THE OHIO STATE UNIVERSITY

Nuclear Reactor Laboratory

1298 Kinnear Road
Columbus, OH 43212-1154

Phone 614-688-8220
FAX 614-292-2209

Daniel E. Hughes, Project Manager
Research and Test Reactors Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

July 26, 2006

RE: Responses provided to the Request for Additional Information Regarding Ohio State University Research Reactor Environmental Report for License R-75 Renewal (TAC NO. MA 7724)

Dear Mr. Hughes,

Please find enclosed responses to your request for additional information of March 31, 2006 addressed to Mr. Andrew Kauffman.

For Item 1 we have enclosed the following to explain how the OSURR ensures compliance with applicable environmental quality standards and requirements.

- A summary entitled "The Coastal Zone Management Act of 1972 as Amended Through P.L. 104-150, The Coastal Zone Protection Act of 1996" in which we have concluded the CZMA does not apply to our facility.
- A summary entitled "The Endangered Species Act of 1973" in which we concluded that our license renewal request is in compliance with the Act.
- A letter from the Ohio Historic Preservation Office that concurred with the OSURR finding of no historic properties affected per 36CFR800 "Protection of Historic Properties". Also enclosed is the letter to the Ohio Historic Preservation Office and appropriate supporting documentation for our request for their review and approval.

For item 2.a. we have included a copy of Radiation Safety procedure RS-18, "Environmental Monitoring", that explains the methodology for estimating a TEDE to a member of the general public.

For Item 3.a. we have calculated the total activity of transferred solid waste to be 275,228,200 Bq. This figure is included on a separate page of this response.

A020

If you have questions on these responses please contact Mr. Andrew Kauffman at 614 688-8220.

I declare under penalty of perjury that the foregoing is true and correct.
Executed on July 19, 2006

Sincerely,

Richard S Denning

Richard Denning, Director

c. W.A. "Bud" Baeslack III, Dean, College of Engineering, w/o enclosures
c. Andrew C. Kauffman, Associate Director, OSU Nuclear Reactor Lab

THE COASTAL ZONE MANAGEMENT ACT OF 1972
AS AMENDED THROUGH P.L. 104-150,
THE COASTAL ZONE PROTECTION ACT OF 1996

The Ohio State University Research Reactor (OSURR) is not required to comply with the Coastal Zone Management Act (CZMA) because our location is about 120 miles from the nearest coast of Lake Erie. While it is true that the CZMA defines Ohio as a coastal state per 1453.Definitions(Section 304)(4), according to 304(1) the zone extends inland only to the extent necessary to control shorelands. 304(3) defines coastal waters of the Great Lakes as the waters of the lakes, their connecting waters, harbors, roadsteads, and estuary-type areas such as bays, shallows, and marshes. Since we are about 120 miles south of any of these areas the CZMA does not apply to our license renewal request.

THE ENDANGERED SPECIES ACT OF 1973

The Ohio State University Research Reactor (OSURR) is located at 1298 Kinnear Road, Columbus Ohio, 43212. Its site description and characterization are found in Chapter 2 of the previously submitted Safety Analysis Report. It is located on property that is generally referred to as West Campus. The license renewal request does not require any new construction nor is the footprint of the facility changing in any manner. Discussions with Dr. John Wenzel, Director, OSU Museum of Biological Diversity located at 1315 Kinnear Road, Columbus Ohio, 43212 indicated there are no known endangered or threatened species on any part of the Columbus campus of OSU including the part called West Campus. We have also determined there are not any designations of critical habitat on the Columbus campus of the Ohio State University. Therefore we have concluded that our license renewal request is in compliance with the Endangered Species Act of 1973.

OHIO
HISTORY

July 18, 2006

Richard Myser, Reactor Operator
OSU Nuclear Reactor Laboratory
1298 Kinnear Road
Columbus, OH 43212

Re: License Renewal, Ohio State University Research Reactor
Columbus, Franklin, Ohio

Dear Mr. Myser,

This is in response to correspondence from your office dated June 7, 2006 (received June 7) regarding the above referenced project. The comments of the Ohio Historic Preservation Office (OHPO) are submitted in accordance with provisions of the National Historic Preservation Act of 1966, as amended (16 U.S.C. 470 [36 CFR 800]).

OSU is applying to renew the license for the above referenced facility. OSU has been licensed to operate this modern facility since 1960. The vernacular, functional, building is located away from the older core of the OSU campus. A check of our records shows that there are properties (sites, buildings, districts, structures, objects, or Traditional Cultural Properties) in the general area surrounding the Research Reactor building. Our records search includes the following: the Ohio Archaeological Inventory, Ohio Historic Inventory (including historic bridges, structures, and dams), National Register of Historic Place, listed historic districts, properties that have been determined eligible for inclusion in the National Register of Historic Places, and local historic districts that have been reported formally to us (see enclosed). The research conducted at this facility makes an important contribution to the overall missions of the Ohio State University. Because this is an application to renew a license, and doesn't involve ground disturbing activities or the replacement of equipment, we agree with the limited Area of Potential Effects described for this undertaking and with the level of effort extended in identifying historic properties. As noted above, systematically reviewing the detailed information in our inventories and considering the photographs and descriptions presented in your documentation, within the Area of Potential Effects of this undertaking there are no historic properties. Based on the information presented in your correspondence we concur with your finding that there will be no historic properties affected by the proposed license renewal undertaking. No further coordination with this office is necessary for this undertaking unless there is a change in the scope of work. In addition, if new or additional properties or potentially adverse effects are discovered, this office should be notified [36 CFR 800.13].

OHIO HISTORICAL SOCIETY
Ohio Historic Preservation Office
567 East Hudson Street, Columbus, Ohio 43211-1030 ph: 614.298.2000 fx: 614.298.2037
www.ohiohistory.org

Mr. Richard Myser
July 18, 2006
Page 2

Any questions concerning this matter should be addressed to David Snyder or Lisa Adkins at (614) 298-2000, between the hours of 8 am. to 5 pm. Thank you for your cooperation.

Sincerely,

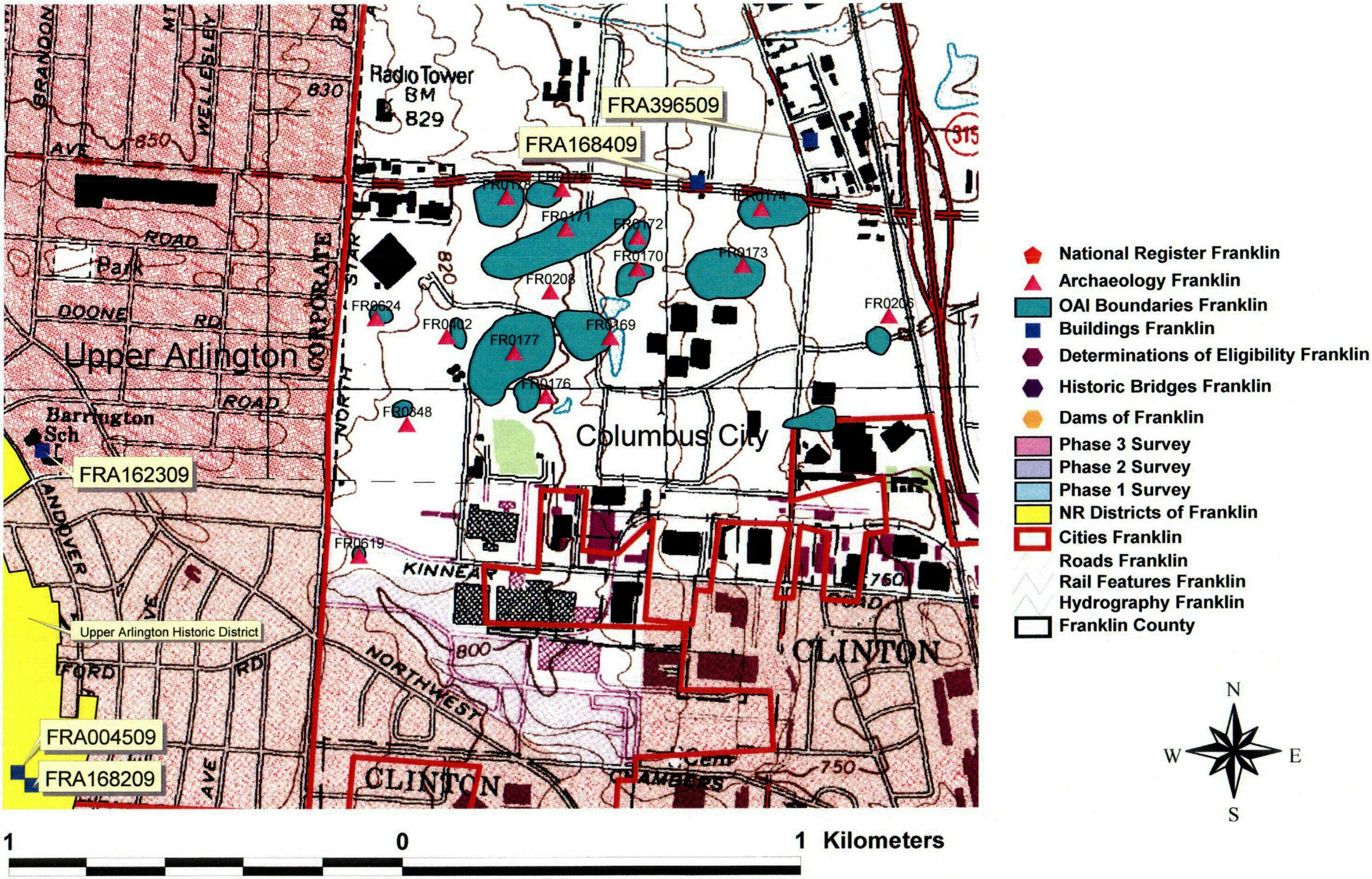
David Snyder

David Snyder, Archaeology Reviews Manager
Resource Protection and Review

DMS/ds (OHPO Serial Number 1006666)

Enclosure

OSU Research Reactor
1298 Kinnear Avenue, Columbus, Ohio



THE OHIO STATE UNIVERSITY

Nuclear Reactor Laboratory

1298 Kinnear Road
Columbus, OH 43212-1154
Phone 614-688-8220
FAX 614-292-2209

Mr. Mark Epstein, Department Head
Resource Protection and Review
Ohio Historic Preservation Office
567 E. Hudson St.
Columbus, OH 43211-1030

June 7, 2006

Dear Mr. Epstein,

We recently spoke with Mr. Dave Snyder of your office about the National Historic Preservation Act (NHPA) and its applicability to the relicensing of the Ohio State University Research Reactor (OSURR) by the U.S. Nuclear Regulatory Commission (NRC). As a result we are submitting the enclosed packet of information supporting our finding that this licensing does not have an historical impact on the surrounding area. We request your concurrence and approval of this finding. The OSURR has been licensed to operate since 1960. In December of 1999 we submitted an application for license renewal to the NRC. In March of 2006 the NRC requested additional information including assurance that we were in compliance with NHPA. We have until about August 11, 2006 to reply to this and other unrelated questions so we hope to have your concurrence in the next six weeks. Please contact Mr. Andrew Kauffman at 614 688-8220 or me at 614 247-7344 with questions about this submittal. Thank you for your prompt attention to this matter.

Sincerely,

Richard Myser

Richard Myser, Reactor Operator
OSU Nuclear Reactor Laboratory
1298 Kinnear Rd
Columbus, OH 43212
myser.2@osu.edu

PROJECT SCOPE

A 20 YEAR LICENSE RENEWAL FOR THE OHIO STATE UNIVERSITY RESEARCH REACTOR (OSURR) R-75 BY THE U.S. NUCLEAR REGULATORY COMMISSION (NRC)

FINDING

THE STAFF OF THE OSURR HAS DETERMINED PER 800.11(d) A FINDING OF NO HISTORIC PROPERTIES AFFECTED

DOCUMENTATION FOR OUR FINDING OF
NO HISTORIC PROPERTIES AFFECTED
36CFR800 PROTECTION OF HISTORIC PROPERTIES

800.11(d) (1) This project is simply a license renewal. There is no new construction and the footprint of the facility remains the same. There are four listings on the National Register of Historic Places for The Ohio State University (OSU). Of these listings, Ohio Stadium is closest to the OSURR but is more than a mile away. The three National Historic Landmarks in Franklin County are also more than a mile away.

800.11(d) (2) We identified historic properties via internet searches.

800.11(d) (3) The basis of our finding that no historic properties are affected is the fact that all activities including teaching, research, and service are conducted inside the Reactor Building located at 1298 Kinnear Rd. Columbus, Ohio 43212. The reactor produces neutrons that are used for these activities. These neutrons remain inside a small fixed in place reactor pool where they are utilized. The building surrounds the pool which in turn surrounds the reactor where the neutrons are produced.

Documents (enclosed) to help support our finding are:

- Summary of activities at the OSU-NRL (OSU Nuclear Reactor Laboratory)
- Aerial photograph showing the location of the Reactor Building (white arrow indicates Reactor Building) bounded by Lane Avenue on the north, Kenny Rd on the east, Kinnear Rd on the south, and North Star on the west. Our web site (www-nrl.eng.ohio-state.edu) also links to an interactive OSU map showing our relative location. We are identified as the Reactor Building #158.
- Recent (5-31-06) photograph of the front of the Reactor Building.
- Promotional photograph of the reactor pool showing the reactor enclosed.
- Chapters 1 and 2 of the OSURR Safety Analysis Report including the introduction and site description.

OSU-NRL Activities

The OSU-NRL is used for a wide range of research endeavors, including neutron activation analysis (NAA), radiation-damage evaluation for electronic components and for other materials, evaluation of neutron and radiation sensitive detectors, isotope production, and biomedical experiments. The OSU-NRL provides a variety of instructional services ranging from general tours to individual and group laboratory sessions and research projects structured to student and faculty interests.

