaxial compression tests on rock cores

Boring No.	Depth (feet)	Elevation (Plant Datum)	Ultimate Compressive Strength (psi)	"Static" Young's Modulus (psi)	"Static" Poisson's Ratio	Sample Description
1	10	876.3	14,210	11.5×10^6	.44	Limestone
1	29	857.3	8,630	--	--	Shale w/limestone stringers & shell fragments
1	31	855.3	13,770	8.5×10^6	.41	Limestone w/thin shale partings
1	37-1/2	848.8	7,210	1.1×10^6	.38	Shale w/occasional shell fossils
1	47-1/2	838.8	5,650	0.8×10^6	.11	Shale w/occasional shell fossils
1	61	825.3	16,750	4.6×10^6	.15	Limestone
1	71-1/2	814.8	19,510	10.3×10^6	.33	Limestone
1	106	780.3	9,410	1.2×10^6	.10	Shale
2	11	862.1	8,410	2.7×10^6	.36	Shale w/limestone stringers & shell fossils
2	18	855.1	6,960	0.9×10^6	.18	Shale w/limestone stringers & shell fossils
2	21	852.1	11,760	1.8×10^6	.23	" " "
2	27	846.1	6,270	0.8×10^6	.25	Shale w/occasional shell fossils
2	31	842.1	12,550	5.0×10^6	.26	Fossiliferous limestone
2	57	816.1	17,410	9.4×10^6	.33	Limestone w/thin shale partings
2	120-1/2	752.6	7,340	1.9×10^6	--	Shale

Table 7.1.5-1 (Continued)

Boring No.	Depth (feet)	Elevation (Plant Datum)	Ultimate Compressive Strength (psi)	"Static" Young's Modulus (psi)	"Static" Poisson's Ratio	Sample Description
3	43	764.3	9,535	1.7×10^6	.33	Shale w/occasional shell fossils
4	63	691.0	16,154	4.6×10^6	.17	Fossiliferous limestone
5	100	629.5	6,148	1.1×10^6	.21	Shale w/limestone stringers & shell fragments
6	98-1/2	638.5	5,740	1.0×10^6	.25	Shale w/occasional shell fragments

Tests performed by Bowser-Morner Testing Laboratories, Inc., Dayton, Ohio

Table 7.1.5-2 Brazilian tensile test data for rock cores

Boring No.	Depth (feet)	Elevation (Plant Datum)	Tensile Strength (psi)	Description
1	8-1/2	877.8	1016	Limestone
1	17	869.3	1146	Limestone
1	23	863.3	956	Limestone
1	26	860.3	451	Shale w/occasional Limestone Stringers
1	42	844.3	1063	Limestone
1	49-1/2	836.8	835	Shale w/occasional Shell Fossils
1	53-1/2	832.8	1182	Limestone
1	54-1/2	831.8	943	Shale
2	7-1/2	865.6	895	Limestone
2	19	854.1	1028	Limestone
2	20-1/2	852.6	965	Limestone
2	33	840.1	1007	Limestone
2	44	829.1	676	Shale
2	45	828.1	572	Shale
2	57-1/2	815.6	864	Limestone
2	120	753.1	856	Shale
3	47-1/2	759.9	723	Shale
5	78-1/2	651.0	1274	Fossiliferous Limestone
6	75	662.0	381	Shale

Average, 11 Limestone Samples: 1036 psi.

Average, 8 Shale Samples: 680 psi.

Table 7.1.5-3 Unconfined compression tests on soil

Boring No.	Depth (feet)	Elevation (Plant Datum)	Unconfined Compressive Strength (psf)
4	37.5	716.5	500
5	23.0	706.5	3600
5	33.0	696.5	1100
6	7.5	729.5	2000
6	15.0	722.0	1200

Moisture and Density Data are given on Table 7.1.5-10.

Table 7.1.5-4 Unconfined compressive strength data for glacial till soils

Depth (feet)	Unconfined Compressive Strength (psf)
0.0- 1.5	9,568
2.5- 4.5	7,207
3.0- 4.5	6,874
3.5- 5.0	14,421
3.5- 5.5	4,918
3.9- 4.4	2,020
4.0- 4.5	5,120
4.0- 4.5	6,495
4.5- 6.0	11,317
5.0- 6.0	7,582
7.0- 7.5	2,920
7.7- 8.2	8,467
8.1- 8.6	10,970
9.5-11.0	14,537
12.3-12.8	2,684
14.0-16.0	3,802
14.5-16.5	4,715
15.0-17.0	4,051
38.5-39.0	3,015
39.0-39.5	2,396
39.5-40.0	5,599

Data from previous foundation reports by Bowser-Morner Testing Laboratories, Inc., Dayton, Ohio

Table 7.1.5-5 Triaxial compression test data (unconsolidated-undrained)

Boring No.	Depth (feet)	Elevation (Plant Datum)	Dry Density (pcf)	Moisture Content (percent)	Confining Pressure* (psf)	Ultimate Deviator Stress (psf)	Failure Strain (percent)
4	5	749	131.6	10.5	778	4,230	9.98
4	15.5	738.5	136.5	8.8	2,200	3,208	13.33
4	22.0	732	136.4	8.9	2,794	14,207	13.86
4	32.5	721.5	124.8	10.5	3,650	5,000+	9.2
5	3	726.5	130.3	11.0	504	8,281	9.50
5	13	716.5	139.7	8.4	1,900	7,747	16.67
5	18	711.5	136.8	8.0	2,750	13,350	15.1
5	28	701.5	137.3	7.8	4,600	1,929	12.33

* Approximate effective overburden pressure.

Table 7.1.5-6 Dynamic properties test data

Boring No.	Depth (feet)	Single Amplitude Shear Strain (percent)	Modulus of Elasticity (psf)	Modulus of Rigidity (psf)	Hysteritic Damping (percent)
4	13	0.0065	5.58×10^6	1.99×10^6	14
		0.0109	4.99×10^6	1.78×10^6	13
		0.0212	3.73×10^6	1.33×10^6	13
		0.0386	2.84×10^6	1.01×10^6	15
		0.0747	1.88×10^6	0.67×10^6	18
		0.1544	1.06×10^6	0.38×10^6	23
		0.2989	0.64×10^6	0.23×10^6	25
		0.6103	0.34×10^6	0.12×10^6	24
		1.2455	0.19×10^6	0.69×10^6	19
4	35	0.0058	7.06×10^6	2.62×10^6	11
		0.0109	5.98×10^6	2.21×10^6	10
		0.0208	4.87×10^6	1.80×10^6	10
		0.0381	4.16×10^6	1.54×10^6	10
		0.0738	3.01×10^6	1.11×10^6	12
		0.1476	2.00×10^6	0.74×10^6	14
		0.2857	1.26×10^6	0.46×10^6	16
		0.5714	0.78×10^6	0.29×10^6	17
		1.2500	0.41×10^6	0.15×10^6	17
5	16	0.0049	6.06×10^6	2.17×10^6	15
		0.0102	4.49×10^6	1.60×10^6	16
		0.0207	3.49×10^6	1.24×10^6	16
		0.0402	2.39×10^6	0.86×10^6	18
		0.0756	1.56×10^6	0.56×10^6	19
		0.1512	0.84×10^6	0.30×10^6	20
		0.3024	0.47×10^6	0.16×10^6	19
		0.6098	0.25×10^6	0.09×10^6	19
5	31	0.0056	9.17×10^6	3.27×10^6	9
		0.0103	7.48×10^6	2.67×10^6	11
		0.0207	5.70×10^6	2.04×10^6	11
		0.0427	3.85×10^6	1.37×10^6	15
		0.0769	2.85×10^6	1.02×10^6	17
		0.1514	1.70×10^6	0.61×10^6	20
		0.3027	0.89×10^6	0.32×10^6	22
		0.6103	0.43×10^6	0.15×10^6	20

Table 7.1.5-6 (Continued)

Boring No.	Depth (feet)	Single Amplitude Shear Strain (percent)	Modulus of Elasticity (psf)	Modulus of Rigidity (psf)	Hysteritic Damping (percent)
6	24	0.0068	6.14×10^6	2.19×10^6	4
		0.0116	5.69×10^6	2.03×10^6	6
		0.0214	4.72×10^6	1.68×10^6	7
		0.0427	3.49×10^6	1.24×10^6	10
		0.0729	2.48×10^6	0.88×10^6	14
		0.1583	1.24×10^6	0.44×10^6	18
		0.3016	0.67×10^6	0.24×10^6	21
		0.5027	0.81×10^6	0.28×10^6	19

All tests were conducted at a confining pressure equal to the effective overburden pressure.

Moisture and density data are given on Table 7.1.5-10.

Table 7.1.5-7 Resonant column test data

Boring No.	Depth (feet)	Confining Pressure (psf)	Shear Strain Amplitude (percent)	Shear Wave Velocity (ft./sec.)	Modulus of Rigidity (psf)	Damping (percent)
1	122	8640.0	0.0048×10^{-3}	2270	25.79×10^{6}	4
		11520.0*	0.0055×10^{-3}	2124	22.59×10^{6}	5
		14400.0	0.0060×10^{-3}	2022	20.48×10^{6}	3
4	5	475.2	0.0493×10^{-3}	637	1.81×10^{6}	5
		777.6*	0.0474×10^{-3}	653	1.90×10^{6}	6
		1555.2	0.0471×10^{-3}	656	1.92×10^{6}	-
4	22	1540.8	0.0959×10^{-3}	498	1.14×10^{6}	4
		2793.6*	0.1137×10^{-3}	708	2.29×10^{6}	4
		5587.2	0.1051×10^{-3}	845	3.28×10^{6}	4
5	3	309.6	0.0871×10^{-3}	426	0.81×10^{6}	4
		504.0*	0.1085×10^{-3}	452	0.92×10^{6}	4
		999.4	0.1429×10^{-3}	617	1.71×10^{6}	7
5	18	1656.0	0.1450×10^{-3}	347	0.55×10^{6}	4
		2750.4*	0.1364×10^{-3}	634	1.84×10^{6}	4
		5500.8	0.1329×10^{-3}	1099	5.54×10^{6}	5
6	34	3117.6	0.0759×10^{-3}	589	1.59×10^{6}	4
		5198.4*	0.1025×10^{-3}	954	4.17×10^{6}	4
		10396.8	0.9036×10^{-3}	1196	6.55×10^{6}	5

* Approximately equal to effective overburden pressure.

Moisture and Density data are given on Table 7.1.5-10.

Table 7.1.5-8 Permeability tests on rock

Boring No.	Depth (feet)	Classification	Effective Porosity	Vertical Permeability	Threshold Pressure
1	34	Shale	6.3%	.000001-md	500 + psi
1	49	Shale	2.9%	.000001-md	500 + psi
1	60-1/2	Shale	1.4%	.000001-md	500 + psi
2	34	Shale	7.1%	.000001-md	500 + psi
2	44	Shale	4.6%	.000001-md	500 + psi
2	62-1/2	Shale	2.0%	.000001-md	500 + psi

Units of Measurement:

Effective Porosity is the ratio of interconnected void volume to total volume, expressed in terms of percent.

Vertical Permeability is measured in units of millidarcys (md) which is related to gallons per day per square foot (gpd/sq.ft.) by the following equation:

1 millidarcy = 0.0182 gpd/sq.ft. (for water at 68°F.)

Threshold Pressure is the minimum pressure required to cause a fluid (water) to flow through the rock, expressed in pounds per square inch (psi).

Tests were performed by Geo-Engineering Laboratories, Inc.
Mt. Vernon, Illinois

Table 7.1.5-9 Permeability tests on soil

Boring	Depth (feet)	Elevation (Plant Datum)	Measured Vertical Permeability (cm/sec)
4	37.5	716.5	3.23×10^{-8}
4	48.5	705.5	5.59×10^{-2}
5	23.0	706.5	2.24×10^{-7}
5	33.0	696.5	3.06×10^{-8}
5	40.5	689.0	7.38×10^{-2}
6	7.5	729.5	3.32×10^{-6}
6	15.0	722.0	2.00×10^{-8}
6	36.0	701.0	7.3×10^{-9}

Table 7.1.5-10 Moisture-Density test results

Boring No.	Depth (feet)	Elevation (Plant Datum)	Moisture Content (percent)	Dry Density (pcf)	Other Tests	Soil or Rock Type
1	122.0	764.3	2.0	158.1	R.C.	Shale
4	5.0	749.0	10.5	130.1	R.C.& TX	Till
4	13.0	741.0	8.9	135.8	D.P.	Till
4	15.5	738.5	8.8	136.5	TX	Till
4	17.5	736.5	8.2	134.9	Con.	Till
4	22.0	732.0	8.9	136.4	R.C.& TX	Till
4	32.5	721.5	10.5	124.8	TX	Outwash
4	35.0	719.0	8.9	134.9	D.P.	Outwash
4	37.5	716.5	9.8	130.6	P&qu	Outwash
4	48.5	705.5	8.5	--	P	Outwash
5	3.0	726.5	11.0	130.3	R.C.& TX	Till
5	13.0	716.5	8.4	139.7	TX	Till
5	16.0	713.5	8.1	138.6	D.P.	Till
5	18.0	711.5	8.0	136.8	R.C.& TX	Till
5	23.0	706.5	9.0	136.6	P&qu	Till
5	28.0	701.5	7.8	137.3	TX	Till
5	31.0	698.5	10.2	132.8	D.P.	Till
5	33.0	696.5	10.9	130.6	P&qu	Till
5	40.5	689.0	9.2	126.1	P&GS	Outwash
6	7.5	729.5	10.9	129.8	P&qu	Till
6	10.5	726.5	9.5	129.7	Con.	Till
6	15.0	722.0	11.1	118.1	P&qu	Till
6	18.0	719.0	9.9	132.1	Con.	Till
6	24.0	713.0	9.5	138.4	D.P.	Till
6	25.5	711.5	8.9	136.1	Con.	Till
6	34.0	703.0	8.8	--	R.C.	Till
6	36.0	701.0	9.6	141.2	P&GS	Outwash

Key to Other Tests:
Con. = Consolidation
D.P. = Dynamic Properties Test
R.C. = Resonant Column Test
G.S. = Grain Size Distribution
P = Permeability
qu = Unconfined Compression
TX = Triaxial Compression

Table 7.1.5-11 Atterberg Limit test data

Boring No.	Depth (feet)	Elevation (Plant Datum)	Moisture Content in percent		
			Liquid Limit	Plastic Limit	Plasticity Index
4	5.0	749.0	23.4	13.3	10.1
4	12.5	741.5	20.9	11.4	9.5
4	17.5	736.5	15.2	11.8	3.4
4	22.0	732.0	20.4	12.5	7.9
5	3.0	726.5	24.3	14.6	9.6
5	16.0	713.5	17.6	11.1	6.5
5	18.0	711.5	19.7	14.4	8.3
5	31.0	698.5	19.2	12.2	7.0
6	10.5	726.5	16.9	5.6	11.3
6	18.0	719.0	14.9	10.0	4.9
6	24.0	713.0	18.7	12.1	6.6
6	25.5	711.5	13.9	10.0	3.9
6	34.0	703.0	20.2	11.7	8.5

Table 7.1.11-1 Ground water levels in borings on March 2, 1973

Boring	Depth to Water (in feet)	Water Elevation (Plant Datum)
1	10	876
2	45	828
3	3	804
4	15-1/2	738.5
5	44	685.5
6	53-1/2	683.5

NOTE: Borings 3, 4, 5 and 6 were left cased and open for future groundwater observations.

Table 7.1.11-2 Foundation data for major structures

Building Name or Number	Foundation Elevation	Foundation Type and Dimension	Foundation Material	Recommended Bearing Capacity (psf)	Design Bearing Capacity (psf)	Apparent Safety Factor
A	865' 8"	sq. footings w/ cont. wall (1'10" wide) sq. 4½ x 4½ x 1'3" (interior) x 1'8" (exterior) 6½ x 6½ central columns (wing units) 1'8" below basement floor level 5-12½ below 1st floor.	Rock	9000	8000	1.1
B	872' 6"-875	cont. wall 1'3" wide w/ sq. footings. 2½ x 2½ x 1'0" (exterior wall) 3'9" x 3'9" x 1'0" (interior wall), 3'3" x 3'3" to 5'3" x 5'3" (interior wall).	Rock	NA	8000	NA
E	875'-877'	cont. wall 1'0" wide w/ sq. footings 2½ x 2½ x 1½ (exterior wall) 3½ x 3½ to 4½ x 4½ (interior wall)	Rock	10,000	8000	1.25
HH	790'-804'	deep sq. footings up to 19' below floor slab 3' x 3' x 1' min. size.	Rock	NA	4000	NA

Table 7.1.11-2 (Continued)

Building Name or Number	Foundation Elevation	Foundation Type and Dimension	Foundation Material	Recommended Bearing Capacity (psf)	Design Bearing Capacity (psf)	Apparent Safety Factor
P	873' 6"-875'	sq. footings w/ cont. wall 1'0"-1'3" wide, size 3' X 3' x 1' to 5'3" x 5'3" x 1' 3½-8' deep.	Rock	5000	NA	NA
SD	fdn. 728' 6" to 793' 8" slabs-785'4"-786' 8".	cont. wall 1'8" thick 2'0" wide mat fdn. 1'8" thick beneath disposal facilities-approx. 12' deep.	Till	3000	NA	NA
W	871'-874'	cont. wall (0'6" above sq. fittings) w/ sq. footings 3'x 3' x 1' to 4½'x4½'x1' 4½'-7' below floor slab.	Rock	12,000	4000	3.0
DS	866'	drilled piers onto "T" building 2' in diameter. T building is set on rock.	"T" building	NA	NA	NA
SM	874'-879'	square footings 3'x3' x1'3" - 3' deep.	Rock	5000	NA	NA
I	858' 6" - 860'	square footings & basement 3'x3'x1'6" exterior & interior	Rock	NA	8000	NA

Table 7.1.11-2 (Continued)

Building Name or Number	Foundation Elevation	Foundation Type and Dimension	Foundation Material	Recommended Bearing Capacity (psf)	Design Bearing Capacity (psf)	Apparent Safety Factor
		walls except 1 interior 4½'x4½'x1'4" wall. 2'9"-3'6" below basement. 8-10' below floor slab.				
M	875' 6"	square footings. 4'x4'x1' on interior walls-3'x3'x1' on exterior walls-3'0" deep	Rock	NA	7000	NA
3	743'-744' 6"	cont. wall footings-exterior walls 1'6"-2'0" wide 9'10"-1'0" thick-3'0" below soil grade- square spreads on interior columns 2'x2'x1'.	Till	7000	4000	1.75
2	743' 10"	continuous wall footings-exterior walls 1'10" wide-0'8" thick 3'0" min. below soil grade.	Till	NA	4000	NA
R-E	874'	2' diam. caissons to rock & 2' into rock. approx. 13' apart, 1'1" wall footing rests on caissons. Used R&E footings on shared walls.	Rock	16,000	NA	NA

Table 7.1.11-2 (Continued)

Building Name or Number	Foundation Elevation	Foundation Type and Dimension	Foundation Material	Recommended Bearing Capacity (psf)	Design Bearing Capacity (psf)	Apparent Safety Factor
WD	773' 2"-791' 6"	cont. wall footings 2'4"-4'4" wide and 1'0"-1'4" thick. Concrete mats 1'0"-1'4" thick for clariflocculators.	Rock	12,000	4000	3.0
R	875' 0"	cont. wall footings 1'3" wide w/ sq. footings 2½'x2½'- 3½'x 3½'	Rock	NA	8000	NA
SW	872' 5"-876' 5"	cont. wall footings 1'6" wide w/ sq. footings 2'x2' to 3½'x3½'	Rock	NA	10,000-15,000	NA
21	868'	mat 1'0"-1'4" thick 3'0" below finish grade.	Weath. Rock?	NA	4000	NA
50	873' 4"-879' 8"	basement w/cont. wall footings-1'8"-2'0" wide & 5½'-8' below ground level.	Rock	6000	6000	1.0
T	809' 6"	7'2" thick reinforced concrete slab set on rock	Rock	NA		
38	873'-877' 6"	cont. wall footings 2'6" wide & 1'0" thick w/sq. fittings at	Rock	15,000	10,000	1.5

Table 7.1.11-2 (Continued

Building Name or Number	Foundation Elevation	Foundation Type and Dimension	Foundation Material	Recommended Bearing Capacity (psf)	Design Bearing Capacity (psf)	Apparent Safety Factor
Radioactive Waste Line	740'-870'	3'0" of earth cover wrapped w/4" foam-glass insulation.	Till & Rock	NA	NA	NA
Stacks #2, #3, #4	#2-min. 875' #3-min. 873' #4-min. 871'	#2-4' thick pier 16' in diam. at base #3-6' thick pier 28' in diam. at base #4-8' thick pier 28' in diam. at base	Rock	NA	5000	NA
Elevated Tank	868' 6"-871' 9"	5 piers 9'8"x9'8" 11" thick @ base w/ 3'4" stem depth 8'3"-11'6"	Rock	NA	5000	NA
SW Add.	top of SW bldg.	matched columns w/ SW bldg.	top of SW bldg.	NA	5000	NA
Nuclear Comp. Devel. & Repro. Facility SW Add.	870'-872'	sq. footings w/ cont. wall. 2'6" above & 1'1" thick wall-4'x4' x1½'. interior column 5½'x5½'x1½'- 9' below floor elev.	Rock	NA	NA	NA
Operational Support Facility	869' 4"-876' 10"	sq. footings w/cont. wall 1'0" wide-sizes vary: 6'x6'x1' (2' depth) to 13½'x13½'x1½' (3½' depth)	Rock	NA	NA	NA

Table 7.1.11-2 (Continued)

Building Name or Number	Foundation Elevation	Foundation Type and Dimension	Foundation Material	Recommended Bearing Capacity (psf)	Design Bearing Capacity (psf)	Apparent Safety Factor
49	745' - 746' 2"	cont. wall footings 1'8"-2'6"- 1'0" thick 5 sq. footings interior 3'9"x3'9" to 6½'x6½' 2'10"-4'0" deep.	Rock	NA	4000	NA
42	731' 6"	cont. wall footings 1'0" wide 3'0" deep	Till	4000	NA	NA
37	867' 10"- 870'	deep cont. wall footings 1'4"x0'8"-10'6" below slab-2'x1'0"- 8' below slab.	Rock	10,000	4000	2.5
45 and 46	839' 0"	cont. wall footings 1'8" wide 3'0" deep	Rock	6000	NA	NA
43	min. 732'	piers to 6000 psf soil- min. 8' deep 2'0" diam. shaft w/Bell 3½'-6'	Till	6000	6000	1.0
36	879'-882'	cont. deep footings 1'0" thick-1'8", 2'0" 2'8" wide, min. 3' deep (6'-9' avg. depth).	Rock	6000	NA	NA
35	742'	cont. wall footings 3'6" deep- east wall 5' wide, 1' thick west wall 4'3" wide 1' thick-isolated columns 4'3" sq. x 1' thick.	Till	4000	NA	NA

Table 7.1.11-2 (Continued)

Building Name or Number	Foundation Elevation	Foundation Type and Dimension	Foundation Material	Recommended Bearing Capacity (psf)	Design Bearing Capacity (psf)	Apparent Safety Factor
W Add.	868' 8"	cont. wall footings 2'0"-2'1" wide, 1' thick 7' deep from floor slab.	Rock	12,000	NA	NA
48	809' - 831' 6"	caissons to rock 2' shaft bell 4'4" corner 6' min. into rock line 1'6" min. into rock.	Rock	7,000	7,000	1.0

NA: indicates information not available.

Apparent Safety Factor is the ratio between the recommended bearing capacity and the design bearing capacity.

Table 7.1.11-3 Summary of static and dynamic properties of subsurface materials

Formation		Glacial Till	Outwash	Richmond Group
CLASSIFICATION		CL-ML	GW	Shale & Limestone
POISSON'S RATIO		.40	.40	.28
ULTIMATE COMPRESSIVE STRENGTH (psf)		2×10^3 to 14×10^3	--	$.8 \times 10^6$ to 2.8×10^6
STATIC MODULUS OF ELASTICITY (psf)		$.4 \times 10^6$ to $.7 \times 10^6$	2×10^6 to 4×10^6	1×10^8 to 16×10^8
DYNAMIC MODULUS OF ELASTICITY (psf)				
Single Amplitude Shear Strain	1.0%	$.2 \times 10^6$ to $.4 \times 10^6$	$.4 \times 10^6$ to $.5 \times 10^6$	--
	0.1%	1.4×10^6 to 2.2×10^6	2.2×10^6 to 2.8×10^6	--
	0.01%	4.5×10^6 to 7.5×10^6	5×10^6 to 6×10^6	3.6×10^8 to 7.9×10^8 *
STATIC MODULUS OF RIGIDITY (psf)		$.1 \times 10^6$ to $.3 \times 10^6$	$.7 \times 10^6$ to 1.4×10^6	$.4 \times 10^8$ to 5.7×10^8
DYNAMIC MODULUS OF RIGIDITY (psf)				
Single Amplitude Shear Strain	1.0%	$.06 \times 10^6$ to $.12 \times 10^6$	$.14 \times 10^6$ to $.18 \times 10^6$	--
	0.1%	$.40 \times 10^6$ to $.85 \times 10^6$	$.85 \times 10^6$ to 1.0×10^6	--
	0.01%	1.6×10^6 to 2.2×10^6	2.0×10^6 to 2.2×10^6	1.4×10^8 to 3.2×10^8 *
DAMPING VALUES (PERCENT OF CRITICAL DAMPING)				
Single Amplitude Shear Strain	1.0%	19-22%	16-17%	--
	.1%	15-21%	12-13%	--
	.01%	9-15%	5-6%	5%*

*These values represent the upper range of the deformation moduli and are valid for strain levels on the order of 10^{-4} to 10^{-5} percent.

Table 7.2-1

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.

TABLE 7.2-2

EARTHQUAKE EPICENTERS, 1776-1973

36.5° - 42.5° N. LATITUDE 80.5° - 89.0° W. LONGITUDE

Note: Earthquakes of Intensity V or greater only are tabulated beyond a distance of 100 miles from the site. All known shocks within 100 miles of the site are indicated.

