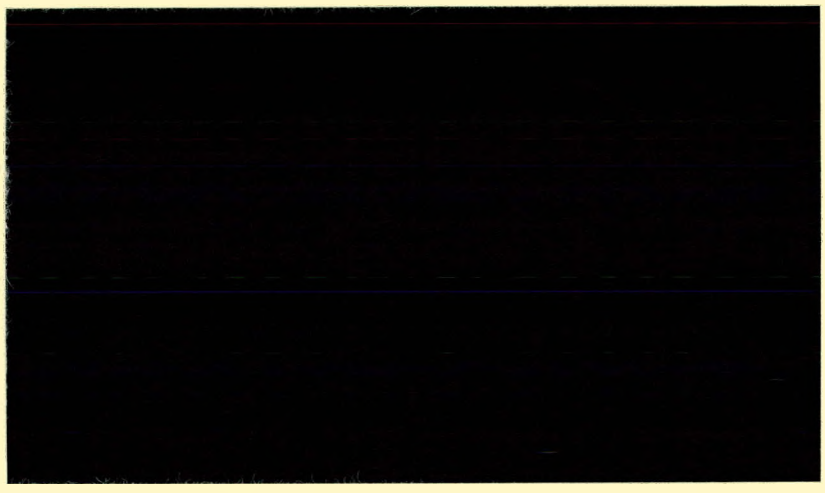


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OFFICE OF NUCLEAR WASTE ISOLATION

ONWI—16

ENVIRONMENTAL CHARACTERIZATION OF BEDDED SALT FORMATIONS AND OVERLYING AREAS OF THE SALINA BASIN

September 1979

BATTELLE MEMORIAL INSTITUTE
505 KING AVENUE
COLUMBUS, OHIO 43201

The information contained in this report was developed by the Office of Nuclear Waste Isolation (ONWI) and by NUS Corporation under subcontract E512-01400 to ONWI and was administered by the Office of Nuclear Waste Isolation

see pp. iii + v

PREPARED FOR THE
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Notice to the Reader:

The Department of Energy is evaluating various geographical regions and geological media in the United States to determine their potential suitability for deep geologic disposal of commercial radioactive wastes. The Office of Nuclear Waste Isolation (ONWI) of Battelle Memorial Institute is responsible to DOE for coordinating a number of subcontractors with geological and environmental expertise to this end. The evaluation program progresses from regional, to area, to location studies. Eventually, one or more repository sites may be selected from a number of potentially suitable locations.

This report is one of four reports being issued to describe the environmental and geologic investigations that have been completed in the Salina Basin.

At present, studies of the Salina Basin have been suspended and no further DOE/ONWI exploration activities will be initiated until appropriate consultation and concurrence with the Salina Basin states has occurred. The limited information in the Environmental Characterization report on Michigan salt areas reflects the absence of state concurrence to date for detailed characterization efforts.

The reports contained in the Salina series are:

Geologic Characterization	Report of Geologic Project Manager--Salina Basin, October, 1978, 2 vols., prepared by Stone & Webster Engineering Corporation (ONWI/SUB-E512-00600/1)
Environmental Characterization	Environmental Characterization of Bedded Salt Formation and Overlying Areas of the Salina Basin, September 1979 prepared by NUS Corporation (ONWI-16)
Environmental Summary	Preliminary Evaluation of the Environmental Aspects of Potential Radioactive Waste Repository Study Areas in the Ohio and New York Portions of the Salina Basin, September 1979, prepared by NUS Corporation (ONWI-23)
Regional Summary	Regional Summary and Recommended Study Areas for Ohio and New York Portions of the Salina Basin, September 1979, prepared by NUS Corporation (ONWI-29).

The Salina Basin characterization reports have received wide circulation and public comment as drafts. Modifications were made in these drafts as a result of comments and suggestions, as appropriate. This set of reports is being sent to you for your information; it describes the extent of progress to date on the characterization studies in the Salina Basin salt deposits.

The Salina Basin characterization efforts were performed during a period of changing national policy toward nuclear waste disposal. The national policy currently awaits final specification by the President. Technology development efforts, exploration, and evaluation of nonsalt media for repositories will be broadened and increased. In addition, the role of the individual states in reviewing the research program will be increased to include a concurrence role regarding studies of their respective areas.

Our records indicate that you may have an interest in this program and we are taking this opportunity to forward to you each of the four reports that characterize the region of the Salina Basin and identify areas that appear suitable for further study.

Sincerely,

J. O. Neff

Mr. J. O. Neff, Program Manager
U.S. Department of Energy
Columbus Program Office
Richland Operations Office

FOREWORD

The U.S. Department of Energy (DOE) has the responsibility to identify sites and construct and operate facilities for the storage or isolation of spent fuel and/or high level radioactive wastes from commercial operations of nuclear power plants. The National Waste Terminal Storage (NWTS) Program has been initiated by DOE to develop the technology and demonstrate the feasibility of burial and isolation of nuclear waste in deep geologic formations. A portion of this program is managed by the Office of Nuclear Waste Isolation (ONWI) of Battelle Memorial Institute, Columbus, Ohio.

The selection process for the identification of qualified site(s) for a waste repository will be an iterative one. Rock formations that could potentially support a waste repository will be evaluated in terms of environmental, geologic, and engineering properties. Those areas within formations that appear most favorable will then be studied in greater detail to identify the most promising locations. Further studies will then be carried out at these locations to provide the environmental, geologic, and engineering data necessary and sufficient to qualify candidate sites. Sites proposed for waste repositories will be subject to Federal and state review and public hearing processes before a construction permit will be issued by the U.S. Nuclear Regulatory Commission (NRC).

This report constitutes one input to the first stage of site qualification studies. It presents a general environmental characterization of the region that is underlain by the Salina bedded salt formation. The formation covers portions of New York, Michigan, Ohio, Pennsylvania, and West Virginia. The Salina bedded salt formation is one of a number of deep, stable geologic formations being studied for potential locations for nuclear waste repositories. These studies will not necessarily lead to selection of a site. They are intended only to provide information necessary to evaluate the suitability of locations for repositories. The report is intended as a general characterization of the existing environmental setting of the Salina Region with emphasis on land, water, and air characteristics; resources, plant and animal life; and on man's organizations and activities. The report provides background information about the role that this regional study will play in the overall plan for environmental impact assessments and statements deemed necessary as input to the decision-making process. Background information on the present concept of nuclear waste repository design and function is also included. The information presented in this report has been summarized from open literature readily accessible to the public. No field work was conducted nor new data used in developing the descriptions contained herein.

The information contained in this report was collected and compiled by the NUS Corporation. The draft of this report was widely distributed to Federal, state and local agencies, recognized experts and interested individuals. These agencies and individuals were asked to review the document and forward their comments to the Department of Energy. Comments received were reviewed and responses were prepared by DOE and NUS Corporation. Individual responses were mailed to each commentor describing how the comments would be addressed in the final report. The draft report was then modified in accordance with these responses.

The environmental information contained in this report and the geohydrological information contained in a report prepared by Stone and Webster are being evaluated together to identify areas within the Salina Basin that are suitable for further studies as potential sites for repositories. This area recommendation report is planned for publication in the fall of 1979, and will be made available to interested agencies and individuals for review and comment.

To assure that these characterization activities are reasonably and adequately conducted, a continuous program of consultation and concurrence will be maintained with officials and agencies of each state. In this way, these activities will be influenced by the states and information collected and recommendations reached will reflect the needs and concerns of the states, and the NWTS Program.

LIST OF ACRONYMS

AEC	U.S. Atomic Energy Commission
APS	American Physical Society
ANSI	American National Standards Institute
ARMS	Aerial Radiological Measurement Surveys
BEA	Bureau of Economic Analysis
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CL	Cladding waste
DEC	Department of Environmental Conservation (New York State)
DNR	Department of Natural Resources (in the states of Michigan, Ohio and West Virginia)
DOE	U.S. Department of Energy
EPA	Environmental Protection Agency
ERDA	U.S. Energy Research and Development Administration
FWS	U.S. Fish and Wildlife Service
HHL	High-level waste
HR	Hydrologic Region
IFR	Instrument flight rules
ILW	Intermediate-level waste
LLW	Low-level waste
LWR	Light-water reactor
MM	Modified Mercalli intensity
MOA	Military operations area
NAS-NRC	National Academy of Sciences-National Research Council
NRC	U.S. Nuclear Regulatory Commission
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NWTS	National Waste Terminal Storage
NWR	National Wildlife Refuge
OBERS	Office of Business Economics, Economic Research Service
OWI	Office of Waste Isolation
PL	Public Law
SAF	Society of American Foresters
SCS	Soil Conservation Service (U.S. Department of Agriculture)
SMSA	Standard Metropolitan Statistical Area
UCC-ND	Union Carbide Corporation, Nuclear Division
USDA	U.S. Department of Agriculture
USDC	U.S. Department of Commerce
USDI	U.S. Department of the Interior
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
VFR	Visual flight rules
WIPP	Waste Isolation Pilot Plant

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1.0 INTRODUCTION

The Office of Nuclear Waste Isolation (ONWI), Battelle Memorial Institute, under subcontract to the U.S. Department of Energy (DOE), is managing a part of the National Waste Terminal Storage (NWTS) Program. The objective of this program is the development of technology for facilities in deep, stable geologic formations for nuclear wastes from commercial facilities.

The plan for identifying potential terminal storage facility sites in geologic media involves geologic studies to ensure that requirements related to public health and safety and to engineering feasibility are met. It also involves, in parallel with the geologic studies, a sequence of environmental studies to ensure that environmental values, both natural and human, are considered in each decision-making step, as required by the National Environmental Policy Act (NEPA), Section 102.

This report presents the formation-wide environmental survey for the Salina bedded salt region. The outline of the region is shown in Figure 1-1.

Details about the environmental studies have been outlined in a planning document (NUS, 1978 a,b). This planning document also included general information on the repository program, such as the need for a repository, the development of the technology, the assessment process, preliminary conceptual facility design, and anticipated impacts. The planning document was transmitted to state agencies, to regional experts, and to various interested inquirers for review and comment and was subsequently issued in final form. The review process by which the plans for environmental studies were developed is also being used for the environmental characterization reports that result from the implementation of study plans. According to the plans, the environmental studies will proceed, in increasing level of detail, from formation-wide surveys to area-wide surveys (approximately 1000 square miles in extent) and finally to studies at confirmatory locations (approximately 30 square miles in extent). The geologic studies are being conducted under a parallel program. Results of both the geologic and the environmental studies will be used in a decision process leading ultimately to the selection of qualified site(s). Results of these studies will also be used to prepare a site-specific environmental impact statement for congressional approval and an environmental report for an application to the U.S. Nuclear Regulatory Commission (NRC) for authorization to construct and operate a repository at a specific site. Before site development can proceed, authorization must be obtained via processes that include regulatory reviews and approvals, and associated public hearings. Further details of the assessment program are given in Section 1.3.

1.1 NEED FOR TERMINAL STORAGE OF NUCLEAR WASTES FROM COMMERCIAL SOURCES

In the United States, electricity is produced principally from the conversion of hydropower; from the conversion of the chemical energy in coal, gas, and oil; and from the conversion of the nuclear energy in uranium. The relative historical utilization of these sources is shown in Figure 1-2 (National Electric Reliability Council, 1975; Federal Power Commission, 1976-1977). Nuclear power plants supplied approximately 9.4% of the nation's electricity in 1976 (Executive Office of the President, 1977).

The locations, generation capacity, and status of commercial nuclear power reactors being built and planned in the United States (USERDA, 1977a) are summarized in Figure 1-3. The distribution of nuclear reactor locations corresponds more or less to the distribution of population; they are mostly located throughout the eastern half of the country and along the West Coast. The total capacity of reactors licensed to operate as of June 1977 was 47.6 GWe*; those licensed to be built or being built will have additional capacity that will bring the total to 142.9 GWe. The dates on which new plants will begin operation include many in the 1980s and a few in the early 1990s. The operating lifetime for each reactor plant is expected to be on the order of 30 to 40 years.

The existing nuclear power industry in the United States is based almost solely on the operation of light-water reactors (LWRs). The LWR fuel cycle is shown diagrammatically in Figure 1-4. Uranium ore is mined and processed in mills to extract the natural uranium in the form of uranium oxide (U_3O_8). The fissionable isotope, uranium-235 (U-235), constitutes only about 0.7% of natural uranium. Since LWRs require uranium with about 3% of U-235 for operation, the uranium oxide must be processed to increase the relative ratio of the fissionable isotope U-235 to the more natural isotope uranium-238 (U-238). To accomplish this enrichment, the uranium oxide is next converted to uranium hexafluoride (UF_6), the chemical form of uranium required as feed material for a gaseous diffusion isotopic enrichment plant. The plant produces uranium that is enriched in the fissionable U-235 isotope as required by the LWR fuel designs. The residual uranium tails depleted in U-235 are stockpiled.

The enriched product is converted to uranium dioxide (UO_2) and fabricated into cylindrical fuel pellets, which are stacked and sealed in zirconium alloy tubes; these tubes (fuel rods) are then assembled into fuel bundles or elements and loaded into the cores of reactor vessels in nuclear power plants. The heat generated within these cores by controlled nuclear reaction (fission) of the uranium is carried away from the fuel elements by circulating water and is used to generate the steam that drives the turbines to produce electricity. After about 3 years in the LWR, the fuel elements need to be replaced (approximately one-third of the core is replaced each year). These spent fuel elements are removed from the reactor core and temporarily stored at the LWR site in spent fuel pools. Storage provides time for the radioactive decay of shorter lived fission products so that the spent fuel elements can be more easily handled.

There are several alternative procedures that may be employed for the long-term disposal of spent fuel after this interim storage period. The spent fuel contains residual fissionable material as unburned U-235 and as plutonium generated in the LWR from U-238 in the fuel. One alternative is therefore to dissolve the fuel material chemically and separate the residual uranium and the plutonium from the fission products. The reprocessing would permit the uranium and plutonium to be recycled back into fuel for nuclear power plants, the plutonium directly and the uranium after reenrichment. It would also permit the classification of wastes by the type of radiation emitted and thus simplify shielding requirements and handling. The extracted fission products constitute the high-level liquid wastes, which produce most of the beta and gamma radiation. Gamma radiation is very penetrating, and therefore these high-level wastes require shielding by layers of dense material such as lead, steel, or concrete to protect personnel. High-level liquid wastes are required to be solidified within 5 years after generation and could be solidified into a highly insoluble material such as a glass matrix and encapsulated in metal

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*The unit GWe refers to a gigawatt of electric power. This is equivalent to 1000 megawatts and to 1,000,000 kilowatts.

containers. Compacted zirconium alloy fuel tubes (cladding hulls) are strong gamma emitters due to activation of the zirconium alloy and will also require shielding when being handled and transferred to terminal storage.

Transuranic wastes (i.e., material containing elements of atomic number higher than 92 and largely emitters of alpha particles, a poorly penetrating radiation) are classified into (1) material that contains fission products and therefore also requires some shielding or (2) material that does not contain beta or gamma ray emitting fission products and therefore does not require shielding. Like high-level wastes and cladding hulls, these transuranic wastes also require long-term isolation from the biosphere.

At present, the benefits of spent fuel reprocessing as currently developed are being reexamined at the highest government levels in the light of available uranium resources and the potential for the diversion or theft of separated plutonium, which can be used for weapons as well as for reactor fuel. Should the decision not to reprocess be reached, the spent fuel assemblies themselves could be encapsulated in sealed metal containers for transfer to a national waste respository. Present conceptual designs for the repositories include a capability for handling wastes in either form: as encapsulated spent fuel or as packaged wastes from reprocessing plants.

Therefore, as outlined above, there is a need for nuclear waste terminal storage, whether for spent fuel or for wastes from reprocessing.

1.2 GEOLOGIC MEDIA FOR COMMERCIAL NUCLEAR WASTE DISPOSAL

Of the alternatives studied over the years for the long-term disposal of high-level radioactive wastes, the use of deep geologic formations as an isolating medium has appeared to be the most promising. One of the earliest evaluations was by the National Academy of Sciences-National Research Council (NAS-NRC), in response to a request from the U.S. Atomic Energy Commission (AEC). In 1955, the NAS-NRC established a committee of geologists to consider the possibilities for the disposal of high-level radioactive wastes in the United States. In 1957, the Committee issued a report (NAS-NRC, 1957) that recommended, as the first choice, disposal of high-level wastes in underground salt deposits.

The suitability of salt deposits as a geologic medium for waste disposal was extensively investigated in both laboratory and field experiments by the Oak Ridge National Laboratory beginning in 1957. Factors investigated included thermal properties such as thermal conductivity, heat capacity, and thermal expansion coefficients; structural and mechanical properties such as stress-strain relationships, creep behavior, and elastic and plastic moduli; trapped moisture effects; brine inclusions; and radiation effects on salt crystal structure. Evaluations of these factors indicated that a repository in salt could be designed to provide the required degree of waste containment (Bradshaw and McClain, 1971).

The early work on salt was directed to determining its suitability for the isolation of high-level wastes in liquid form. In late 1961, the NAS-NRC Committee, having reviewed progress in waste solidification and the investigations of salt deposits, recommended that the program be reoriented to focus on the storage of solidified, packaged wastes in those formations (NAS-NRC, 1961).

Field experiments in a bedded salt formation were carried out at an inactive salt mine in Lyons, Kansas, as Project Salt Vault, beginning in the early 1960s. The experiments included the determination of in situ salt properties, demonstration of emplacement equipment, demonstration of salt stability under effects of heat and radiation from emplaced irradiated fuel elements and electric heaters, and, overall, "the feasibility and safety of handling highly radioactive materials in an underground environment" (Bradshaw and McClain, 1971).

On the basis of the successful experimental results from Project Salt Vault, it was proposed to establish the facility as a pilot demonstration repository to handle prospective solidified commercial high-level waste and a large volume of low-level plutonium-contaminated debris from a fire at the AEC weapons facility at Rocky Flats, Colorado (USNRC, 1976). Because of difficulties associated with locating and plugging old oil and gas wells and the possible interaction of a solution mining salt project in the vicinity of the Lyons mine, it was decided to cancel the Lyons project. However, geologic exploratory work continued with respect to bedded salt formations at other locations in Kansas and New Mexico.

While the focus of the NWTS Program is the disposal of wastes from commercial nuclear reactors, similar Federal efforts are under way to develop geologic repositories for defense radioactive wastes. The investigation of the New Mexico bedded salt deposits led to the selection of a site near Carlsbad, New Mexico, as the location for the Waste Isolation Pilot Plant (WIPP). This plant is planned by the Department of Energy to be used for the isolation of transuranic low-level and intermediate-level defense waste and to allow testing with high-level wastes (USERDA, 1977b). Defense radioactive wastes are those resulting from the reprocessing of fuel elements from reactors used in nuclear-powered ships and in other defense programs. Defense wastes include low-level, intermediate-level, and high-level radioactive wastes. High-level wastes from weapons programs are currently being stored in steel tanks at the Hanford site near Richland, Washington, and at the Savannah River Plant near Aiken, South Carolina. Defense high-level wastes from reprocessing spent fuel elements from military nuclear reactors are currently being stored at the Idaho National Engineering Laboratory near Idaho Falls, Idaho. Much of the develpment work leading to successful demonstration of geologic disposal of defense wastes as a long-term solution will be applicable to the disposal of wastes from the commercial nuclear power program.

In May 1976, the U.S. Energy Research and Development Administration issued an extensive evaluation of technical alternatives for the management of radioactive wastes from the commercial nuclear fuel cycle (USERDA, 1976). This assessment concluded that, of the alternatives examined for the management of high-level wastes, emplacement of solidified wastes in deep geologic formations is the option that has the highest probability of acceptable use in a reasonable time frame. A 1978 DOE report that reviewed nuclear waste management in the United States concluded that "there appears to be a substantive consensus and valid technical basis for the view that present plans and actions should rely on geological containment of wastes which can be achieved in a safe and environmentally acceptable manner" (USDOE, 1978). A similar conclusion was reached by the American Physical Society's Study Group on Nuclear Fuel Cycles and Waste Management, which stated in its recent report (APS, 1978) that "effective long-term isolation for spent fuel, high-level or transuranic waste can be achieved by geologic emplacement." The Federal Government is now pursuing on a priority basis a plan for demonstrating the suitability of using geologic media as a radioactive waste repository. The NWTS Program is an integral part of this Federal effort.

1.3 THE ASSESSMENT PROCESS FOR SELECTING CANDIDATE SITES

The technical studies planned to support decision-making on potential repository sites in bedded salt formations, involve two separate and complementary study programs. The first and most important of these is the assessment of the geologic formations under consideration, since formation stability and compatibility with long-term waste storage are fundamental to the integrity of the repository and to the health and safety of the public. A parallel study program involves the development of the non-geologic data and the analyses required to support the site selection process and environmental impact assessments of the proposed repository as required by the NEPA.

1.3.1 GEOLOGIC ASSESSMENT PROCESS

Geologic studies (Lomenick, 1976) will investigate the general characteristics and features of bedded salt formations to determine their fundamental suitability for use as radioactive waste repositories. The principal geologic requirement for a storage site in any rock formation is that the formation be able to contain any emplaced waste for the period of time necessary for the radioactive materials to decay to innocuous levels.

The geologic investigations will be conducted in three phases: regional, formation-wide reconnaissance; study-area investigations; and confirmatory location studies. First, regional, formation-wide reconnaissance studies will be undertaken of the rock types of interest to locate areas in which the rock unit being considered (1) has at least the minimum thickness necessary for a storage facility; (2) does not exceed the maximum depth for optimum emplacement; (3) is not within the area affected by regional tectonic and seismic activity beyond the allowable limits; (4) has favorable hydrologic characteristics; and (5) contains negligible quantities of valuable mineral resources (principally oil and gas but possibly other minerals). Areas in which these considerations are met may be designated as geologically suitable for study areas.

For the study areas identified, which may be about 1000 square miles in extent, evaluation will focus on such variables as geologic stratigraphy and structure, groundwater and surface-water hydrology, erosion, tectonics and seismicity, and mineral resources. Area studies will include the gathering and interpretation of existing pertinent data from such sources as well logs, cuttings and cores, and available geophysical surveys (e.g., seismic, magnetic, and gravity surveys). Where existing information is inadequate, additional coring, logging, and geophysical survey work may be necessary to define more completely the geology and hydrology of an area. Surficial geologic features will be described, especially the occurrence and depth of unconsolidated deposits. The present oil and gas fields within the area will be accurately defined, and the potential of the study area for future oil and gas or other mineral development ascertained from comprehensive evaluations, including the consideration of future economics. The fluid-bearing character of the rocks from the land surface to at least a few tens of meters below the rock unit will be studied since these properties are important in assessing the potential for radionuclide migration. Also, surface waters and groundwaters will be characterized according to such criteria as recharge and discharge, base flow, quality, and utility. In parallel with these area studies, in situ engineering studies of mechanical and thermal stress behavior and other properties of the rock type will be made. Area study results will be subject to review and consultation with appropriate authorities. If the results of the study investigations suggest that particular locations have potential as a repository site, then one or more candidate locations may be identified for further work, and a third phase of investigation will begin.

Confirmatory location studies will include a very detailed geologic and hydrologic evaluation of the localized area (of about 30 square miles) to determine the mineralogy, stratigraphy, and hydrology of the rock unit. Studies of the migration of water and ions in the particular rock unit may be made, if necessary, to extend the data acquired during the area studies. Results of the confirmatory location geologic studies will be significant inputs into the site identification process.

1.3.2 ENVIRONMENTAL ASSESSMENT PROCESS

The geologic studies are intended to locate geologic rock units with characteristics that will satisfy safety and engineering design requirements. While geologic suitability is a fundamental requirement, other conditions must also be satisfied. In particular, additional environmental assessments are necessary to meet the requirements of the NEPA.

The environmental studies will generally parallel the geologic evaluations, starting with broad regional, formation-wide studies and progressing to study areas and confirmatory locations. The environmental studies will be directed to the areas of geologic interest. As in the case of the geologic assessment program, the environmental studies are planned as phased efforts, with review of results and decision-making at the end of each phase regarding (1) whether to proceed and (2) the focus of further investigations.

The first step in the environmental assessment process has been the development of plans for the performance of each of the environmental studies, that is, of the geologic formation-wide region, of the study area(s), and of the confirmatory location(s). The plans have been circulated for review and comment to Federal and state agencies, to environmental experts, and to interested public groups.

The regional, formation-wide report will provide a general description of the environmental setting of the region, with emphasis on the land, water, and air characteristics and resources, on plant and animal life, and on man and his industries. As was done for the planning document, the results of the formation-wide environmental study will also be circulated for review and comment to Federal, state, and regional government authorities, to environmental experts, and to interested public groups in that region.

The topical coverage in study-area reports will be similar to that in the formation-wide reports, but the scope will be a smaller area in more detail. Data used will be drawn principally from existing information. Parameters addressed will cover the total environment, including geography, terrestrial and aquatic ecology, hydrology, meteorology, land and water resources and use, demography, and economic, historic, institutional, and societal factors. The environmental characterization of study areas may require some data in addition to those available in the existing literature. Study-area reports will be circulated for review and comment by Federal, state, and local organizations, environmental experts, and interested public groups.

Confirmatory location reports will characterize candidate locations in terms of those parameters that will be important to the assessment of potential repository impacts. Parameters addressed will be the same as those in the area reports, but the report will be much more location-specific. These studies will require the collection of field data in addition to those presently available. Location reports will also be circulated for review and comment, in the same way as the region and area reports. In brief, confirmatory location environmental reports are intended to provide significant input to the decision-making process for identifying potential repository sites.

1.3.3 REGULATORY ASSESSMENT PROCESS

The sequence of environmental and geologic evaluations will lead to the development of a report summarizing the site-selection process and the various formal environmental assessment documents. A draft environmental impact statement for each proposed repository site must be prepared by the DOE in accordance with 10 CFR 711 (USERDA, 1977c) for review and comment by Congress, by other Federal, state, and local agencies, and by the public. It is anticipated that the NRC will establish (in 10 CFR 60) requirements for a safety analysis report (SAR) and an environmental report (ER) (Bishop, 1977).

The review process to be followed by the NRC (USNRC, 1977) is expected to be sequential in nature and to include a preliminary site review, a review of repository development, and a review of repository operation. The process is expected to include public hearings.

1.4 REPOSITORY DESIGN, CONSTRUCTION, AND OPERATION

Conceptual repository design studies have been under way for some time, and a generic bedded salt conceptual study was completed during fiscal year 1979. Although the descriptions that follow are primarily for a facility to handle spent unreprocessed fuel, the same concepts would be applicable for vitrified and/or encapsulated wastes from reprocessing, if that option were to be selected. Design concepts are based on the assumption that these waste products will be received at a repository over a period of several decades and that they must be stored with complete integrity for an indefinite period.

The following descriptions are based on preliminary conceptual design efforts for repositories located within a bedded salt formation (Parsons, Brinckerhoff, Quade and Douglas, Inc., 1976; UCC-ND Engineering, 1977; Kaiser Engineers, 1978).

A typical repository is shown in Figure 1-5 and will consist of a large number of excavated chambers located deep underground. On the surface, specially designed facilities will receive rail and truck shipments of containerized waste and the containers will be prepared for descent through shafts to the underground workings. A repository could, if warranted by the mix of waste receipts, have two sets of receiving facilities and shafts: one set for wastes that require shielding and one set for wastes that can be handled directly. Other surface facilities will house administrative offices, maintenance and warehouse areas, utility systems, and equipment for raising to the surface and hauling away material mined out during the construction of the underground rooms. All surface structures, constituting the only visible evidence of the repository, will be confined within an area of approximately 240 acres.

The mined material will be brought to the surface and transferred to onsite storage piles by stacker/conveyor units. Access may be provided adjacent to the storage piles for possible rail or truck shipment off the site for permanent disposal of the mined material. A typical design will require the mining of about 20 million tons of salt, of which some 10 million tons will be used to refill the rooms containing wastes to 50% of the original density. The surface stored material must be managed to control effluents and erosion--for example (D'Appolonia, 1976), by means of a temporary cover over the embankment such as a movable plastic or shed cover, or leachate collection and appropriate disposal in local deep wells or to local surface waters after treatment. Excess mined material (i.e., about 10 million tons) will require disposal either at or off the site by appropriate means (e.g., D'Appolonia, 1976).

The spent fuel receiving building (Figure 1-5) will provide the facilities and equipment necessary to receive and handle canisters of spent fuel shipped to the facility in shielded shipping casks. It is expected that each shipping cask will contain several canisters of spent fuel. Typically, canisters would be about 16 feet long, and slightly larger than 1 foot in diameter. An option currently being investigated calls for shipment of base spent fuel to the repository, with encapsulation operations then performed at the site. Wastes from reprocessing, such as high-level wastes (HLW), cladding wastes (CW), and intermediate level wastes (ILW), should they be handled by the repository, will have been vitrified and/or encapsulated at the processing plant, prior to shipment to the repository. Typically, canisters for these wastes would be about 10 feet long, with diameters of about 1 foot for HLW and perhaps 2 feet for other waste types.

The spent fuel receiving building could accomodate modest quantities of low-level waste. In the event large volumes of this waste type were to be received, a separate low-level waste (LLW) building could provide the facilities and equipment necessary to receive and handle all low-level waste shipped to the facility via railroad or truck in closed cargo carriers. Each cargo carrier will carry palletized units approximately 4 by 6 by 6 feet. The unit will be either a steel box measuring 6 by 4 by 6 feet or an array of 55-gallon drums (2 drums x 3 drums) on two levels, for a total of 12 drums per pallet.

The underground facilities will be multiple--that is, separate shafts, areas, and storage works will be used for shielded and nonshielded wastes. Segregation of wastes will be maintained by devoting different levels to each category of waste. In the spent fuel shielded-waste areas, specially designed transporter vehicles will receive the waste container and its shielding unit as they complete the descent through the shaft and will convey the unit to its storage point in the mine. At this point, containerized waste will be lowered into a predrilled hole in the floor of the room, and a shielding plug will be inserted over it for radiation protection, as shown in Figure 1-6. Low-level waste containers that can be handled directly, without shielding, will be stacked on the floor in other rooms using standard warehousing practices. The total area of the underground (bedded salt) mine might include as much as 2000 acres (about 3 square miles). The depth of the mine will vary from one repository to another, depending on the type of rock and the thickness of the seams. Generally speaking, depths between approximately 800 and a few thousand feet are considered feasible.

The repository will be initially operated in a mode that allows retrievability of the waste; that is, all the rooms will be kept open and the waste so emplaced that it can be removed from the repository with relative ease if circumstances develop that would require this action. Conceptual design studies have looked at 5- and 25-year periods for removal of waste. Operation of the repository in the initial phase will be reviewed to determine agreement with the predictions on such parameters as the rock mechanics and stability of the rock when subjected to actual use as a repository. It is expected that after operation for a number of years, during which the emplaced wastes will be maintained in a readily retrievable configuration, the provision for ready retrievability will be eliminated and the repository will be expanded to full-scale operation. When the initial phase has been satisfactorily completed, operations performed to maintain retrievability will cease and storage rooms will be backfilled with compatible rock material as they become filled with the radioactive wastes. When the entire repository has been filled, the surface facilities will be decommissioned and dismantled, and all shafts and other accesses to the mine will be plugged and sealed. Active surveillance will be maintained for an additional period, after which monitoring will be continued as required to confirm that waste isolation is indeed maintained.

Title to the land over the excavations (see Figure 1-7) is expected to be acquired by the Department of Energy. This will ensure the safety of the repository by preventing drilling, mining, or other activities that could conceivably breach the storage formation. However, selective surface rights for this area might be leased for such purposes as grazing or farming. For bedded salt sites, additional restrictions will be established on subterranean activities in an area extending outward approximately 2 miles around the excavation. It is planned that, where possible, these restrictions will be defined through the acquisition of perpetual subterranean rights as opposed to fee simple title, thus allowing unrestricted use of the land surface. A typical repository might operate over a period of about 20 to 30 years and might employ about 500 persons during the first 5 years of repository construction and operation, about 1100 persons during the next 20 years, and about 500 persons during the last 5 years. These figures are approximate and subject to revision as the design work proceeds to address specific sites.

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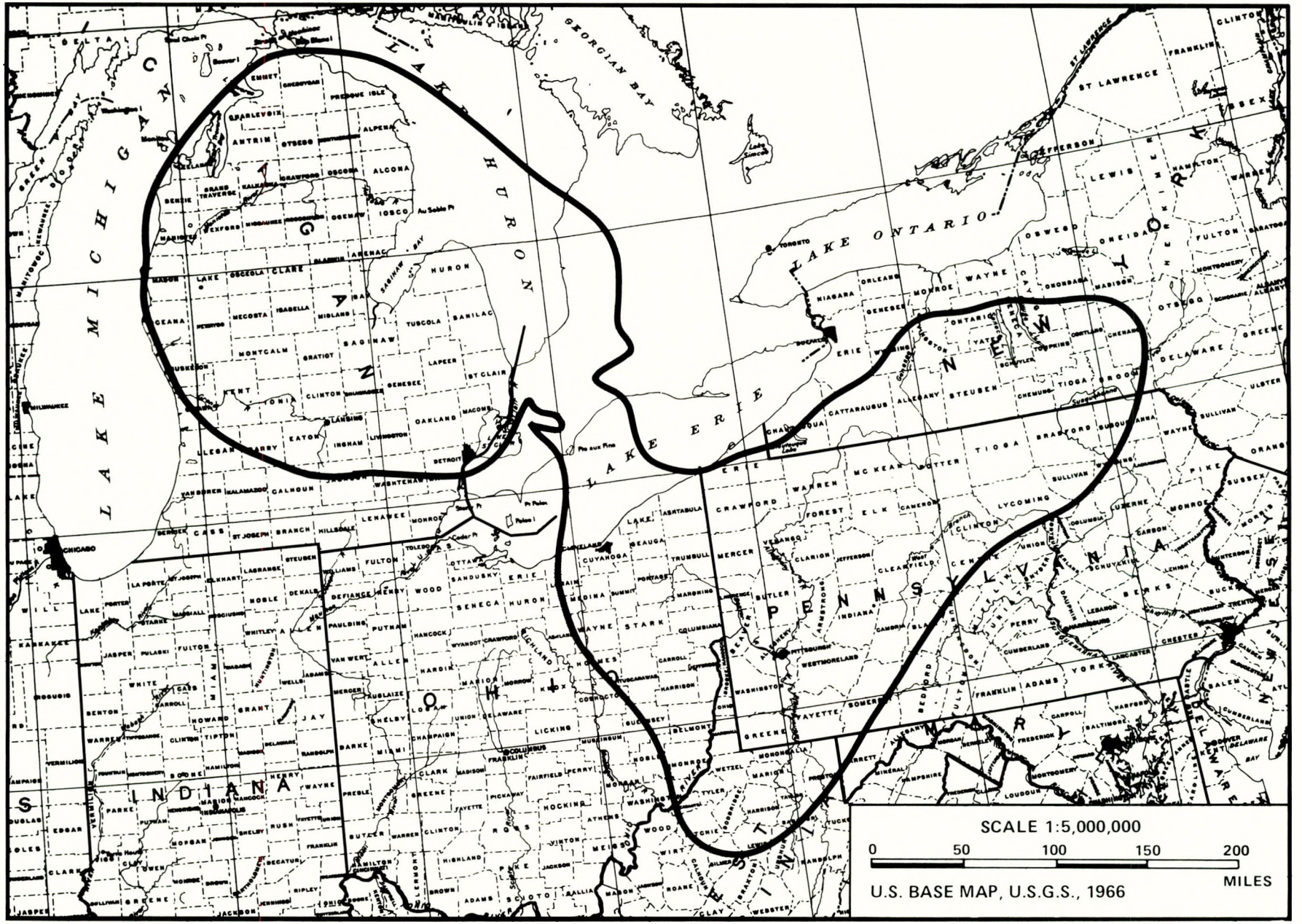
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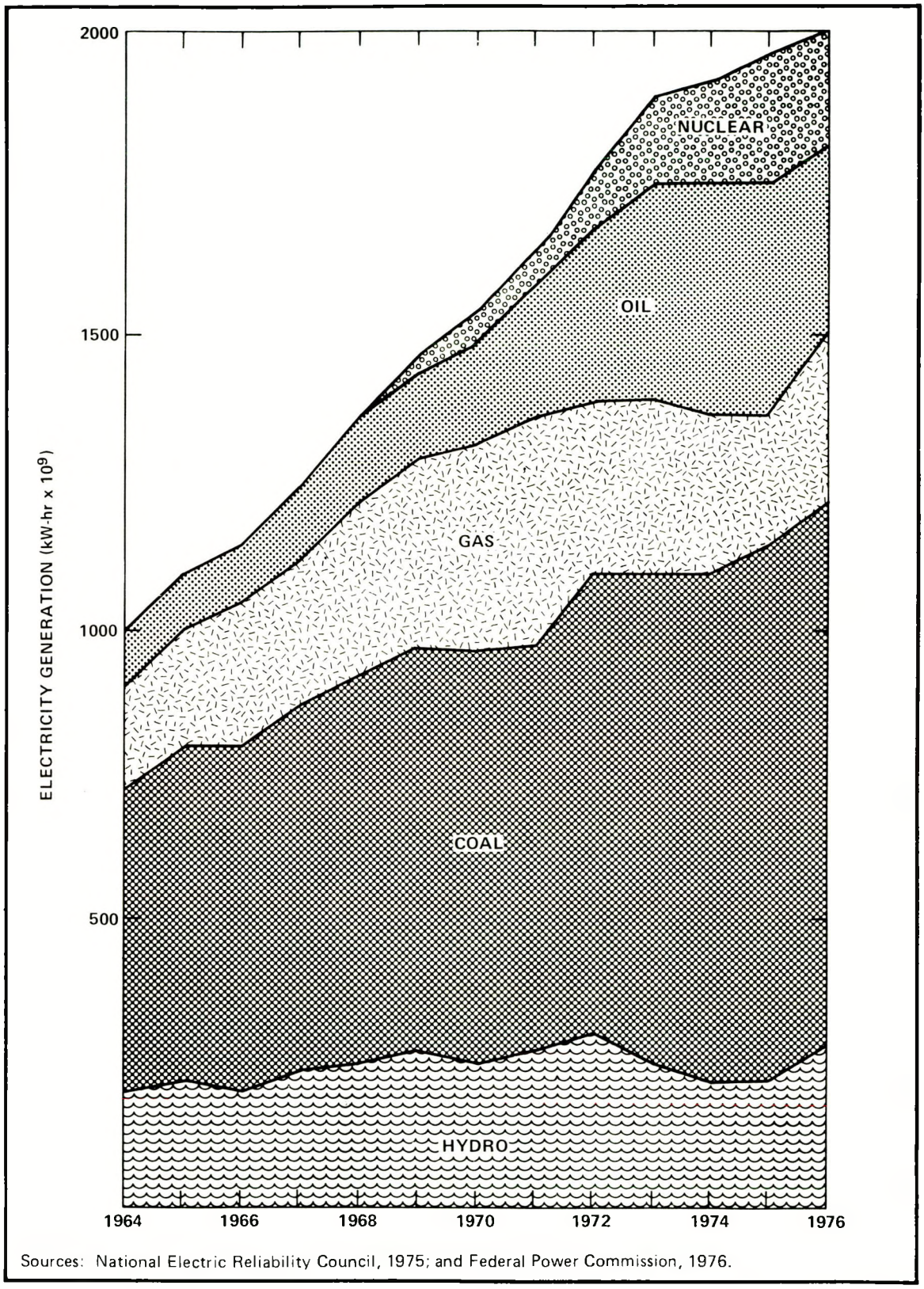
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OWI/ESP-55

Figure 1-1

Boundaries of the Regional Environmental Study Area

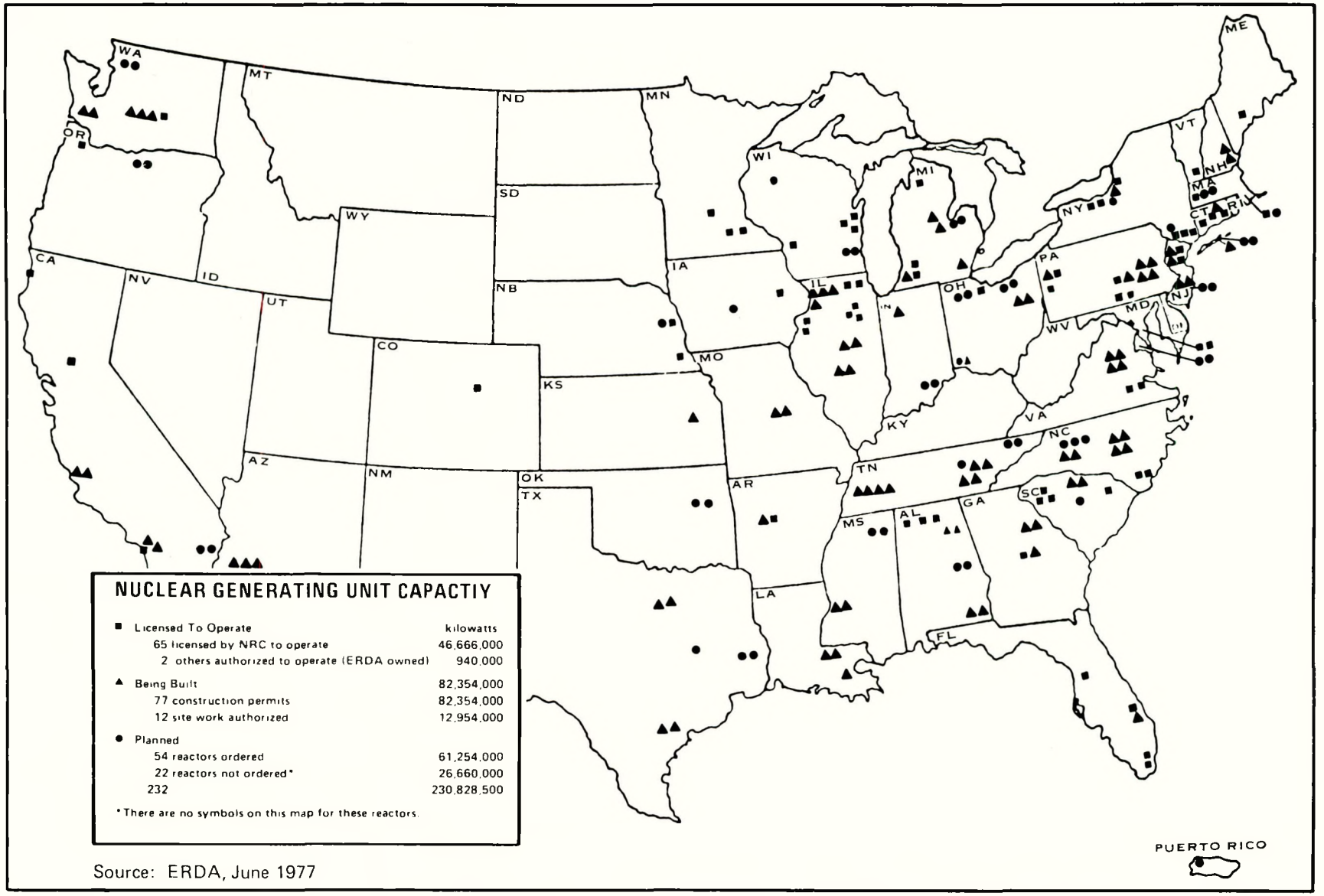


Sources: National Electric Reliability Council, 1975; and Federal Power Commission, 1976.

OWI/ESP-135

Figure 1-2

Electric Power Generation by Principal Sources in the Contiguous United States



OWI/ESP-124

Figure 1-3

Nuclear Power Reactors in the United States

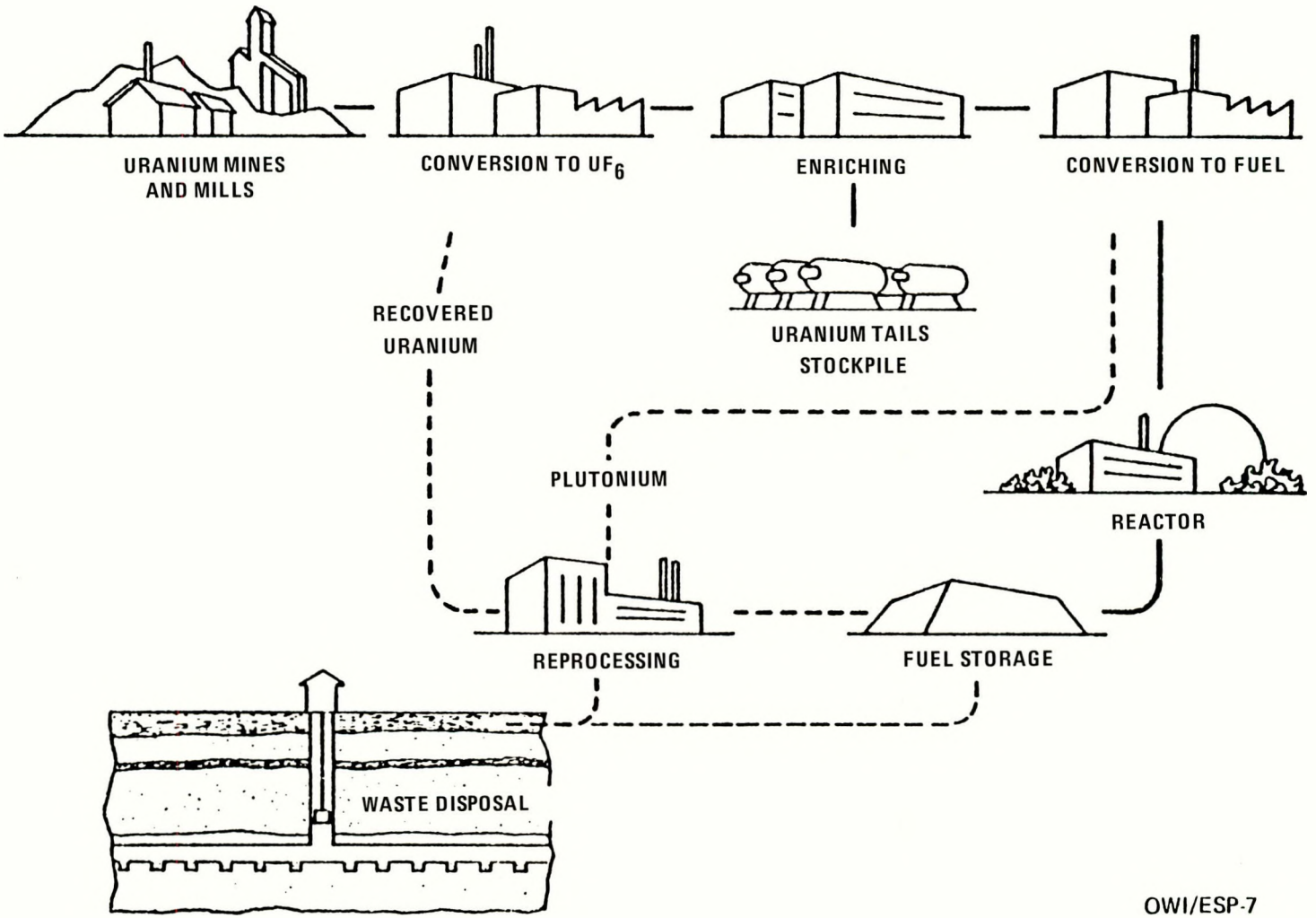


Figure 1-4

The Light-Water-Reactor Nuclear Fuel Cycle

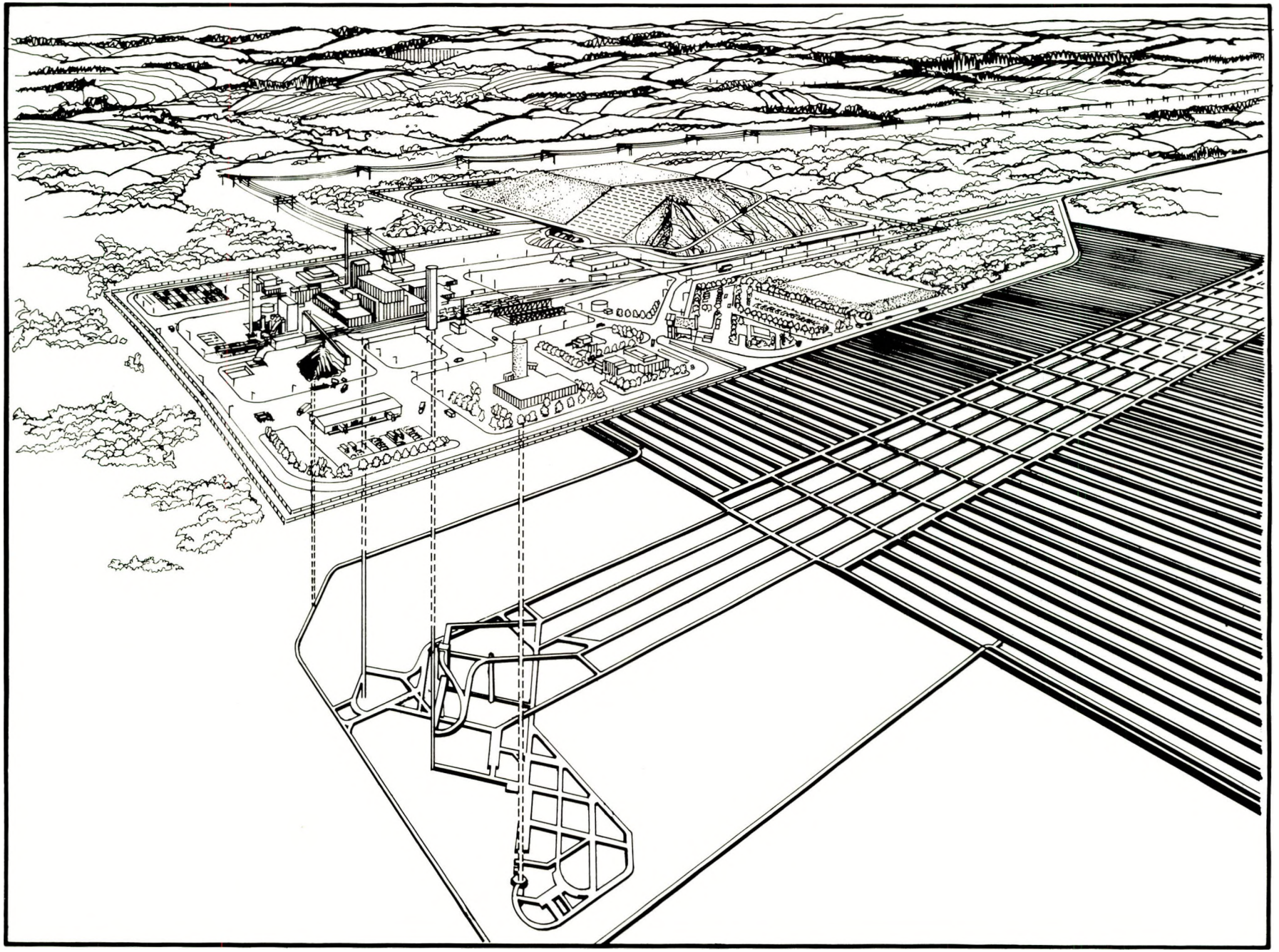


Figure 1-5

Artist's Conception of a Geologic Repository

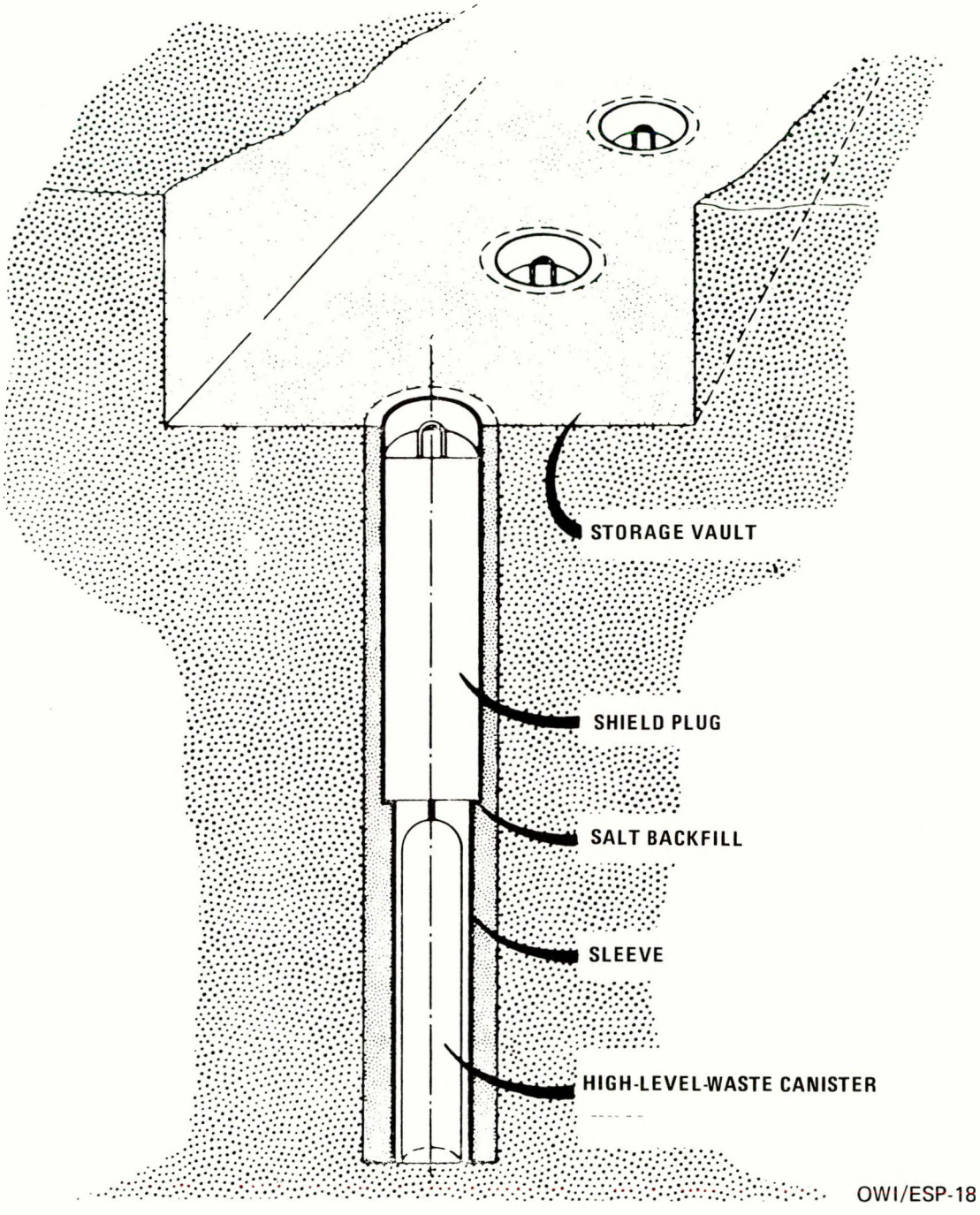


Figure 1-6

Emplacement of Waste Canister in Salt

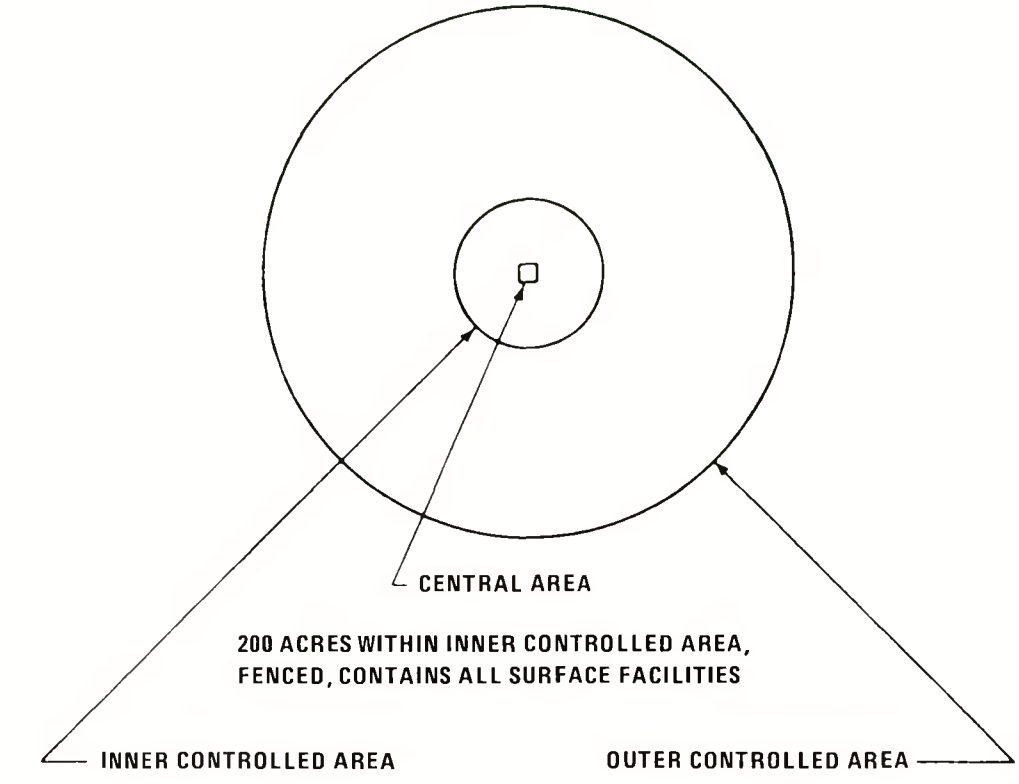


Figure 1-7

Idealized Controlled Zones for Waste Repository in Bedded Salt

2.0 GEOSPHERE

The geologic descriptions developed here and in the more detailed environmental reports that will follow on specific areas and candidate locations provide a general geologic characterization of a region having potential for a repository site. The characterization is intended to focus on those geologic considerations that are of fundamental importance to an assessment of the environmental impact of a repository. These considerations include the following:

- The isolation capability of the rock unit.
- Potential routes of radioactive material transport from repository to ecosystems and people.
- The influence of facility design and operation on rock unit stability.