Teaching

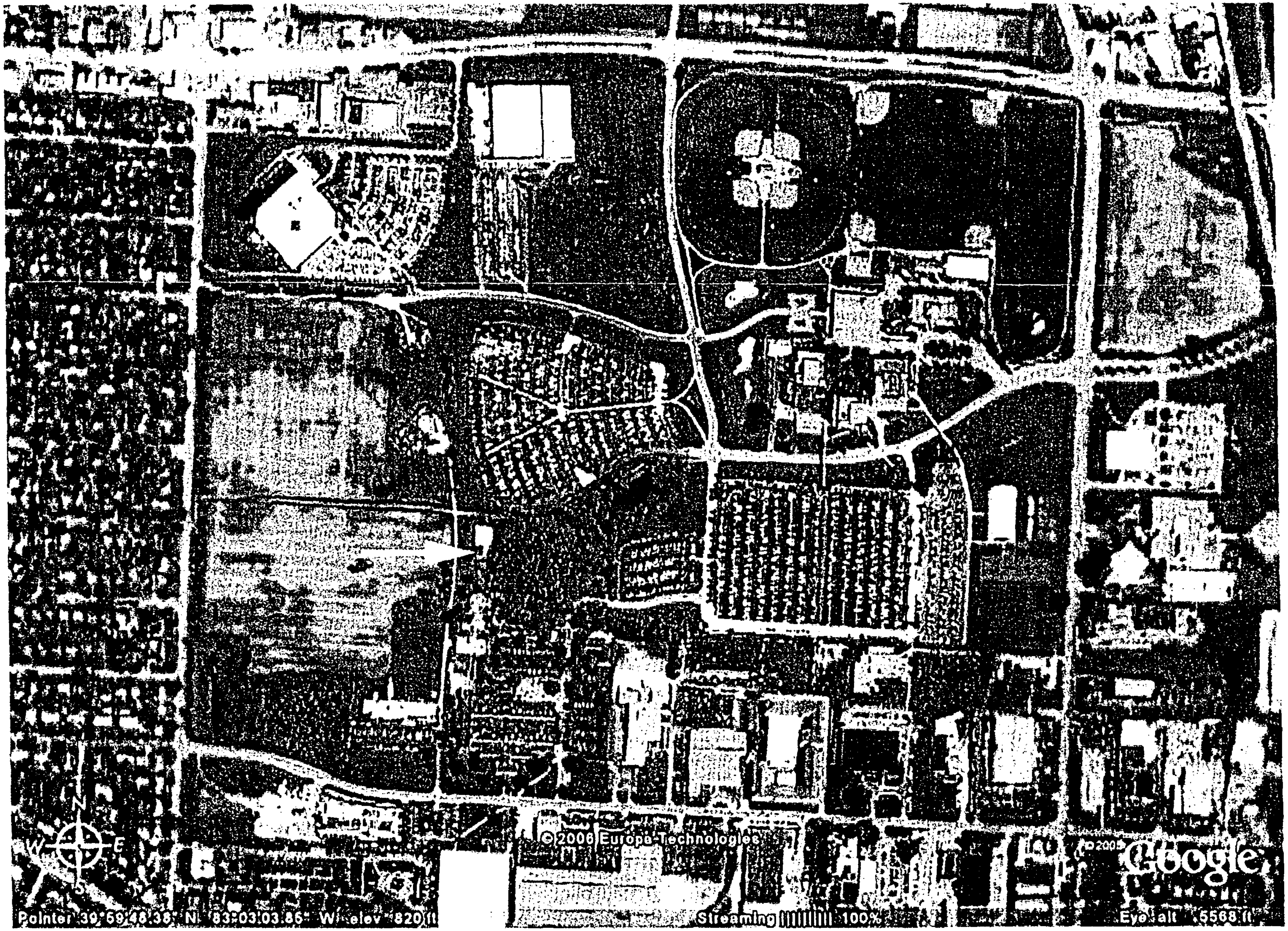
Education is a large part of the mission of the NRL. In addition to the laboratory support provided to the nuclear engineering graduate program at OSU, NRL facilities are used by a wide variety of students and educators. Several local middle and high school science classes tour the facility each year. Some of the students return to the NRL when the spring science fairs are announced. Recent projects have involved trace element analysis (through neutron activation), radiation effects on seeds, and half-life determination. Nuclear engineering and physics students from other universities in Ohio also utilize the NRL. Activities include basic reactor experiments (approach to critical, control rod calibration, etc.), neutron activation analysis demonstrations, and radiation safety training.

Research

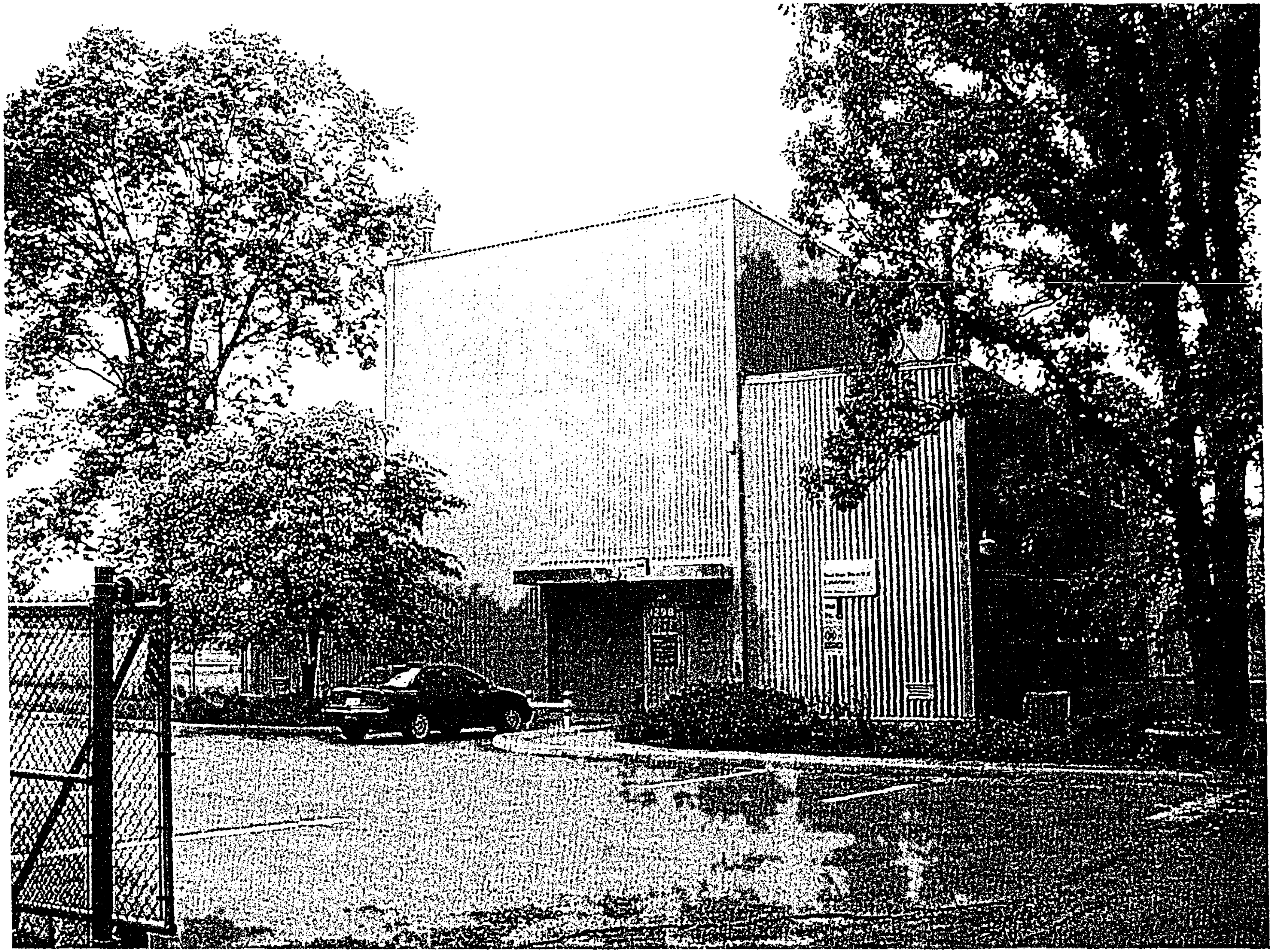
Research activities at the NRL are largely dictated by the interests of our users. These interests change as funding opportunities shift from one topic to another. In the last few years, we have been involved in boron neutron capture therapy (BNCT), radiation damage studies, and reactor safety systems. Neutron activation analysis (NAA) is always in demand. It is a tool with wide-ranging applications. In recent years, NAA has been used at the NRL to look for trace elements in plastics, soil, crustacean shells, and bird feathers.

Services

The reactor and other NRL facilities are used to provide general radiation services to universities and businesses in the region. The reactor is routinely used for detector testing, isotope production, and neutron activation analysis. The gamma irradiators are usually used by individuals wishing to sterilize various substances. In addition to being used in activation analysis, the gamma spectroscopy system is also used for identification and quantification of radioactive samples.



N
W
E
S
© 2006 Europa Technologies
Google
Pointer 39°59'48.38" N 83°03'03.86" W elev 820 ft
Streaming |||||||||| 100%
Eye alt 5568 ft



Nuclear Engineering Program
650 Ackerman Road, Suite 255
Columbus, OH 43202
Phone: 614-292-8519
Fax: 614-292-3163
http://rclsgi.eng.ohio-state.edu/nuclear/
nuclear@osu.edu

The Ohio State University

Nuclear Reactor Laboratory
1298 Kinnear Road
Columbus, OH 43212
Phone: 614-688-8220
Fax: 614-292-2209
http://www-nrl.eng.ohio-state.edu

CHAPTERS 1 AND 2 OF THE OSU RESEARCH REACTOR SAFETY ANALYSIS REPORT

1.0 INTRODUCTION
2.0 SITE DESCRIPTION AND CHARACTERIZATION

1.0 Introduction

1.1 Purpose

This document will present a description and safety analysis for The Ohio State University Research Reactor (OSURR). This reactor, owned and operated by The Ohio State University, is located on the Columbus Campus of The Ohio State University, within the City of Columbus, in central Ohio. The descriptions and analyses presented in this report will provide sufficient information to show that the reactor can be operated with reasonable assurance that the health and safety of the public will be protected.

The description of the reactor system and its associated components are sufficiently detailed to allow an understanding of the general features, characteristics, and basic operation of the reactor. The safety analysis makes conservative assumptions to allow larger safety margins.

1.2 General Facility Description

The OSURR is a pool-type reactor using light water as a moderator and coolant. The core of the reactor utilizes uranium fuel, enriched to 19.5%, in uranium-silicide (U_3Si_2) form, clad in aluminum. The fuel is in solid flat plate form, commonly called MTR-type fuel. Fuel plates are mechanically joined into fuel assemblies (also called fuel elements), which are stacked to form an approximately symmetric rectangular solid. The fuel assemblies are positioned in a grid plate forming a 5 by 6 rectangular matrix for available fuel assembly positions. The grid plate is bolted to the floor of the reactor pool. A plutonium-beryllium (Pu-Be) startup source provides an initial population of neutrons to the core for controlled reactor startup.

Reactor control is effected by three control rods of boron-stainless steel composition (called shim safety rods), and an additional control rod composed-only of stainless steel (known as the regulating rod). These control rods are positioned by electric motors. The three shim safety rods are held by electromagnets and can be inserted into the core under the influence of gravity by turning off the current to these electromagnets. The rods move within aluminum shrouds and extend into special control rod fuel elements. The active length of the control rods is sufficient to completely cover the active portion of the core. The control rod housings are held by brackets mounted to the sides of the reactor pool.

A number of experimental facilities converge at the reactor core. This allows simultaneous performance of a number of different experiments. These facilities include two beam ports, a pneumatic transfer facility (rabbit), a main graphite thermal column, a smaller graphite thermal column, a central irradiation facility (CIF) that can extend into either a water or graphite-filled flux trap, movable graphite isotope irradiation elements (GIIE), and movable dry tubes.

The reactor pool wall is made of barytes concrete. The interior surface of the pool is coated with a waterproof liner. The reactor pool has a capacity of 5800 gallons, with a minimum water depth of 15 feet maintained above the top of the core for shielding. Water purity is maintained by a process system composed of a circulating pump, demineralizer, and particulate filter. Makeup water is added to the reactor pool from city water supplies, after passing through a resin bed demineralizer unit.

The reactor is licensed to operate at continuously variable thermal power up to a maximum of 500 kilowatts. Operation is limited to steady-state power, with no pulsing capabilities. At maximum steady-state power, the average thermal neutron flux in the core is 4.66×10^{12} neutrons/cm^2/second. In cold, clean critical condition, the core contains approximately 2.6% $\Delta k/k$ excess reactivity. Because of their location, geometry, and composition, the controls rods have a total worth of approximately 8.45% $\Delta k/k$. The shutdown margin is at least 1% $\Delta k/k$ with the regulating rod and the highest-worth shim safety rod fully removed from the core.

The core is cooled by natural convective flow of pool water vertically through the core within the flow channels between the fuel plates. Pool water enters the bottom of the core at an inlet temperature of approximately 20 °C, is heated by the core, and exits the top of the core at approximately 60 °C Heated water enters an aluminum plenum, is withdrawn from the plenum and circulated through a closed-loop heat removal system. Heat rejection is achieved through a two-stage, closed-loop secondary cooling system. The primary-secondary heat exchanger removes primary coolant heat to an ethylene-glycol and water mixture, from which heat is rejected to the outside atmosphere through a fan-forced air circulation cooling unit (also referred to as a dry cooler). An additional secondary-loop heat exchanger provides further cooling of the ethylene-glycol and water coolant by using city water as its heat sink. The total heat removal capacity of the cooling system is sufficient to remove all of the 500 kilowatts of thermal energy generated in the core, and maintain an average equilibrium bulk pool temperature of 20-25 °C under all credible environmental conditions.