DATE	MMI	LOCATION	N. LAT.	W. LONG.	FELT AREA (SQ.MI.)
1776 Summer	VI	Southeast Ohio	---	---	---
1804 Aug 24	V	Fort Dearborn, Ill	42.0	87.8	30,000
1827 Aug 6	VI	New Albany, Ind	38.3	85.8	---
1827 Aug 7	VI	New Albany, Ind	38.3	85.8	---
1834 Nov 20	V	Northern, Ky	---	---	---
1841 Nov 27	V	Western Ky	---	---	---
1843 Feb 16	V	Ky	---	---	---
1850 Apr 4	V	Louisville, Ky	38.2	85.8	---
1854 Feb 28	VI	Lexington, Ky	38.1	84.5	---
1860 Aug 7	VI	Henderson, Ky	37.8	87.6	---
1869 Feb 20	V	Lexington, Ky	38.1	84.5	---
1875 Jun 18	VII	Anna, Ohio	40.2	84.0	40,000
1876 Jun	III	Anna, Ohio	40.2	84.0	Local
1876 Sep 25	VI	Evansville, Ind	38.5	87.7	60,000
1877 Jan 23	III	South Central Ohio	38.6	83.6	Local
1877 Aug 17	V	Near Detroit, Mich	42.3	83.3	200
1882 Feb 9	V	Anna, Ohio	40.2	84.2	Local
1883 Feb 4	VI	Kalamazoo, Mich	42.3	85.6	8,000
1884 Sep 19	VI	Anna, Ohio	40.7	84.1	125,000
1884 Dec 23	III	Anna, Ohio	40.2	84.3	Local
1887 Feb 6	V	Vincennes, Ind	38.7	87.5	75,000
1887 Aug 2	VI	Cairo, Ill	37	89	---
1889 Sep	II	Anna, Ohio	40.2	84.3	Local
1891 Jul 26	V	Evansville, Ind	37.5	87.9	---
1891 Sep 26	V	Cairo, Ill	37	89	---
1892 Summer	III	Anna, Ohio	40.2	84.3	Local
1896 Mar 15	IV	Anna, Ohio	40.2	84.3	Local
1897 May 31	VIII	Virginia	37.3	80.7	280,000
1899 Apr 29	VII	Southern Ind	38.5	87.0	40,000
1901 May 17	V	Southeast Ohio	39.3	82.5	7,000
1906 May 8	III-IV	Columbus, Ind	39.2	85.9	Local
1906 May 11	V	Petersburg, Ind	38.5	87.2	800
1906 May 21	V	Flora, Ill	37.5	88.5	---
1906 Jun 27	V	Fairport, Ohio	41.4	81.6	400
1909 May 26	VII	Illinois	42.5	89.0	500,000
1909 Sep 22	V	Southern Indiana	38.7	86.5	---
1909 Sep 27	VII	Indiana	39.0	87.7	30,000
1909 Oct 23	V	Indiana	39.0	87.7	8,000

TABLE 7.2-2 - Continued

DATE	MMI	LOCATION	N. LAT.	W. LONG.	FELT AREA (SQ.MI.)
1912 Jan 2	VI	Illinois	41.5	88.5	40,000
1914	II	Anna, Ohio	40.2	84.3	Local
1915 Oct 26	V	Mayfield, Ky	36.7	88.6	Local
1919 May 25	V	Southeastern Ind	38.5	87.5	18,000
1922 Mar 22	V	Southern Illinois	37.3	88.6	25,000
1925 Mar 27	V	Southwestern Ohio	---	---	---
1925 Apr 4	II	Cincinnati, Ohio	39.1	84.5	Local
1925 Apr 26	V	Indiana	38.0	87.5	100,000
1925 May 13	V	Edwardsville, Ill	36.7	88.6	3,000
1925 Sep 2	VI	Kentucky	37.8	87.6	75,000
1925 Oct	II	Anna, Ohio	40.2	84.3	Local
1926 Nov 5	VI	Southeast Ohio	39.1	82.1	350
1927 May 7	VII	Mississippi Valley	36.5	89.0	130,000
1928 Sep 9	V	Cleveland, Ohio	41.5	82.0	1,500
1928 Oct 27	III	Anna, Ohio	40.4	84.1	Local
1929 Mar 8	V	Anna, Ohio	40.3	84.2	5,000
1930 Jun 26	III	Anna, Ohio	40.5	84.0	Local
1930 Jun 27	IV	Anna, Ohio	40.5	84.0	Local
1930 Jul 10	II	Marion, Ohio	40.7	83.2	Local
1930 Sep 20	VI	Anna, Ohio	40.3	84.2	---
1930 Sep 30	VII	Anna, Ohio	40.3	84.3	---
1930 Oct	III	Anna, Ohio	40.2	84.3	Local
1931 Jan 5	V	Elliston, Ind	39.0	87.0	500
1931 Mar 21	II	Anna, Ohio	40.3	84.2	Local
1931 Apr 1	III	Anna, Ohio	40.4	84.1	Local
1931 Jun 10	V	Malinta, Ohio	41.6	84.0	---
1931 Sep 20	VII	Anna, Ohio	40.2	84.3	40,000
1931 Oct 8	III	Anna, Ohio	40.2	84.3	Local
1933 Feb 22	III	Anna, Ohio	40.3	84.2	Local
1933 May 28	V	Maysville, Ky	38.7	83.7	600
1936, Oct 8	III	Cincinnati, Ohio	39.1	84.5	Local
1936 Dec 26	III	Cincinnati, Ohio	39.1	84.5	2 Shocks
1937 Mar 2	VII	Anna, Ohio	40.7	84.0	110,000
1937 Mar 3	V	Anna, Ohio	40.5	84.0	Local
1937 Mar 9	VIII	Anna, Ohio	40.6	84.0	150,000
1937 Apr 23	III	Anna, Ohio	40.2	84.3	Local
1937 Apr 27	III	Anna, Ohio	40.3	84.2	Local
1937 May 2	III	Anna, Ohio	40.3	84.2	Local
1937 Oct 16	III	Cincinnati, Ohio	39.1	84.5	Local
1939 Mar 18	II	Anna, Ohio	40.3	84.2	Local
1939 Mar 18	III	Anna, Ohio	40.4	84.1	Local
1939 Jun 17	IV	Anna, Ohio	40.4	84.1	Local
1939 Jul 9	II	Anna, Ohio	40.4	84.1	Local

TABLE 7.2-2 - Continued

DATE	MMI	LOCATION	N. LAT.	W. LONG.	FELT AREA (SQ.MI.)
1943 Mar 9	V	Lake Erie	42.2	80.9	40,000
1944 Nov 13	III	Anna, Ohio	40.2	84.2	Local
1947 Mar 26	VI	Paducah, Ky	37.0	88.4	Local
1947 Aug 9	VI	Southcentral Michigan	42.0	85.0	50,000
1948 Feb 9	VI	Campbell Co, Tenn	36.5	88.1	---
1950 Apr 20	III	Dayton, Ohio	39.7	84.2	Local
1952 Jun 20	VI	Zanesville, Ohio	39.8	82.2	10;000
1955 May 26	V	Cleveland, Ohio	41.5	81.7	Local
1955 Jun 28	V	Cleveland, Ohio	41.5	81.7	Local
1956 Jan 27	V	Anna, Ohio	40.2	84.2	---
1957 Mar 26	V	Paducah, Ky	37.0	88.4	Local
1957 Jun 23	V	Hardin Valley, Tenn	36.5	84.5	---
1958 Jan 27	V	Ill, Ky, Mo Border	37	89	300
1958 May 1	V	Cleveland, Ohio	41.3	81.4	Local
1958 Nov 7	VI	Ill, Ind Border	38.4	87.9	33,000
1961 Feb 22	V	Findlay, Ohio	41.2	83.4	Local
1962 Jun 26	V	Southern Ill	37.7	88.5	---
1963 Aug 2	V	Ill-Ky Border	37.0	88.8	---
1967 Apr 8	V	Columbus, Ohio	39.6	82.5	4,000
1968 Jul 26	II-III	Anna, Ohio	---	---	(Willis, D., U. of Mich, unpublished)
1968 Nov 9	VII	Southwestern Ill	38.0	88.5	580,000 (M=5.5)
1968 Dec 11	V	Kentucky	37.0	85.5	---
1969 Nov 19	VI	West Virginia	37.5	81.0	100,000

Table 7.5-1 Values of unconfined compressive strength of surficial glacial till soils used in slope stability analysis

Bowser-Morner

Report Date	Building Area	Sample Depth (feet)	Unconfined Compressive Strength (psf)	Wet Density (pcf)
Dec. 7, 1962	3	0.0-1.5	9568	159
Dec. 7, 1962	3	3.5-5.5	4918	125
Dec. 7, 1962	3	14.5-16.5	4715	151.5
Dec. 7, 1962	3	39.5-40.0	5599	151
Sep. 17, 1965	35	3.0-4.5	6874	143.5
Sep. 17, 1965	35	7.7-8.2	8467	148.4
Feb. 2, 1967	3	4.0-4.5	6495	150
Mar. 11, 1964	S2750 W3625	5.0-6.0	7582	157.3
Mar. 11, 1964	S2000 W1800	2.5-4.5	7207	149
Jan. 25, 1969	3	4.0-4.5	5120	146.8
Jul. 10, 1967	42	14.0-160	3802	117.4
Jul. 10, 1967	42	15.0-17.0	4051	128.6

Mean = 6199.8 psf

Standard Deviation = 1815 psf

Average cohesion = 3100 psf

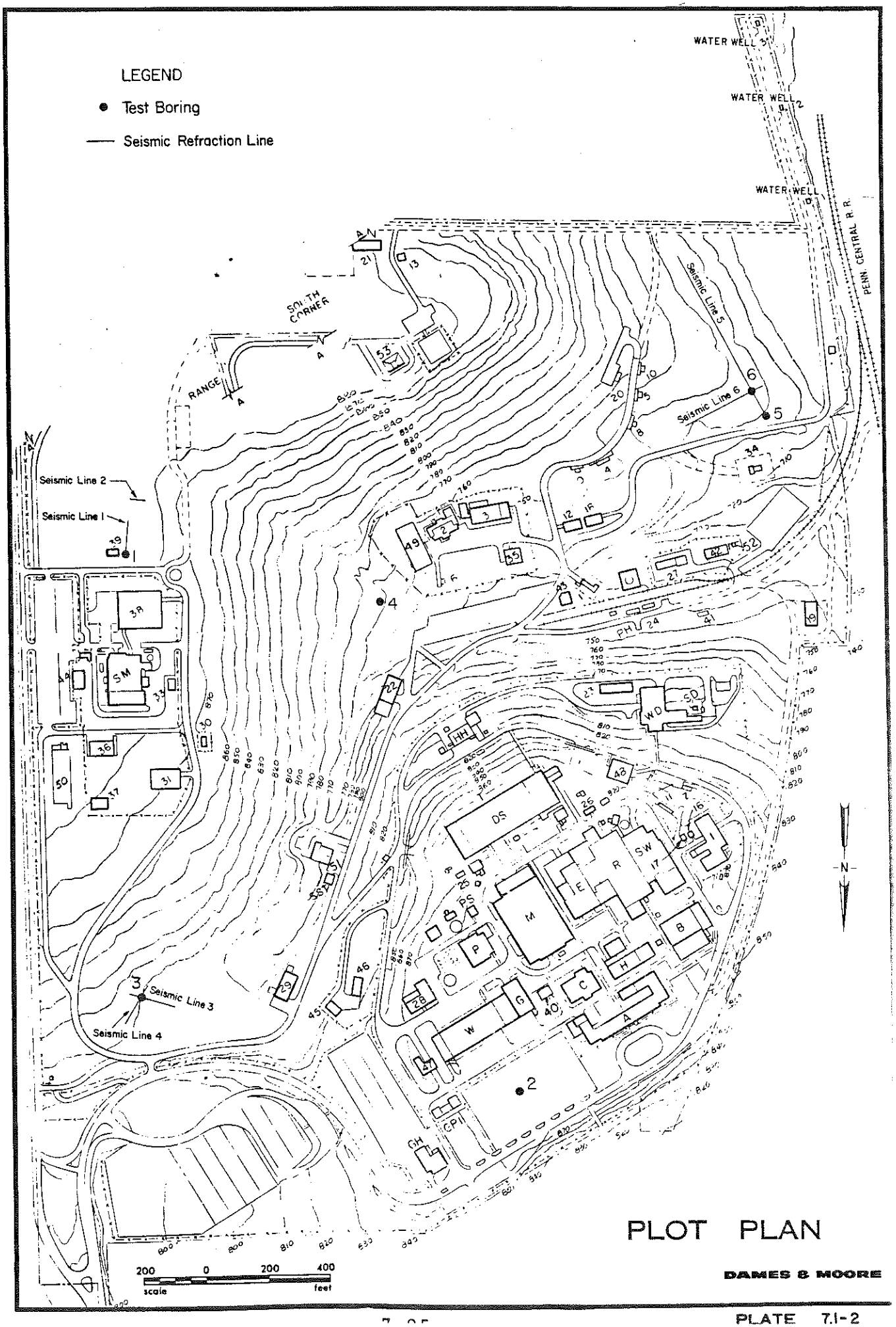
Average cohesion minus 1 S.D. ≅2200 psf

Average cohesion minus 2 S.D. ≅1300 psf

Site Vicinity Map

Adapted from, Div. of Geological Survey –
Ohio Dept. of Natural Resources

DAMES & MOORE

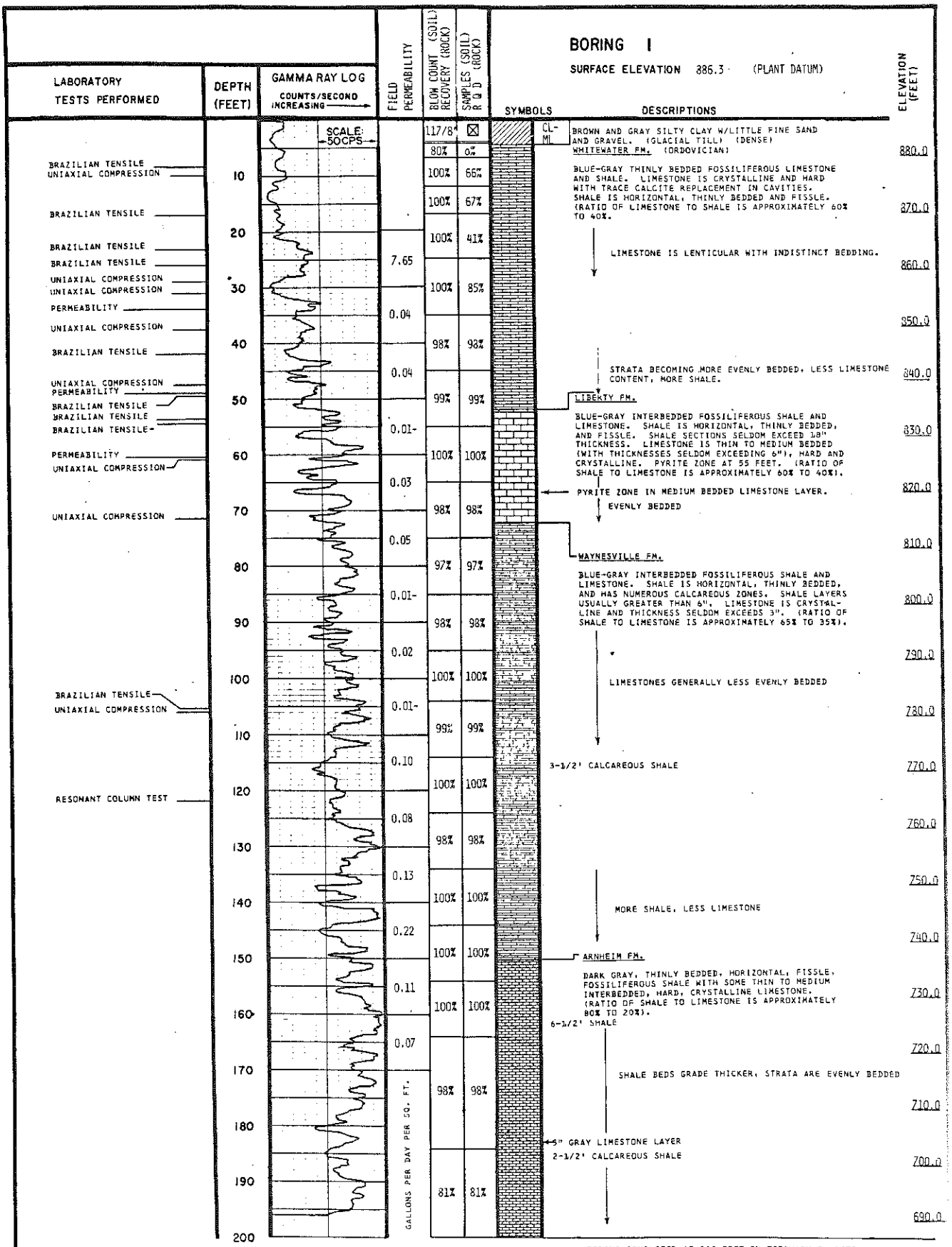


PLOT PLAN

DAMES & MOORE

BORING I

SURFACE ELEVATION 886.3 (PLANT DATUM)



BORING COMPLETED AT 200 FEET ON FEBRUARY 5, 1973.

TWO-INCH DIAMETER SPLIT SPOON SAMPLER DRIVEN BY A 140 LB. HAMMER FALLING 30 INCHES.

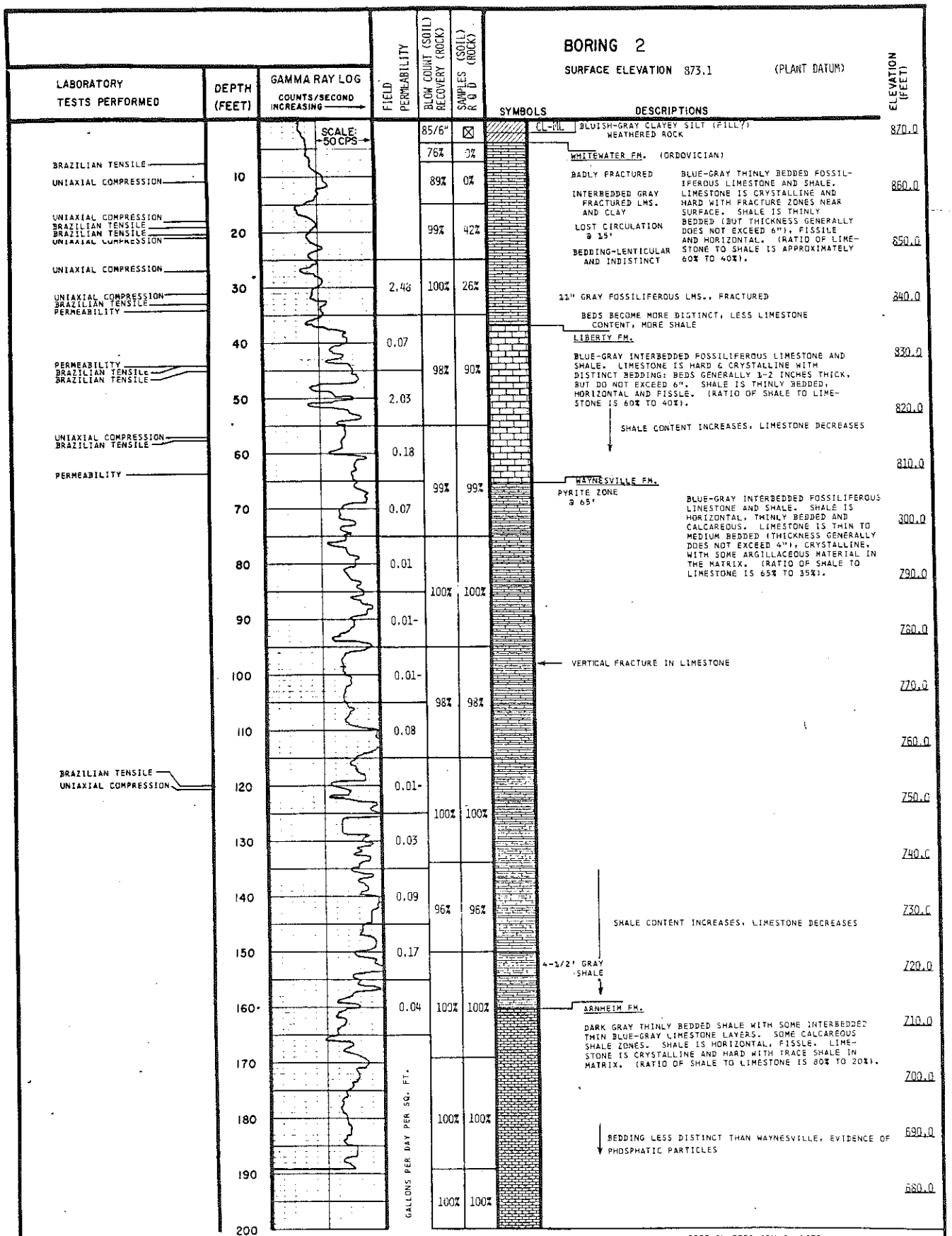
DEPTH TO WATER WAS 10 FEET ON MARCH 2, 1973.

LOG OF BORING

DAMES & MOORE

BORING 2

SURFACE ELEVATION 873.1 (PLANT DATUM)



BORING COMPLETED AT 200 FEET ON FEBRUARY 8, 1973

TWO-INCH DIAMETER SPLIT SPOON SAMPLER DRIVEN BY A 140 LB. HAMMER FALLING 30 INCHES.

DEPTH TO WATER WAS 45 FEET ON MARCH 2, 1973.

LOG OF BORING

DAMES & MOORE

BORING 3

SURFACE ELEVATION 807.3 (PLANT DATUM)

LABORATORY TESTS PERFORMED	DEPTH (FEET)	GAMMA RAY LOG COUNTS/SECOND INCREASING →	FIELD PERMEABILITY	BLOW COUNT (SOIL) RECOVERY (ROCK)	SAMPLES (SOIL) R Q D (ROCK)	SYMBOLS	DESCRIPTIONS	ELEVATION (FEET)
				13				
				22		CL-ML	BROWN, CLAYEY SILT W/LITTLE FINE - COARSE SAND, TRACE OF GRAVEL (GLACIAL TILL) (DENSE)	800.0
				25				
				16				
	10			60/11"				
				50/3"		ML	BROWN, CLAYEY SILT W/LITTLE FINE - COARSE SAND, INTERBEDDED WITH BLUISH-GRAY WEATHERED SHALE.	790.0
				50/4"				
	20			50/4"			BLUISH-GRAY WEATHERED SHALE W/LIMESTONE FRAGMENTS.	
							TOP OF HARD BEDROCK	780.0
				90%	35%		CLAY & LIMESTONE	
	30						WAYNESVILLE FM. (ORDOVICIAN)	
				100%	92%		4" CLAY & LIMESTONE 7" LMS. LAYER BLUE-GRAY INTERBEDDED FOSSILIFEROUS LIMESTONE AND SHALE. SHALE IS HORIZONTAL, THINLY BEDDED AND CALCAREOUS. LIMESTONE IS THIN TO MEDIUM BEDDED, BUT THICKNESS DOES NOT NORMALLY EXCEED 4". WHEN BEDDING IS DISTINCT, LIMESTONE IS CRYSTALLINE. (RATIO OF SHALE TO LIMESTONE IS APPROXIMATELY 65% TO 35%).	770.0
	40							
UNIAXIAL COMPRESSION				83%	83%		SHALE CONTENT INCREASE, LIMESTONE BEDS BECOME FEWER AND LESS DISTINCT	760.0
BRAZILIAN TENSILE	50						BORING COMPLETED AT 50 FEET ON FEBRUARY 9, 1973. TWO-INCH DIAMETER SPLIT SPOON SAMPLER DRIVEN BY A 140 LB. HAMMER FALLING 30 INCHES.	750.0

DEPTH TO WATER WAS 3 FEET ON MARCH 2, 1973.

LOG OF BORING

DAMES & MOORE

BORING 4

SURFACE ELEVATION 754.0 (PLANT DATUM)

LABORATORY TESTS PERFORMED	DEPTH (FEET)	GAMMA RAY LOG (COUNTS/SECOND INCREASING →)	FIELD PERMEABILITY	BLOW COUNT (SOIL) RECOVERY (ROCK)	SAMPLES (SOIL) R Q D (ROCK)	SYMBOLS	DESCRIPTIONS	ELEVATION (FEET)
RESONANT COLUMN TEST TRIAXIAL COMPRESSION TEST & GRAIN SIZE		SCALE: 100CPS		10 26 39		CL-ML	TOPSOIL	750
GRAIN SIZE & DYNAMIC PROPERTIES TEST TRIAXIAL COMPRESSION TEST CONSOLIDATION TEST	10			45 50 30 60		CL-ML	MOTTLED BROWN & GRAY CLAYEY SILT WITH LITTLE FINE-COARSE SAND, TRACE OF GRAVEL. (GLACIAL TILL) (DENSE) (GRADING MORE SAND AND GRAVEL).	740
TRIAXIAL COMPRESSION TEST & RESONANT COLUMN TEST & GRAIN SIZE	20			38 34 39 78		GW	MOTTLED BROWN & GRAY, SILTY, FINE TO COARSE SAND AND GRAVEL. (DENSE)	730
TRIAXIAL COMPRESSION TEST DYNAMIC PROPERTIES TEST & GRAIN SIZE PERMEABILITY & UNCONFINED COMPRESSION	30 40			62 64 50 104 34 40				720
PERMEABILITY & GRAIN SIZE	50			130 90%	90%	80% LMG. 20% SH.	BLUISH-GRAY WEATHERED SHALE ARNHEIM FM. (ORDOVICIAN)	700
UNIAXIAL COMPRESSION	60 70			99%	78%	85% - 90% SH. WITH SOME CALCAREOUS ZONES	DARK GRAY INTERBEDDED SHALE AND LIMESTONE WITH SOME FOSSILS AND TRACE PHOSPHATIC NODULES. SHALE IS HORIZONTAL, THINLY BEDDED AND VERY FISSLE. LIMESTONE IS ABUNDANT IN UPPER SECTION, THIN TO MEDIUM BEDDED, AND CRYSTALLINE. DECREASES ABRUPTLY AT APPROXIMATELY 55' WHERE BEDDING BECOMES INDISTINCT. (RATIO OF SHALE TO LIMESTONE IS 80% TO 20%). (LIMESTONE BEDS SELDOM EXCEED 4" IN THICKNESS).	690 680

BORING COMPLETED AT 75 FEET ON FEBRUARY 11, 1973.

DAMES & MOORE TYPE U SAMPLER DRIVEN BY A 300 LB. HAMMER FALLING 24 INCHES.

DEPTH TO WATER WAS 15-1/2 FEET ON MARCH 2, 1973.

LOG OF BORING

DAMES & MOORE

PLATE 7.1-6

BORING 5

SURFACE ELEVATION 729.5 (PLANT DATUM)

LABORATORY TESTS PERFORMED	DEPTH (FEET)	GAMMA RAY LOG COUNTS/SECOND INCREASING →	FIELD PERMEABILITY	BLOW COUNT (SOIL) RECOVERY (ROCK)	SAMPLES (SOIL) R Q D (ROCK)	SYMBOLS	DESCRIPTIONS	ELEVATION (FEET)
TRIAXIAL COMPRESSION TEST & RESONANT COLUMN TEST & GRAIN SIZE		SCALE: ←50CPS→		39, 34		CL-ML	BROWN CLAYEY SILT WITH LITTLE FINE - COARSE SAND, TRACE OF GRAVEL (GLACIAL TILL) (DENSE)	
	10			40, 36			(COLOR CHANGING TO GRAY)	720
TRIAXIAL COMPRESSION TEST; DYNAMIC PROPERTIES TEST & GRAIN SIZE				42, 39				
TRIAXIAL COMPRESSION TEST & RESONANT COLUMN TEST & GRAIN SIZE	20			36, 52				710
PERMEABILITY & UNCONFINED COMPRESSION				44, 36				
TRIAXIAL COMPRESSION TEST; DYNAMIC PROPERTIES TEST & GRAIN SIZE; PERMEABILITY & UNCONFINED COMPRESSION	30			41, 28, 32				700
				150/3", 150/5"		GW	BROWN, SILTY, FINE - COARSE SAND AND GRAVEL (VERY DENSE)	
PERMEABILITY & GRAIN SIZE	40			197, 220/9", 100			(GRADING COARSER)	690
	50			173/10", 57				680
							WEATHERED BEDROCK	
	60			75%	35%		TOP OF HARD ROCK	670
							ARNHEIM FM. (ORDOVICIAN)	
	70			95%	51%		DARK GRAY INTERBEDDED LIMESTONE AND SHALE WITH SOME FOSSILS AND TRACE PHOSPHATIC NODULES. SHALE IS HORIZONTAL, THINLY LAMINATED TO THIN BEDDED, AND VERY FISSLE. INDIVIDUAL SECTIONS MAY REACH SEVERAL FEET IN THICKNESS. LIMESTONE IS THIN TO MEDIUM BEDDED, CRYSTALLINE WHERE THE BEDDING IS DISTINCT, AND HARD. BEDS SELDOM EXCEED 4" THICKNESS IN THIS SECTION.	660
				100%	80%		55% SHALE, 45% LMS.	
BRAZILIAN TENSILE	80			100%	73%			650
	90			100%	84%			640
UNIAXIAL COMPRESSION	100						SHALE INCREASES, LESS LIMESTONE 85% SHALE, 15% LMS.	630
				100%	87%			
	110							620

BORING COMPLETED AT 110 FEET ON FEBRUARY 21, 1973. DAMES & MOORE TYPE U SAMPLER DRIVEN BY A 300 LB. HAMMER FALLING 24 INCHES.

DEPTH TO WATER WAS 44 FEET ON MARCH 2, 1973.

LOG OF BORING

DAMES & MOORE

BORING 6

SURFACE ELEVATION 737.0 (PLANT DATUM)

LABORATORY TESTS PERFORMED	DEPTH (FEET)	GAMMA RAY LOG (COUNTS/SECOND INCREASING →)	FIELD PERMEABILITY	BLOW COUNT (SOIL) RECOVERY (ROCK)	SAMPLES (SOIL) R Q D (ROCK)	SYMBOLS	DESCRIPTIONS	ELEVATION (FEET)
		SCALE: 50CPS		24, 22			BROWN CLAYEY SILT WITH LITTLE FINE - COARSE SAND, TRACE OF GRAVEL (GLACIL TILL) (DENSE)	730
PERMEABILITY & UNCONFINED COMPRESSION				30				
CONSOLIDATION	10			32		CL-ML	(COLOR CHANGING TO MOTTLED BROWN & GRAY)	
PERMEABILITY & UNCONFINED COMPRESSION				19, 21				720
CONSOLIDATION				25			(COLOR CHANGING TO GRAY)	
	20			20			(MORE COARSE GRAVEL)	
DYNAMIC PROPERTIES TEST & GRAIN SIZE				20				
CONSOLIDATION				21				710
	30			27				
TRIAXIAL COMPRESSION TEST & GRAIN SIZE & RESONANT COLUMN TEST				29				
PERMEABILITY & GRAIN SIZE				28				700
				130, 140			BROWN, SILTY, FINE - COARSE SAND AND GRAVEY (VERY DENSE)	
	40			118		GW		
				74, 28			(GRADING COARSER)	690
				31				
	50			150/3"			WEATHERED BLUISH-GRAY SHALE	
								680
	60			96%	86%	90% SHALE, 10% LMS.	ARNHEIM FM. (ORDOVICIAN) GRAY INTERBEDDED FOSSILIFEROUS SHALE & LIMESTONE. SHALE IS HORIZONTAL, THINLY LAMINATED TO THINLY BEDDED, WITH SOME SECTIONS REACHING SEVERAL FEET IN THICKNESS. DISTINCT LIMESTONE BEDS ARE THIN TO MEDIUM BEDDED WITH BEDS SELDOM EXCEEDING 5" THICKNESS. MATRIX IS CRYSTALLINE WHERE BEDS ARE DISTINCT, AND HARD. (RATIO OF SHALE TO LIMESTONE IS APPROXIMATELY 85% TO 15%).	670
	70							
BRAZILIAN TENSILE				100%				660
	80					65% SHALE, 35% LMS.		
								650
	90							
								640
UNIAXIAL COMPRESSION	100			100%	88%	95% SHALE, 5% LMS.		
								630

BORING COMPLETED AT 108 FEET ON FEBRUARY 20, 1973. DAMES & MOORE TYPE U SAMPLER DRIVEN BY A 300 LB. HAMMER FALLING 24 INCHES.

DEPTH TO WATER WAS 53-1/2 FEET ON MARCH 2, 1973.

LOG OF BORING

DAMES & MOORE

MAJOR DIVISIONS			GRAPH SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	SAND AND SANDY SOILS	CLEAN SAND (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND-SILT MIXTURES
				SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS.

SOIL CLASSIFICATION CHART

UNIFIED SOIL CLASSIFICATION SYSTEM

FORM NO. 4673 12 61

DAMES & MOORE

Richmond Group (Ordovician)

- Whitewater Formation
- Liberty Formation
- Waynesville Formation
- Arnheim Formation

KEY TO SAMPLES:

14 ■ INDICATES UNDISTURBED SAMPLE

25 ⊠ INDICATES DISTURBED SAMPLE

39 □ INDICATES SAMPLING ATTEMPT WITH NO RECOVERY

└ INDICATES NUMBER OF BLOWS REQUIRED TO DRIVE SAMPLER 1 FOOT.

RQD ROCK QUALITY DESIGNATION
A MODIFIED CORE RECOVERY PERCENTAGE IN WHICH ONLY THE PIECES OF SOUND CORE OVER 4 INCHES LONG ARE COUNTED AS RECOVERY. THE MODIFIED SUM OF CORE RECOVERED IS THE EXPRESSED AS A PERCENTAGE OF THE TOTAL LENGTH OF THE CORE RUN.

90% RECOVERY INDICATES TOTAL AMOUNT OF CORE RECOVERED FOR EACH RUN, EXPRESSED AS A PERCENTAGE OF THE TOTAL LENGTH OF THE CORE RUN.