This regional geologic characterization is drawn from numerous detailed geologic reports and studies, including a report by Stone & Webster (1978). This summarization attempts to condense a large amount of technical geologic information and evaluation and present it in a form more understandable to those who are not specialists in geotechnical information. Explanations of the importance of the various geologic parameters to the development of a repository are included to aid the reader in understanding the significance of the geologic features described. Brief definitions and explanations of technical terms are also given on occasion.

Environmental impact assessments are concerned with both the surface and the subsurface facilities of a repository. This necessitates considering the entire geologic column, from rock units beneath the storage salt unit, through overlying rock units, to surficial deposits. Special attention is given to the storage salt unit. Furthermore, to support assessments of long-term geologic stability, geologic characterizations cover an extensive time period. The historical aspects of some of the geologic parameters are described to provide a better understanding of past geologic forces and events influencing the region, as well as to provide a basis for projections of geologic processes in the future.

Six parameters have been selected to characterize generally the geology of the Salina Region:

- Physiography and topography
- Structural geology
- Stratigraphy
- Tectonic history
- Seismology
- Energy and mineral resources.

These parameters are interrelated and build on each other in the following way: Beginning with physiography and topography, the Salina Region is located geographically and with respect to surface features. Because mountain ranges, hills, and valleys are geologic features people are most familiar with, this parameter begins the report. Since the repository will be a facility constructed in bedrock many hundreds of feet beneath the surface, descriptions of the subsurface geology are necessary. To assist the reader in understanding this less familiar part of geology, structural geology is

next described. While topography and physiography established surface forms, structural geology describes forms and features beneath them. This discipline constructs a structural framework--an organization for the bedrock. Under stratigraphy, the bedrock "contained" by this structural framework is described, including rock types and the relationships among rock units. Both structural geology and stratigraphy are instrumental in reconstructing the tectonic history of the region. The tectonic history section of this report focuses on the major tectonic events (crustal movements) that have formed the structures, bedrock units, and landforms of the region as well as on the age of those events. Historical descriptions of the origin of rock types and life forms are not considered relevant to a repository and therefore are not presented in this report. Such matters are extensively described by other authors. Tectonic history is relevant to a repository since it is concerned primarily with the stability of the region in ancient times. To provide a broad picture of stability through time, the stability of the region in more recent history is depicted by descriptions of the earthquake record under seismology. Much like the first parameter of this report, the last one, energy and mineral resources, is close to the everyday experience of man. The economic value of the bedrock in the region is discussed in this final parameter.

A geologic concept most people rarely deal with is the dimension of geologic time. This report is concerned primarily with rocks and structures that evolved over the past 570 million years--a staggering length of time to grasp. Discussions of geologic parameters within this report often refer to time or names of time periods. In some cases time periods are used as an organizational tool in presenting information. A geologic time scale is provided in Section 2.4 (see Figure 2-9) to assist the reader in dealing with time and the names of time periods.

2.1 PHYSIOGRAPHY AND TOPOGRAPHY

The physical features of the land surface are of interest because surface features and variations in relief influence both short-term and long-term erosion potential. The terrain can sometimes provide an indication of the complexity of subsurface geology. Surface-water drainage patterns and replenishment zones for underground aquifers are determined by surface features. The terrain is also significant to the overall view of a drainage basin, influencing its water and wind systems, both of which are of interest in locating a repository.

2.1.1 PHYSIOGRAPHIC PROVINCES

The United States has been divided into 11 major divisions, each of which is divided into natural regions called physiographic provinces. Each province has distinctive characteristics--particular structural frameworks resulting in particular landforms. For the most part they also have distinctive climate, vegetation, soils, water, and other resources. The Salina Region straddles two physiographic provinces--the Central Lowland to the west and the Appalachian Plateaus to the east (Figure 2-1).

2.1.1.1 The Central Lowland

The largest of all the physiographic provinces is the Central Lowland. At its eastern edge, where it joins the Appalachian Plateaus, the elevation is about 1000 feet. The elevation decreases westward to about 500 feet along the Mississippi River, a distance of about 400 miles. The Central Lowland is essentially a vast plain making up the agricultural heart of the continent, and as such it shows little relief.

Most of this province was glaciated, and the sections of the province are distinguished chiefly on the basis of differences in their glacial histories. The Salina Region lies within the Great Lakes section of the Central Lowland physiographic province (Figure 2-1).

This section is essentially a plain of glacial till (unsorted deposits of rock and soil debris laid down directly by glaciers) of Wisconsin age.

2.1.1.2 The Appalachian Plateaus

The Appalachian Plateaus physiographic province has a typical plateau structure, with nearly horizontal formations sloping generally to the west. However, the formations are so elevated relative to adjacent provinces and so dissected by winding stream valleys that there is considerable local relief. Elevations range from about 1000 feet along the western edge in central Ohio to just over 3000 feet at the Allegheny Front just east of the Salina Region. The eastern boundary of the Salina Region runs along the Allegheny Front, which is a southeast-facing escarpment (cliff) that divides the Appalachian Plateaus from the adjacent Valley and Ridge province. The Salina Region also crosses the western boundary of the Appalachian Plateaus, which is an escarpment of Mississippian and Pennsylvanian age that has been dissected by erosion.

2.1.2 LANDFORMS AND RELIEF

About half of the Salina Region is in the Great Lakes section of the Central Lowland province. Lakes dominate the section, which is made up of the Great Lakes (excluding Lake Superior) and their surrounding basins. Prominent end moraines, outwash plains, lakes, swamps, eskers (long, narrow ridges or mounds of sand, gravel, or stones deposited by a stream flowing on, within, or beneath a stagnant glacier), and drumlins (oval hills of glacial drift) all attest to the prominent effects of glaciation in this section. Till-plain terrain is rare, but rolling round moraines are found between the end moraines. The lake basins have various origins: some are glacially modified preglacial lowlands, some are the result of irregular deposition of glacial material, and others are kettle lakes (depressions in the ground formed by the melting of a block of ice that was buried in glacial materials).

There are two bedrock features that have a significant effect on the regional terrain: the Niagara Cuesta (a hill or ridge with a steep face on one side and a gentle slope on the other) and the Marshall Cuesta. The Niagara Cuesta extends in a band westward through New York and forms a half circle around Lakes Huron and Michigan. It is made of resistant limestone that forms escarpments and gorges wherever it is cut by rivers or fronts on a lake. The Marshall Cuesta of the lower peninsula of Michigan is composed of sandstone. It is circular in shape and continuous except where it is cut by rivers. This cuesta is not as prominent as the Niagara.

The Appalachian Plateaus province is topographically different from the Great Lakes section. It is composed of shallow river valleys and broad ridges, with escarpments that provide abrupt changes in elevation. The ridges are mostly the result of gently sloping anticlines (arches of stratified rock) and synclines (troughs of stratified rock) that have been deeply eroded. The western boundary of the province in central Ohio is locally referred to as the "Knob Belt." This is because of the scattered buttes (isolated hills with precipitously steep sides) and promontories that characterize the area.

The average relief in the entire Salina Region is about 400 feet. Elevations in the Appalachian Plateaus range from 1000 to 2000 feet, while the Great Lakes section of the Central Lowland is about 1000 feet above sea level (Figure 2-2).

2.2 STRUCTURE

Structural geology describes the framework beneath the earth's surface in which rock strata are contained. Rock structures also provide the broad geometry of rock units and a record of major regional rock deformations. This record contributes to the interpretation of the processes responsible for the origin of the structures and ultimately to the reconstruction of the tectonic history of the region and to a determination of its general stability. Descriptions of regional structures and regional patterns of minor structures supply a background to which later, more detailed characterizations and environmental impact assessments of smaller areas can be linked. These descriptions are necessary for eventual assessments of storage rock unit isolation capability, potential pathways of radionuclide migration, and existing or potential groundwater systems.

The Salina Region lies within two major tectonic divisions: the Central Stable Region in the west and the orogenic (mountain-building) belts of the Atlantic margin in the east. The Central Stable Region has a basement of Precambrian rocks and is an extension of the Canadian shield, the tectonic division bounding the Salina Region to the north. Together these two divisions compose the great stable interior of the North American continent. To the east the orogenic belts of the Atlantic margin contain mountainous areas made up of rocks deposited and deformed to various degrees during the Paleozoic Era (Eardley, 1962).

The major structural features of the Salina Region are few, uncomplicated, and broad in extent. These major structures are the Michigan and Appalachian basins (see Figure 2-3). During the Paleozoic Period, 225 to 570 million years before the present, these basins intermittently subsided. Subsidence stopped at the end of the period and has not resumed. Immediately adjacent to the Salina Region and separating these two basins of subsidence are other major structures such as the Cincinnati, Findlay, and Algonquin arches (Eardley, 1962).

During the Paleozoic Era these arches were areas of stability or gentle uplift as opposed to the subsidence, or depressional, areas of the Michigan and Appalachian basins. All these structures are ancient, and the movements within the earth's crust that caused them ceased in the late Paleozoic to early Mesozoic time (approximately 190 million years ago). Other major structures bordering the Salina Region include the Kankakee arch and structures made of Precambrian rocks, such as the Wisconsin dome, the Canadian shield, the Adirondack uplift, and what are referred to here as the East Coast Precambrian outcrops. These East Coast Precambrian outcrops are in part made up of the Blue Ridge Mountains, New Jersey Highlands, Hudson Highlands, Berkshire Highlands, and Green Mountains, which immediately border the Appalachian basin on the east.

Minor structures such as folds and faults within the Michigan and Appalachian basins are relatively few and simple within the Salina Region. In the eastern portion, these minor structures are more numerous and complex but will not be shown or described in this report. Eardley (1962), Rogers (1970), and many other sources may be referred to for detailed descriptions.

2.2.1 MICHIGAN BASIN

The Michigan basin is a major sedimentary basin that embraces most of the southern peninsula of Michigan as well as parts of Wisconsin, Illinois, Indiana, Ohio, and Ontario. It is separated from the Appalachian basin to the east by the Algonquin arch in Ontario and the Findlay arch in northern Ohio (Figure 2-3). The strata dip gently inward toward the center of the basin from the adjacent arches and the Canadian shield at a rate of

25 to 50 feet per mile (equal to 0.25 to 0.50 degree) and are only locally folded or faulted. Subsidence of the Michigan basin was in progress during the latest Precambrian (more than 570 million years ago) and continued throughout the ensuing Paleozoic Era. The basin interior continued to subside relative to its margins, with the accumulation of a thick sequence of sediments. A long period of continuous subsidence took place in the Late Silurian, during which a thick sequence of evaporites was deposited. Evaporites are rocks composed of minerals that have been precipitated from solution--for instance, in a lake or body of seawater. Examples of evaporites are rock salt, gypsum, and anhydrite. The Michigan basin has had a history of relative stability since the end of the Paleozoic Era and has been little affected by mountain-building processes. The Salina salts and younger strata appear to be virtually free of significant deformation except near the Howell anticline and various salt-cored anticlines discussed below (Johnson and Gonzales, 1976).

A number of presalt structures have been discussed by Stone & Webster (1978). One such structure, a southwest-dipping monocline, is located in the southeast rim of the Michigan basin and is referred to as the Lucas-Monroe monocline. It appears to be the extension of the Bowling Green fault of Ohio. The term "monocline" describes a structure of rock strata "tilted" in one direction. A number of similar linear structures that have been mapped on the Ordovician surface may be related to the Taconic orogenic cycle (Stone & Webster, 1978).

Minor, gentle structural deformation is characteristic of the post-salt time period. Within the central basin numerous northwest-southeast anticlines are reported. Two types of anticline can be distinguished: those that have resulted from compression and the so-called salt-cored anticlines. The salt-cored anticlines resulted from either (1) the draping of strata over elongate remnants of Salina salt that remained after the adjacent salt was dissolved by groundwater, (2) creep of salt in response to lateral and vertical tectonic stresses, or (3) tensional boudinage (pillowlike segments) resulting from sagging of the basin. The remaining folds are almost flat and widely spaced. These folds are not ascribed to major tectonism; they are considered to be a consequence of subsidence. The Howell anticline of Livingston County is the most significant structural feature affecting Paleozoic and younger rocks in the Michigan basin. It is the largest of several broad parallel folds that are a part of a much larger uplifted block, referred to as the Washtenaw anticlinorium. Activity along the anticline was in progress during the Early Mississippian (Stone & Webster, 1978). Two additional major anticlines within the central basin are the West Branch anticline of Ogemaw County and the Freedom anticline of Jackson County.

Radial rim folds, which occur around the perimeter of the Michigan basin, plunge inward toward the basin's center. Stone & Webster (1978) identifies rim folds in the following counties:

Charlevoix	Presque Isle
Emmet	Muskegon
Cheboygan	Allegan
Alpena	Wayne
Sanilac	Tuscola
Lapeer	Saginaw

These radial folds did not develop in response to tectonic activity but are a consequence of the gentle subsidence of the basin (Stone & Webster, 1978).

There are few major faults within the confines of the Michigan basin. The most significant fault is on the west flank of the Howell anticline and is referred to as the Howell fault.

Stone & Webster (1978) lists 10 major oil fields in Michigan that are believed to be fault-controlled, including the following:

Oil Field	County	Oil Field	County
Albion-Scipio	Calhoun and Hillsdale	Howell	Livingston
Hanover	Jackson	Pinconning	Bay
Freedom	Washtenaw	Deep River	Arenac
Deerfield	Monroe	North Adams	Arenac
Northville	Wayne	Skeels	Galdwin

Johnson and Gonzales (1976) conclude that more regional and local studies are needed to identify fault-free areas within the basin.

Dissolution breccias (rocks composed of cemented rock fragments) in the Salina salt beds occur along the northern margin of the Michigan basin (Landes et al., 1945; Stone & Webster, 1978). These breccias developed as a consequence of evaporite dissolution and collapse since the Silurian. Johnson (1974) reports similar post-Silurian collapse breccias from Monroe County on the southern rim of the basin.

Structural readjustments have continued in the Michigan basin since the Pleistocene with the final retreat of the great glacial ice sheets. Removal of the weight of the ice has prompted a continuous process of glacial (elastic) rebound in the Michigan basin.

2.2.2 APPALACHIAN BASIN

The Appalachian basin is the major structural feature dominating the eastern part of the Salina Region. As defined by Colton (1970), it is an extensive, oblong basin of sediments geographically situated approximately parallel to the Atlantic coastline. It extends from the Canadian provinces of Quebec and Ontario southwestward to central Alabama (Figure 2-3). The basin's western boundary is defined by the crests of the Findlay and Cincinnati arches. Its eastern boundary coincides with the west flank of the Blue Ridge in the south and with the west edge of the New England uplands in the north (see Figure 2-1 for the locations of these physiographic features). Essentially the Appalachian basin, which is a structural feature beneath the earth's surface, underlies much of the Allegheny Plateau and the Valley and Ridge physiographic provinces (Figure 2-1). If one excludes parts of the basin in southern Canada and north and east of the Adirondack Mountains in New York, the Appalachian basin is about 1030 miles long, with a maximum width of about 330 miles (Colton, 1970).

The Appalachian basin as described above is a downwarped portion of the earth's crust in which a great thickness of sediment accumulated during the Paleozoic Era. The greatest thickness of rocks preserved in the basin is between 35,000 and 40,000 feet and occurs in east-central Pennsylvania (Colton, 1970). This wedge of sediments thins toward the margins of the basin in central Ohio and southern New York. The sediment filling the basin is described in Section 2.3, Stratigraphy.

Rocks on the northern flank of the Appalachian basin in southern New York dip nearly due south off the Precambrian rocks to the north. On the west flank of the basin, rocks dip

southeast to due east in Ohio off the broad Cincinnati and Findlay arches. Superimposed on this generally even dip are the folds described later in this section (Rogers, 1970).

The eastern lobe of the Salina Region overlies only the north and west-central portion of the Appalachian basin. Portions of southern New York, western Pennsylvania, eastern Ohio, and northernmost West Virginia lie within this part of the Appalachian basin. This eastern part of the Salina Region roughly coincides with the Allegheny Plateau and the easternmost part of the Central Lowland physiographic provinces.

Within this structural basin the major activities were subsidence, uplift, compression, and tension. These activities caused the deformations of the rock strata seen today as various structural features--the major one being the basin itself and many minor structures (e.g., folds and faults) within the basin.

The subsidence and deposition of sediments began in late Precambrian time (more than 570 million years ago) and continued intermittently until late Paleozoic or early Mesozoic time (about 225 million years ago). Subsidence was greatest in the eastern part of the basin. This accounts for the deepest portion of the basin and thickest unit of rocks in the east as well as the asymmetry of the basin (Figure 2-3).

Since the Appalachian basin is the only major structure of the eastern part of the Salina Region, a general summary of minor structures is also provided. More detailed descriptions of these minor structures are available in the literature (Rogers, 1970; Stone & Webster, 1978).

According to Colton (1970), compression stresses from the east and southeast resulted in severely deformed rocks in the east and progressively less to the north and west. This is directly reflected by the type, complexity, and frequency of structures. The intensely deformed eastern portion of the basin with complex structures is outside the Salina Region and will not be further described here (see Colton (1970) and Rogers (1970) for detailed regional descriptions of this area). The less intensely deformed western portion of the Appalachian basin approximately coincides with the Salina Region. The minor structures of this portion of the basin are characterized by Colton (1970) as being gentle surface folds (Figure 2-1). These folds are steeper, more closely spaced, and more commonly parallel to the regional trend toward the eastern part of the Salina Region. Near this eastern area some folds are asymmetrical. According to Rogers (1970), the crests of these folds are generally about 6 to 12 miles apart and have a structural relief (crest-to-trough height) that ranges from 500 feet or less to as much as 2500 feet for the larger folds (anticlines) in the east. Westward the folds become flatter, more widely spaced, and more varied in trend (Colton, 1970). These folds form a broad arcuate pattern from southwestern Pennsylvania to southern New York (Figure 2-3). This regional pattern reflects the change in the direction (strike) of the axes of these folds from north-northeast in Pennsylvania to almost due east in the Appalachian Plateau of southeastern New York (Rogers, 1970).

The westernmost part of the basin is characterized by very broad gentle arches. Two of these are major structures of broad extent bordering the Appalachian basin. They are the Findlay and Cincinnati arches south of the Salina Region in western Ohio.

In addition to the folds just described, a few faults also occur in the western part of the Appalachian basin within the Salina Region. This part of the region is characterized by a lack of known thrust faults intersecting the surface; thrust faults, together with other types of faulting, are more common in the eastern part of the basin outside the Salina Region (Colton, 1970). Generally faults are rare at the surface, but high-angle

reverse faults are found beneath the surface on the crests of some folds (Rogers, 1970). Folds are less commonly faulted to the west (Colton, 1970). Strike-slip faults offset the folds and can be as much as 50 miles long (Stone & Webster, 1978). Finally, low-angle thrust faults described later are not often exposed at the surface but lie within weak rock strata such as salt or shale beneath the surface.

Many of the folds and faults described above were formed by large blocks of Devonian, Mississippian, and Pennsylvanian strata slipping or shearing within underlying weak layers of rock. These slip zones are often along the Salina salt beds of the Silurian and along shales beneath Silurian strata. These slip zones are in fact the low-angle thrust faults mentioned earlier (Stone & Webster, 1978). The slipping of rock units was due to compression forces from the uplift and deformation in the east during the Appalachian orogeny. This deformational phenomenon, or "decollement," explains the folds in the basin as simply buckles formed within or at the leading edge of a block of strata slipping to the west and northwest over salt beds. In fact the limit of more than very mild folding corresponds well to the limit of relatively thick salt. Strike-slip faults offset the folds and are found within or at the margins of the large slip blocks. They were formed as the slipping blocks tore loose from adjacent rock (Colton, 1970).

In the northern part of the Appalachian basin there is only one seismically active fault system. This system, called the Clarendon-Linden fault, is a series of parallel normal faults with some right lateral movement in western New York and is not a part of the faulting associated with the folds in the basin. These faults are not all expressed as surface ruptures but primarily as surface flexures that become faults beneath the surface. This fault system is interpreted as being a reactivated Lower to Middle Ordovician (about 500 million years old) fault and cuts the basement rocks (Stone & Webster, 1978).

Although there were many periods of tectonic activity during the Paleozoic (see Section 2.4, Tectonic History), the event that most profoundly altered the Appalachian basin was the Appalachian orogeny in late Paleozoic and early Mesozoic time (approximately 300 to 225 million years ago). As mentioned earlier, compressional forces are responsible for the system of parallel folds and most of the faulting. This deformation is associated with the uplift of rocks forming the present-day Appalachian Mountains. Major deformation began about Early Permian time and may have extended at least into Late Triassic time. Tensional forces dominated during the later part of this time, causing downfaulting along the east edge of the Appalachian basin, outside the Salina Region. As mentioned in Section 2.4, this tensional stress led to the second breakup of the North American and European continents. The Appalachian orogeny was the last major tectonic event in the Appalachian basin and was followed by a period of nearly 190 million years of stability. Only episodes of relatively mild uplift or tilting and subsequent erosional periods characterize this stable time (Colton, 1970).

2.3 STRATIGRAPHY

Stratigraphy is the branch of geologic science concerned with the description, organization, and classification of stratified rocks. By this definition, it establishes the regional geologic framework. Major lithologies (rock types) and their spatial relationships are fundamental to descriptions and assessments of the following:

- Storage rock unit isolation capability
- Potential pathways of radionuclide migration

- Potential for subsidence following the mining and backfilling of the storage cavity
- Composition and environmental effects of mined material
- Long-term rates of erosion and denudation
- Existing and potential groundwater systems
- Rock structures
- Deformational events and their ages (tectonic history).

For the purposes of this report, the stratigraphic column of the Salina Region is described by system from oldest to youngest. Systems are major units of rock formed during a geologic time period. Rock types, age, and thickness of each system are summarized by representative geologic columns (Figure 2-4). The subsurface extent of rock units and the relationships of various rock units to each other are shown on representative cross sections (Figures 2-5 and 2-6). The generalized outcrop pattern is shown on the bedrock geology map (Figure 2-7).

For this regional report it is most convenient to discuss each system by structural basin and by state when more detail is necessary. The Salina Region is essentially entirely contained within major portions of both the Appalachian basin in the east and the Michigan basin in the west. This region comprises portions of the states of New York, Pennsylvania, West Virginia, and Ohio in the Appalachian basin and only Michigan in the Michigan basin (Figure 2-3). As shown in Figure 2-8, salts of both Silurian and Devonian age are found in the Salina Region (ERDA, 1976; Stone & Webster, 1978).

Although separate structural features, both basins contain similar thick sequences of sedimentary rocks of predominantly Paleozoic age (approximately 570 to 225 million years old) overlying Precambrian crystalline basement rocks and capped by very young Pleistocene and Recent deposits.

The stratified rocks occupying the Appalachian basin constitute a wedge-shaped mass that is thickest along the eastern margin of the basin and thinnest along the western margin. The maximum thickness of stratified rocks preserved in any one part of the basin today is between 35,000 and 40,000 feet. The sedimentary rocks are predominantly Paleozoic in age, whereas the volcanic rocks are predominantly Late Precambrian in age. According to Colton (1970), these rocks are 41% limestone and dolomite, 35% shale, 23% sandstone, and 0.4% evaporites (halite and anhydrite).

The Michigan basin contains sedimentary rocks largely of Paleozoic age. The rocks are thickest in the central part of the southern peninsula of Michigan, the center of the basin, where the sedimentary rocks are more than 14,000 feet thick. These rocks are 47% carbonate, 23% sandstone, 18% shale, and 12% evaporite (halite and anhydrite). About 80% of the rocks were deposited during the early part of the Paleozoic Era (Cambrian through Silurian); the remaining 20% were deposited in the later part of the Paleozoic (Devonian through Permian).

To introduce the stratigraphy of the Salina Region and to aid in understanding the sequence of rock types making up both basins, a lithologic summary taken from Stone & Webster (1978) is provided below; it organizes the sedimentary rocks into five groups

or sequences of similar rock types that were deposited in similar environments. Three groups are predominantly clastic, and two are mostly carbonate or carbonate-evaporitic.

The basal clastic sequence (stage I) of the Middle to Late Cambrian represents the oldest Paleozoic rocks lying directly over the profound angular unconformity that developed on the Precambrian basement. The initial beds consist of arkoses and well-sorted sandstones. The subsequent deposits of the sequence contain mostly quartz sandstone and calcareous sandstone with interbedded sandy carbonates. In the Appalachian basin the basal clastic sequence is wedge-shaped and about 6000 feet thick near the Allegheny front. In the Michigan basin area, this sequence is between 2000 and 3000 feet thick.

The lower carbonate sequence (stage II) of the upper Late Cambrian to Middle Ordovician conformably overlies the basal clastic sequence. Its lower part is dominated by dolostone, including sandy dolostone and interbeds of dolomitic and quartzose sandstone. The upper part is dominated by limestone with argillaceous limestone grading into calcareous shale. Both parts are separted by a major unconformity. The thickness of this sequence reaches 6000 feet along the Allegheny front in the Appalachian basin; it exceeds 1000 feet in the Michigan basin and is slightly less than 1000 feet thick in the arch area between the basins.

The intermediate clastic sequence (stage III) is of Middle Ordovician to Early Silurian age. It conformably overlies the older carbonate sequence. Compared with other sequences, it exhibits the lowest degree of lateral uniformity. In the Michigan basin, it includes carbonates in addition to fine clastic deposits. In the Appalachian basin, it is almost entirely clastic, with pronounced wedge-shaped thickness of this sequence reaches 6000 feet along the Allegheny front in the Appalachian basin; it exceeds 1000 feet in the Michigan basin and is slightly less than 1000 feet thick in the arch area between the basins.

The stratigraphic and depositional character of the upper carbonate and evaporite sequence (stage IV) is unique in comparison with the remainder of the Paleozoic system, because of the presence of the Salina Group with extraordinarily thick salt deposits. The upper carbonate and evaporite sequence consists of three parts, with considerable departure from vertical and lateral uniformity. The contact with the underlying clastic sequence is conformable.

The lower part is represented in the Michigan basin by limestone and dolostone with limited shale members. In the Appalachian basin these carbonates are interfingered with shale and siltstone grading into sandstone and with a persistent dolostone bed at the top.

The middle part (the Salina Group), in both the Michigan and Appalachian basins, is essentially evaporitic, containing interbedded salt, anhydrite, dolostone, and shale.

The upper part is complex and is predominantly carbonate in the Michigan basin and predominantly calcareous shale and shale in the Appalachian basin, where this interval grades laterally from marine to nonmarine toward the east and southeast. Four major intervals are recognized and correlated in both basins. These intervals are, in ascending order, (1) carbonate interval overlying the Salina Group with many local disconformities; (2) a prominent sandstone layer marking a major regional disconformity; (3) another carbonate interval that encloses salt deposits in the Michigan basin (Detroit River Group) and represents the uppermost horizon of thick limestone in the Appalachian basin; and (4) a series of interstratified limestone, argillaceous limestone, calcareous shale, and shale.

The uppermost clastic sequence (stage V) of the upper Middle Devonian and younger formations is laterally very uniform and therefore comparable throughout the Michigan and Appalachian basins. It is, however, rather diverse vertically and consists of two basic parts. Its maximum thickness is approximately the same in both basins and ranges from about 2500 to 4500 feet.

The lower part of this sequence is predominantly shale, siltstone, and sandstone, with limestone at the upper interval in the Michigan basin and in the southern portion of the Appalachian basin. Local disconformities in this part are common.

The upper part commonly exhibits a sharp and disconformable contact with the underlying deposits. It is represented by combined continental and marine sediments with lateral transition and vertical alternation of these two facies, which resulted in the deposition of cyclothems. These rock-units are characterized by similar composition and recurring succession of shale, siltstone, and sandstone, with minor amounts of limestone, coal, and claystone.

The uppermost part of this sequence is Jurassic and is found only in the Michigan basin, where it disconformably overlies the Paleozoic formations. It consists entirely of lacustrine and alluvial sandstone, siltstone, and shale.

2.3.3 ROCK SYSTEMS

2.3.3.1 Precambrian

Rocks of Precambrian age do not outcrop in the Salina Region. In the Appalachian basin, they form the floor of the basin and include the basement complex and Late Precambrian stratified sequence. Little is known of the nature of these ancient rocks because of their great depth. The basement complex is composed of igneous rocks such as gneiss and granite. The late Precambrian stratified sequence contains interbedded metamorphosed sedimentary and volcanic rocks (Colton, 1961).

Similarly, much of the Michigan basin is underlain by granite or other types of igneous rocks. Metamorphic rocks such as quartzite, schist, and dolomite are found locally (DeWitt, 1961). They probably range in age from about 800 million to about 1.5 billion years (Dorr and Eschman, 1970).

2.3.3.2 Cambrian

In the Appalachian basin, the Late Precambrian stratified sequence is overlain unconformably in most places by predominantly Lower Cambrian clastic sedimentary rocks (sandstone, siltstone, shale, etc.). Lower Cambrian rocks are wedge-shaped, thickest along the east side of the Appalachian basin in southwestern Pennsylvania and West Virginia, and thinnest to the west. These rocks have not been reported in north-central Ohio, northwestern Pennsylvania, and New York. Middle and Late Cambrian rocks, largely composed of limestone and dolomite with some sandstone, unconformably overlie the Precambrian basement where the Lower Cambrian clastic sequence is missing (Colton, 1961).

The Cambrian rocks in the Michigan basin consist of a clastic sequence composed largely of quartz sandstone and siltstone. The upper part of the Cambrian changes from quartz sandstone in the north to interbedded sandy dolomite and dolomite in the south (DeWitt, 1961). Cambrian rocks do not outcrop in the Salina Region and are found

only in the subsurface. They range in thickness from several hundred feet in the southeast to an estimated 2600 feet in the north-central part of the basin (Johnson and Gonzales, 1976).

2.3.3.3 Ordovician

Carbonates such as those of the upper Cambrian also dominate the Lower and Middle Ordovician of the Appalachian basin. Limestone and dolomite are found throughout the basin, with shale in the upper portion of the section in the east. These rocks are thickest along the east edge of the Appalachian basin and thin rapidly east and more gradually to the western portion of the basin. In contrast, the Late Ordovician consists predominantly of noncalcareous clastic rocks. Examples include shale ranging from black to red in color and siltstone and sandstone ranging from gray to red.

These rocks are thickest in eastern Pennsylvania and thin uniformly to the north, west, and southwest. The rocks in the eastern part of the basin are coarse-grained deltaic clastics that grade into finer grained marine shales to the west. Shales interbed with gray to black limestone on the western edge of the basin. In northwest Pennsylvania and in contiguous parts of Ohio and New York, the Upper Ordovician rocks are composed of about 2000 feet of noncalcareous rocks. To the west, in northwest Ohio, these rocks thin to less than 1000 feet (Colton, 1961). Ordovician rocks do not outcrop in the Appalachian basin and are found only deep in the subsurface.

The Ordovician rocks of the Michigan basin are the lowest rocks of a major carbonate-evaporite sequence that dominates the Michigan basin through the Middle Devonian. Lower and Middle Ordovician rocks consist predominantly of dolomite and limestone alternating with some sandstone and shale. The carbonates are thickest in the basin center and thin toward the basin margins, while the clastic rocks are thickest in the west and thin to the east. The Upper Ordovician rocks consist of an extensive regional basal black shale, similar to those in the Appalachian basin, and thicken eastward into Ohio and New York. These are overlain by gray, highly fossiliferous limestone and dolomite, which increasingly predominate to the north. The Ordovician rocks range in thickness from about 300 to 3000 feet (DeWitt, 1961). No exposures occur in the southern Michigan Peninsula, but a good subsurface record exists (Dorr and Eschman, 1970).

2.3.3.4 Silurian

2.3.3.4.1 General Description

Extending throughout the Appalachian basin is a Lower Silurian clastic sequence. Like the underlying Upper Ordovician sequence, the Lower Silurian clastics are thickest and coarsest grained in the northeastern part of the basin, where they consist largely of sandstone and conglomerate. The Silurian rocks thin to the north and west, where they are composed largely of shale, siltstone, and sandstone. Along the western part of the basin they are composed largely of limestone and dolomite.

The Middle and Upper Silurian rocks consist of predominantly carbonate rocks with some evaporites and shales. In north-central Ohio, rocks are largely dolomite, limestone, anhydrite, halite, and shale. Much of the carbonates are fossil reefs. The sequence thickens eastward into northwestern Pennsylvania and New York, where shales, anhydrites, and halite are also present. These rocks then thin rapidly to the western margin of the basin (Colton, 1961). Outcrops occur along the western edge of the basin in Ohio and along the northern edge in New York State in a band roughly parallel to the northern limit of the Salina Region (Figure 2-7). Elsewhere it occurs in the subsurface.

In the Michigan basin the Lower Silurian contains interbedded dolomite, limestone, and shale to the east and cherty dolomite to the west. The Middle Silurian has massive crystalline dolomite with some dolomitic limestone and shale. These rocks contain fine examples of marine organic reefs forming a reef platform along the margin of the basin. Overlying the reef carbonate is the Upper Silurian carbonate-evaporite sequence of the Salina Group, which consists of alternating halite, anhydrite, dolomite, limestone, and shale. These beds are thickest in the center of the basin and thin rapidly or even disappear toward the margins of the basin (DeWitt, 1961). Outcrops of Silurian rocks occur along the rim of the basin in southeastern Michigan (Figure 2-7). The total thickness of Silurian strata ranges from 600-1500 feet in the south to 4000 feet in the central northern part of the basin (Fisher, 1969). Since the salts of the Upper Silurian Salina Group are being considered as host rocks for a radioactive-waste storage repository, they are described below in more detail.

2.3.3.4.2 The Salina Group

The Salina Group contains the major deposits of rock salt (halite) in the Michigan and Appalachian basins. It consists of a number of rock units each composed predominantly of salt, carbonate, or shale (Johnson and Gonzales, 1976). Although the Michigan and Appalachian basins are distinct, these stratigraphic units are nearly identical and can be traced from one basin to the other (Rickard, 1969).

The Salina Group of the Appalachian basin attains a maximum thickness of 2500 feet in the subsurface of north-central Pennsylvania. In the Michigan basin, the group exceeds 4000 feet. The aggregate thickness of salt in the Salina Group is greatest in the center of the basin, reaching more than 2000 feet; it decreases outward from the center of the basin (Johnson and Gonzales, 1976). The areal extent and thickness of salt are less in the Appalachian basin than in the Michigan basin (Figure 2-6). The aggregate thickness ranges from about 300 feet in Ohio to 900 feet in New York (ERDA, 1976).

In an attempt to generally summarize the lithologies of the complex Salina Group, the stratigraphic units, which can be traced with some modification in content and name from the Michigan basin into the Appalachian basin, are described as follows from youngest to oldest (Alling and Briggs, 1961):

- Unit G: Uppermost Salina formation, 4 to 100 feet thick; characteristically gray shaly dolomite, green and red shales near the Mackinac Straits
- Unit F: Uppermost salt in the Salina section, 0 to 1230 feet thick; thick beds of salt separated by shale, shaly dolomite, dolomite, and anhydrite
- Unit E: 30 to 122 feet of gray or red shale with some dolomite, shaly dolomite, and anhydrite
- Unit D: 25 to 65 feet, nearly pure halite, with thin partings of buff dolomite
- Unit C: 60 to 160 feet, largely shale or shaly dolomite with anhydrite and buff dolomite in places
- Unit B: 240 to 400 feet thick, almost pure halite with minor dolomite

- Unit A: 30 to 1105 feet thick, limestone, dolomite, halite, and anhydrite

  - A2: Buff to brown dolomite or limestone
    Dark-gray dolomite
    Salt or anhydrite

  - A1: Fine brown to grayish brown dolomite or limestone
    Fine-gray dolomite or limestone
    Halite or anhydrite

2.3.3.5 Devonian

In the Appalachian basin, carbonate rocks similar to those of the Silurian continue into the Lower and Lower Middle Devonian. They are characterized by fossiliferous limestone with some calcareous sandstone and shale. The Middle and Upper Devonian rocks change sharply to a clastic sequence of rocks composed largely of shale, siltstone, and sandstone. To the east, rocks are generally coarse grained, with an increase in siltstone, sandstone, and red beds. Rocks to the west are finer grained, with gray and black shale dominating. This sequence is wedge shaped, being thickest near the east margin of the basin and thinnest near the west margin (Colton, 1961). Rocks are exposed at the surface along the northern and western sides of the basin (Figure 2-7). They cover much of the Salina Region in New York State and northern Pennsylvania and form a north-south band in central Ohio.

After a period of uplift and erosion at the end of the Silurian in the Michigan basin, the carbonate-evaporite sequence of the Silurian returns and continues through the Middle Devonian. The lower rocks are characterized by fossiliferous, cherty limestone and dolomite. Overlying these is an exceptionally pure, well sorted quartz sandstone in the southeastern part of the basin, overlain in turn by a sequence of alternating limestone, dolomite, shale, anhydrite, and halite extending throughout the basin. Although much less extensive than the salt beds of the Salina Group, the salt beds of the Detroit River Group cover much of the northern half of the southern Michigan Peninsula and have an aggregate thickness of more than 500 feet. There are as many as eight different salt beds, mostly 20 to 80 feet thick, with the thickest being 115 feet thick (Johnson and Gonzales, 1976). These rocks grade upward into the Upper Devonian rocks consisting of interbedded calcareous shale and fossiliferous limestone. Devonian rocks are exposed in curved bands in the northern and southern part of the southern Michigan Peninsula (Figure 2-7). The Devonian rocks typically are thickest in the center of the basin and thin toward the margins (DeWitt, 1961). The total thickness ranges from several hundred feet in the south to about 3400 feet in the north-central part of the basin (Johnson and Gonzales, 1976).

The uppermost Devonian black shale grades westward and upward into gray and greenish-gray shale of the Lower Mississippian (Dorr and Eschman, 1970).

2.3.3.6 Mississippian

Devonian clastic rocks are conformably overlain by Mississippian clastic rocks in the Appalachian basin. In general the grain size of these rocks is greatest in the eastern part of the basin, where the sequence is thickest. Red and tan sandstone, shale, and conglomerate predominate in the northeast; gray shale and siltstone in the northwest; and interbedded sandstone and limestone in the east-central part of the basin. Basal sandstone also occurs in Ohio, interbedded and overlain with gray shale and siltstone. In West Virginia, marine limestone is interbedded with shale and sandstone. Rocks are about 800 to

1000 feet thick in central Pennsylvania and thin westward to about 100 to 600 feet in northeast Ohio. Because of its stratigraphically high position, this sequence is exposed at the surface or is at relatively shallow depth in large parts of the basin in Pennsylvania and Ohio (Colton, 1961). These rocks crop out in patches in northern Pennsylvania and a north-south band in central Ohio. Mississippian rocks are absent from the Salina Region of New York State (Figure 2-7).

In the Michigan basin, the Upper Devonian black shale grades upward into gray and gray-green shale of the Mississippian. This sequence is made up largely of marine shale, silty shale, and siltstone, although locally sandstone, dolomite, limestone, anhydrite, and gypsum are present. Sandstone and siltstone are most common in the upper part of the system, with deltaic sandstone along the margin of the basin. Complex vertical and horizontal lithological patterns reflect complicated, shifting depositional environments. Many of these clastic rocks are similar to those found to the east, in Ohio. Adding to the complexities, the Upper Mississippian also contains some interfingering dolomite, shale, anhydrite, gypsum, and locally halite in the central part of the basin. These are overlain by fossiliferous limestone interbedded with dolomite, quartz siltstone, and sandstone. At the close of the Mississippian, erosion produced an irregular surface upon which the overlying Pennsylvanian sediments were deposited. The Mississippian rocks crop out in a broad elliptical band surrounding the center of the southern Michigan Peninsula. These rocks are in the subsurface of the basin center, where they attain their maximum thickness (DeWitt, 1961).

2.3.3.7 Pennsylvanian and Permian

Appalachian basin rocks of the Pennsylvanian and Permian systems are grouped together here largely because they are very similar lithologically. These rocks unconformably overlie the Mississippian rocks. As the bulk of these rocks has been removed by erosion since the end of Paleozoic time, only remnants are preserved in synclines and in larger basinal areas within the Appalachian basin. These rocks are exposed throughout much of the central part of the basin and are most completely represented in the southwest corner of Pennsylvania, the southeast edge of Ohio, and much of northern West Virginia. In this area the maximum thickness is about 2000 feet. The rocks are made up of a heterogeneous succession of interbedded sandstones, siltstones, mudrocks, and shales. Coal, clay, and limestones are minor constituents by volume (Colton, 1961). These rocks are the youngest consolidated rocks in the Appalachian basin and are partially overlain by Quaternary glacial deposits or recent river alluvium.

In the Michigan basin, an unconformity separates the Lower Pennsylvanian rocks from the underlying Mississippian rocks. Only rocks of the Lower Pennsylvanian are preserved. These rocks are predominantly continental deposits, as opposed to the underlying rocks, which are predominantly marine deposits. The Pennsylvanian rocks are made up largely of continental clastic rocks--shale, siltstone, and channel sandstone. Coal, argillaceous limestone, anhydrite, and gypsum are found locally. These rocks vary greatly in thickness and interfinger abruptly. They are present in the middle of the Michigan basin and thin to the margins. They also are irregularly exposed at the surface in the middle of the basin owing to pre-Quaternary erosion as well as to glacial scour (DeWitt, 1961). Rocks once thought to be of Permian age in the Michigan basin are apparently of Jurassic age and are briefly discussed below.

2.3.3.8 Jurassic

Rocks of the Upper Jurassic system of the Mesozoic Era are preserved only in the center of the Michigan basin and are not found in the Appalachian basin. They consist primarily

of red to greenish-gray micaceous sandy shale, gypsum, and red and tan sandstone. They interfinger abruptly with other types of rocks and vary greatly in thickness (DeWitt, 1961; Dorr and Eschman, 1970).

These rocks are the only ones preserved above the Pennsylvanian. Therefore, rocks of the following ages are missing: latest Paleozoic (Permian) in the Michigan basin, nearly all of the Mesozoic series (except those described above), and all those of the Cenozoic Era except the unconsolidated deposits of the Quaternary described below. Rocks corresponding to about 280 million years of geologic time are missing.

2.3.3.9 Quaternary

The Quaternary system is the youngest system of the Cenozoic Era and the youngest system found in the Salina Region. Quaternary deposits overlying bedrock are unconsolidated and composed of a complex sediment pattern of lake, river, and glacial origin. These surficial deposits cover all of the Michigan basin and the northern parts of Ohio and Pennsylvania, and most of New York State, including all of the Salina Region. Bedrock in the remainder of the basin is covered by soils and thick alluvium in river valleys, in great part derived from glacial runoff. The glacial deposits are thickest in the north and central parts of the Michigan basin and thin to the south. In the southern Michigan Peninsula, the deposits are thickest in buried pre-Quaternary stream channels, with a maximum thickness of over 850 feet. These deposits are commonly 200 to 300 feet thick in much of the southern Michigan Peninsula and 50 to 500 feet thick in northwest Ohio (DeWitt, 1961; Johnson and Gonzales, 1976). In western New York, glacial deposits fill valleys up to many hundreds of feet. Elsewhere, especially in the high hills, the till is only a few feet thick (Weaver, 1976).

Generally these surficial deposits are made up of till, outwash, and lake deposits. Glacial till is a glacier-deposited heterogeneous mixture of sediments ranging from clay and sand to gravel, and even boulder sizes. Outwash sediments are sorted, stratified gravels and sands deposited by glacial meltwaters. Lake deposits are stratified sands, silts, and clays.

2.4 TECTONIC HISTORY

A chronological sequence of major tectonic events (those involved in deforming the earth's crust) that influenced the development of the Salina Region was reconstructed with the aid of stratigraphic and structural information. This synopsis provides the temporal and spatial relationships of tectonic events, such as uplift and deformation, in the region. Reconstruction of the tectonic history of the Salina Region is necessary in considering its future stability. The chronological summary presented below identifies the principal tectonic events experienced by the region during the past billion years (Figure 2-9) in addition to varying degrees of subsidence in both the Michigan basin and the Applachian basin during the Paleozoic Era.

A series of Precambrian events (more than 570 million years ago) resulted in the stabilization of a large crystalline province known as the Canadian shield. Its final episode involved a prolonged period of mountain building, igneous intrusion, and metamorphism, collectively referred to as the Grenville orogeny. The crystalline materials produced by this orogeny are not exposed at the surface in the Salina Region. Rocks of Grenville age (1 billion years old) underlie most of the stable region and are designated as basement rocks. The exception is basement rock of Grenville to pre-Grenville age underlying

portions of the Michigan basin (Hinze et al., 1975). Volcanic activity accompanied the Grenville orogenic event, with an outpouring of basaltic lavas into the precursor of the Michigan basin (Snyder, 1968).

The Adirondack Mountains of New York represent an extension of the Canadian Laurentian Mountains, which were deformed during the Grenville episode. This area has sustained numerous periods of erosion since Precambrian time. Additional Precambrian structures within the region that generally remained as tectonically inactive areas of high relief are the Wisconsin arch and the Kankakee arch.

A period of tectonic inactivity of approximately 450 million years preceded the next major orogenic event to affect the Salina Region. The period preceding the orogenic event began with the separation of the North American continent from Europe during the latest Precambrian time. A Proto-Atlantic Ocean developed between the separating continents (French et al., 1977), an event that triggered the influx of extensive Cambrian seas across North America. The Proto-Atlantic Ocean closed over the long period from the Ordovician to the Devonian as the North American and European continents moved closer together. The initial collision of North America with Europe occurred sometime during the Middle Ordovician (approximately 450 million years ago). The resulting mountain building and deformation along the eastern margin of North America are known as the Taconic orogeny. Its primary influence on the Salina Region was to develop a thick wedge of coarse sediments across New York and Pennsylvania, referred to as the Queenston delta. Concurrently, extensive faulting and folding occurred in Pennsylvania, while the Michigan Basin continued to subside and received sediments from bordering lands.

During the Silurian period (approximately 435 to 395 million years ago) minor disturbances related to the Taconic orogeny continued along the zone of the present-day Appalachians but had little effect on the Salina Region to the west. However, the Michigan basin was undergoing rapid subsidence; the central portion of the basin subsided 1500 meters relative to its borders (Fairbridge, 1975). At the same time certain bordering areas remained stable and formed the Findlay and Cincinnati arches. The end of the Silurian period was characterized by an absence of tectonic activity.

Tectonism resumed during the Middle Devonian (approximately 375 million years ago) as a result of renewed collision between North America and Europe. This renewed period of mountain building is known as the Acadian orogeny. It involved areas from New York to Newfoundland, with deformation as far west as southwestern Pennsylvania (Rodgers, 1970) and the eastern Catskills of New York (Bird and Dewey, 1973). The mountain building sent a thick wedge of coarse sediments known as the Catskill delta into Pennsylvania and New York.

A renewed period of tectonism to the east once again sent a series of deltaic fans into the Salina Region. This youngest period of mountain building, known as the Appalachian orogeny, was responsible for the formation of the folded mountain belts of Pennsylvania and West Virginia during late Pennsylvanian, Permian, and Triassic times (see Figure 2-9). Tensional stress began to build to the east of the Salina Region during the Triassic (approximately 192.5 million years ago). This stress buildup peaked in the mid-Jurassic, leading to the second continental breakup of North America and Europe. The opening of the present Atlantic Ocean resulted from the migration of the two continents from an active volcanic spreading center, the Mid-Atlantic Ridge. Since the focus of tensional stress and continental spreading was far to the east, the effect on the Salina Region was minimal. This was the last major period of mountain building in the Appalachians and was followed by a period of nearly 190 million years of stability.

Large glacial ice sheets covered the Salina Region intermittently during the first part of the Quaternary, known as the Pleistocene epoch (about 1 million years ago). The tremendous weight of these ice sheets depressed the glaciated region. Melting of the glacial ice relaxed the pressure; the affected areas responded with a very gradual rebounding that is still continuing. The glaciers retreated from the region about 9000 years ago (Fairbridge, 1975). (See Section 4.2, Paleoclimatology, for further discussion of glaciation.)