1.3 Background Information

The OSURR was first operated in 1961. Its operation is regulated by the U.S. Nuclear Regulatory Commission (NRC), under facility license number R-75, docket number 50-150.

The design of the OSURR is based on the Bulk Shielding Reactor (BSR), which was located at the Oak Ridge National Laboratory (ORNL). This reactor is in a class of reactors generally known as a Materials Testing Reactor (MTR). This class of reactors share various common features, among them are light water moderation and cooling, open pools, and plate-type fuel. The reactor itself was supplied by Lockheed Nuclear Products, then a division of the Lockheed Georgia Company. Lockheed operated a reactor very similar in design to the OSURR, at a power level of 1 megawatt steady-state thermal power, in a forced convection cooling mode. When operated in the natural convection cooling mode at power levels up to 10 kilowatts, the Lockheed reactor was essentially identical in operating characteristics to the OSURR for the first 25 years of OSURR operation.

License R-75 authorized The Ohio State University to operate the OSURR at steady-state thermal power levels up to 10 kilowatts, using natural convection cooling. Originally, up to 8 kilograms of 93% enrichment ^{235}U was permitted to be possessed by the university at the reactor site. This was later lowered to 4.6 kilograms upon removal of the Fission Plate from the Bulk Shielding Facility (BSF) of the OSURR, by License Amendment 7, in 1976. As of the end of 1986, nominal (i.e., without considering fuel burnup) 3575.81 grams of ^{235}U was located at the reactor site in the form of fuel, and approximately 80 grams of plutonium was contained in the startup source. In 1988, LEU fuel was received to replace the HEU fuel, and the HEU fuel was shipped offsite in 1995.

The OSURR is utilized by the university for a variety of instructional, research, and service activities. Reactor use is not confined to persons employed or associated with the university. Past utilization has involved area universities and colleges, as well as local secondary and middle schools. Other individuals and groups in private industry and other state and federal governmental agencies have used the OSURR in a variety of ways. At the end of 1999, the OSURR was the only operating research reactor in the State of Ohio.

1.4 Report Organization

A description and characterization of the OSURR site is presented in the following chapter. Details of the facility design are discussed in Chapter 3. The operating characteristics of the OSURR under normal conditions are presented in Chapter 4. Auxiliary systems and radioactive waste management are discussed in Chapters 5 and 6, respectively. Facility features and operational procedures for radiation protection are the subjects of Chapter 7. Chapter 8 contains the safety analysis for the OSURR. Chapter 9 presents the administrative organization and controls for the reactor facility, and Chapter 10 discusses financial qualifications. Appendix A contains the complete Technical Specifications for the OSURR.

2.0 Site Description and Characterization

2.1 General Location

The OSU research reactor is located on property owned by The Ohio State University, west of the main campus. Aerial photographs are shown in Figures 2.1 and 2.2. A map of the surrounding territory with a 3 mile radius circle centered on the reactor building is shown in Figure 2.3.

2.2 Demographics

2.2.1 Surrounding Population

The map shown in Figure 2.3 shows that the reactor building is completely surrounded by residential dwellings within a three mile radius of the reactor site. Figures 2.4 and 2.5 show the locations of major industrial buildings found within a one mile radius of the site. Most industrial and business activities are located south and east of the reactor building. To the west are primarily residential areas. Some businesses are located to the northwest, but census data indicates that these employ relatively few people compared with those firms located to the east and south within a one mile radius of the reactor site.

Data for both residential and industrial populations are as follows:

Type	Radius	Population
Residential	3 Mile	141,600
Industrial	1 Mile	4,600

2.2.2 Local Activities

As of Autumn Quarter, 1998, The Ohio State University is composed of approximately 65,000 students, staff, and faculty. It is a land grant institution, engaged in teaching, research and public service activities. Various community services are provided, including medical and dental services. The university is active in the performing arts, as well as in athletics, and has recently completed construction of the Wexner Center for the Arts as well as the Schottenstien Arena. Activities in these facilities periodically draw up to 100,000 additional people to the campus area for special events such as performing arts concerts, football, basketball and NHL games, circuses, and rock concerts.