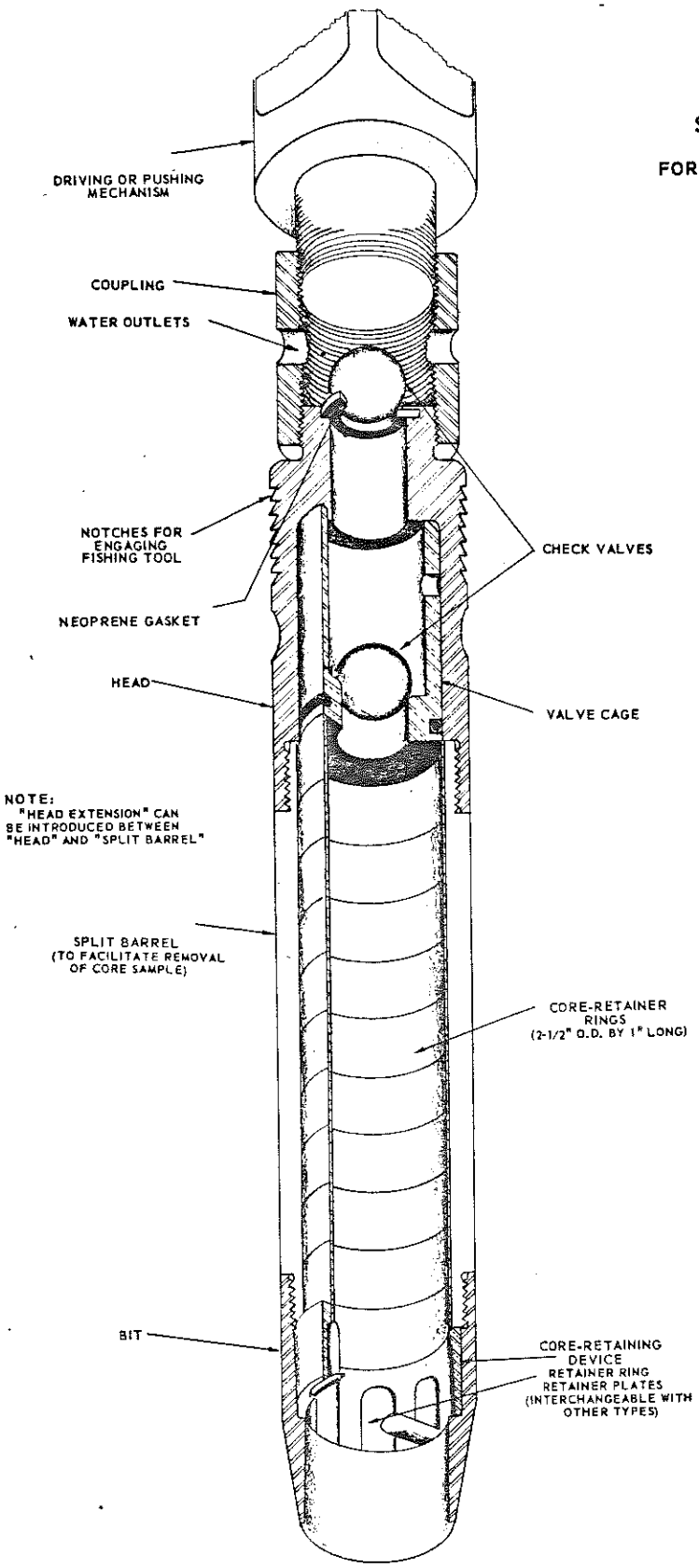
ELEVATIONS REFER TO PLANT DATUM WHICH IS 1,143 FEET HIGHER THAN U.S.C. & G. S. NORTH AMERICAN DATUM OF 1927.

THE DISCUSSION IN THE TEXT IS NECESSARY FOR PROPER UNDERSTANDING OF THE NATURE OF THE SUBSURFACE MATERIALS.

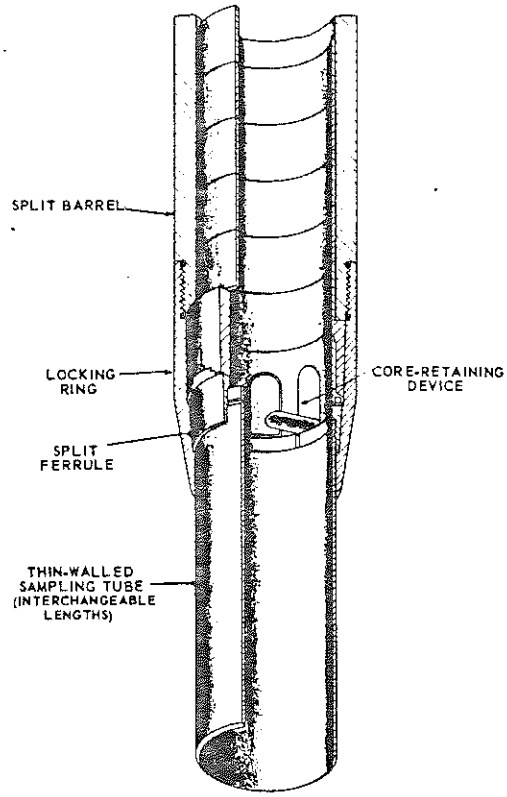
Bedrock Classification System with Key to Samples

SOIL SAMPLER TYPE U

FOR SOILS DIFFICULT TO RETAIN IN SAMPLER



ALTERNATE ATTACHMENTS



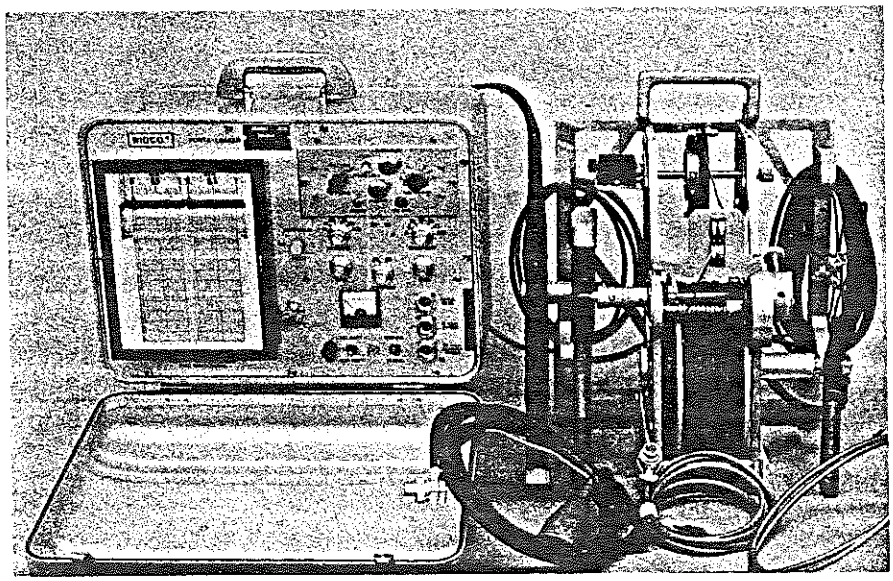
417.9 (5-68)

DAMES & MOORE

PLATE 71-11

THE WIDCO PORTA-LOGGER

THE WIDCO PORTA-LOGGER IS A BOREHOLE GEOPHYSICAL DEVICE WHICH UTILIZES A NUMBER OF WIRELINE PROBES IN CONJUNCTION WITH AN ELECTRONIC MODULE AND RECORDING UNIT. DEPENDING ON THE NATURE OF THE PROBE USED, A GRAPHICAL PRINT-OUT OF GEOPHYSICAL PROPERTIES VERSUS HOLE DEPTH IS PRODUCED. GEOPHYSICAL PROPERTIES MEASURED BY THIS INSTRUMENT INCLUDE ELECTRICAL RESISTANCE, SPONTANEOUS POTENTIAL, GAMMA RADIATION AND TEMPERATURE. IN VARIOUS COMBINATIONS, THESE LOGS CAN BE USED FOR A WIDE VARIETY OF GEOLOGICAL AND ENGINEERING APPLICATIONS WHICH SUPPLEMENT INFORMATION DERIVED FROM THE ROCK AND SOIL SAMPLES NORMALLY RECOVERED FROM BORINGS. TYPICAL APPLICATIONS INCLUDE STRATIGRAPHIC CORRELATION, IDENTIFICATION OF LITHOLOGY AND BED THICKNESSES, DEFINITION OF AQUIFER BOUNDARIES, LIMITED WATER QUALITY DETERMINATION, MINERAL PROSPECTING (PARTICULARLY COAL AND URANIUM) AND IDENTIFICATION OF BOREHOLE TEMPERATURE GRADIENTS.



ELECTRICAL LOGGING SURVEY

SINGLE ELECTRODE RESISTANCE AND SPONTANEOUS POTENTIAL (SP) ARE RECORDED SIMULTANEOUSLY. THE LOGGING PROBE CANNOT BE USED INSIDE OF CASING AND MUST BE IMMERSED IN A CONDUCTIVE FLUID SUCH AS WATER OR DRILLING MUD. THE SINGLE ELECTRODE RESISTANCE IS EXPRESSED IN UNITS OF OHMS, AND IS RECORDED ON THE RIGHT TRACK OF THE RECORDER CHART. SPONTANEOUS POTENTIAL IS EXPRESSED IN UNITS OF MILLIVOLTS, AND IS RECORDED ON THE LEFT TRACK OF THE RECORDER CHART. THE SP LOG IS ESPECIALLY SIGNIFICANT WHEN A SALINITY CONTRAST EXISTS BETWEEN FORMATION WATER AND THE BOREHOLE FLUID.

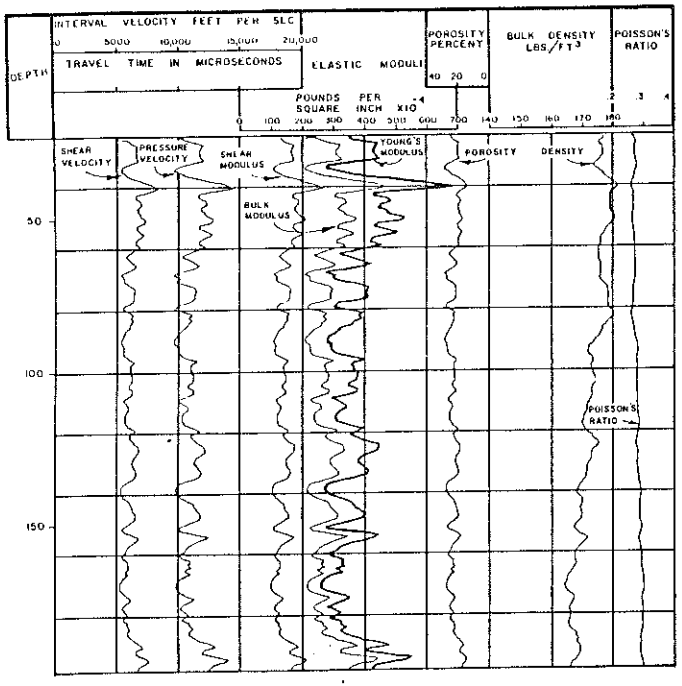
GAMMA RAY LOGGING SURVEY

THE GAMMA RAY LOG PROVIDES A PROFILE OF NATURALLY OCCURRING RADIATION EMITTED FROM GEOLOGIC FORMATIONS AND EXPRESSED IN TERMS OF COUNTS PER SECOND. THE SOURCE OF THIS RADIOACTIVITY IS PRINCIPALLY DERIVED FROM NATURAL DECAY OF URANIUM, THORIUM, AND A POTASSIUM ISOTOPE OF ATOMIC WEIGHT 40. FORMATIONS SUCH AS CLAY AND SHALE USUALLY CONTAIN A HIGHER PROPORTION OF THESE ELEMENTS THAN DO SANDSTONES AND LIMESTONES, AND THEREFORE SHOW A RELATIVELY HIGHER LEVEL OF GAMMA RADIATION. THE GAMMA RAY LOGGING TOOL MAY BE USED IN HOLES WHICH ARE CASED OR UNCASED, AND IS NOT AFFECTED BY THE PRESENCE OR ABSENCE OF BOREHOLE FLUID.

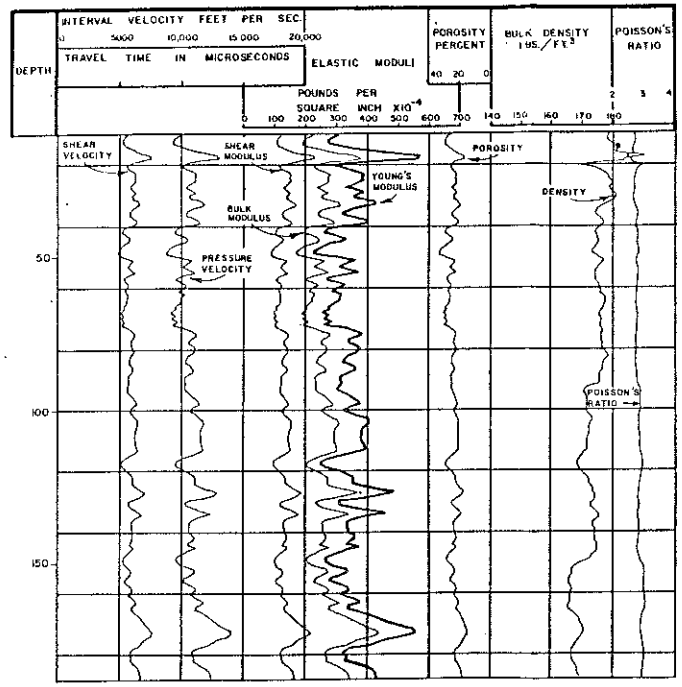
TEMPERATURE LOGGING SURVEY

THIS LOG PROVIDES A PROFILE OF BOREHOLE TEMPERATURE AND CAN BE USED TO LOCATE SIGNIFICANT POINTS OF FLUID ENTRY. THE THERMOCOUPLE PROBE IS IMMERSED IN WATER OR DRILLING FLUID TO GAIN SATISFACTORY SENSITIVITY.

BORING NO. 1



BORING NO. 2



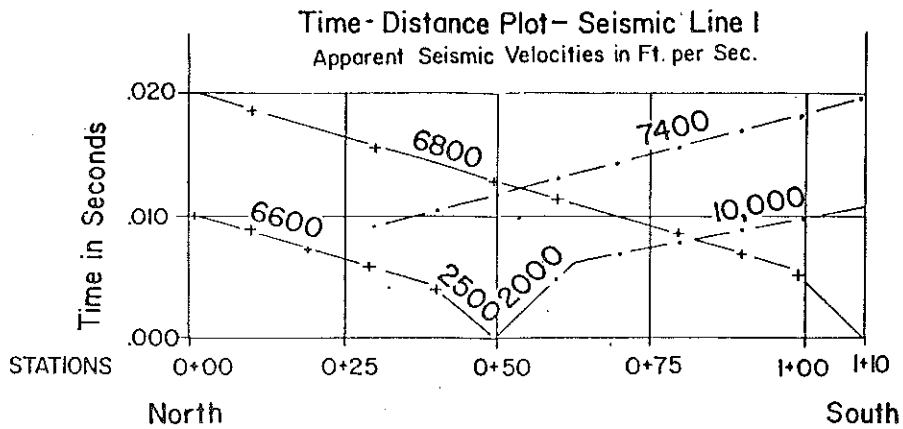
NOTE:
THE SHEAR WAVE VELOCITY IS A CALCULATED VALUE WHICH HAS COMPUTED ON THE BASIS OF P-WAVE VELOCITY AND DENSITY DATA.

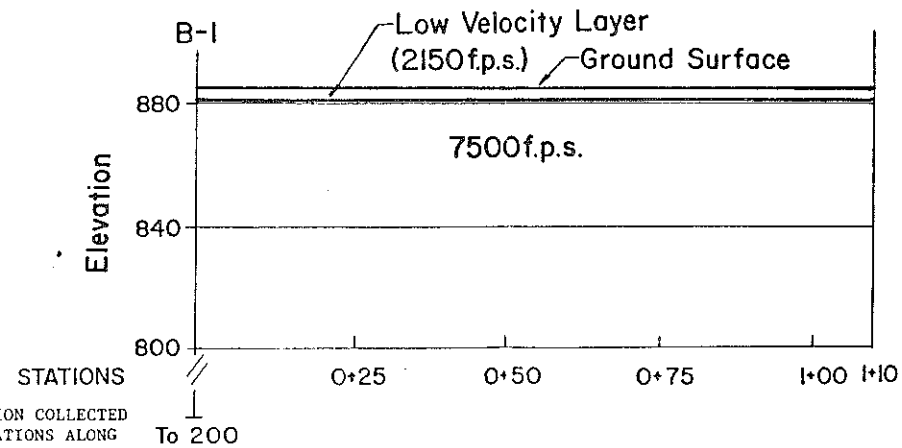
THE ELASTIC PROPERTIES LOG IS BASED UPON COMPUTER PROCESSED DATA OBTAINED FROM 3-DIMENSIONAL VELOCITY LOG, DENSITY LOG AND CALIPER LOG SURVEYS, PERFORMED BY BIRDWELL DIVISION OF SEISMOGRAPH SERVICE CORPORATION

Elastic Properties Logs

DAMES & MOORE

PLATE 7.1-13





NOTE:

TIME DISTANCE PLOTS REFLECT INFORMATION COLLECTED FROM SHOT POINTS MADE AT SEVERAL LOCATIONS ALONG A SEISMIC LINE, FOR CLARIFICATION, TWO PLOT SYMBOLS HAVE BEEN USED TO INDICATE THE ORIGIN OF THE SHOCK: FROM THE LEFT (•) FROM THE RIGHT (+).

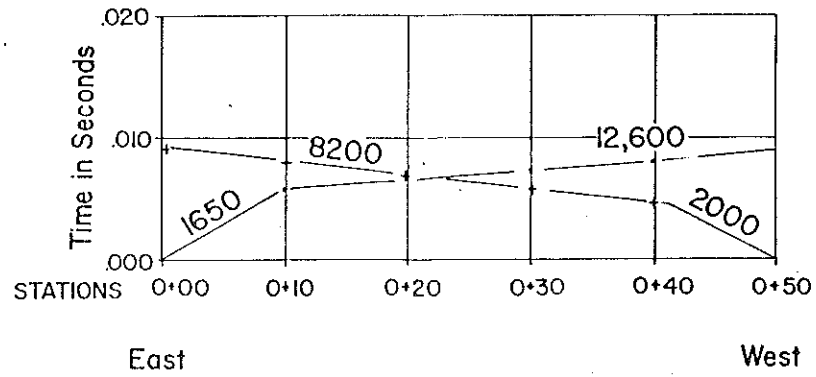
THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATIONS OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

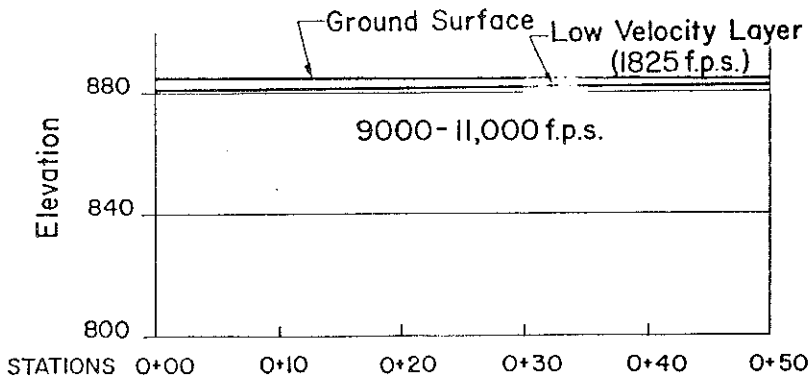
SEISMIC REFRACTION LINE I

DAMES & MOORE

Time-Distance Plot – Seismic Line 2

Apparent Seismic Velocities in Ft. per Sec.





NOTE:

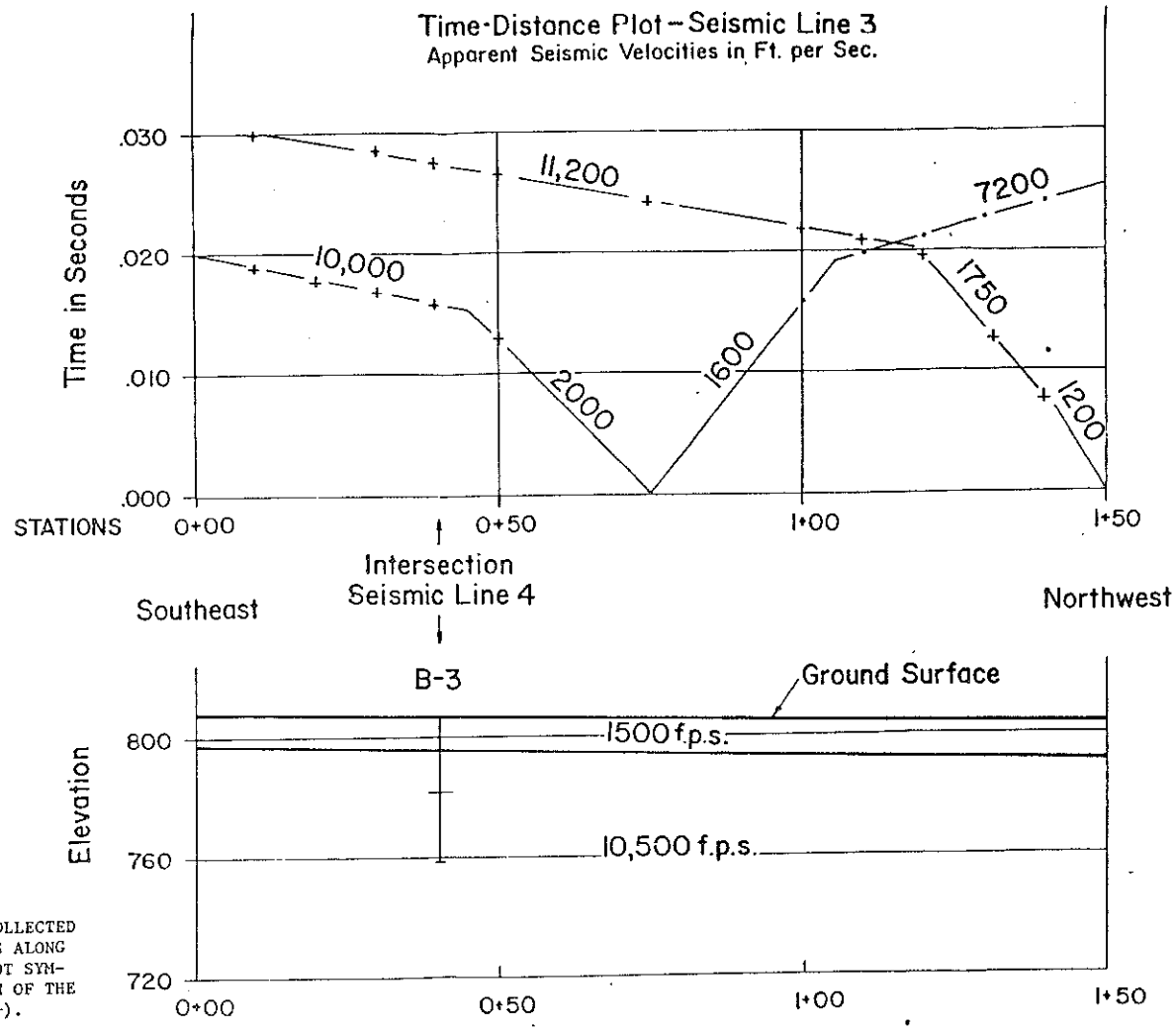
TIME DISTANCE PLOTS REFLECT INFORMATION COLLECTED FROM SHOT POINTS MADE AT SEVERAL LOCATIONS ALONG A SEISMIC LINE, FOR CLARIFICATION, TWO PLOT SYMBOLS HAVE BEEN USED TO INDICATE THE ORIGIN OF THE SHOCK: FROM THE LEFT (•) FROM THE RIGHT (+).

THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATIONS OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

SEISMIC REFRACTION LINE 2

DAMES & MOORE

PLATE 7I-15



NOTE:

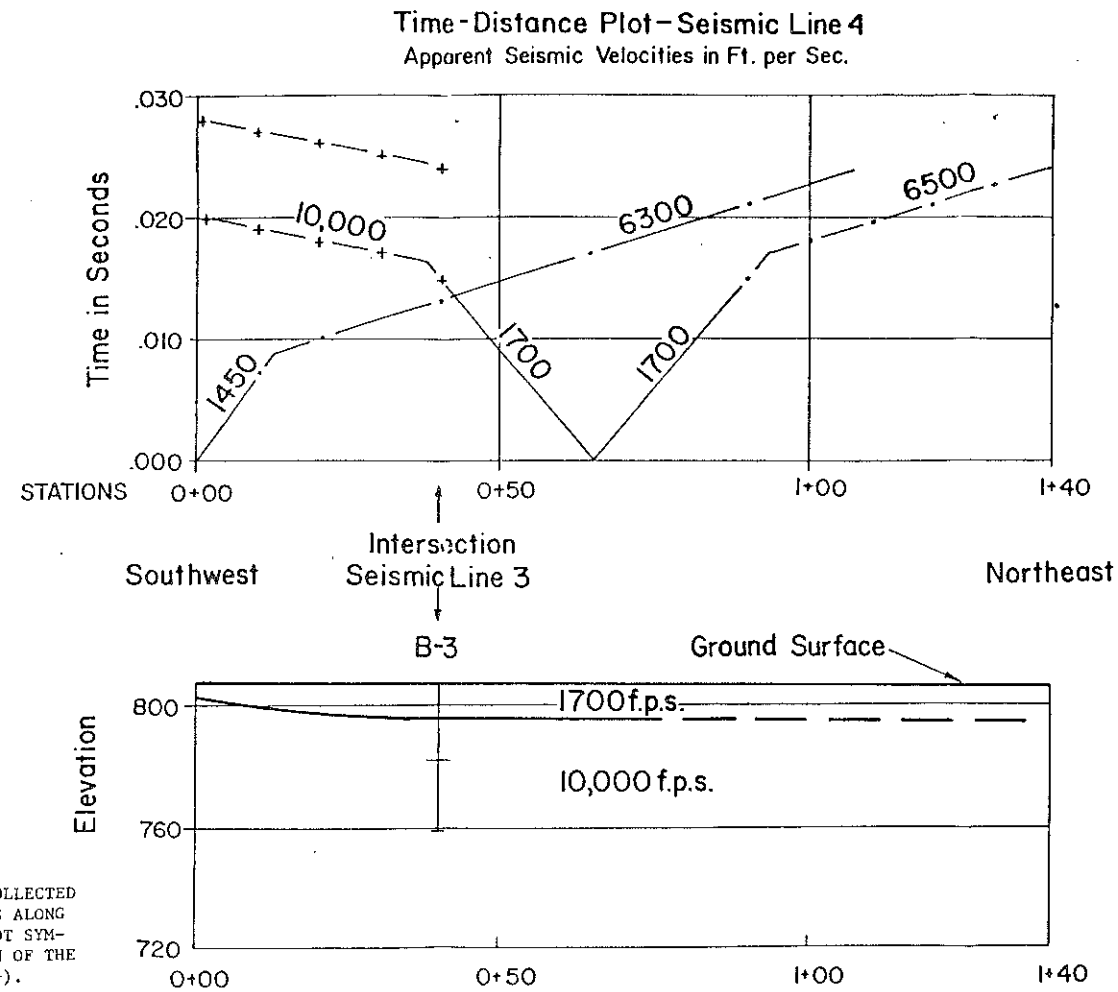
TIME DISTANCE PLOTS REFLECT INFORMATION COLLECTED FROM SHOT POINTS MADE AT SEVERAL LOCATIONS ALONG A SEISMIC LINE, FOR CLARIFICATION, TWO PLOT SYMBOLS HAVE BEEN USED TO INDICATE THE ORIGIN OF THE SHOCK: FROM THE LEFT (•) FROM THE RIGHT (+).

THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATIONS OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

SEISMIC REFRACTION LINE 3

DAMES & MOORE

PLATE ZI-16



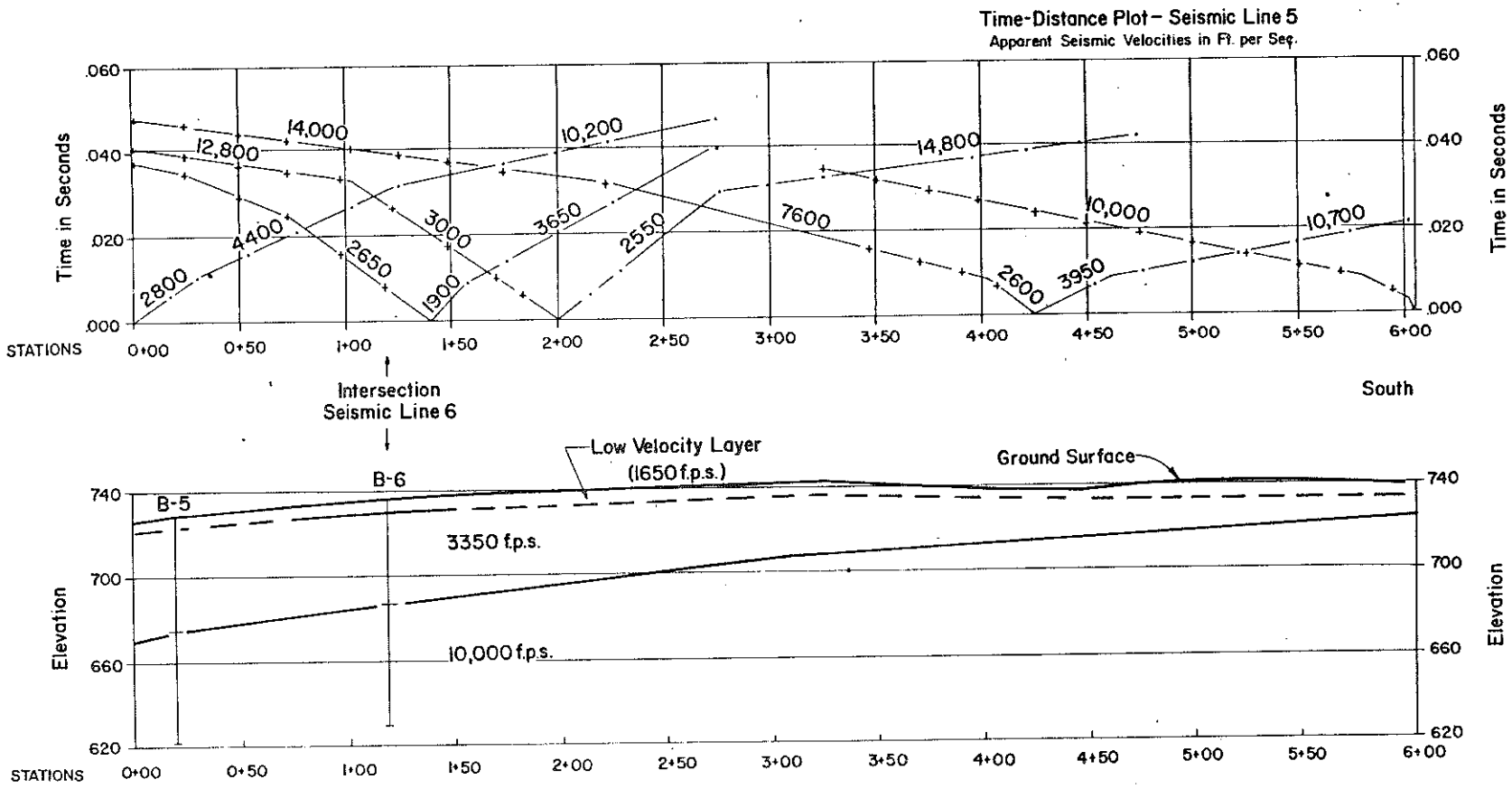
NOTE:

TIME DISTANCE PLOTS REFLECT INFORMATION COLLECTED FROM SHOT POINTS MADE AT SEVERAL LOCATIONS ALONG A SEISMIC LINE, FOR CLARIFICATION, TWO PLOT SYMBOLS HAVE BEEN USED TO INDICATE THE ORIGIN OF THE SHOCK: FROM THE LEFT (•) FROM THE RIGHT (+).

THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATIONS OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

SEISMIC REFRACTION LINE 4

DAMES & MOORE



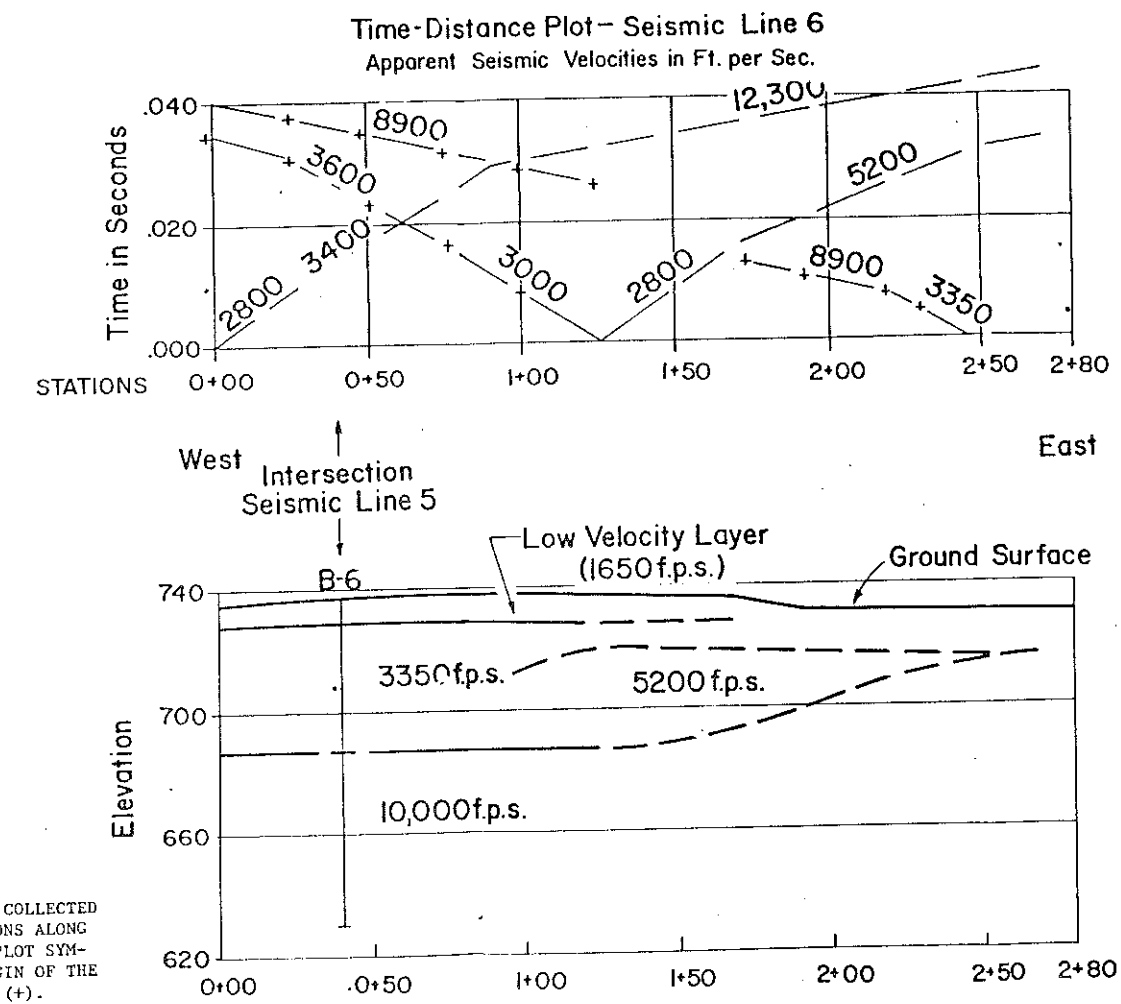
NOTE:

TIME DISTANCE PLOTS REFLECT INFORMATION COLLECTED FROM SHOT POINTS MADE AT SEVERAL LOCATIONS ALONG A SEISMIC LINE, FOR CLARIFICATION, TWO PLOT SYMBOLS HAVE BEEN USED TO INDICATE THE ORIGIN OF THE SHOCK: FROM THE LEFT (•) FROM THE RIGHT (+).

THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATIONS OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

SEISMIC REFRACTION LINE 5

DAMES & MOORE



NOTE:

TIME DISTANCE PLOTS REFLECT INFORMATION COLLECTED FROM SHOT POINTS MADE AT SEVERAL LOCATIONS ALONG A SEISMIC LINE, FOR CLARIFICATION, TWO PLOT SYMBOLS HAVE BEEN USED TO INDICATE THE ORIGIN OF THE SHOCK: FROM THE LEFT (•) FROM THE RIGHT (+).

THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATIONS OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

SEISMIC REFRACTION LINE 6

DAMES & MOORE

PLATE 7.1-19

General Description	Compressional Wave Velocity (Ft./sec.)	Poisson's Ratio	Shear Wave Velocity (Ft./sec.)
Sandy, Clayey Silt	1650	.45	500
Sandy, Clayey Silt	3350	.41	1300
Alternating Limestone & Shale	10,000	.305	5300

10 20 30 40 50 60 70 80

Geologic Column
Boring 5

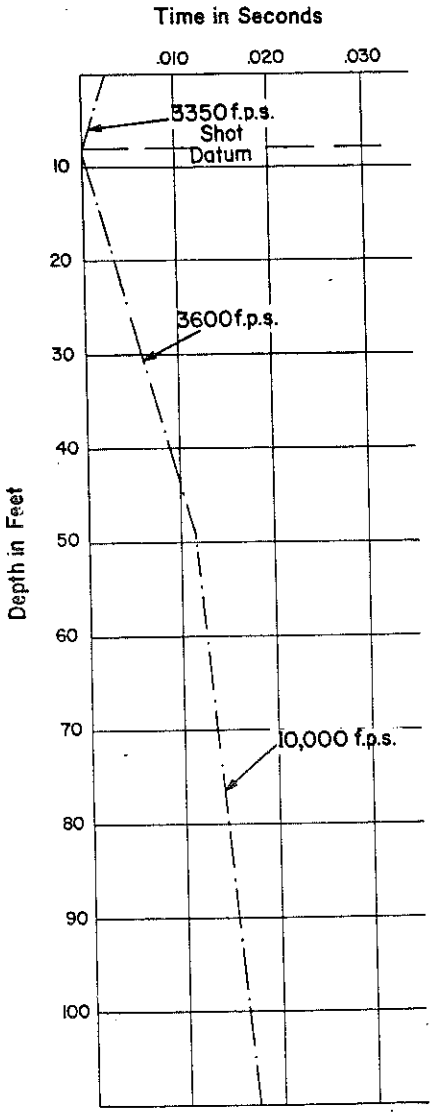
General Description	Compressional Wave Velocity (Ft./sec.)	Poisson's Ratio	Shear Wave Velocity (Ft./sec.)
Sandy, Clayey Silt	1650	.45	500
Sandy, Clayey Silt	3350	.41	1300
Alternating Limestone & Shale	10,000	.305	5300

10 20 30 40 50 60 70 80

Geologic Column
Boring 6

Wave Velocity Profiles
at Boring 5&6

DAMES & MOORE

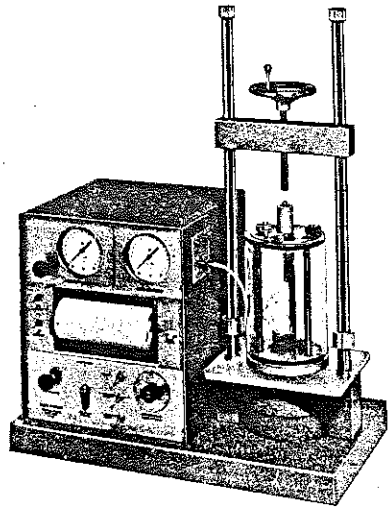


Uphole Velocity Survey
at Boring 6

METHODS OF PERFORMING UNCONFINED COMPRESSION AND TRIAXIAL COMPRESSION TESTS

THE SHEARING STRENGTHS OF SOILS ARE DETERMINED FROM THE RESULTS OF UNCONFINED COMPRESSION AND TRIAXIAL COMPRESSION TESTS. IN TRIAXIAL COMPRESSION TESTS THE TEST METHOD AND THE MAGNITUDE OF THE CONFINING PRESSURE ARE CHOSEN TO SIMULATE ANTICIPATED FIELD CONDITIONS.

UNCONFINED COMPRESSION AND TRIAXIAL COMPRESSION TESTS ARE PERFORMED ON UNDISTURBED OR REMOLDED SAMPLES OF SOIL APPROXIMATELY SIX INCHES IN LENGTH AND TWO AND ONE-HALF INCHES IN DIAMETER. THE TESTS ARE RUN EITHER STRAIN-CONTROLLED OR STRESS-CONTROLLED. IN A STRAIN-CONTROLLED TEST THE SAMPLE IS SUBJECTED TO A CONSTANT RATE OF DEFLECTION AND THE RESULTING STRESSES ARE RECORDED. IN A STRESS-CONTROLLED TEST THE SAMPLE IS SUBJECTED TO EQUAL INCREMENTS OF LOAD WITH EACH INCREMENT BEING MAINTAINED UNTIL AN EQUILIBRIUM CONDITION WITH RESPECT TO STRAIN IS ACHIEVED.



TRIAXIAL COMPRESSION TEST UNIT

YIELD, PEAK, OR ULTIMATE STRESSES ARE DETERMINED FROM THE STRESS-STRAIN PLOT FOR EACH SAMPLE AND THE PRINCIPAL STRESSES ARE EVALUATED. THE PRINCIPAL STRESSES ARE PLOTTED ON A MOHR'S CIRCLE DIAGRAM TO DETERMINE THE SHEARING STRENGTH OF THE SOIL TYPE BEING TESTED.

UNCONFINED COMPRESSION TESTS CAN BE PERFORMED ONLY ON SAMPLES WITH SUFFICIENT COHESION SO THAT THE SOIL WILL STAND AS AN UNSUPPORTED CYLINDER. THESE TESTS MAY BE RUN AT NATURAL MOISTURE CONTENT OR ON ARTIFICIALLY SATURATED SOILS.

IN A TRIAXIAL COMPRESSION TEST THE SAMPLE IS ENCASED IN A RUBBER MEMBRANE, PLACED IN A TEST CHAMBER, AND SUBJECTED TO A CONFINING PRESSURE THROUGHOUT THE DURATION OF THE TEST. NORMALLY, THIS CONFINING PRESSURE IS MAINTAINED AT A CONSTANT LEVEL, ALTHOUGH FOR SPECIAL TESTS IT MAY BE VARIED IN RELATION TO THE MEASURED STRESSES. TRIAXIAL COMPRESSION TESTS MAY BE RUN ON SOILS AT FIELD MOISTURE CONTENT OR ON ARTIFICIALLY SATURATED SAMPLES. THE TESTS ARE PERFORMED IN ONE OF THE FOLLOWING WAYS:

UNCONSOLIDATED-UNDRAINED: THE CONFINING PRESSURE IS IMPOSED ON THE SAMPLE AT THE START OF THE TEST. NO DRAINAGE IS PERMITTED AND THE STRESSES WHICH ARE MEASURED REPRESENT THE SUM OF THE INTERGRANULAR STRESSES AND PORE WATER PRESSURES.

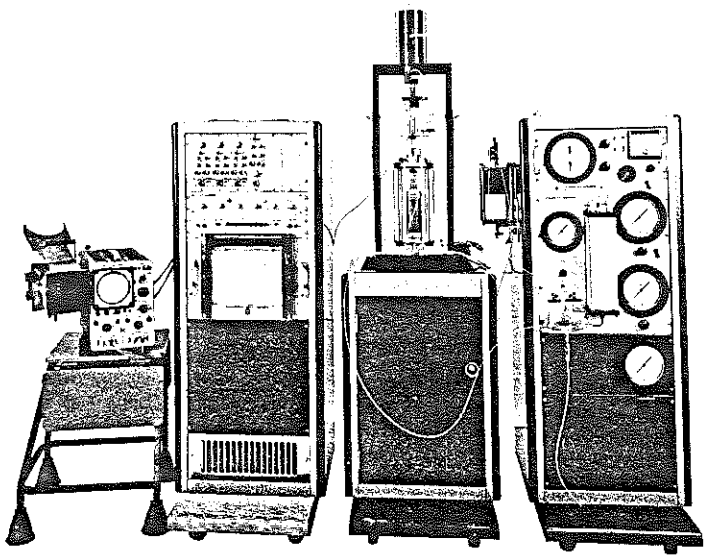
CONSOLIDATED-UNDRAINED: THE SAMPLE IS ALLOWED TO CONSOLIDATE FULLY UNDER THE APPLIED CONFINING PRESSURE PRIOR TO THE START OF THE TEST. THE VOLUME CHANGE IS DETERMINED BY MEASURING THE WATER AND/OR AIR EXPELLED DURING CONSOLIDATION. NO DRAINAGE IS PERMITTED DURING THE TEST AND THE STRESSES WHICH ARE MEASURED ARE THE SAME AS FOR THE UNCONSOLIDATED-UNDRAINED TEST.

DRAINED: THE INTERGRANULAR STRESSES IN A SAMPLE MAY BE MEASURED BY PERFORMING A DRAINED, OR SLOW, TEST. IN THIS TEST THE SAMPLE IS FULLY SATURATED AND CONSOLIDATED PRIOR TO THE START OF THE TEST. DURING THE TEST, DRAINAGE IS PERMITTED AND THE TEST IS PERFORMED AT A SLOW ENOUGH RATE TO PREVENT THE BUILDUP OF PORE WATER PRESSURES. THE RESULTING STRESSES WHICH ARE MEASURED REPRESENT ONLY THE INTERGRANULAR STRESSES. THESE TESTS ARE USUALLY PERFORMED ON SAMPLES OF GENERALLY NON-COHESIVE SOILS, ALTHOUGH THE TEST PROCEDURE IS APPLICABLE TO COHESIVE SOILS IF A SUFFICIENTLY SLOW TEST RATE IS USED.

AN ALTERNATE MEANS OF OBTAINING THE DATA RESULTING FROM THE DRAINED TEST IS TO PERFORM AN UNDRAINED TEST IN WHICH SPECIAL EQUIPMENT IS USED TO MEASURE THE PORE WATER PRESSURES. THE DIFFERENCES BETWEEN THE TOTAL STRESSES AND THE PORE WATER PRESSURES MEASURED ARE THE INTERGRANULAR STRESSES.

417.14 (5-63)

METHODS OF PERFORMING PULSATING LOAD TRIAXIAL TESTS



PULSATING AXIAL LOAD TESTS ARE PERFORMED TO EVALUATE THE DYNAMIC PROPERTIES AND THE LIQUEFACTION POTENTIAL OF THE SOILS UNDER SIMULATED ANTICIPATED FIELD LOADING CONDITIONS.

PULSATING LOAD TESTS ARE STRESS CONTROLLED AND ARE PERFORMED ON UNDISTURBED OR RECONSTITUTED SAMPLES OF SOIL APPROXIMATELY 6 INCHES IN LENGTH AND 2½ INCHES IN DIAMETER. THE SAMPLES ARE ENCASED IN A RUBBER MEMBRANE, PLACED IN A TEST CHAMBER AND SUBJECTED TO CONFINING PRESSURE THROUGHOUT THE DURATION OF THE TEST. THE TESTS MAY BE RUN ON SOILS AT FIELD MOISTURE CONTENT OR ON ARTIFICIALLY SATURATED SAMPLES. THE TRIAXIAL EQUIPMENT ACTING THROUGH A BELLOFRAM SYSTEM APPLIES A PULSATING AXIAL LOAD. THE CYCLING SPEED OF THE LOAD CAN BE VARIED BETWEEN ½ TO 5 CYCLES PER SECOND TO SIMULATE THE FIELD LOADING FREQUENCY.

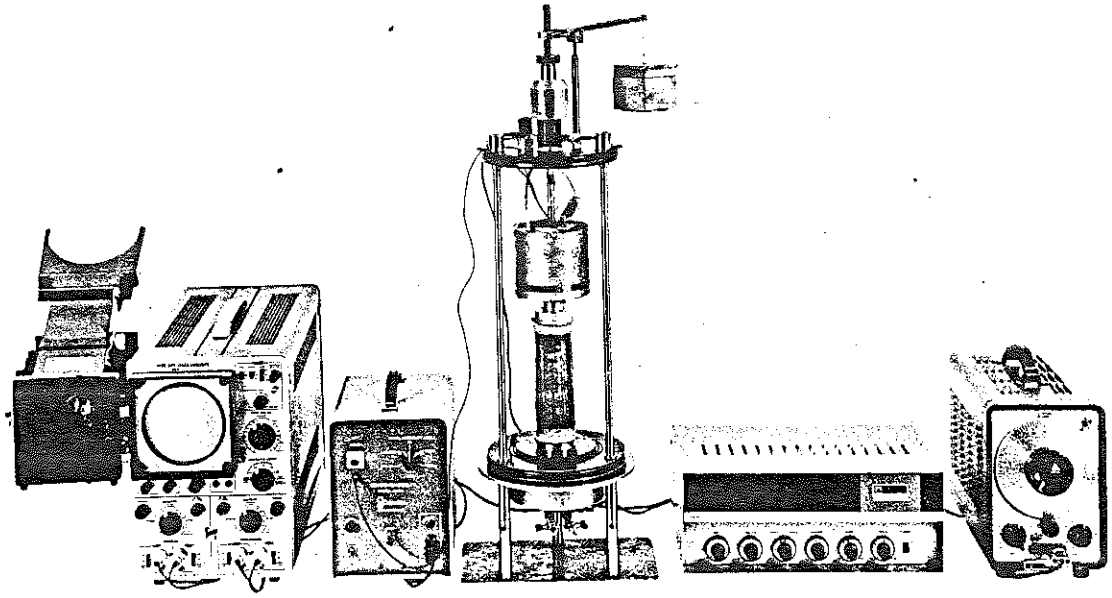
DYNAMIC PROPERTIES DETERMINATION

TO EVALUATE THE DYNAMIC PARAMETERS, THE SOIL SAMPLE IS LOADED IN CYCLIC COMPRESSION. THE LOAD AND DEFLECTION ARE RECORDED ON TWO CHANNELS OF A RECORDING OSCILLOGRAPH. BY TAPPING THE OUTPUT OF THE LOAD AND DEFLECTION TRANSDUCERS AND APPLYING THESE TO VERTICAL AND HORIZONTAL PLATES, RESPECTIVELY, OF A CATHODE RAY OSCILLOSCOPE, A HYSTERESIS LOOP IS PRODUCED. THIS LOOP IS PHOTOGRAPHED, AND THE PHOTOGRAPH IS USED TO EVALUATE THE DAMPING VALUE PRESENT. THE PROCEDURE IS REPEATED AT VARIOUS STRAIN AMPLITUDES TO EVALUATE THE DYNAMIC PROPERTIES IN THE RANGE OF INTEREST ON A PARTICULAR SAMPLE. THE LOAD AND DEFLECTION VALUES OBTAINED FROM THE OSCILLOGRAPH ARE USED TO EVALUATE THE DYNAMIC MODULI OF ELASTICITY.

LIQUEFACTION POTENTIAL

TO EVALUATE THE LIQUEFACTION POTENTIAL, THE SOIL SAMPLE IS SUBJECTED TO AXIAL CYCLIC LOADING. THE MAGNITUDE, FREQUENCY, DURATION AND SEQUENCE OF LOADING IS DETERMINED ON THE BASIS OF PAST EARTHQUAKE RECORDS. THE LOAD, DEFLECTION, AND PORE PRESSURE ARE RECORDED ON THREE CHANNELS OF A RECORDING OSCILLOGRAPH. THESE RECORDS ARE USED TO EVALUATE THE LIQUEFACTION POTENTIAL FOR THAT PARTICULAR SOIL TYPE UNDER THE TEST CONDITIONS.

METHODS OF PERFORMING RESONANT COLUMN TESTS

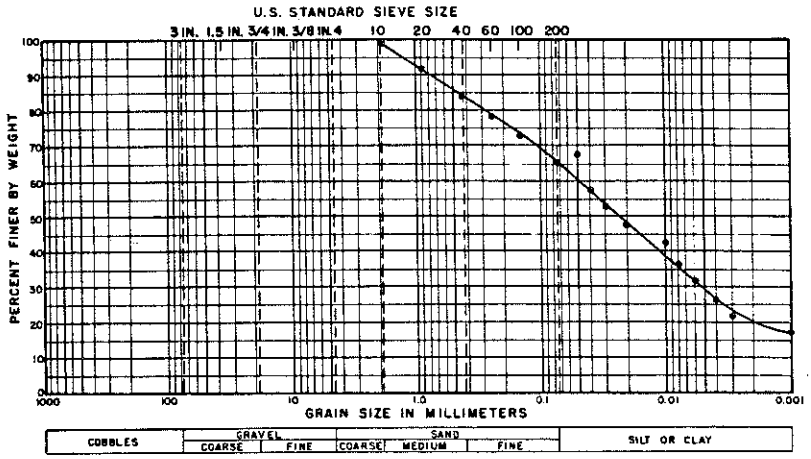


RESONANT COLUMN TESTS ARE PERFORMED TO EVALUATE THE DYNAMIC PROPERTIES OF THE SOIL OR ROCK SAMPLES. UTILIZING THE RESONANT COLUMN APPARATUS, A CYLINDRICAL COLUMN OF SOIL OR ROCK IS SUBJECTED TO A STEADY STATE SINUSOIDAL FORCING FUNCTION, WHICH STRESSES THE SAMPLE IN TORSION. THE FREQUENCY OF THE APPLIED FORCE IS VARIED UNTIL THE RESONANT FREQUENCY OF THE SOIL APPARATUS SYSTEM IS OBTAINED. THE RESONANT FREQUENCY IS THAT WHICH PRODUCES THE MAXIMUM AMPLITUDE OF OUTPUT RECORDED. THE RESONANT FREQUENCY THUS OBTAINED IS RELATED TO THE TORSIONAL SHEAR MODULUS OF THE MATERIAL TESTED.

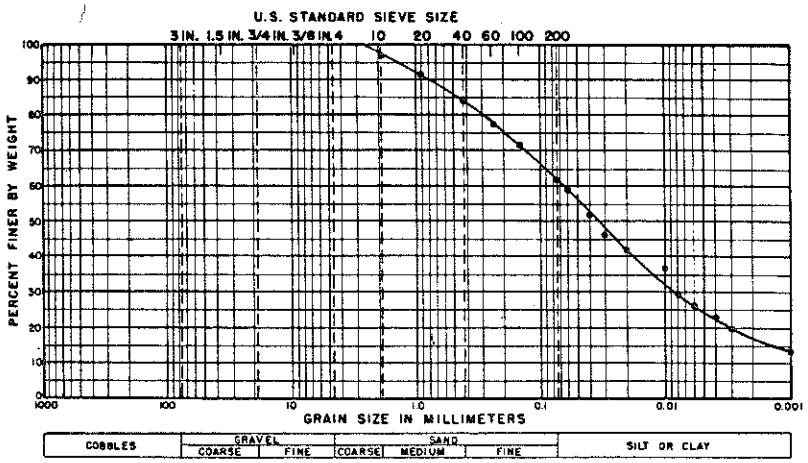
RESONANT COLUMN TESTS ARE PERFORMED ON UNDISTURBED OR RECONSTITUTED CYLINDRICAL SAMPLES OF SOIL APPROXIMATELY 6 INCHES IN LENGTH AND 2½ INCHES IN DIAMETER. THE SAMPLES ARE ENCASED IN A RUBBER MEMBRANE AND PLACED IN A TEST CHAMBER. THE TESTS MAY BE PERFORMED CONFINED OR UNCONFINED ON SOILS AT FIELD MOISTURE OR ON ARTIFICIALLY SATURATED SAMPLES. THE APPARATUS EMPLOYS A VIBRATION EXCITATION DEVICE, POWERED BY A VARIABLE FREQUENCY SINE WAVE GENERATOR WHICH APPLIES A FORCING TORQUE TO THE FREE END OF THE SPECIMEN. THE RESULTING VIBRATIONS ARE MEASURED BY AN ACCELEROMETER WHICH PRODUCES A CALIBRATED OUTPUT THAT IS A MEASURE OF THE ANGULAR ACCELERATION OF THE FREE END OF THE SPECIMEN. THE SINUSOIDAL VOLTAGE USED TO PRODUCE THE FORCING TORQUE AND THE OUTPUT OF THE ACCELEROMETER ARE DISPLAYED ON THE X-Y AXES OF THE OSCILLOSCOPE RESULTING IN ELLIPTICAL CONFIGURATIONS FOR ASSOCIATED FREQUENCIES. THESE ELLIPTICAL LOOPS ARE PHOTOGRAPHED AND EVALUATED TO DETERMINE THE DAMPING CHARACTERISTICS OF THE SAMPLES TESTED.

FORM NO. 417.16

Boring No. 4 – Depth 5 ft.



Boring No. 4 – Depth 12.5 ft.



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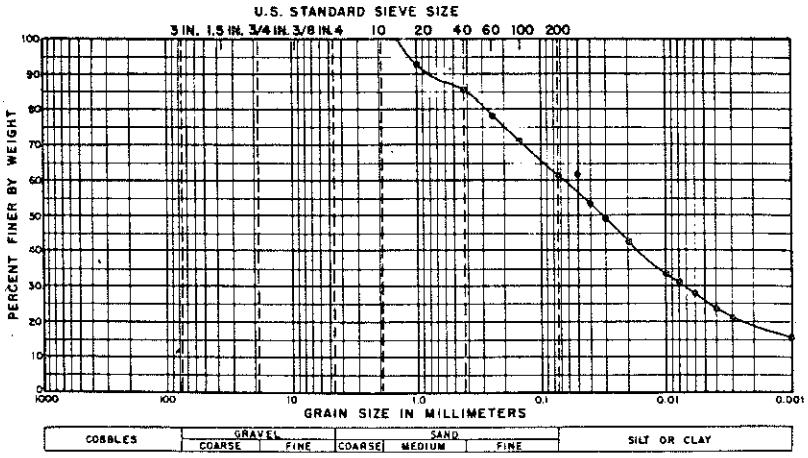
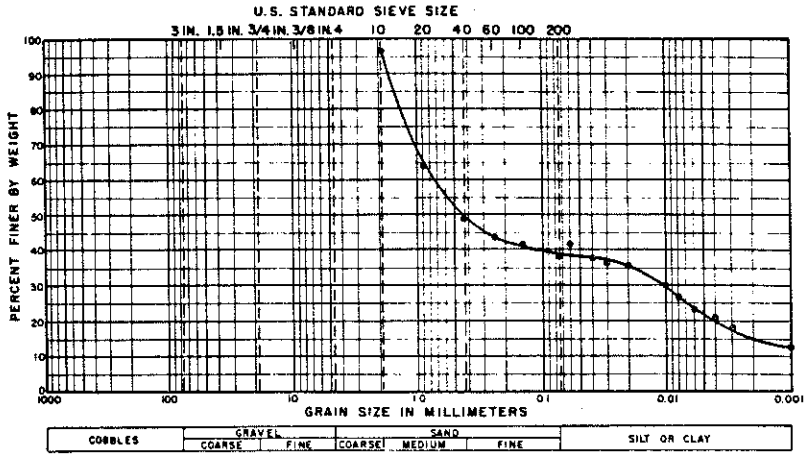


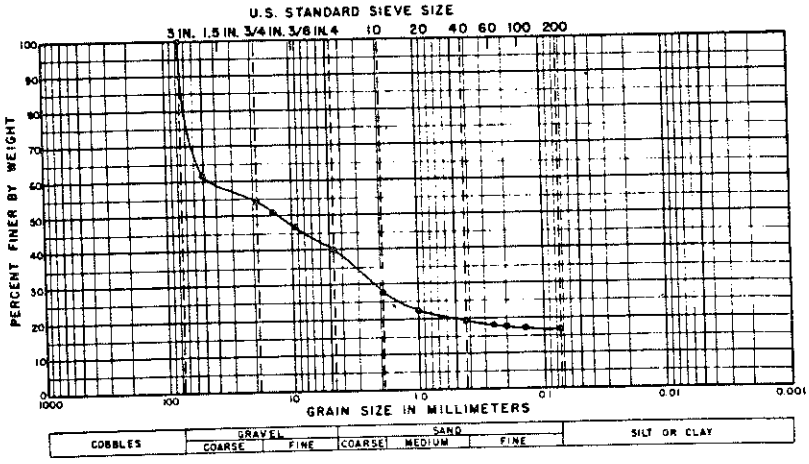
PARTICLE SIZE ANALYSES

DAMES & MOORE

Boring No. 4 - Depth 35 ft.