In summary, the Salina Region has experienced no major internal tectonic activity since the Precambrian (1 billion years ago). The geologic development of the region--including sediment dispersal and deposition, distribution of inland seas, and structural readjustments—was in response to external mountain building in the more tectonically active borderland to the east. Structural readjustments within the region were concentrated in the Appalachian basin of New York, Pennsylvania, Ohio, and West Virginia and had little effect on the continuing Paleozoic sedimentation of the Michigan basin. With the exception of the glacial rebound of the past 7000 years, the Salina Region has been stable for the last 225 million years. Consequently, it is not surprising that the Salina Region is included in the Central Stable Region of North America (Dorr and Eschman, 1970).

2.5 SEISMOLOGY

A seismic characterization of the Salina Region is developed here to indicate the short-term geologic stability of the region's rock units. Damaging seismic events might result in surface and subsurface deformation as well as uplift or subsidence. Such occurrences could jeopardize the mining operation and the surface facility and might alter the integrity of the storage rock unit. On a less damaging scale, a seismic event might alter surface features, resulting in changed erosional patterns. This could also affect erosional processes acting on mined-rock tailings.

Earthquakes that have occurred within the region are mapped, and major earthquakes that might have affected the region are listed. Where a relationship between structure and seismic patterns is known, that too is described. For the purpose of listing and describing earthquakes, the National Oceanic and Atmospheric Administration (NOAA) has divided the country into nine regions (U.S. Department of Commerce, 1973). This arrangement has been made chiefly with reference to natural seismic divisions. The states included in the Salina Region fall into three of these seismic regions.

New York is in the Northeastern Region, which contains some zones of relatively high seismic activity. New York has experienced numerous shocks, several of which were quite severe. This region is also affected by some large earthquakes originating in adjacent Canada, primarily in the Laurentian trough and the St. Lawrence Valley.

Pennsylvania falls within the Eastern Seismic Region, which, except for the Charleston, South Carolina, earthquake, has had only a moderate amount of low-level activity. The processes that have resulted in the present condition of the Appalachian Mountain system probably have settled into a relatively inactive state (Coffman and von Hake, 1973). Although earthquakes occur throughout the region, most activity generally parallels the coastline, and most seismic activity in Pennsylvania appears in the eastern half of the state, relatively parallel to the coastline.

Ohio and Michigan fall within the Central United States Region. While the nonmountainous interior portions of continents usually are less earthquake-prone than any part of the earth, the Central United States Region is an exception. The Upper Mississippi and Ohio valleys are regions of relatively frequent earthquakes. Three of the great historic U.S. earthquakes occurred in the Upper Mississippi region in 1811 and 1812. Their extent, severity, and topographic effects are not equalled by those of any other earthquake in the contiguous United States (Coffman and von Hake, 1973).

2.5.1 SEISMIC RISK ZONES

The inset map in Figure 2-10 shows the Salina Region in the context of the seismic risk zones of the United States. The risk-zone map was developed in 1969 by S. T. Algermissen of NOAA's Environmental Research Laboratories and divides the United States into four zones:

Zone 0: areas with no expectancy of earthquake damage

Zone 1: expected minor damage

Zone 2: expected moderate damage

Zone 3: major destructive earthquakes may occur.

The Salina Region contains risk zones 1, 2, and 3. However, most of the area under study is in risk zone 1: all of Michigan, all of Ohio but the extreme northeastern corner, all of Pennsylvania but its northwestern corner, and a small wedge of south-central New York. A tongue of zones 3 and 2 follows the northwestern boundary of New York along lakes Erie and Ontario, extending minimally into the intersecting corners of Ohio and Pennsylvania.

2.5.2 EARTHQUAKES THAT HAVE OCCURRED IN THE REGION

Figure 2-10 shows the earthquakes that have occurred in the Salina Region. It can be seen from this map that the region under study is one of low seismicity.

Western New York State, near Attica, is characterized by greater seismic activity than any other part of the Salina Region. The largest of the several historic earthquakes in this area was the Attica earthquake of 1929, which had a Modified Mercalli (MM) intensity of VIII (reclassified as MM VII by Fox and Spiker in 1977). Four additional events occurred in the same vicinity in 1929 (MM V), 1955 (MM V), 1966 (MM VI), and 1967 (MM VI).

The Pennsylvania portion of the the Salina Region is virtually earthquake-free. Only one MM V event is recorded for the area, and that occurred in 1934, near Erie. The West Virginia portion of the Salina Region has also not experienced any recorded earthquake of intensity higher than MM V.

The earthquakes in the Ohio portion of the Salina Region are all concentrated in the vicinity of Cleveland. Four MM V quakes have been recorded there (in 1906, 1928, 1955, and 1958). One other similar earthquake occurred north of Ohio, in Lake Erie.

The Michigan portion of the Salina Region is virtually earthquake-free. Two MM V events were recorded there, in 1872 near Wenona and in 1877 in southeastern Michigan, near the western tip of Lake Erie.

2.5.3 MAJOR EARTHQUAKES AFFECTING THE REGION

Table 2-1 lists major earthquakes (magnitude VII and greater) that have, or might have, affected the region. A more complete list of earthquakes has been compiled by Stone & Webster (1978). There are three zones of higher seismicity outside the Salina Region. One zone trends northwest-southeast in western Quebec, about 200 miles from the Salina Region of New York, and includes one MM VIII event (1944). A second zone runs parallel to the Appalachians in the Valley and Ridge and the Blue Ridge physiographic provinces. Seismic activity here is typically at a low level, though one MM VIII event occurred in Giles County, Virginia, in 1897.

The third area of seismic activity that might influence the Salina Region is located in western Ohio near Anna, where an event of MM VII-VIII occurred in 1937.

There are two additional seismic zones significantly south of the Salina Region. One extends from eastern Tennessee to South Carolina; it was here that the Charleston earthquake of 1886 (MM IX-X) occurred. The second, to the southwest, has experienced the largest earthquakes known to have occurred in eastern North America. The three largest earthquakes (MM XII) occurred in 1811 and 1812 between Arkansas and New Madrid, Missouri.

2.5.4 PATTERNS OF EARTHQUAKES AND RELATIONSHIPS TO STRUCTURE

Earthquakes in the New York portion of the Salina Region may be explained by the readjustment of the crust after the most recent Ice Age (Coffman and von Hake, 1973). Most geologists suggest that during the glacial periods the ice load deformed the earth's crust, which is now coming back to its normal position. Because the adjustments may occur deep within the earth, major surface faulting, uncommon in this region, need not occur. Seismic activity in the Attica area, however, is centered near the Clarendon-Linden fault, a major north-south-trending tectonic feature extending from the Pennsylvania-New York border to Lake Ontario. This structure is interpreted as a system of north-striking, high-angle faults (Stone & Webster, 1978).

Generally, the reason for most earthquakes (other than the 1811-1812 New Madrid events) in the Central Seismic Region, which includes Ohio and Michigan, is not fully understood (Coffman and von Hake, 1973). Investigations by Thompson and others (1976) have suggested that there are three normal faults in the Anna, Ohio, seismic area, but this view has yet to be confirmed.

2.6 ENERGY AND MINERAL RESOURCES

The energy and mineral resources of the Salina Region have been identified from available published documents. The existing and known potential extents of surface and subsurface resources within the boundaries of the region are displayed on a base map at a scale of 1:5,000,000. Resources within 25 miles of the boundaries are included because of their potential influence on the search for prospective repository sites. Avoidance of areas with extensive energy and mineral resources is a search guideline. The resources that have been considered include oil and gas, coal, radioactive minerals, metals, and nonmetals.

TABLE 2-1

MAJOR EARTHQUAKES AFFECTING THE SALINA REGION

Year	Date	Locality	°N Lat.	°W Long.	Modified Mercalli Intensity
1638	June 11	Probably St. Lawrence Valley	46.5	72.5	IX
1661	February 10	St. Lawrence Valley	45.5	73.0	Violent
1663	February 5	St. Lawrence River region	47.6	70.1	X
1732	September 16	St. Lawrence Valley	45.5	73.6	IX
1737	December 18	Near New York City	40.8	74.0	VII
1811	December 16	New Madrid, Mo.	36.6	89.6	XII
1812	January 23	New Madrid, Mo.	36.6	89.6	XII
1812	February 7	New Madrid, Mo.	36.6	89.6	XII
1860	October 17	Canada, felt to south	47.5	70.0	VIII-IX
1861	July 12	Canada, felt to south	45.4	75.4	VII
1875	June 18	Western Ohio	40.2	84.0	VII
1877	November 4	Northern New York	44.5	74.0	VII
1884	August 10	Near New York City	40.6	74.0	VII
1886	August 31	Charleston, S.C.	32.9	80.0	IX-X
1905	July 26	Calumet, Mich.	47.3	88.4	VII
1906	May 26	Keweenaw Peninsula, Mich.	47.3	88.4	VIII
1909	September 27	Indiana	39.0	87.6	VII
1914	February 10	Canada, felt to south	45.0	76.9	VII
1925	February 28	St. Lawrence River region	47.7	70.5	VIII
1926	November 5	Southeastern Ohio	39.1	82.1	VII
1929	August 12	Attica, N.Y.	42.9	78.3	VIII
1930	September 30	Ohio	40.3	84.3	VII
1931	April 20	Lake George, N.Y.	43.4	73.7	VII
1931	September 20	Anna, Ohio	40.4	84.2	VII
1937	March 2	Western Ohio	40.4	84.2	VII
1944	September 4	Massena, N.Y.	44.9	74.8	VIII
1954	February 21	Wilkes-Barre, Pa.	41.2	75.9	VII
1968	November 9	South-central Illinois	38.0	88.5	VII

SOURCE: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Earthquake History of the United States, 1973; and United States Earthquakes, 1973, 1974, 1975, 1976.

2.6.1 ENERGY RESOURCES

All three major types of "mineral" energy resources--oil and gas, coal, and uranium--occur within the Salina Region. Oil and gas fields have been developed in all five states, coal is produced in all states of the region except New York, and potential uranium resources have been identified along the eastern border of the Salina Region in Pennsylvania. Additional energy resources that may be developed in the Salina Region in the future include oil shales and peat.

The depths of rock systems containing energy and mixed resources are identified in Figures 2-5 and 2-6 in the Stratigraphy portion of this report.

2.6.1.1 Oil and Gas

The Salina Region is divisible into two large stratigraphic basins, the Michigan and Appalachian basins, which are separated by the Findlay arch (Figure 2-3). Both basins are major oil and gas producers, and exploration has continued to rise steadily in the past several years. Areas within this region where gas and oil fields have been developed and areas that may undergo future development are identified below.

2.6.1.1.1 Michigan Basin

The four primary types of producing fields in the Michigan basin are (1) the Silurian Niagaran reef trends circumscribing the basin, (2) the Devonian and Mississippian reservoirs of the central basin, (3) the Cambrian and Ordovician reservoirs in the southern portion of the basin, and (4) scattered fault-controlled fields.

2.6.1.1.1.1 Niagaran Reef Trends. Drilling activity in the Michigan basin has been highest for the past 8 years along the Niagaran reef trends (Ells, 1977) of Silurian age. Three petroleum-rich reef areas are recognized: (1) a northeast-southwest trending band in the northwest, (2) a south-central, northeast-southwest band, and (3) a southeastern area (Figure 2-11). Silurian carbonate oil and gas reservoirs include reefs, folds, and salt collapse structures. Future exploration in the Michigan basin is expected to focus along these reef trends (Netherland, Sewell, and Associates, 1975) and established carbonate reservoirs. Niagaran reef reservoirs found in 1976 in Cheboygan and Presque Isle counties greatly expand the territory to be explored (Ells, 1977).

2.6.1.1.1.2 Central Portion of the Basin. Major fields within the central portion of the Michigan basin occur above the salt and are localized by folds and faults. Numerous oil and gas accumulations occur in sediment layers that have draped over ancient salt ridges. These structures are referred to as salt-cored anticlines (Johnson and Gonzales, 1976). Sediment layers of Devonian to Mississippian age are the prime reservoir rocks within the central area of the basin. In recent years, exploration along these structures has diminished, and future exploration is not expected to be extensive (Netherland, Sewell, and Associates, 1975). The Mississippian sands and shales have an erratic distribution, which causes difficulty in locating their reservoirs. Consequently, the future potential of Mississippian reservoirs cannot be projected. Strata younger than Mississippian in the central region are essentially unproductive.

2.6.1.1.1.3 Southern Portion of the Basin. Productive areas in Ordovician strata are located in the southern portion of the Michigan basin. A major field known as the Albion-Scipio (Figure 2-11) is confined to a northwesterly plunging syncline. Local porous reservoir zones exist in the Trenton and Black River Ordovician limestones (Netherland, Sewell, and Associates, 1975). Exploration for similar subtle structural features is

continuing. Leasing activity during 1976 in the southern parts of Hillsdale, Branch, Lenawee, and Cass Counties indicates that this southern area of Cambrian-Ordovician rocks may be the focus of future exploration (Ells, 1977).

2.6.1.1.1.4 Fault-Controlled Fields. There are ten major fault-related fields in the Michigan basin (Stone & Webster, 1978), the largest of which are (1) the Albion-Scipio field of Hillsdale, Jackson, and Calhoun Counties and (2) the Howell field of Livingston County (Figure 2-11). Some of these fields, such as the Albion-Scipio field, are considered to be fold-related structures (Netherland, Sewell, and Associates, 1975; Ells, 1977). Seismic surveys are continuing to project trends along these structures and to locate new structurally controlled reservoirs.

The results of current investigations conducted for the Office of Nuclear Waste Isolation indicate that the Michigan basin contains extensive areas in which no significant economic oil and gas accumulations are likely (Netherland, Sewell, and Associates, 1975; Johnson and Gonzales, 1976). Michigan counties within the regional boundaries that have such areas include the following:

Charlevoix	Crawford	Emmet	Oscoda
Cheboygan	Alcona	Presque Isle	Iosco
Leelanau	Huron	Benzie	Tuscola
Antrim	Sanilac	Montmorency	Genesee
Alpena	Oakland	Eaton	

2.6.1.1.2 Appalachian Basin

The eastern Salina Region is confined to the northern portion of the Appalachian basin in southwestern New York, western Pennsylvania, northern West Virginia, and eastern Ohio (Figure 2-11). The three primary oil and gas subdivisions are (1) a broad central region of relatively shallow fields in rocks of Pennsylvanian, Mississippian, and Devonian ages, above the layers of Silurian salt; (2) a western region of Silurian fields extending from eastern Ohio to western New York; and (3) Ordovician and Cambrian fields in the northern and western margins of the basin. Drilling activity in the central Appalachian basin has focused on reservoirs above the Silurian salt beds. Wells that have penetrated the Silurian have a much sparser distribution of less than one well per 100 square miles (Netherland, Sewell, and Associates, 1975). However, owing to recent gas and oil shortages, oil and gas exploration has increased in marginally producing areas below the Silurian, such as in southwestern New York (Van Tyne, 1977).

2.6.1.1.2.1 Central Region. The Devonian, Mississippian, and Pennsylvanian rocks form a wedge of sediments that is thin in the west and thickens to over 8000 feet along the eastern limits of the Appalachian basin. Drilling in the central region is most concentrated in those rock units that lie above the Silurian salt-bearing layers. Along the eastern border of the basin these sediments have been extensively folded, faulted, and metamorphosed. The underlying Silurian salt layers vary in thickness as a consequence of the folding (Netherland, Sewell, and Associates, 1975). Along the western margin of the basin these rocks are unmetamorphosed. Primary reservoirs include horizontal sandstone layers and lenses in the Devonian, Mississippian, and Pennsylvanian rock systems. Upper Devonian sandstone beds have yielded over 80% of Pennsylvania's crude oil and substantial amounts of oil in New York and West Virginia as well as large volumes of natural gas (Meyer and Edgerton, 1968). Recent gas discoveries in Devonian reefs extending from Steuben County, New York, to McKean County, Pennsylvania, may trigger future exploration (Netherland, Sewell, and Associates, 1975). Fractured Devonian shales in West Virginia and eastern Ohio are also productive. During 1976, the

Department of Energy sponsored an Upper Devonian shale gas project for the basin (Lytle et al., 1977). The deepest well to date (1977) in the Appalachian basin was drilled 21,460 feet to upper Cambrian rock in Somerset County, Pennsylvania, but was unproductive.

2.6.1.1.2.2 Silurian Fields in the Western Margin of the Appalachian Basin. The most important gas fields of New York occur in Silurian sandstone layers (Medina sandstone) along Lake Erie and Lake Ontario (Van Tyne, 1977). These fields extend southwestward into eastern Ohio. Of the 4987 wells drilled in Ohio from 1974 to 1976, 4317 were drilled to Silurian sandstones (Clinton and Medina sandstones). Silurian and older rocks occur at much deeper levels in the basin to the west, but drilling activity there is minimal. Future exploration is anticipated to extend westward under Lake Erie. Definition of the areal extent of established fields will also continue.

2.6.1.1.2.3 Cambrian-Ordovician Fields in the Western Margin of the Appalachian Basin. Oil and gas production from Cambrian and Ordovician rocks is primarily confined to the western and northern margins of the Appalachian basin in eastern Ohio and western New York. These rocks are thinnest at the western margin and thicken to the east. Rocks of these systems occur at depths of nearly 30,000 feet below sea level in the eastern portions of the basin and at much shallower depths of near 3000 feet below sea level along the western margin. Oil and gas accumulations within the deep basin have migrated through porous zones upward and northwestward. As of 1977, the deepest producing well in the central basin area of Pennsylvania was in lower Silurian rocks (Lytle, 1977), and deeper reservoirs are not being developed. Along the western and northern margin of the basin, Cambrian and Ordovician oil and gas fields occur at much shallower depths. These accumulations are in fractured sandstones and shales, and along porous zones of ancient erosional surfaces (unconformities).

In portions of eastern Ohio, western Pennsylvania, and southwestern New York, oil and gas development involving primary, secondary, and tertiary recovery efforts may have affected the stability of the Silurian salt layers. Such recovery methods include water flooding and rock fracturing with explosives.

2.6.1.2 Coal

Coal is extracted from deposits in Pennsylvania, Ohio, and West Virginia (Figure 2-12); it was formerly extracted in Michigan as well. The major coal reserves in the Salina Region occur in Pennsylvania, for which 1974 estimates of 31,000 million short tons were reported (Averitt, 1975). The 1974 estimates were 119 million short tons for Michigan, 39,590 million short tons for West Virginia, and 21,077 million short tons for Ohio (Averitt, 1975). The reserve estimates for West Virginia include considerable tonnage (roughly 75%) that occurs within the state but outside the Salina Region. The reserve base is defined as the amount of coal that is suitable for 1974 extraction methods (Averitt, 1975). In the Salina Region much of the coal is within 300 feet of the surface and occurs in layers well above the salt beds being considered for potential repository sites. Most of the coal within the confines of the regional boundary is medium- to high-volatile bituminous coal.

2.6.1.3 Uranium

Uranium occurs in sandstones and conglomerates along the eastern margin of the Salina Region in Pennsylvania (Figure 2-12). These deposits are concentrated primarily in the Catskill Formation of late Devonian age (see Section 2-4) (Butler and Stanfield, 1968).

Most of the deposits are not of economic importance at present but are being considered as a future resource by the National Uranium Resource Evaluation program (NURE).

2.6.1.4 Oil Shale

Oil shale is a black shale with a high content of organic matter. It has the potential of yielding 10 to 25 gallons or more of light oil per ton (Culbertson and Pitman, 1973). Such shales of Ordovician age are recognized in New York, and younger shales of Devonian to Mississippian age are found in Michigan (locally known as the Antrim shale). These resources are not currently being considered but may be an important future source of oil and gas.

2.6.1.5 Peat

See Section 2.6.3.2 for further discussion of peat in the Salina Region.

2.6.2 METALS

Only two types of metalliferous deposits are recognized within the Salina Region. These include deposits of (1) iron ore and (2) lead-zinc, but they are of only marginal importance (Figure 2-13). In addition, deposits of iron ore occur within 25 miles of the regional boundary in New York and Pennsylvania. Small deposits of silver, vanadium, and copper are known east of the Salina Region in Pennsylvania.

2.6.2.1 Iron Ore

Iron-ore deposits that are recognized within the Salina Region in eastern Ohio, southwestern Pennsylvania, and northern West Virginia are extremely low grade ores and are not considered to be economically important at present. These iron ores are of sedimentary origin. The iron-bearing mineral is the iron carbonate siderite, which is present as a coating on other sediments. Important iron ores occur along the northern border in New York and the eastern border in Pennsylvania. These ores (referred to as the Clinton Iron Ores) are iron oxides and are also of sedimentary origin. Future production of these ores is also expected to be minimal.

2.6.2.2 Lead-Zinc

Lead-zinc deposits in the Salina Region are confined to Pennsylvania. Most of the occurrences are small noneconomic deposits. Two major types of deposits are represented: (1) spherical masses (nodules or concretions) found in sediments and (2) veins. The nodules are found in Allegheny, Westmoreland, Indiana, Armstrong, Clarion, and Butler Counties in western Pennsylvania. The nodules have high amounts of zinc (as the mineral sphalerite), iron (as the minerals siderite and pyrite), and lead (as the mineral galena). The mining of these vein deposits of lead and zinc has been sporadic from 1816 to the 1950s (Wedow and Sweeney, 1968).

2.6.2.3 Silver, Copper, and Vanadium

Silver, copper, and vanadium prospects occur to the east of the Salina Region in central Pennsylvania. The main silver mineral is argentite, whereas copper is present mainly as the mineral chalcopyrite. Silver and copper were recovered during the late 1800s and early 1900s as by-products of lead-zinc mining. Vanadium occurs with uranium in sedimentary rocks of the Catskill Formation of Devonian age. It occurs as the uranium vanadate mineral carnotite. Vanadium has not been mined in the Salina Region.

2.6.3 NONMETALS

Nonmetals that are extracted in the Salina Region are salt, salt brines, peat, marl, pyrophyllite and talc, silica, barite, and fluorite (Figure 2-14).

2.6.3.1 Salt

Salt is produced in Michigan, northeastern Ohio, and western New York. In 1974, about 4.4 million short tons of salt were extracted in the State of Michigan (Lewis, 1975). Michigan salt-producing counties include Gratiot, Manistee, Midland, Muskegon, St. Clair, and Wayne. Salt-mining operations in Ohio are located in its northeast corner, in Lake, Cuyahoga, Summit, and Wayne Counties (Duffield, 1977). New York operations occur in the Finger Lakes Region, in Schuyler, Tompkins, Livingston, Onondaga, and Wyoming Counties (Great Lakes Basin Commission, 1974). Salt is used on icy highways and for the manufacture of chlorine, chemicals, and table salt. Since salt deposits underlie most of the Salina Region, their extraction is not expected to interfere with the siting of waste repositories (Johnson and Gonzales, 1975).

Salt brines are recovered from deposits mined by solution processes. Brines are an important source of bromine, magnesium compounds, and soda ash. Brines are produced from wells in Michigan, New York, and Ohio (Figure 2-14).

2.6.3.2 Peat

Peat is currently used as a mulch for horticultural and agricultural purposes. It is not currently used as fuel in the United States (Cameron, 1973). Extensive peat deposits occur along the southern margin of the Salina Region in the State of Michigan, which produced 244,223 short tons of peat in 1974 (Lewis, 1975). Additional deposits extend from western Pennsylvania to southwestern New York and in the southeasternmost area of the Salina Region in Pennsylvania and Ohio.

2.6.3.3 Marl

Marl deposits occur in New York and in Allegan, Barry, Kalamazoo, Calhoun, and Cass Counties in Michigan. Marl deposits are sediments rich in calcium carbonate with additional amounts of silt, sand, and clay. Marl is used locally as a soil conditioner.

2.6.3.4 Pyrophyllite and Talc

Pyrophyllite and talc prospects in the Salina Region are restricted to Lycoming and Tioga Counties in Pennsylvania. The beds are reported to occur in slates and are only a few inches thick, although two localities have beds ranging between 5 and 8 feet (Wedow and Sweeney, 1968). These prospects are not expected to affect waste repository siting because of their small extent.

2.6.3.5 Silica

Silica is processed from deposits of sand, sandstone, conglomeratic sandstone, and quartzites in the Salina Region. Silica is the main raw material used in the manufacture of glass. It has numerous other uses, as an abrasive, molding sand, paint extender, insulation, and filler in plastics; it is also used in semiconductors, silicones, and ceramics (Carter, 1973). Sources of silica are concentrated in western Ohio and eastern Pennsylvania; additional deposits are scattered throughout the region. Silica resources are extremely abundant in the Salina Region.

2.6.3.6 Barite

Barite has been identified in only one locality, just outside the regional boundary in Blair County, Pennsylvania (Brobst-Hobbs, 1968). Barite is used as a source of barium compounds. It occurs as a secondary mineral in lead-zinc veins and is not of commercial interest at present.

2.6.3.7 Fluorite

Fluorite occurrences have a wide distribution in the Salina Region (Figure 2-14). However, only four localities are commercially viable at present, and these have less than 50,000 tons remaining, as calcium fluoride. They are found near Ithaca, New York; Indiana and Uniontown, Pennsylvania; and Midland, Michigan (Worl et al., 1973). In the past Michigan and Pennsylvania produced 71,286 and 168,154 short tons, respectively; New York statistics were unreported in 1973 (Wood, 1973). Most of the fluorite is converted to hydrofluoric acid for commercial use. In addition, it is also used in the manufacture of fluorocarbons and lubricants, and in the fluoridation of drinking water.

2.6.4 CONSTRUCTION MATERIALS

The construction materials that have been identified in the Salina Region are sand and gravel, stone, shale and clay, and gypsum and anhydrite (Figure 2-15).

2.6.4.1 Sand and Gravel

Sand and gravel occurrences have the widest distribution and greatest abundance of any of the geologic resources of the region. Deposits exist in every state and in nearly every county. Three major categories of sand and gravel are currently being extracted: (1) glacial materials in Michigan, New York, Ohio, and portions of Pennsylvania; (2) alluvium derived by the recent erosion cycle and concentrated along river banks and channels; and (3) materials derived by the breakdown of steep slopes via gravity (colluvium) in the eastern Appalachian basin of Pennsylvania and West Virginia. This material is used mainly for road construction, building construction, fill, as molding sand, and in the manufacture of glass.

2.6.4.2 Stone

Stone-quarrying operations are located in all five states of the Salina Region. Quarries are found along the periphery of the Michigan basin. These quarries produce over 40 million short tons of limestone and dolomite every year, placing Michigan in the top ten in national output. Other important limestone and dolomite areas are found in portions of eastern Ohio, northwestern Pennsylvania, and southwestern New York. This type of stone has numerous uses, such as (1) blocks for building, (2) crushed aggregate for bituminous aggregate, (3) concrete, (4) roadbase, (5) agricultural purposes, (6) flux stone, (7) lime manufacture, and (8) flue-gas scrubbing. In addition, abundant supplies of sandstone are found in Pennsylvania, Ohio, West Virginia, and New York. It is primarily used for construction purposes.

2.6.4.3 Shale and Clay

Shale and clay extraction is most heavily concentrated along the Ohio-Pennsylvania border, and additional quarries are scattered throughout the region. The primary uses include the

manufacture of heavy clay products such as building brick, portland cement, and lightweight aggregate. In addition, these materials are utilized in manufacturing refractories and as fillers (in paper, rubber, plastics, paints, fertilizers, and pesticides).

2.6.4.4 Gypsum and Anhydrite

Gypsum and anhydrite are produced in four Salina Region locations, including Iosco and Kent Counties of Michigan; Ottawa County, Ohio; and along the northern margin of the region in New York from Buffalo to Syracuse. Michigan ranks first in the United States in gypsum and anhydrite production. Primary uses are in the manufacture of portland cement, agricultural additives, and plaster.

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Worl, R. G., Van Alstine, R. E., and Heyl, A. V., 1974. Fluorite in the United States, U.S. Geological Survey, Mineral Investigations, Resource Map MR-60 (1:3,168,000).

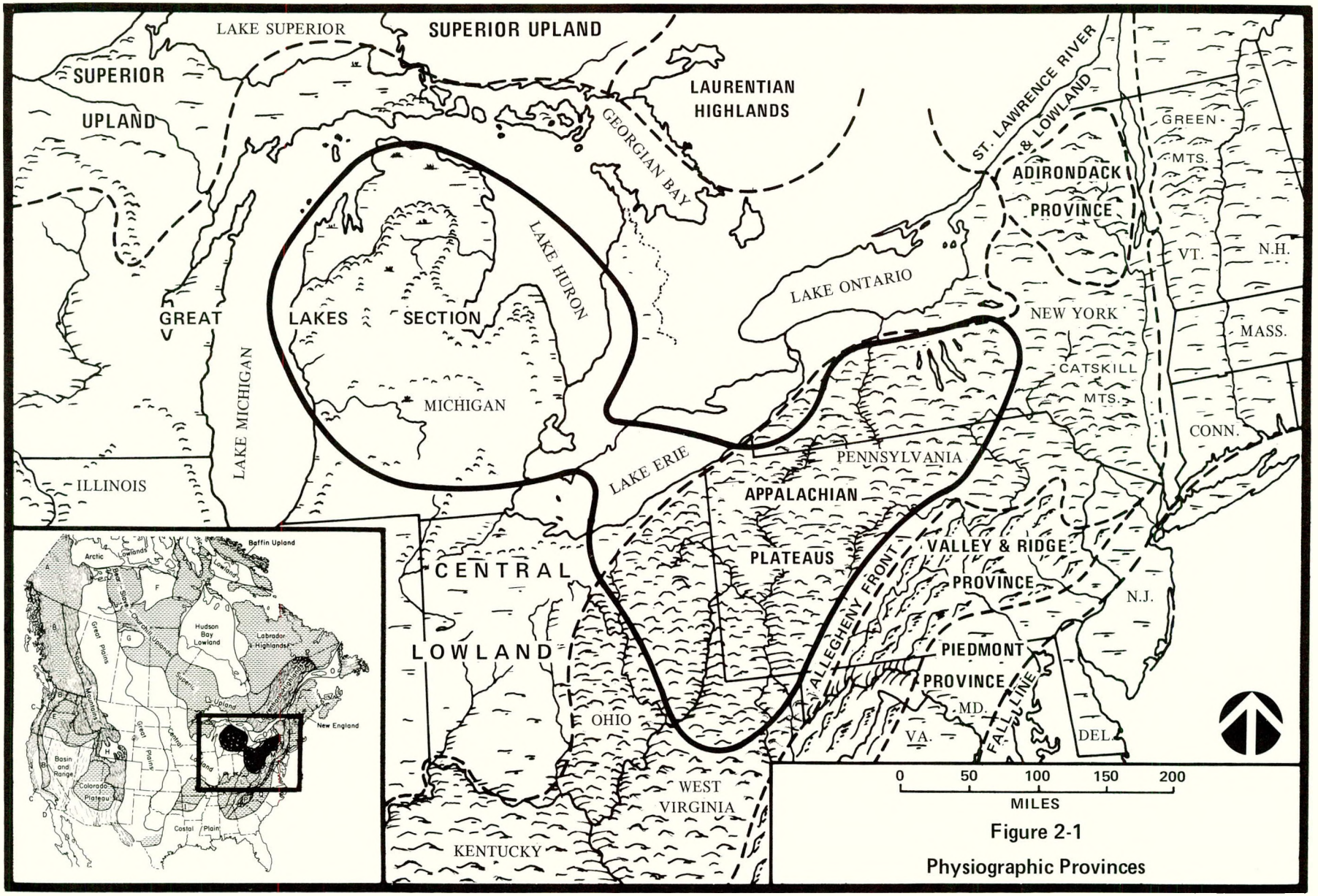


Figure 2-1

Physiographic Provinces

Adapted from Hunt (1974)

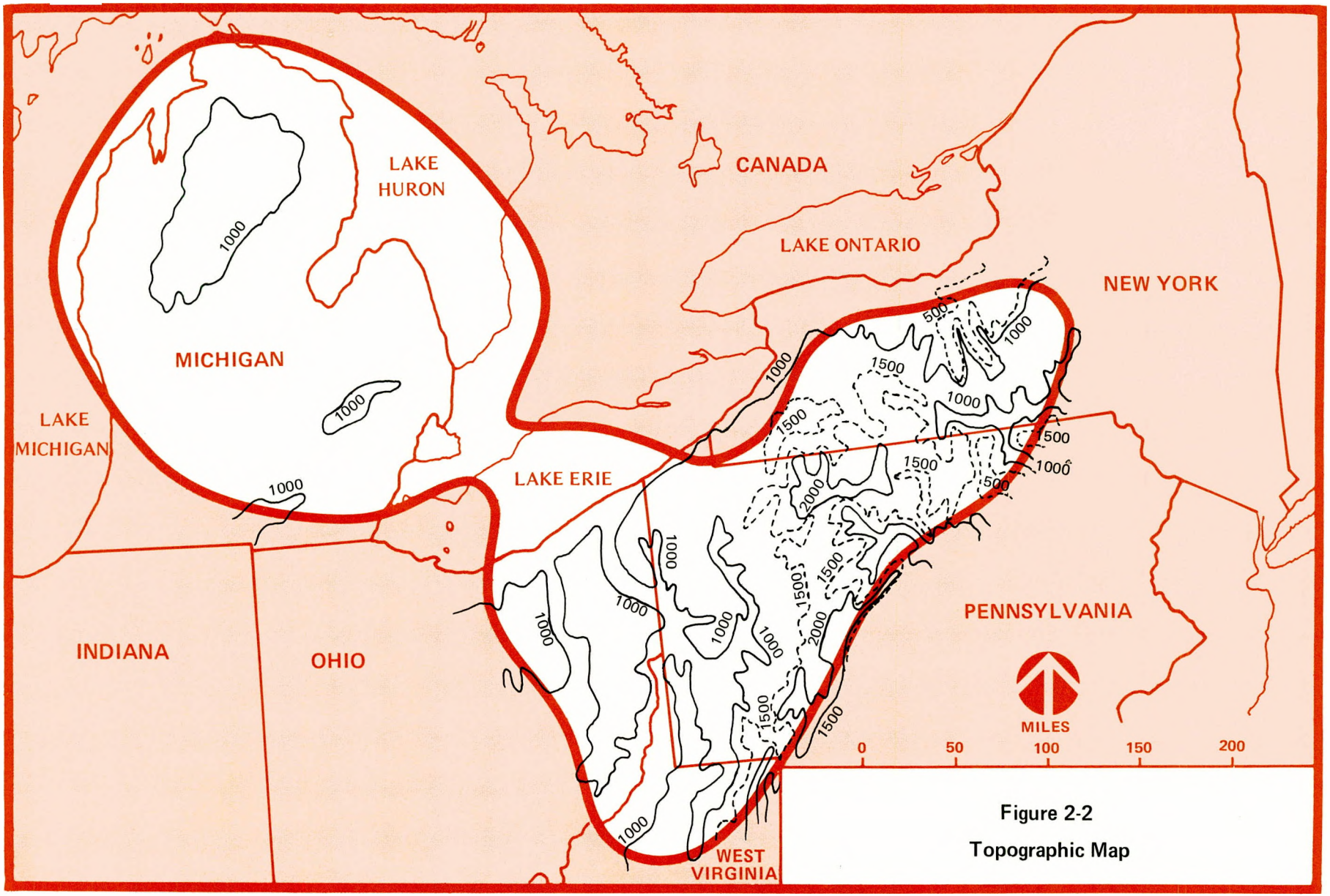


Figure 2-2

Topographic Map

NOTE: Contour interval 500 feet, Datum is mean sea level.

Modified from (USGS (1975a)

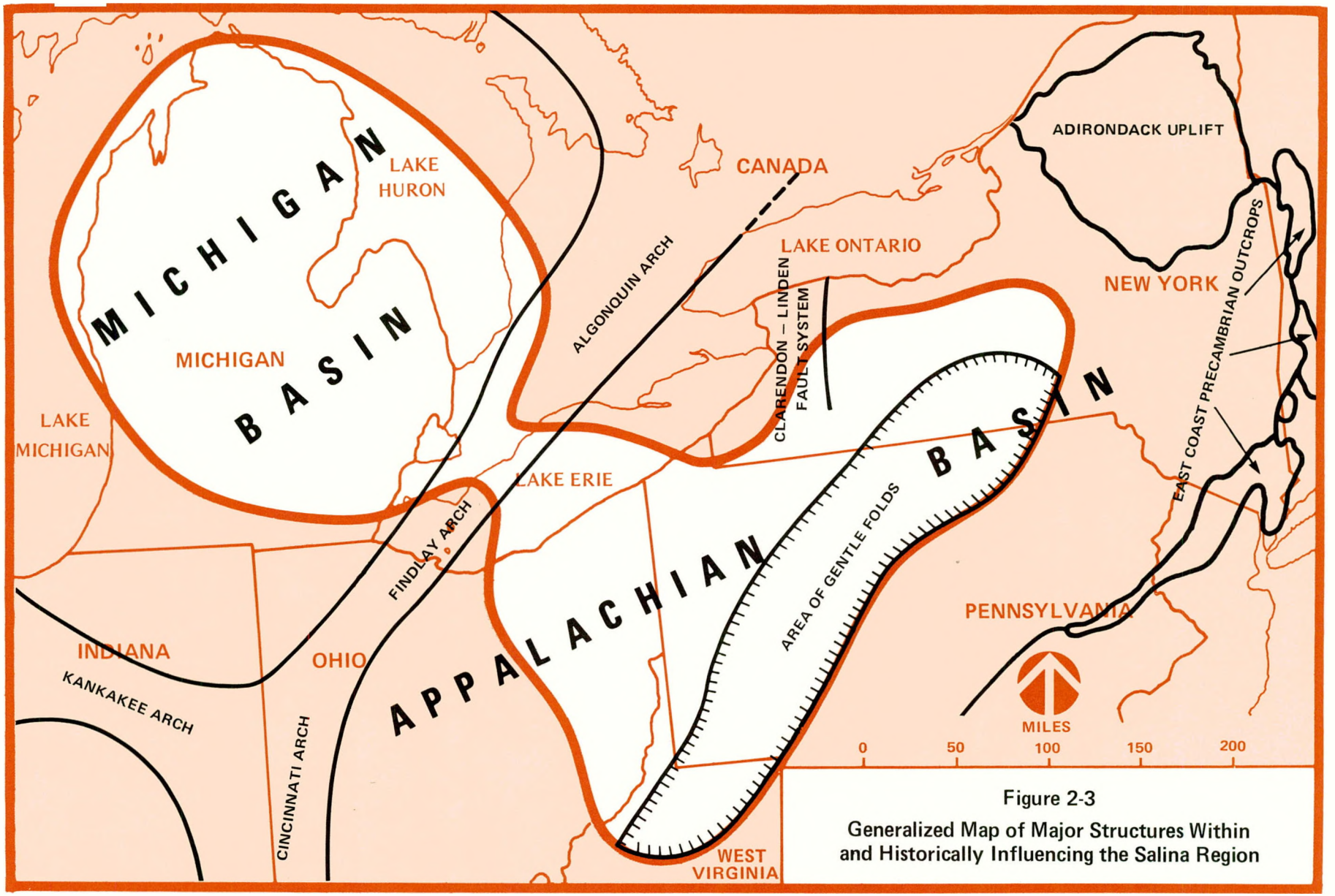


Figure 2-3
Generalized Map of Major Structures Within and Historically Influencing the Salina Region

Adapted from Johnson (1976), Colton (1970), and Stone & Webster (1978)

MICHIGAN[a]				CENTRAL NEW YORK AND WESTERN PENNSYLVANNIA[b]	
DOMINANT ROCK TYPE	APPROXIMATE MAXIMUM THICKNESS (FEET)	SYSTEM AND TIME [c]	ERA	APPROXIMATE THICKNESS (FEET)	DOMINANT ROCK TYPE
UNCONSOLIDATED TILL, GRAVEL, SAND, SILT, AND CLAY	800	QUATERNARY 136-1.8	CENSOZOIC	100+	UNCONSOLIDATED TILL, GRAVEL, SAND, SILTS, AND CLAY
SHALE AND SANDSTONE	220	JURASSIC 225-192.5	MESOZOIC		
		PERMIAN 280	PALEOZOIC		SHALE, SANDSTONE, AND THIN LIMESTONE AND COAL
SHALE, SILTSTONE, SANDSTONE, AND COAL	750	PENNSYLVANIAN 310		1500	SANDSTONE, SHALE, LIMESTONE, AND COAL
SHALE, SILTSTONE, AND LIMESTONE	3050	MISSISSIPPIAN 345		1200	SANDSTONE AND SHALE
DOLOMITE, LIMESTONE, SHALE, SANDSTONE, ANHYDRITE, AND HALITE (SALT)	4315	DEVONIAN 395		4600-5600	SANDSTONE, SHALE, AND LIMESTONE
DOLOMITE, SHALE, ANHYDRITE, AND HALITE (SALT)	5030	SILURIAN 435		2800	LIMESTONE, DOLOMITE, SHALE, SANDSTONE, ANHYDRITE, AND HALITE (SALT)
DOLOMITE, LIMESTONE, SHALE, AND SANDSTONE	2735	ORDOVICIAN 500		3000	LIMESTONE, SHALE, AND SANDSTONE
SANDSTONE AND DOLOMITE	3025+	CAMBRIAN 570		1200	SANDSTONE
PRECAMBRIAN IGNEOUS AND METAMORPHIC ROCKS				IGNEOUS AND METAMORPHIC ROCKS	

ROCK SYSTEMS THAT INCLUDE POSSIBLE STORAGE SALT UNITS

[a] Adapted from Stratigraphic Succession in Michigan, Michigan Department of Conservation, 1964

[b] Adapted from Woodford (1965).

[c] Time in millions of years before present.

NOTE: These columns are highly generalized columns representing the complex geology in both the Michigan and Appalachian basins.

Figure 2-4

Generalized Geologic Column

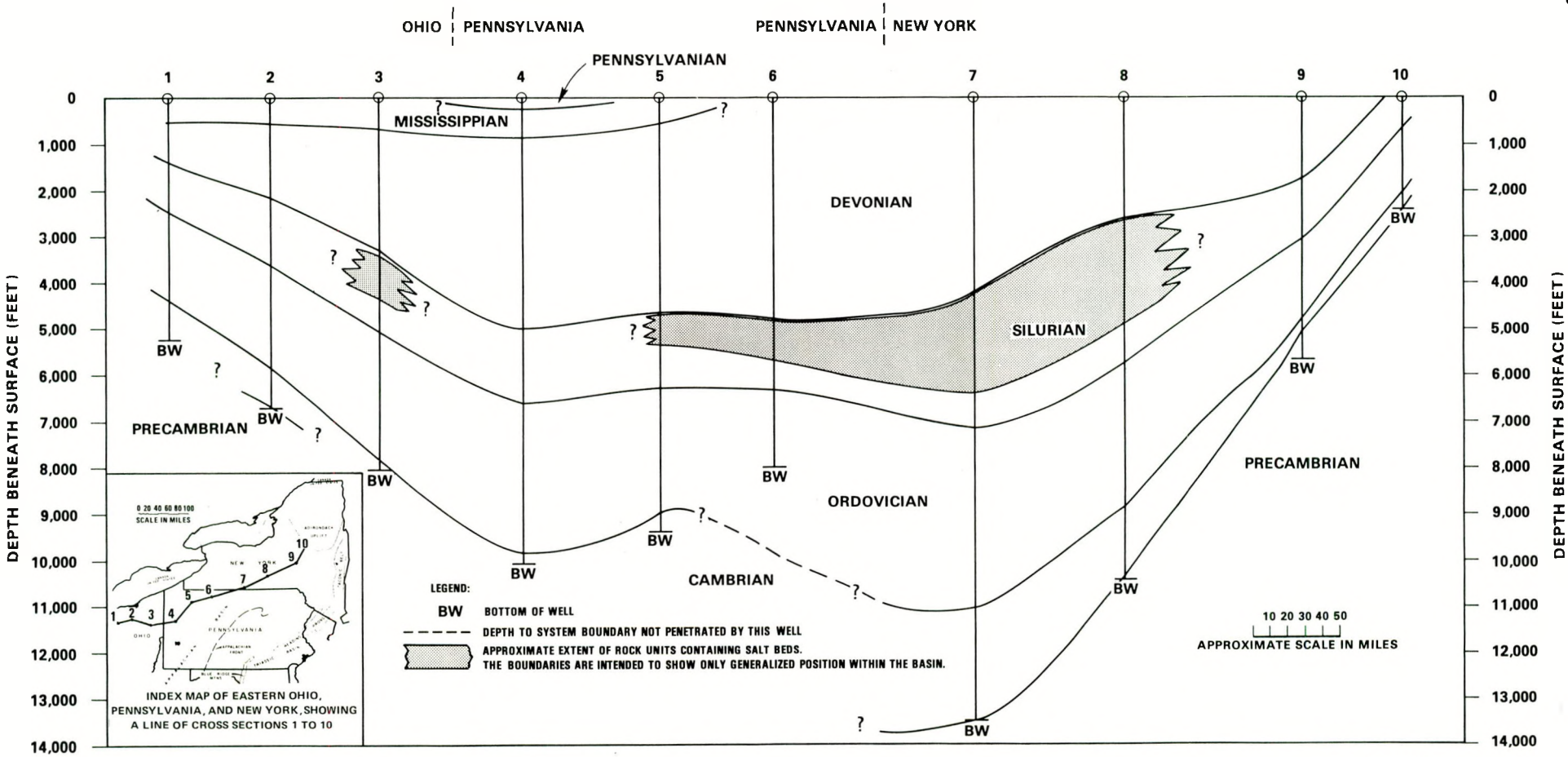


Figure 2-5
Generalized Cross Section of Rock Systems in the Appalachian Basin

Adapted from Adkison, 1966.