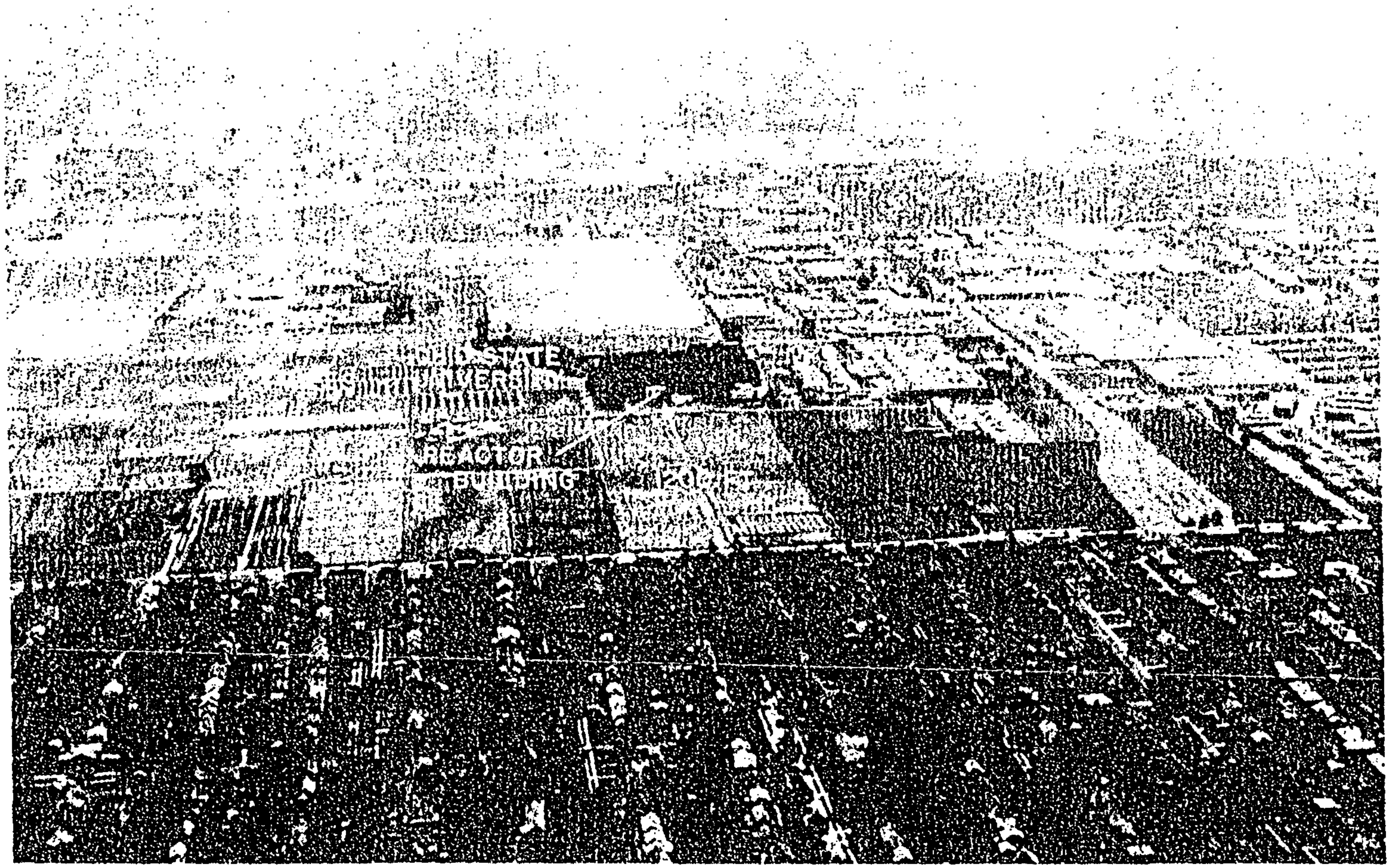


Figure 2.1: Aerial View of the OSURR Site, West-East Perspective

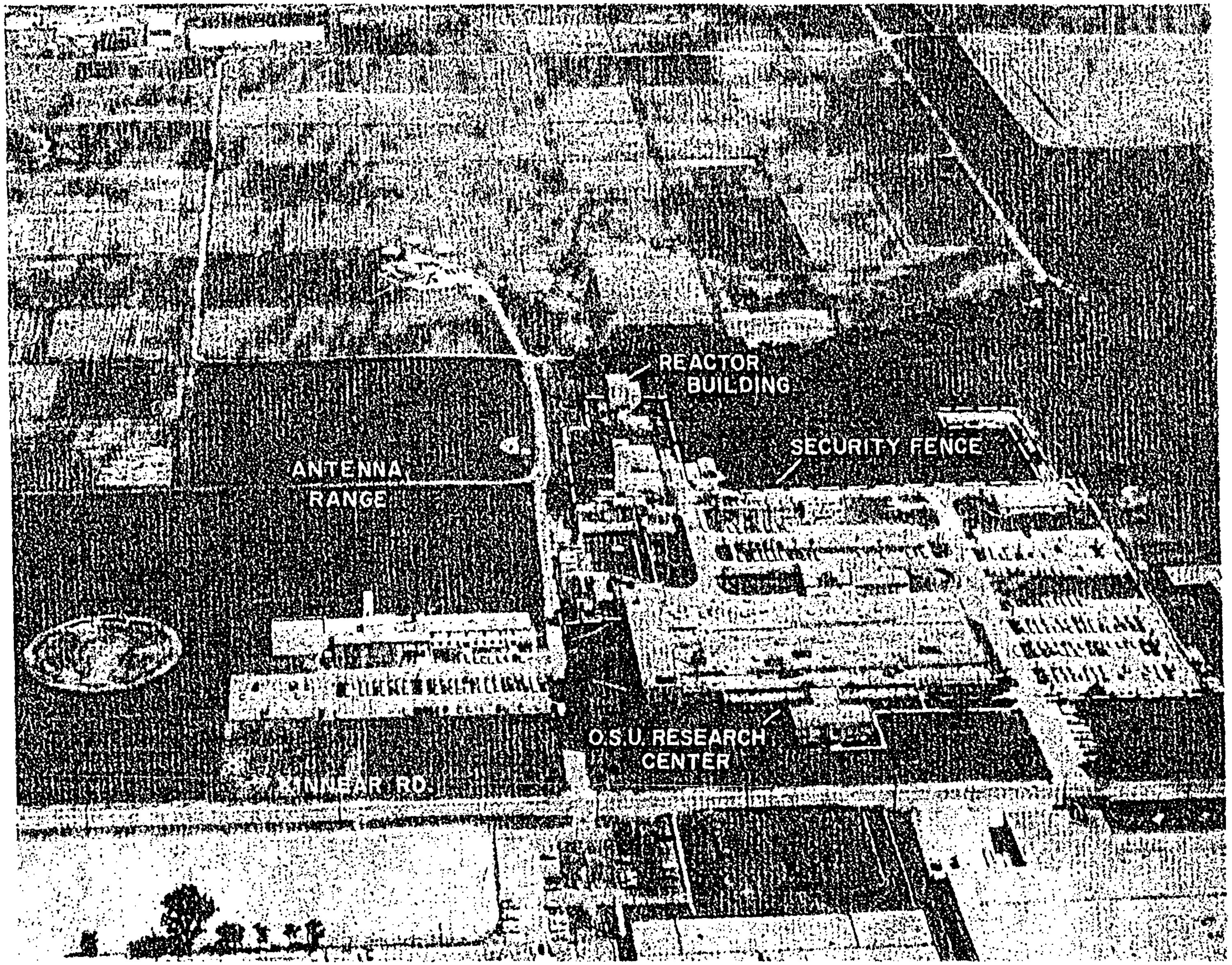


Figure 2.2: Aerial View of the OSURR Site, South-North Perspective

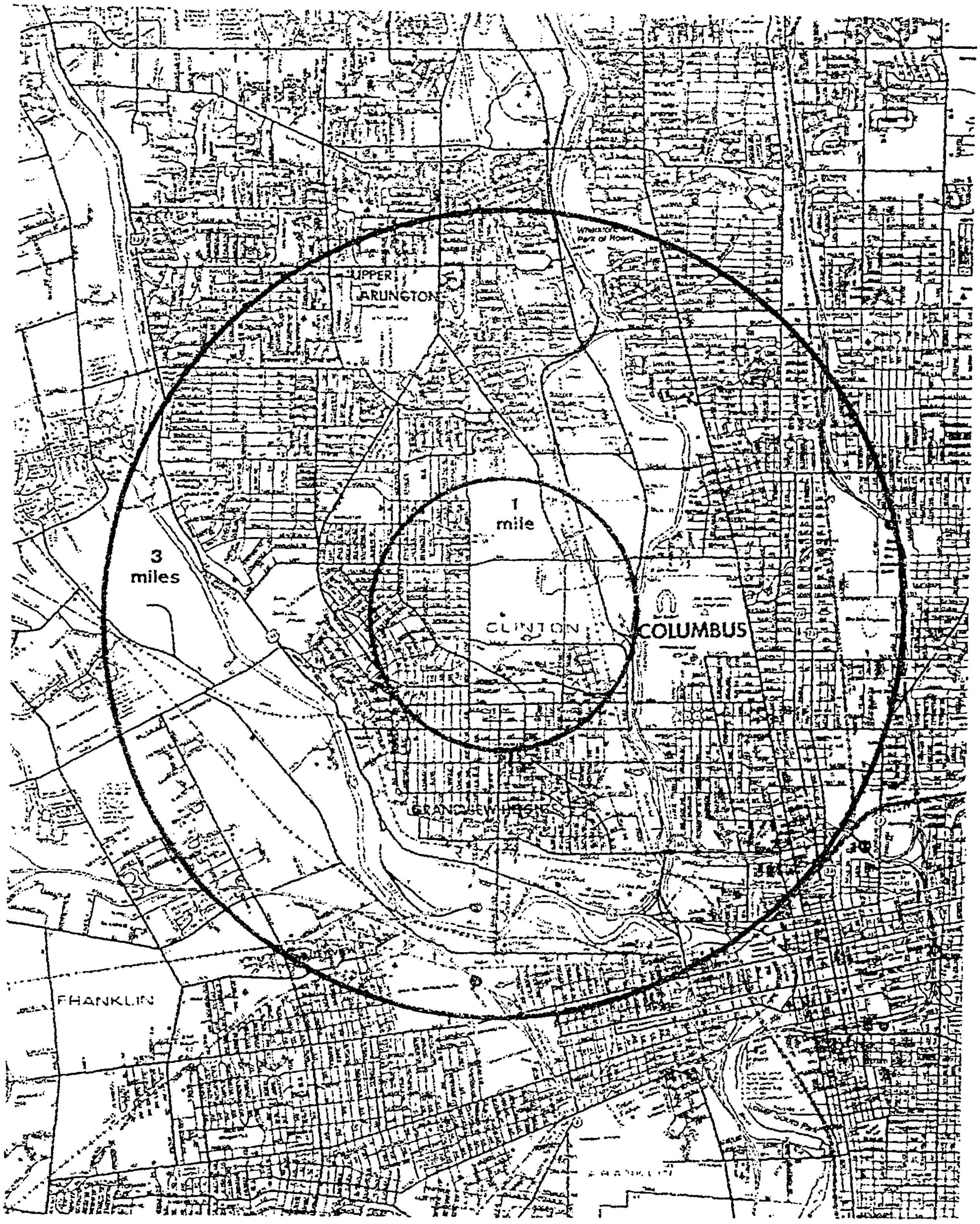


Figure 2.3: Detailed Map of the OSURR Surrounding Areas

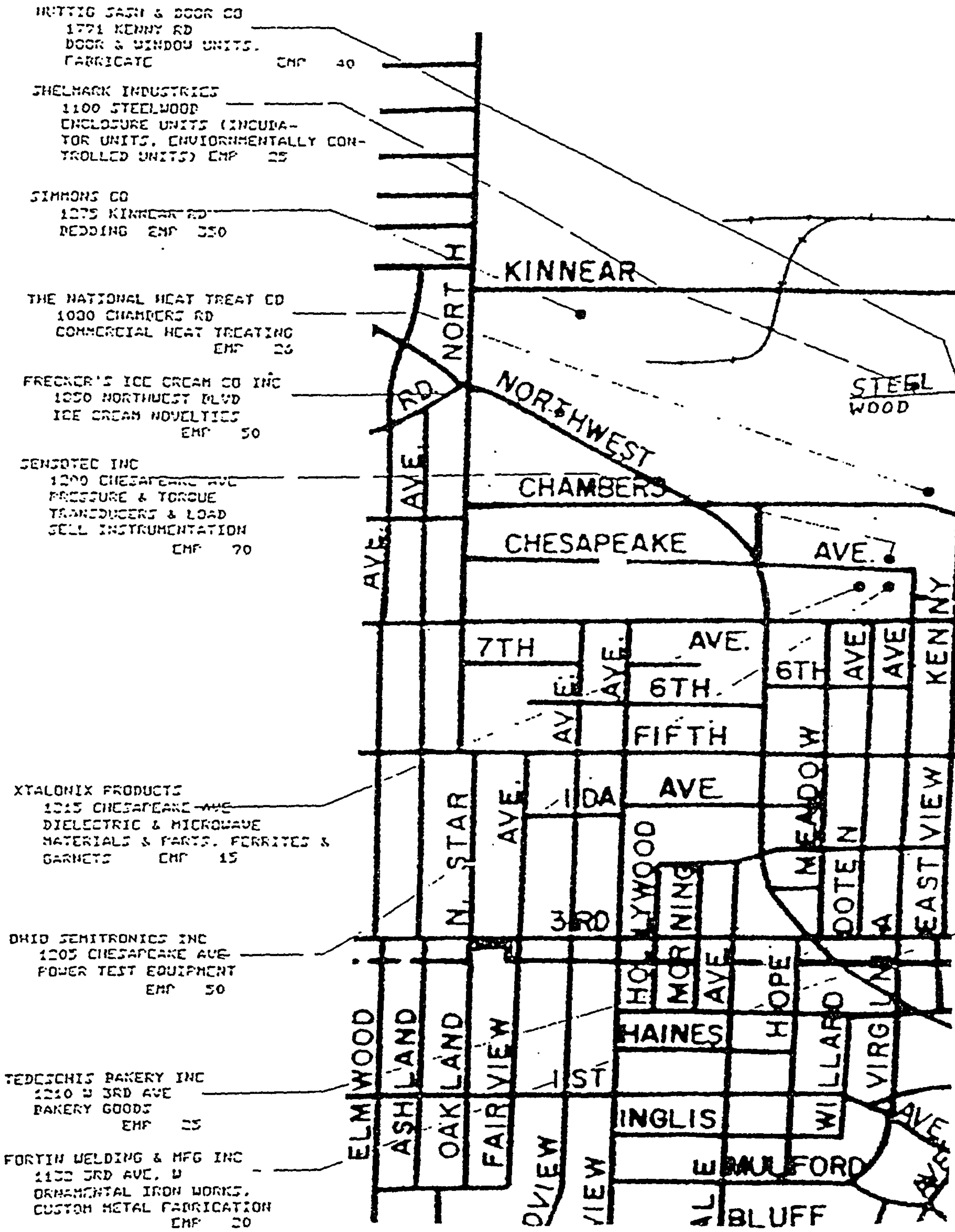


Figure 2.4: Businesses and Industries in the Areas South and East of the Reactor Building and Site

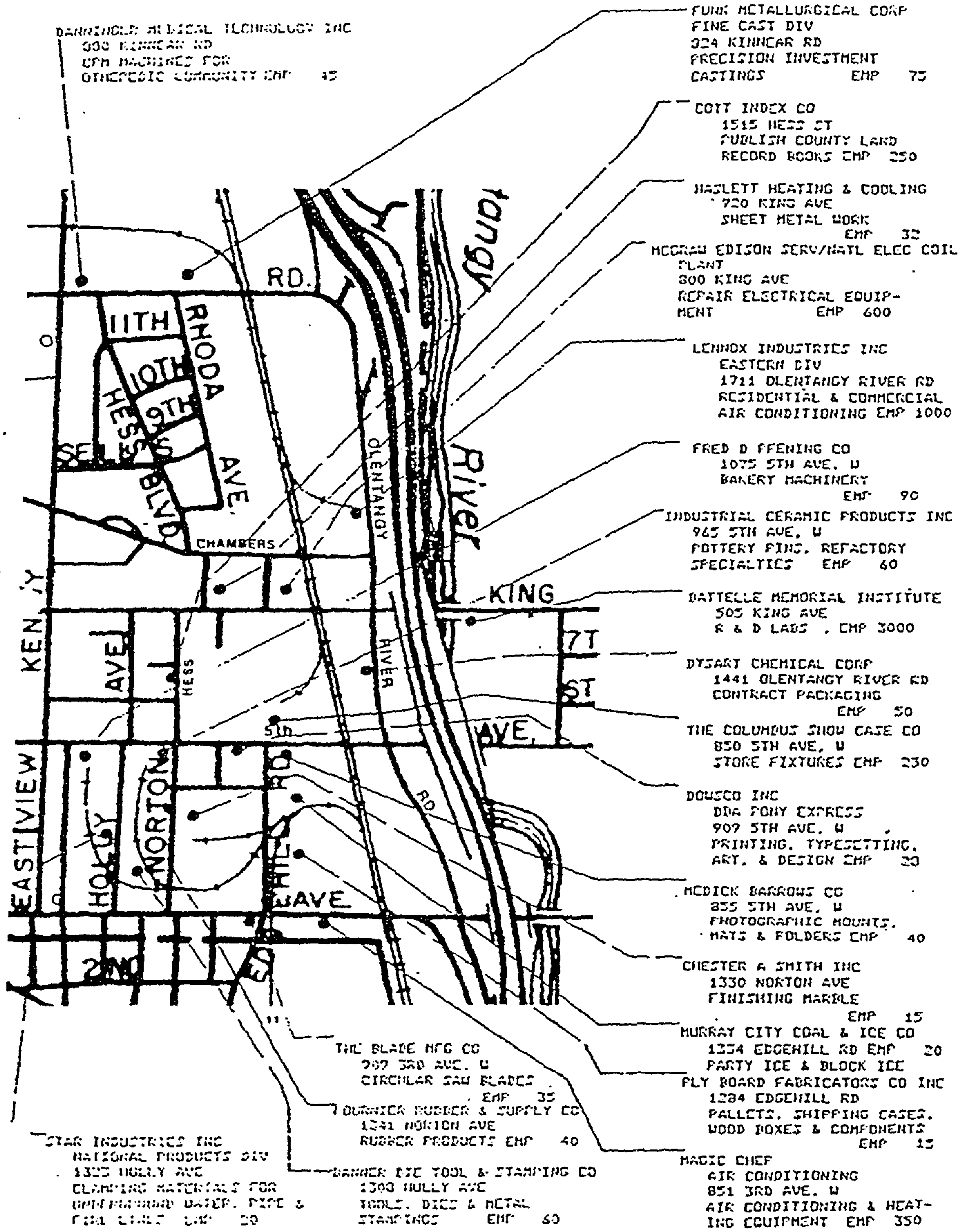


Figure 2.5: Businesses and Industries in the Area East of the Reactor Building and Site

2.3 Topography, Geology, and Seismology

2.3.1 Topography

Most of Ohio includes portions of two physiographic provinces called the Appalachian Plateau and the Central Lowlands. Franklin County is divided into these two sections by a series of north-south scarps and terraces which form a gentle step-like ascent eastward to the Appalachian Plateau. The highest altitude of the county is an elevation of 1130 feet above mean sea level, located in the northeast corner of Plain Township, and the lowest is an elevation of 665 feet above mean sea level at the efflux of the Scioto River from Franklin County. In the northern part and southwestern one-third of the county, the valley floors range in altitude from 780 to 890 feet above mean sea level, hilltops range from 860 to 960 feet above mean sea level, and local relief seldom exceeds 170 feet. The range in altitude of the valley floors in the northeastern and north central parts of the county is 710 to 840 feet. The hilltops range from 900 to 1130 feet above sea level. In the south central and southeastern parts of the county the valley floors range in altitude from 670 to 760 feet and hilltops range generally from 690 to 780 feet (locally they are 840 feet) above mean sea level. Except in the extreme southeast part of Madison Township, local relief does not exceed 50 feet. Columbus is located in the center of the county with a ground elevation of about 812 feet above mean sea level. The reactor site is about 780 feet above mean sea level.

2.3.2 Geology

Columbus lies on the glaciated plains section at the eastern edge of the central lowlands physiographic province. When the Plio-Pleistocene Ice Age began two million years ago, a continental scale ice sheet originating near Hudson Bay moved southward modifying the pre-glacial landscape. The deposits from the most recent glacial advance, the Wisconsin Glaciation, lie directly on the limestone and shale bedrock underlying Columbus. The area was completely buried by glacial till, generally 10 to 30 feet thick, consisting of unsorted clay, silt, sand, pebbles, and boulders (mainly derived from the Canadian Shield) carried south at the base of the ice sheet. Large out-wash deposits in the Scioto and Olentangy Valleys resulted from the great volumes of melt water coming from the kilometer-thick ice sheet (thickening to three kilometers near its source at Hudson Bay). The deposits occur above the present drainage level as gravel terraces and serve as water recharge areas north and south of downtown Columbus, principally on the west side of the Scioto River.

The bedrock immediately underlying the area is composed of the Columbus and Delaware Limestone, and the Olentangy and Ohio Shale of Devonian Age, deposited approximately 350 million years ago when Ohio was at the eastern edge of ancestral North America and was a near-shore marine environment. The Columbus and Delaware Limestone and the

Olentangy Shale represent successive depositional stages from a shallow marine environment to deeper marine environment. All sedimentary rocks underlying Columbus dip gently to the southeast. The pre-Devonian sedimentary rocks were derived from the Cincinnati Arch, a belt of Precambrian crystalline igneous and metamorphic rocks trending north-south along the Ohio-Indiana border. Now confined to the subsurface, this arch controls the linear pattern of Paleozoic deposition in western and central Ohio. The bedrock sediments outcrop in bands extending roughly north-south in Central Ohio. The Ohio Shale outcrops in the eastern part of the Columbus area; the Columbus and Delaware Limestone outcrop on the west side of the Scioto River. Near the close of the Paleozoic Era, the convergence of Africa and North America resulted in the Appalachian Orogeny. The western limits of this major mountain building episode are seen from northeast to south-central Ohio, where the regional southeastern dip of paleozoic strata rapidly steepens and the crustal thickness markedly begins to increase beneath the Appalachian Mountains.

Underlying Devonian strata in the Columbus area are older Paleozoic sedimentary formations. These are in turn underlain by Precambrian igneous and metamorphic basement rocks which make up the Proterozoic Craton extending northward and westward to outcrop in Canada as the Canadian Shield. These basement rocks are roughly 2 kilometers below the surface in central Ohio.

The bedrock at the reactor site is Delaware Limestone, a mixture of argillaceous cherty blue limestones and calcareous brown shales. These strata are covered by glacial drift which is predominantly gravel and clay. A boring analysis taken at a point about 500 feet southwest of the reactor site gave the information shown in Table 2.1.