Boring No. 4 - Depth 48.5 ft.

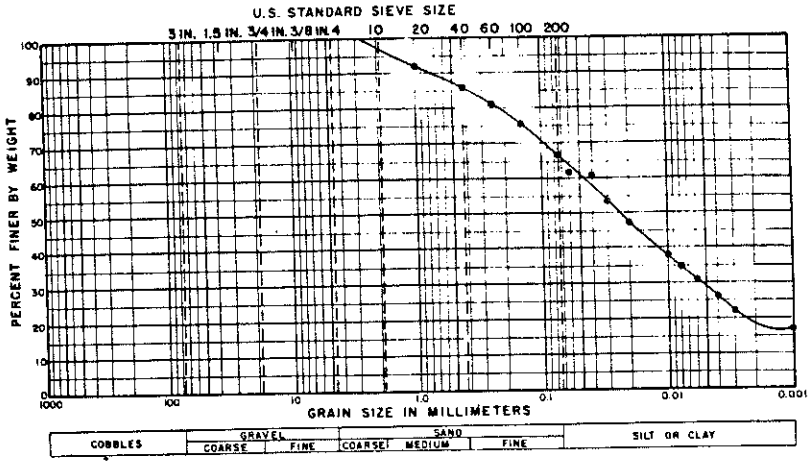


PARTICLE SIZE ANALYSES

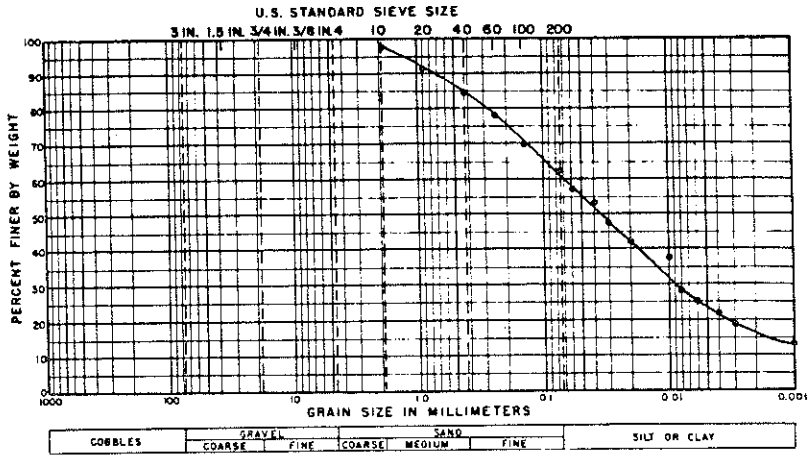
DAMES & MOORE

PLATE 7.1-25A

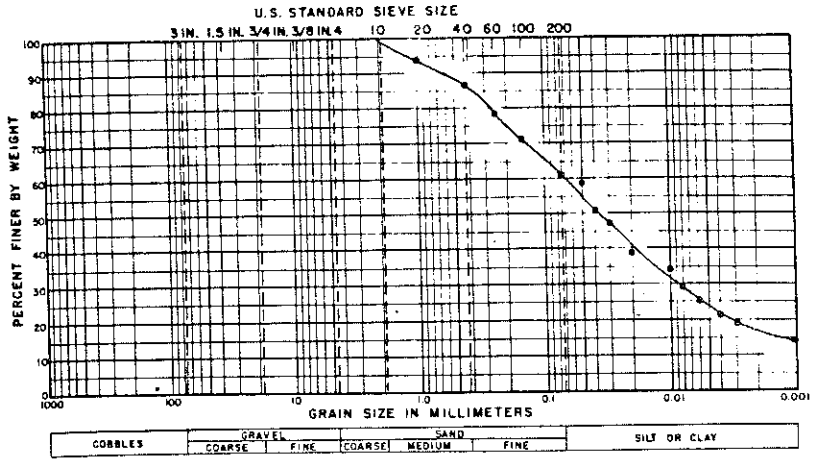
Boring No. 5-Depth 3ft.



Boring No.5- Depth 16 ft.



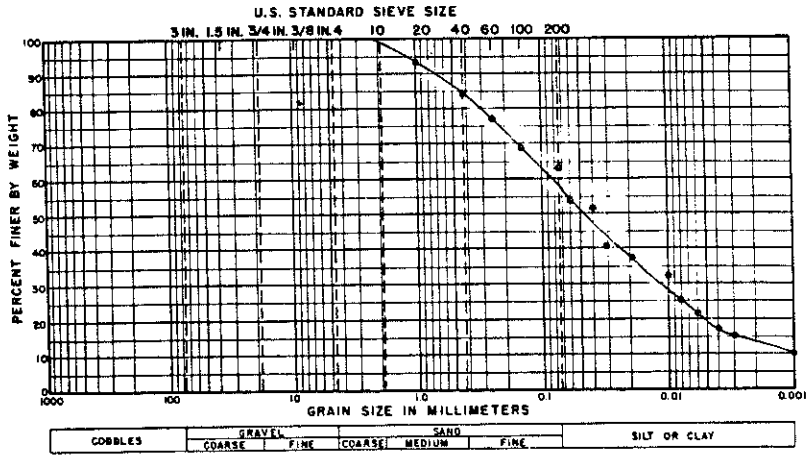
Boring No.5- Depth 18ft.



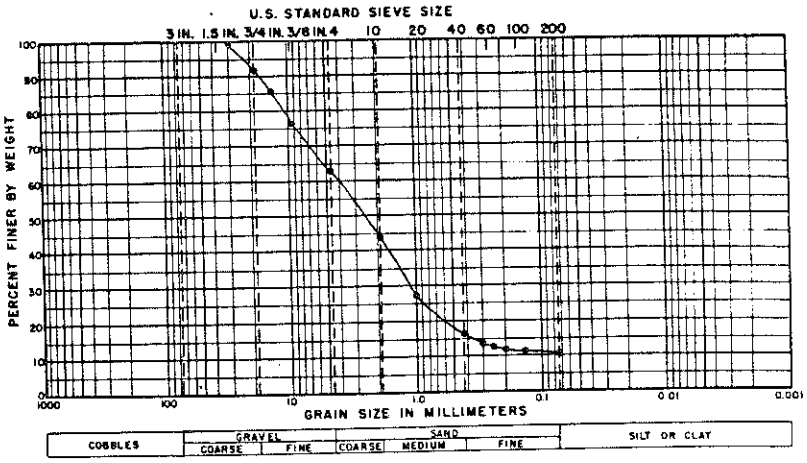
PARTICLE SIZE ANALYSES

DAMES & MOORE

Boring No. 5 - Depth 31ft.



Boring No. 5 - Depth 40.5 ft.

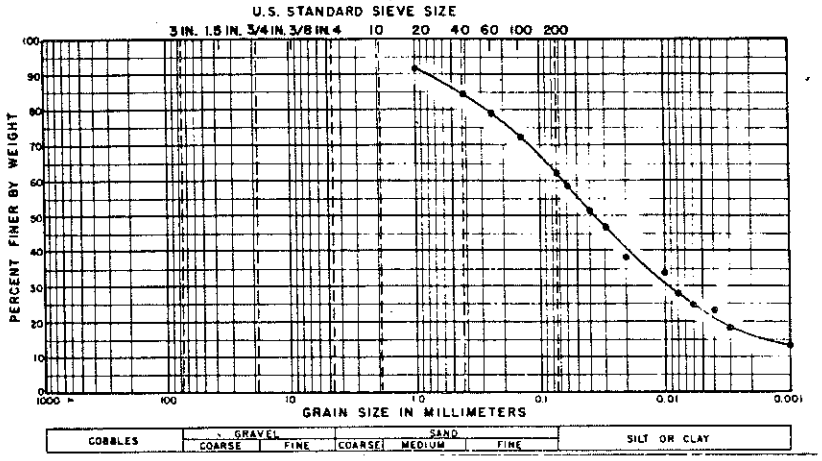


PARTICLE SIZE ANALYSES

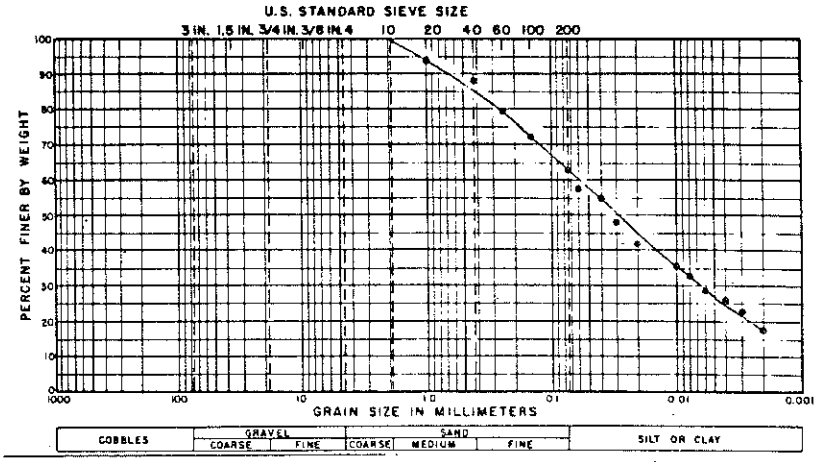
DAMES & MOORE

PLATE 71-26A

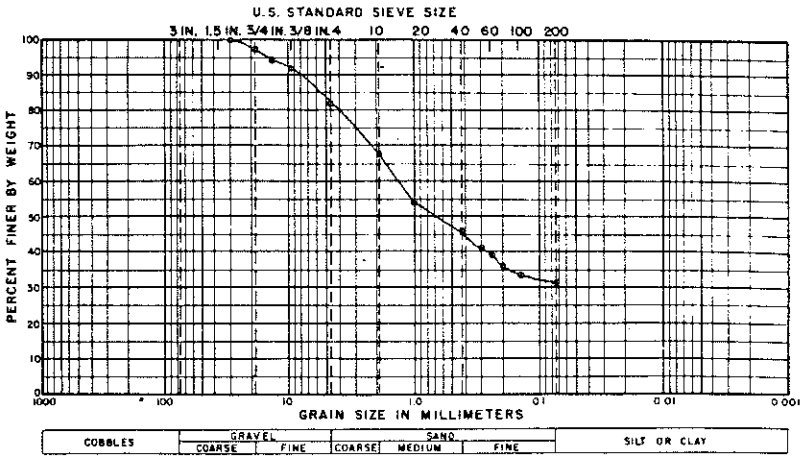
Boring No. 6- Depth 24ft.



Boring No. 6- Depth 34ft.



Boring No.6-Depth 36 ft.



PARTICLE SIZE ANALYSES

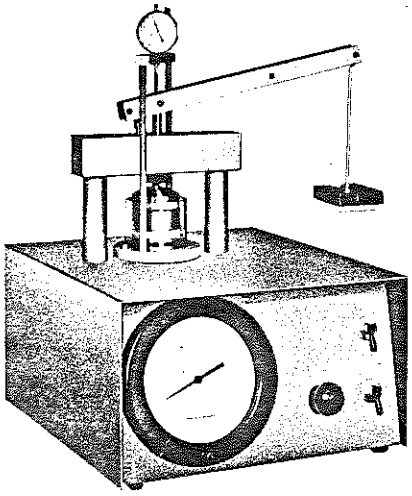
DAMES & MOORE

PLATE 71-27

METHOD OF PERFORMING CONSOLIDATION TESTS

CONSOLIDATION TESTS ARE PERFORMED TO EVALUATE THE VOLUME CHANGES OF SOILS SUBJECTED TO INCREASED LOADS. TIME-CONSOLIDATION AND PRESSURE-CONSOLIDATION CURVES MAY BE PLOTTED FROM THE DATA OBTAINED IN THE TESTS. ENGINEERING ANALYSES BASED ON THESE CURVES PERMIT ESTIMATES TO BE MADE OF THE PROBABLE MAGNITUDE AND RATE OF SETTLEMENT OF THE TESTED SOILS UNDER APPLIED LOADS.

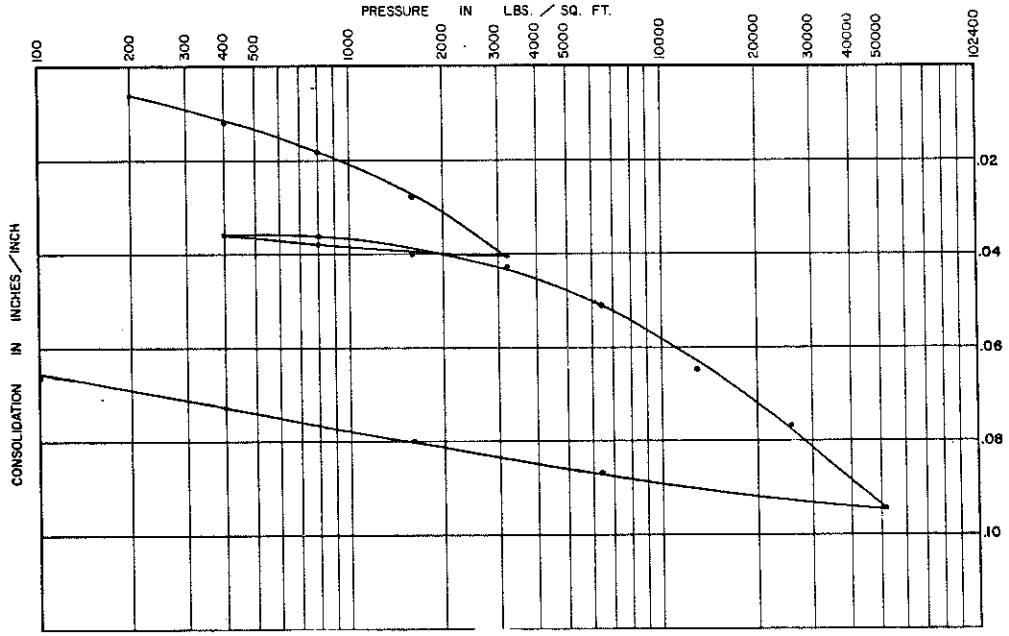
EACH SAMPLE IS TESTED WITHIN BRASS RINGS TWO AND ONE-HALF INCHES IN DIAMETER AND ONE INCH IN LENGTH. UNDISTURBED SAMPLES OF IN-PLACE SOILS ARE TESTED IN RINGS TAKEN FROM THE SAMPLING DEVICE IN WHICH THE SAMPLES WERE OBTAINED. LOOSE SAMPLES OF SOILS TO BE USED IN CONSTRUCTING EARTH FILLS ARE COMPACTED IN RINGS TO PREDETERMINED CONDITIONS AND TESTED.



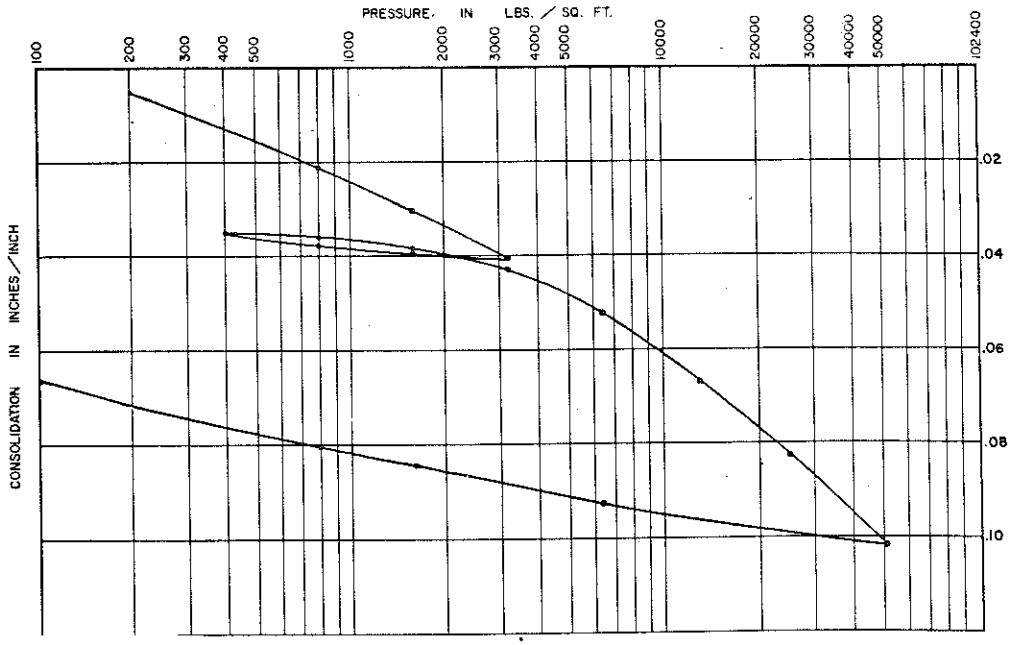
DEAD LOAD-PNEUMATIC CONSOLIDOMETER

IN TESTING, THE SAMPLE IS RIGIDLY CONFINED LATERALLY BY THE BRASS RING. AXIAL LOADS ARE TRANSMITTED TO THE ENDS OF THE SAMPLE BY POROUS DISKS. THE DISKS ALLOW DRAINAGE OF THE LOADED SAMPLE. THE AXIAL COMPRESSION OR EXPANSION OF THE SAMPLE IS MEASURED BY A MICROMETER DIAL INDICATOR AT APPROPRIATE TIME INTERVALS AFTER EACH LOAD INCREMENT IS APPLIED. EACH LOAD IS ORDINARILY TWICE THE PRECEDING LOAD. THE INCREMENTS ARE SELECTED TO OBTAIN CONSOLIDATION DATA REPRESENTING THE FIELD LOADING CONDITIONS FOR WHICH THE TEST IS BEING PERFORMED. EACH LOAD INCREMENT IS ALLOWED TO ACT OVER AN INTERVAL OF TIME DEPENDENT ON THE TYPE AND EXTENT OF THE SOIL IN THE FIELD.

BORING NO. 4 Depth 17.5 ft.



BORING NO. 6 Depth 10.5 ft.

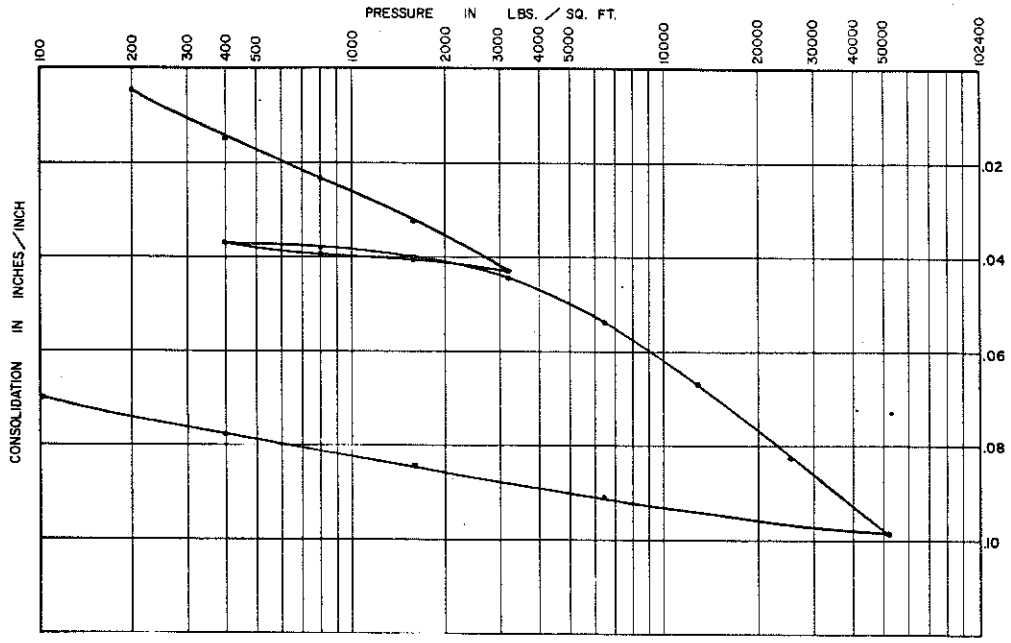


CONSOLIDATION TEST DATA

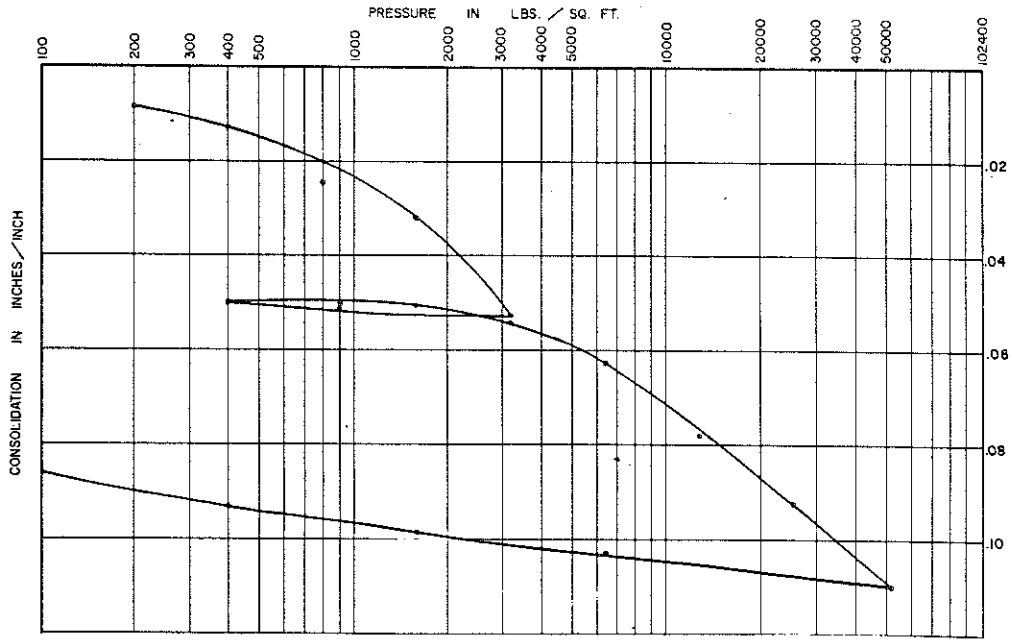
DAMES & MOORE

PLATE 71-29

BORING NO. 6 Depth 18 ft.



BORING NO. 6 Depth 25.5 ft.



CONSOLIDATION TEST DATA

DAMES & MOORE

Generalized Geologic Column

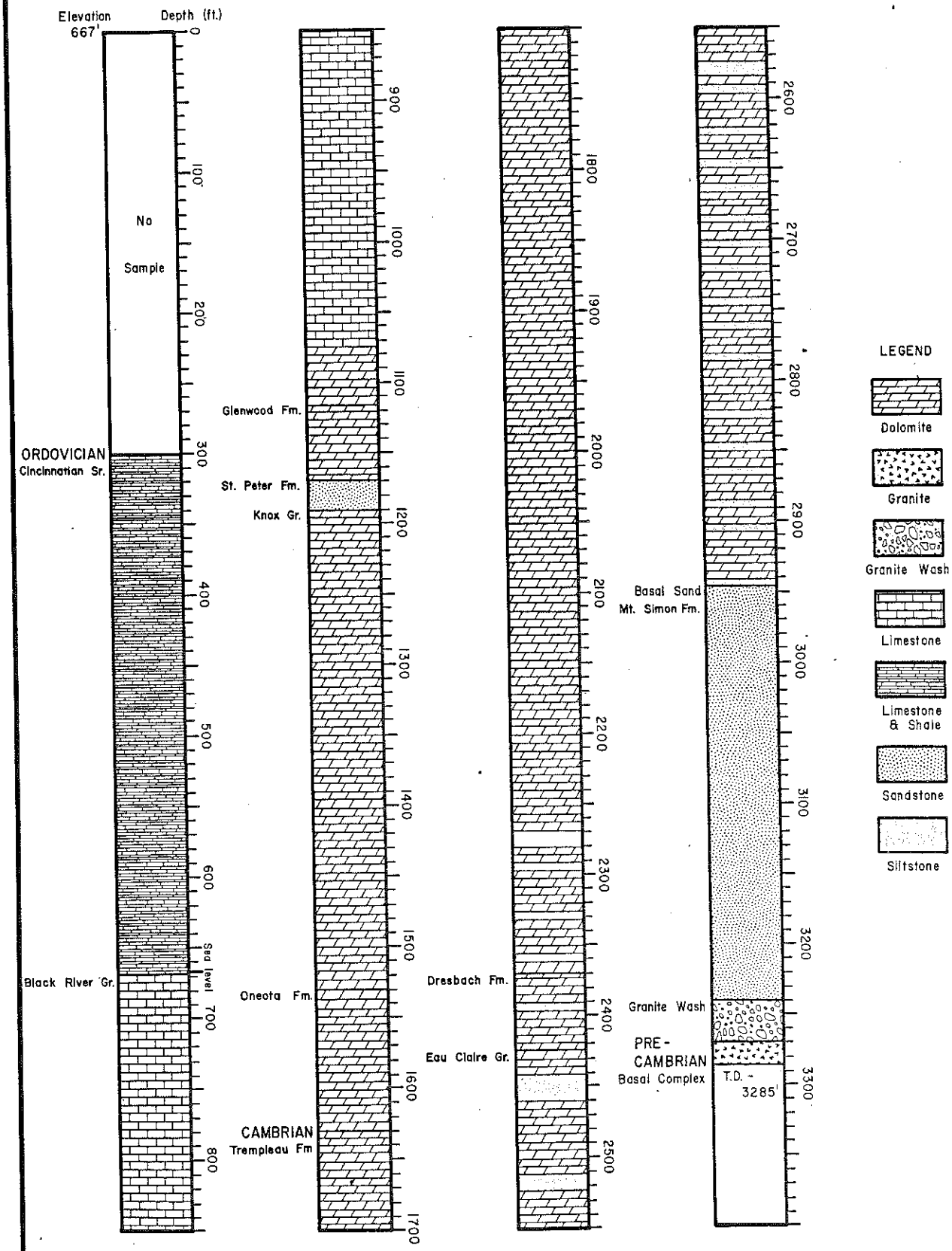
Years Ago (in millions)	ERA	SYSTEM	Series	Sub-Series	Group	FORMATION	Rock type	Thickness in feet
	CENOZOIC					Quaternary Glacial Deposits		
280		PERMIAN			Dunkard	Greene	SS Sh	65
						Washington	SS Sh	175
		PENNSYLVANIAN				Monongahela Group	Coal lms SS	270
						Conemaugh Group	SS lms	400
						Allegheny Group	SS Coal lms	200
310						Pottsville Group	SS Coal Cong	250
		MISSISSIPPIAN		Kinderhook		Mauch Chunk	lms	60
						Logan	SS, Cong	60
						Cuyahoga	SS, Sh	450
						Sunbury	Sh	20
						Berea	SS	50
345						Bedford	Sh	70
		DEVONIAN		Chautauquan		Ohio	Sh	600
				Erian		Olentangy	Sh	20
						Delaware	lms	45
405				Ulsterian		Columbus	lms	100
				Corygan	Salina	Tymochtee	Del	150
		SILURIAN				Greenfield	Del	200
				Niagaran	Clinton-Lockport	Cedarville	Del	70
						Springfield	Del	10
						Alger	Sh	55
				Alexandria		Dayton	Del, lms	10
425						Brassfield	lms	70
					Richmond	Elkhorn (Queenston)	Sh	65
						Whitewater	Sh, lms	75
						Liberty	Sh, lms	35
				Cincinnatian		Waynesville	Sh, lms	95
						Arnheim	Sh, lms	60
					Maysville	McMillan	Sh, lms	90
						Fairview	Sh, lms	115
					Eden	Kope	Sh	245
		ORDOVICIAN		Champlainian	Trenton	Ft. Pleasant (Cincinnatian)	lms, Del	185
						Lexington (Galena)	lms, Del	150
					Mohawk	Plattsville	lms, Del	405
					Black River	Glenwood	Del	20
						St. Peter	SS	20
					Chaz	Shakopee	Del	70
				Canadian	Beekmantown	New Richmond	SS, Del	20
500						Oneota	Del	275
					Knox	Tremployeau (Copper Ridge)	Del	525
		CAMBRIAN		St. Croixian		Dresbach (Franconia)	SS, Del	115
						Eau Claire	Del, SS	530
600						Mt. Simon	SS	220
		PRECAMBRIAN				Undifferentiated	(Granite)	?