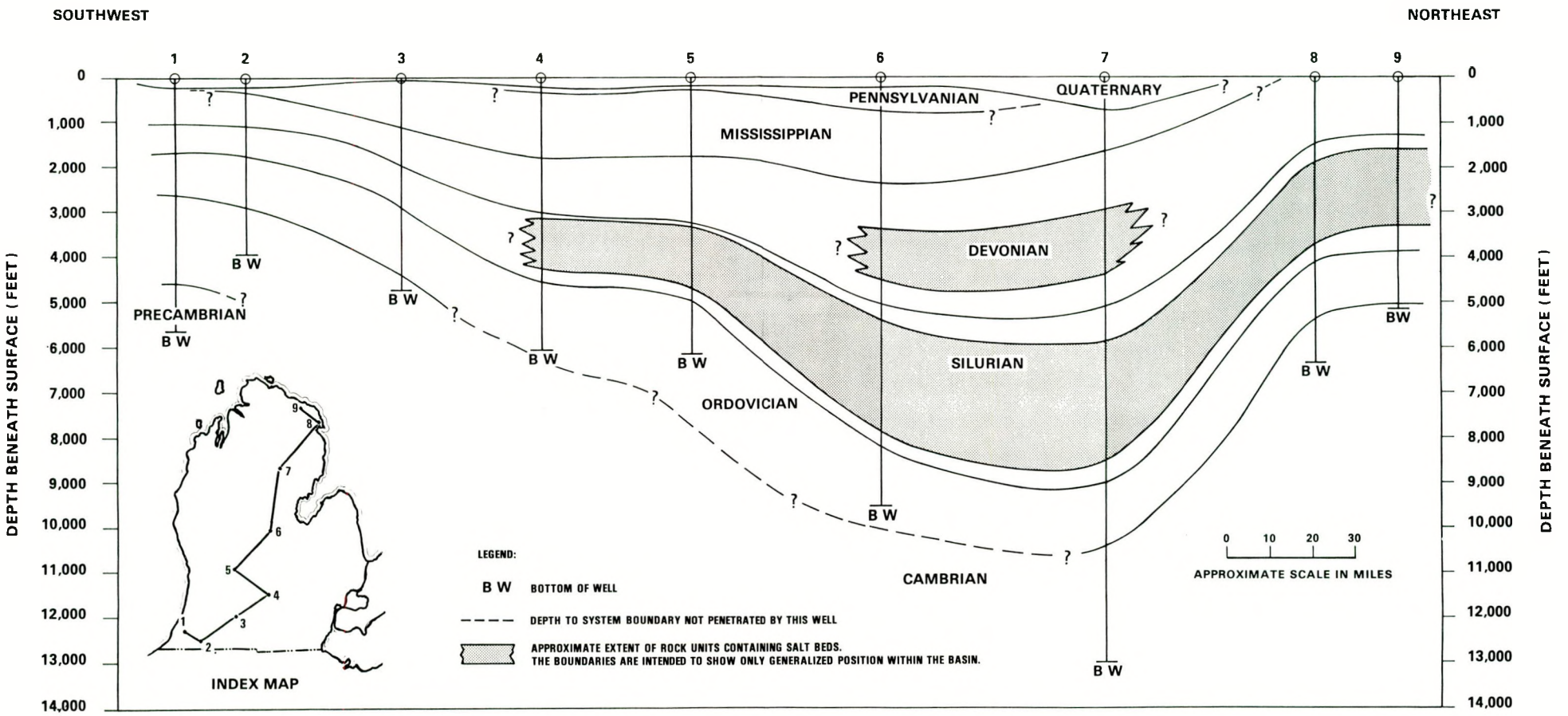


Figure 2-6
Generalized Cross Section
of Rock Systems in the Michigan Basin

Adapted from the Michigan Basin Geological Society (1969)

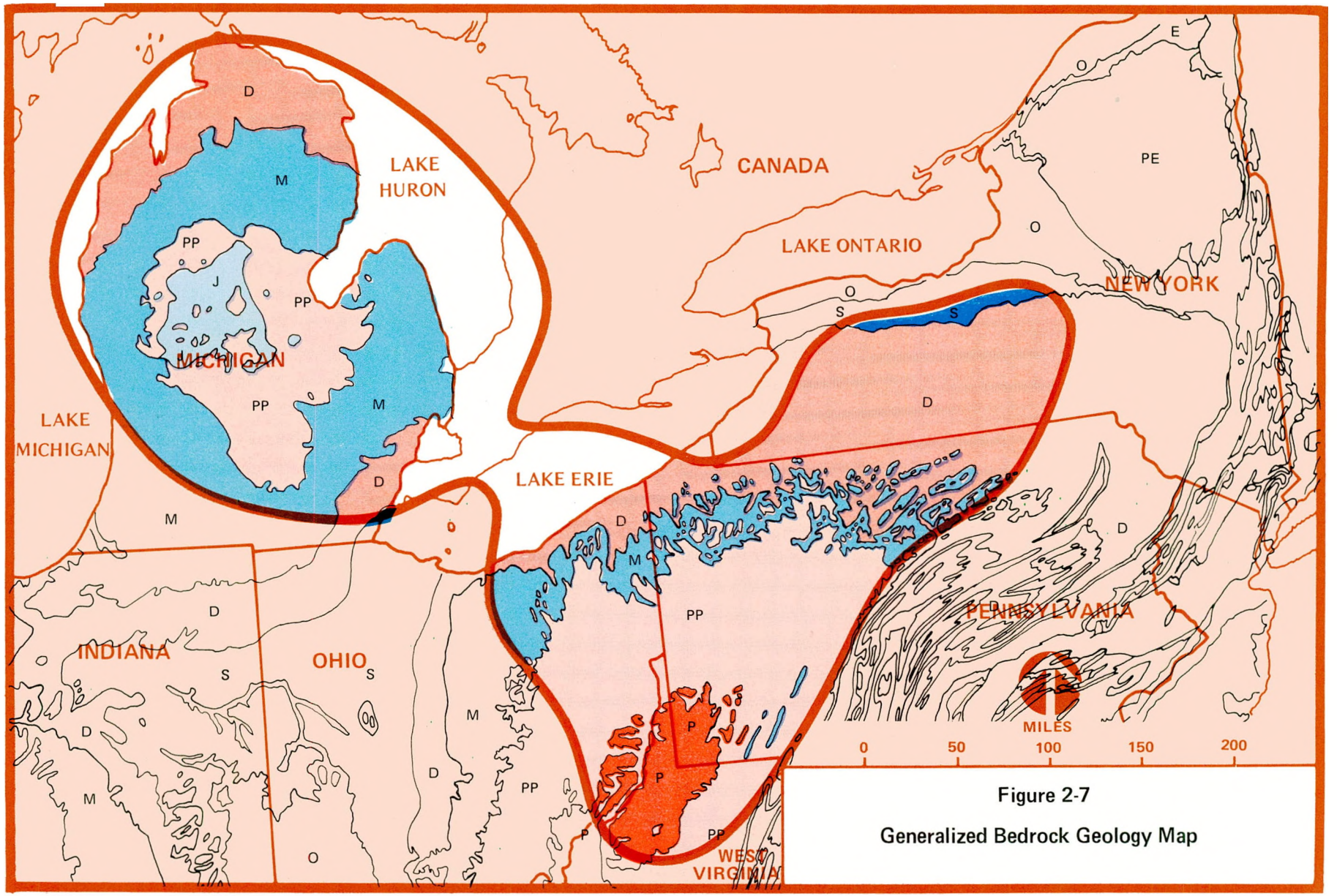


Figure 2-7

Generalized Bedrock Geology Map

Adapted from USGS (1974a)

J JURASSIC
P PERMIAN
PP PENNSYLVANIAN
M MISSISSIPPIAN
D DEVONIAN
S SILURIAN
O ORDOVICIAN
E CAMBRIAN
PE PRECAMBRIAN

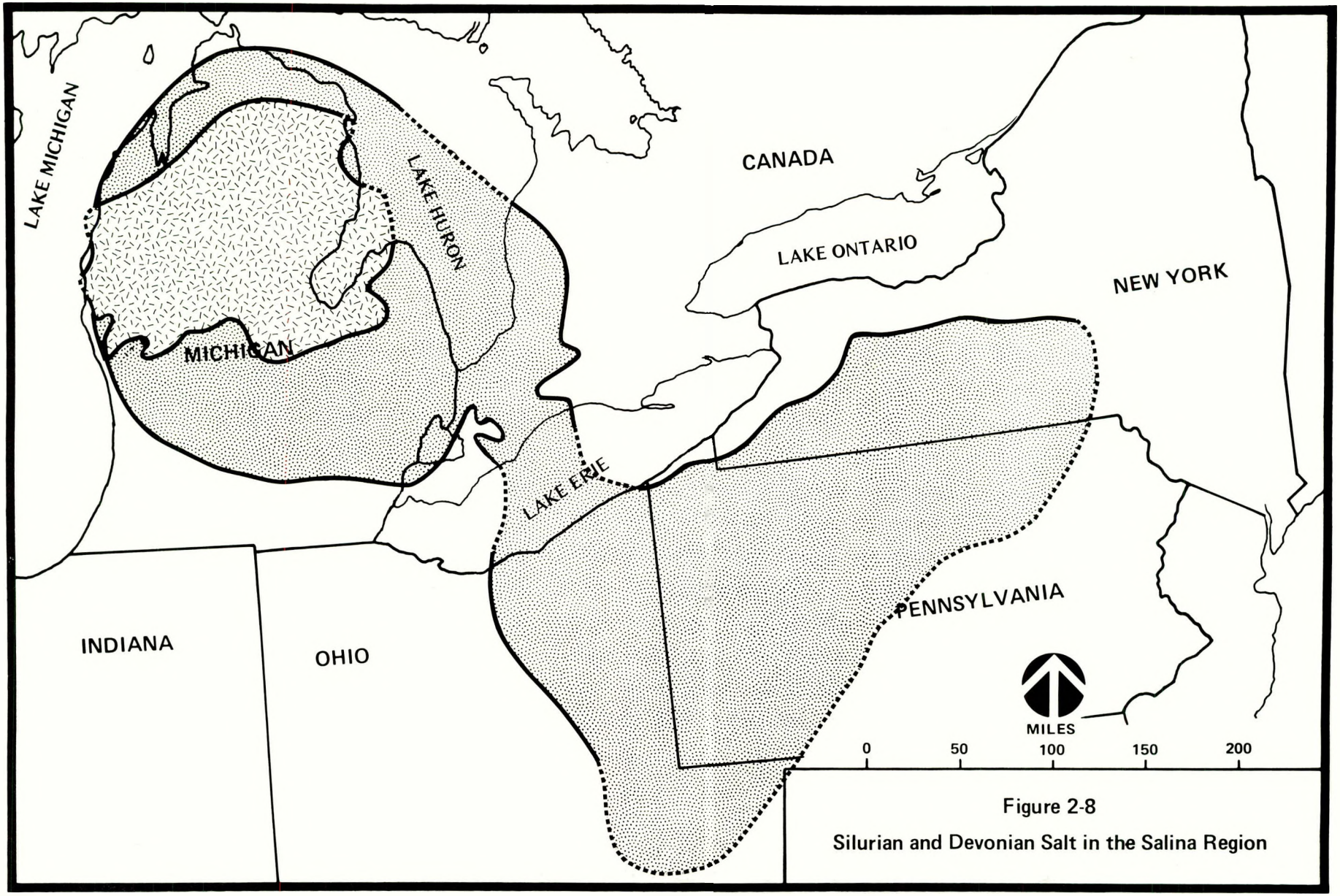


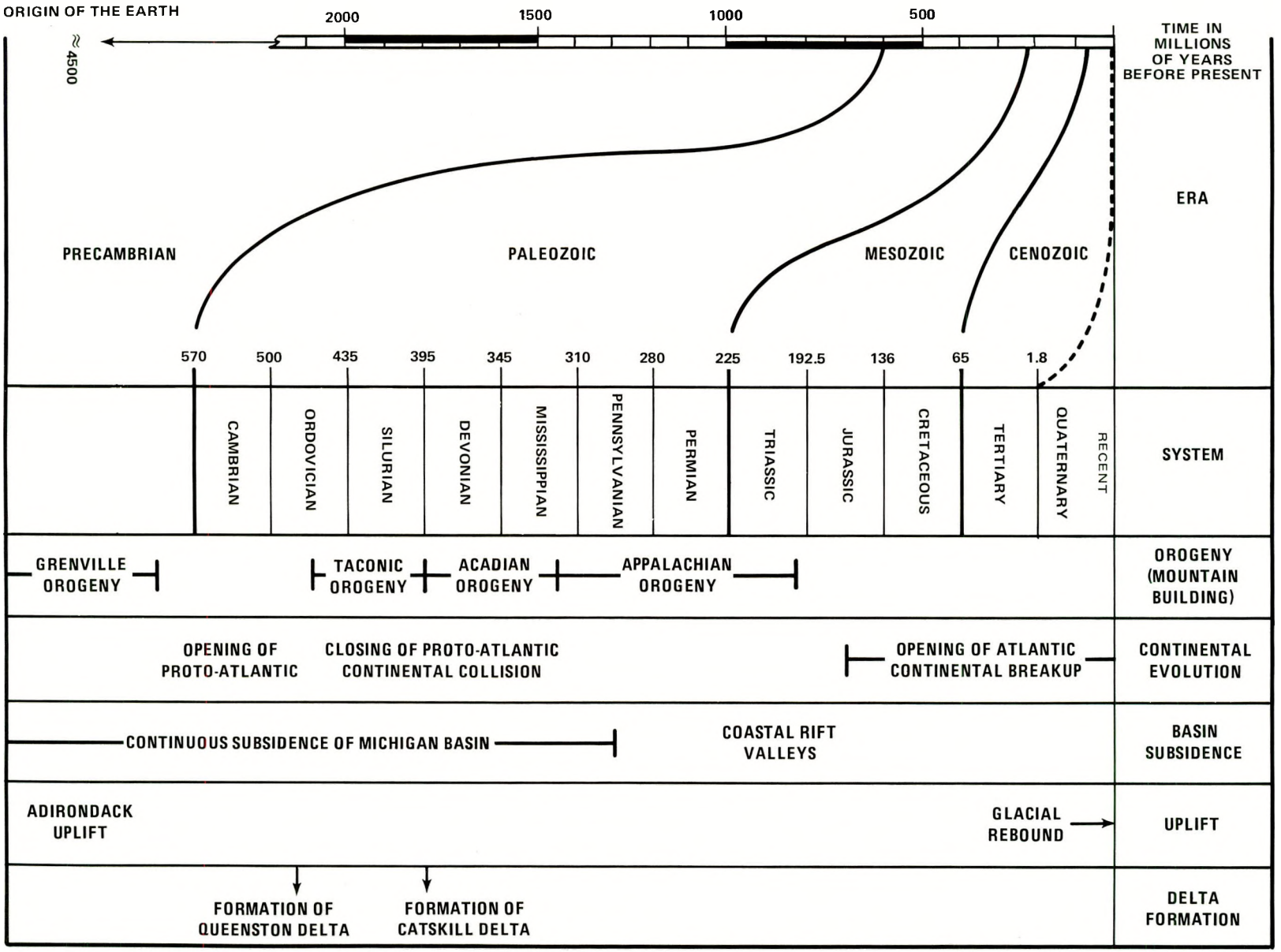
Figure 2-8

Silurian and Devonian Salt in the Salina Region

EXTENT OF SILURIAN ROCK UNITS CONTAINING SALT (after ERDA, 1976)

EXTENT OF DEVONIAN ROCK UNITS CONTAINING SALT (after Stone & Webster, 1978)

NOTE: The boundaries of the portions of the Silurian and Devonian rock units containing salt represent the lines of zero thickness for those salt units, as defined by ERDA (1976) and Stone & Webster (1978).



NOTE: Boundaries of geologic events are from many sources and are approximate.

Figure 2-9

Tectonic Evolution of the Salina Region

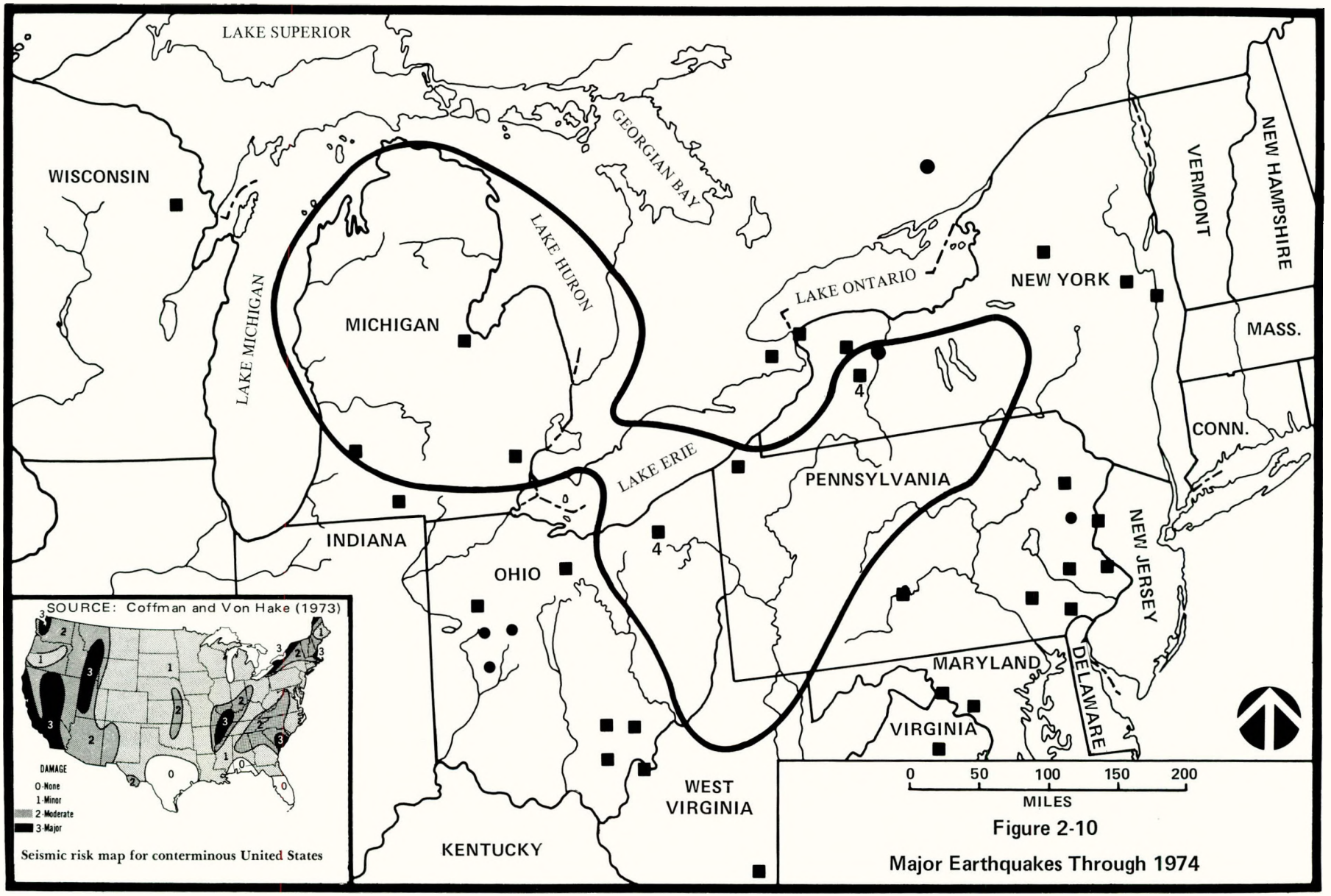


Figure 2-10

Major Earthquakes Through 1974

■ INTENSITY V-VII
● INTENSITY VII-VIII
● INTENSITY VIII-IX

Based on seismic history provided by NOAA's National Geophysical and Solar-Terrestrial Data Center

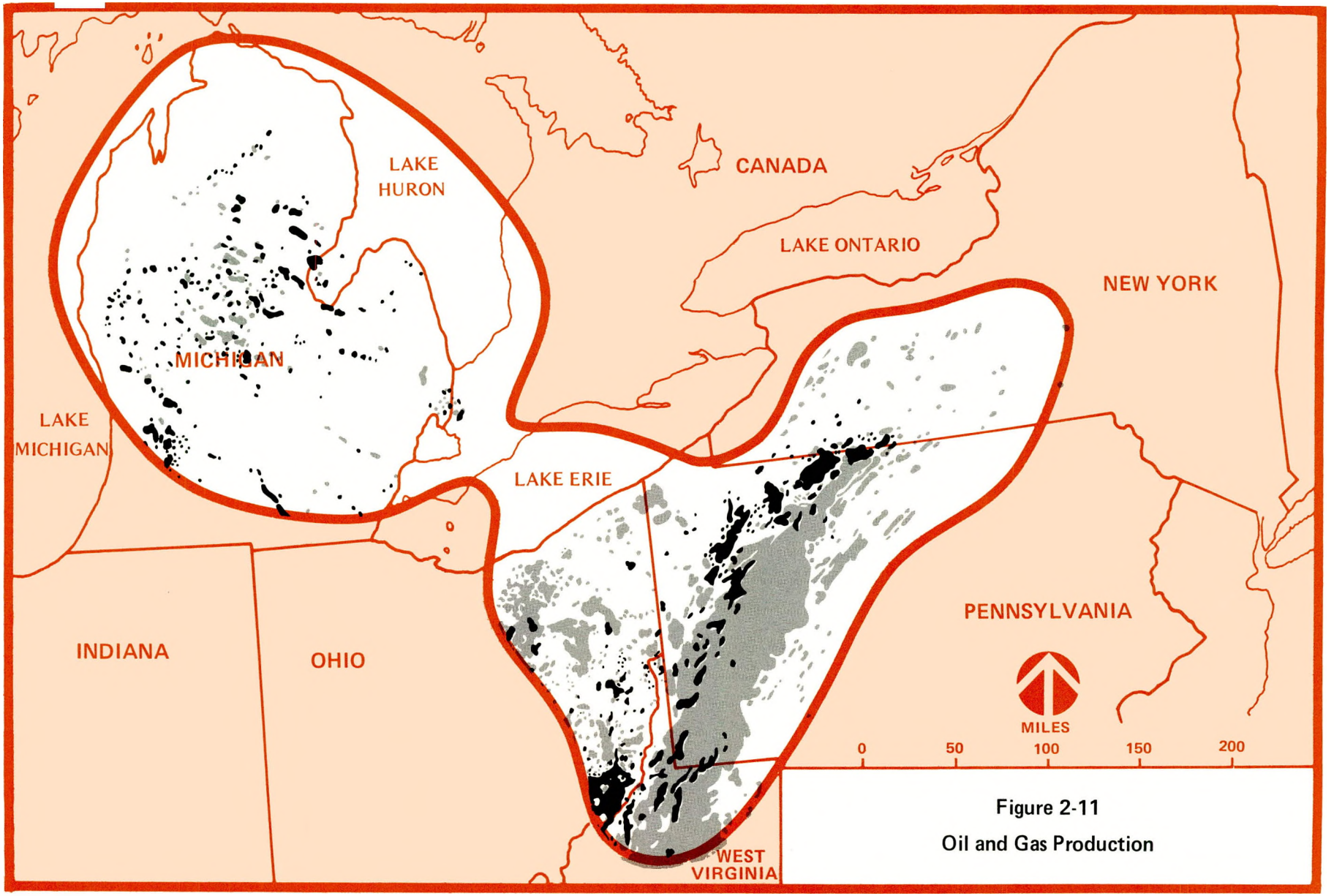


Figure 2-11

Oil and Gas Production

Adapted from USGS (1964a)

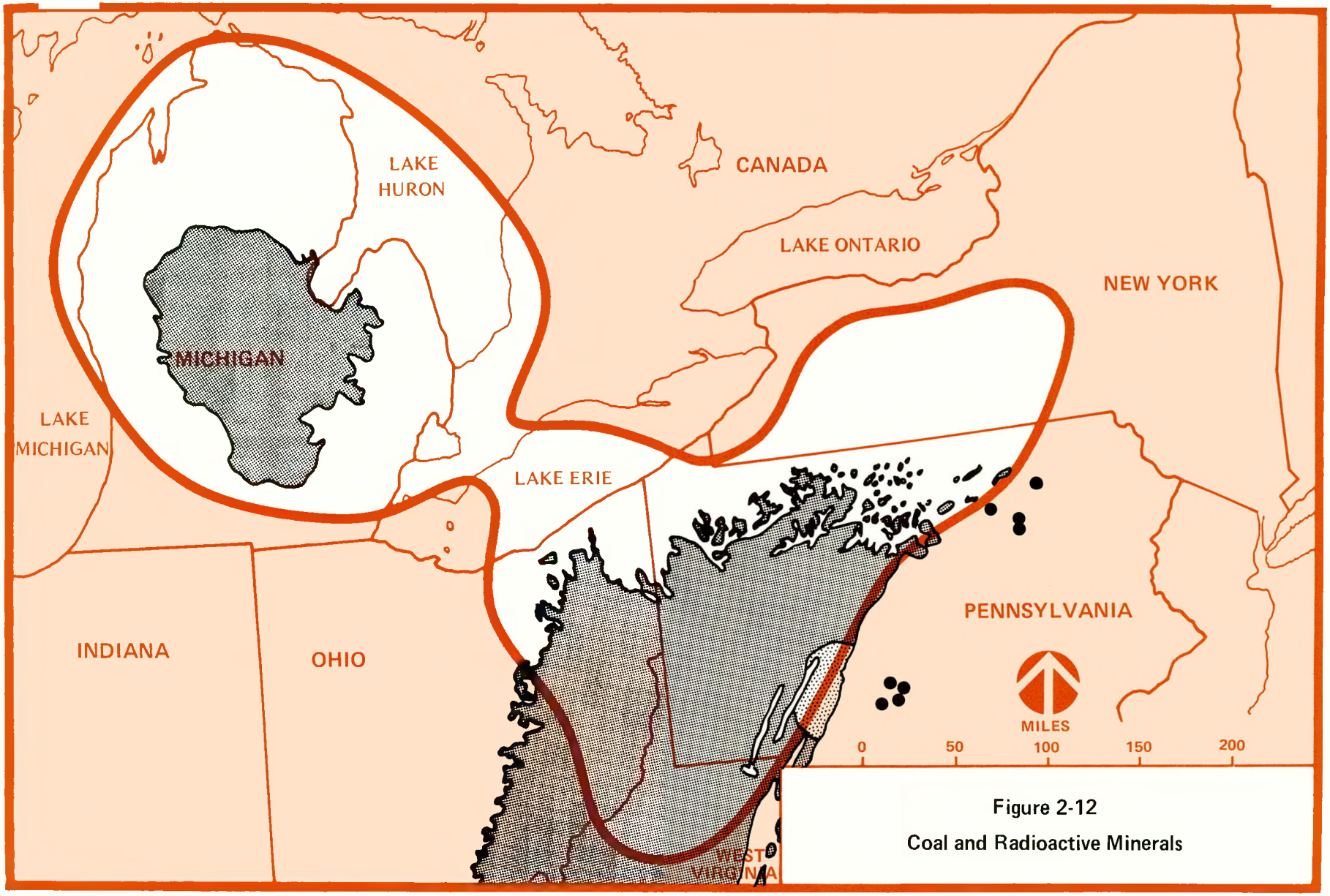


Figure 2-12

Coal and Radioactive Minerals

LOW-VOLATILE BITUMINOUS COAL

MEDIUM- AND HIGH-VOLATILE BITUMINOUS COAL

URANIUM

Adapted from USGS (1960, 1968)

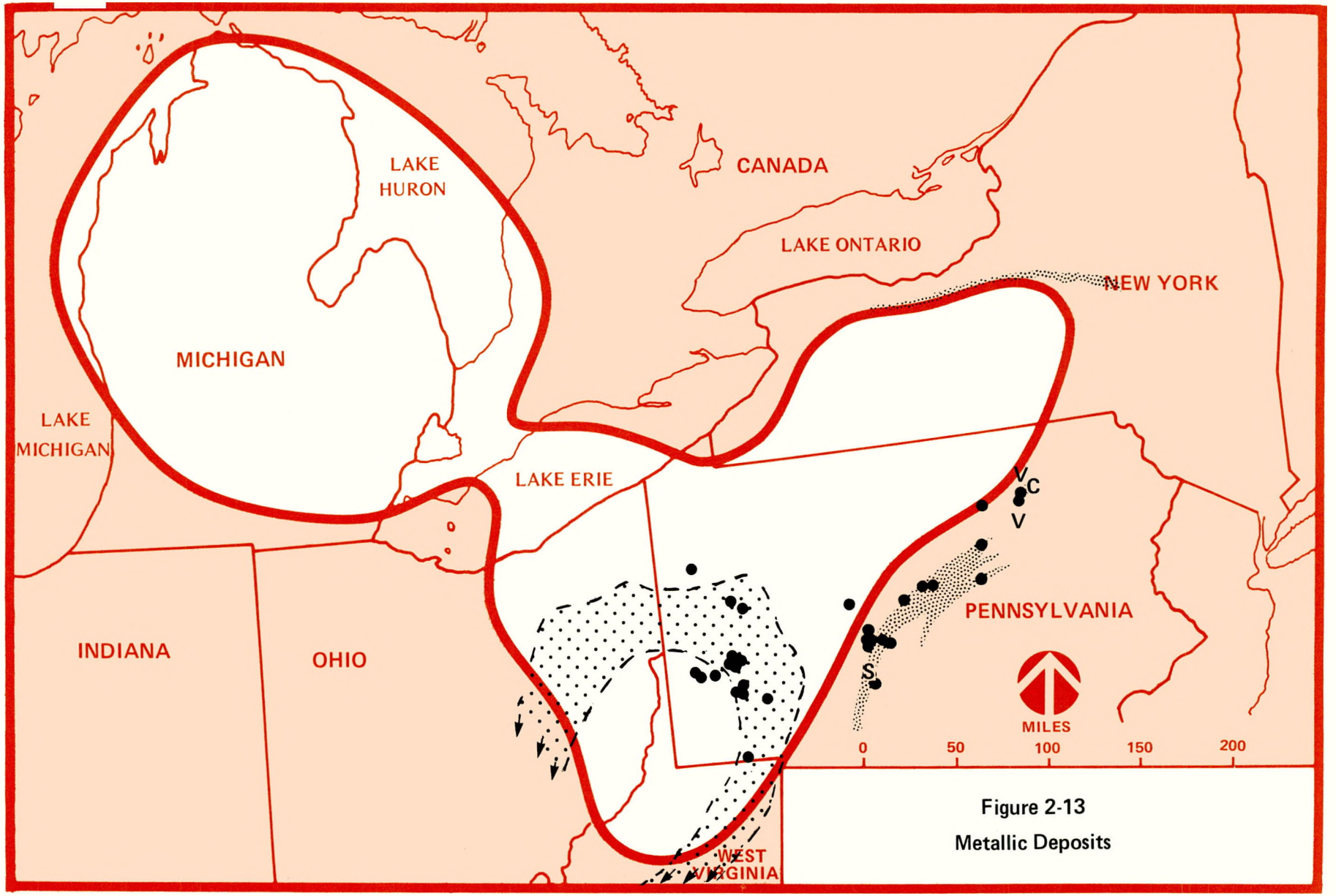


Figure 2-13

Metallic Deposits

IRON ORE

- CLINTON
- LOW-POTENTIAL SIDERITE ORE
- ● LEAD AND ZINC
- C COPPER
- S SILVER
- V VANADIUM

Adapted from USGS (1967a, 1962b, 1967a, 1967b)
Carr et al (1967)
Kinkel et al (1968)
Luttrell and Stansfield (1968)

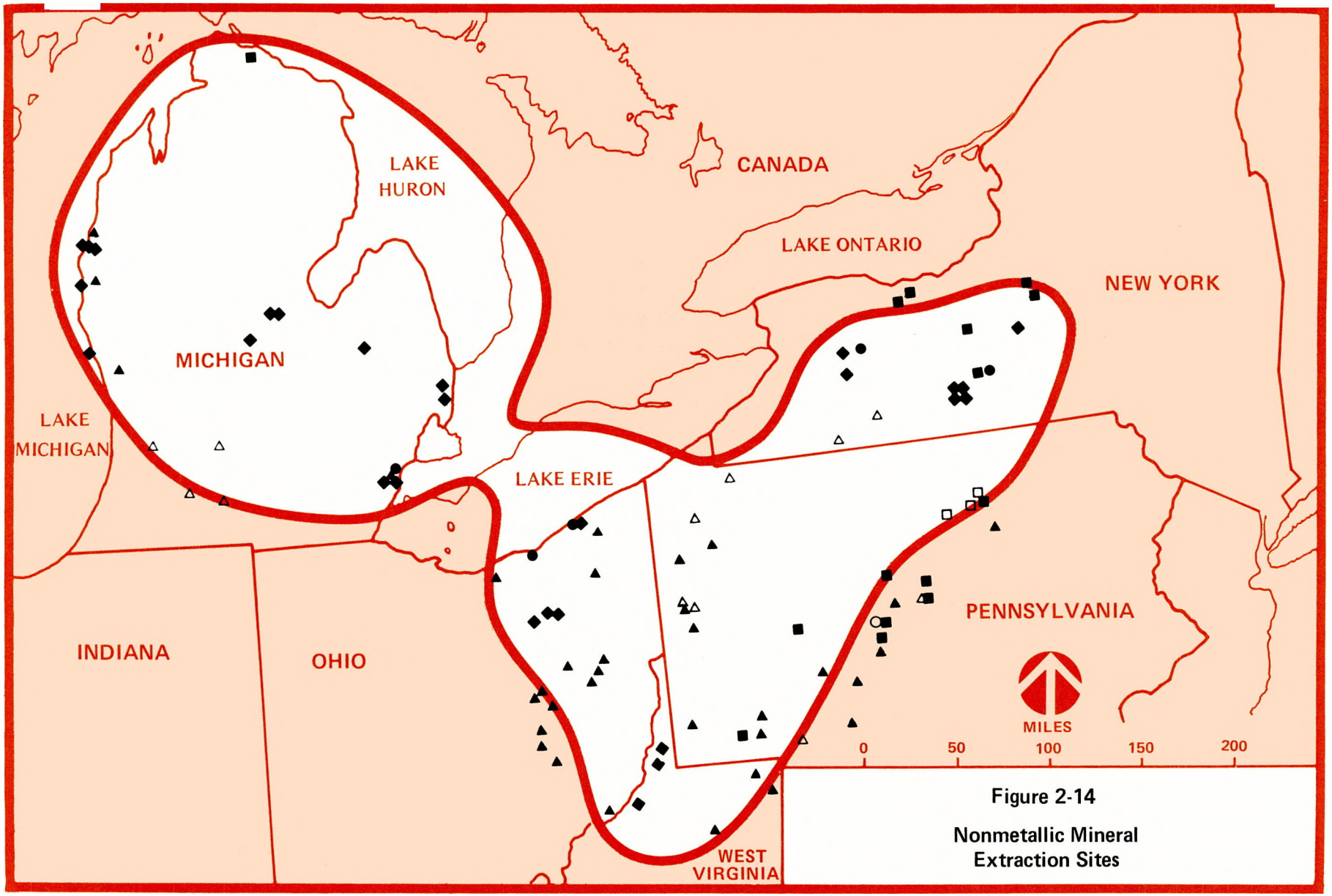


Figure 2-14

Nonmetallic Mineral Extraction Sites

● ACTIVE SALT MINE
◆ ACTIVE SALT BRINE FIELD
△ PEAT
□ PYROPHYLLITE AND TALC
▲ SILICA
○ BARITE
■ FLUORITE

Adapted from USGS (1959, 1964b, 1965, 1974b)
Worl et al (1974)
Industrial Atlas Corporation (1967)
Stone and Webster (1978)

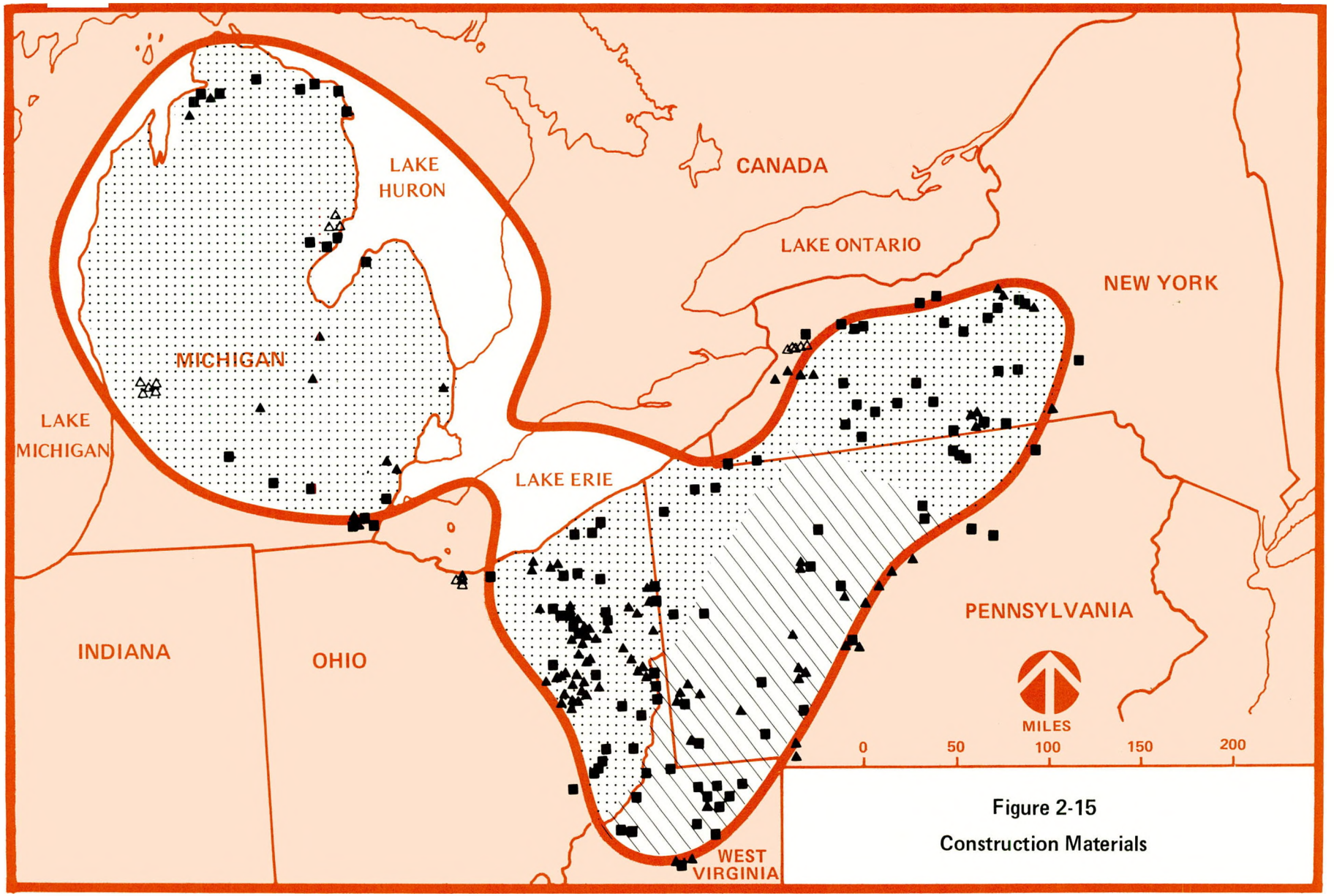


Figure 2-15

Construction Materials

- ■ STONE (LIMESTONE, SANDSTONE, ETC.)
- ▲ SHALE AND CLAY
- △ GYPSUM AND ANHYDRITE

GRAVELS

- GLACIAL DRIFT AND OUTWASH
- LOCAL COLLUVIUM AND ALLUVIUM

Adapted from
Hosterman et al (1968)
Maxwell et al (1968)
USGS (1962c)
Washington (1962)

3.0 HYDROSPHERE

The ground and water resources of a region are major assets. Their protection and enhancement are fundamental to the well-being of the human settlements and biotic communities they sustain. The capability to use a geologic rock unit for a waste repository without risk of contaminating vital water resources is a fundamental precept guiding the search for candidate repository locations. An important feature sought in a geologic rock unit being considered for storing wastes is isolation from both surface-water and groundwater resources. Such an attribute is a way of ensuring mine stability in the near term and avoiding the risk that leachates containing radionuclides may be transported into man's environment during the long residual period before the radioactivity decays to innocuous levels.

On the basis of the regional boundaries developed by the U.S. Water Resources Council (1970) for identifying major river basins in the United States, the Salina Region can be divided into three Hydrologic Regions (HR), as shown in Figure 3-1. Hydrologic Region I covers the southeastern part of the Great Lakes Region; HR II, the northwestern corner of the Mid-Atlantic Region; and HR III, the northeastern part of the Ohio Region. The hydrologic characterization of the Salina Region is presented on the basis of the three HRs. When sufficient data are available, a more detailed discussion by subregion within each HR is also included.

On an area-wide scale, the characterization is associated with the features that are broadly descriptive of surface water and groundwater. In order to be systematic in the presentation, the surface-water regime is discussed in terms of physical description, runoff, water quality, and water use, while the groundwater regime is discussed in terms of physical description, water yield, water quality, and water use.

3.1 SURFACE WATERS

3.1.1 HYDROLOGIC REGION I

3.1.1.1 Physical Description

Hydrologic Region I, as shown in Figure 3-1, covers the lower Michigan Peninsula, the northeast corner of Ohio, the northwest corner of Pennsylvania, and a portion of western New York. Hydrologically, HR I belongs to the drainage area of Lake Michigan, Lake Huron, Lake Erie, and Lake Ontario. Because of continuous glaciation over many thousands of years, the terrain of HR I is characterized by flat land, lakes, marshes, and peat bogs, reflecting the poor development of regional drainage systems. The streams are relatively short and follow the lows of the glaciated topography. The divides separating basins are characteristically broad and vary from almost level plains to low rolling hills. The terrain is therefore more conducive to infiltration than to direct, rapid surface runoff. Infiltration is also aided because a great portion of the subsurface material consists of sand and gravel (Great Lakes Basin Commission, 1976).

The hydrologic characteristics of a region are determined largely by its climate. Hydrologic Region I has a continental to semimaritime climate, largely influenced by the atmospheric circulation from west to east and the modifying influences of the Great Lakes. The area is normally humid, with cold winters and cool summers in the north and warm summers in the south. The average frost-free season is 4 to 6 months. Prevailing

winds in the area are generally from the west. Mean annual surface air temperatures range from 39 to 49°F. Minimum and maximum monthly temperatures occur in February and July. The difference in latitude from south to north accounts for the 10°F difference in temperatures. Annual precipitation over most of HR I ranges from approximately 28 to 37 inches, increasing generally from northwest to southeast. Annual snowfall ranges from 40 to 120 inches. Greater precipitation may be caused by higher elevations. The lake effect influences precipitation patterns, with spring and summer precipitation being greater over the land than over the lakes and coastal areas and, conversely, winter precipitation being greater over the lakes and coastal areas than inland. Figure 3-2 shows the isopleths of the mean annual precipitation within HR I (USDI, 1972a,b; 1973a; 1974). Generally speaking, about one-third of the mean annual precipitation, nearly 12 inches, becomes runoff and eventually reaches the surrounding Great Lakes (Great Lakes Basin Commission, 1976).

The water available for withdrawal and use in HR I comes primarily from precipitation that falls over the land. Interflows of groundwater from adjacent basins contribute insignificantly to the system. The precipitation that falls into the lakes or remains above ground in streams and rivers is immediately accessible for use. The precipitation that percolates deep into the soil may enter aquifers that underlie much of the area. Water that percolates to relatively shallow depths in the soil maintains the base flow in the streams of the area. The soils of HR I are for the most part developed from glacial drift, which allows water to infiltrate.

Reservoirs are used to control stream flows so that various water management alternatives can be applied. Existing reservoirs with more than 500 acres of available surface area in HR I are listed in Table 3-1 and shown in Figure 3-3 (Great Lakes Basin Commission, 1976, Appendix 2).

3.1.1.2 Runoff

Nearly all surface-water runoff from tributary streams in HR I is supplied from precipitation; only minor contributions to runoff come from municipal and industrial withdrawals of water from subsurface aquifers. The annual runoff in HR I varies from 9 to 38 inches, the average being 11.6 inches. The annual runoff is significantly influenced by temperature, vegetation, terrain, surficial features, land use, and geology. Isopleths for the mean annual runoff for HR I are shown in Figure 3-4 (USDI, 1972a, b; 1973a; 1974). Table 3-2 presents the average, maximum, and minimum discharges for selected gaging stations (shown in Figure 3-5) within or immediately adjacent to HR I (USDI, 1975b, c, e).

Major floods and most damaging floods in HR I are usually the result of rain and snowmelt on frozen or nearly saturated ground. Intense summer storms have created destructive floods, but these are ordinarily confined to local areas (Great Lakes Basin Commission, 1976, Appendix 14).

3.1.1.3 Water Quality

Although rain and snow contain only traces of dissolved mineral matter, waters that flow in rivers, streams, and impoundments always contain a significant percentage of dissolved solids. These constituents in water originate from the weathering of soils and rocks. The concentration of total dissolved solids is generally a good indicator of water quality and is used to classify water as fresh, brackish, salty, and brine.

TABLE 3-1

MAJOR RESERVOIRS[a] WITHIN OR IMMEDIATELY ADJACENT TO THE SALINA REGION IN HR I

No.[c]	Reservoir	River	Total Storage Capacity[b] (acre-feet)	Area (acres)
		MICHIGAN		
1	--	Grand River	--	600
2	--	Grand River	--	660
3	--	Manistee River	--	1,540
4	--	Muskegon River	--	610
5	--	Muskegon River	--	1,380
6	--	Penoyer Creek	--	3,970
7	--	Manistee River	--	2,025
8	--	Huron River	--	975
9	--	Huron River	--	1,425
10	Morrow Lake	Kalamazoo River	6,000	1,000
11	Lake Allegan	Kalamazoo River	17,200	1,600
12	Alcona Pond	Au Sable River	--	1,075
13	Cooke Dam	Au Sable River	--	1,800
14	Fletcher Pond	Upper South Branch, Thunder Bay	--	1,850
15	Hubbard Lake	Lower South Branch, Thunder Bay	30,000	8,800
		OHIO		
16	--	Bridge Creek	18,110	1,500
17	--	Cuyahoga River	7,060	769
18	--	Little Cuyahoga River	6,900	900
		NEW YORK		
19	Canadice Lake	Canadice Outlet	--	640
20	Conesus Lake	Conesus Creek	--	3,200
21	Hemlock	Hemlock Outlet	--	1,860
22	Rushford Lake	Caneadea Creek	--	580
23	Silver Lake	Silver Lake Outlet	--	770
24	Honeoye Lake	Honeoye Creek	--	1,790
25	Mount Morris	Genesee River	337,000	3,680
26	Salmon Reservoir	Salmon River	--	2,640
27	Canandaigua Lake	Canandaigua Outlet	--	10,600
28	Cayuga Lake	Seneca River	--	42,500
29	Cazenovia Lake	Chittenango Creek	--	1,060
30	De Ruyter Reservoir	Limestone Creek	--	560

TABLE 3-1 (Continued)

No.[c]	Reservoir	River	Total Storage Capacity[b] (acre-feet)	Area (acres)
		NEW YORK (continued)		
31	Keuka Lake	Keuka Outlet	--	11,200
32	Oneida Lake	Oneida River	--	51,100
33	Otisco Lake	Ninemile Creek	--	2,200
34	Owasco Lake	Owasco Outlet	--	6,650
35	Seneca Lake	Seneca River	--	42,700
36	Skaneateles Lake	Skaneateles River	--	8,840

a. Larger than 500 acres.

b. Total storage capacity is the capacity below the lowest uncontrolled outlet or spillway.

c. Index for Figure 3-3.

TABLE 3-2

DISCHARGE DATA FOR GAGES WITHIN OR IMMEDIATELY ADJACENT TO THE SALINA REGION IN HR I

No.[a]	River	Location	Drainage Area (miles^2)	Period of Record	Discharge (cfs) Avg.	Min.	Max.
1	Kalamazoo River	Near Comstock, Mich.	1010	1932-75	839	119	6,910
2	Grand River	Lansing, Mich.	1230	1934-75	829	2.8	24,500
3	Grand River	Grand Rapids, Mich.	4900	1930-75	3534	381	54,000
4	Manistee River	Near Manistee, Mich.	1780	1952-75	1987	992	6,980
5	Muskegon River	Newaygo, Mich.	2350	1930-75	1947	52	14,950
6	Au Sable River	Mio, Mich.	1100	1952-75	988	18	4,160
7	Au Gres River	Near National City, Mich.	169	1950-75	979	5.9	2,500
8	Tittabawassee River	Midland, Mich.	2400	1936-75	1645	39	34,000
9	Cass River	Cass City, Mich.	370	1947-75	197	0.5	8,460
10	Black River	Near Fargo, Mich.	475	1944-75	276	1.8	14,400
11	Huron River	Ann Arbor, Mich.	729	1948-75	449	21	3,140
12	Cazenovia Creek	Ebenezer, N.Y.	134	1941-75	221	2.6	13,500
13	Genesee River	Portageville, N.Y.	981	1909-75	1227	18	90,000
14	Fall Creek	Near Ithaca, N.Y.	126	1926-75	183	3	15,500

a. Index for Figure 3-5.

The entire HR I contains generally nonsaline water, with the exception of the area between Cleveland and Ashtabula along the Lake Erie shoreline, where the water becomes salty (Geraghty, 1973). Table 3-3 presents data on the surface-water quality, in terms of specific conductance, of HR I by selected water quality stations (shown in Figure 3-6) (USDI, 1975c, e, g).

3.1.1.4 Water Use

Present and projected water demands are indicative of trends in the utilization and management of water resources in the environment. Since no study has been conducted on water use in HR I, statistics can only be presented by five subregions that cover the approximate area of HR I. These five subregions--East Lake Michigan (404), Lake Huron (405), St. Clair-West Lake Erie (406), Eastern Lake Erie (407), and Lake Ontario (408)--are defined by the U.S. Water Resources Council and are shown in Figure 3-7 to relate their location to HR I.

Tables 3-4A through 3-4E present data on the present and projected water uses in the five subregions by major category of use: agriculture, steam-electricity generation, manufacturing, domestic, commercial, mineral, public lands, fish hatchery, and miscellaneous purposes (U.S. Water Resources Council, 1978).

3.1.2 HYDROLOGIC REGION II

3.1.2.1 Physical Description

Hydrologic Region II, as shown in Figure 3-1, covers a section of midcentral Pennsylvania and a part of western New York. The entire region is located in the headwaters area of the Susquehanna River, which flows southeasterly through Pennsylvania and Maryland, and empties into Chesapeake Bay. The two major tributaries of the Susquehanna River that flow through HR II are the West Branch of the Susquehanna River and the Chemung River. Hydrologic Region II lies within the Appalachian Plateaus physiographic province, which is characterized by deeply eroded, steep-sided, flat-bottomed valleys and flat to gently rolling plateaus varying in relief from several hundred feet in New York to nearly 2000 feet in Pennsylvania. This type of landscape apparently tends to shorten the time needed for precipitation to accumulate in the stream and consequently promotes the possibility of flooding (Susquehanna River Basin Committee, 1970).

The climate of HR II is closely associated with the hydrologic characteristics of the region; it is continental, modified somewhat by the moisture periodically entering the area from the Gulf of Mexico and the Atlantic Ocean. Atmospheric conditions within HR II are controlled primarily by high- and low-pressure systems that normally move eastward across the United States. Weather changes are frequent, with high-pressure systems usually bringing west to northwest winds, lower temperatures, and clearing skies, while low-pressure systems normally bring southerly winds, rising temperatures, and some form of precipitation. Mean annual temperature ranges from 45°F in the New York portion of HR II to 55°F at the southern edge of HR II.

The south boundary of Tioga County in Pennsylvania serves as an approximate divide of land glaciation for HR II. The area north of this boundary is the glaciated portion of the Appalachian Plateaus province and has generally good to poor soil infiltration capacity; the area south of this boundary is unglaciated and has excellent to good soil infiltration capacity. Evapotranspiration in HR II ranges from 17 to 20 inches annually (Susquehanna River Basin Committee, 1970).

TABLE 3-3

CONDUCTIVITY DATA FOR GAGES WITHIN OR IMMEDIATELY ADJACENT TO THE SALINA REGION IN HR I

No.[a]	River	Location	Drainage Area (miles^2)	Period of Record	Daily Specific Conductance (μmhos) Minimum	Maximum
		MICHIGAN				
1	Kalamazoo River	Saugatuck	2,020	1974-75	321	590
2	Muskegon River	Near Bridgeton	2,420	1974-75	282	397
3	Manistee River	Manistee	2,000	1974-75	290	1,680
4	Cheboygan River	Cheboygan	1,500	1974-75	140	900
5	Rifle River	Near Sterling	320	1974-75	157	480
6	Saginaw River	Saginaw	6,060	1974-75	324	1,120
7	Clinton River	Mount Clemens	734	1974-75	254	1,440
8	Detroit River	Detroit	228,800	1974-75	200	290
		PENNSYLVANIA				
9	West Branch, French Creek	Near Hornby	--	1974-75	200	254
		OHIO				
10	Ashtabula River	Ashtabula	136	1968-71	50	2,980
11	Grand River	Painesville	701	1950-52 1962-68 1970-71	300	30,300
12	Cuyahoga River	Cleveland	794	1964-71	450	3,020
13	West Branch, Black River	Elyria	170	1969-71	168	922

TABLE 3-3 (Continued)

No.[a]	River	Location	Drainage Area (miles^2)	Period of Record	Daily Specific Conductance (μmhos) Minimum	Maximum
		NEW YORK				
14	Genesee River	Rochester	2,457	1974-75	418	880
15	Cattaraugus Creek	Irving	554	1974-75	370	450
16	Tonawanda Creek	Millersport	357	1974-75	342	950

a. Index for Figure 3-6.

TABLE 3-4A

PRESENT AND PROJECTED WATER USE IN THE EAST LAKE MICHIGAN SUBREGION (404)

Use Category	Surface-Water and Groundwater Withdrawals (mgd)		
	1975[a]	1985	2000
Agriculture	78	107	137
Steam-electricity	1153	877	418
Manufacturing	498	169	136
Domestic	229	264	306
Commercial	66	72	80
Mining	71	90	119
Public lands	1	2	2
Fish hatcheries	9	9	9
Miscellaneous	--	--	--
TOTAL	2105	1590	1207

SOURCE: U.S. Water Resources Council, The Nation's Water Resources. The Second National Assessment of Water and Related Land Resources, 1978.

a. The total groundwater withdrawal for 1975 was 319 mgd.

TABLE 3-4B

PRESENT AND PROJECTED WATER USE
IN THE LAKE HURON SUBREGION (405)

Use Category	Surface-Water and Groundwater Withdrawals (mgd)		
	1975[a]	1985	2000
Agriculture	16	20	25
Steam-electricity	1100	519	118
Manufacturing	679	153	127
Domestic	93	111	132
Commercial	31	35	40
Mining	73	92	119
Public lands	<1	1	1
Fish hatcheries	--	--	--
Miscellaneous	--	--	--
TOTAL	1993	931	562

SOURCE: U.S. Water Resources Council, The Nation's Water Resources. The Second National Assessment of Water and Related Land Resources, 1978.

a. The total groundwater withdrawal for 1975 was 91 mgd.

TABLE 3-4C

PRESENT AND PROJECTED WATER USE
IN THE ST. CLAIR-WEST LAKE ERIE SUBREGION (406)

Use Category	Surface-Water and Groundwater Withdrawals (mgd)		
	1975[a]	1985	2000
Agriculture	26	30	36
Steam-electricity	5402	4114	1529
Manufacturing	3115	1015	703
Domestic	932	1048	1200
Commercial	215	236	265
Mining	137	179	242
Public lands	--	--	--
Fish hatcheries	--	--	--
Miscellaneous	--	--	--
TOTAL	9827	6622	3975

SOURCE: U.S. Water Resources Council, The Nation's Water Resources. The Second National Assessment of Water and Related Land Resources, 1978.

a. The total groundwater withdrawal for 1975 was 258 mgd.

TABLE 3-4D

PRESENT AND PROJECTED WATER USE
IN THE EASTERN LAKE ERIE SUBREGION (407)

Use Category	Surface-Water and Groundwater Withdrawals (mgd)		
	1975[a]	1985	2000
Agriculture	15	18	21
Steam-electricity	4295	4658	3530
Manufacturing	2668	776	492
Domestic	560	597	649
Commercial	188	197	212
Mining	61	73	90
Public lands	--	--	--
Fish hatcheries	--	--	--
Miscellaneous	--	--	--
TOTAL	7787	6319	4994

SOURCE: U.S. Water Resources Council, The Nation's Water Resources. The Second National Assessment of Water and Related Land Resources, 1978.

a. The total groundwater withdrawal for 1975 was 143 mgd.

TABLE 3-4E

PRESENT AND PROJECTED WATER USE
IN THE LAKE ONTARIO SUBREGION (408)

Use Category	Surface-Water and Groundwater Withdrawals (mgd)		
	1975[a]	1985	2000
Agriculture	24	27	32
Steam-electricity	1771	4691	7304
Manufacturing	339	138	116
Domestic	197	224	262
Commercial	59	66	75
Mining	59	76	106
Public lands	--	--	--
Fish hatcheries	--	--	--
Miscellaneous	--	--	--
TOTAL	2449	5222	7895

SOURCE: U.S. Water Resources Council, The Nation's Water Resources. The Second National Assessment of Water and Related Land Resources, 1978.

a. The total groundwater withdrawal for 1975 was 149 mgd.

Precipitation averaging nearly 38 inches annually in HR II is the major source of water supply. Average yearly totals range from 32 to 35 inches along the Pennsylvania-New York border and through the midcentral portions of Pennsylvania to as much as 40 inches at the south end of HR II. Isopleths of the mean annual precipitation in HR II are shown in Figure 3-2 (USDI, 1973a, 1974).

Gaged major reservoirs within or immediately adjacent to HR II are listed in Table 3-5 and shown in Figure 3-3 (USDI, 1975a, g).

3.1.2.2 Runoff

Mean annual runoff in HR II varies from about 15 to 25 inches. About 50% of the mean annual runoff occurs during the 3-month period from March through May, with only about 18% occurring during the 5 months from June through October. The month of greatest runoff is usually March, and that of least flow is usually August or September. Long-term mean annual runoff in HR II is shown in Figure 3-4 (USDI, 1973a, 1974). Table 3-6 presents the average, maximum, and minimum discharges for selected gaging stations (shown in Figure 3-5) within or immediately adjacent to HR II (USDI, 1975a, g).

Generally, floods occur each year in HR II, and major floods can occur in all seasons of the year. Flooding is, however, more frequent in early spring, usually in March. Major floods have been caused by heavy rainfall on top of heavy snowfall and by heavy rainfall on previously saturated ground. Occasionally, local flooding is caused by ice jams. Flooding over small drainage areas also results from thunderstorms during the summer months. Record floods have occurred at most localities in the area on one of the following dates: June 1889, July 1935, March 1936, May 1946, and June 1972 (Susquehanna River Basin Study Coordinating Committee, 1970, Appendix D).

3.1.2.3 Water Quality

The principal chemical constituents of surface water in HR II are calcium bicarbonate and calcium sulfate. The southern tributaries of the West Branch of the Susquehanna River upstream from Lock Haven are influenced by acid mine drainage from bituminous coal fields. The quantity and quality of the acid mine waste vary seasonally, and the dissolved solids of most streams in this area vary with the amount and concentration of wastewater introduced and with the stream flow. Although the area influenced by acid mine wastewater is large, the dissolved-solids concentration of most streams in HR II seldom exceeds 800 ppm. Most of the southern tributaries of the West Branch of the Susquehanna River have a pH of 4.0 or less. Records for the West Branch of the Susquehanna River at Lock Haven indicate that the pH was higher than 4.5 less than 10% of the time (Durfor and Anderson, 1963). Table 3-7 presents data on the surface-water quality, in terms of specific conductance, of HR II by selected water quality stations (shown in Figure 3-6) (USDI, 1975a, g).

3.1.2.4 Water Use

Present and projected water demands are indicative of trends in the utilization and management of water resources in the environment. Since no study has been conducted on water use in HR II, statistics can only be presented for the Susquehanna Subregion (204). The whole of HR II is located in the Susquehanna Subregion and covers about one-third of the subregion area (see Figure 3-7).