2.3.3 Seismology

Figure 2.6 is a map of all of the instrumentally recorded earthquakes of Richter Magnitude 4.5 or greater that have occurred in the United States from 1899 through 1990. A belt of seismic activity (the St. Lawrence Seismic Belt) runs through Northwestern Ohio. Although the most persistently seismically active regions in the United States do not lie in Ohio, Ohio is not a-seismic contrary to popular opinion. Figure 2.7 gives the Modified Mercalli Intensity Scale with approximate corresponding values of equivalent Richter Magnitude.

Historically, the most active seismic region in Ohio is near Anna in Shelby County, approximately 60 miles northwest of Columbus. To date this region has had at least 35 earthquakes, including the three largest seismic events instrumentally recorded in Ohio. A map of the historically known earthquakes in Ohio with Richter Magnitude 2.0 or greater is provided in Figure 2.8. Modified Mercalli Intensitiy equivalent of each event is color coded. As of 1999, the first statewide seismic network was established in Ohio became operational (Hansen, 1999). Called "OhioSeis", this network digitally records seismic events of global origin but is intended to significantly

Table 2.1: Rock Types Underlying the Reactor Building Site

Strata	Depth (ft)
Clay	0 to 60
Slab Rock	60 to 63
Hard Clay	63 to 81
Rock	81 to 85
Hard Clay and Gravel	85 to 109
Hard Rock	109 to 115
Clay	115 to 138
Rock	138 to 142
Soft Clay	142 to 158
Limestone	158 to 190

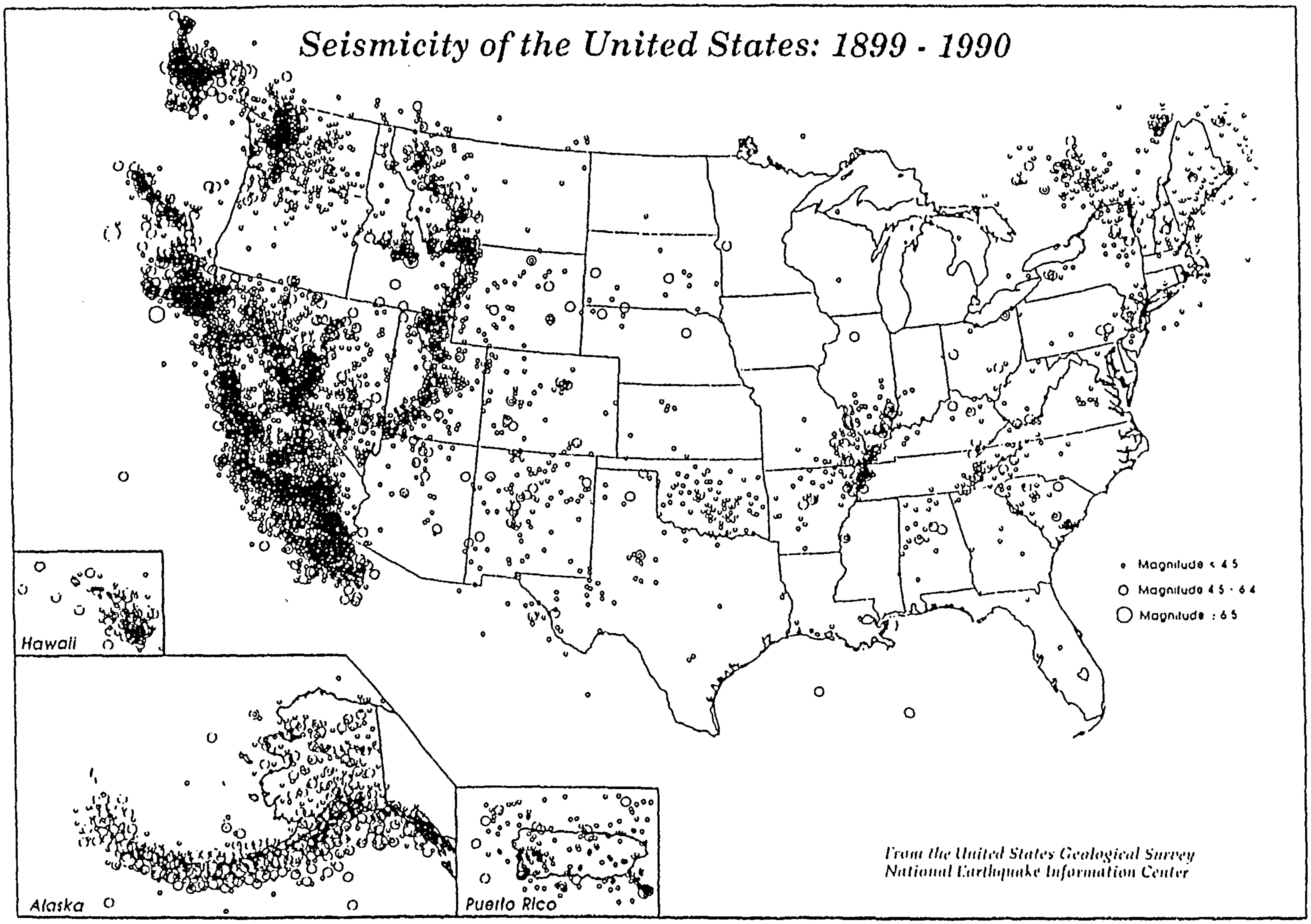


Figure 2.6: Seismicity of the United States: 1899-1990

Modified Mercalli Intensity Scale	
I	Detected only by sensitive instruments
II	Felt by few persons at rest, especially on upper floors; delicately suspended objects may swing
III	Felt noticeably indoors, but not always recognized as earthquake; standing autos rock slightly, vibrations like passing truck
IV	Felt indoors by many, outdoors by few, at night some awaken; dishes, windows, doors disturbed; standing autos rock noticeably
V	Felt by most people; some breakage of dishes, windows, and plaster; disturbance of tall objects
VI	Felt by all, many frightened and run outdoors, falling plaster and chimneys, damage small
VII	Everybody runs outdoors; damage to buildings varies depending on quality of construction; noticed by drivers of autos
VIII	Panel walls thrown out of frames; walls, monuments, chimneys fall; sand and mud ejected; drivers of autos disturbed
IX	Buildings shifted off foundations, cracked, thrown out of plumb; ground cracked, underground pipes broken
X	Most masonry and frame structures destroyed; ground cracked, rails bent, landslides
XI	Few structures remain standing; bridges destroyed, fissures in ground, pipes broken, landslides, rails bent
XII	Damage total; waves seen on ground surface, lines of sight and level distorted, objects thrown up into air

Magnitude Scale: 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5, 8

Figure 2.7: Modified Mercalli Intensity Scale with Approximate Equivalent Richter Magnitude

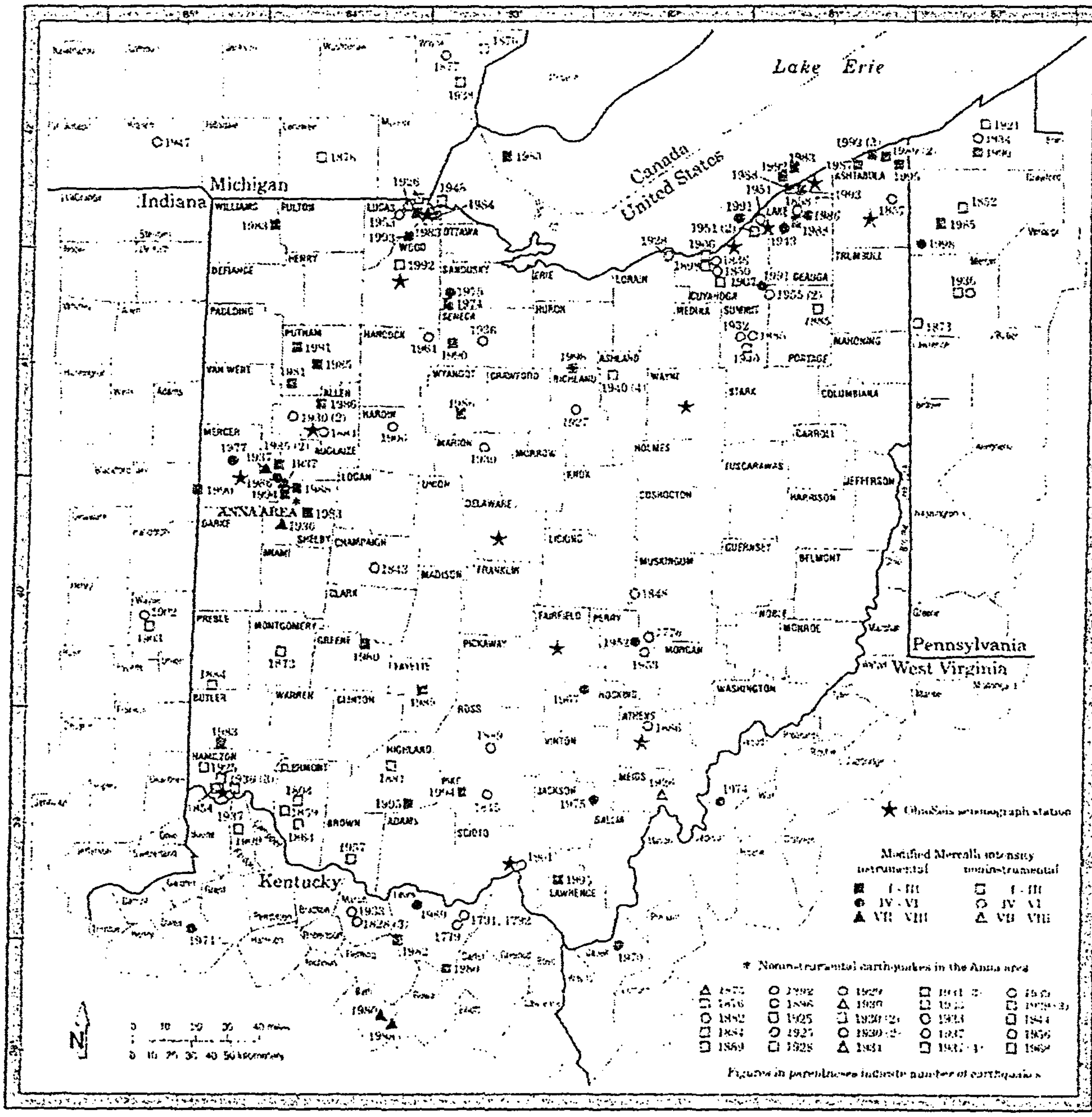


Figure 2.8: Map of Historically Known Earthquakes in Ohio with Richter Magnitude 2.0 or Greater

Notes:

1) Equivalent Modified Mercalli Intensity is color coded.
2) OhioSeis seismic network locations are shown by stars.

enhance the detection, location and magnitude of future seismic events in the mid-continent in general and Ohio in particular. In the near future, the seismic risk assessment to structures of all kinds due to earthquakes originating within and near Ohio's borders will be better understood.

Although very little historical information is available on earthquakes with epicenters in or near Columbus, or about the effects of such earthquakes on the city, it is appropriate to assume that known mid-continent earthquakes have historically had some effects here. Figure 2.9 shows the potential Modified Mercalli Intensity distribution resulting from a Richter Magnitude 8.0 seismic event in the New Madrid area. Damage consistent with MM VIII would be likely in central Ohio.

Figure 2.10 shows the Mid-continent regional distribution of peak lateral ground acceleration (as a percentage of gravitational acceleration = 1 g) having a two percent probability of being exceeded in 50 years. The Anna, Ohio, area discussed above is clearly discernable. More detailed information about this and related seismic risk information is available at the USGS Geological Hazards Web site http://geohazards.cr.usgs.gov/eq/.

The possibility of a Richter Magnitude 7.0 or greater seismic event in the New Madrid area (southeast Missouri - northwest Arkansas - western Tennessee) affecting the Columbus Metropolitan Area 400 miles (600 kilometers) away is unfortunately real. However, The Ohio State University reactor facility is not likely to suffer sufficient damage resulting in a serious hazard. Cracking of the shield would probably be the most serious damage. Should the pool liner be ruptured, pool water would escape from the pool leaving the reactor unshielded in the vertical direction. The reactor would then be sub-critical because of the absence of the moderator.

2.4 Meteorology

Figure 2.11 is a graph of the average wind speed versus wind direction. Tables 2.2 and 2.3 contain summaries of temperature and precipitation for Columbus, Ohio. Table 2.4 contains various other relevant meteorological data. Meteorological information given in Figure 2.11 and Table 2.4 was taken from data published by the National Climatic Center in Asheville, North Carolina. The data in Tables 2.2 and 2.3 was obtained from the WWW page of the State Climate Office for Ohio at http://twister.sbs.ohio-state.edu/climoff.htm.