KEY

Unconformity

Boundary of unconformity uncertain

SS = Sandstone
Sh = Shale
lms = Limestone
Cong = Conglomerate
Del = Dolomite

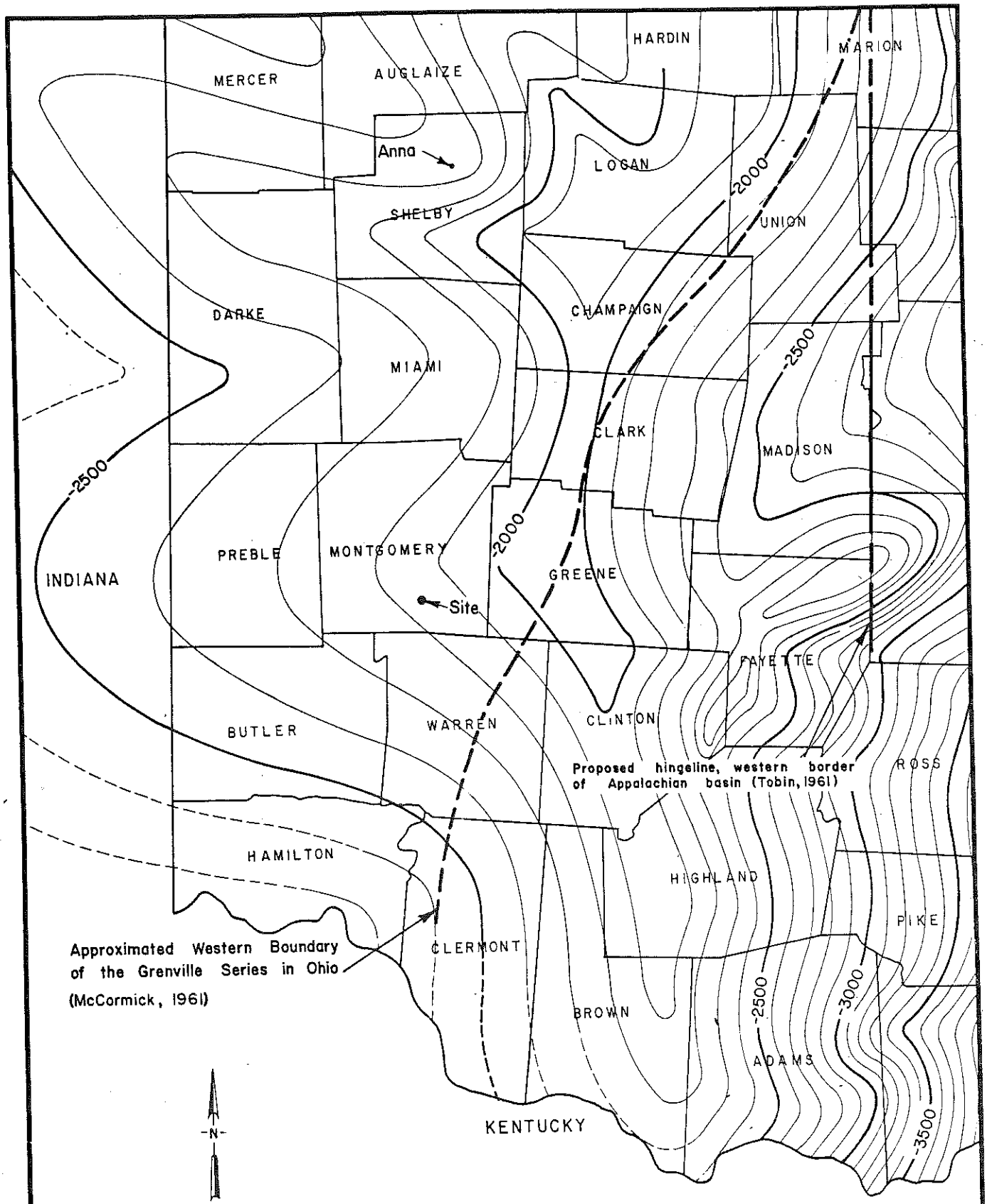


Generalized Geologic Log of Armco Deep Well No. 2

Located 10 Miles SSW of Site

DAMES & MOORE

Adapted from Strip Log by Geological Sample Log Co., Pittsburgh, Pa.



Contour Map of the Precambrian Surface

Contour Interval = 100'

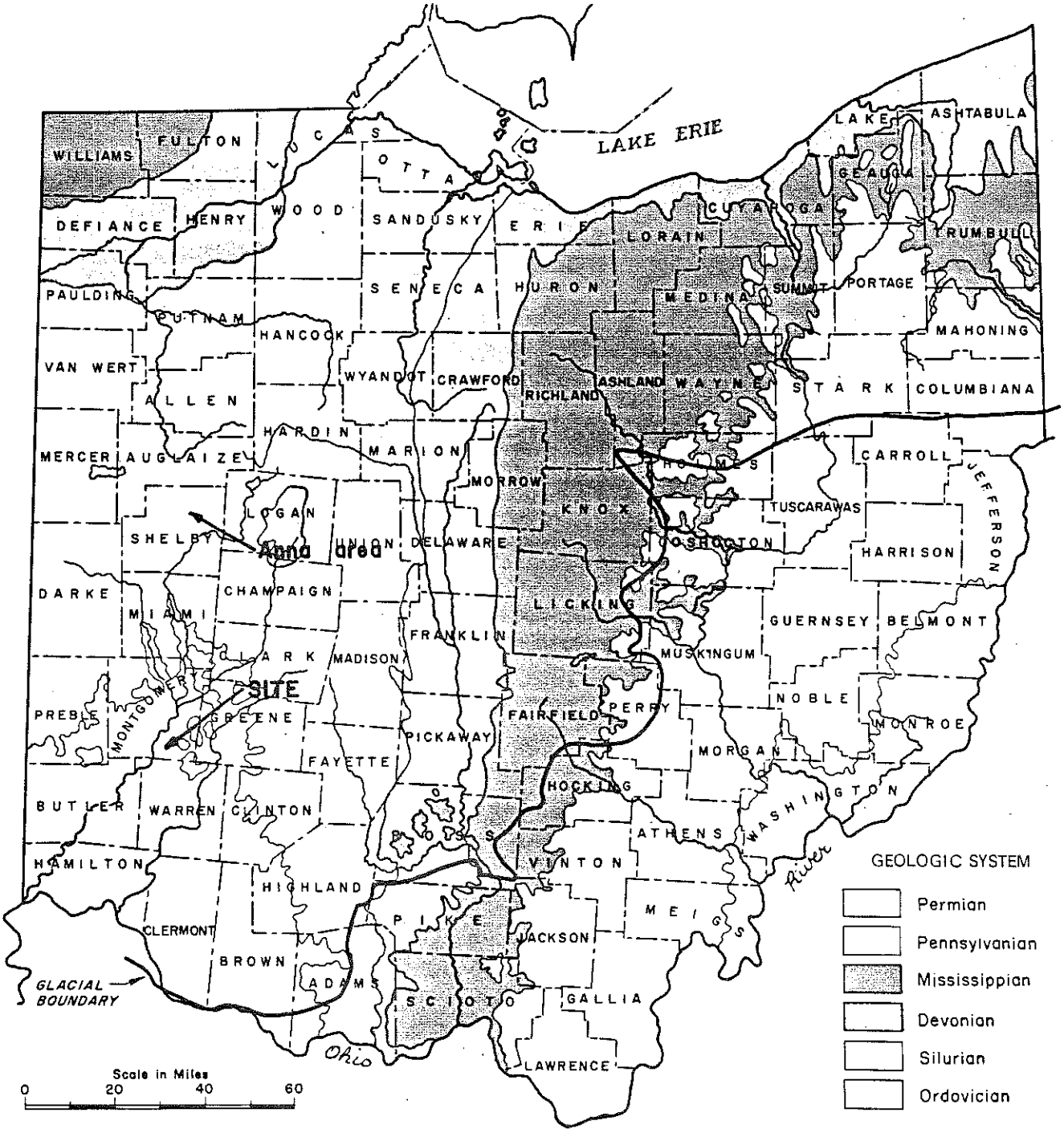
SCALE 10 0 10 20 MILES

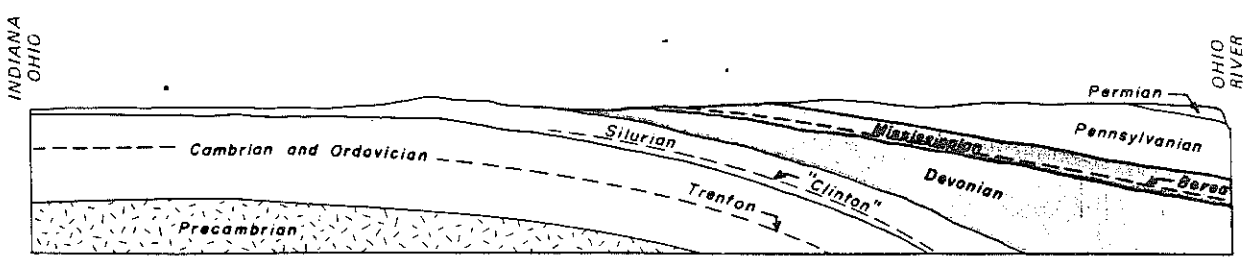
Adapted from Gordon L. Owens, 1967

Contours Referenced to Mean Sea Level

DAMES & MOORE

PLATE 7.1-33

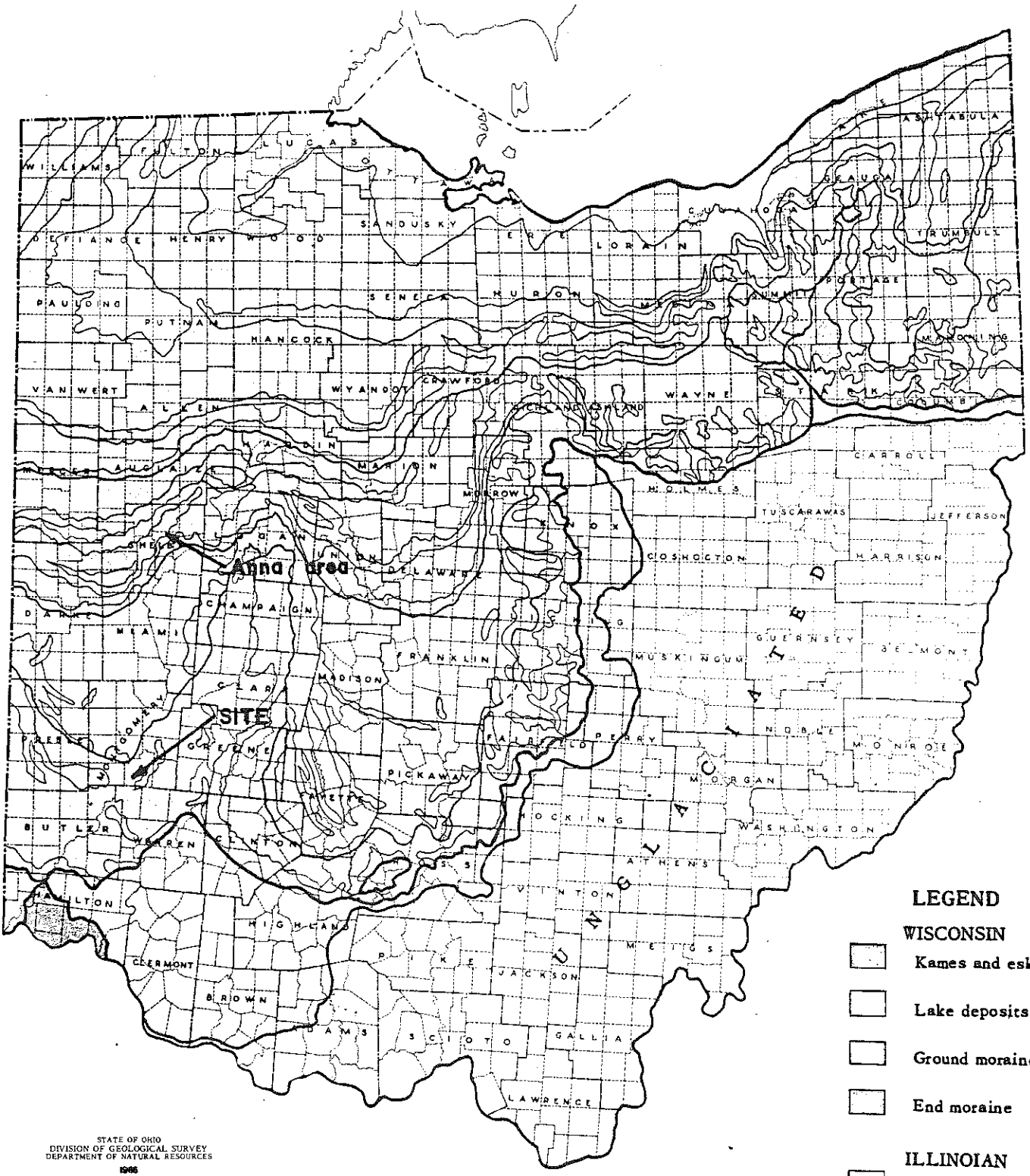




OHIO DIVISION OF GEOLOGICAL SURVEY

GEOLOGIC MAP AND CROSS SECTION OF OHIO

DAMES & MOORE



ADAPTED FROM GLACIAL MAP OF OHIO,
U.S. GEOL. SURVEY MISC. GEOL. INV. MAP I-316

GLACIAL DEPOSITS OF OHIO

DAMES & MOORE

GWY 9/73

Glacial

5627-003

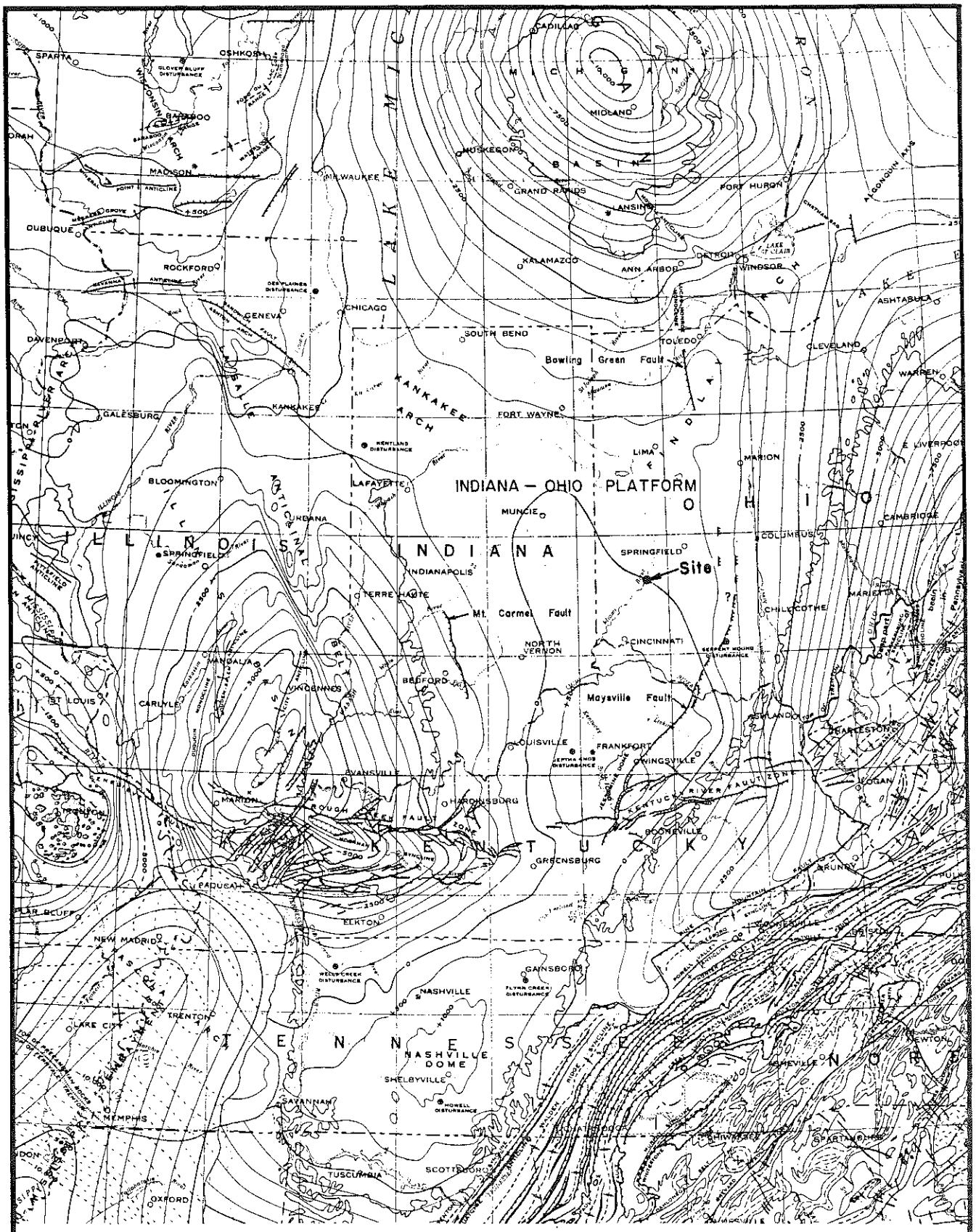
PHYSIOGRAPHIC SECTIONS OF OHIO

DAMES & MOORE

CHECKED BY _____ FILE 5627-003 Physiographic BY G.W.Y. DATE 3/93

Landform Map of Ohio

DAMES & MOORE



Tectonic Map

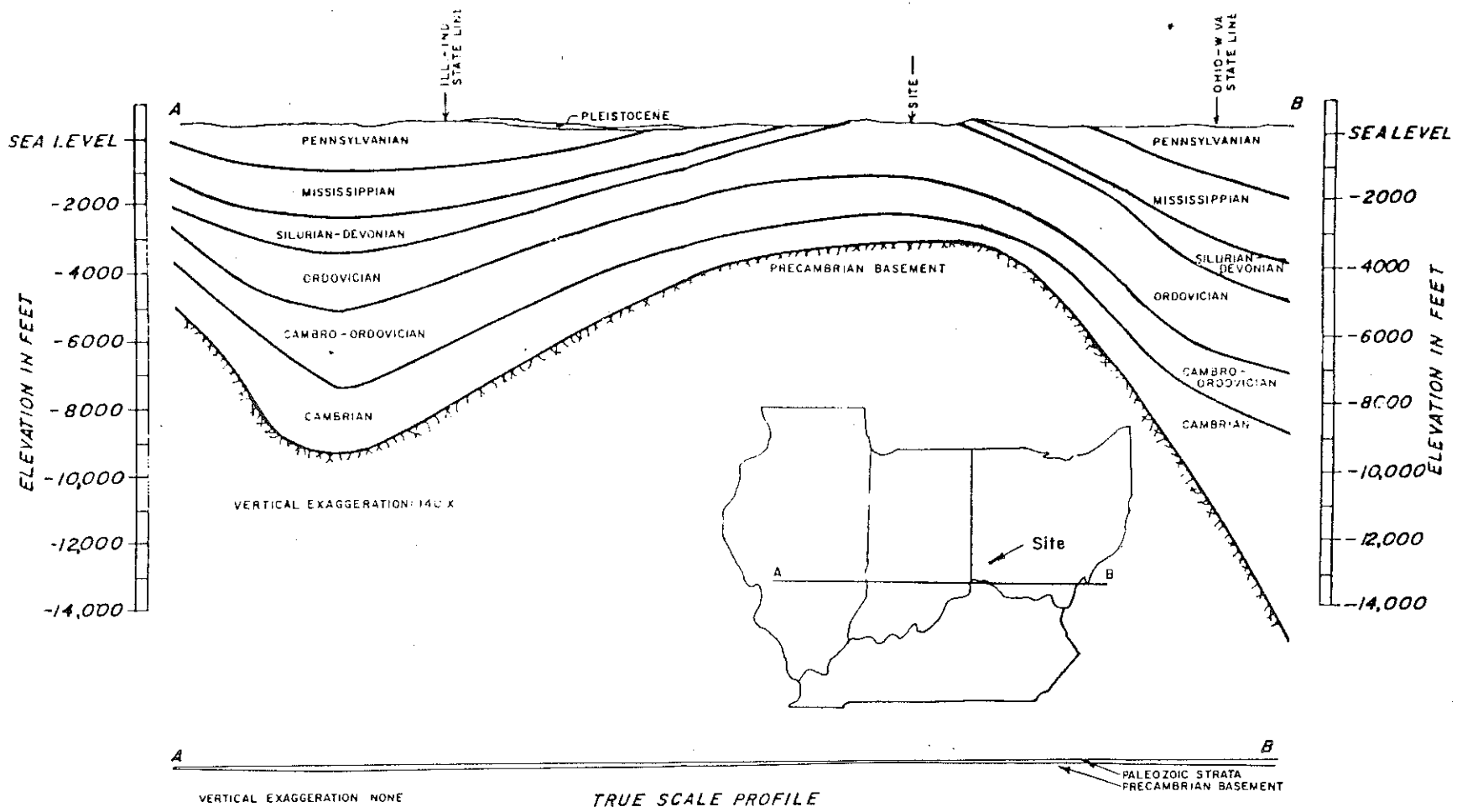
Structure Contours on top of Trenton Limestone

Adapted from Tectonic Map of United States U.S.G.S. & A.A.P.G., 1962.

25 0 25 50 75 100 MILES

DAMES & MOORE

PLATE 7.1-38



Generalized Regional Cross Section

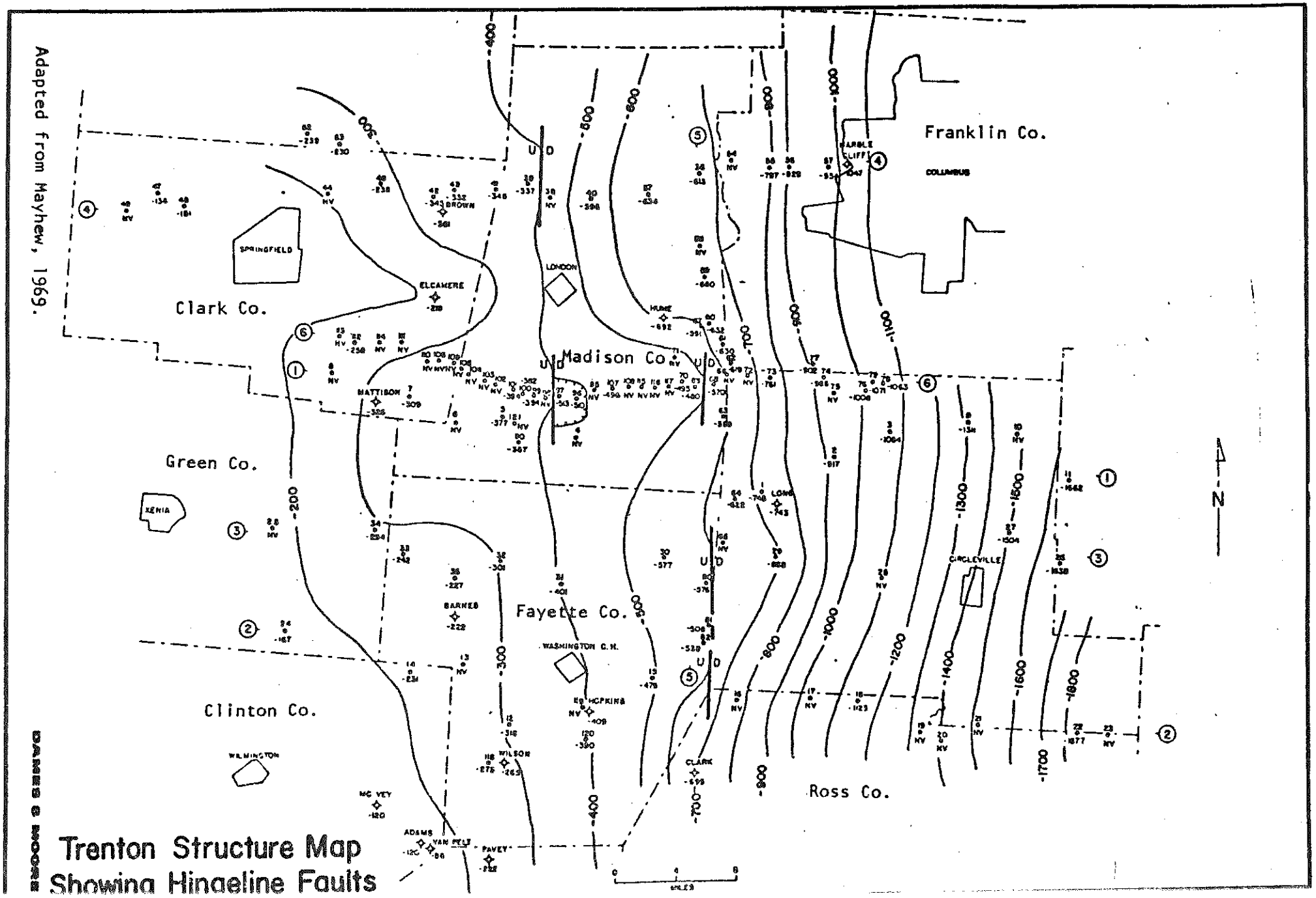
DAMES & MOORE

PLATE 7.1-39

46.7 (REV. 6-61)

BY _____ DATE _____ REVISIONS

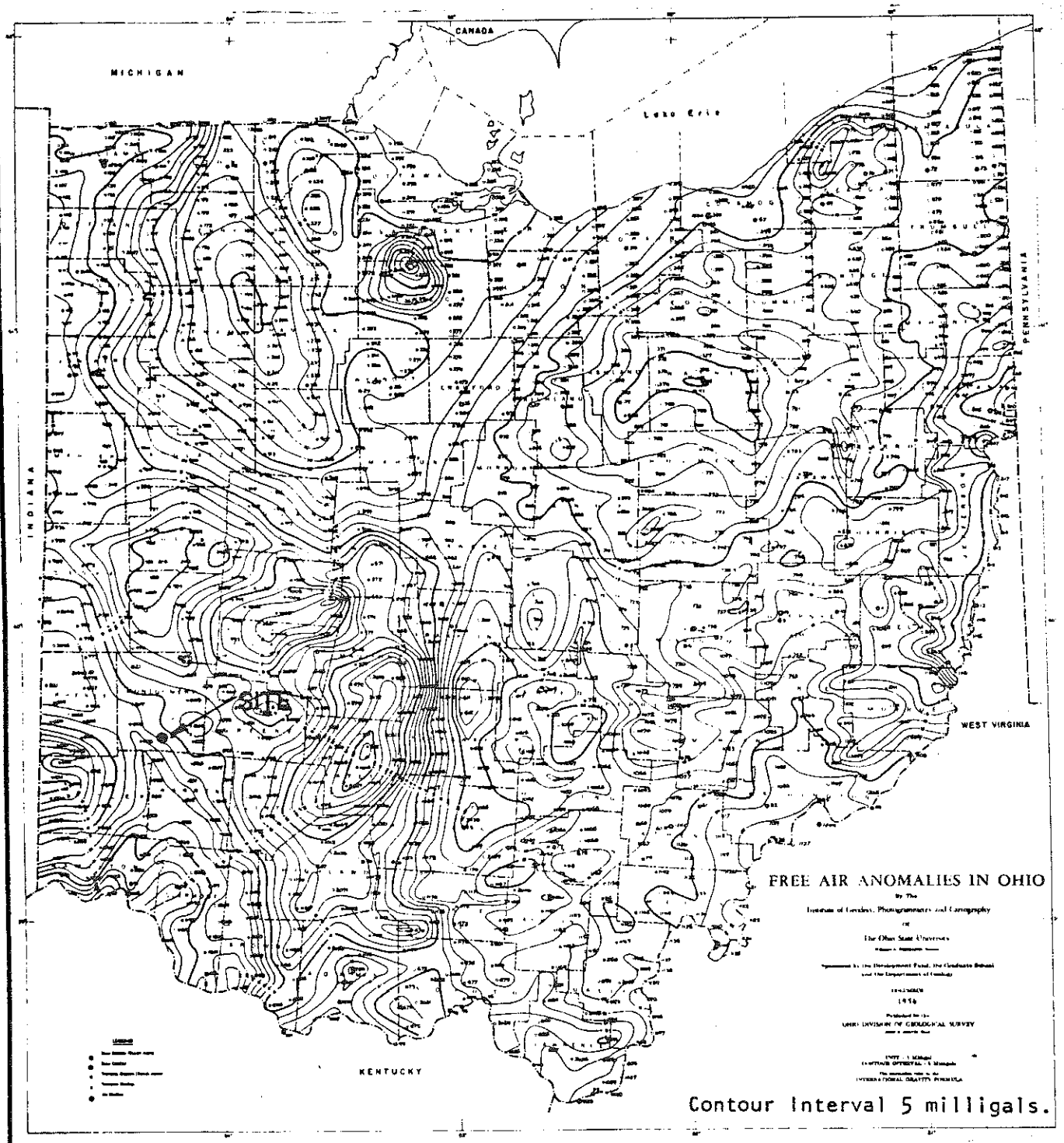
CHECKED BY _____ FILE _____ BY _____ DATE _____



Adapted from Mayhew, 1969.