TABLE 3-5

MAJOR RESERVOIRS WITHIN OR IMMEDIATELY ADJACENT TO THE SALINA REGION IN HR II

No.[b]	Reservoir	River	Completion Date	Total Storage Capacity[a] (acre-feet)	Area (acres)	Use[c]
		NEW YORK				
37	Canadarago Lake	Oaks Creek	--	--	1895	FC, R
38	East Sidney Lake	Ouleout Creek	1950	33,550	--	FC, R
39	Whitney Point Lake	Otselic River	1942	86,440	--	FC, R
40	Arkport Reservoir	Canisteo River	1940	7,936	--	FC
41	Almond Lake	Canacadea Creek	1949	14,800	--	FC, R
		PENNSYLVANIA				
42	Stillwater Reservoir	Lackawanna River	1959	12,000	--	M, FC
43	First Fork Sinnemahoning Creek Reservoir	First Fork Sinnemahoning Creek	1956	75,800	--	FC, R
44	Kettle Creek Lake	Kettle Creek	1962	75,000	--	FC, R
45	Curwensville Lake	West Branch Susquehanna River	1965	124,200		FC, R
46	Glendale Lake	Beaverdam Run	1960	41,200	--	FC, R

a. Total storage capacity is the capacity below the lowest uncontrolled outlet or spillway.
b. Index for Figure 3-3.
c. Key: M = municipal; FC = flood control; R = recreation.

TABLE 3-6

DISCHARGE DATA FOR GAGES WITHIN OR IMMEDIATELY ADJACENT TO THE SALINA REGION IN HR II

No.[a]	River	Location	Drainage Area (miles^2)	Period of Record	Discharge (cfs) Avg.	Min.	Max.
			NEW YORK				
15	Otselic River	Cincinnatus	147	1938-64 1969-75	269	3.8	8,390
16	Owego Creek	Near Owego	185	1930-75	274	20	14,200
17	Canisteo River	Hornell	158	1942-75	155	7.4	9,560
18	Tioga River	Near Erwins	1377	1918-75	1358	18	190,000
			PENNSYLVANIA				
19	West Branch Susquehanna River	Karthaus	1462	1940-75	2467	100	84,300
20	Clearfield Creek	Dimeling	371	1913-75	572	6.0	30,600

a. Index for Figure 3-5.

TABLE 3-7

CONDUCTIVITY DATA FOR GAGES WITHIN OR IMMEDIATELY ADJACENT TO THE SALINA REGION IN HR II

No.[a]	River	Location	Drainage Area (miles^2)	Period of Record	Daily Specific Conductance (μmhos) Minimum	Maximum
		NEW YORK				
17	Gridley Creek	Above E. Virgil	10.4	1974-75	75	308
18	Chemung River	Chemung	2510	1974-75	103	480
19	Five Mile Creek	Near Kanona	66.8	1974-75	111	450
		PENNSYLVANIA				
20	Tioga River	Tioga	282	1974-75	105	377
21	West Branch Susquehanna River	Renovo	2980	1968-75	87	973
22	Beech Creek	Monument	152	1968-75	75	519

a. Index for Figure 3-6.

Present and projected water use in the Susquehanna Subregion is presented in Table 3-8 for major categories of usage: agriculture, steam-electricity generation, manufacturing, domestic, commercial, mineral, public lands, fish hatchery, and miscellaneous (U.S. Water Resources Council, 1978).

The abundant water in the Susquehanna Subregion is being looked to by communities outside the area as a supply source for the future. Currently significant quantities of water are transmitted by pipeline to Chester, Pennsylvania, and Baltimore, Maryland. Rural water supply needs will also increase rapidly in the future. This includes rural domestic use, consumption by livestock, and irrigation. The increases are not as dramatic as in the urban areas, but they are nevertheless substantial and must be planned for, particularly where they compete directly with urban needs.

3.1.3 HYDROLOGIC REGION III

3.1.3.1 Physical Description

Covering portions of Pennsylvania, Ohio, New York, and West Virginia, HR III, as shown in Figure 3-1, lies in the northeastern section of the Ohio River basin. Major streams in this region are the Allegheny River, Monongahela River, Muskingum River, Beaver River, and the main stem of the Ohio River (Ohio River Basin Survey Coordinating Committee, 1969). Hydrologic Region III is the headwaters area of the Allegheny and the Monongahela Rivers, which meander through the western part of Pennsylvania and join at Pittsburgh to form the main stem of the Ohio River. Flowing in a generally southwesterly direction through HR III, the Ohio River joins the Beaver River and the Muskingum River from the north and the Little Kanawha River from the south. The whole of HR III lies within the Appalachian Plateaus physiographic province, which is characterized by rugged terrain resulting from the differing resistance of the rock to weathering and runoff. Extensive forest cover, poor-quality soils, narrow valleys, steep stream gradients, and flash floods during the dry seasons are characteristic of this area. The streams, in their upper reaches, flow parallel to sharp ridges, then generally turn to cut through the ridges, and flow in their lower reaches normal to the main stem of the Ohio River.

The climate of HRIII is temperate, with marked seasons. The eastward passage of cyclonic storms causes changes in weather, considerable rainfall, snowfall, and humidity. Several tornadoes occur within the area each year, and hurricanes occasionally encroach on the area before their energy is spent. Summers are moderately warm and humid, with temperatures averaging from 70 to 80°F. Winters range from moderately to severely cold, with temperatures averaging from 26 to 40°F.

Vegetation is generally sufficient to retard runoff and minimize erosion. The stream channels are generally free of vegetation, but the overbank areas are covered with trees, brush, and other growth. Roughness coefficients for the streams cover the complete range of values from those used for very straight clear streams to channels that are hardly discernible and choked with trees and weeds (Ohio River Basin Survey Coordinating Committee, 1969).

Precipitation averages about 45 inches annually. Although precipitation is usually greatest in June or July and least in October, the average seasonal variation is small. Nevertheless, there may be considerable variation from one month to another within a year and for the same month from year to year. Although the precipitation is generally sufficient for agriculture, local droughts occur frequently, and widespread, prolonged

TABLE 3-8

PRESENT AND PROJECTED WATER USE
IN THE SUSQUEHANNA SUBREGION (204)

Use Category	Surface-Water and Groundwater Withdrawals (mgd)		
	1975[a]	1985	2000
Agriculture	34	39	45
Steam-electricity	1801	1566	1853
Manufacturing	507	219	182
Domestic	498	560	633
Commercial	83	89	97
Mining	86	95	113
Public lands	--	--	--
Fish hatcheries	15	15	15
Miscellaneous	--	--	--
TOTAL	3024	2583	2938

SOURCE: U.S. Water Resources Council, The Nation's Water Resources. The Second National Assessment of Water and Related Land Resources, 1978.

a. The total groundwater withdrawal for 1975 was 504 mgd.

droughts have also occurred. In most instances, crops are not lost entirely, but yields are reduced. Long-term average annual precipitation is presented in Figure 3-2 (USDI, 1972a; 1973a, b; 1974).

Major impoundments (total storage of 50,000 acre-feet or more or a surface area of 1000 acres or more) in HR III are listed in Table 3-9 and shown in Figure 3-3 (Ohio River Basin Survey Coordinating Committee, 1967).

3.1.3.2 Runoff

Runoff in HR III normally follows a markedly seasonal pattern, the average annual values varying considerably with location, geologic features, and terrain. Average monthly runoff is typically high during late winter and spring, with the maximum usually in January. The low occurs from late summer through October. The higher elevations of the Appalachian Plateaus have greater precipitation, lower evaporation, and little infiltration into the soil, which results in high runoff. Extremes in this area range from about 11 to 25 inches per year. Many minor tributary streams throughout the area normally cease flowing during the dry season, with drought periods adding to their number. Often during late summer and early fall, stream flow from precipitation is negligible, the only flow being from groundwater seepage. During these dry periods, below-normal flows result in water supply shortages, stream-quality problems, and inadequate fish habitats. Long-term mean annual runoff is shown in Figure 3-4 (USDI, 1972a; 1973a, b; 1974).

Table 3-10 presents the average, maximum, and minimum discharge for selected gaging stations (shown in Figure 3-5) within or immediately adjacent to HR III (USDI, 1975b, d, f).

The flood season in HR III is from December through April. However, floods on the tributaries may occur in any month. Studies have shown that most major floods on these tributaries occur from January through April, with very few widespread ones from July through November. Summer storms with intense rainfall, but of shorter duration, also occur in the smaller drainage areas. Thus the design of dam spillways is based on maximum probable storms generally occurring during the summer (Ohio River Basin Survey Coordinating Committee, 1966a).

Major floods of modern record in the area are those of March 1913, March 1936, January 1937, March 1945, and March 1964. Each is briefly described below.

The March 1913 flood originated in the northern part of the region, particularly in the watersheds of the Beaver and Muskingum Rivers, where all previous high-water records were exceeded.

The March 1936 flood was caused by storms centered largely over the Monongahela and Allegheny River basins. The rainfall was particularly heavy in the mountainous eastern portions. Snowfall on the ground added to the runoff, which in some areas for certain periods was greater than the precipitation. The heavy rains were so timed that flood crests on the Monongahela and Allegheny Rivers arrived almost simultaneously at Pittsburgh, Pennsylvania, resulting in a record high.

The flood of January-February 1937 was the most disastrous in the area. Excessive and almost continuous rainfall from January 6 through 25 caused maximum recorded river stages. This flood interrupted virtually all communications and transportation between the north and south banks of the Ohio River for periods of a week to a month.

TABLE 3-9

MAJOR RESERVOIRS WITHIN OR IMMEDIATELY ADJACENT TO THE SALINA REGION IN HR III

No.[b]	Reservoir	River	Total Storage Capacity[a] (acre-feet)	Area (acres)	Use[c]
		NEW YORK			
47	Lake Chautaugua	Tributary of Conewango Creek	--	13,570	FC, R
		PENNSYLVANIA			
48	Tionesta Reservoir	Tionesta Creek	133,400	2,770	FC, R
49	Mahoning Reservoir	Mahoning Creek	74,200	2,370	FC, R
50	Conemaugh Reservoir	Conemaugh River	274,000	6,280	FC, R
51	Loyalhanna Reservoir	Loyalhanna Creek	95,300	3,280	FC, R
52	Youghiogheny Reservoir	Youghiogheny River	254,000	3,570	FC, R
53	Pymatuning Reservoir	Shenango River	194,000	16,420	
		OHIO			
54	Mosquito Creek Reservoir	Tributary of Mahoning River	104,100	8,900	FC, M, R
55	Berlin	Mahoning River	91,200	5,500	FC, M, R
56	Bolivar Reservoir	Tuscarawas River	149,600	--	FC
57	Beach City Reservoir	South Fork, Sugar Creek	71,700	6,150	FC, R
58	Dover Reservoir	Tuscarawas River	203,000	10,100	FC, R
59	Tappan Reservoir	Tributary of Stillwater Creek	61,600	3,100	FC, R
60	Clendening Reservoir	Tributary of Stillwater Creek	54,000	2,620	FC, R
61	Piedmont Reservoir	Stillwater Creek	66,700	3,270	FC, R

TABLE 3-9 (Continued)

No.[b]	Reservoir	River	Total Storage Capacity[a] (acre-feet)	Area (acres)	Use[c]
		OHIO (Continued)			
62	Senecaville Reservoir	Seneca Fork, Will Creek	88,500	5,170	FC, R
		WEST VIRGINIA			
63	Tygart Lake	Tygart Valley River	287,700	3,430	FC, R

a. Total storage capacity is the capacity below the lowest uncontrolled outlet or spillway.

b. Index for Figure 3-3.

c. Key: M = municipal; FC = flood control; R = recreation.

TABLE 3-10

DISCHARGE DATA FOR GAGES WITHIN OR IMMEDIATELY ADJACENT TO THE SALINA REGION IN HR III

No.[a]	River	Location	Drainage Area (miles^2)	Period of Record	Discharge (cfs) Avg.	Min.	Max.
			PENNSYLVANIA				
21	Allegheny River	Kinzua Dam	2,180	1935-75	3,784	--	60,500
22	French Creek	Near Union City	220	1909-75	42	3.9	20,000
23	Allegheny River	Franklin	5,982	1914-75	10,330	334	138,000
24	Ohio River	Sewickley	19,500	1933-75	32,400	1800	574,000
25	Youghiogheny River	Sutersville	1,715	1920-75	3,000	57	108,000
26	Conemaugh River	Seward	715	1938-75	1,269	--	54,000
27	Monongahela River	Charleroi	5,213	1933-75	9,022	--	158,000
			OHIO				
28	Mahoning River	Leavittsburg	575	1940-75	557	60	20,300
29	Tuscarawas River	Massillon	518	1937-75	424	57	10,700
			WEST VIRGINIA				
30	Cobun Creek	Morgantown	10.9	1965-75	16.0	0.0	1,770
31	West Fork River	Clarksburg	384	1923-75	591	0.0	17,800

a. Index for Figure 3-5.

The March 1945 flood was severe along the entire main stem of the Ohio River, increasing in severity from Pittsburgh, Pennsylvania, to the downstream section, where it was the second highest of record. It was not serious on most tributaries, many of which did not exceed flood stage in the upper reaches. Six reservoirs in operation in the Allegheny and Monongahela basins reduced the 1945 flood stage at Pittsburgh by 1.8 feet. These and two reservoirs in the Beaver River basin resulted in a 2.3-foot reduction at Wheeling, West Virginia. The 14 reservoirs in the Muskingum River basin reduced flood stages at Marietta, Ohio, by 3.0 feet.

The March 1964 flood was caused by rainfall ranging from 13 to 16 inches. The reservoirs are located mostly in the upper reaches of tributaries, and heaviest rainfall occurred below them. As a consequence, they were less effective in reducing flood stages than they would have been had the rainfall been more widely distributed.

3.1.3.3 Water Quality

The total-dissolved-solids concentrations of surface water in HR III average from 250 to 550 ppm. High concentrations of 350 to 1000 ppm have been observed along the Allegheny River and the Monongahela River near Pittsburgh. The area between and around Akron, Ohio, and Wheeling, West Virginia, also exhibits high concentrations of total dissolved solids, ranging from 530 to 2500 ppm (Geraghty et al., 1973).

Table 3-11 presents the surface-water quality, in terms of specific conductance, of HR III by selected water quality stations (shown in Figure 3-6) (USDI, 1975b, d, f).

3.1.3.4 Water Use

Present and projected water demands are indicative of trends in the utilization and management of water resources in the environment. Since no study has been conducted on water use in HR III, statistics can only be presented by three subregions defined by the U.S. Water Resources Council. These three subregions, Ohio Headwaters (501), Upper Ohio-Big Sandy (502), and Muskingum-Scioto-Miami (503), are shown in Figure 3-8 to relate their location to HR III.

Tables 3-12A, 3-12B, and 3-12C summarize the present and projected water use in the above-mentioned three regions by major category of usage: agriculture, steam-electricity generation, manufacturing, domestic, commercial, mineral, public lands, fish hatchery, and miscellaneous (U.S. Water Resources Council, 1978).

3.2 GROUNDWATER

3.2.1 HYDROLOGIC REGION I

3.2.1.1 Physical Description

Hydrologic Region I (HR I), as shown in Figure 3-1, lies principally within the Interior Lowland physiographic province. Portions of HR I in New York and along the south side of Lake Erie lie in the Appalachian Plateaus province (Great Lakes Basin Commission, 1976, Appendix 3). The entire area was subjected to four major phases of glaciation during the Pleistocene Era. Glacial deposits as much as 1100 feet thick overlie the bedrock surface. Postglacial streams partly reworked the glacial drift and deposited alluvium in the modern stream channels. The variety of glacial deposits resulted in an

TABLE 3-11

CONDUCTIVITY DATA FOR GAGES WITHIN OR IMMEDIATELY ADJACENT TO THE SALINA REGION IN HR III

No.[a]	River	Location	Drainage Area (miles^2)	Period of Record	Daily Specific Conductance (μmhos) Minimum	Maximum
			PENNSYLVANIA			
23	Oil Creek	Centerville	--	1974-75	125	220
24	West Hickory Creek	Near W. Hickory	--	1974-75	105	1450
25	Laborde Branch	Near Homecamp	--	1974-75	160	410
26	Ohio River	South Heights	--	1974-75	--	559
27	Allegheny River	New Kensington	11,500	1972-75	140	380
28	Monongahela River	Braddock	7,340	1972-75	158	937
			OHIO			
29	Mahoning River	Below Lowell-ville	1,075	1967-75	219	1480
30	Stillwater Creek	Uhrichsville	367	1974-75	595	1660
31	Ohio River	Shadyside	--	1974-75	--	650
32	Black Fork, Mohican River	Loudonville	349	1968-75	84	1270

a. Index for Figure 3-6.

TABLE 3-12A

WATER USE DATA FOR THE OHIO HEADWATERS SUBREGION (501)

Use Category	Surface-Water and Groundwater Withdrawals (mgd)		
	1975[a]	1985	2000
Agriculture	6	6	6
Steam-electricity	862	792	207
Manufacturing	386	145	110
Domestic	282	295	309
Commercial	44	44	44
Mining	46	69	80
Public lands	1	2	2
Fish hatcheries	15	15	15
Miscellaneous	--	--	--
TOTAL	1642	1368	773

SOURCE: U.S. Water Resources Council, The Nation's Water Resources. The Second National Assessment of Water and Related Land Resources, 1978.

a. The total groundwater withdrawal for 1975 was 170 mgd.

TABLE 3-12B

WATER USE DATA FOR THE UPPER OHIO-BIG SANDY SUBREGION (502)

Use Category	Surface-Water and Groundwater Withdrawals (mgd)		
	1975[a]	1985	2000
Agriculture	18	20	23
Steam-electricity	8,907	8,445	4022
Manufacturing	5,834	1,786	1123
Domestic	383	409	437
Commercial	171	177	184
Mining	139	194	235
Public lands	<1	<1	<1
Fish hatcheries	--	--	--
Miscellaneous	--	--	--
TOTAL	15,453	11,032	6025

SOURCE: U.S. Water Resources Council, The Nation's Water Resources. The Second National Assessment of Water and Related Land Resources, 1978.

a. The total groundwater withdrawal for 1975 was 329 mgd.

TABLE 3-12C

WATER USE DATA
FOR THE MUSKINGUM-SCIOTO-MIAMI SUBREGION (503)

Use Category	Surface-Water and Groundwater Withdrawals (mgd)		
	1975[a]	1985	2000
Agriculture	24	25	27
Steam-electricity	1316	1365	240
Manufacturing	1099	470	360
Domestic	478	542	628
Commercial	92	101	113
Mining	83	105	130
Public lands	--	--	--
Fish hatcheries	3	3	4
Miscellaneous	--	--	--
TOTAL	3095	2611	1502

SOURCE: U.S. Water Resources Council, The Nation's Water Resources. The Second National Assessment of Water and Related Land Resources, 1978.

a. The total groundwater withdrawal for 1975 was 721 mgd.

imperfect drainage system, with hundreds of thousands of lakes, ponds, marshes, and bogs. The terrain and the materials of the glacial deposits control the rate of groundwater recharge (Piper, 1972).

Sand and gravel beds within the unconsolidated sediments are the most permeable portion and form the principal aquifers. Groundwater is present throughout HR I. Water infiltrates into the groundwater aquifers wherever the soil is permeable enough. This groundwater is derived directly from precipitation or indirectly from surface bodies of water. Recharge to the aquifers beneath the soil zone occurs after surface evaporation, transpiration needs, and soil moisture deficiencies are satisfied. Recharge to surficial deposits by such infiltration occurs throughout HR I.

Most groundwater recharge occurs as a result of water percolating to the water table during the spring snowmelt period. During the summer, the amount of water lost by evapotranspiration usually exceeds the amount of water retained from rainfall, and little or no recharge occurs. Groundwater recharge resumes in the fall, after evapotranspiration losses are reduced, and may continue through part of the winter. However, severe winter conditions that result in extensive frost penetration, most prevalent in the northern part of HR I, inhibit winter groundwater recharge. In places where the sand and gravel aquifers are confined, the recharge potential is lower because recharge has to occur through the confining layer. Thus unconsolidated sediments in the area not only are significant as aquifers but also act as the recharge medium for bedrock aquifers.

Although water-bearing formations underlie all of HR I, the depth to the water table varies with the season, local geologic characteristics, and terrain. Groundwater surface fluctuation has been observed at a number of wells located in HR I. Table 3-13 summarizes data on well locations, periods of record, and average, minimum, and maximum water levels below land surface. Well locations are shown in Figure 3-9 (USDI, 1975b, c, e, g).

3.2.1.2 Water Yield

In HR I, productive aquifers (defined by the U.S. Geological Survey as aquifers generally capable of yielding to a well at least 50 gpm of water containing not more than 2000 ppm of dissolved solids) are mostly located in the lower peninsula of Michigan. Their formation consists of alluvial sand and gravel in the unconsolidated and/or semiconsolidated sediments that are underlain by either sandstone or carbonate rock in the consolidated bedrock. In the Ohio, Pennsylvania, and New York portions of HR I, productive aquifers are located only along some of the main watercourse alluvial valleys traversed by perennial streams from which recharge can occur (McGuinness, 1964).

Generally speaking, the lower portion of the Michigan Peninsula is the most productive groundwater field in HR I. Its average groundwater yield ranges from 100 to 300 gpm and increases to more than 500 gpm at locations where sand and gravel deposits occur along streams. In the Ohio, Pennsylvania, and New York portions of HR I, the average groundwater yield ranges from 10 to 25 gpm and increases to more than 100 gpm in sand and gravel stream valleys (USDI, 1972a, b; 1973a; 1974).

3.2.1.3 Water Quality

Mineralized groundwater underlies large areas of the United States. In 1965, the U.S. Geological Survey conducted a survey to determine the depth to shallowest groundwater containing more than 1000 ppm of dissolved solids (Feth, 1965). The results

TABLE 3-13

GROUNDWATER WELL DATA FOR HR I

No.[a]	Well Location	Period of Record	Water Level Below Land Surface (ft) Avg.	Min.	Max.
		MICHIGAN			
1	10 miles north of Lansing	1950-70	18	15	20
2	Lansing	1945-70	120	60	170
3	Near Battle Creek	1950-70	9	1	14
4	Above Houghton Lake	1950-70	5	3	8
5	Near Roscommom	1950-70	5	3	6
6	Near Posen	1960-70	12	5	17
7	Near Alma	1950-70	16	13	18
8	Near Flint	1955-70	28	22	34
9	Near Linwood	1963-70	11	5	13
10	Near Elmer	1950-70	20	15	25
11	Near Ypsilanti	1950-70	35	10	60
		OHIO			
12	Near Mentor	1950-70	18	14	24
13	Near Akron	1950-70	30	19	42
14	Near Oberlin	1950-70	20	1	33
		NEW YORK			
15	Near Geneseo	1950-70	4	1	7

a. Index for Figure 3-9.

of the study showed that in the lower portion of the Michigan Peninsula in HR I depth to the shallowest groundwater containing dissolved solids of 1000 to 3000 ppm ranges from 500 feet to more than 1000 feet. The belt area, about 25 miles wide and extending along the Lake Huron and Lake Erie shoreline from Au Sable Point to Stony Point in the lower peninsula of Michigan, has an average depth of 500 feet to groundwater containing 3000 to 10,000 ppm of dissolved solids. In the Ohio and Pennsylvania portions of HR I, groundwater with a dissolved-solids content of 1000 to 3000 ppm is found at an average depth of less than 500 feet. In the New York portion of HR I, it is more than 1000 feet below land surface to groundwater containing 1000 to 3000 ppm of dissolved solids. In summary, mineralized groundwater containing dissolved solids of more than 1000 ppm underlies the entire HR I at varying depth.

The commonest substance adversely affecting groundwater quality in HR I is sodium chloride. Exceptions have been observed at wells near Lansing, Michigan, where groundwater contains high concentrations of calcium bicarbonate, and near the shore along Lake Ontario, where calcium sulfate occurs in groundwater (Feth, 1965).

Groundwater hardness, expressed as calcium carbonate, in HR I is generally between 120 to 240 ppm; an exception is the lower portion of the Michigan Peninsula, where groundwater hardness may be more than 240 ppm (Geraghty et al., 1973).

3.2.1.4 Water Use

Although HR I has productive aquifers and good recharge capability, groundwater usage has not been extensively developed and is generally under 10% of the total water use of HR I. Tables 3-4A through 3-4E present estimates of groundwater use for each subregion defined in Section 3.1.1.4. Major groundwater uses are for the irrigation, domestic, livestock, and commercial categories.

3.2.2 HYDROLOGIC REGION II

3.2.2.1 Physical Description

The Appalachian Plateaus province underlies all of HR II. The rocks are nearly horizontal and are of Devonian, Mississippian, and Pennsylvanian age. They consist of shale, siltstone, sandstone, limestone, and bituminous coal. These rocks can yield appreciable quantities of water that is generally of good quality, except near coal mines, which are common in much of HR II below Tioga County, Pennsylvania. In most parts of HR II, the groundwater at shallow and moderate depths is fresh, whereas that at greater depths, below the drainage level, may be brackish or saline. Some of these deep-seated waters are brines that are more highly concentrated than seawater. The level strata of the Appalachian Plateaus contrast sharply with the inclined rocks of the Valley and Ridge province and allow the choice of more than one aquifer at most localities in HR II (Susquehanna River Basin Study Coordinating Committee, 1970).

Glacial deposits in the form of stratified drift along most of the valleys in the upper section of HR II are also a significant source of groundwater. Consisting of not only highly permeable outwash sand and gravel but also ancient lake deposits of silt and low-permeability clay, the stratified drift has the potential of yielding more than 1000 gpm and is the most productive and readily recharged aquifer in HR II. As a result, groundwater in the rocks of the Appalachian Plateaus has not been widely utilized as a source of supply since most urban communities are situated on water-bearing glacial deposits in the valleys.

In HR II, groundwater level varies with the season, local geologic characteristics, and terrain. Water-level measurements have been made at a number of wells in or adjacent to HR II. Table 3-14 summarizes data on well locations, periods of record, and average, minimum, and maximum water levels below land surface. Well locations are shown in Figure 3-9 (USDI, 1975a, g).

3.2.2.2 Water Yield

In HR II, productive aquifers (defined by the U.S. Geological Survey as aquifers generally capable of yielding to a well at least 50 gpm of water containing not more than 2000 ppm of dissolved solids) are located along main watercourse alluvial valleys traversed by perennial streams from which recharge can occur. The area in and around Cameron County, Pennsylvania, also has productive aquifers in the consolidated sandstone bedrock (McGuinness, 1964).

On the Appalachian Plateaus, in general, rocks will have high yields only where they have been somewhat folded, as they are adjacent to the Valley and Ridge province. In the Pennsylvania portion of HR II, some fairly high yields, up to 500 gpm, have been obtained from wells tapping the Mississippian and Pennsylvanian rocks in the Appalachian Plateaus, but the average potential yield may be less than 200 gpm. The yields of wells are expected to decrease from east to west and from south to north owing to the increase in the amount of shale and the decrease in structural deformation (Susquehanna River Basin Study Coordinating Committee, 1970, Appendix D). In the New York portion of HR II, the yields of wells are significantly lower than they are in the Pennsylvania portion. The average potential yield is about 60 gpm.

In some stream valleys where stratified drifts of sands and gravels are encountered, many wells may yield up to more than 1000 gpm.

3.2.2.3 Water Quality

Mineralized groundwater underlies large areas of the United States. In 1965, the U.S. Geological Survey conducted a survey to determine the depth to shallowest groundwater containing more than 1000 ppm of dissolved solids (Feth, 1965). The study showed that the upper two-thirds of the HR II area has an average depth of more than 1000 feet to groundwater containing dissolved solids of 1000 to 3000 ppm. In the lower one-third of the HR II area, the depth diminishes to less than 500 feet.

The chemical properties of natural groundwaters that determine their suitability for most purposes are the total dissolved solids (i.e., mineral) concentration, the total hardness, and the iron content. The quality of groundwater in HR II generally ranges from 100 to 500 ppm, 50 to 250 ppm, and 0.1 to 1.0 ppm for dissolved solids, total hardness, and iron, respectively (Susquehanna River Basin Committee, 1970, Appendix F). These ranges indicate that the groundwaters of HR II are of good quality and suitable for most uses without much treatment, except chlorination for domestic consumption. However, high iron concentration may be a problem locally, particularly in the coal-bearing geologic formation. Brackish or saline water also occurs at greater depth.

3.2.2.4 Water Use

Information on groundwater use in HR II is not available since no study has been conducted. As an approximation, in 1975, the Susquehanna Subregion, which includes the entire HR II area, withdrew about 504 mgd of groundwater (see Table 3-8); this represents about 17% of the total water use, 3024 mgd (U.S. Water Resources Council,

TABLE 3-14

GROUNDWATER WELL DATA FOR HR II

No.[a]	Well Location	Period of Record	Water Level Below Land Surface (ft)	
			Minimum	Maximum
	NEW YORK			
16	City of Cortland, Cortland County	1947-75	3.0	11.4
17	Johnson City, Broome County	1947-75	9.7	33.5
	PENNSYLVANIA			
18	Near Towanda, Bradford County	1966-75	1.5	11.1
19	Near Walton, Potter County	1967-75	5.2	29.8
20	Near Tiadaghton, Tioga County	1935-75	4.2	22.0
21	Near Cameron, Cameron County	1967-75	21.0	26.0
22	Near Renova, Clinton County	1950-75	44.0	57.0
23	Near Glen Richey, Clearfield County	1946-75	16.8	21.4
24	Near Bellefonte, Center County	1968-75	54.9	80.1
25	Near Hollidaysburg, Blair County	1969-75	11.0	18.7
26	Near Calvin, Huntingdon County	1969-75	48.8	55.6
27	Near Cessna, Bedford County	1965-75	3.9	41.4
28	Near Cessna, Bedford County	1966-75	22.6	38.4

a. Index for Figure 3-9.

1978). It is also estimated that at least one-fourth of the population of the Susquehanna Subregion uses water derived from underground sources for domestic, agricultural, and livestock purposes. More than 400 municipalities in the Susquehanna Subregion depend on groundwater for all or part of their supply. The total quantity of groundwater use may be expected to increase even as major new urban supplies of surface water are developed (Susquehanna River Basin Study Coordinating Committee, 1970, Appendix F).

3.2.3 HYDROLOGIC REGION III

3.2.3.1 Physical Description

The Appalachian Mountains along the eastern divide of HR III serve as the headwaters area of major streams in HR III. The Allegheny River flows southward across the Appalachian Plateaus, and the Monongahela River flows northward to Pittsburgh, Pennsylvania, where the two rivers join to form the Ohio River. From Pittsburgh to Marietta, Ohio, the Ohio River flows generally southwestward through the center of the Appalachian Plateaus along a course roughly parallel to the Appalachian Mountains.

The bedrock systems that underlie HR III are Pennsylvanian, Devonian, Mississippian, and Permian. The Pennsylvanian rocks form the bedrock surface over about two-thirds of HR III. These rocks consist mainly of sandstone, and the lower units are good sources of groundwater; the upper units tend to grade into siltstones and shales, and are relatively poor sources of water. The Devonian rocks underlie the Allegheny River headwaters areas, which cover the New York section and adjoining parts of Pennsylvania in HR III. These rocks consist mainly of shales interbedded with fine-grained siltstones and sandstones, and are not important sources of water. Only the Chemung Formation, composed predominantly of sandstones, is a good water producer. The Mississippian rocks in HR III are located south of the Devonian rock system, forming a west-to-east band approximately 25 miles in width. These rocks consist mainly of sandstones with some shales and are good water bearers. The Permian and Pennsylvanian rocks cover the area from Pittsburgh, Pennsylvania, to Marietta, Ohio, in a band about 50 miles wide. These rocks are composed principally of shales and siltstones, and are poor sources of water.

The great potential for groundwater sources in HR III results largely from the presence of unconsolidated glacial sediments consisting mainly of permeable sand and gravel. The valley-fill sediments, consisting both of glacial outwash and recent alluvium, in the Ohio River valley from Pittsburgh to Marietta are the most important single source of groundwater in HR III. The average thickness of the permeable zone ranges from 20 to 100 feet. The valleys of the Allegheny, the Muskingum, and other major tributaries north of the Ohio River main stem are also filled with permeable glaciofluvial sediments capable of yielding very large quantities of water either naturally or under conditions of artificial recharge. In addition, a belt about 75 miles wide along the upper edge of HR III is covered with till and pockets of washed sand and gravel deposits, and provides a good source for moderate water supply needs (Ohio River Basin Survey Coordinating Committee, 1966, Volume VI).

In HR III, the groundwater level varies with the season, local geologic characteristics, and the terrain. Water-level measurements have been made at a number of wells located in or adjacent to HR III. Table 3-15 summarizes data on well locations, periods of record, and average, minimum, and maximum water levels below land surface. Well locations are shown in Figure 3-9 (USDI, 1975b, d, f, g).

TABLE 3-15

GROUNDWATER WELL DATA FOR HR III

No.[a]	Well Location	Period of Record	Water Level Below Land Surface (ft) Minimum	Maximum
	PENNSYLVANIA			
29	Near Kane, McKean County	1973-75	27.1	33.1
30	Near Mosiertown, Crawford County	1967-75	20.1	48.9
31	Near Whiskerville, Butler County	1970-75	5.5	29.2
32	Near Glenfield, Allegheny County	1967-75	5.2	8.9
33	Near Lemon Furnace, Fayette County	1967-75	19.7	40.0
	OHIO			
34	Near Canfield, Mahoning County	1946-75	30.4	110.8
35	Near Canton, Stark County	1941-75	6.9	22.0
36	Dover, Tuscarawas County	1960-75	3.2	19.4
37	Martins Ferry, Belmont County	1948-75	0.1	38.9
38	Near Coshocton, Coshocton County	1949-75	0.43	17.8
39	Newark, Licking County	1951-75	21.8	26.2
40	Near Zanesville, Muskingum County	1942-75	8.5	37.3
	WEST VIRGINIA			
41	Jacksonburg, Wetzel County	1971-75	6.1	19.9
42	Harrisville, Ritchie County	1966-75	17.9	21.8

a. Index for Figure 3-9.

3.2.3.2 Water Yield

In HR III, productive aquifers (defined by the U.S. Geological Survey as aquifers generally capable of yielding to a well at least 50 gpm of water containing not more than 2000 ppm of dissolved solids) are located along the main stem of the Ohio River and along the channel valleys of other major tributaries. A belt approximately 50 miles wide and extending from Mansfield, Ohio, to Dubois, Pennsylvania, contains productive aquifers of sandstone in the consolidated bedrock (McGuinness, 1964).

A previous study (Ohio River Basin Survey Coordinating Committee, 1966, Volume VI) estimated the rates at which aquifers in the Ohio Region can yield water to wells. These estimates were prepared on the basis of rock type, geologic structure, known well and spring production, low-flow stream-flow records, drillers' records, and general knowledge of the local geohydrology. Both consolidated and unconsolidated aquifers were classified on an areal basis into the following four categories:

Category	Yield (gpm)	Portion of HR III Covered (%)
Highest yield	500	4
High yield	100 to 500	11
Intermediate yield	25 to 100	35
Low yield	25	50

In HR III, the highest-yield and high-yield areas are generally the valleys of the Ohio River and its north-side tributaries. Other than these stream valleys, most of the Ohio and West Virginia portion of HR III fall into the low-yield category, while the Pennsylvania and New York portion fall into the intermediate-yield category (Bloyd, 1974).

3.2.3.3 Water Quality

Mineralized groundwater underlies large areas of the United States. In 1965, the U.S. Geological Survey conducted a survey to determine the depth to shallowest groundwater containing more than 1000 ppm of dissolved solids (Feth, 1965). The results of the study indicated that all of HR III is underlain by groundwater with a dissolved-solids content of 1000 to 3000 ppm at an average depth of less than 500 feet.

In the eastern portions of HR III, from the Allegheny River basin to the Monongahela River basin, groundwater at shallow depths in the surficial aquifers is generally soft and relatively low in mineral content. This is especially true of the widespread Pennsylvanian sandstone aquifers in Pennsylvania and West Virginia. High iron concentrations, however, are common in these waters. This is the case in the hard-water as well as the soft-water areas.

The quality of groundwater in the glacial drift and alluvial aquifers generally reflects the sources of these sedimentary deposits. The water in the glacial drift aquifers of the drainage basin north of the Ohio River main stem is generally very hard and high in mineral content (especially calcium, magnesium, bicarbonate, and sulfate) because much of the drift was derived from the limestone, dolomite, and shale bedrock common along the northern portions of HR III, as well as from source areas farther to the north.

Approximate concentration ranges of key mineral constituents in groundwater are presented in Table 3-16 for four major basins contained in HR III. These concentrations are shown only to indicate the general quality of groundwater in HR III (Ohio River Basin Survey Coordinating Committee, 1966, Volume VI).

3.2.3.4 Water Use

Traditionally, groundwater supplies have been developed primarily for use at points of need. Since many of the aquifers in HR III cover hundreds of square miles, the cones of depression resulting from large-scale pumping occupy a relatively small area of these extensive aquifers. Most of the aquifer is therefore left untouched and the water stored in it, unused. The piping or transferring of groundwater for considerable distances from areas of availability to points of need is rare in HR III. A notable exception to the traditional pattern of development is offered by Canton, Ohio, which taps a valley-fill deposit and pipes the water about 17 miles upbasin for use in the city. Tables 3-12A, 3-12B, and 3-12C present estimates of groundwater use for each subregion defined in Section 3.1.3.4.

TABLE 3-16

GENERAL GROUNDWATER CHEMICAL
CHARACTERISTICS FOR HR III

River Basin	Aquifer Type	Hardness (mg/l)	Sulfate (mg/l)	Chloride (mg/l)	Iron (mg/l)	Total Dissolved Solids (mg/l)
Allegheny basin	Unconsolidated	36-280	1-350	1-900	0-8.5	57-600
	Consolidated	10-330	1-160	1-160	0-19	22-580
Monongahela basin	Unconsolidated	120-1700	50-1500	20-350	1-120	300-3000
	Consolidated	10-350	0-150	1-250	0.2-6	50-700
Ohio River main stem	Unconsolidated	130-400	50-200	5-60	0.1-3	200-650
	Consolidated	60-350	2-280	2-80	0.1-3	200-800
Muskingum and Hocking basin	Unconsolidated	150-900	--	0-800	0-8	180-1000
	Consolidated	20-570	--	0-650	0.1-5	50-1000

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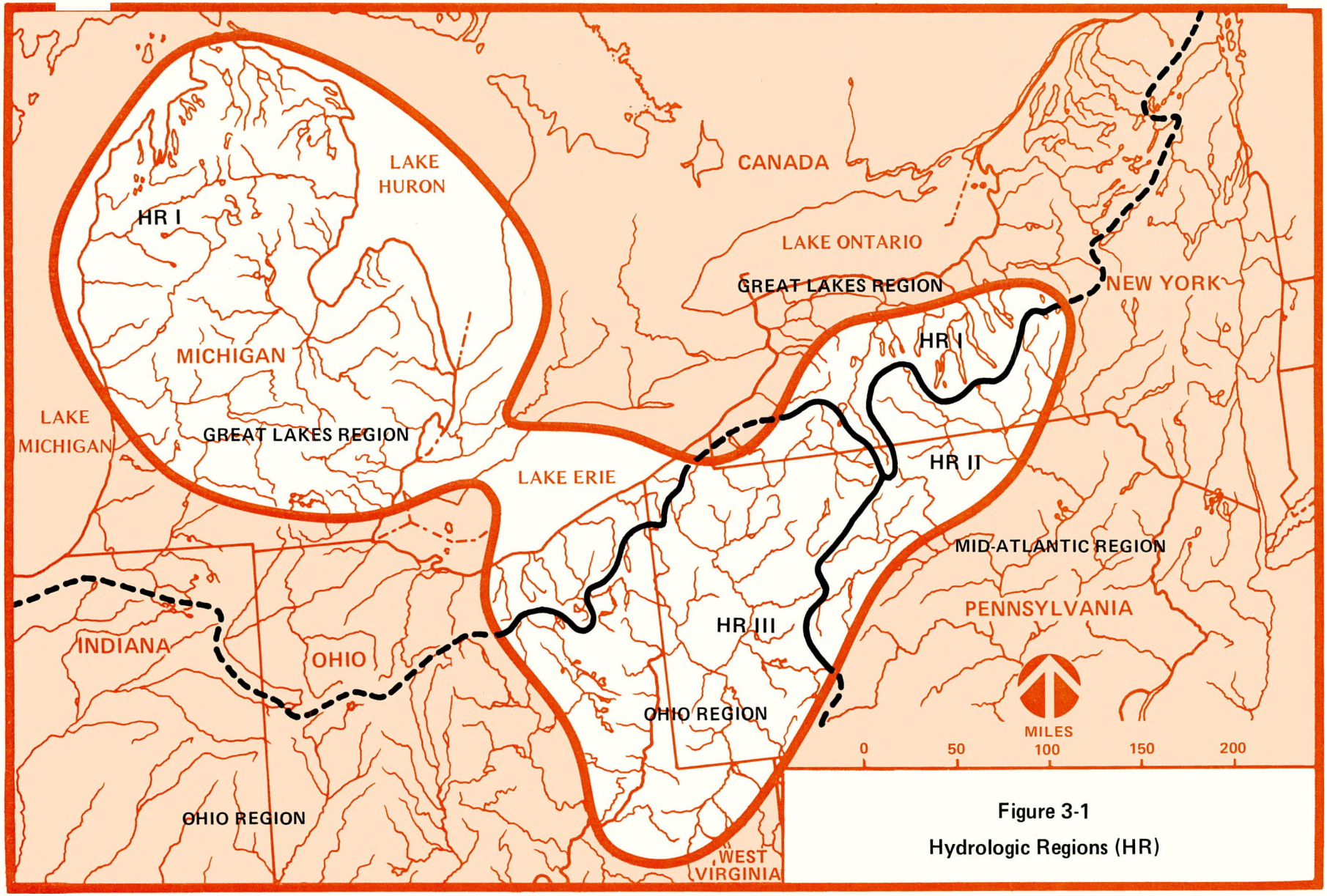


Figure 3-1

Hydrologic Regions (HR)

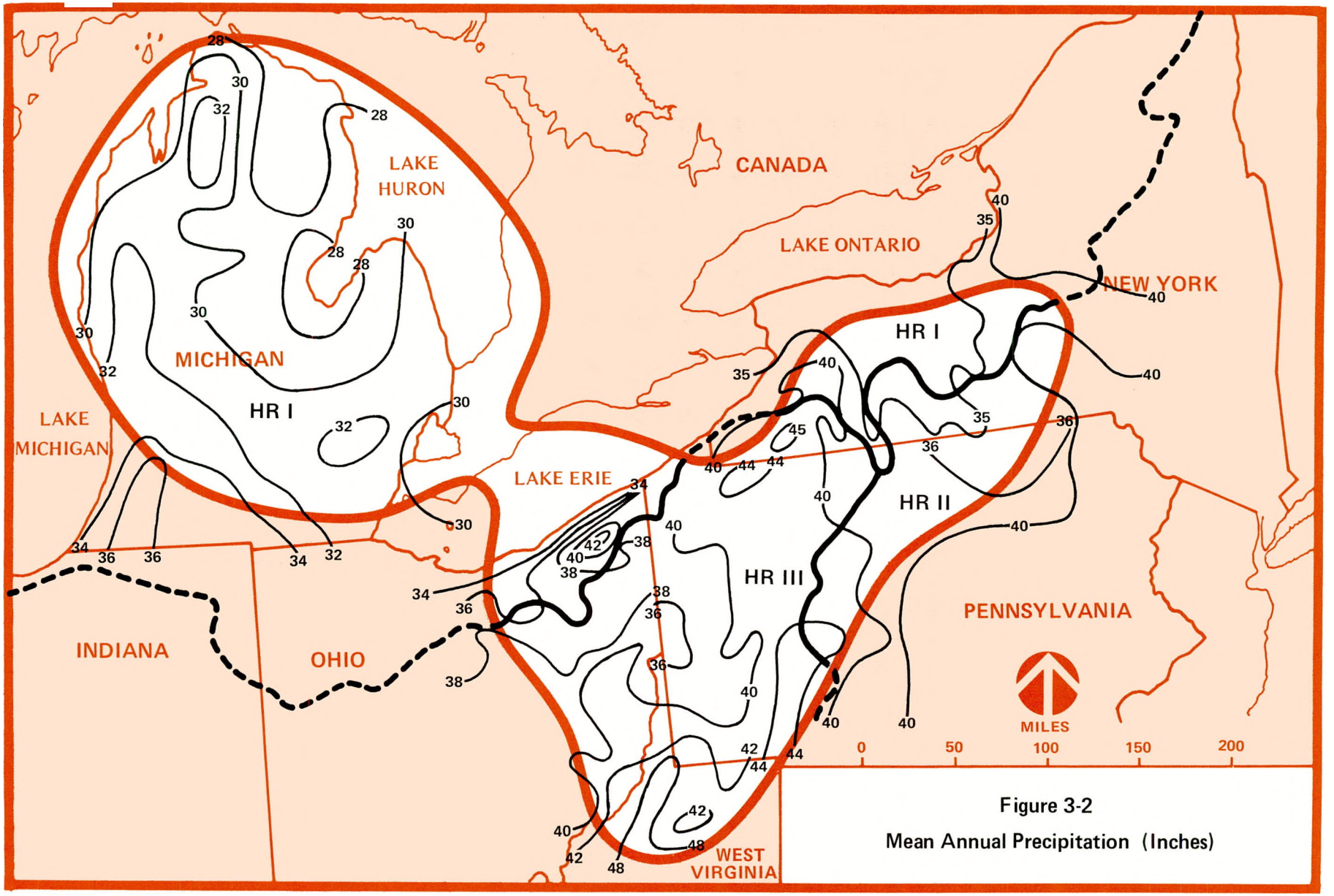


Figure 3-2

Mean Annual Precipitation (Inches)

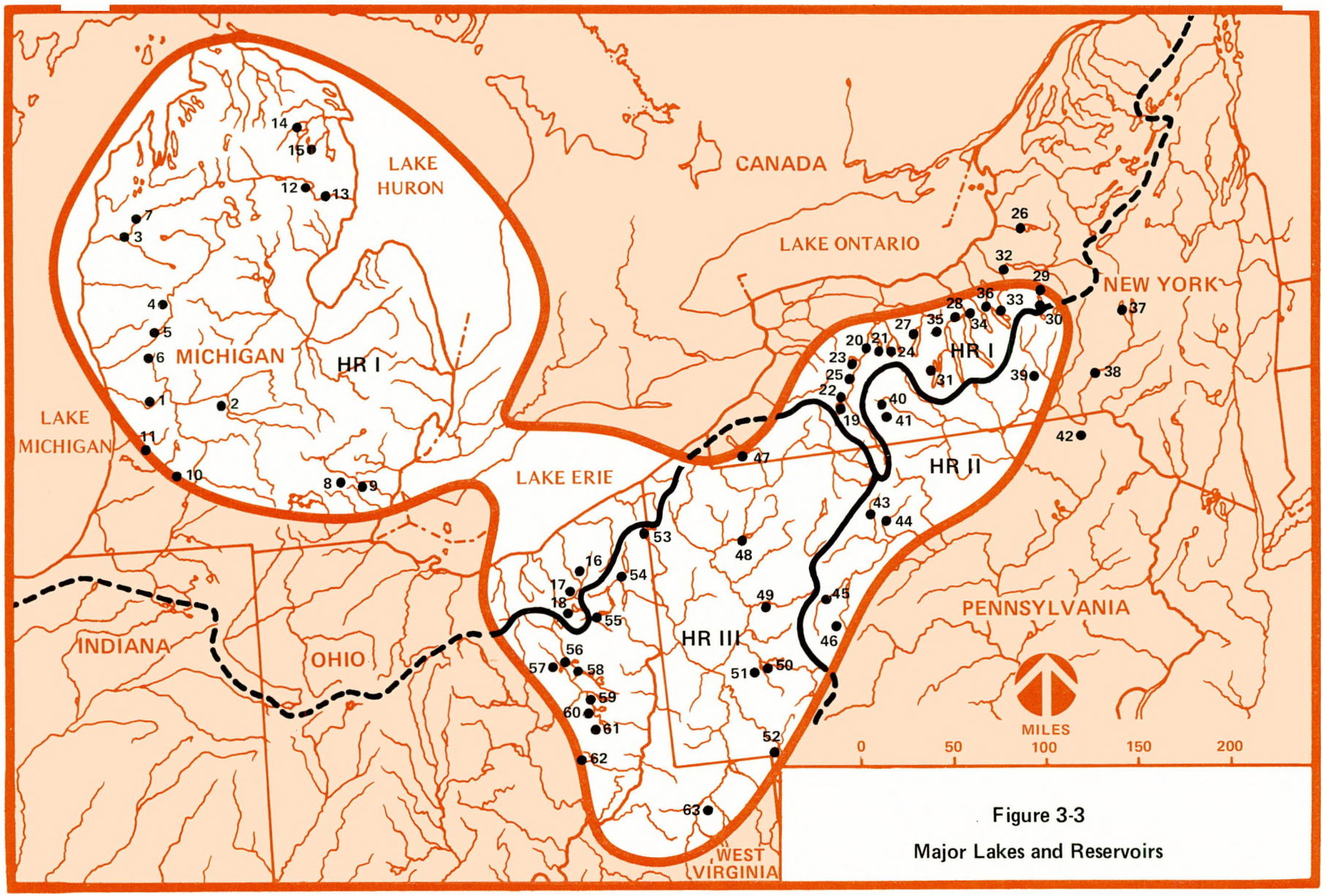


Figure 3-3

Major Lakes and Reservoirs

NOTE: See Tables 3-1, 3-5, and 3-9 for names and pertinent data.

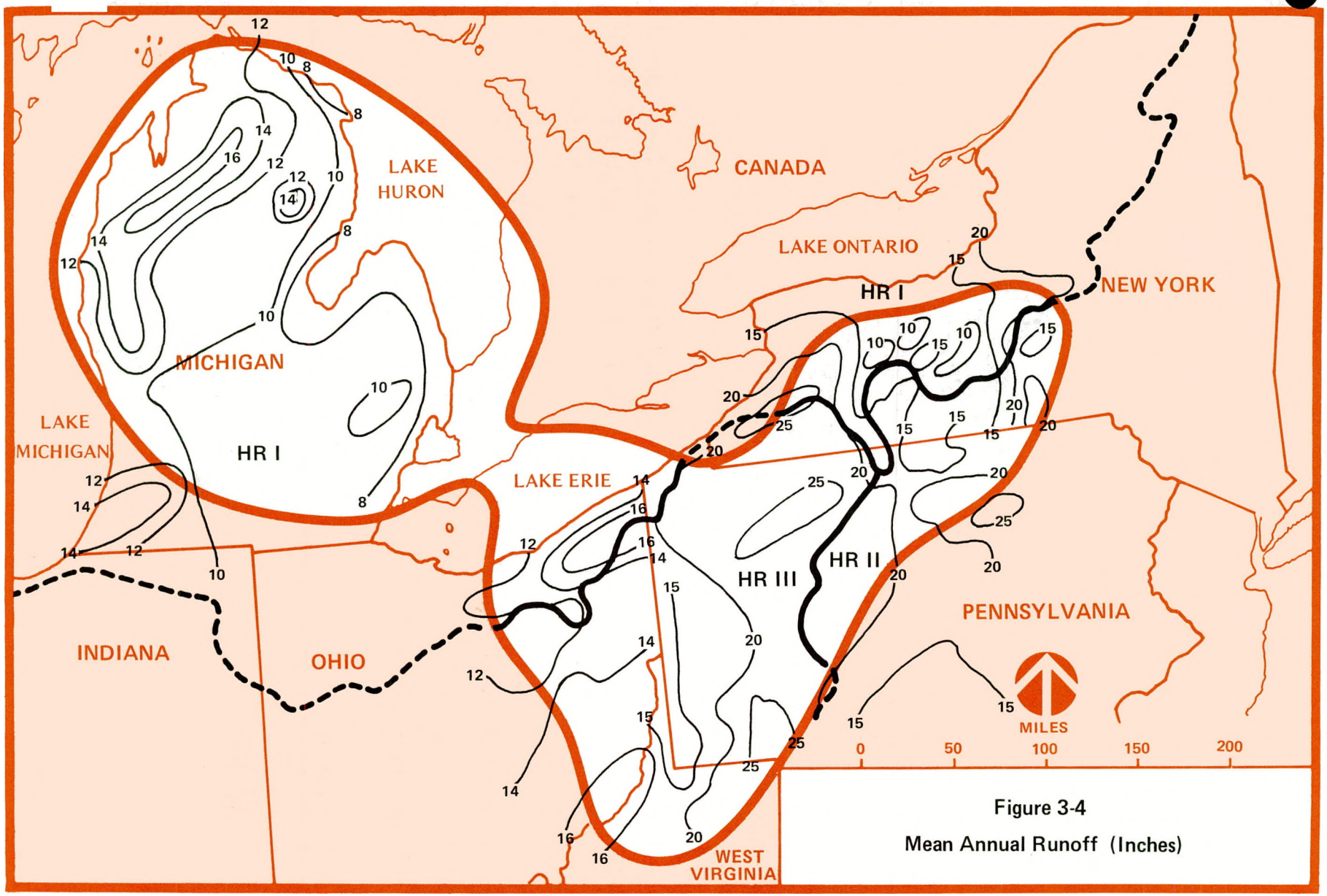


Figure 3-4

Mean Annual Runoff (Inches)

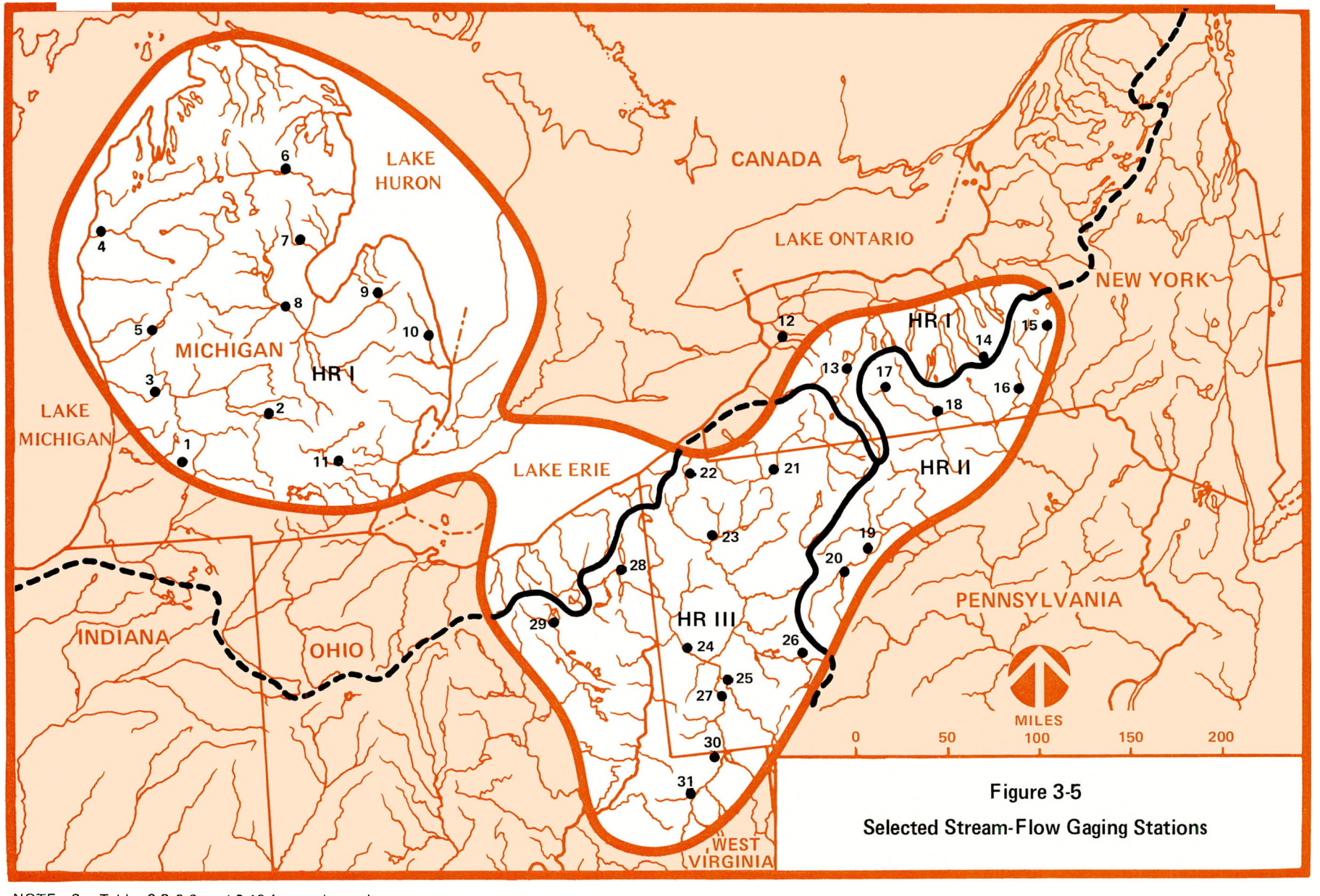


Figure 3-5

Selected Stream-Flow Gaging Stations

NOTE: See Tables 3-2, 3-6, and 3-10 for pertinent data.