2.5 Hydrology

2.5.1 Surface Water

Columbus is located in the center of the state and in the drainage area of the Ohio River. Four nearly parallel streams run through or

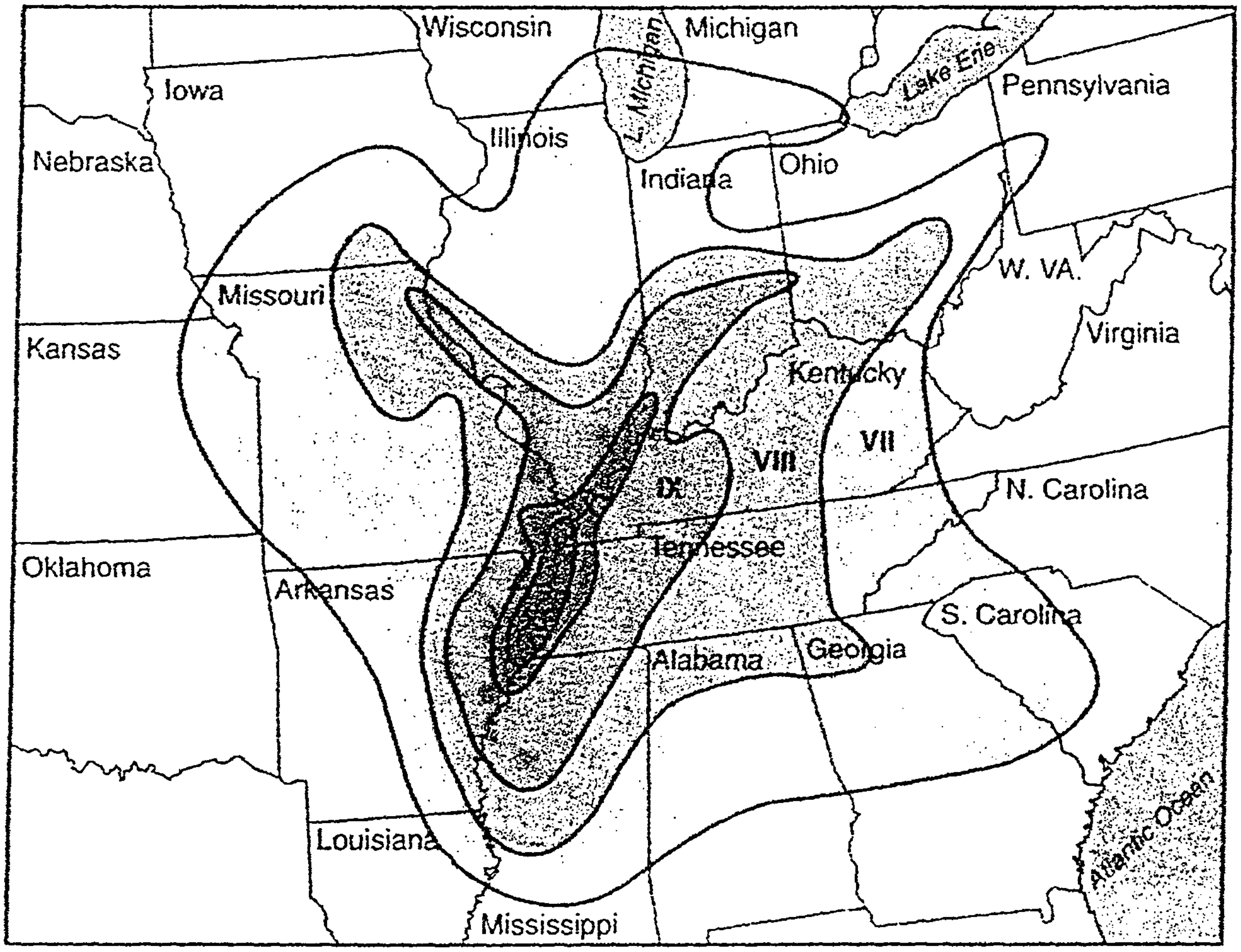


Figure 2.9: Potential Regional Modified Mercalli Intensity Map Projected for a Future Possible Richter Magnitude 8.0 Earthquake in the New Madrid Area

Note: Refer to Figure 2.7 for interpretation of the local severity of projected structural damage in terms of local Modified Mercalli Intensity.

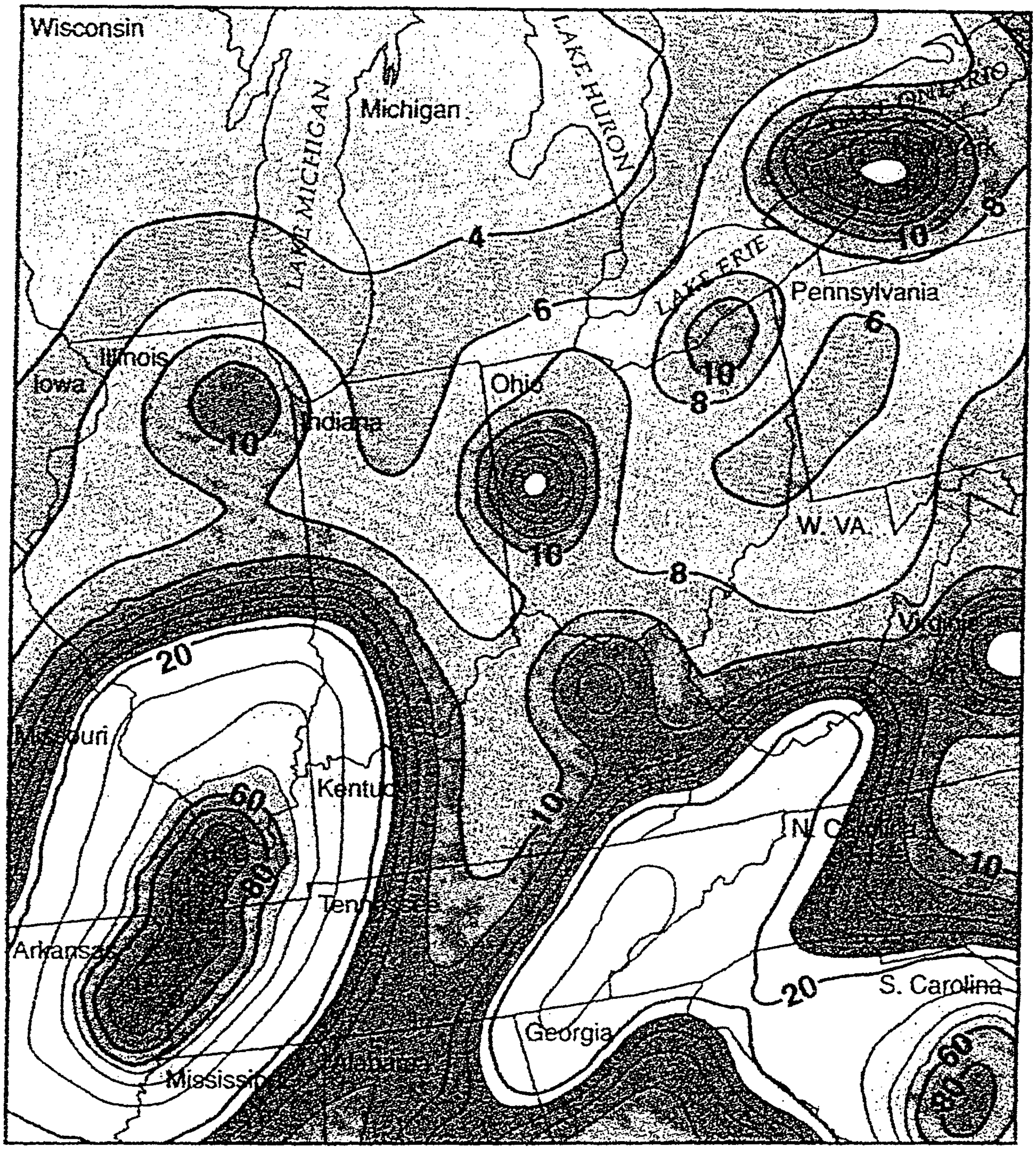


Figure 2.10: Mid-Continent Regional Distribution Map of Peak Lateral Ground Acceleration (as a percent of gravitational acceleration) Having a Two Percent Probability of Being Exceeded in Fifty Years

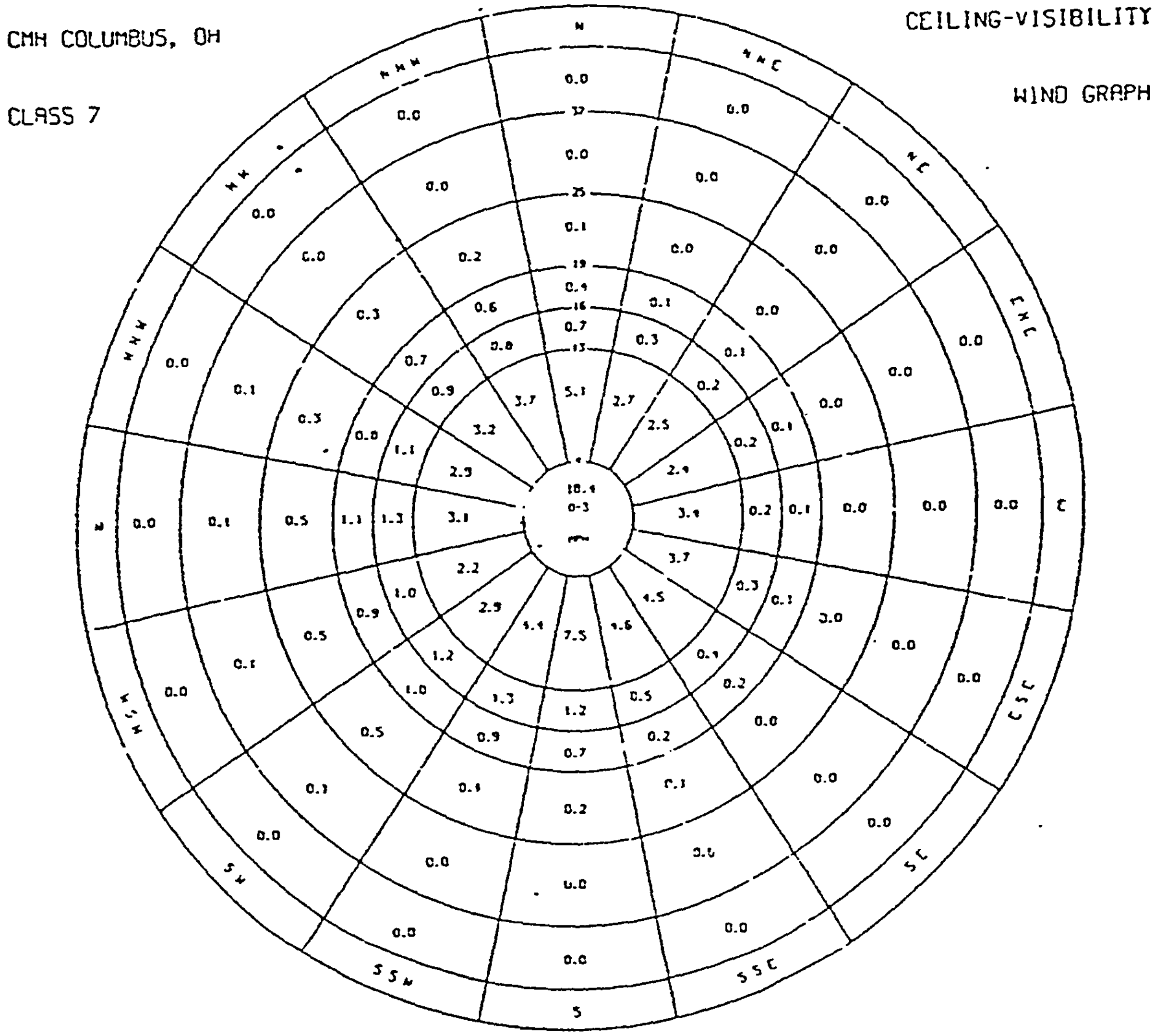


Figure 2.11: Wind Speeds and Directions in the Columbus Area

Table 2.2: Temperature Summary

****
********************** TEMPERATURE SUMMARY ******************************
****

Station: (331786) COLUMBUS_WSO_AIRPORT Missing Data: 0% NCDC Averages
Averages: 1961-1990 Extremes: 1948-1996

	Averages			Daily Extremes				Mean Extremes				#Day-Max		#Day-Min	
	Max	Min	Mean	High	Date	Low	Date	High	Yr	Low	Yr	=> 90	<= 32	<= 32	<= 0
Ja	34.1	18.5	26.4	74	25/1950	-22	19/1994	39.9	50	11.4	77	0	12	26	2.2
Fe	38.0	21.2	29.6	73	25/1957	-13	02/1951	39.0	54	16.6	78	0	8.0	23	1.2
Ma	50.5	31.2	40.9	82	31/1981	-6	09/1984	50.4	73	28.4	60	0	2.3	18	0.1
Ap	62.0	40.0	51.0	88	23/1960	14	07/1982	57.4	54	45.8	50	0	0.1	6.7	0
Ma	72.3	50.1	61.2	93	30/1953	25	10/1966	70.9	91	55.4	67	0.6	0	0.5	0
Jn	80.4	58.0	69.2	101	25/1988	35	11/1972	75.0	91	63.6	72	4.3	0	0	0
Jl	83.7	62.7	73.2	104	14/1954	43	06/1972	79.0	55	70.5	71	6.8	0	0	0
Au	82.1	60.8	71.5	101	20/1983	39	29/1965	78.4	95	68.3	67	4.8	0	0	0
Se	76.2	54.8	65.5	100	02/1953	31	21/1962	71.0	61	60.4	67	1.6	0	0.1	0
Oc	64.5	42.9	53.7	90	05/1951	17	21/1952	59.9	63	47.4	88	0	0	3.7	0
No	51.4	34.3	42.9	80	01/1950	-4	30/1958	48.2	85	33.9	76	0	1.3	14	0
De	39.2	24.6	31.9	76	03/1982	-17	22/1989	40.8	56	19.8	89	0	8.2	24	0.8
An	61.2	41.6	51.4	104	07/14/54	-22	01/19/94	55.4	91	49.7	76	18	32	116	4.4
Wi	37.1	21.4	29.3	76	12/03/82	-22	01/19/94	36.4	49	20.7	77	0	28	72	4.3
Sp	61.6	40.4	51.0	93	05/30/53	-6	03/09/84	57.0	91	46.6	84	0.6	2.4	26	0.1
Su	82.1	60.5	71.3	104	07/14/54	35	06/11/72	75.9	91	68.6	72	16	0	0	0
Fa	64.0	44.0	54.0	100	09/02/53	-4	11/30/58	57.5	73	47.7	76	1.6	1.3	18	0