Trenton Structure Map Showing Hingeline Faults

BARNES & MOORE



Free Air Gravity Anomalies

Adapted from Heiskanen & Uotila, 1956

DAMES & MOORE

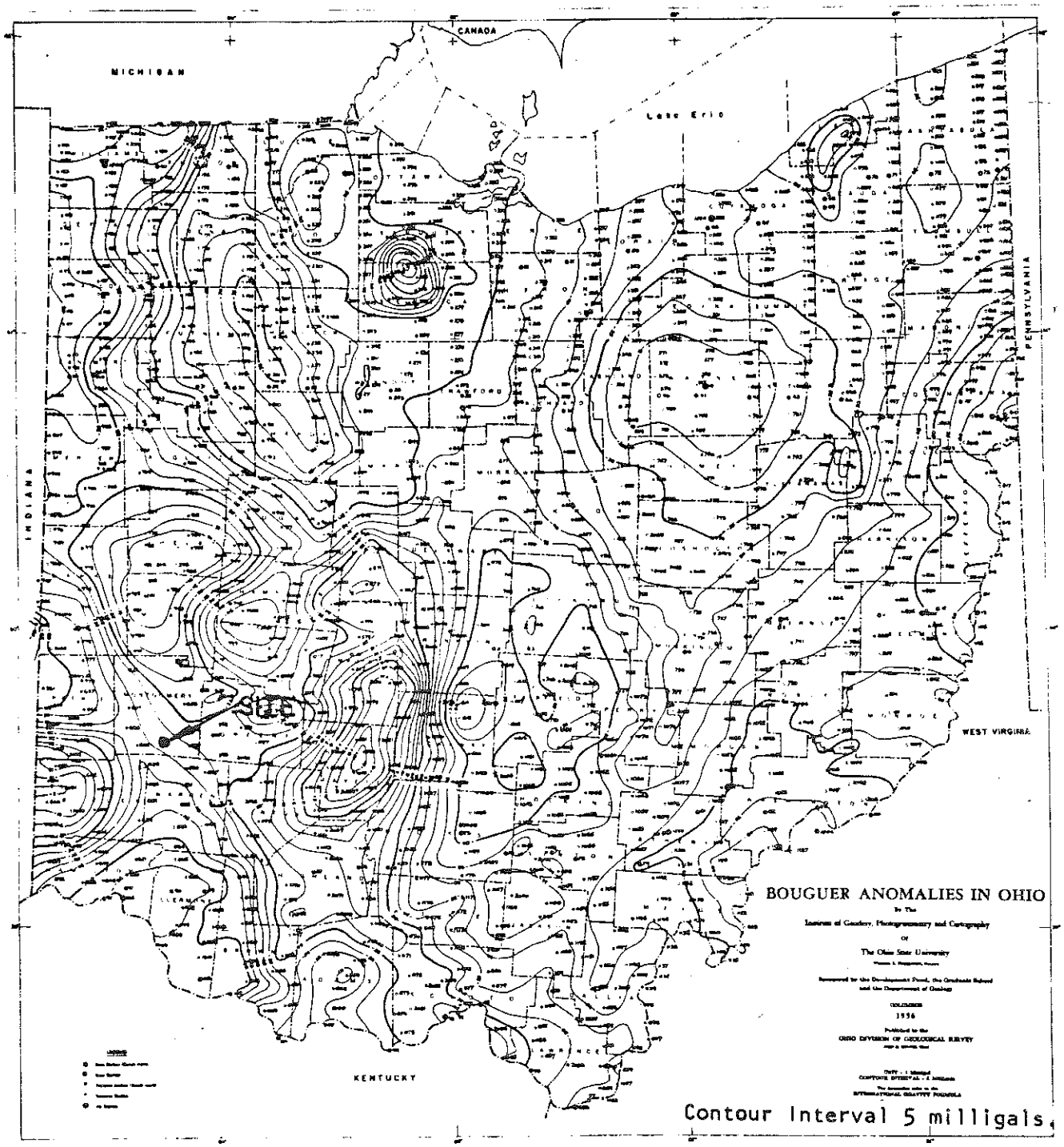
REVISIONS BY _____ DATE _____

FILE _____

BY _____ DATE _____

CHECKED BY _____

16.7 (REV. 6-61)



Bouguer Gravity Anomalies

Adapted from Heiskanen & Uotila, 1956

DAMES & MOORE

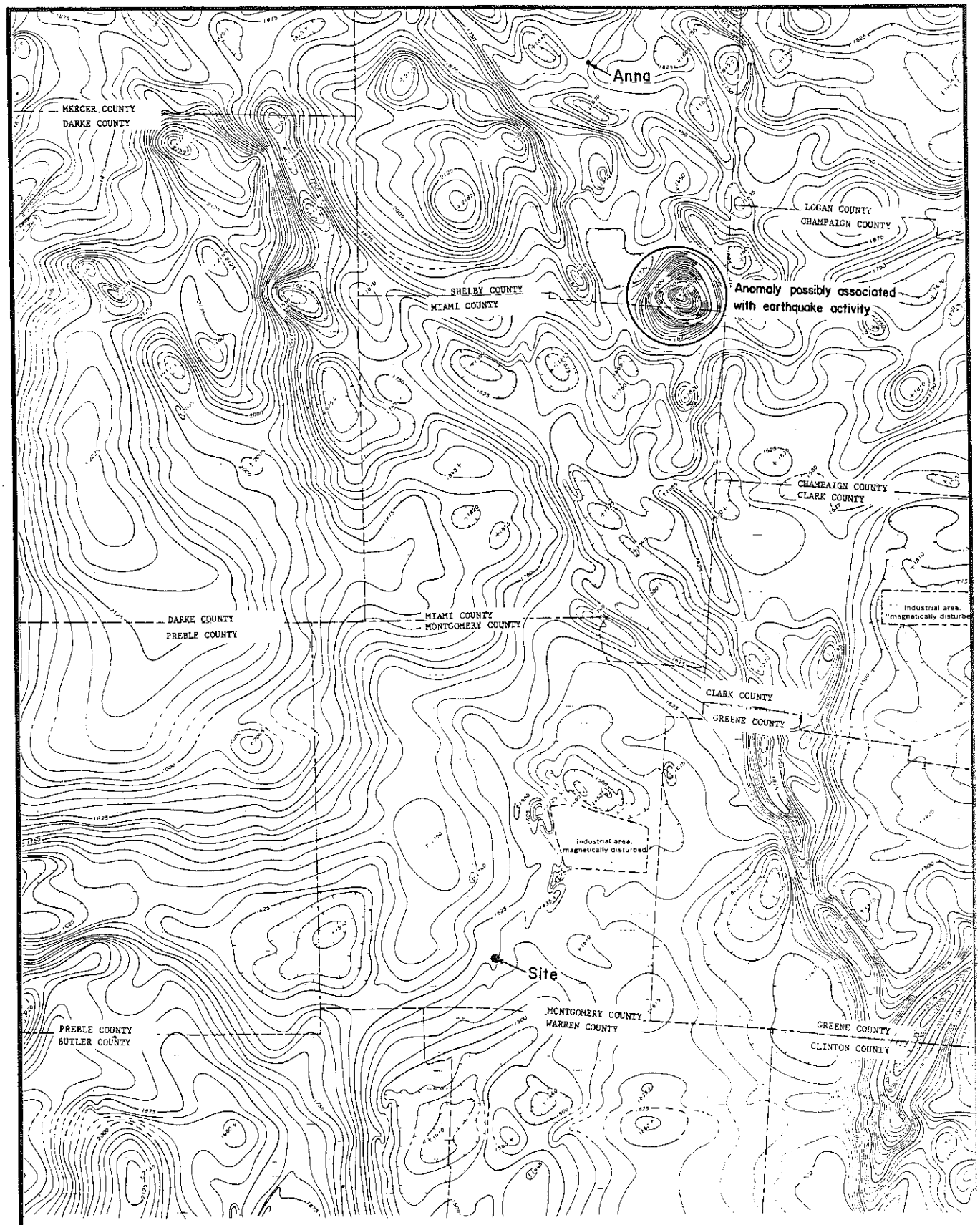
REVISIONS BY DATE

FILE

BY DATE

CHECKED BY

6.7 (REV. 6-61)



EXPLANATION

Magnetic contours showing total intensity magnetic field of the earth in gammas relative to arbitrary datum

Hachured to indicate closed areas of lower magnetic intensity, dashed where data are incomplete

CONTOUR INTERVAL 25 GAMMAS

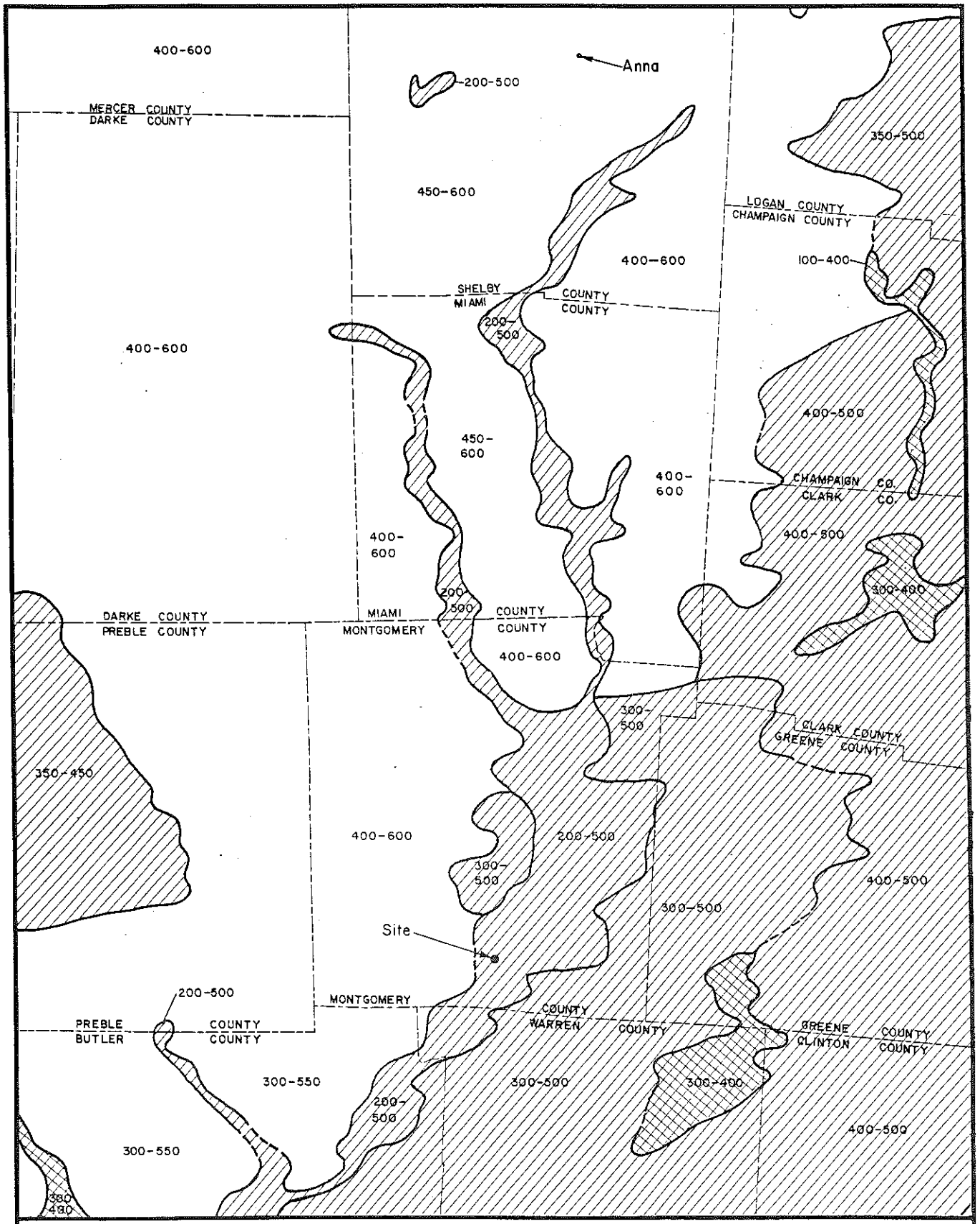
Aeromagnetic Map

N

DAMES & MOORE

Adapted from Philbin, Long, & Moore, 1965.

PLATE 71-43



N

Natural Gamma Aeroradioactivity Map

LEGEND

100-400 200-500 350-600

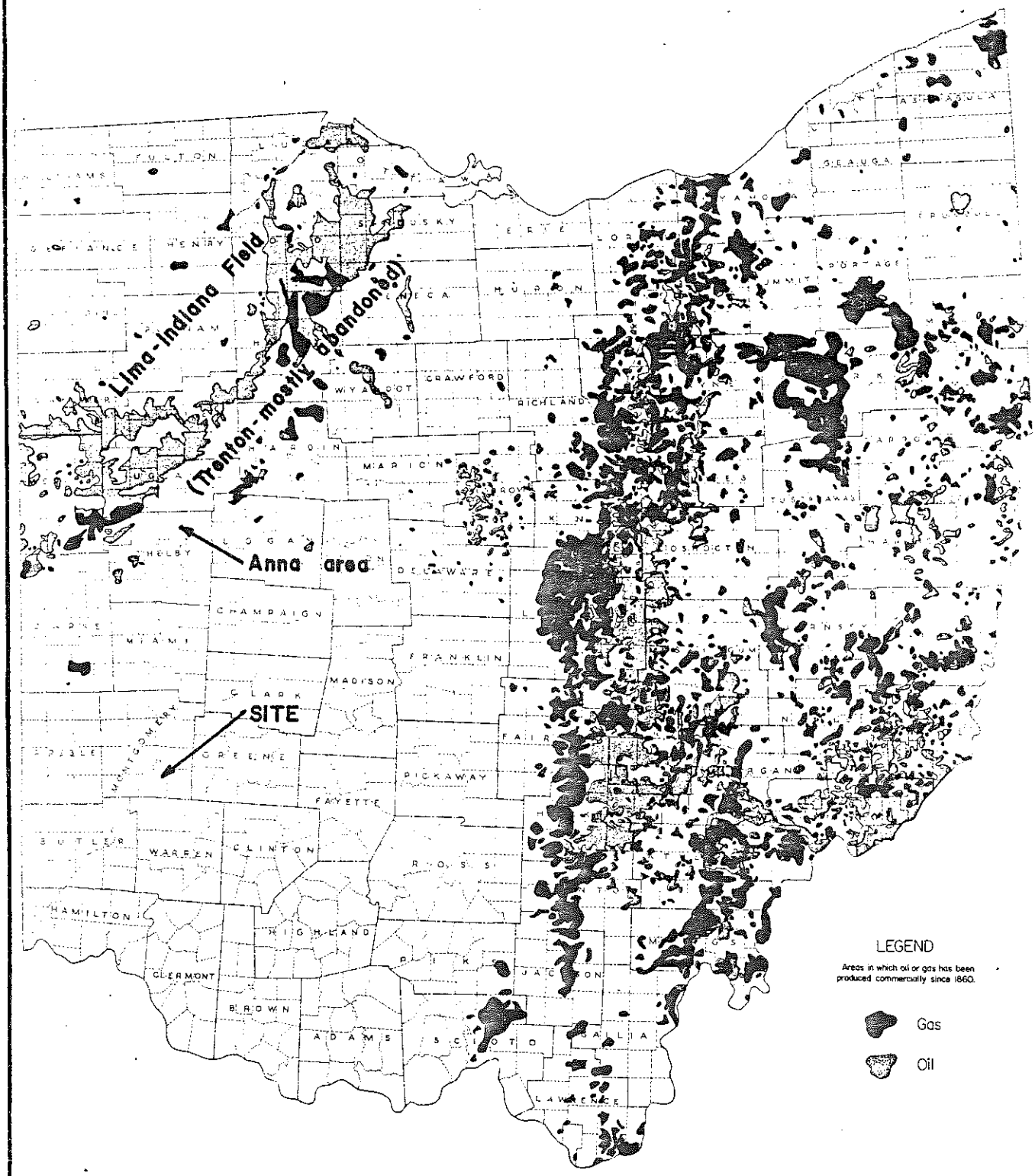
counts/second

5 0 5 10 MILES

Adapted from Robert G. Bates, 1965

DAMES & MOORE

PLATE 7.1-44



STATE OF OHIO
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL SURVEY, 1966

OIL & GAS FIELDS MAP OF OHIO

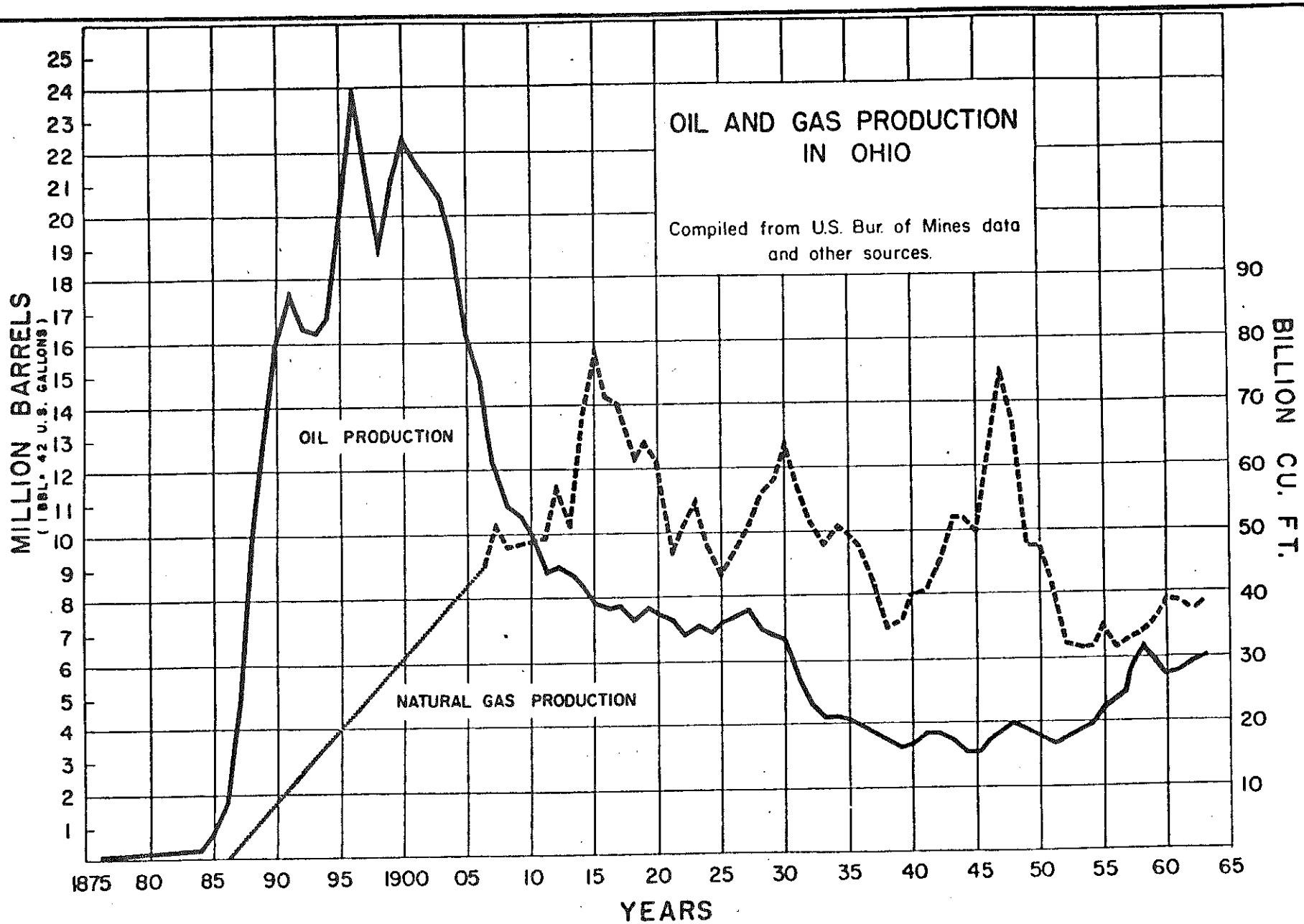
Scale

DAMES & MOORE

.7 (REV. 6-61)

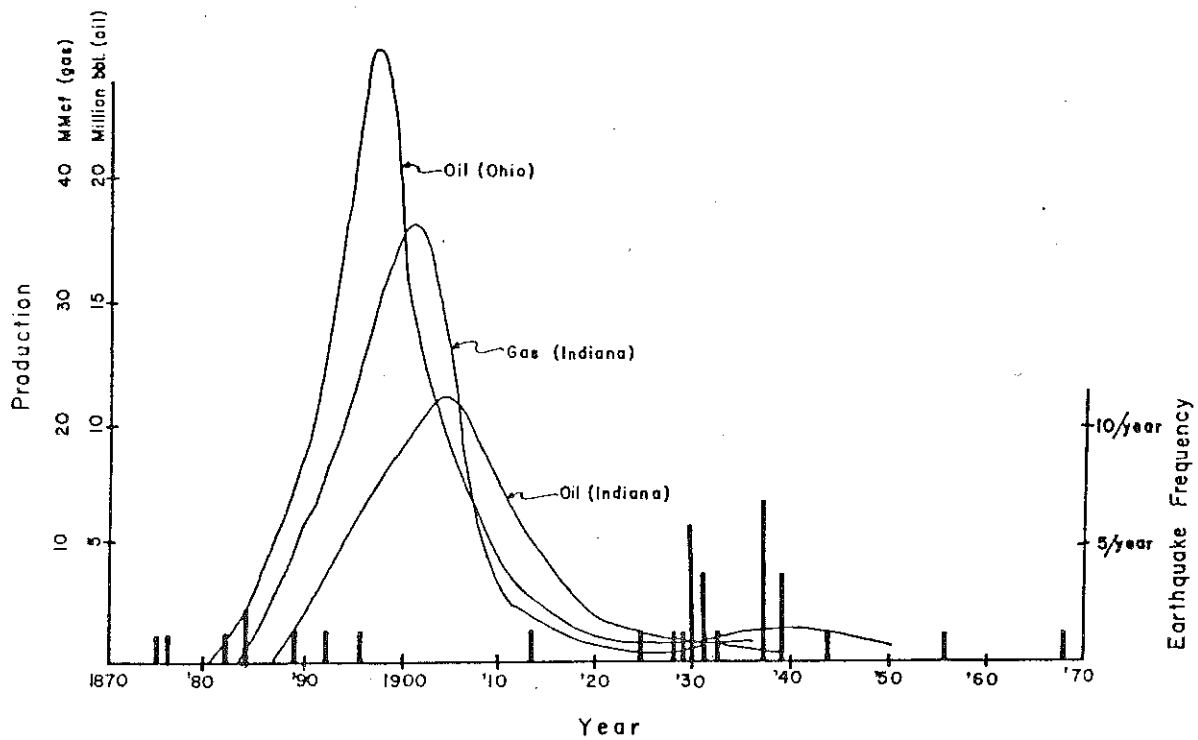
BY GW.Y DATE 4/73
CHECKED BY _____ FILE 5627-00

REVISIONS
BY _____ DATE _____



Oil and gas production in Ohio, 1876-1963.

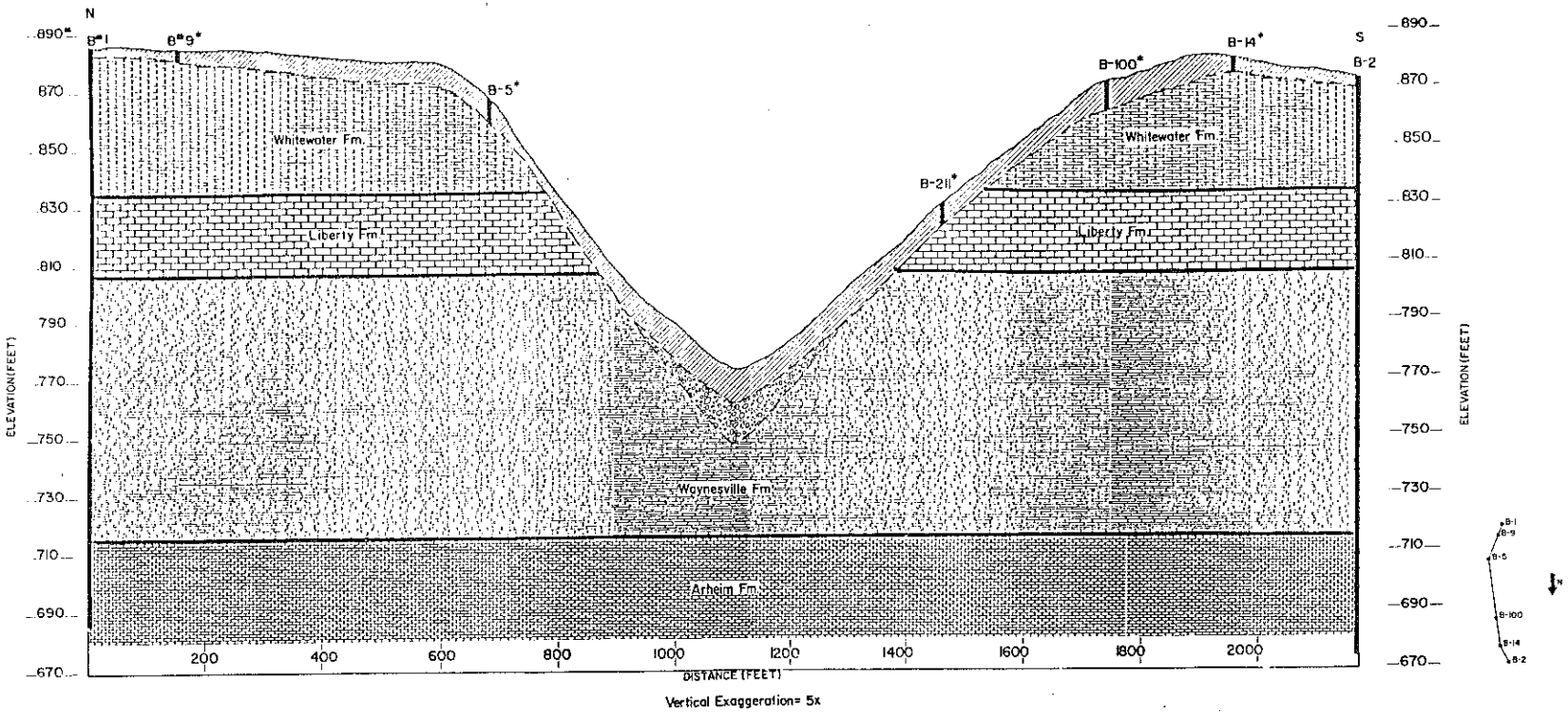
DAMES & MOORE



Petroleum Production from
Trenton Field and
Frequency of Anna Earthquakes

DAMES & MOORE

PLATE 7.1-47

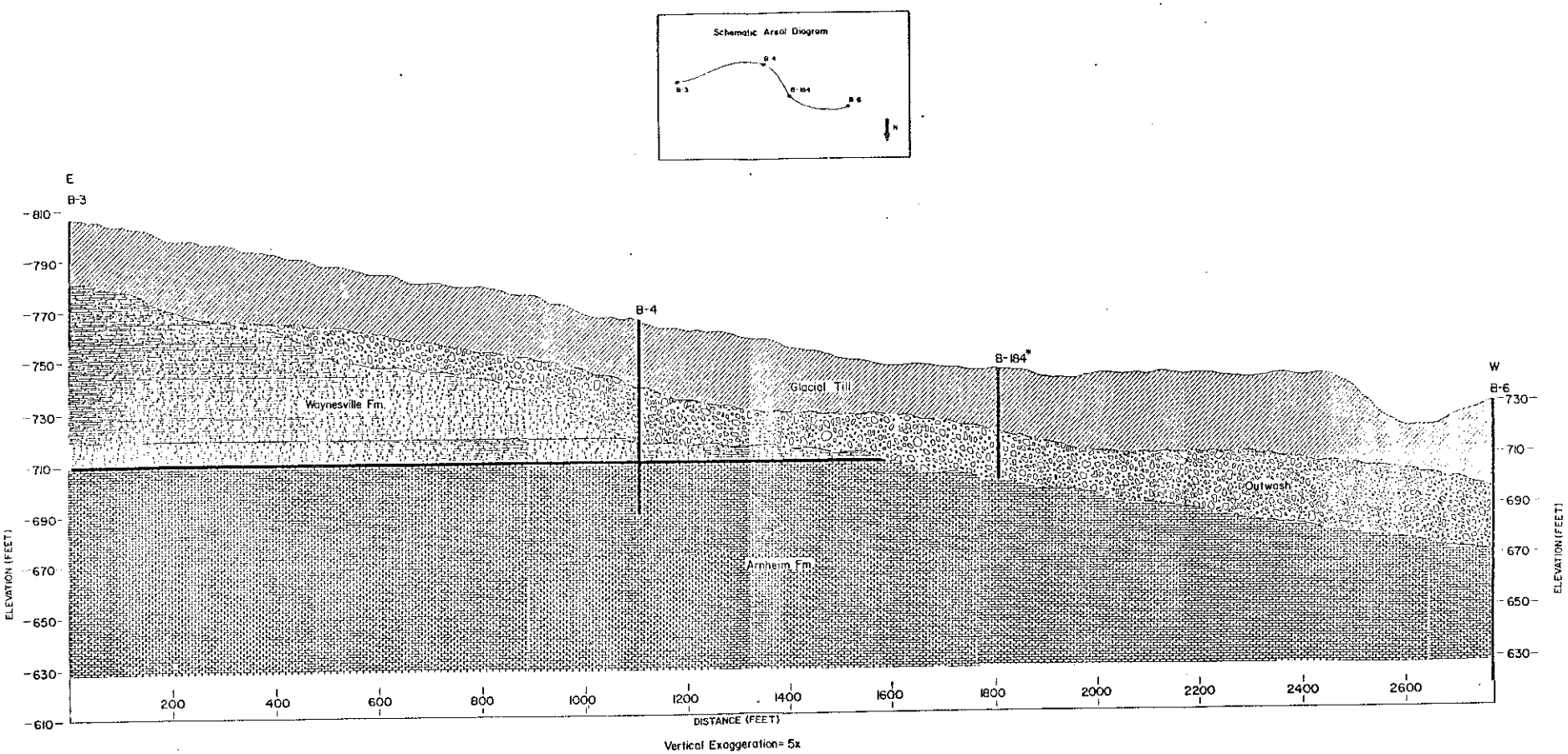


North-South Cross Section through Mound Laboratory

* BORING OBTAINED FROM MONSANTO DRAWING NUMBER 5-1332 DATED 9-11-64.