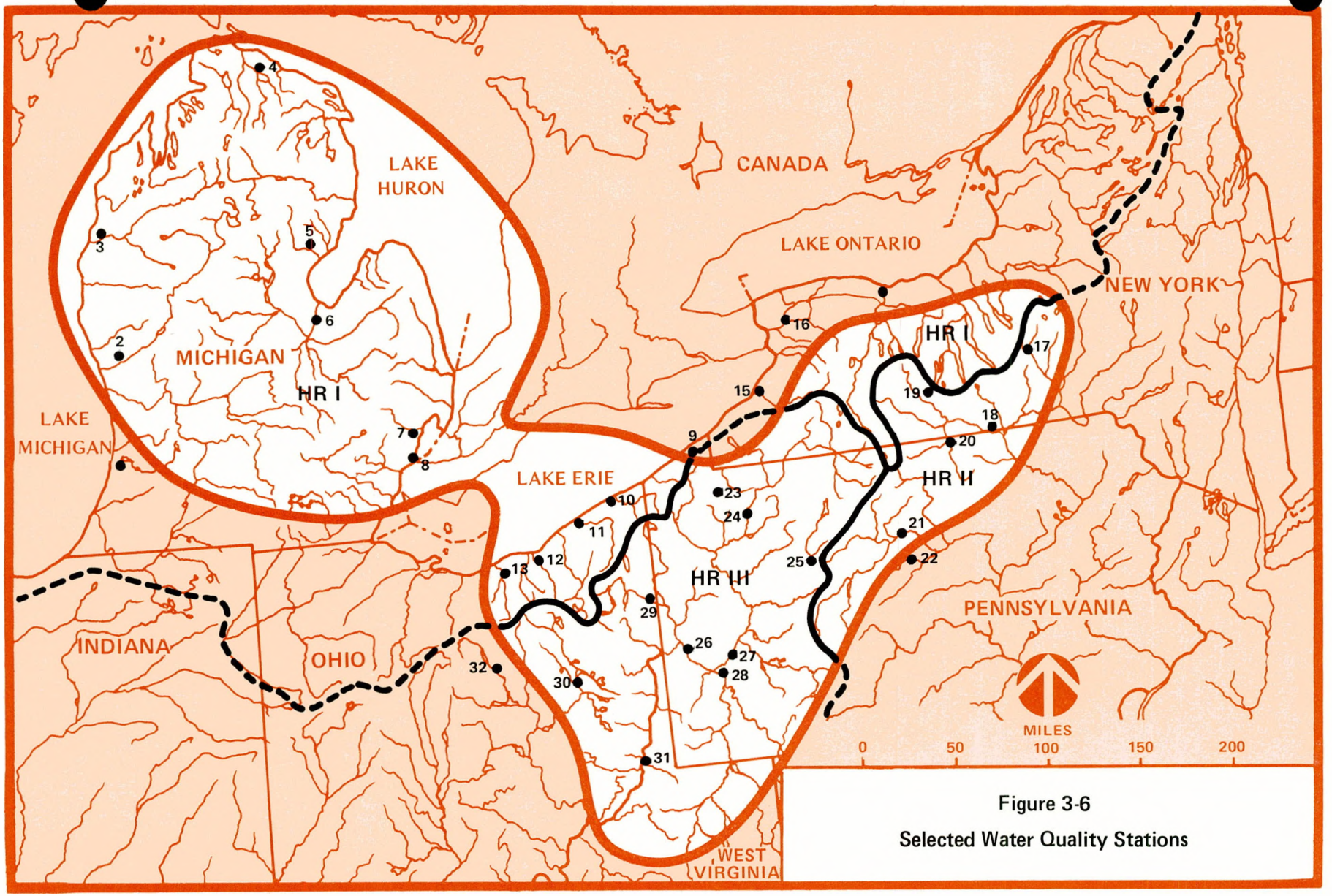


Figure 3-6

Selected Water Quality Stations

NOTE: See Tables 3-3, 3-7, and 3-11 for pertinent data.

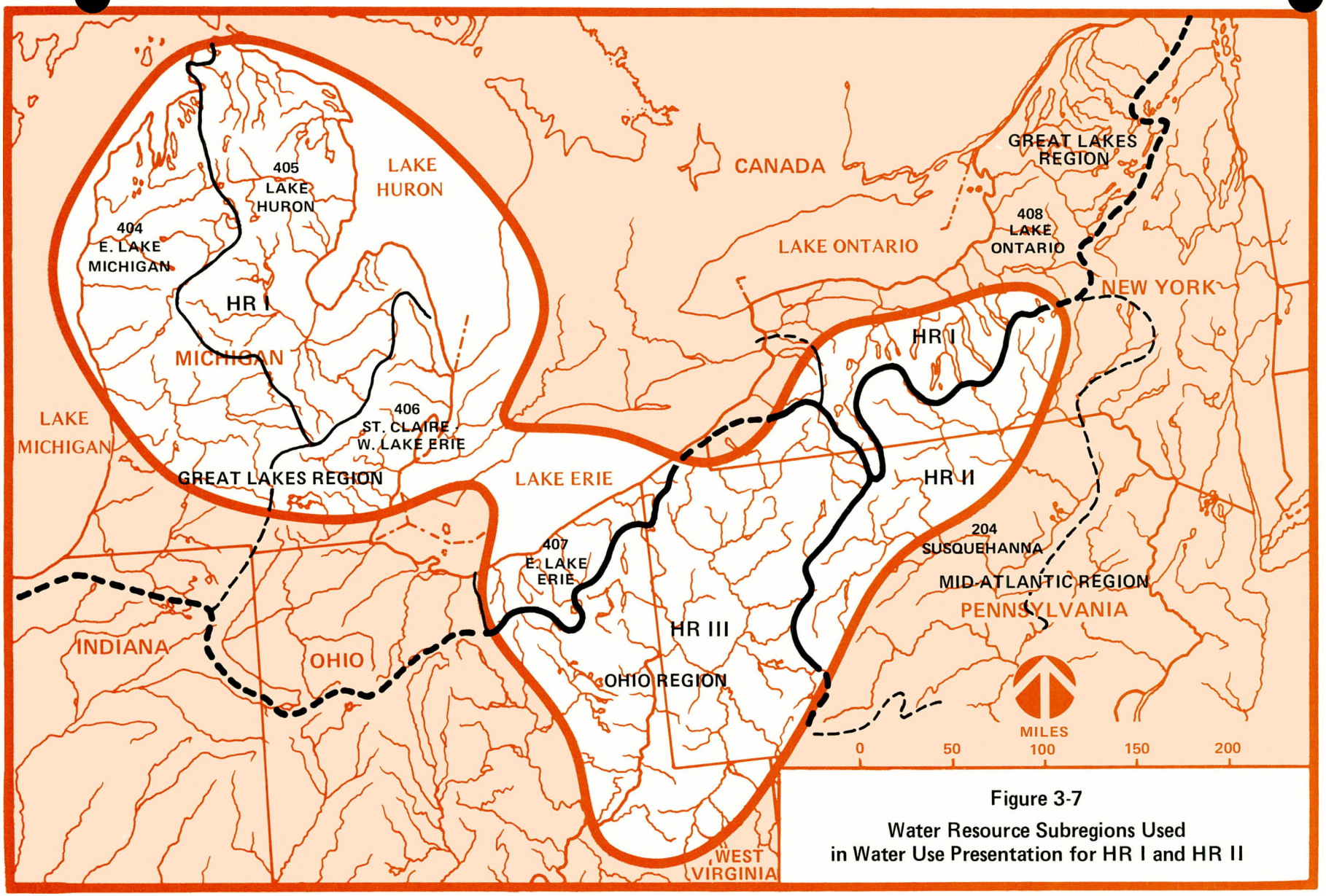


Figure 3-7

Water Resource Subregions Used
in Water Use Presentation for HR I and HR II

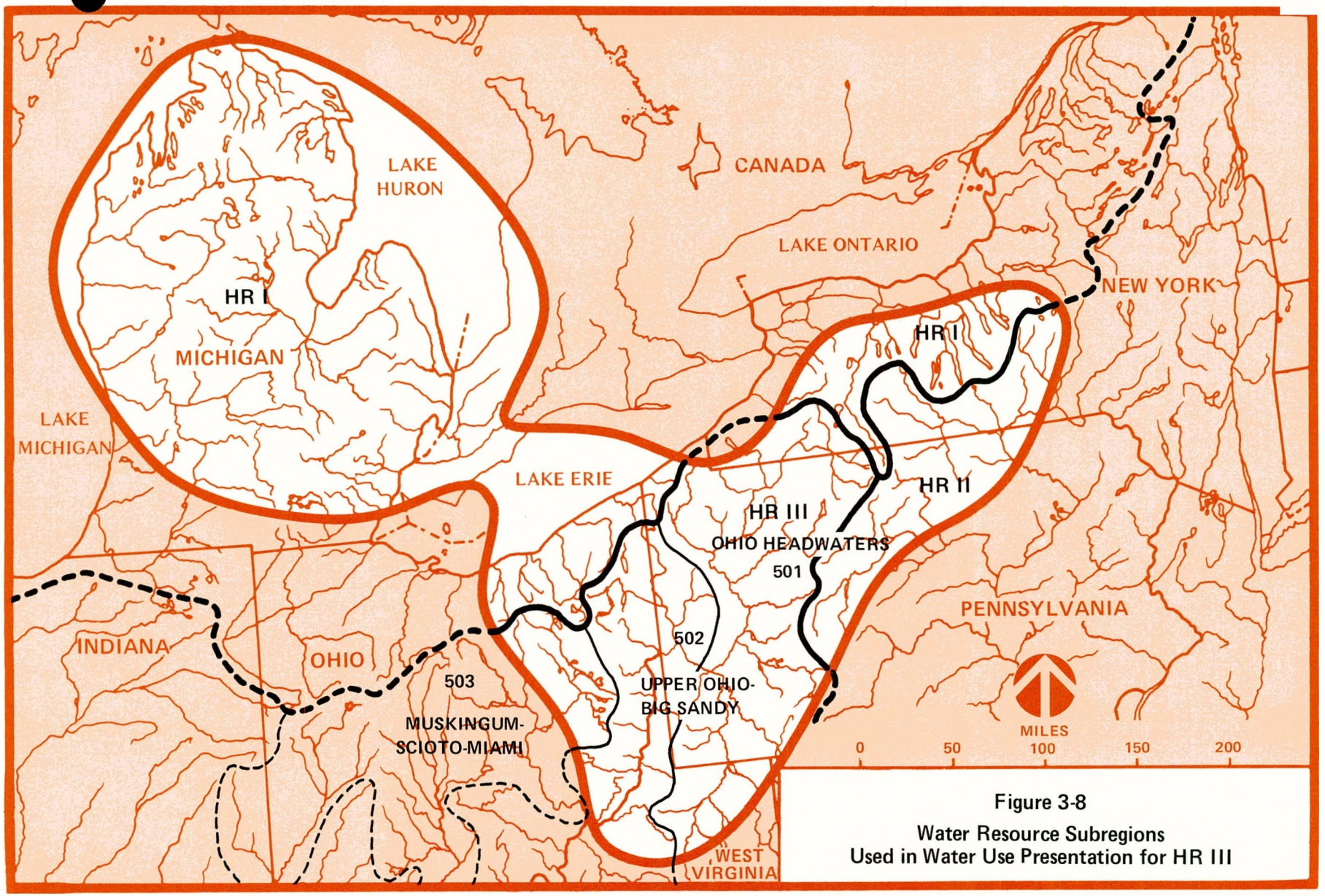


Figure 3-8
Water Resource Subregions
Used in Water Use Presentation for HR III

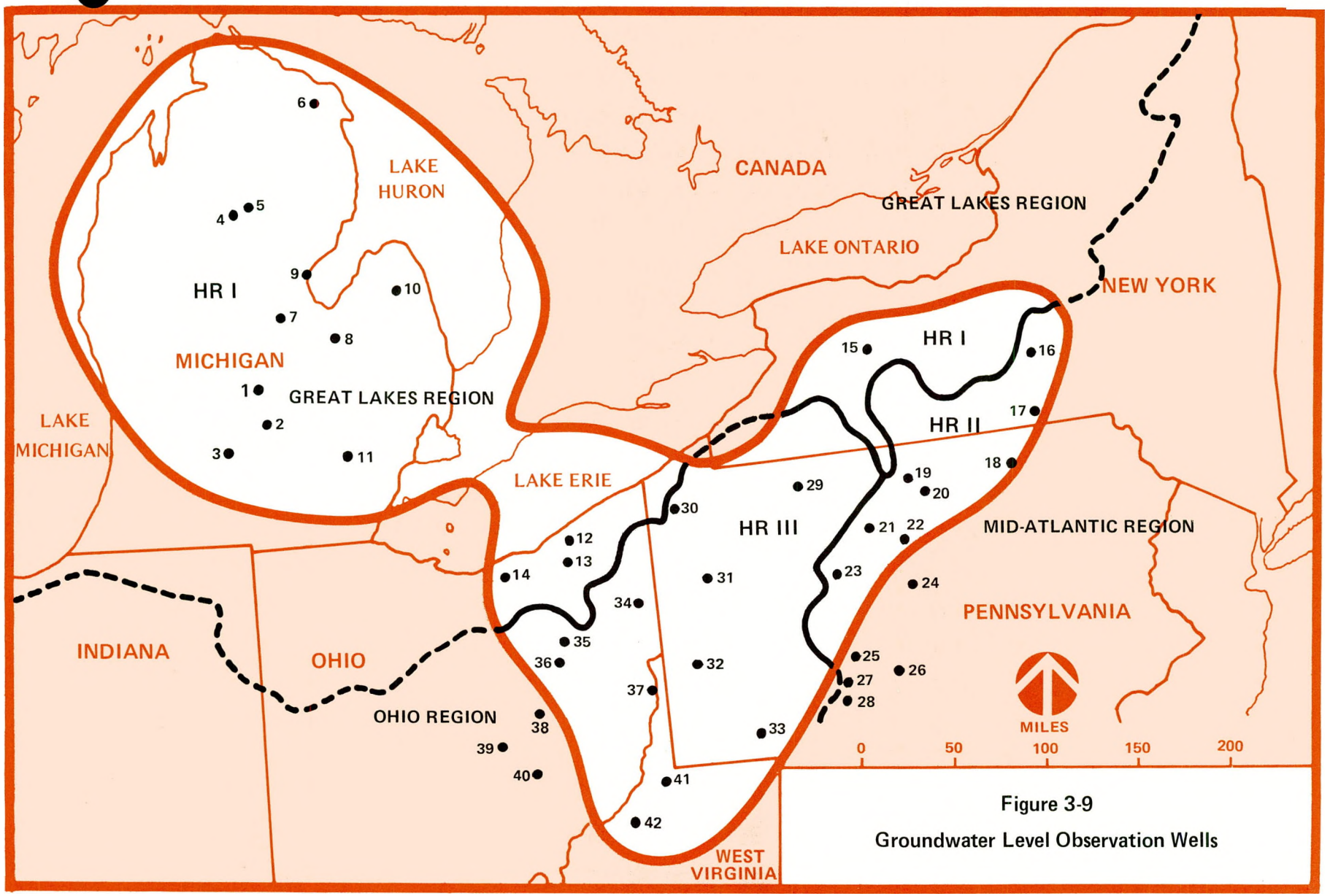


Figure 3-9

Groundwater Level Observation Wells

NOTE: See Tables 3-13 through 3-15 for pertinent data.

4.0 ATMOSPHERE

Atmospheric factors are important considerations in assessing the environmental impact of, and for defining the safety and design requirements for, the construction and operation of a waste repository. At the regional level the primary atmospheric factors of interest are climate, paleoclimatology, severe weather, restrictive dispersion conditions, topography, atmospheric dispersion and transport, as well as air quality.

The climate of the region is important for providing an overview of the environmental setting, although generally it is not directly used for analyses. However, there are certain climatic parameters, such as the precipitation-evaporation index, that can be used in calculating wind erosion and fugitive dust emissions due to the aboveground handling and storage of mined material. In addition, the potential for mine-tailing leaching and site erosion is dependent on precipitation. The effects of severe weather, such as flooding and wind damage, are important safety and design considerations that must be evaluated. Restrictive dispersion conditions, topographic effects, and atmospheric dispersion and transport conditions are important factors in characterizing the impact of releases, both radioactive and nonradioactive, from a waste repository. Furthermore, the relation of present air quality levels to ambient air quality and nondegradation regulations can affect the siting of a new source.

Data presented at the regional level, in general, are not intended for use in computing direct estimates of environmental effects. The detailed data that are required for such analyses are generally not available or meaningful at the regional level. Therefore, various factors and parameters have been selected on the basis of regional data availability and are intended as gross indices for characterizing the regional environment.

4.1 CLIMATE

The regional climate is discussed in terms of general temperature and precipitation characteristics and parameters that can be used as indices of the potential for wind erosion and the generation of fugitive dust (i.e., due to construction and operation activities such as mined-rock storage and disposal).

The Salina Region is located within the Great Interior climatic zone, although its extreme eastern portion is within the western border of the Appalachian Mountain Region. In general, climatic changes are gradual across the Great Interior zone because there are no significant climatic barriers. Differences in climatic conditions within this zone are controlled primarily by latitude, general air masses and other storm movements, elevation, and distance from sources of moisture. The climatic effects of the Great Lakes include moderation of temperature extremes and some localized wind flows (lake and land breezes) near the shores as well as a snowbelt (i.e., region of increased snowfall) on the eastern shores of the lakes (Baldwin, 1973).

Spatial climatic changes can be significant in the Appalachian Mountains. Orographic lifting effects during the passage of storms and frontal systems frequently result in increased rainfall during the warm months and heavy snowfall in winter. In general, the climate of the Salina Region is frequently influenced by cold polar or arctic air masses during the winter and warm, moist maritime air masses during the summer (Baldwin, 1973).

A standard methodology for the classification of climates based on general temperature and precipitation criteria has been developed by Köppen (Petterssen, 1958). The classification and distribution of Köppen climatic regions within and adjacent to the Salina Region are shown in Figure 4-1. On the basis of such a classification, the climate of the Region can be summarized as ranging from cool (without a dry season and with warm summers) in the northern section to warm temperate and rainy (without a dry season and with warm to hot summers) in the southern section.

The potential for leaching of soluble materials from the rocks mined during the construction and operation of a repository can be estimated generally from the average precipitation rate for the region.

The normal seasonal and annual precipitation values for the Salina region are presented in Figures 4-2 through 4-6 by state climatic division. Data for the months of January, April, July, and October have been selected to represent the winter, spring, summer, and fall seasons, respectively.

Annual normal precipitation in the Salina Region ranges from a minimum of 28.52 inches in the northwestern portion (east central lower climatic division in Michigan) to 46.17 inches in the southeastern portion (north central climatic division in Ohio). On a seasonal basis, the minimum normal precipitation occurs during the fall and winter seasons. Maximum values occur during the spring and summer; this is attributed to the frequent occurrence of warm, moist air advection during the spring and summer.

Fugitive dust (i.e., particulate emissions) can be generated by wind erosion of material mined during the construction and operation of a repository. For this study, an empirical climatic factor C is used to indicate the wind erosion potential, a standard approach used by the U.S. Department of Agriculture. This parameter includes a term to account for the cube of the average wind speed and also a term (Thornthwaite's precipitation-evaporation index) to account for surface moisture. Specifically, the climatic factor C can be calculated as follows (PEDCo, 1973):

$$C = 34.5\left[V^3/(PE)^2\right]$$

where:

V = mean annual wind velocity (miles per hour) corrected to a standard height of 30 feet

PE = yearly sum of monthly precipitation minus potential evaporation totals (inches).

The moisture content of surface materials is a more direct indicator of wind erosion potential than is the precipitation-evaporation index. However, moisture content measurements are not routinely made, whereas precipitation and evaporation measurements are frequently available.

Annual wind erosion climatic factors for the Salina Region are less than 10 and are therefore indicative of a very low erosion potential, which is typical for the eastern United States (Chepil et al., 1962; Jutze and Axetell, 1976).

The PE values are also used to calculate suspended dust emissions from storage piles (tailings, etc.) as illustrated below, assuming a 3-month storage cycle (USEPA, 1976a):

$$E = \frac{0.33}{(PE/100)^2}$$

where:

E = emission factor, pounds per ton placed in storage per 3 months.

Annual PE values for the Salina Region are presented in Figure 4-7 by state climatic division. The spatial distribution of PE values reflects the precipitation distribution shown in Figure 4-6 (i.e., relatively low PE values are associated with relatively low precipitation values). In general, the range of PE values in the Region (from 91 inches in the southeast lower climatic division of Michigan to 124 inches in the northwest plateau and central mountain climatic divisions of Pennsylvania as well as the north central division of West Virginia) is indicative of a rainy climate.

4.2 PALEOCLIMATOLOGY

Climates of the past provide an indication of the long-term variability of the climate in a region and a basis for estimating future climatic changes that may affect the future impact of a repository. Considering the expected storage time commitments for nuclear wastes at a repository, the most significant historical time period is the last 500,000 years. Detailed climatological information is not available for this historical period. However, qualitative estimates of temperature and precipitation regimes have been made, and the extent of glaciation and flooding can be fairly accurately estimated from geologic evidence. It should be noted that much of the available paleoclimatological information is generalized for large geographical areas (continents, hemispheres, etc.), and hence specific climatic conditions for the Salina Region frequently must be inferred from these generic climatological descriptions.

The Pleistocene Epoch, which began about 1.8 million years ago, is the latest glacial period. This epoch ended approximately 7000 years ago with the beginning of the Holocene Epoch, although continuous ice sheets are still in existence at the polar regions (Seyfert and Sirkin, 1973).

Advances of glaciers from the polar regions are called glacial stages; the retreats are interglacial stages. Within the Pleistocene there have been at least four glacials and three interglacials. A summary of the stages of the Pleistocene is presented in Table 4-1. Principal areas covered by ice during the last major glacial maximum (Pleistocene) in the vicinity of the Salina Region are shown in Figure 4-8. Ice covering was extensive, and these glaciers had a very significant effect on the climate of the Region during the Pleistocene. Furthermore, although the southward extension of the glacial ice sheet was not as great as that of the three previous advances, the Wisconsin Glacial was the coldest and driest of the four (Sellers, 1965).

During the Wisconsin Glacial, there were a series of glacier advances and retreats (interstadials).

TABLE 4-1

STAGES OF THE PLEISTOCENE EPOCH

Stage	Age (Thousands of Years)	
Wisconsinan Glacial	7	120
Sangamonian Interglacial	120	380
Illinoian Glacial	380	550
Yarmouthian Interglacial	550	900
Kansan Glacial	900	1340
Aftonian Interglacial	1340	1520
Nebraskan Glacial	1520	1800

SOURCE: Seyfert and Sirkin (1973).

The advance of glaciers was initially associated with the appearance of a cold, damp climate, followed by a cold, dry climate that developed over the ice sheet itself (Schwarzbach, 1963). Precipitation over the glaciated area was probably not as high as that over the same region at present. Average temperatures in the temperate latitudes of the Northern Hemisphere were approximately 8 to 16°C lower than present values during the coldest glaciation (Wisconsin) of the Pleistocene.

During glaciation periods in North America, the westerly wind belt was displaced toward the equator (Brooks, 1970; Schwarzbach, 1963). This change resulted in some areas south of the glacier receiving increased (pluvial) rainfall (Schwarzbach, 1963). In the United States, pluvial effects occurred in the Great Basin and the Great Plains (Schwarzbach, 1963). Several lakes were formed or expanded during the pluvial, especially in the western United States, many areas of which are now deserts (Flint, 1967; Schwarzbach, 1963).

The interglacials of the Pleistocene were typically free of ice and were drier than at present (Sellers, 1965). Moreover, temperatures were similar or at times slightly warmer than those at present (Schwarzbach, 1963; Sellers, 1965). As an indication of these temperature differences, average world temperatures were approximately 1.7°C above those of the present (Sellers, 1965). Fossil evidence indicates that, during the Sangamon Interglacial, the temperature in the vicinity of Toronto, Canada, was 2.3°C higher than that at present (Schwarzbach, 1963). The advance and subsequent retreat and melting of the glaciers (resulting in flooding conditions) created the Great Lakes, whose boundaries once extended further south than they do at present (see Figure 4-8).

The current epoch is the Holocene, which, as previously indicated, began approximately 7000 years ago and is considered to be interglacial. A brief summary of the climate of this epoch is presented in Table 4-2. Oscillations of the interglacial climate in the United States during the Holocene have been less severe than those experienced during the Pleistocene, when conditions varied between glacial and interglacial (Lamb, 1966). There are indications that a natural long-term global cooling trend is still under way at present, although there has been a relatively recent short-term period (approximately 40 to 100 years ending about 1950) of global warming (Kukla and Matthews, 1972; Lamb, 1966).

4.3 SEVERE WEATHER

Information about severe weather is mainly important for assessing the potential danger of structural damage and flooding at a repository location. Aboveground waste handling facilities and administrative offices may be exposed to severe weather. Therefore, the frequency and intensity of severe weather events are used as design considerations for these facilities. At the regional level, the most significant severe-weather parameters are maximum 24-hour precipitation, tornadoes, and extreme winds.

Maximum 24-hour precipitation is a significant factor in evaluating peak runoff and the potential for flooding as well as severe erosion and leaching. Isopleths of the maximum 24-hour rainfall associated with a 100-year recurrence interval are presented for the Salina Region in Figure 4-9. Maximum rainfall values range from approximately 4 inches in the northwestern portion to approximately 6 inches in the eastern portion of the Region. These values are rather typical for the contiguous United States.

TABLE 4-2

A BRIEF CHRONOLOGY OF THE CLIMATE OF THE LAST 10,000 YEARS

Dates	Region	Climate
9000-6000 B.C.	Southern Arizona	Warm and arid.
7800-6800 B.C.	Europe	Cool and moist, becoming cool and dry by 7000 B.C. Ice sheets left Sweden in 6840 B.C.
6800-5600 B.C.	North America, Europe	Cool and dry, with possible extinction of mammals, particularly in Arizona and New Mexico. Cochrane Readvance in Alaska and southeast Canada.
5600-2500 B.C.	Both hemispheres	Warm and moist, becoming warm and dry by 3000 B.C. (Climatic Optimum). Intermittent drought in the western United States after 5500 B.C. Start of glacial retreat in the McMurdo Sound region of Antarctica about 4000 B.C. Maximum glacial retreat in Alaska near 3500 B.C.
2500-500 B.C.	Northern hemisphere	Generally warm and dry with periods of heavy rain (in Europe near 1300 B.C.; in the Near East about 1100 B.C. and between 850 and 800 B.C.; and in the western United States after 660 B.C.) and intense droughts (in Europe after 2200 B.C., between 1200 and 1000 B.C., and between 700 and 500 B.C.; in China from 842 to 771 B.C.; and in the western United States near 510 B.C.). Glaciation in Alaska (between 2380 and 1340 B.C. and near 600 B.C.).
500 B.C.-A.D. 0	Europe	Cool and moist. Glacial maximum in Scandinavia and Ireland between 500 and 200 B.C.
330	United States	Drought in the Southwest.
600	Alaska	Glacial advance.
590-645	Near East, England	Severe drought in the Near East, followed by cold winters. Drought in England.
673	Near East	Black Sea frozen.

TABLE 4-2 (Continued)

Dates	Region	Climate
800	Mexico	Start of moist period.
800-801	Near East	Black Sea frozen.
829	Africa	Ice on the Nile.
900-1200	Iceland	Glacial recession (Viking period).
1000-1011	Africa	Ice on the Nile.
1000-1100	Utah	Snowline 300 m higher than today.
1200	Alaska	Glacial advance.
1180-1215	United States	Wet in the West.
1220-1290	United States	Drought in the West.
1276-1299	United States	"Great Drought" in the Southwest.
1300-1330	United States	Wet in the West.
1500-1900	Europe, United States	Generally cool and dry (Little Ice Age). Periodic glacial advances in Europe (1541-1680, 1741-1770, and 1801-1890) and North America (1700-1750). Drought in the southwestern United States from 1573 to 1593.
1880-1940	Both hemispheres	Increase of winter temperatures by 1.5°C. Drop of 5.2 m in the level of the Great Salt Lake. Alpine glaciation reduced by 25% and arctic ice by 40%. Rapid glacial recession in the Patagonian Andes (1910-1920) and the Canadian Rockies (1931-1938).
1920-1958	United States	25% decrease in mean annual precipitation in the Southwest.
1942-1960	Both hemispheres	Worldwide temperature decrease and halt of glacial recession.

SOURCE: W. D. Sellers (1965).

The frequency and intensity of tornadoes are important design and safety considerations for aboveground facilities. Various dangers posed by tornadoes include wind-blown missiles, extreme pressure differentials, and extreme wind forces. An indication of the frequency of tornadoes in and near the Salina Region is presented in Figure 4-10, which shows the total number of tornadoes reported during the period 1955-1967 by 1-degree squares. The frequency of tornadoes is noticeably greater in southern Michigan and eastern Ohio than in other sections of the Region. However, the frequency of tornadoes in the Region is significantly lower than that in the Central United States (Pautz, 1969; Thom, 1963). In general, tornadoes within the Region can be characterized as of relatively moderate to high intensity (based on average tornado path areas and average maximum tornado wind speeds) (Abbey, 1976; Markee and Beckerly, n.d.).

Extreme winds, defined as the fastest passage of 1 mile of wind at 30 feet above ground, are an important factor in specifying wind loadings for buildings and structures. A standard index used for the design and construction of structures is the annual extreme fastest mile associated with a 100-year recurrence interval. The fastest mile is defined as the fastest passage of 1 mile of wind and includes all wind events except tornadoes. The 100-year recurrence interval is used for structures that are sensitive to wind loads and for situations dangerous to life. Isopleths of these maximum wind estimates are presented in Figure 4-11. These values were determined by the methodology developed by Thom (1954, 1967). Figure 4-11 indicates that most of the Salina Region experiences 100-year maximum winds of less than 90 mph, which is typical for most of the continental United States.

4.4 RESTRICTIVE DISPERSION CONDITIONS

Restrictive dispersion conditions can be described in terms of mixing levels and also periods of poor dispersion conditions that persist for a relatively long time.

The term "mixing level" is defined as the height above the surface below which relatively vigorous vertical mixing occurs. Therefore, the mixing level indicates the practical vertical limit of dispersion and is significant for dispersion over large distances and for cases involving significant plume rise. Mixing levels are generally estimated from the analysis of upper air temperature profiles obtained by balloon soundings. For this application the afternoon mixing level is considered to be an appropriate indication of mixing-level conditions for the Region. Afternoon mixing levels as used for this application are defined as the intersection of the vertical temperature profile at 1200 hours Greenwich mean time with the dry adiabatic extension of the maximum surface temperature observed from 1200 through 1600 hours local standard time (Holzworth, 1972).

Seasonal and annual average afternoon mixing levels are presented in Figures 4-12 through 4-16. Values are at a maximum during the summer and at a minimum during the winter. In general, mixing heights in the Salina Region decrease from the southeast to the northwest and can be characterized as typical of normal conditions for the eastern United States.

Poor dispersion conditions that persist for long periods have the potential for increased ground-level concentrations of emissions.

Specifically, the conditions of interest for this study are the occurrences of mixing heights of less than 1500 meters on at least two consecutive days with wind speeds of

less than 4.0 m/sec and no significant precipitation. These conditions are frequently associated with the stagnation of large-scale high-pressure systems.

The occurrence of restrictive dispersion conditions, based on the criteria discussed above, is summarized for the Salina Region in Figure 4-17. Data available for weather stations within and adjacent to the Region indicate that episodes of poor dispersion conditions are relatively frequent in the extreme southern section compared with the rest of the Region and the contiguous United States.

4.5 TOPOGRAPHY

The characteristics of the terrain significantly influence atmospheric dispersion and transport conditions. In general, a complex terrain (e.g., mountains, valleys, and ridges) is associated with modified (compared to conditions over flat land) air flows affecting wind speed, direction, and stability distributions. It is therefore necessary to evaluate the various types of land formations and their effects on atmospheric transport and dispersion conditions, considering the types of release that may occur from a waste repository.

The topographic, physiographic, and landform features of the Salina Region have been discussed and graphically presented in Section 2.1. Since most of the Region consists of plains, tablelands, and hills, large-scale topographic effects influencing the climate are not expected. Exceptions to this are temperature and precipitation effects attributable to the Great Lakes and the Appalachian Mountains (adjacent to the eastern border of the Region), which have been discussed in Section 4.1. These effects are large scale in nature and are generally reflected in the climatic data that have been used to characterize the Region. However, it should be noted that there is also the potential for localized topographic influences on ambient wind and stability conditions, especially in the eastern section of the Region and along the shores of the Great Lakes.

The hill and valley terrain in the eastern section of the Salina Region is conducive to channeling large-scale wind flows along the orientation of major terrain features. Local wind flows such as slope-valley circulations may also develop. These local circulations, which are diurnal in nature, are caused by differences in the rate of heating and cooling of slope and valley surfaces and the resulting buoyancy effects. Additional topographic effects include the greater frequency of inversions within the valleys and the increased wind turbulence that occurs to the lee of large hills and mountains (Slade, 1968).

The potential for local lake and land breezes exists along the Great Lakes. These circulations result from the difference between the surface temperatures of the land and the water. Lake breezes are characterized by an onshore wind (i.e., flowing from the lake toward the shore) and are most frequent during spring and summer afternoons. These onshore flows may penetrate inland only a few hundred meters, if constrained by opposing gradient winds or rising terrain, or more than 50 kilometers during favorable conditions (Lyons, 1975). Onshore flows during both lake-breeze and gradient (i.e., large-scale) wind flows result in local changes in the wind turbulence and atmospheric stability conditions along the shoreline. Land breezes, which are local offshore winds, generally occur less frequently and are weaker than lake breezes (Slade, 1968).

The hill/valley and lake/land topographic effects discussed above are important factors that can significantly affect atmospheric dispersion and transport. These effects would

be most significant in the near vicinity of a release since large-scale wind patterns become dominant with greater travel distances.

4.6 DISPERSION CONDITIONS

The atmospheric transport and dispersion of emissions, both radioactive and nonradioactive (e.g., from mined-rock storage piles), can be estimated on the basis of wind conditions and atmospheric stability. However, joint frequency distributions of wind direction and speed as a function of atmospheric stability or concurrent wind/stability data are necessary for these calculations. These detailed data sets are generally not available to characterize regional conditions. Therefore, in describing the environment of the Salina Region, only the mean wind speed and the prevailing wind direction are used as gross indicators of regional wind conditions.

The atmospheric dispersion of airborne emissions from a source is directly proportional to wind speed for normal release conditions, all other factors remaining constant. However, there are certain complex situations in which high wind speeds may result in poor dispersion (e.g., aerodynamic downwash, reduced plume rise) or other adverse effects (e.g., wind erosion of dust from rock storage piles).

Seasonal and annual mean wind speeds and prevailing wind directions in the Salina Region are presented in Figures 4-18 through 4-22, based on normals available for representative climatological stations. Data for the months of January, April, July, and October have been selected to represent the winter, spring, summer, and fall seasons, respectively.

Annually, prevailing winds in the Salina Region are from the west-southwest through south. Seasonal variations in general are relatively minor, except for some locations along the Great Lakes (e.g., Erie, Pennsylvania). However, it should be noted that secondary wind flows with northerly components (not shown in Figures 4-18 through 4-22) are relatively more frequent in winter than in other seasons. Geographical variations across the Region are most noticeable along the Great Lakes (as previously indicated) and in the eastern section, in the foothills of the Appalachian Mountains. These areas are subject to the influences discussed above in Section 4.5.

Maximum mean wind speeds occur during the winter and spring seasons, whereas the lowest mean wind speeds occur during the summer. Annual mean wind speeds range from a minimum of 7.5 mph (Alpena, Michigan) to a maximum of 11.4 mph (Erie, Pennsylvania). A mean wind speed average of approximately 10 mph for the Region is considered typical of average conditions in the contiguous United States (Environmental Data Service, 1968).

4.7 AIR QUALITY

The construction and operation of an underground waste repository will require the aboveground handling, storage, and disposal of several thousand tons of mined material daily. The operations of crushing, transporting, and disposing of the mined material can be considered similar to other large mining operations in that fugitive dust will be generated and may affect local air quality. Federal, state, and local air quality standards as well as nondeterioration statutes can therefore affect the siting of a new source of emissions. A new source cannot be located in an area that is not attaining the national

ambient air quality standards (USEPA, 1971) (unless certain emission offset criteria are satisfied) or where its emissions would result in violations of the air quality standards or cause the increments established by the Clean Air Act Amendments of 1977 to be exceeded (House of Representatives, 1977).*

The national ambient air quality standards for particulate matter, listed in Table 4-3, will be a significant air quality factor in the location and operation of the repository.* The particulate emissions from the repository plus the background particulate concentration must not cause either the primary or the secondary national ambient air quality standards to be exceeded. Another significant air quality factor will be the allowed increase in particulate concentration in areas where the 1974 ambient concentrations were lower than the national secondary air quality standards. The particulate emissions from all new sources in the area since 1974 may not increase the particulate concentration by more than 19 $\mu g/m^3$ for the annual geometric mean or 37 $\mu g/m^3$ for the maximum 24-hour concentration (USEPA, 1977a).

Table 4-4 presents the 1974 and 1975 summaries of ambient air quality suspended particulate data (USEPA, 1976b, 1977b) for all the particulate monitors in the Salina Region. Although there are many particulate monitors in the Salina Region, a detailed characterization of the air quality throughout the region is difficult because of the concentration of many of the monitors in the larger cities and the large variation in particulate concentrations in industrialized areas. In general, the data summaries in Table 4-4 indicate that the national secondary ambient air quality standards for particulates are being exceeded throughout the area encompassing northeastern Ohio, southwestern Pennsylvania, and the northern section of West Virginia, and in the areas in and around all the major cities as well. Furthermore, many of the cities have particulate concentrations exceeding the primary standards. Figure 4-23 shows the areas in the Salina Region in which the concentrations of suspended particulate matter exceed the national secondary ambient air quality standards.

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*Various state air quality standards are more restrictive than the national ambient air quality standards in some areas and as such would be of greater significance than the national ambient air quality standards.

TABLE 4-3

NATIONAL AMBIENT AIR QUALITY STANDARDS
FOR SUSPENDED PARTICULATE MATTER

Parameter	Primary Standards ($\mu g/m^3$)	Secondary Standards ($\mu g/m^3$)
Annual average geometric mean	75	60
Maximum 24-hour concentration, not to be exceeded more than once per year	260	150

TABLE 4-4

SUSPENDED-PARTICULATE AIR QUALITY DATA FOR THE SALINA REGION

Location	1975(a) Highest 24-Hour Values ($\mu g/m^3$) 1st	2nd	1975(a) Geometric Mean ($\mu g/m^3$)	1974(b) Highest 24-Hour Values ($\mu g/m^3$) 1st	2nd	1974(b) Geometric Mean ($\mu g/m^3$)
NEW YORK						
Auburn	164	151	55	115	88	44
	73	70	33	60	58	28
Cortland	124	111	49	147	102	44
	100	81	36	128	85	36
Cortland County	97	86	30	79	66	23
Onondaga County	82	74	34	82	76	31
	293	267	99	279	260	85
	137	127	53	195	155	44
	159	124	57	100	98	45
	135	104	55	177	167	58
	96	89	61	171	143	55
	160	144	59	143	128	48
	156	134	64	169	130	58
	127	121	51	148	142	46
Genesee	92	72	31	76	63	26
Geneva	114	98	57	412	102	48
Penn Yan	82	80	36	62	60	26
Wyoming County	83	82	32	119	114	37
Alfred	62	52	22	44	42	19
Allegany County	92	69	29	121	72	33
Cattaraugus	65	59	27	68	47	21
County	82	78	34	115	107	32
	74	65	29	57	49	20
Chemung County	127	94	44	88	88	34
Corning	106	86	56	217	192	58
Ellicott	78	54	26	81	68	29
Elmira	177	167	82	133	129	64
Horseheads	120	89	47	132	112	43
Ithaca	125	82	47	102	91	46
Jamestown	263	196	64	214	162	66
	152	145	69	205	179	70
	112	102	44	98	93	34
Watkins Glen	157	136	56	107	101	46
Wellsville	71	66	28	74	65	29
Warsaw	116	105	45	119	104	36
PENNSYLVANIA						
Johnstown	252	203	73	232	206	78
	182	181	86	266	216	105
	142	104	55	193	123	70

TABLE 4-4 (Continued)

Location	1975[a] Highest 24-Hour Values ($\mu g/m^3$) 1st	2nd	1975[a] Geometric Mean ($\mu g/m^3$)	1974[b] Highest 24-Hour Values ($\mu g/m^3$) 1st	2nd	1974[b] Geometric Mean ($\mu g/m^3$)
PENNSYLVANIA (Continued)						
Westmont	86	63	31	124	109	47
Allegheny County	490	414	100	473	430	114
	185	181	30	312	188	81
	195	114		203	142	70
	125	112	56	181	153	65
	117	115	61	470	146	65
	279	227	85	513	419	116
	70	60		310	197	76
Ambridge	290	226	98	245	201	114
Baden	328	279	137	285	270	138
Beaver County	321	235	95	579	405	118
	251	227	82	269	238	90
	754	514	106	231	214	77
Beaver Falls	151	142				
	280	140	67	256	245	74
Braddock	487	379	137	803	573	176
	404	312	112	572	496	138
Brownsville	186	149	81	217	170	85
Clariton	314	277	112	286	281	114
Duquesne	314	228	104	389	332	121
Midland	364	344	142	454	442	175
Monessen	425	302	113	377		152
Pittsburgh	126	111	72	159	147	78
	262	234	92	196	188	
	258	234	87	311	258	95
	386	229	104	327	279	107
	211	183		402	278	94
	484	358	158	347	316	132
	186	173	78	213	156	83
Rochester	241	227	83	313	235	99
Springdale	171	159	57	170	150	61
Washington	320	205		661	287	122
County	168	110	50	147	147	66
	334	185	69	138	133	67
West Mifflin	332	278	77	414	352	83
Westmoreland	116	108	44	146	137	66
Clarion County	66	33				
Erie County	121	99	42	125	103	43
Farrell	202	189	89	185	184	97
Lawrence County	733	578	210	1713	896	238
New Castle	338	276	121	346	272	125
Ashtabula	194	161	75	169	155	75
Ashtabula County	125	122	54	92	90	52
	137	120	58	103	98	55

TABLE 4-4 (Continued)

Location	1975[a] Highest 24-Hour Values ($\mu g/m^3$) 1st	2nd	1975[a] Geometric Mean ($\mu g/m^3$)	1974[b] Highest 24-Hour Values ($\mu g/m^3$) 1st	2nd	1974[b] Geometric Mean ($\mu g/m^3$)
			OHIO			
Astabula County	143	139	69	192	130	75
(cont'd)	136	99	44	92	87	41
Campbell	367	314	111	376	284	111
Girard	227	182	79	274	263	91
Niles	201	195	74	203	202	76
Struthers	287	245	96	249	242	118
Trumbull County	158	119	61	287	157	71
Warren	135	130	64	197	158	71
	142	141	74	269	210	75
	203	171	84	235	223	105
	239	209	83			
Youngstown	177	139	81	160	140	84
	408	362	120			
	129	126	69	139	131	78
	159	150	88	187	173	101
	331	249	105	312	223	109
	383	295	102			
	368	279	129	390	357	148
	336	328	137			
Belpre	217	194	62	552	132	64
Marietta	202	156	69	157	105	64
Akron	137	131	69	134	126	70
	167	117	65	146	128	64
	133	122	70	170	151	75
	148	146	76	213	207	93
	185	175	89	242	212	97
	184	181	83	233	208	84
	139	123	78	140	110	76
Alliance	168	154	76	167	162	78
Barberton	151	137	77	154	146	77
Beachwood	174	131	66	141	129	71
Bedford Heights	205	188	79	248	186	79
Canton	158	135	75	174	154	76
	242	227	83			
	131	128	78	160	140	96
	166	127	65	147	116	63
	178	165	74	180	178	81
	127	115	65	192	162	72
	133	130	64	152	122	68
	201	132	68	218	188	78
	114	108	52	231	124	53

TABLE 4-4 (Continued)

Location	1975[a] Highest 24-Hour Values ($\mu g/m^3$) 1st	2nd	1975[a] Geometric Mean ($\mu g/m^3$)	1974[b] Highest 24-Hour Values ($\mu g/m^3$) 1st	2nd	1974[b] Geometric Mean ($\mu g/m^3$)
			OHIO (Continued)			
Canton (cont'd)	111	78				
	157	129				
	287	225	95	211	198	86
Chardon	130	125	56	135	116	51
Cleveland	297	243	94	261	248	96
	132	92		172	146	74
	261	190	89	202	199	86
	153	87	53	205	122	53
	181	177	67	123	119	60
	292	289	173	440	386	139
	324	312	143			
	284	194	93	159	155	78
	268	246	113			
	209	185	69	247	150	74
	173	165	71	136	131	65
	230	225	108	397	274	120
	233	223	111			
	383	340	149	534	509	181
	308	306	153			
	132	104		196	132	74
	253	235	98	261	231	93
	201	173	69	158	139	62
	202	146	65	199	154	60
	112	110		199	178	60
	408	364	139	368	352	168
	441	356	151			
	374	236	92	321	299	97
	339	265	111			
	133	105		197	150	65
	335	334		472	444	108
	456	393	129	497	389	155
	363	363	146			
	402	337	133			
	569	456	129			
Eastlake	156	138	69	834	667	81
	151	147	67	130	111	59
Euclid	191	157	70			
	269	179	99			
Fairport	149	114				
Geauga County	120	119	61	1178	774	80
	119	103	50	116	108	42
Independence	75	72				
Kent	132	128	55	135	127	62

TABLE 4-4 (Continued)

Location	1975(a) Highest 24-Hour Values ($\mu g/m^3$) 1st	2nd	1975(a) Geometric Mean ($\mu g/m^3$)	1974(b) Highest 24-Hour Values ($\mu g/m^3$) 1st	2nd	1974(b) Geometric Mean ($\mu g/m^3$)
			OHIO (Continued)			
Lake County	140	137	53	411	359	56
	122	113	48	649	641	57
	138	137	57	115	110	55
	111	109	49	122	107	49
Lorain	149	133	75	129	119	71
	195	150	83	274	155	73
	108	108				
	238	165	84			
	130	129	66	168	107	64
	179	129	79	107	105	68
Massillon	133	116	63	148	120	68
Medina	169	111	61	107	107	61
Mentor	149	142	59	1066	730	80
North Olmstead	124	95		111	107	62
Painesville	193	160	70	983	842	83
	246	166	73	171	149	
Parma	180	124	76	224	183	71
Ravenna	135	132	67	144	119	71
Stark County	87	85	43	155	118	48
	149	127	60	159	146	72
	107	96	59	151	108	45
	176	146	63	177	164	65
	107	101	55	211	118	57
Stow	136	134	64	139	135	66
Summit County	149	143	55	110	105	52
	166	166	57	194	181	73
Tallmadge	149	144	78	185	166	87
Twinsburgh	160	137	68	150	147	79
Wadsworth	158	147	78	175	155	83
Westlake	74	73				
Wickliffe	147	144	65	150	144	68
Willoughby Hills	119	100	48	768	393	57
Willowick	138	131	67	125	115	56
Orrville	134	109	55			
Rittman	172	168	52			
	210	146	56			
	114	109				
	172	167	63			
	118	110				
Wooster	160	122	61	117	110	59
	180	143	55			
Belmont County	427	294	117	616	536	138
East Liverpool	271	258	114	300	250	102
	712	296	120	292	290	100

TABLE 4-4 (Continued)

Location	1975[a] Highest 24-Hour Values ($\mu g/m^3$) 1st	2nd	1975[a] Geometric Mean ($\mu g/m^3$)	1974[b] Highest 24-Hour Values ($\mu g/m^3$) 1st	2nd	1974[b] Geometric Mean ($\mu g/m^3$)
			OHIO (Continued)			
East Palestine	179	163	57	268	222	80
Jefferson County	280	238	79	533	358	103
	246	235	67	303	266	70
	302	282	118	300	255	134
Lisbon	155	151	77	188	186	79
Martins Ferry	388	263	92	452	242	96
Mingo Junction	538	455	147	667	475	202
Monroe County	488	449	132	469	391	118
	274	195	57	305	200	62
St. Clairsville	117	105	51	151	128	58
Salem	147	144	73	169	160	83
	305	159	72	265	241	91
Shadyside	186	161	83	255	223	84
Steubenville	364	286	95	824	522	
	435	314	134	480	433	179
	664	636	135	696	605	147
	241	195	101	260	220	
Toronto	289	266	94	266	202	
Wellsville	257	210	109	294	267	112
Woodsfield	122	118	47	242	170	56
Tuscarawas County	195	152	74			
			WEST VIRGINIA			
Follansbee	675	511	173	598	577	163
Hancock County	287	275	110	351	274	88
	289	252	88	367	283	76
Moundsville	245	223	96	238	229	110
Weirton	450	351	144	370	338	173
	377	344	130			
Wellsburg	385	339	138	457	302	125
Wheeling	182	167	87	303	206	107
	179	167	87	284	254	104
	187	154		258	179	94
	163	134	62	164	141	72
	162	151	68	166	146	70
Vienna	118	115	59	239	151	64
Parkersburg	246	152	70	208	174	78
Wood County	205	201	67	308	194	75
Clarksburg	161	151	69	168	146	72
Fairmont	295	253	81	284	246	87
	186	117	54	163	109	63
Harrison County	87	84	45	157	148	49

TABLE 4-4 (Continued)

Location	1975[a] Highest 24-Hour Values ($\mu g/m^3$) 1st	2nd	1975[a] Geometric Mean ($\mu g/m^3$)	1974[b] Highest 24-Hour Values ($\mu g/m^3$) 1st	2nd	1974[b] Geometric Mean ($\mu g/m^3$)
WEST VIRGINIA (Continued)						
Morgantown	143	140	66			
	238	126	54			
MICHIGAN						
Bay City	159	148	60	160	124	
Big Rapids	49	46	25			
East Grand Rapids	105	97	42	96	93	42
Essexville	105	101	49	308	221	
	118	117	46	81	73	
Flint	149	129	49	112	86	45
	132	126	55	109	102	57
	106	105	49	93	90	51
	194	156	67	154	122	63
	122	119	50	120	97	47
	133	130	52	110	109	55
	136	120	66	180	110	
	122	116	52	112	111	49
	168	161	59	235	185	57
	126	104	46	112	92	49
	143	123	54	109	109	48
	178	134	52	123	114	52
	137	115	39	129	103	44
	108	99	40	105	98	46
	152	144	69	125	121	64
Grand Rapids	145	118	61	130	81	
	196	161	66	163	136	64
	190	124	52	143	131	63
	202	157	58	147	135	64
	166	105	39	96	92	40
	137	123	51	222	147	59
	109	106	39	121	118	40
	98	88	36	95	94	34
Kentwood	103	100	35			
Ludington	134	101	39	135	97	37
	152	101	37	118	96	41
	128	100	37	95	83	34
Midland	117	106	51	161	125	33
Muskegon	237	124	50	162	143	48
	137	126	42	182	148	49
	121	117	47	180	178	53
	135	101	38	174	135	39
Muskegon Heights	157	145	59	299	188	60

TABLE 4-4 (Continued)

Location	1975[a] Highest 24-Hour Values ($\mu g/m^3$) 1st	2nd	1975[a] Geometric Mean ($\mu g/m^3$)	1974[b] Highest 24-Hour Values ($\mu g/m^3$) 1st	2nd	1974[b] Geometric Mean ($\mu g/m^3$)
MICHIGAN (Continued)						
Oscoda-Au Sable	168	80				
Saginaw	140	120	55	110	110	58
	210	176	69	648	333	95
	123	107	49	106	101	51
	128	119	47	106	106	51
	199	155	64	152	137	60
	140	110	50	135	104	59
	188	128	54			
Spring Lake	99	85	36	129	103	37
Wyoming	125	107	45	107	102	48
Allen Park	284	192	88	258	234	96
Dearborn	265	180	86	190	180	71
	306	260	126	321	304	134
	260	179	69	307	212	59
Detroit	160	140	76	220	170	84
	147	130	61	163	125	64
	307	304	129	423	357	145
	243	223	92	314	251	98
	178	178	88	212	174	94
	200	199	86	264	197	78
	197	193	69	189	152	74
	302	283	109	400	339	124
East Detroit	130	129	61	124	108	58
Fraser	136	123	57	148	135	65
Grosse Ile	218	156	71	216	148	81
Livonia	148	120	55	154	134	60
Macomb County	106	99	37	77	64	29
	128	113	61	128	100	57
	128	118	45	129	112	46
Marine City	120	111	56	114	96	50
Mount Clemens	139	138	54	134	106	47
New Baltimore	114	113	41	133	132	45
Pontiac	137	82	54	74	72	
	185	161	72	80	78	42
Port Huron	239	164	77	161	133	71
	203	134	67	122	107	62
	191	172	75	94	81	
	130	124	42	103	102	38
River Rouge	217	214	102	253	230	109
Royal Oak	126	111	67	163	129	60
St. Clair	139	137	48	121	120	58
St. Clair Shores	142	135	54	124	107	51
Southfield	125	104	53	136	128	54

TABLE 4-4 (Continued)

Location	1975[a] Highest 24-Hour Values ($\mu g/m^3$) 1st	2nd	1975[a] Geometric Mean ($\mu g/m^3$)	1974[b] Highest 24-Hour Values ($\mu g/m^3$) 1st	2nd	1974[b] Geometric Mean ($\mu g/m^3$)
MICHIGAN (Continued)						
Sterling Heights	141	137	56	228	170	61
	155	139	57	147	126	51
Trenton	200	69		131	110	72
	149	148	73	160	150	75
	140	127	67			
Warren	193	153	67	153	136	68
	176	169	61	196	147	53
Wayne County	178	119	68	178	160	72
Westland	118	117	64	119	112	58
Wyandotte	188	174	83	181	169	83
Albion	109	89	42	97	80	39
	103	102	41			
Ann Arbor	132	120	62	114	107	59
Battle Creek	112	91	44	114	106	53
East Lansing	113	85	39	108	96	43
	131	115	47	124	99	48
Jackson	100	87	47	117	93	42
Lansing	190	153	68	270	130	66
	97	93	49	123	121	45
	164	105	52	175	156	56
	308	221	65			
	108	104				
Ypsilanti	144	123	57	142	142	58
	69	68				
Alpena	677	435	71	589	241	74
	149	134	60	177	173	56
	771	331	69	472	442	57
Cadillac	65	53	27	107	93	32
Charlevoix	72	61		145	104	29
	106	79	45	101	91	33
Manistee	218	137	62	152	134	58
Manistee County	97	91	39	122	116	51
Petoskey	109	97	32	326	95	40
	181	156	47	425	291	76

a. Data from U.S. Environmental Protection Agency, Air Quality Data--1975 Annual Statistics, EPA-450/2-77-002, May 1977.

b. Data from U.S. Environmental Protection Agency, Monitoring and Air Quality Trends Report, 1974, EPA-450/1-76-001, February 1976.