****
************* Midwestern Climate Center, Champaign IL *********************
****

Table 2.3: Precipitation Summary

```
*******************************************************************************
*********************** PRECIPITATION SUMMARY *********************************
*******************************************************************************

Station: (331786) COLUMBUS_WSO_AIRPORT        Missing Data:   0%
Averages: 1961-1990  Extremes: 1948-1996
                Total Precipitation                     Snow       #Days Precip
    Mean   High--Yr    Low--Yr      1-Day Max     Mean  High--Yr =>.01 =>.50 =>1.
--------------------------------------------------------------------------------
Ja  2.18   8.29  50   0.65  61   4.79  21/1959   9.2  34.4  78  13.7  1.8  0.4
Fe  2.24   5.15  90   0.31  78   2.15  23/1975   7.0  16.4  79  11.6  1.3  0.2
Ma  3.27   9.60  64   1.01  79   3.40   9/1964   4.4  13.5  62  13.8  1.8  0.3
Ap  3.21   6.39  96   0.67  71   2.03  30/1983   1.1  12.6  87  13.2  2.1  0.6
Ma  3.93   9.11  68   0.95  77   2.12  29/1982   0.0   0.8  89  12.5  2.7  0.7
Jn  4.04   9.75  58   0.71  84   2.55  13/1981   0.0   0.0  49  10.7  2.9  1.0
Jl  4.31  12.36  92   0.99  51   5.13  13/1992   0.0   0.0  49  10.8  3.0  1.1
Au  3.72   8.63  79   0.58  51   3.17   5/1995   0.0   0.0  49   9.4  2.3  0.8
Se  2.96   6.76  79   0.51  63   2.66  14/1979   0.0   0.0  49   8.5  1.9  0.5
Oc  2.15   5.24  54   0.11  63   1.69   3/1986   0.1   4.6  93   9.0  1.1  0.3
No  3.22  10.67  85   0.60  76   2.38  10/1985   1.9  15.2  50  11.6  2.0  0.5
De  2.86   6.99  90   0.46  55   1.74   8/1978   5.3  17.3  60  13.2  1.6  0.3

An 38.09  53.18  90  24.51  63   5.13  7/13/92  29.0  47.5  78 138.8 24.6  6.7
Wi  7.28  14.39  50   3.52  77   4.79  1/21/59  21.9  46.4  78  38.5  4.6  0.8
Sp 10.41  17.91  64   5.02  76   3.40  3/ 9/64   5.6  18.5  87  39.5  6.6  1.6
Su 12.07  22.02  58   6.00  51   5.13  7/13/92   0.0   0.0  49  30.9  8.2  2.9
Fa  8.33  13.78  85   1.42  63   2.66  9/14/79   2.0  15.2  50  29.6  5.2  1.3

*******************************************************************************
************* Midwestern Climate Center, Champaign IL  *************************
*******************************************************************************
```

Table 2.4: Other Meteorological Data

COLUMBUS, OH
PORT COLUMBUS INTL AP

ANNUAL

PERIOD OF RECORD 1965-74
29211 OBSERVATIONS

TABLE 10. CEILING, VISIBILITY, AND WEATHER BY WIND DIRECTION (PERCENT FREQUENCY OF OBSERVATIONS)

WIND DIR	CEILING (FEET) 0	100	200 TO 300	400 TO 900	1000 TO 1400	1500 TO 1900	2000 TO 2900	3000 TO 4900	5000 TO 9500	OVER 9500	VISIBILITY (MILES) 0 TO 3/16	1/4 TO 3/8	1/2 TO 3/4	1 TO 2 1/2	3 TO 6	OVER 6	WEATHER: RAIN AND/OR DRZL	FRZ RAIN AND/OR FRZ DRZL	SNOW AND/OR IP	FOG	FOG AND SMOKE	SMOKE AND/OR HAZE	TSTM	HAIL
N	.0	.0	.1	.7	.5	.5	.8	.8	.7	5.5	.0	.0	.1	.6	2.2	4.8	.7	.0	.5	1.3	.0	1.7	.1	
NNE	.0	.0	.0	.2	.2	.2	.2	.4	.3	2.2	.0	.0	.0	.2	.7	2.8	.3	.0	.2	.3	.0	.6	.0	
NE	.0	.0	.0	.2	.1	.1	.2	.3	.4	2.4	.0	.0	.0	.2	.7	2.9	.3	.0	.1	.4		.6	.0	
ENE		.0	.0	.2	.1	.1	.2	.3	.4	2.2		.0	.0	.3	.7	2.6	.3	.0	.1	.4	.0	.7	.0	
E	.0	.0	.0	.2	.1	.2	.3	.5	.7	4.0	.0	.0	.0	.3	1.4	4.1	.5	.0	.1	.8	.0	1.4	.0	
ESE		.0	.0	.3	.1	.2	.3	.6	.8	3.7	.0	.0	.0	.3	1.6	4.0	.7	.0	.1	.9	.0	1.4	.0	
SE	.0	.0	.1	.4	.2	.2	.4	.6	.8	3.4	.0	.0	.0	.3	1.7	3.8	.9	.0	.1	1.0	.0	1.5	.1	
SSE	.0	.0	.1	.2	.1	.1	.3	.6	.8	3.5	.0	.0	.0	.4	1.6	3.7	.8	.0	.0	.8	.0	1.5	.0	
S	.0	.1	.1	.8	.4	.4	.8	1.4	1.6	6.7	.0	.0	.1	1.0	3.3	7.9	1.3	.0	.2	1.6	.1	3.2	.1	
SSW	.0	.0	.1	.3	.3	.2	.3	.8	.7	3.0	.0	.0	.1	.4	1.5	4.0	.6		.1	.6	.0	1.5	.1	
SW		.0	.1	.3	.3	.4	.6	.8	.4	2.6	.0		.0	.3	1.1	4.1	.6		.2	.4	.0	1.1	.1	
WSW		.0	.0	.3	.3	.5	.8	.7	.3	2.0	.0		.0	.3	1.0	3.7	.4	.0	.4	.4	.0	.8	.1	
W			.0	.4	.4	1.0	1.4	1.2	.6	3.6		.0	.0	.3	1.5	6.9	.4	.0	1.0	.6	.0	1.1	.1	.0
WNW	.0		.0	.3	.4	.5	1.0	.8	.3	1.8	.0	.0	.0	.3	.8	4.0	.4	.0	.5	.3		.6	.0	
NW	.0		.1	.3	.3	.4	.6	.6	.3	1.7	.0		.0	.2	.8	3.2	.3	.0	.4	.4		.6	.0	
NNW	.0	.0	.1	.5	.3	.4	.5	.5	.3	2.0	.0	.0	.1	.3	.9	3.3	.4	.0	.6	.6		.7	.0	
CALM	.0	.0	.0	.0	.0	.0	.1	.1	.2	2.8	.1	.0	.0	.2	.9	2.1	.1		.0	.8	.0	.8		
TOT	.1	.2	.9	5.7	4.3	5.5	9.2	11.1	9.7	53.1	.3	.1	.6	6.5	22.4	69.9	9.0	.2	4.5	11.8	.3	19.8	.7	.0

IP – ICE PELLETS (REPLACES SLEET AND SMALL HAIL)

TABLE 11. WIND DIRECTION VS. WIND SPEED (PERCENT FREQUENCY OF OBSERVATIONS)

A. ALL WEATHER

WIND DIR	WIND SPEED (KNOTS) 0-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	OVER 40	TOT	AVG SPEED
N	.7	4.5	2.9	1.4	.1	.0				9.6	7.1
NNE	.3	1.8	1.1	.4	.0					3.8	6.5
NE	.5	1.9	1.2	.3	.0					3.9	6.3
ENE	.4	1.6	1.2	.3	.0					3.6	6.4
E	.8	3.0	1.9	.4	.0					6.1	6.2
ESE	.4	3.0	2.2	.5	.0					6.1	6.6
SE	.3	2.3	2.5	.9	.0	.0				6.1	7.5
SSE	.3	2.6	2.3	.6	.0					5.8	7.0
S	.3	4.2	5.0	2.5	.2	.0				12.3	8.2
SSW	.1	1.0	2.5	2.0	.3	.0	.0			5.9	10.1
SW	.1	.8	1.9	2.2	.4	.1	.0	.0	.0	5.5	11.0
WSW	.1	.6	1.7	2.1	.5	.1	.0			5.0	11.4
W	.1	1.2	3.1	3.5	.8	.1	.0			8.8	11.0
WNW	.1	.8	2.3	2.1	.3	.1	.0			5.1	10.6
NW	.2	1.0	1.6	1.4	.2	.0				4.3	9.5
NNW	.3	1.6	1.4	1.2	.1	.0				4.7	8.3
CALM	3.3									3.3	
TOT	8.4	31.9	34.4	21.7	3.0	.5	.1	.0	.0	100.0	8.2

ALL WEATHER; ALL WIND OBSERVATIONS

B. IFR

WIND DIR	WIND SPEED (KNOTS) 0-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	OVER 40	TOT	AVG SPEED
N	.1	.4	.3	.3	.0					1.2	8.4
NNE	.0	.1	.1	.1	.0					.3	7.8
NE	.0	.2	.1	.0	.0					.3	6.7
ENE	.0	.2	.1	.0						.3	6.7
E	.1	.3	.2	.0						.6	6.4
ESE	.0	.3	.2	.1						.7	7.3
SE	.1	.2	.3	.1	.0					.7	7.5
SSE	.0	.3	.2	.1						.6	6.7
S	.1	.6	.6	.2	.0					1.5	7.7
SSW	.0	.1	.3	.2	.0	.0				.7	8.8
SW	.0	.1	.2	.2	.0	.0				.5	9.4
WSW	.0	.1	.2	.2	.0	.0	.0			.5	10.3
W	.0	.1	.2	.2	.1	.0				.7	10.0
WNW	.0	.1	.2	.2	.0	.0				.5	9.7
NW	.0	.1	.2	.2	.0	.0				.5	9.8
NNW	.0	.2	.2	.2	.0	.0				.7	9.4
CALM	.3									.3	
TOT	.8	3.4	3.8	2.3	.3	.0	.0			10.6	8.1

IFR: CEILING < 1000 FT AND/OR VISIBILITY < 3 MI BUT ≥ 200 FT AND ≥ 1/2 MI.

TABLE 12. WEATHER CONDITION BY HOUR (MEAN NO. OF DAYS)

	WEATHER CONDITIONS	HOUR (LST) 01	04	07	10	13	16	19	22
WEATHER TYPE	RAIN AND/OR DRIZZLE	32.3	33.7	32.6	33.0	32.7	35.8	32.1	30.7
	FRZ RAIN AND/OR FRZ DRIZZLE	.9	1.3	1.2	.4	.6	.2	.3	.4
	SNOW AND/OR ICE PELLETS	14.3	16.0	17.5	18.7	17.7	17.4	13.9	14.8
	HAIL								.1
	PRECIPITATION	46.7	50.4	50.5	50.9	49.8	52.4	45.5	45.4
	FOG	39.6	61.0	101.5	43.7	25.1	22.9	24.3	25.8
	FOG AND SMOKE	.1	.8	6.1	.8	.3	.2	.2	.1
	SMOKE AND/OR HAZE	39.4	48.8	110.8	129.5	82.7	65.0	58.4	42.9
	OBSTRUCTIONS TO VISION	68.7	89.6	163.6	159.4	103.7	85.4	78.6	62.6
	THUNDERSTORM	2.3	1.9	1.3	.7	3.4	3.6	4.8	3.0
WIND SPEED (KNOTS)	CALM	22.5	29.4	21.5	4.3	2.2	.8	2.3	13.2
	1 – 6	176.8	176.1	169.3	100.7	73.6	72.6	138.9	171.4
	7 – 10	110.0	104.2	112.1	140.3	134.9	133.8	144.6	120.2
	11 – 16	48.3	48.8	50.0	99.5	127.3	133.9	68.4	52.6
	17 – 21	6.5	5.7	5.3	12.0	21.6	20.6	8.8	6.7
	22 – 27	.9	.8	.8	2.2	4.9	3.1	1.7	.9
	28 – 33	.1	.1	.1	.1	.5	.4	.2	.2
	OVER 33					.2			
VISIBILITY (MILES)	0 – 3/16	1.1	3.0	4.3	.8	.2			.3
	1/4 – 3/8	.6	1.1	1.4	.4	.3	.1	.2	.2
	1/2 – 3/4	.9	1.8	4.6	4.2	2.3	2.5	.9	.7
	1 – 2 1/2	9.7	14.2	53.8	48.4	23.3	21.6	13.3	7.2
	3 – 6	48.8	62.4	86.4	78.1	54.6	45.3	50.0	46.9
	OVER 6	304.0	282.6	214.6	233.2	284.5	295.7	298.7	309.7
TEMPERATURE (°F)	ZERO OR LOWER	.6	2.3	2.4	1.1	.3	.2	.4	.3
	1 – 32	80.6	86.0	89.6	68.0	47.7	45.3	58.2	71.2
	33 – 44	72.8	76.5	73.6	63.6	63.3	60.3	64.6	68.8
	45 – 64	137.7	143.3	137.9	102.2	92.7	93.2	99.4	123.8
	65 – 89	73.4	56.8	61.6	130.2	156.4	158.9	142.1	98.9
	90 – 99					4.8	7.4	.4	
	OVER 99								

VALUES ARE ROUNDED TO NEAREST TENTH, BUT NOT ADJUSTED TO MAKE THEIR SUMS EXACTLY EQUAL TO COLUMN OR ROW TOTALS.