DAMES & MOORE

PLATE 7.1-48

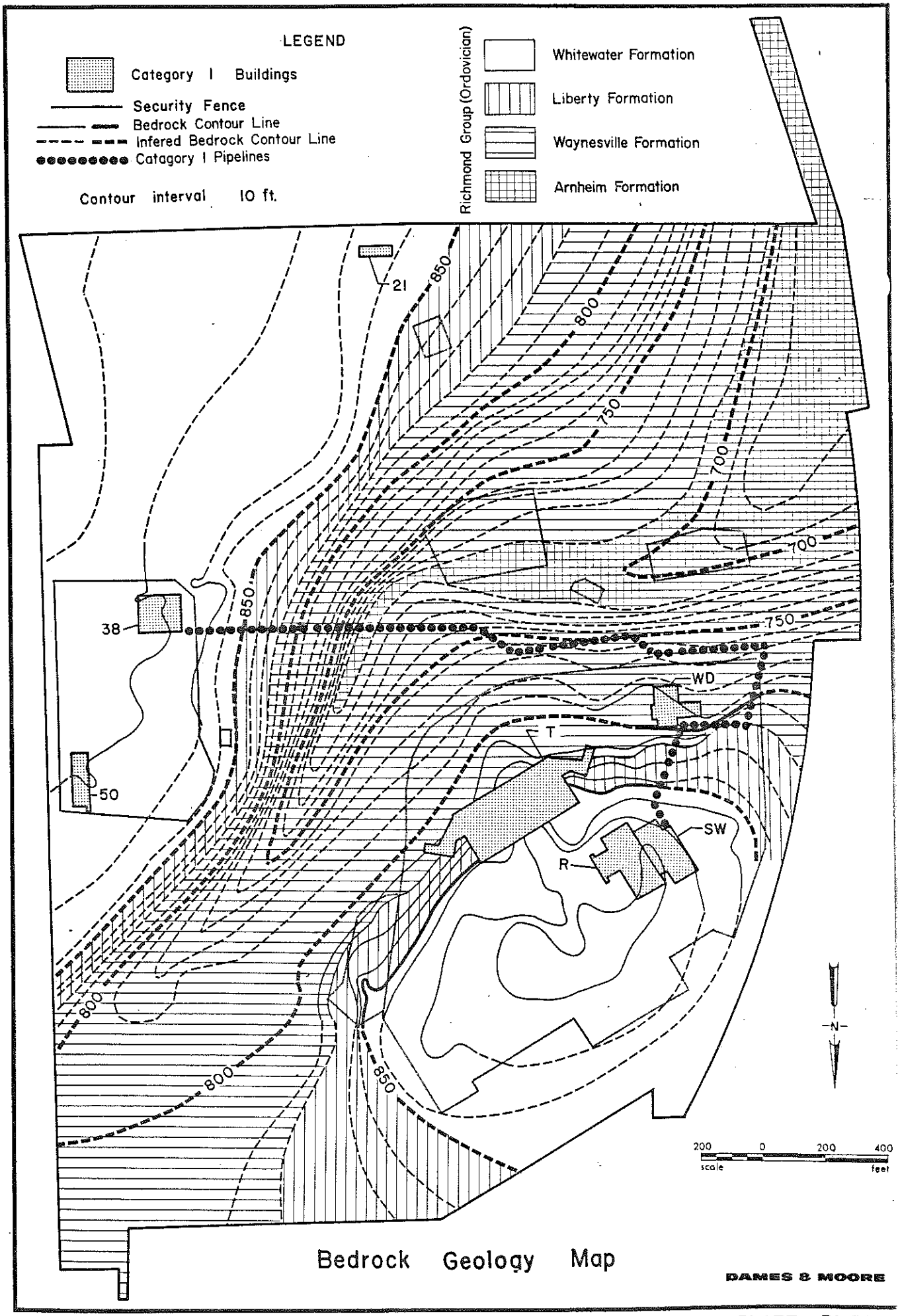


* BORING OBTAINED FROM MONSANTO DRAWING NUMBER 5-1582 DATED 9-11-64.

East - West Cross Section through Mound Laboratory

DAMES & MOORE

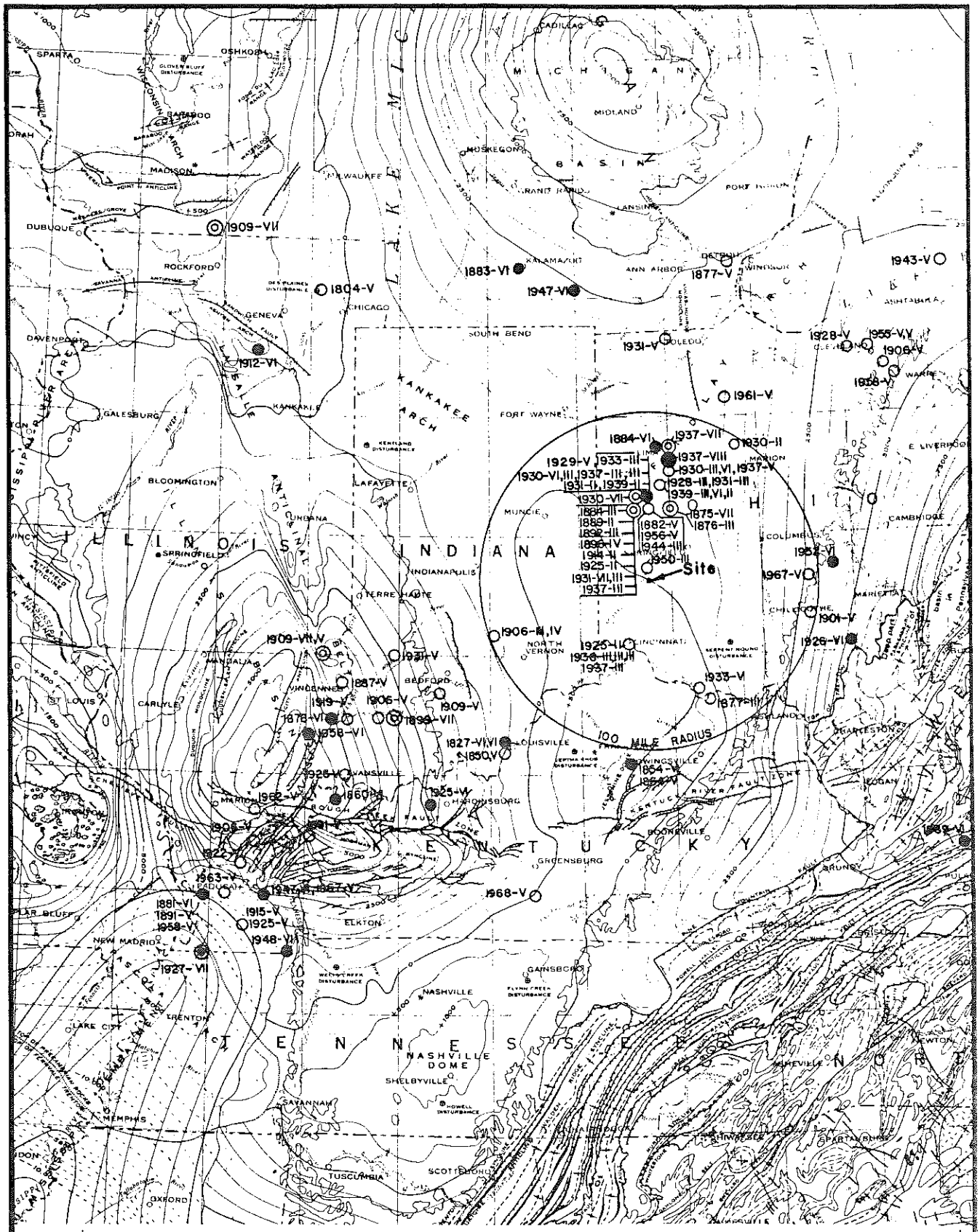
PLATE 7I-49



Bedrock Geology Map

DAMES & MOORE

PLATE 7.1-50



EARTHQUAKES OF INTENSITY V AND GREATER ARE SHOWN BEYOND A DISTANCE OF 100 MILES FROM THE SITE. ALL KNOWN SHOCKS WITHIN 100 MILES OF THE SITE ARE INDICATED.

Earthquake Epicenters

1776 – 1973

36.5°-42.5° N.Lat. 80.5°-89.0° W. Long.

KEY

SYMBOL	INTENSITY
●	VIII
◎	VII
●	VI
○	V or less

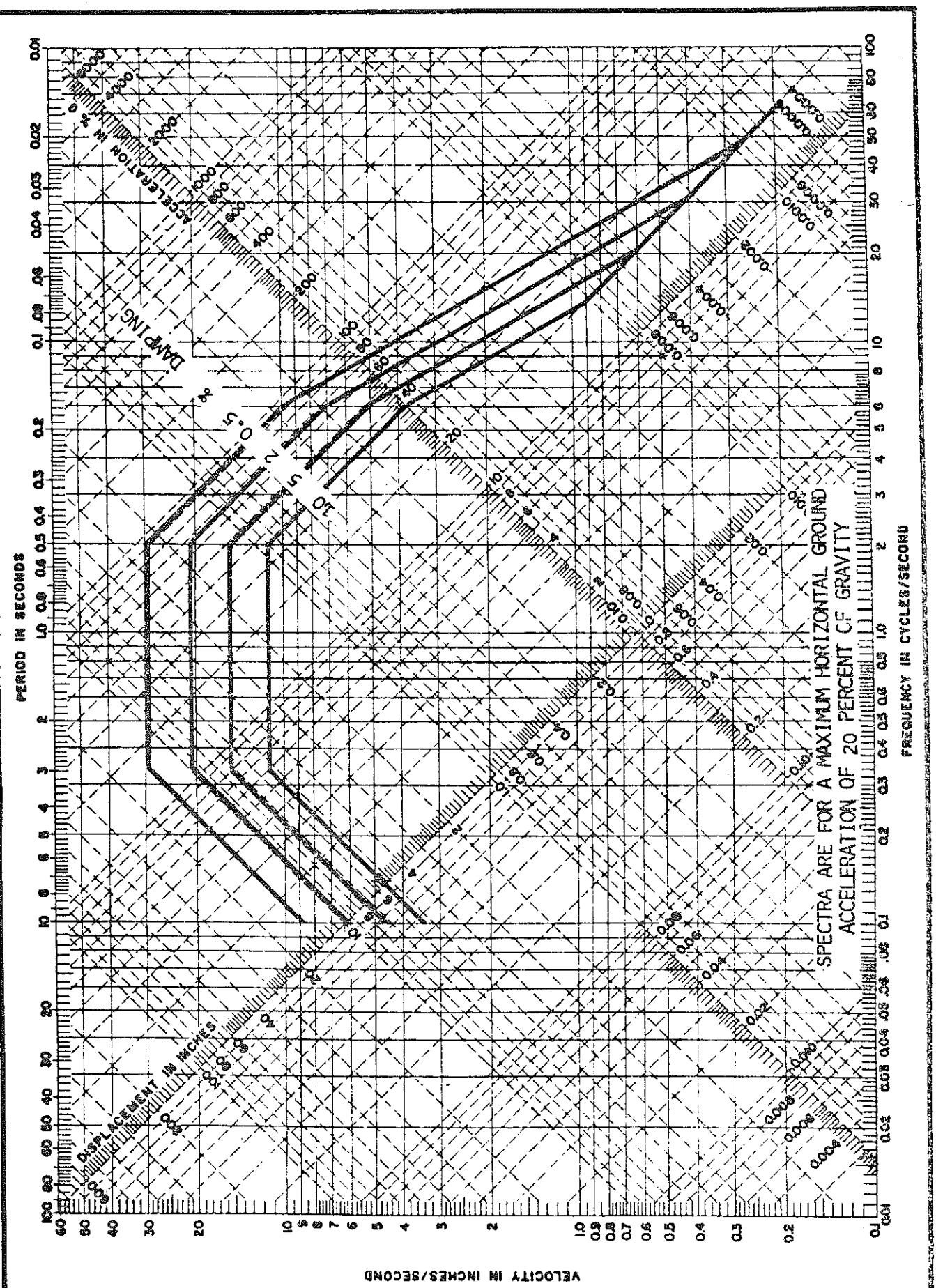
-N-

Base Map
Ref: Tectonic Map of United States
U.S.G.S. & A.A.P.G., 1962.

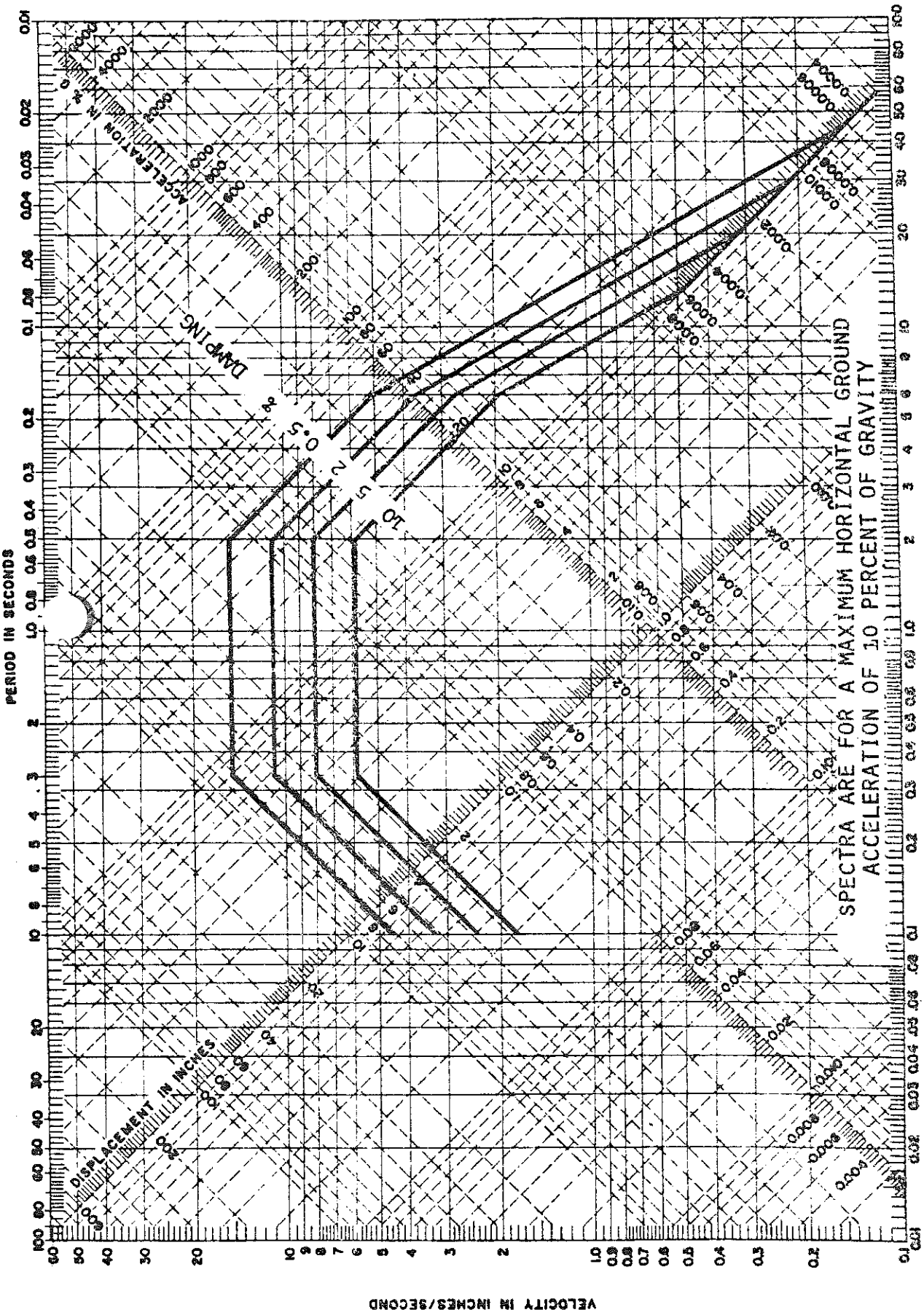
25 0 25 50 75 100 MILES

DAMES & MOORE

PLATE 7.2-1



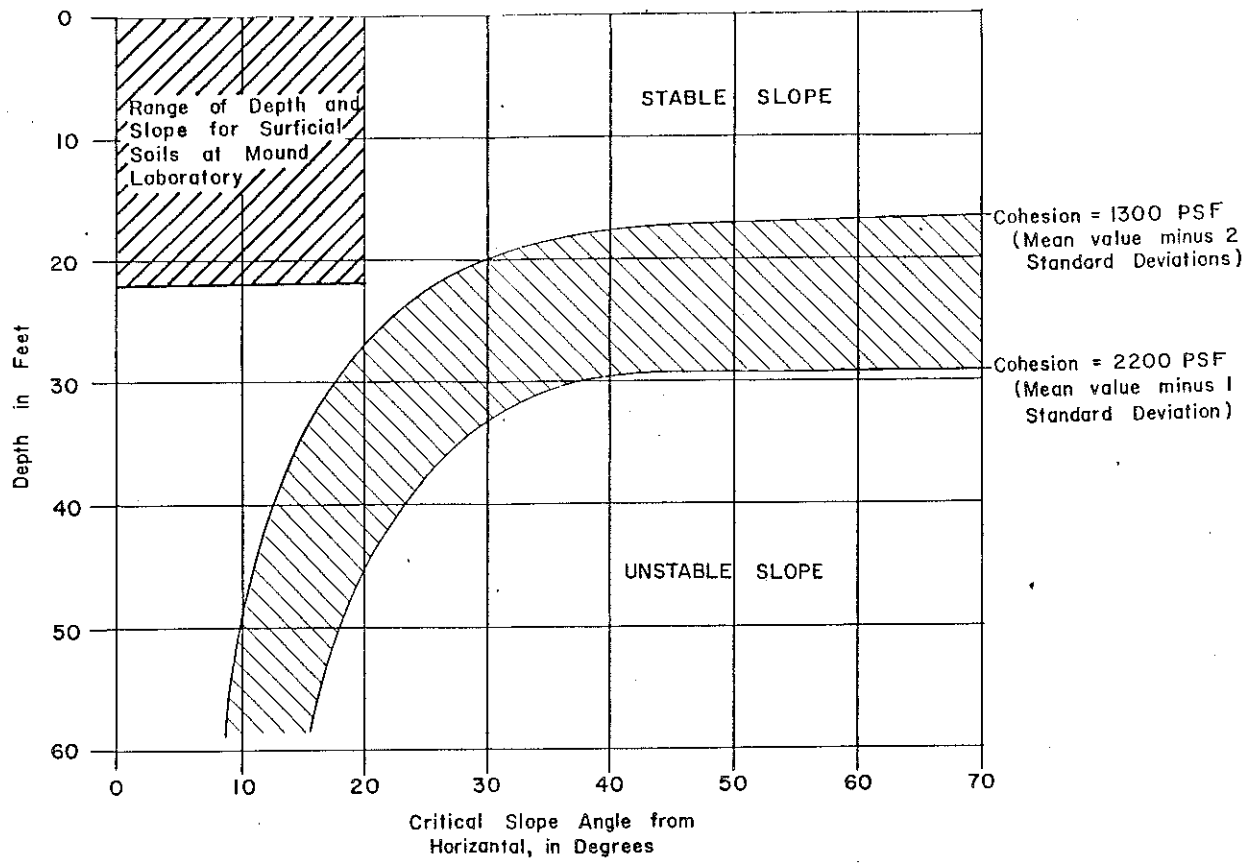
Response Spectra
SAFE SHUTDOWN EARTHQUAKE



Response Spectra

OPERATING BASIS EARTHQUAKE

PLATE 7.2-3



FOOTNOTE:
Analysis assumes an infinite slope and a cohesive ($\phi = 0$) soil. Cohesion is assumed equal to 1/2 unconfined compressive strength. Saturated unit weight of soil assumed to be 150 lb./cubic ft.

Slope Stability Analysis

DAMES & MOORE

PLATE 7.5-1

REGIONAL AIR POLLUTION CONTROL AGENCY
Serving Clark, Darke, Greene, Miami, Montgomery & Preble Counties
451 W. Third Street, P.O. Box 972, Dayton, Ohio 45422, (513) 225-4435

Ref. 59

June 11, 1986

Mr. Richard M. Munson
U. S. Department of Energy
Dayton Area Office
P. O. Box 66
Miamisburg, OH 45342

Dear Mr. Munson

Your applications to open burn for the purposes of fire training and disposal of explosive containing material have been reviewed and approved in accordance with OAC Rule 3745-19-03(D). This letter shall constitute your permit to open burn.

This permit shall be effective for one (1) year from the date of issuance. This permit is granted subject to the conditions listed below:

Fire Training Exercise

1. No more than two fire fighter training sessions shall take place in any one week.

2. Each burn shall be conducted using the least amount of fuel as possible to adequately perform training objectives.

3. Each training exercise shall be conducted as expeditiously and nuisance free as possible.

4. No burn shall be conducted during an air alert, warning, or emergency.

5. No burning shall be performed when the atmospheric dispersion level is poor.

6. All burning shall take place Monday through Friday between the hours of 10:00 a.m. and 4:00 p.m.

7. All fires must be completely extinguished at the end of the fire training exercise.

Disposal of Explosive Material

1. No burn shall be performed using more than fifty pounds of explosive material.

2. All burning shall take place Monday through Friday between the hours of 10:00 a.m. and 4:00 p.m.

3. Each burn shall be conducted as expeditiously and nuisance free as possible.

4. No burn shall be conducted during an air alert, warning, or emergency.

5. No burn shall be performed when the atmospheric dispersion level is poor.

As always, if you have any questions or comments regarding this letter, please contact the undersigned.

Sincerely,

Thurman D. Smith
Air Pollution Control Specialist
Abatement Unit

/ed

Department of Energy
Albuquerque Operations
Dayton Area Office
P.O. Box 66
Miamisburg, Ohio 45342

RECEIVED
JUN 03 1986
REGIONAL AIR POLLUTION CONTROL AGENCY

JUN 2 1986

Ms. Donna Gorby Lee
Air Pollution Control Specialist
Regional Air Pollution Control Agency
451 West Third Street
P. O. Box 972
Dayton, Ohio, 45422

Dear Ms. Lee:

Enclosed are completed renewal "Open Burning Permit Applications" for explosives burning and fire fighting training for the Mound Plan.

Also enclosed is a map of the area showing locations of these operations and Mound's boundaries. If any further information is required, please contact D. S. Ingle, 513-865-3597.

Sincerely,

Richard M. Munson
Chief, Administrative Branch

Enclosures: a/s

cc: C. Friedman, MRC, w/o attach.

REGIONAL AIR POLLUTION CONTROL AGENCY
451 West Third St. - P.O. Box 972
Dayton, Ohio 45422

OPEN BURNING PERMIT APPLICATION - FIRE TRAINING EXERCISE

Name of Department DOE/Mound

Address Mound Road

Telephone 865-3597

Location Where Burning is to Occur Fire Fighter Training Facility

Description of Material to be Burned Diesel or unusable fuel, clean lumber, cardboard, paper

Total Number of Men and Departments Involved 15 Fire Fighters & 100 Brigade Members

Type of Training Fire Fighter Training

Equipment Standard Fire Fighter Apparatus

Date of Last Training Utilizing Open Burning 9/85

Description of Area: Size of Lot, Distance to Nearest Neighbor in all Directions, etc. (Use Other Side for Drawing) Approximately 300 A

2600' to north, 2200' to south, 2500' to east, 800' to west

Date and Time Burning is to Occur Twice per week between 10:00 a.m. and 4:00 p.m.

Alternate Dates

THIS IS TO CERTIFY THAT THE ABOVE INFORMATION IS TRUE AND CORRECT TO THE BEST OF MY KNOWLEDGE AND THAT SUCH BURNING IS FOR INSTRUCTION IN METHODS OF FIRE FIGHTING AND RESEARCH ONLY AND NOT FOR THE PURPOSE OF DISPOSAL OR REMOVAL.

5-27-86
Date

David L. Kiff
Signature of Fire Chief

REGIONAL AIR POLLUTION CONTROL AGENCY

Montgomery County Office
451 W. Third Street, P.O. Box 972
Dayton, Ohio 45422
Phone: 225-4435

OPEN BURNING PERMIT APPLICATION

Name of Applicant DOE/Mound Phone 865-3597

Mailing Address P.O. Box 66 (Street) Miamisburg, OH (City) 45342 (Zip Code)

Location of Burning Site Mound Facility - Explosive Burn Compound

Is this land being farmed? Yes ____ No X Township ____

Distance to nearest: Residence 1400 ft Roadway 1400 ft Structure 50 ft

PLEASE USE REVERSE SIDE TO DRAW A DIAGRAM showing location of the burning site with respect to neighbors, roadways. Label all roads.

Description of material to be burned: Scrap materials containing explosives and scrap explosives - maximum of 40 lb of explosives per burn

Preferred date(s) and time of burning Monday through Friday between 10:00 a.m. and 4:00 p.m. as needed.

Alternative disposal method(s) investigated, other than open burning Open burning is the only acceptable method specified by DOE/EU/06194-2

NOTE: Upon our receipt of your completed application, an agency representative will conduct an on-site inspection of the proposed material to be burned. Written correspondence and/or telephone communication will follow the site inspection. Permission to open burn is generally prohibited in incorporated areas.

In accordance with your instructions, if said application is approved, I will remit twenty-five dollars ($25) and hereby agree to abide by all of the conditions and provisions set forth by the issuance of the open burning permit.

DATE ____ SIGNATURE OF APPLICANT ____

FOR OFFICIAL USE ONLY

✓ Approved

____ Denied

$25 - PAYABLE UPON APPLICATION APPROVAL

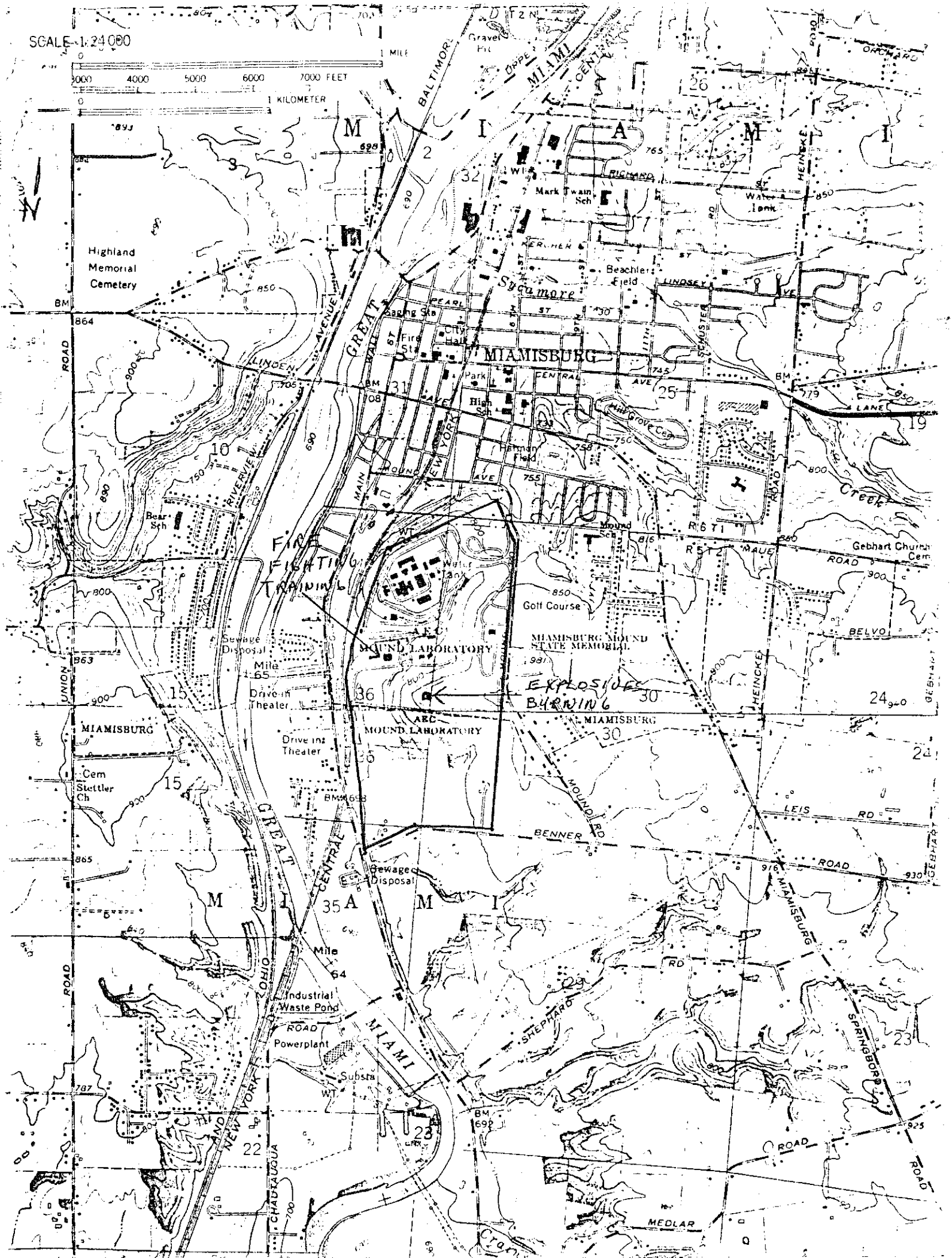
Receipt Number 91333

Remarks: See Permit

6-86
Date

Air Pollution Control Specialist

5-16-80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1 MILE
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Highland Memorial Cemetery
MIAMISBURG
Sycamore
Mark Twain Sch
Beachler Field
Water Tank
Gaging Sta
City Hall
Fire Sta
High Sch
Park
Hill Grove Cem
Harman Field
Bear Sch
Mound Sch
Gebhart Church Cem
Golf Course
MIAMISBURG MOUND STATE MEMORIAL
AEC MOUND LABORATORY
Sewage Disposal
Drive-in Theater
Cem
Stettler Ch
Industrial Waste Pond
Powerplant
Substa
FIRE FIGHTING TRAINING
EXPLOSIVES BURNING
GREAT MIAMI
BALTIMORE
UPPER MIAMI CENTRAL
LINDEN AVENUE
RIVERVIEW
MAIN
NEW YORK
MOUND AVE
CENTRAL AVE
PEARL ST
RICHARD
LINDSEY AVE
SCHUSTER
HEINCKE
ORCHARD
MAUE ROAD
BELVO
LEIS RD
BENNER ROAD
MOUND RD
SHEPHARD RD
SPRINGBORO ROAD
MEDLAR
UNION ROAD
OHIO AND NEW YORK
CHAUTAUQUA
Creek

Department of Energy
Albuquerque Operations
Dayton Area Office
P.O. Box 66
Miamisburg, Ohio 45342

RECEIVED
JUN 27 1986
REGIONAL AIR
POLLUTION
CONTROL AGENCY

JUN 26 1986

Mr. Thurman D. Smith
Air Pollution Control Specialist
Abatement Unit
Regional Air Pollution Control Agency
451 West Third Street
P. O. Box 972
Dayton, Ohio 45422

Dear Mr. Smith:

In accordance with your memorandum dated June 11, 1986, attached is a check for $25.00 to cover the permit fee for "Open Burning" at the Mound Plant. The check, per your instructions, is made payable to the Montgomery County Combined Health District.

If you need further information, please contact D. S. Ingle at (513) 865-3597.

Sincerely,

R. M. Munson

R. M. Munson
Chief, Administrative Branch

Attachment: a/s

cc: R. Neff, MRC, w/o attach.
C. Friedman, MRC, w/o attach.
D. Heitz, w/o attach.