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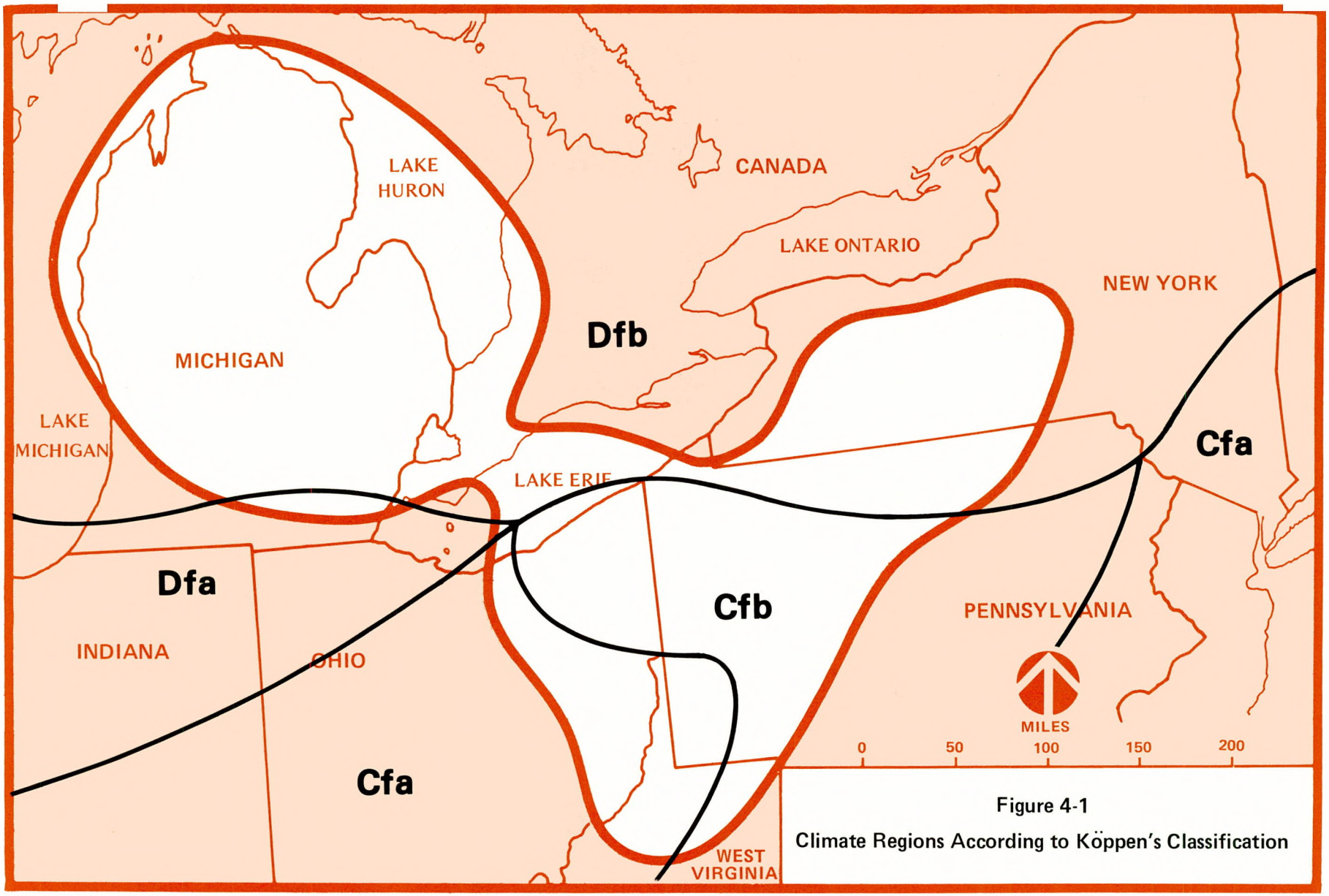


Figure 4-1

Climate Regions According to Köppen's Classification

SOURCE: Petterssen (1958)

Cfa WARM TEMPERATE RAINY CLIMATE (WITHOUT DRY SEASON, WITH HOT SUMMERS)

Cfb WARM TEMPERATE RAINY CLIMATE (WITHOUT DRY SEASON, WITH WARM SUMMERS)

Dfa COOL CLIMATE (WITHOUT DRY SEASON, WITH HOT SUMMERS)

Dfb COOL CLIMATE (WITHOUT DRY SEASON, WITH WARM SUMMERS)

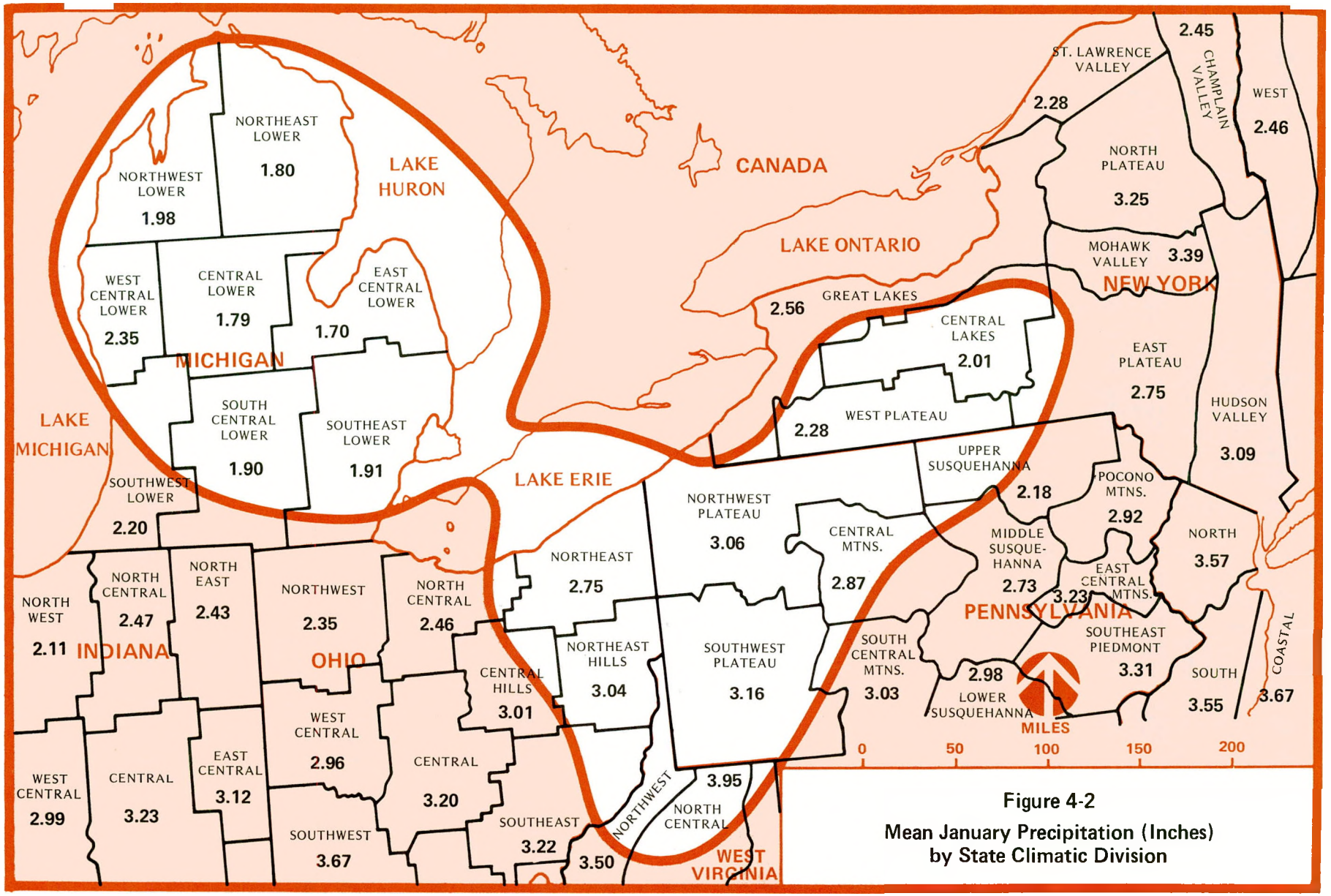


Figure 4-2
Mean January Precipitation (Inches) by State Climatic Division

SOURCE: Environmental Data Service (1968)

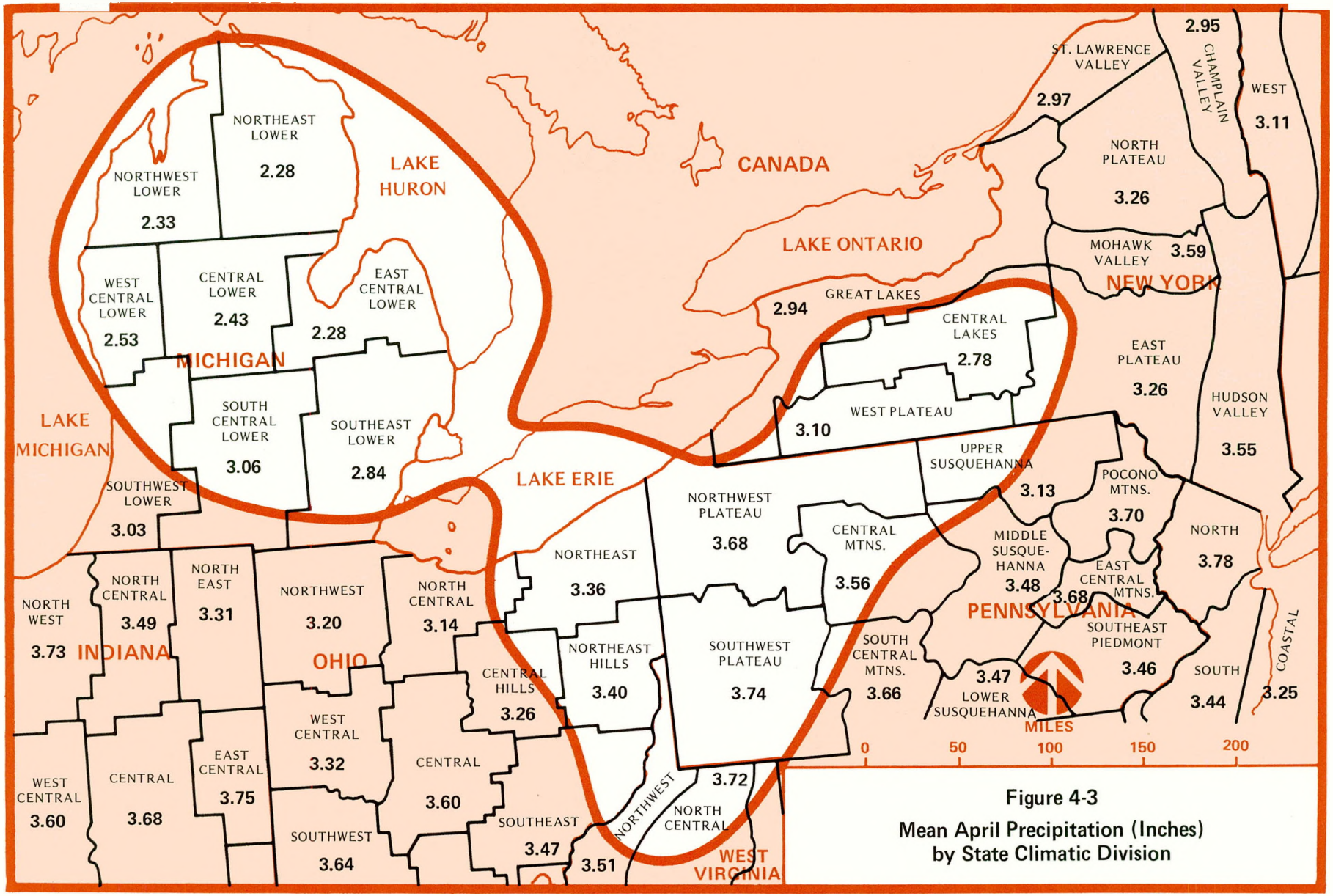


Figure 4-3
Mean April Precipitation (Inches) by State Climatic Division

SOURCE: Environmental Data Service (1968)

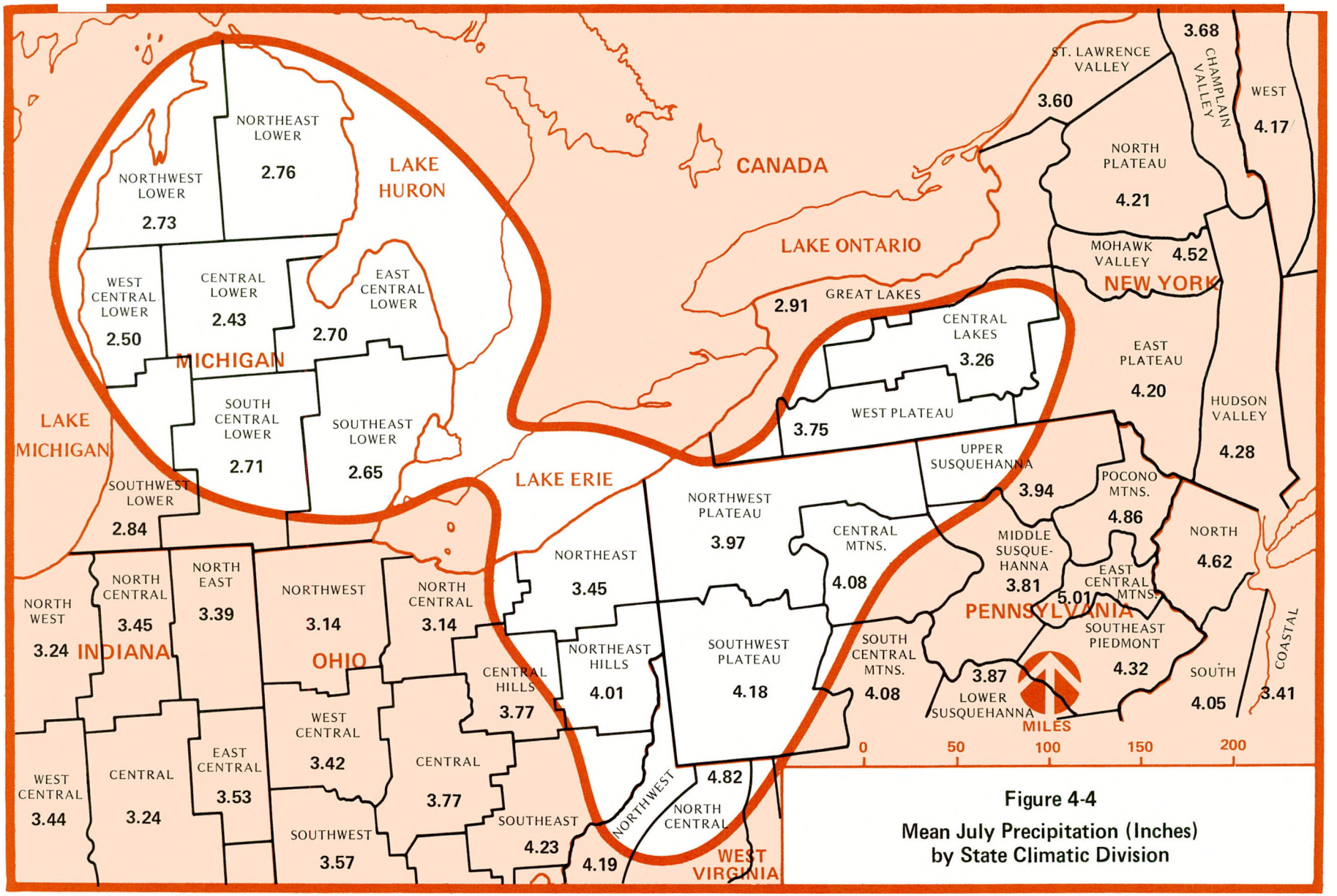


Figure 4-4

Mean July Precipitation (Inches) by State Climatic Division

SOURCE: Environmental Data Service (1968)

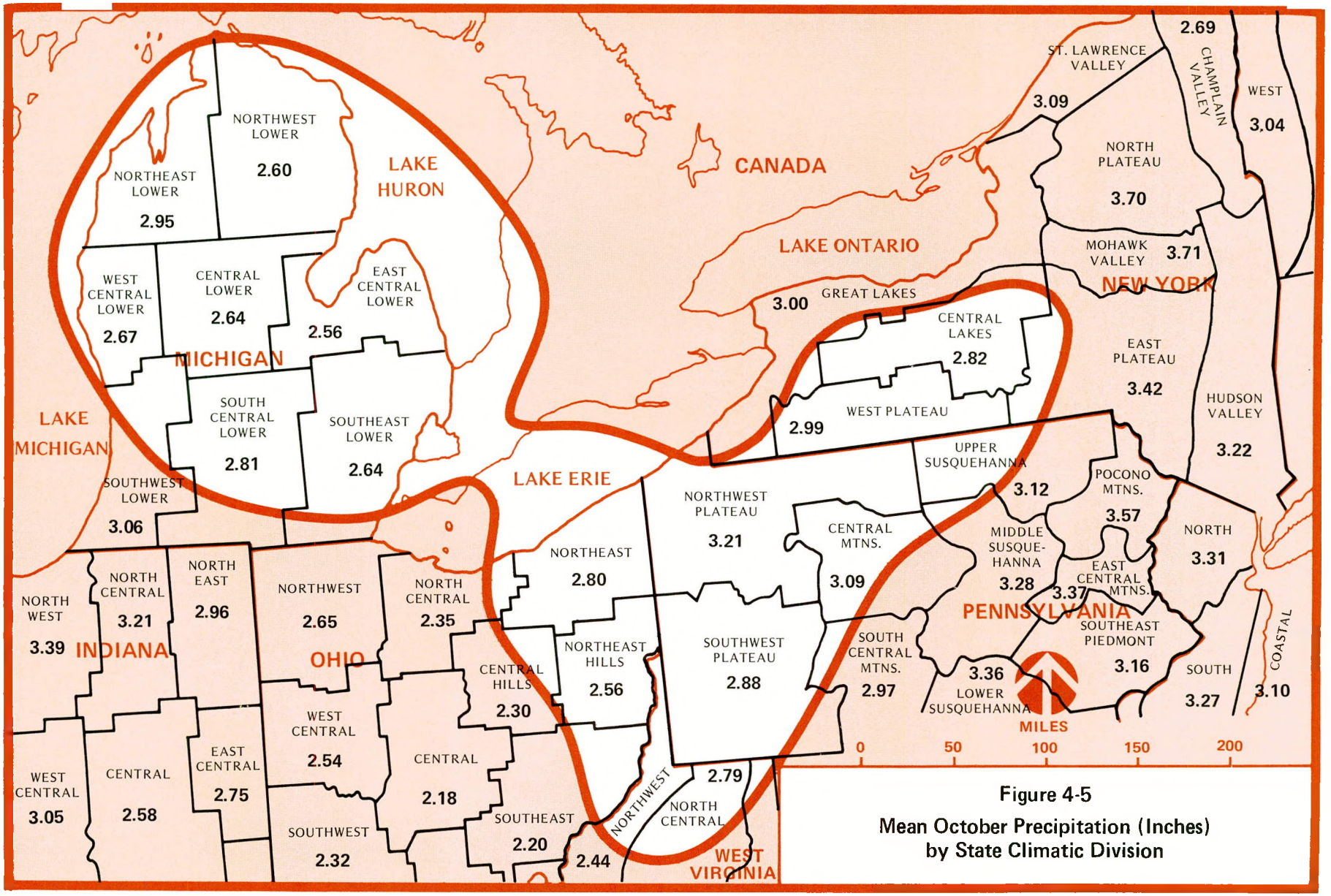


Figure 4-5

Mean October Precipitation (Inches) by State Climatic Division

SOURCE: Environmental Data Service (1968)

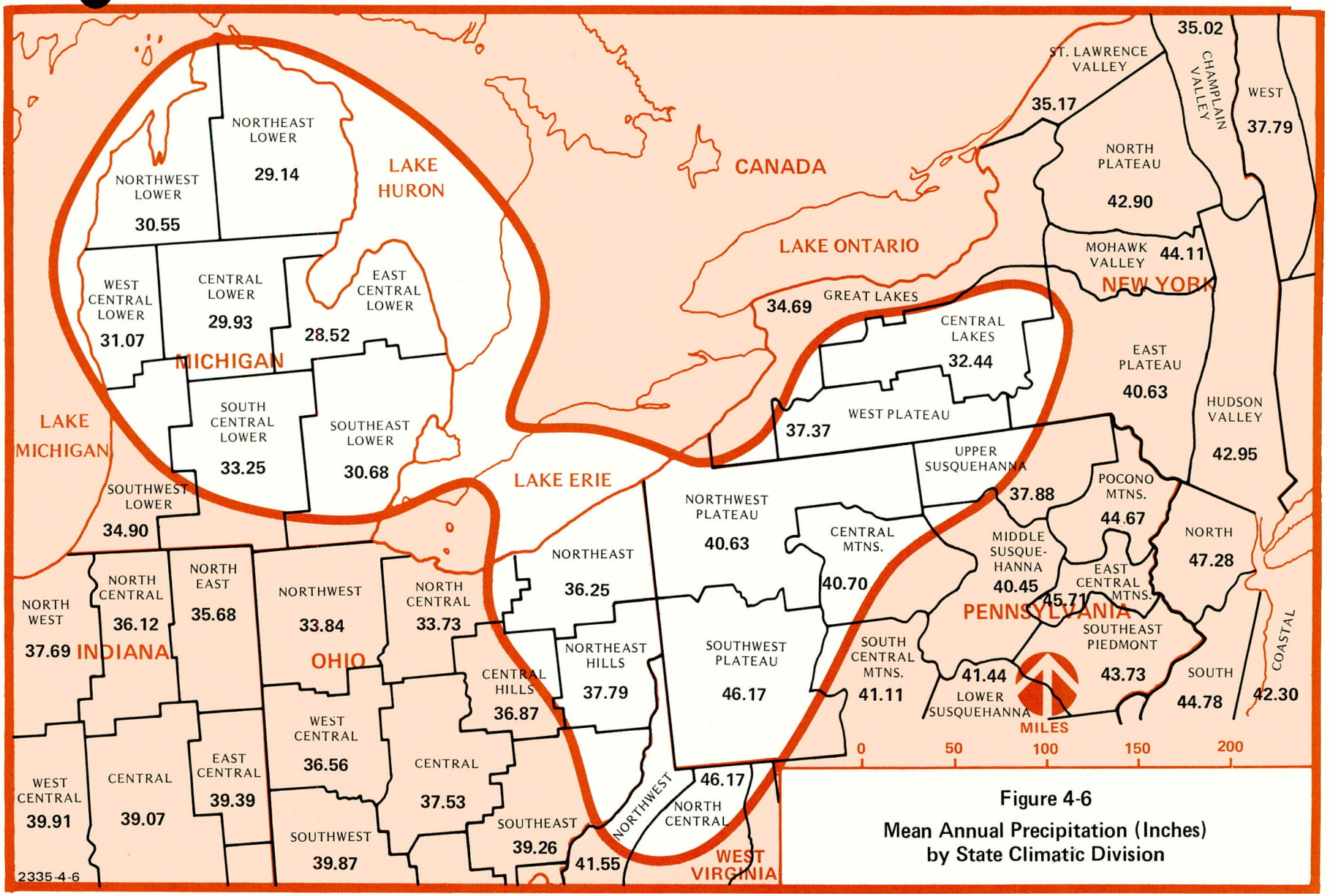


Figure 4-6
Mean Annual Precipitation (Inches) by State Climatic Division

SOURCE: Environmental Data Service (1968)

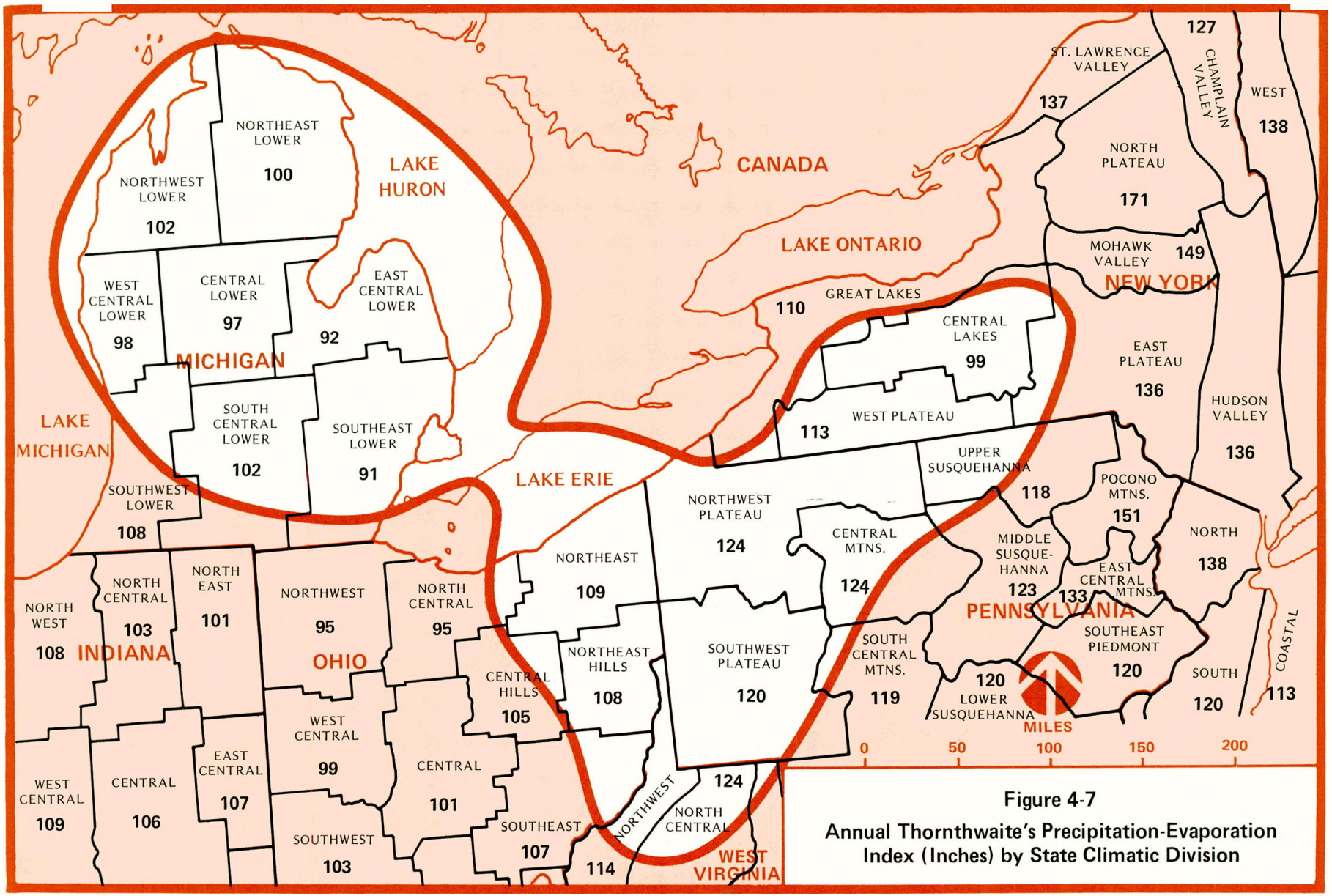


Figure 4-7

Annual Thornthwaite's Precipitation-Evaporation Index (Inches) by State Climatic Division

SOURCE: Environmental Data Service (1968)

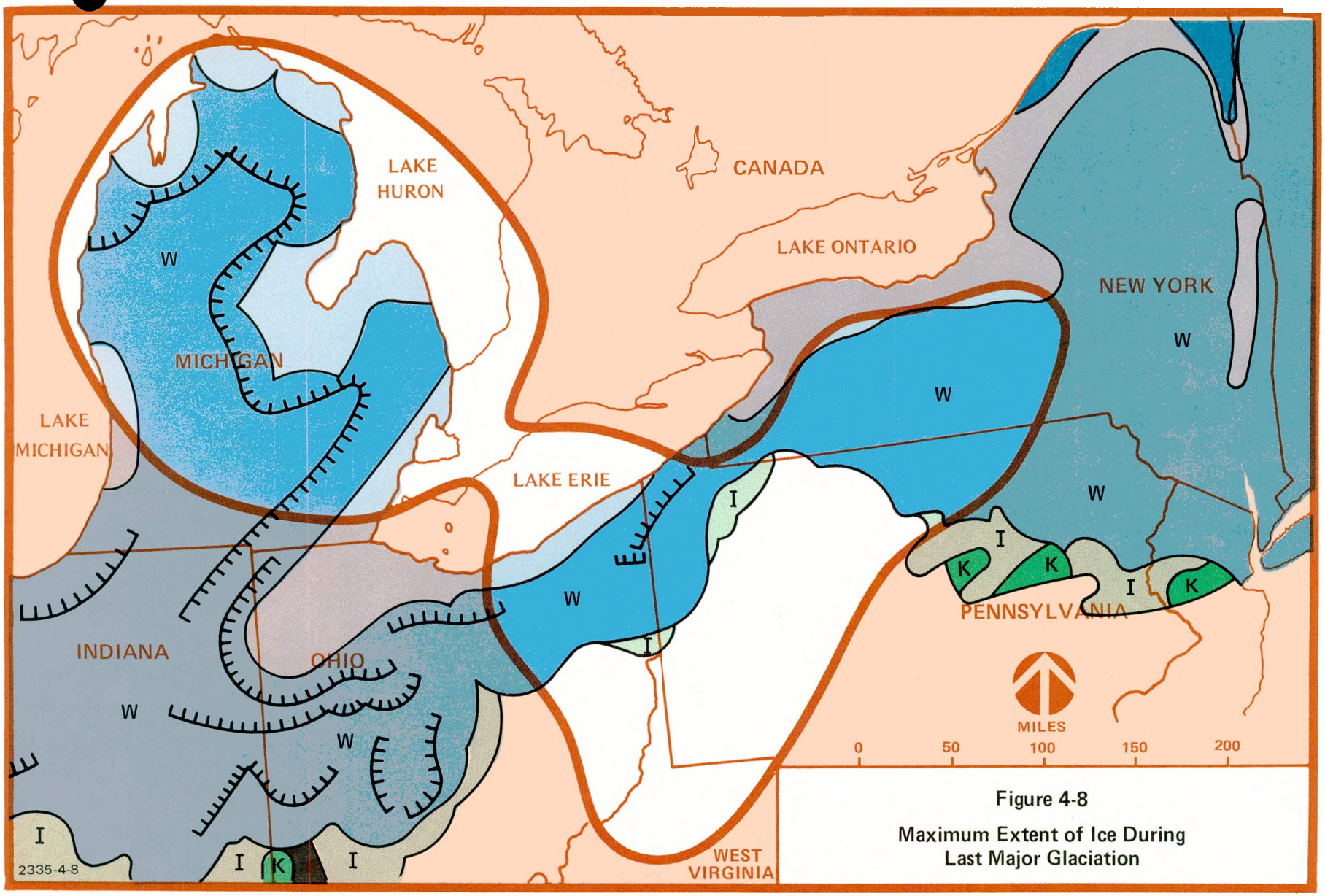


Figure 4-8

Maximum Extent of Ice During Last Major Glaciation

EXTINCT GLACIAL LAKE
ILLINOIAN GLACIATION
KANSAN GLACIATION
AREA OF SUBMERGENCE DURING GLACIATION
NEBRASKAN GLACIATION
WISCONSIN GLACIATION
OUTLINES OF PRINCIPAL ICE LOBES OF WISCONSIN GLACIATION

Adapted from USGS (1970)

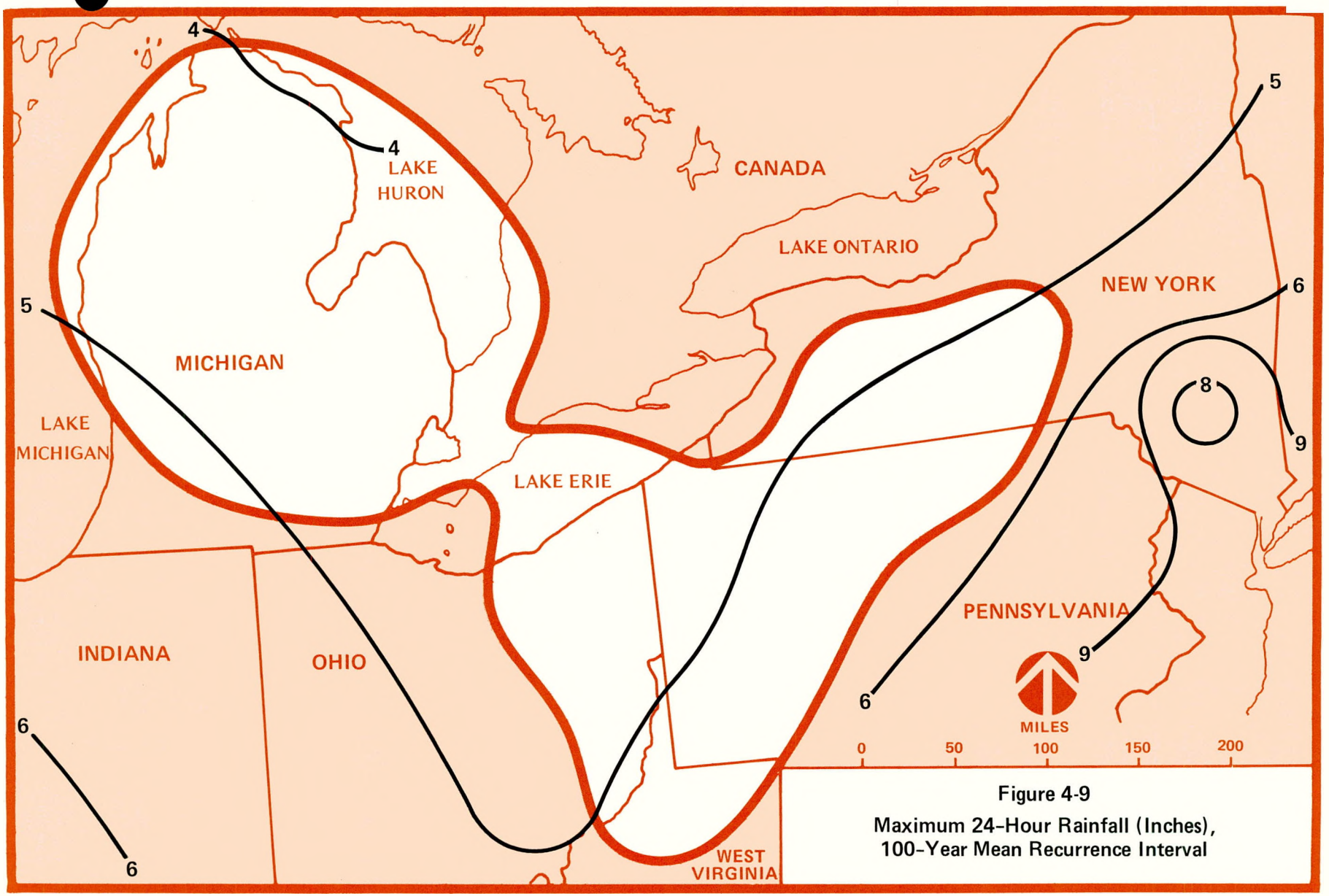


Figure 4-9

Maximum 24-Hour Rainfall (Inches),
100-Year Mean Recurrence Interval

SOURCE: NOAA (1961)

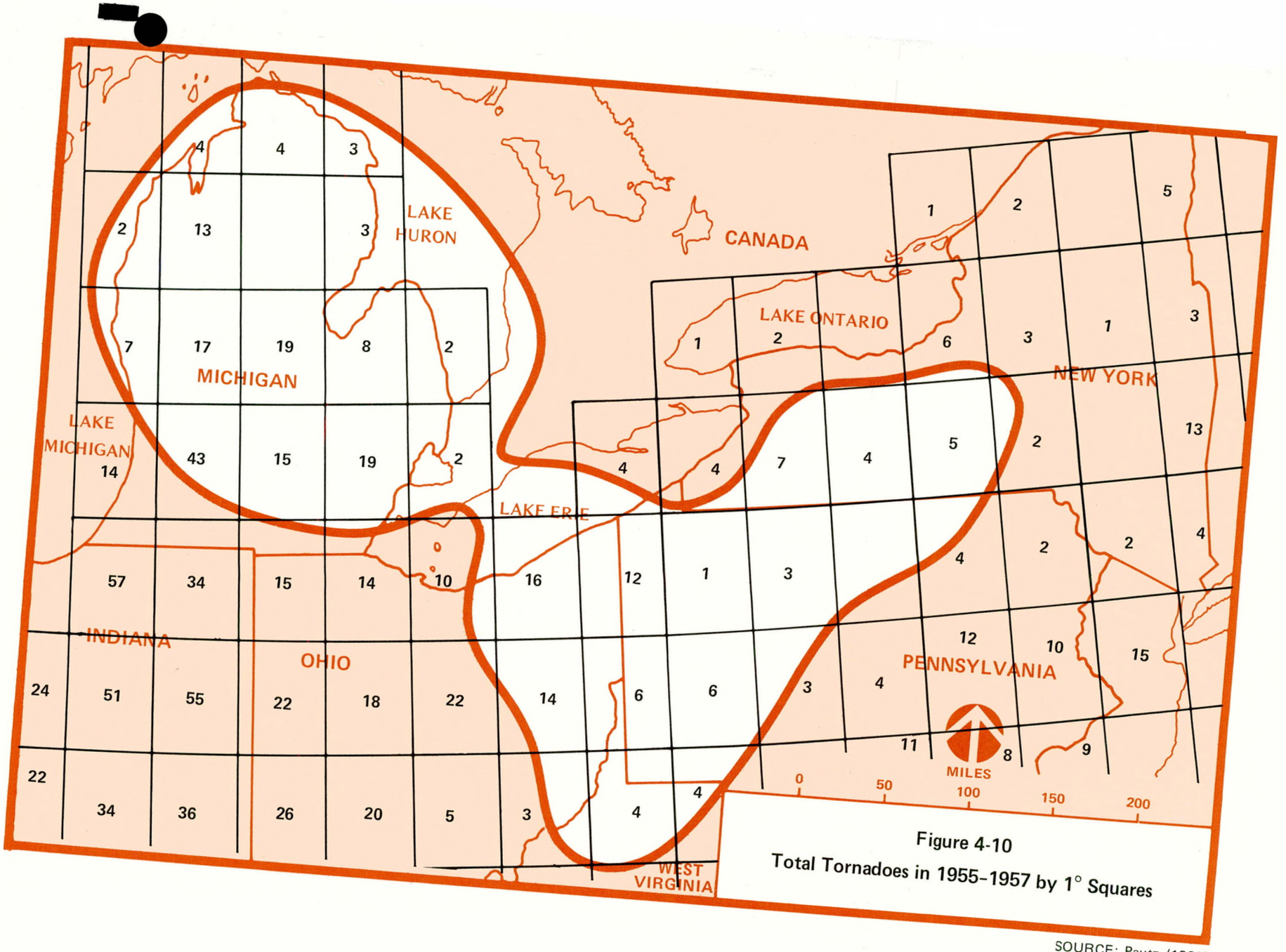


Figure 4-10
Total Tornadoes in 1955–1957 by 1° Squares

SOURCE: Pautz (1969)

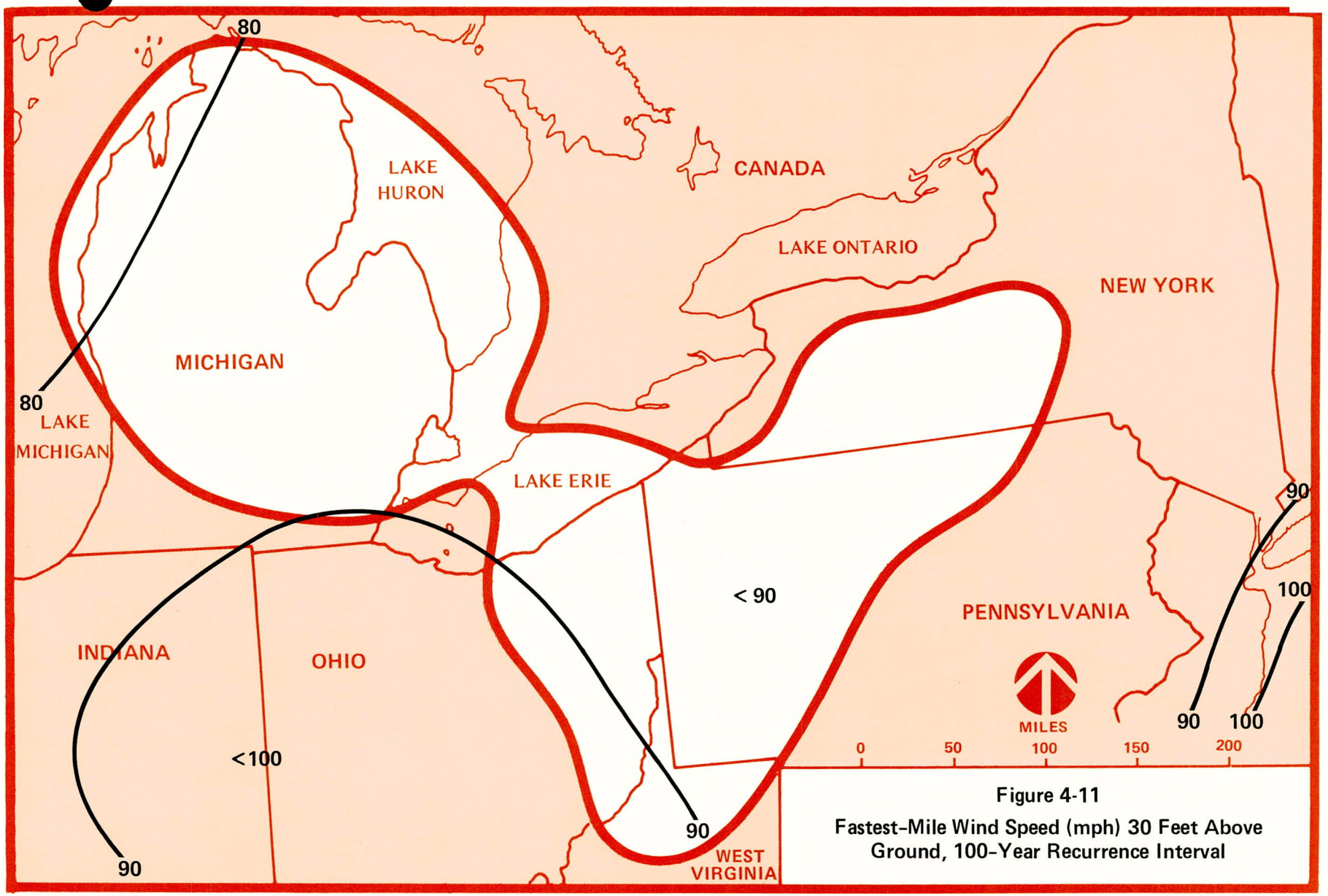


Figure 4-11

Fastest-Mile Wind Speed (mph) 30 Feet Above Ground, 100-Year Recurrence Interval

SOURCE: ANSI (1972)

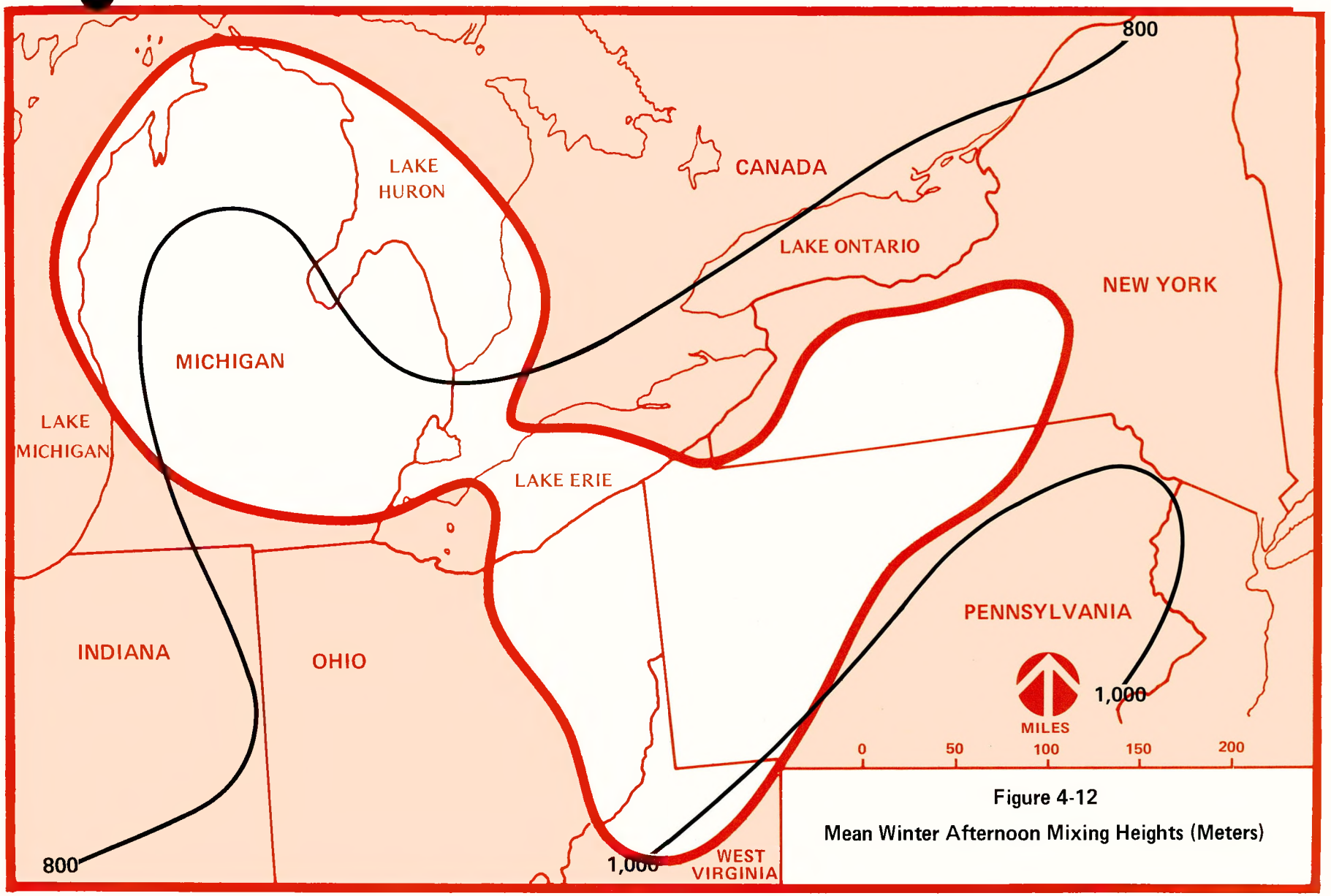


Figure 4-12

Mean Winter Afternoon Mixing Heights (Meters)

SOURCE: Holzworth (1972)