THESE VALUES ARE BASED ON 3–HOURLY OBSERVATIONS.

adjacent to the city. The Scioto River, located to the west of the city and of the reactor site, is the principal stream and flows from the northwest into the center of the city and then flows straight south toward the Ohio River. The Olentangy River, which is located to the east of the reactor site, runs almost due south and empties into the Scioto just west of the business district. Two minor streams, Alum Creek and Big Walnut Creek, run through portions of Columbus and skirt the eastern and southern fringes of the area. Alum Creek empties into the Big Walnut southeast of the city and the Big Walnut empties into the Scioto a few miles downstream. The Scioto and Olentangy feature gorge-like formations with very little flood plain and the two creeks have only a little more flood plain or bottomland.

2.5.2 Ground Water

Infiltration from the reactor site enters the groundwater table which is approximately 45 to 50 feet below the surface. The groundwater flows toward the Olentangy River which is 1.1 miles to the east. The Olentangy River joins the Scioto River at a point about 2.5 miles south of the site, and flows past the city of Columbus in a southern direction. The Dublin Road Water Treatment Plant for the city of Columbus is located on the Scioto River 2.2 miles south by southeast of the reactor site. This location is upstream of the confluence of the Scioto and Olentangy Rivers and uses water collected from the Scioto River basin. Thus, contamination of the city of Columbus' water supply by infiltration of the reactor pool water is virtually impossible. The next major town using water from the Scioto River is Circleville, located 30 miles south of Columbus.

I. SCOPE:

This instruction describes the procedure for performing radiation exposure monitoring in restricted and unrestricted areas to ensure compliance with 10CFR20.1301.

II. DISCUSSION:

A. The intent of the Environmental Monitoring procedure is to ensure that the internal and external exposure to the general public does not exceed those limits set by **10 CFR 20.1301, Dose Limits for Individual Members of the Public.** The following information is provided to explain the methods, measurements, and calculations that were used to demonstrate compliance with the dose limits per 10 CFR 1301.

B. Definitions:

1. "Restricted Area" is defined by 10CFR20 as "an area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials." The interior of the reactor building and the fenced area with locked gate access on the west side of the reactor building are the restricted areas for the NRL. Other areas are fenced and locked after hours but do not meet the aforementioned definition of a restricted area.

2. "Total Effective Dose Equivalent" (TEDE), is defined by 10CFR20 as "The sum of the deep dose equivalent (for external exposures) and the committed dose equivalent (for internal exposures)."

3. "Committed Dose Equivalent" is defined by 10CFR20 as "the dose equivalent to organs or tissues of reference (T) that will be received from an intake of radioactive material by an individual during the 50 year period following the intake."

4. "Deep Dose Equivalent" is defined by 10CFR20 " which applies to whole body exposures, is the dose equivalent at a tissue depth of 1 cm (1000 mg/cm2)

C. Rationale

1. The NRL is required to make surveys in unrestricted and restricted areas available, and to demonstrate compliance with 10 CFR 20 by measurement or calculation ensuring that the TEDE to the individual likely to receive the highest dose from the licensed operation does not exceed the limits set forth in 20.1301. Per 10CFR 20.1301.a.1 and a.2, the release of AR-41 and disposal of radioactive material into sanitary sewerage in accordance with 20.2003 are excluded from the annual limit of 100 mrem TEDE and the acute limit of 2 mrem in any one hour to an individual member of the public. Therefore, external exposure from licensed operations at the NRL is the main focus of this procedure.

2. To demonstrate compliance with section 20.1301, the following actions were taken:

   a. The radiation levels in this estimate were levels taken from a survey with the reactor at full power (450kw) and the CIF plug removed. In addition, the readings were taken in contact with the individual barriers in each location to ensure that the most conservative values were used. These readings are shown on a map as attachment A.

   b. An estimate of the individual most likely to receive the highest dose from operations at the NRL was performed. In determining the individual most likely to receive the highest dose, both the radiation level and the expected stay time were considered. Therefore, the areas with the highest radiation levels are not necessarily the locations that are used for this calculation due to the amount of time that an individual is likely to be present in those locations. This individual was determined to be a student working in the classroom adjacent to the NRL on the north side. The highest dose rate obtainable in the classroom was .23 mrem/hr per the above survey.

   c. The highest effective full power usage of the reactor from 1994 to 2002 was 1995, at 267.24 effective full power hours, based on 450kw. This value of effective full power hours is calculated by adding up hours of operations at all power levels and scaling them to show an equivalent of hours at full power and therefore is conservative. For an additional margin of error, it is assumed that the student in the classroom will be present in contact with the classroom wall for the complete 267.24 effective full power hours of operation. Therefore, the student would receive 61.47 mrem/year.

   d. Therefore, using the above combination of measurement and conservative calculation, it can be determined that the TEDE to an individual of the public would not exceed that allowed by section 10 CFR 20.1301.

3. To ensure compliance with 10 CFR 20.1302.a, the following surveys are taken and available for review:

   a. Dosimetry badges are located at the boundaries of the NRL per Section V of this procedure. These dosimetry badges are read quarterly and a record of their readings is kept permanently at the Radiation Safety Section office.

   b. Surveys are completed inside the NRL weekly and each day that the reactor is operated.

III. REFERENCES:

A. 10 CFR Part 20

IV. PRECAUTIONS:

A. Radiation dosimetry reports from Radiation Safety should be reviewed to ensure all recorded doses are at expected levels. If any dosimeters receive a dose that is not consistent with previous values, considering operational schedule, the cause must be investigated and the full power radiation survey re-performed.

B. If changes are made to reactor power or operational limits, or the amount, location, or type of shielding present, such that radiation levels outside of the restricted areas of the NRL could change significantly, perform an area radiation survey with the reactor at full power to ensure the dose an individual member of the public is likely to receive has not increased.

V. PROCEDURES:

A. Reactor Laboratory Environmental Monitoring for external sources of radiation.

1. Dosimetry badges shall be replaced quarterly. Obtain the required replacement dosimeters from the OSU EHS Radiation Safety Section. Currently these are mailed to the NRL.

2. Collect currently distributed dosimeters at the locations shown on Attachment B and replace each dosimeter with a new dosimeter.

3. Return collected dosimeters to the Radiation Safety Section for processing.

VI. ATTACHMENTS:

A. NRL Unrestricted Area Survey Map

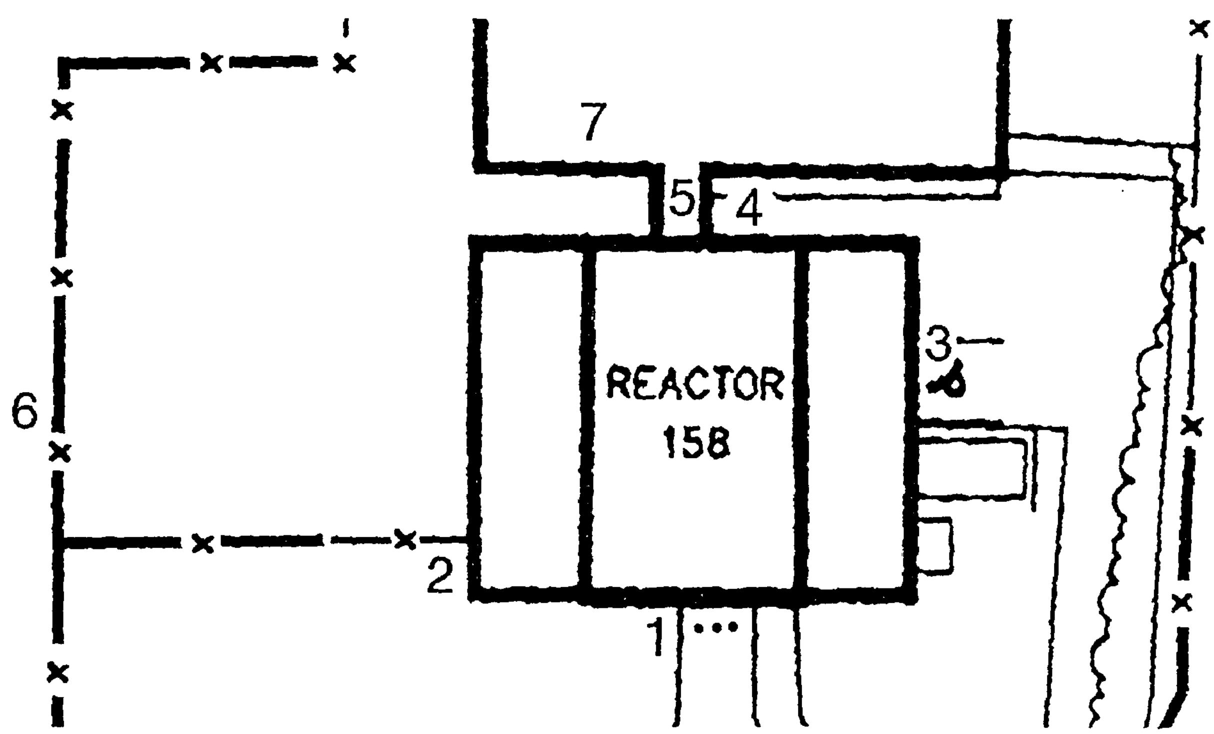
B. Environmental Monitoring Dosimetry Location Map

ATTACHMENT A

UNRESTRICTED AREA SURVEY MAP

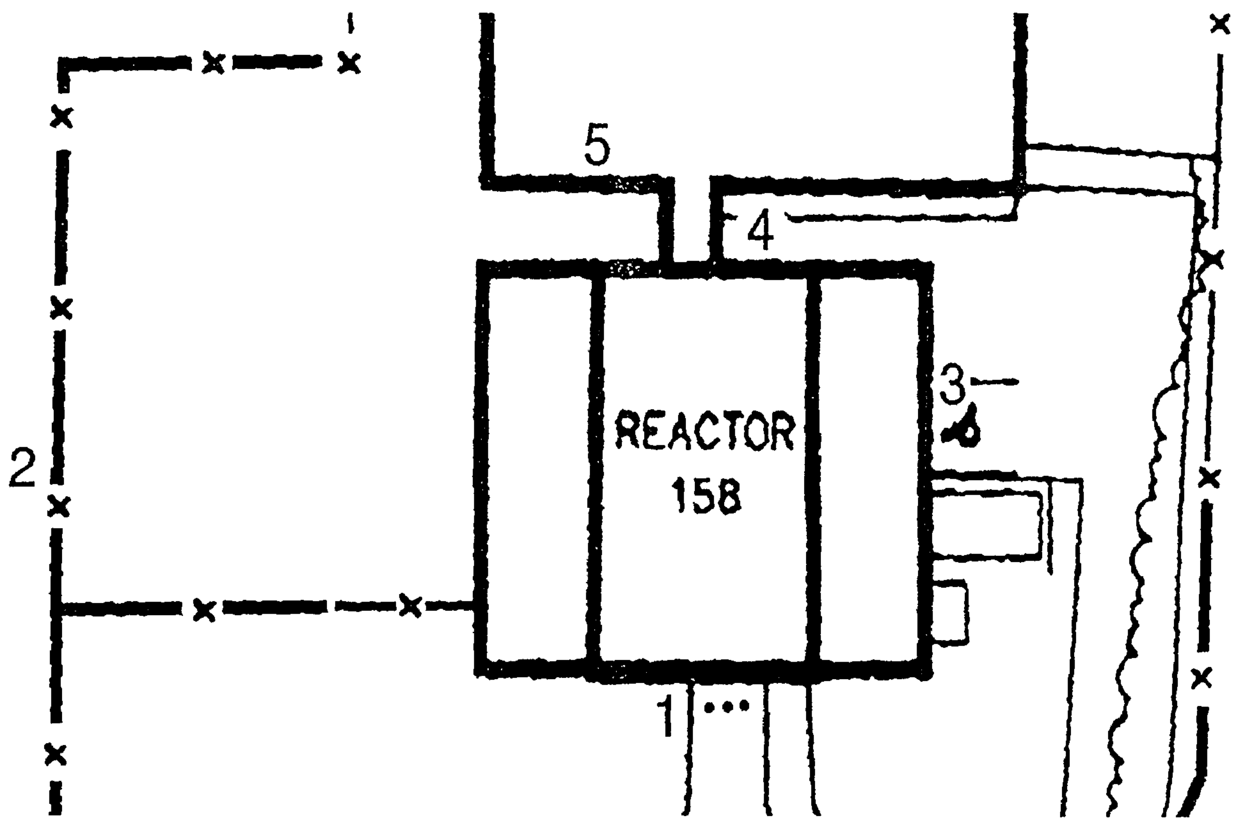
Reactor Power Level 450 KW Survey Instrument Victoreen 450P

No.	Location	Instrument Reading (mrem/hr)	Comments
1	South side of building, on contact with roll-up door	.55	Centered horizontally, approximately core height
2	Southwest corner of building	.23	In contact with building at junction of building and fence, at boundary of restricted area, approximately core height
3	East side of building	.25	On contact with east side of building, approximately core height,
4	North side of building	.62	North side of building, in passageway between OEMA and NRL, approximately core height,
5	Outside rear NRL access door	.51	On contact with door, approximately core height
6	West side of restricted area	.06	On contact with the outside of the west fence, aligned from north to south with core, approximately core height
7	South wall of classroom	.25	South wall of classroom, in contact with windows



ENVIRONMENTAL MONITORING DOSIMETRY LOCATION MAP

No.	Location	Comments
1	South side of building, on contact with building	On contact with west side of door opening, approximately core height
2	West side of restricted area	Mounted on fence at boundary of restricted area, centered north to south with core, approximately core height
3	East side of building	On contact with east side of building, approximately core height,
4	North side of building	Mounted on north side of building, in passageway between OEMA and NRL, directly north of high radiation storage cave, approximately core height,
5	Inside north classroom	Mounted in the center of the eastern most window at the base



TOTAL ACTIVITY OF TRANSFERRED SOILD WASTE

The activity of the solid waste we reported in our environmental report was 275,228,200 becquerels (Bq) or about 7,438.6 microcuries. This was for the period July 1999 through June 2004.