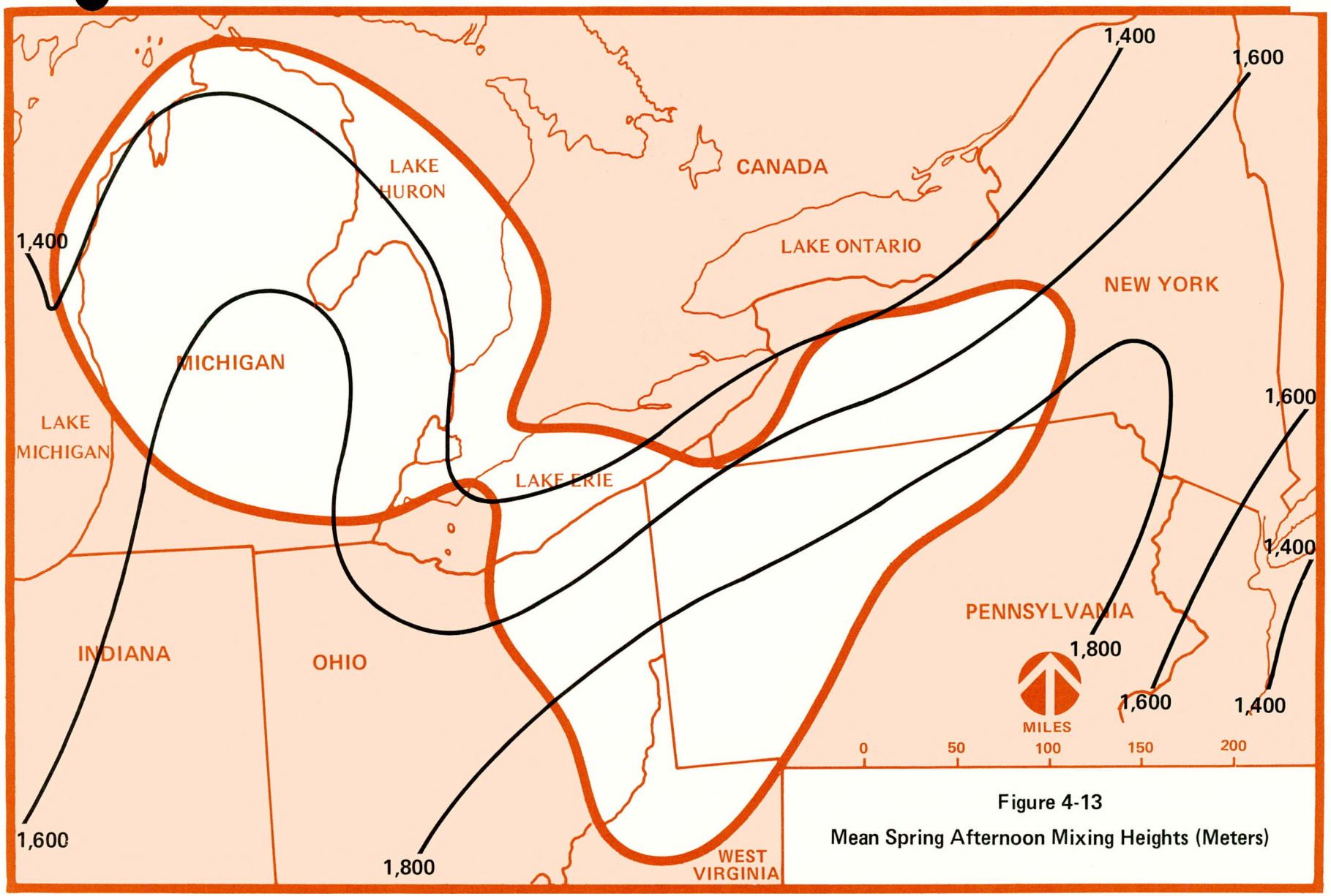


Figure 4-13

Mean Spring Afternoon Mixing Heights (Meters)

SOURCE: Holzworth (1972)

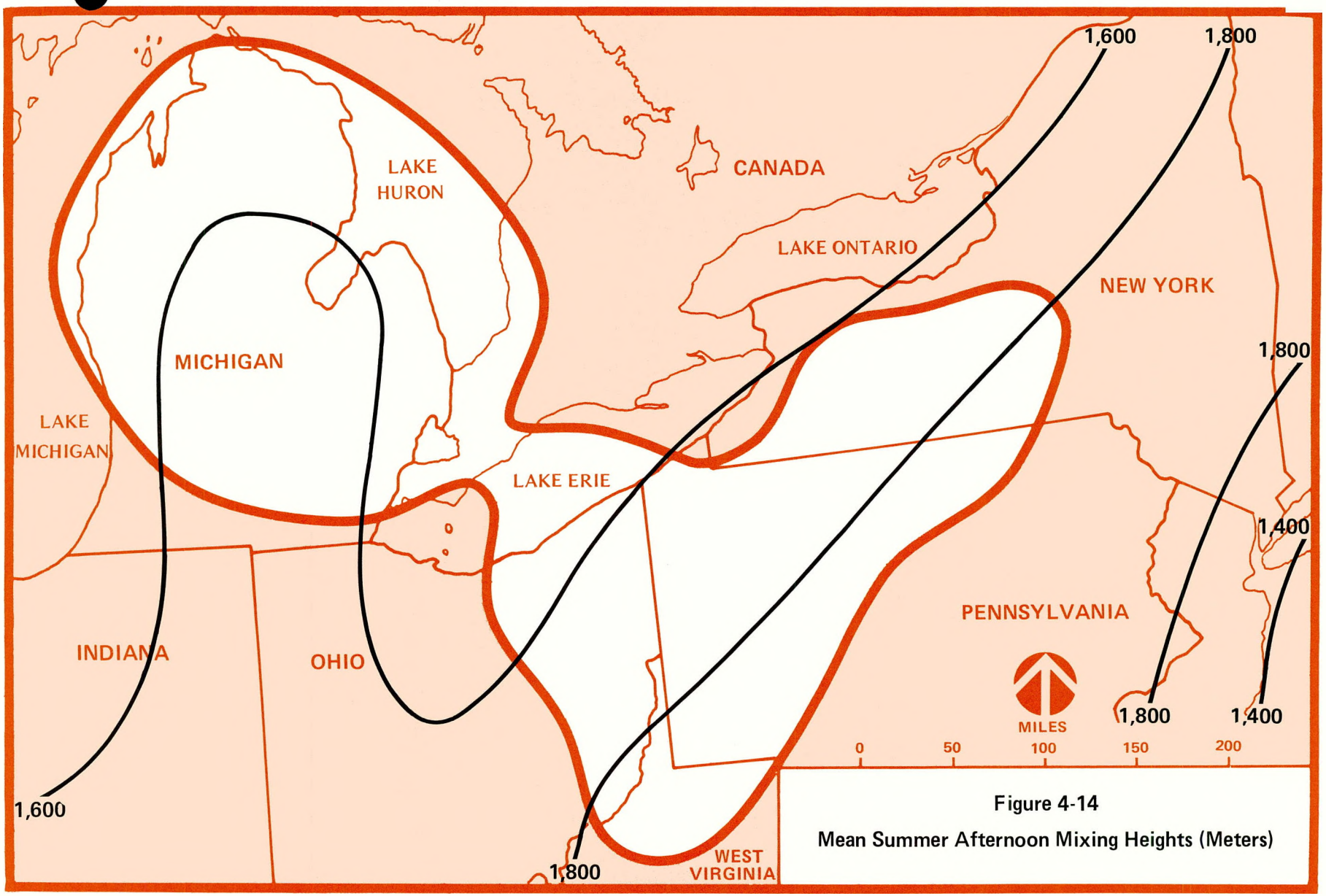


Figure 4-14

Mean Summer Afternoon Mixing Heights (Meters)

SOURCE: Holzworth (1972)

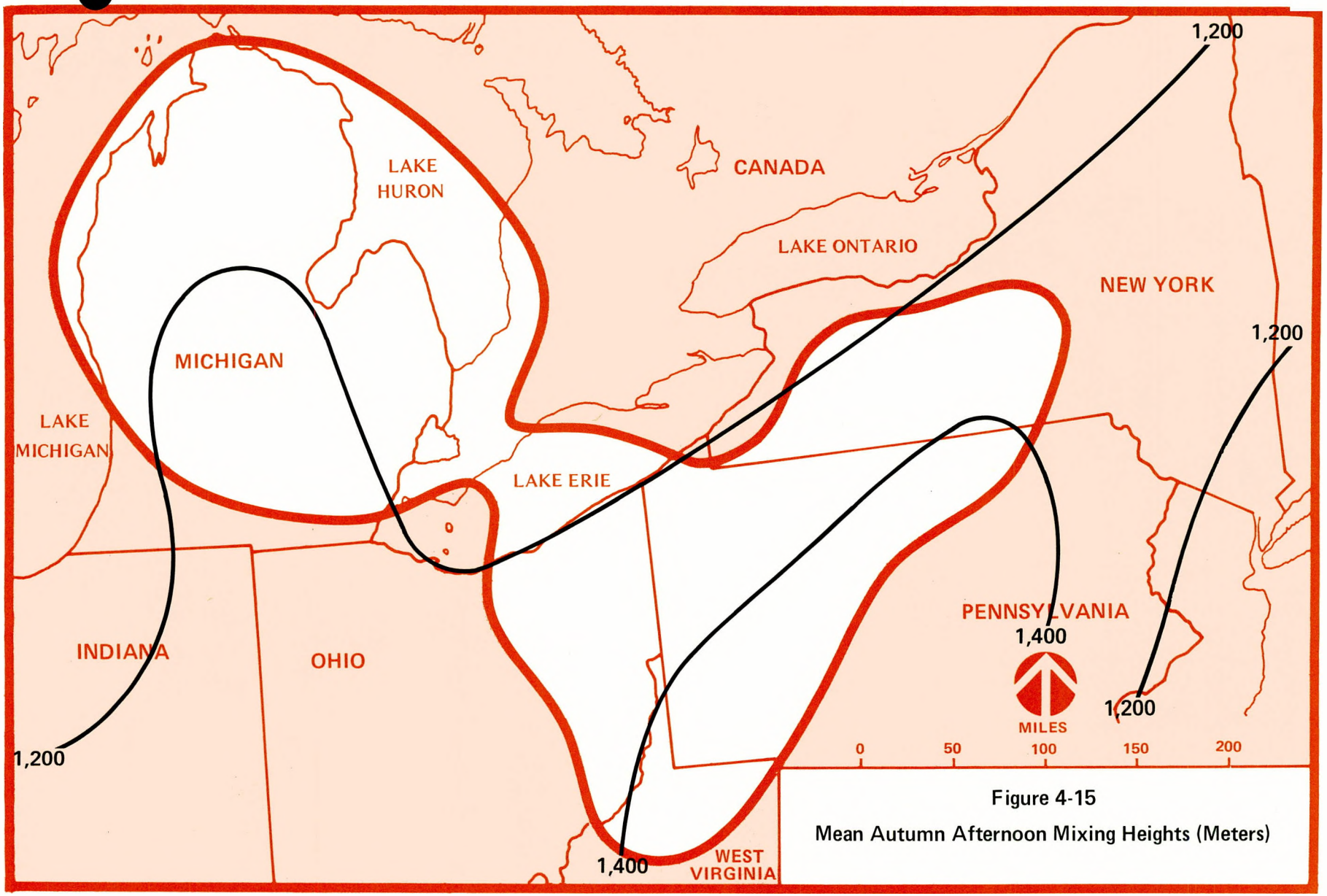


Figure 4-15

Mean Autumn Afternoon Mixing Heights (Meters)

SOURCE: Holzworth (1972)

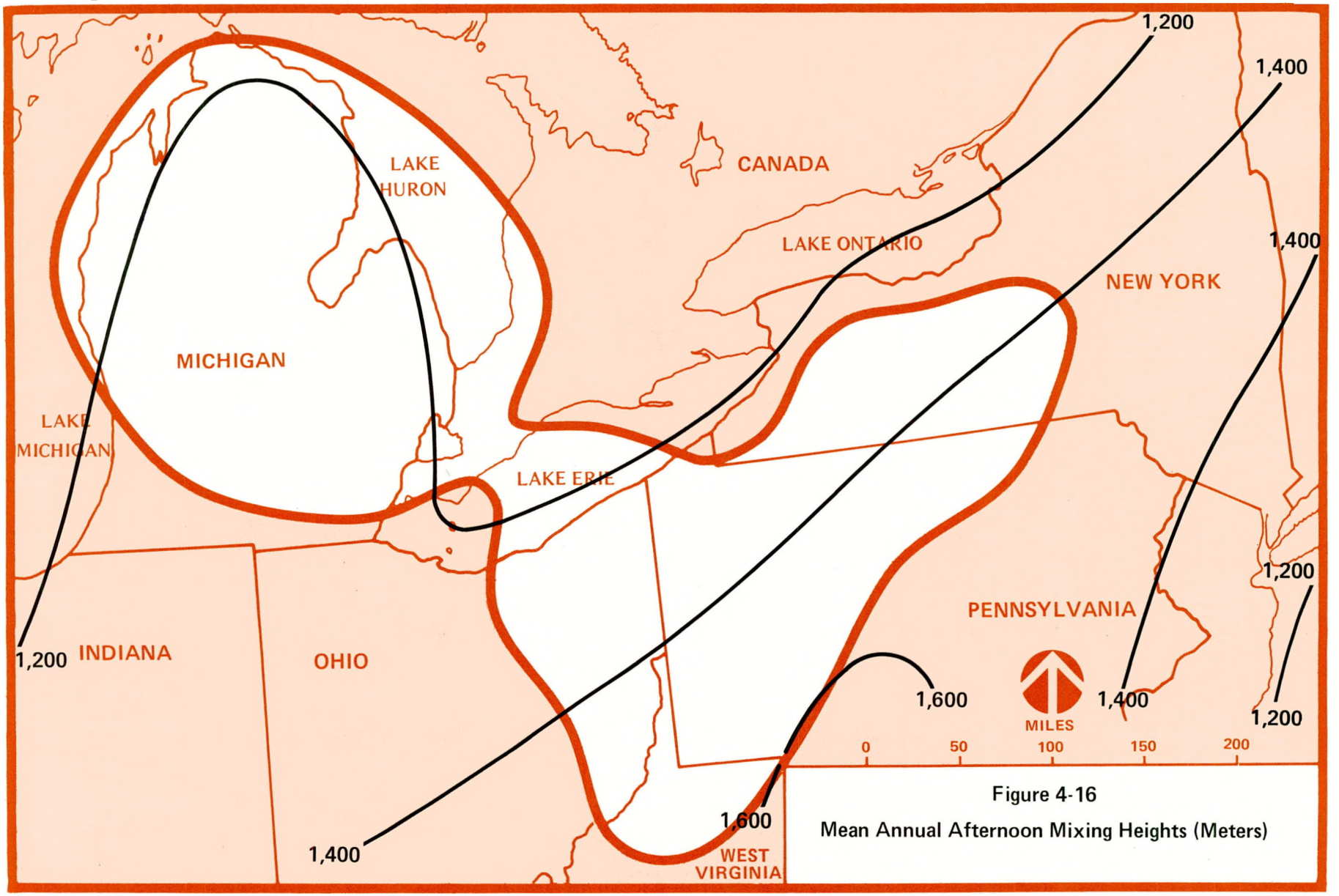


Figure 4-16

Mean Annual Afternoon Mixing Heights (Meters)

SOURCE: Holzworth (1972)

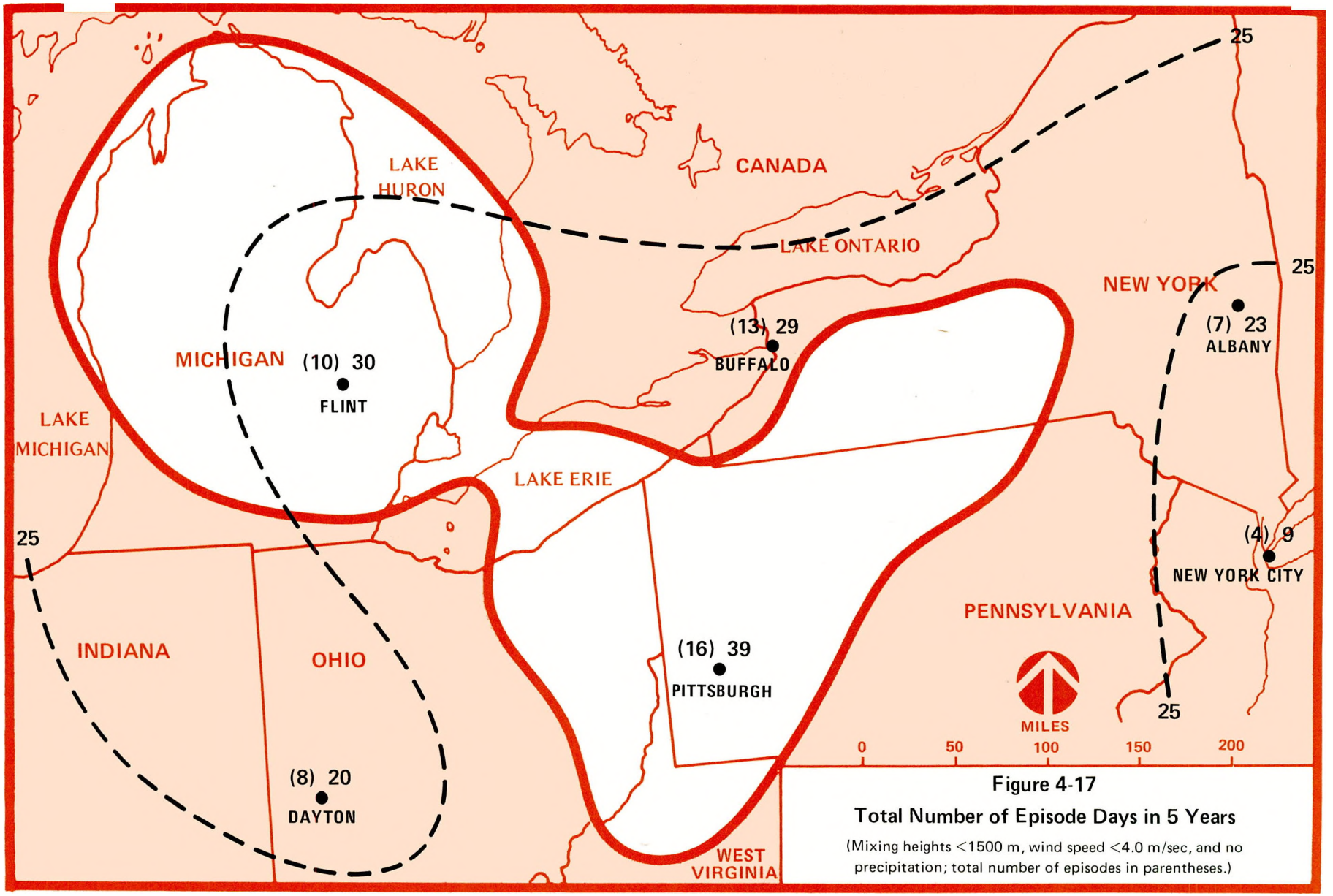


Figure 4-17

Total Number of Episode Days in 5 Years

(Mixing heights <1500 m, wind speed <4.0 m/sec, and no precipitation; total number of episodes in parentheses.)

SOURCE: Holzworth (1972)

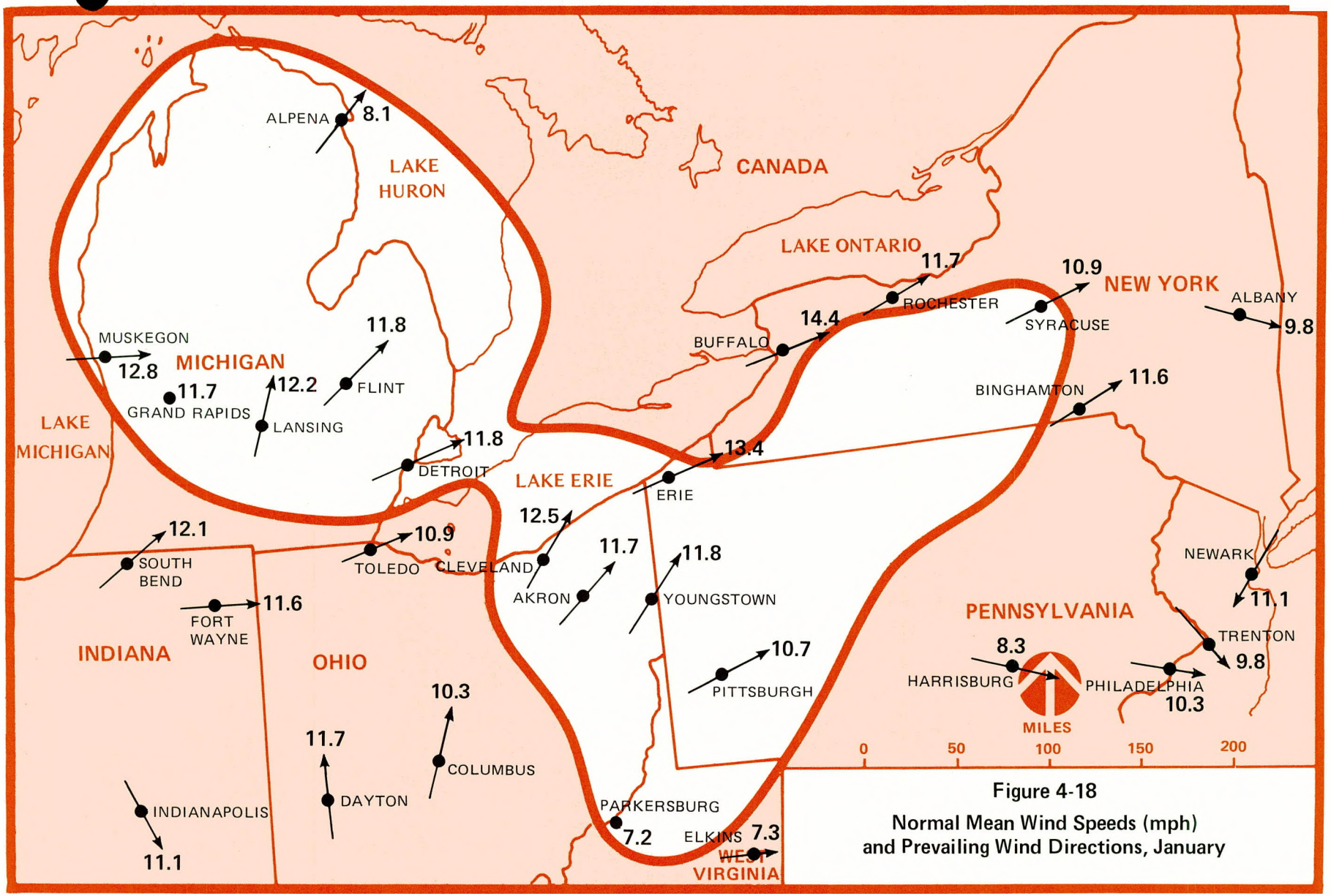


Figure 4-18

Normal Mean Wind Speeds (mph) and Prevailing Wind Directions, January

NOTE:
Arrows fly with the winds.
Wind direction data not available for
Grand Rapids, Michigan, and Parkersburg, West Virginia.

SOURCE: Environmental Data Service (1976)

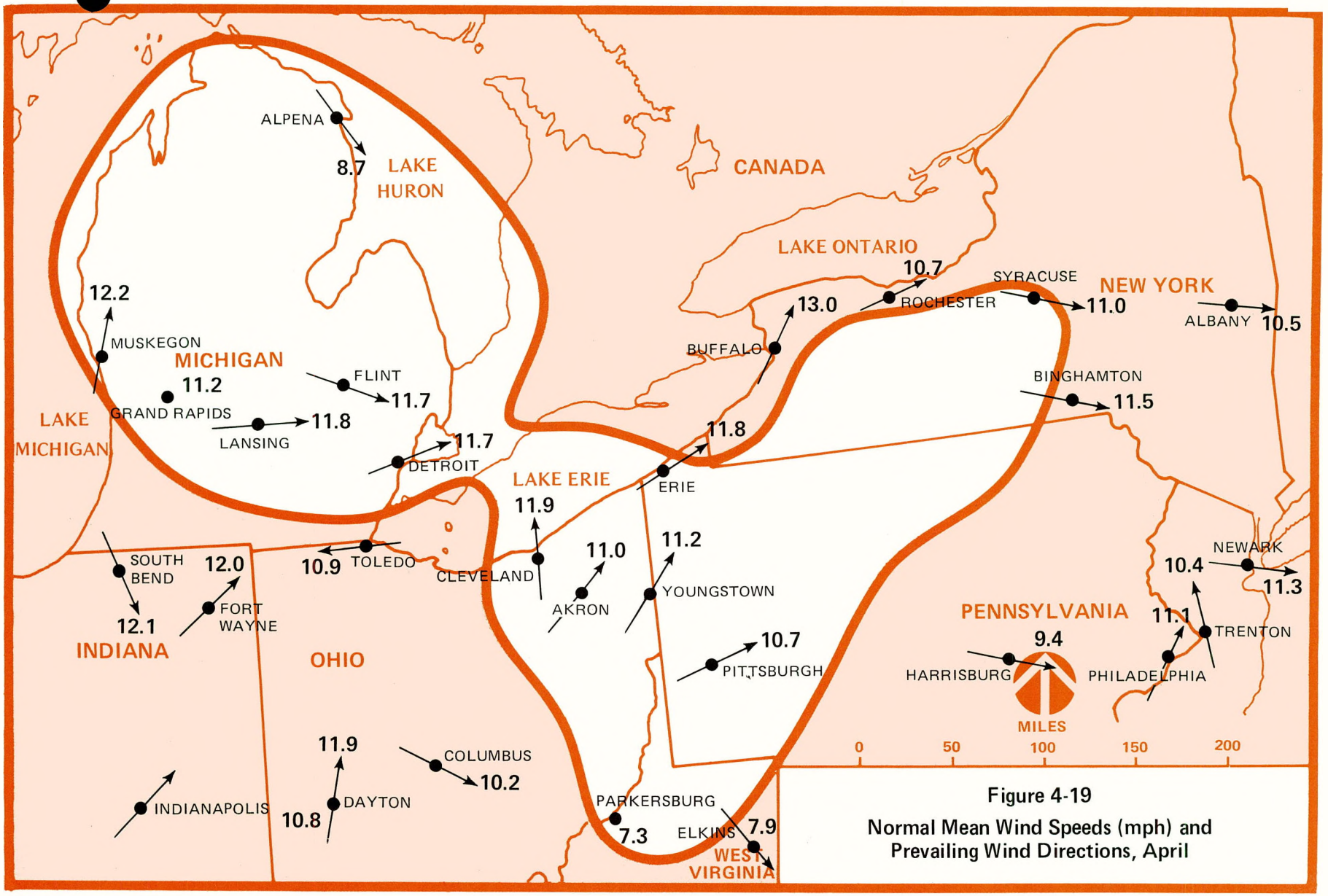


Figure 4-19

Normal Mean Wind Speeds (mph) and Prevailing Wind Directions, April

NOTE:
Arrows fly with the winds.
Wind direction data not available for
Grand Rapids, Michigan, and Parkersburg, West Virginia.

SOURCE: Environmental Data Service (1976)

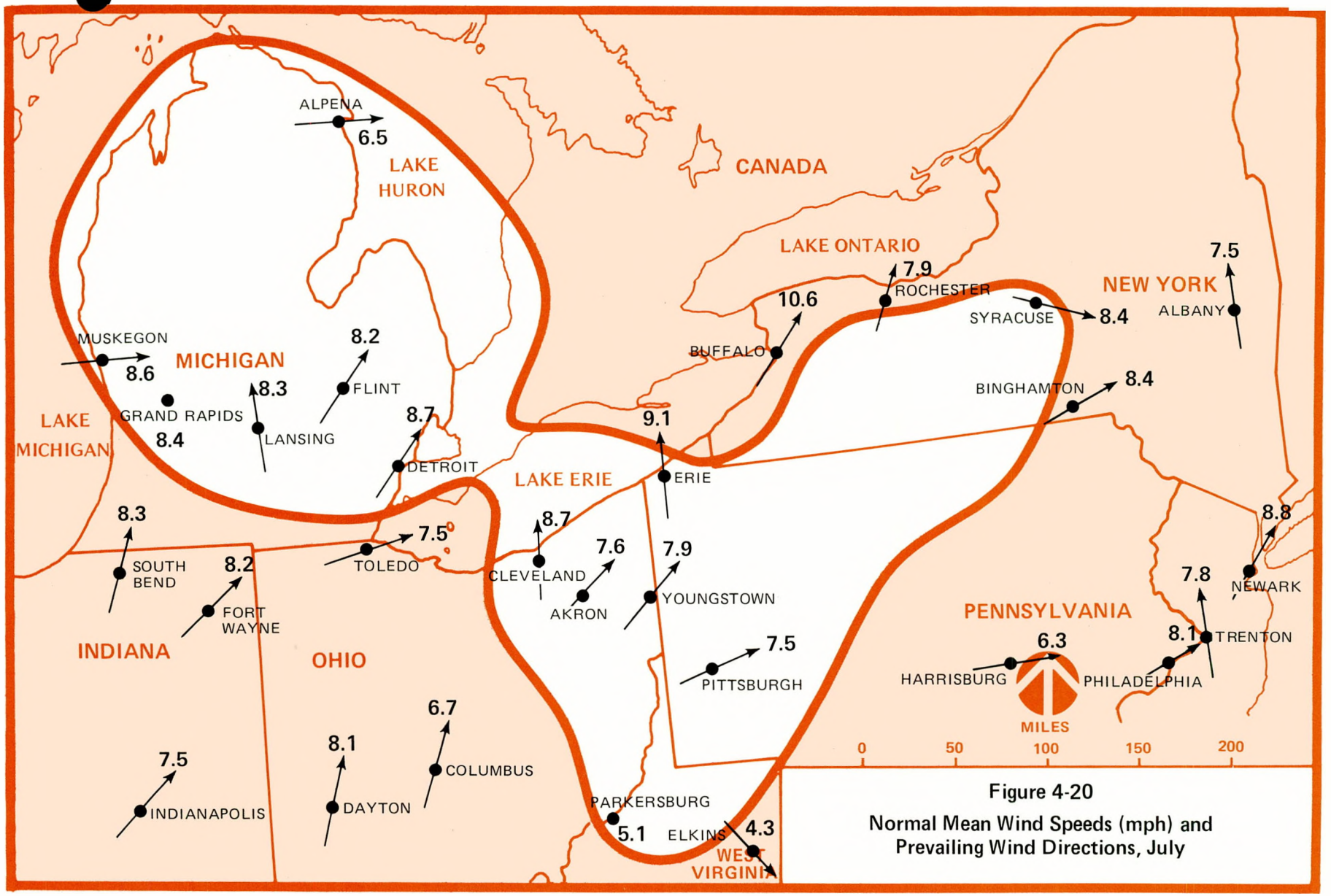


Figure 4-20

Normal Mean Wind Speeds (mph) and Prevailing Wind Directions, July

NOTE:
Arrows fly with the winds.
Wind direction data not available for
Grand Rapids, Michigan, and Parkersburg, West Virginia.

SOURCE: Environmental Data Service (1976)

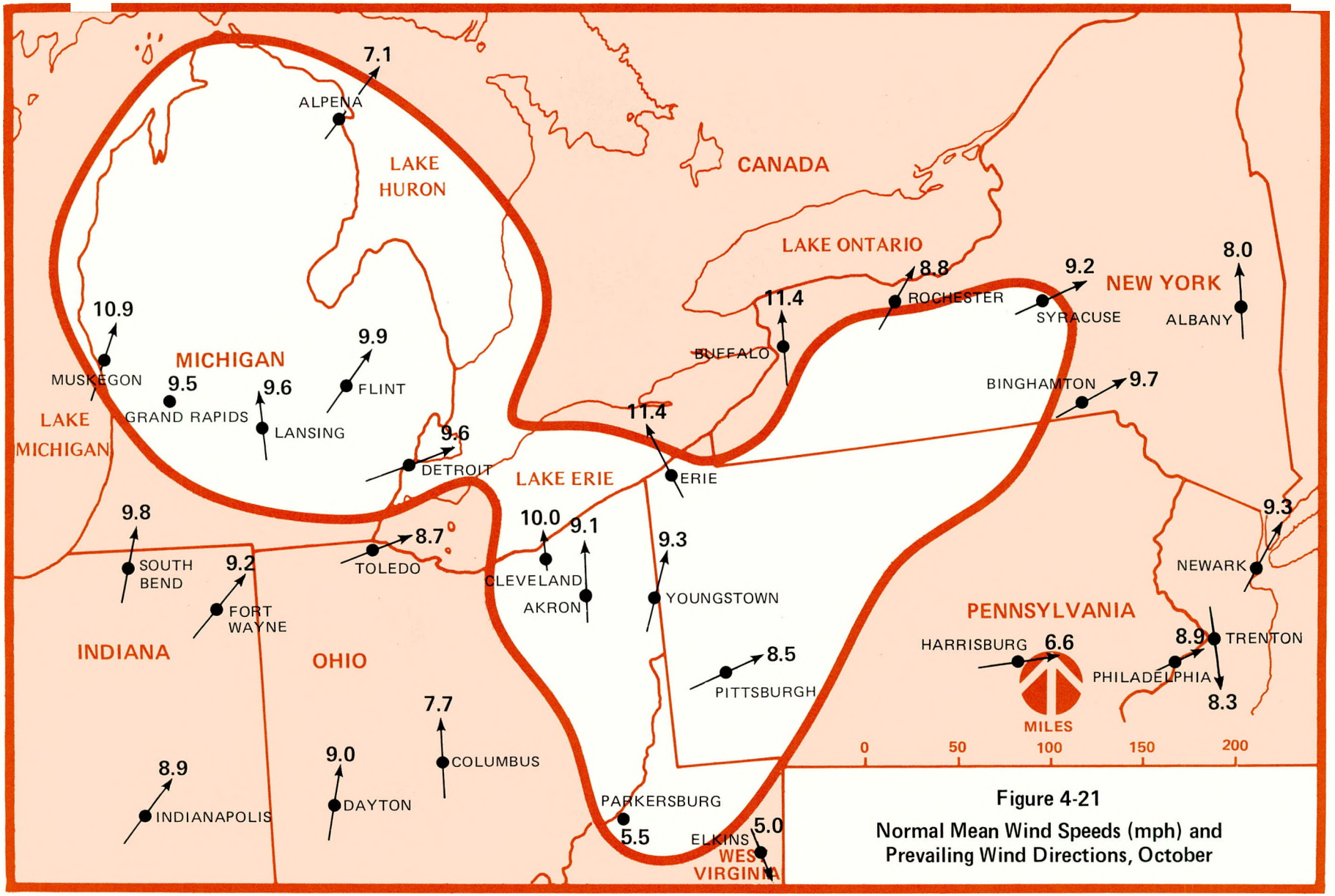


Figure 4-21

Normal Mean Wind Speeds (mph) and Prevailing Wind Directions, October

NOTE:
Arrows fly with the winds.
Wind direction data not available for
Grand Rapids, Michigan, and Parkersburg, West Virginia.

SOURCE: Environmental Data Service (1976)

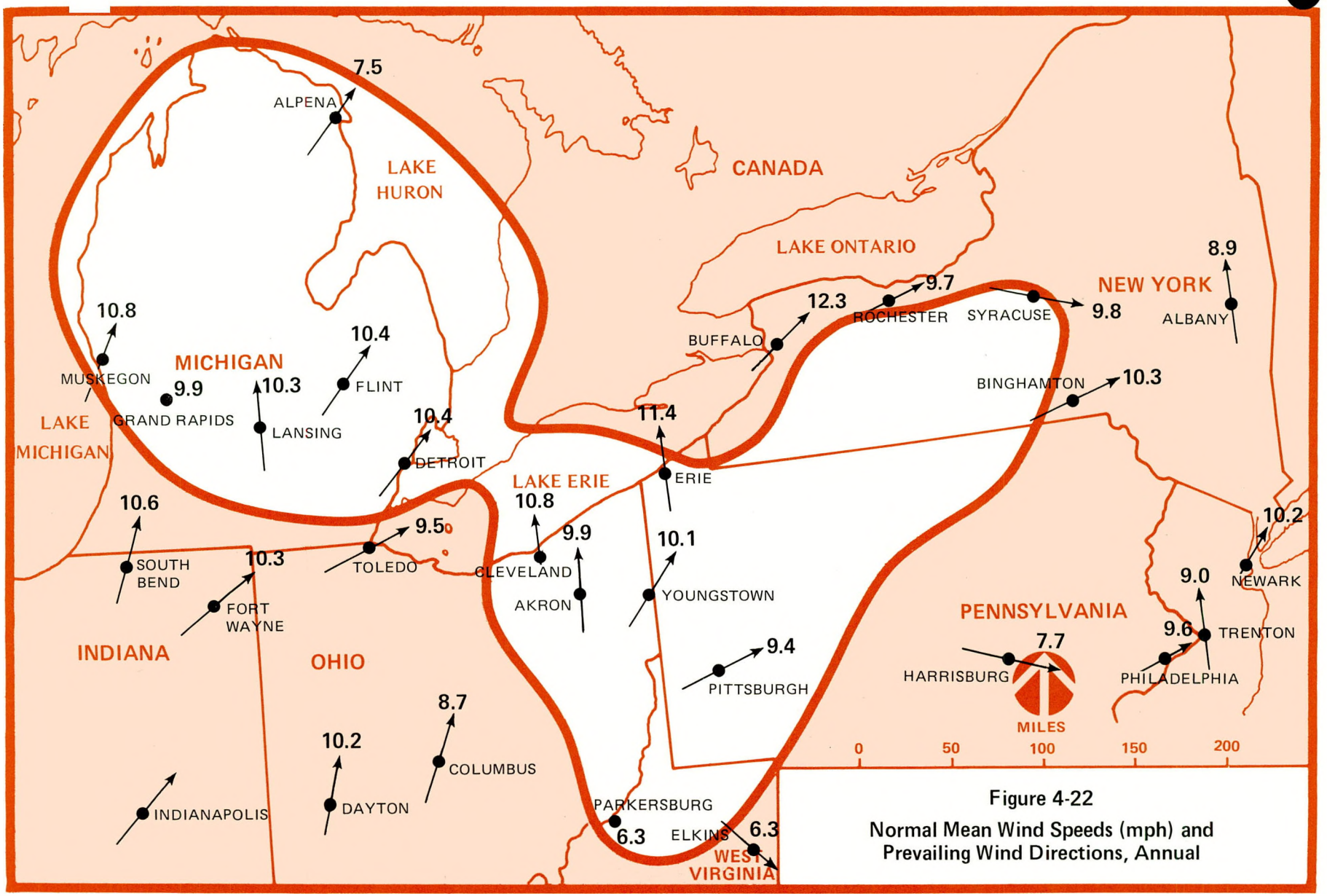


Figure 4-22

Normal Mean Wind Speeds (mph) and Prevailing Wind Directions, Annual

NOTE:
Arrows fly with the winds.
Wind direction data not available for
Grand Rapids, Michigan, and Parkersburg, West Virginia.

SOURCE: Environmental Data Service (1976)

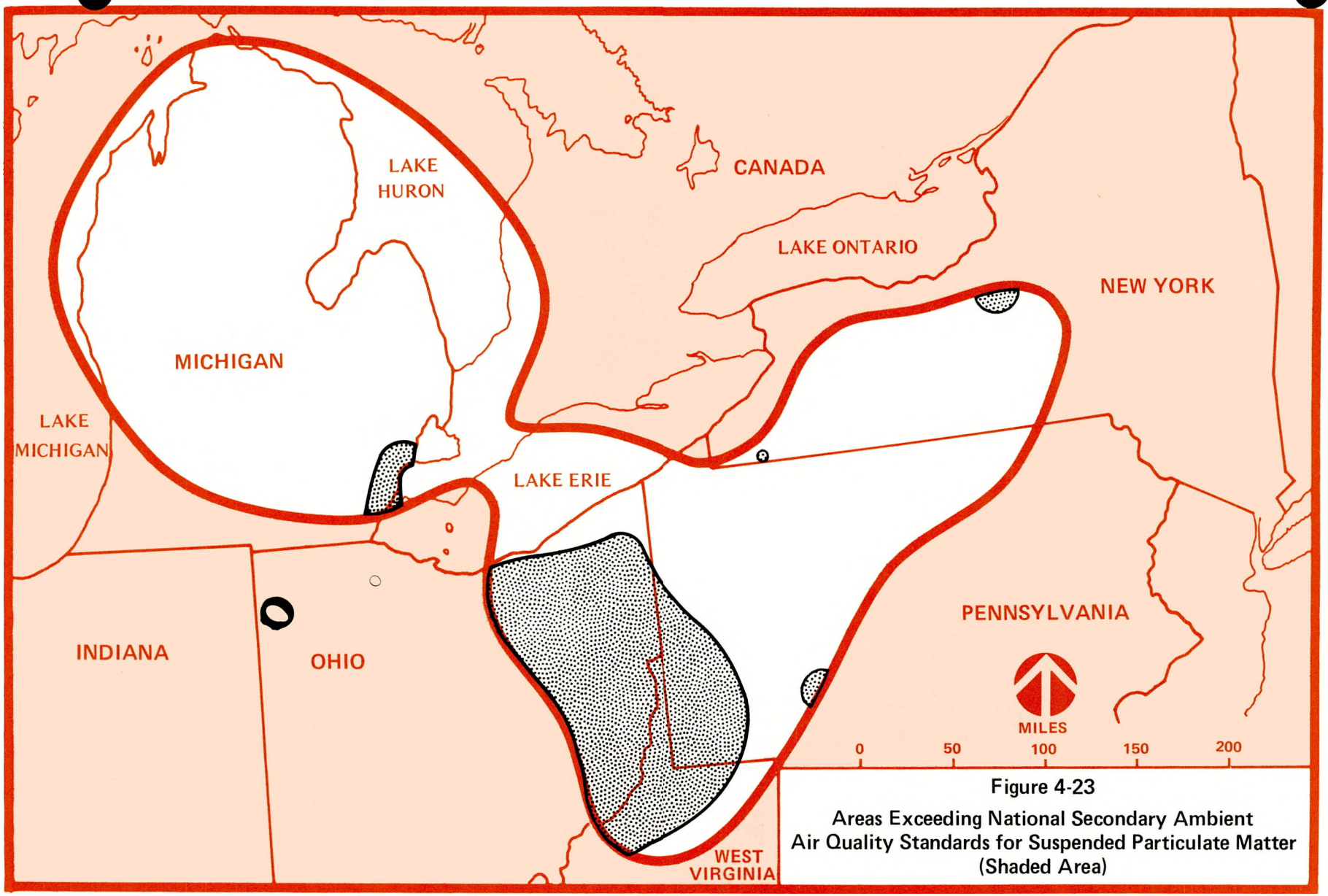


Figure 4-23

Areas Exceeding National Secondary Ambient Air Quality Standards for Suspended Particulate Matter (Shaded Area)

5.0 BACKGROUND RADIATION

Data on the variation of background radiation within a geological region (the area above a particular rock formation) are useful for putting into perspective potential radiation doses to individuals (or populations) from man-made sources of radiation.

The largest sources of ionizing radiation exposure, and resulting dose, to the population are the natural radiation environment and the fallout from weapons testing. This exposure is neither constant nor uniform for all individuals, but varies with elevation, geologic features, and the extent of weapons testing.

5.1 SOURCES

For purposes of this study, background radiation is defined as the external radiation dose to an unshielded person resulting from cosmic, terrestrial, and fallout sources. Each of these radiation sources is briefly defined and discussed below.

5.1.1 COSMIC RADIATION

The term "cosmic radiation" refers both to the primary energetic particles of extraterrestrial origin that strike the earth's atmosphere and to the secondary particles generated by their interaction with the atmosphere. The primary radiation itself consists of two components: "galactic" particles externally incident on the solar system and "solar" particles emitted by the sun. The intensity of cosmic radiation is dependent on geomagnetic latitude and very dependent on elevation, increasing somewhat with latitude and significantly with elevation.

5.1.2 TERRESTRIAL RADIATION

Terrestrial radioactivity is present in the environment as a result of naturally occurring radioactive isotopes of a number of elements that are found in the earth's crust. The radionuclides of primary importance are potassium-40 and the radioactive decay chains of uranium-238 and thorium-232. Terrestrial radiation is highly dependent on the type of soil and rock in any area.

5.1.3 FALLOUT RADIATION

Fallout radiation is the result of the deposition of radioactive material created as a result of the testing of nuclear weapons. The large-scale atmospheric tests of 1961-1962 were the major sources. However, the continued French and Chinese tests have been sufficient to maintain a relatively constant annual fallout deposition. Cesium-137 is the major source of external ionizing radiation from long-lived fallout, while a number of short-lived radionuclides contribute to exposures during the first few years after their production.

5.2 REGIONAL BACKGROUND

The nature of natural background radiation and its spatial variation over the continental United States have been treated extensively in the literature (NCRP, 1975; Oakley,

1972; USEPA, 1976, 1977). Background radiation levels have been estimated for a considerable number of locations within the United States (NCRP, 1975; Oakley, 1972).

A number of these locations are within or near the Salina Region. Table 5-1 lists background radiation dose rates for these locations. The total values in millirem per year shown in Table 5-1 represent the sum of the terrestrial, cosmic, and fallout components.

The cosmic ray dose equivalent rates were calculated from the elevation by using the relationship between elevation and dose rate shown in Figure 5-1 (Oakley, 1972).

The terrestrial dose equivalent rates given in Table 5-1 are based on information obtained from the analysis of nationwide aerial surveys, in particular the surveys conducted as part of the Aerial Radiological Measurement Surveys (ARMS) program (Jobst, 1977). For locations that were within the boundaries of the ARMS areas, the tabulated terrestrial values are measured values. For locations outside the ARMS areas, the terrestrial dose equivalent rates represent values assigned based on analysis of the ARMS data. The ARMS data indicate that there are three distinct areas of background radiation within the United States: the Coastal Plain areas, the non-Coastal Plain areas (excluding Denver), and the Denver area. The Salina Region was assumed to fall into the category of a non-Coastal Plain area, and locations within it were assigned a value of 45.6 mrem/yr (Oakley, 1972, Table 14).

A uniform value of 4.8 mrem/yr, independent of the location, has been used for fallout radiation. This is consistent with information presented in the literature (Oakley, 1972).

For some areas within the Salina Region data were not available. To complete the region-wide characterization, additional locations were designated within or near these areas and background radiation levels were estimated.

Figure 5-2 shows locations in and near the Salina Region for which background radiation dose rates have been compiled. There is a variation of background radiation levels within the Salina Region. Among the locations tabulated in Table 5-1 and shown in Figure 5-2, the largest difference in dose rate levels is 47.9 mrem/yr (Wheeling, West Virginia, vs. Charlevoix, Michigan). The mean value for the locations listed, both within and near the Salina Region, is 93.9 mrem/yr.

TABLE 5-1

BACKGROUND RADIATION LEVELS FOR THE SALINA REGION

Location	Level (mrem/yr)			
	Cosmic Rays[a]	Terrestrial	Fallout[b]	Total
MICHIGAN				
Ann Arbor[c]	43.9	45.6	4.8	94.3
Bay City[c]	42.8	45.6	4.8	93.2
Charlevoix	43.0	21.0[d]	4.8	68.8
Detroit[c]	42.8	45.6	4.8	93.2
Flint[c]	43.3	45.6	4.8	93.7
Grand Rapids[c]	42.9	45.6	4.8	93.3
Jackson[c]	44.2	45.6	4.8	94.6
Kalamazoo[c]	43.4	45.6	4.8	93.8
Lansing[c]	43.7	45.6	4.8	94.1
Monroe	43.0	48.0[d]	4.8	95.8
Muskegon[c]	42.9	45.6	4.8	93.3
Saginaw[c]	42.8	45.6	4.8	93.2
NEW YORK				
Binghamton[c]	43.9	45.6	4.8	94.3
Buffalo[c]	42.8	45.6	4.8	93.2
Elmira	44.0	45.6[e]	4.8	94.4
Jamestown	47.0	45.6[e]	4.8	97.4
Oswego	42.0	30.0[d]	4.8	76.8
Rochester	42.5	44.0[d]	4.8	91.3
Syracuse[c]	42.1	45.6	4.8	92.5
OHIO				
Akron[c]	44.6	45.6	4.8	95.0
Canton[c]	44.7	45.6	4.8	95.1
Cleveland[c]	43.1	45.6	4.8	93.5
Steubenville[c]	43.3	60.5	4.8	108.6
Youngstown[c]	43.8	40.8	4.8	89.4

TABLE 5-1 (Continued)

Location	Level (mrem/yr)			
	Cosmic Rays[a]	Terrestrial	Fallout[b]	Total
		PENNSYLVANIA		
Altoona[c]	45.2	45.6	4.8	95.6
Erie[c]	43.1	45.6	4.8	93.5
Johnstown[c]	45.3	45.6	4.8	95.7
Pittsburgh[c]	43.4	52.0	4.8	100.2
		WEST VIRGINIA		
Morgantown	44.0	45.6[e]	4.8	94.4
Parkersburg	43.0	45.6[e]	4.8	93.4
Wheeling[c]	43.0	68.9	4.8	116.7

a. Based on elevation of location, using Figure 5-1.

b. Taken as a constant value for all locations; data from Section 3.3.2 of Oakley (1972).

c. Cosmic ray and terrestrial components taken directly from Table A-1 of Oakley (1972).

d. National Council on Radiation Protection and Measurements (NCRP, 1975, page 72).

e. Representative of non-Coastal-Plain areas of the United States; data from Table 14 of Oakley (1972).

REFERENCES FOR CHAPTER 5

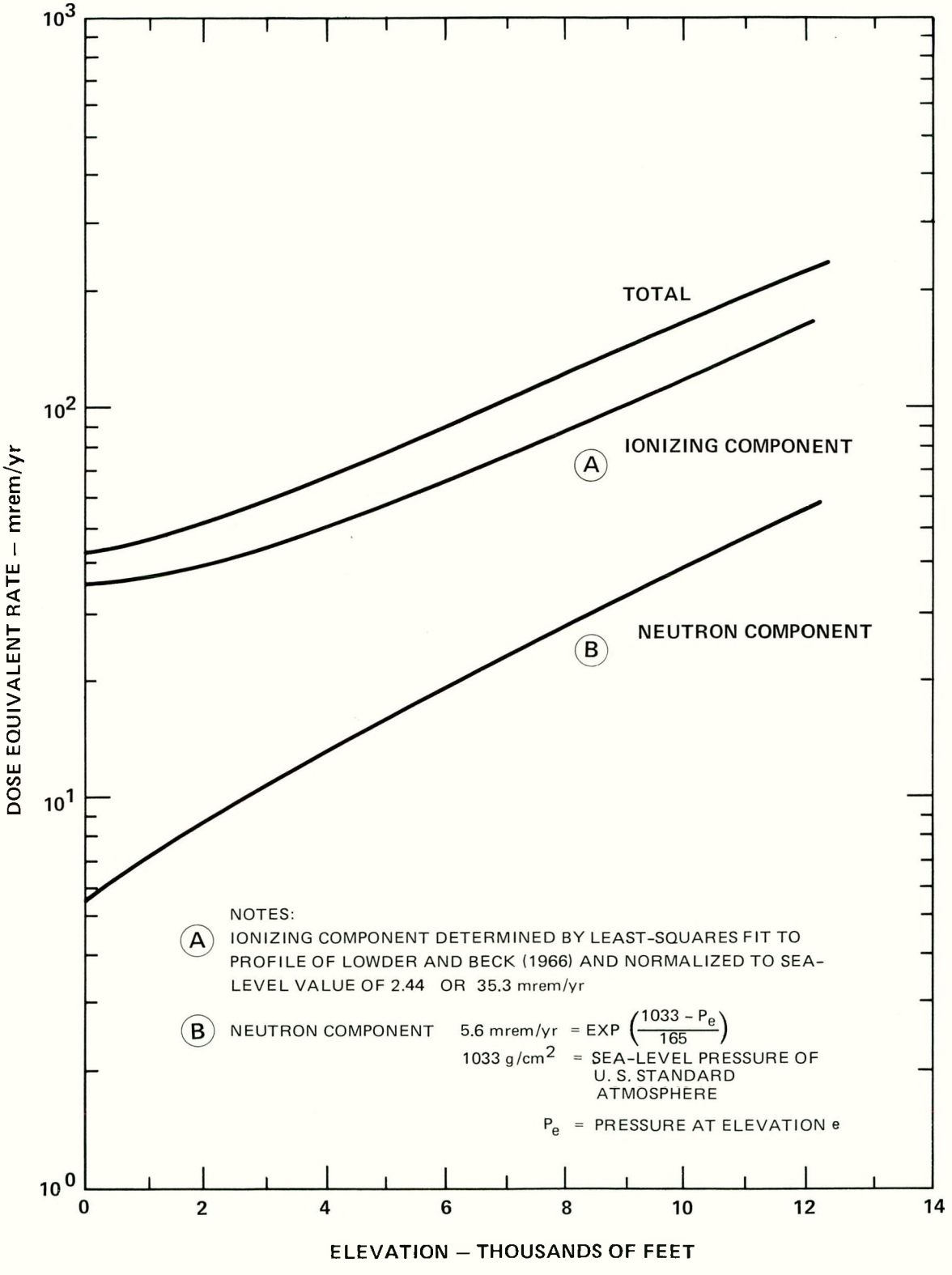
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USEPA, 1977. Radiological Quality of the Environment in the United States, U.S. Environmental Protection Agency, Washington, D.C., EPA 520/1-77-009.



SOURCE: Oakley (1972)

Figure 5-1

Cosmic Ray Dose Equivalent vs. Elevation

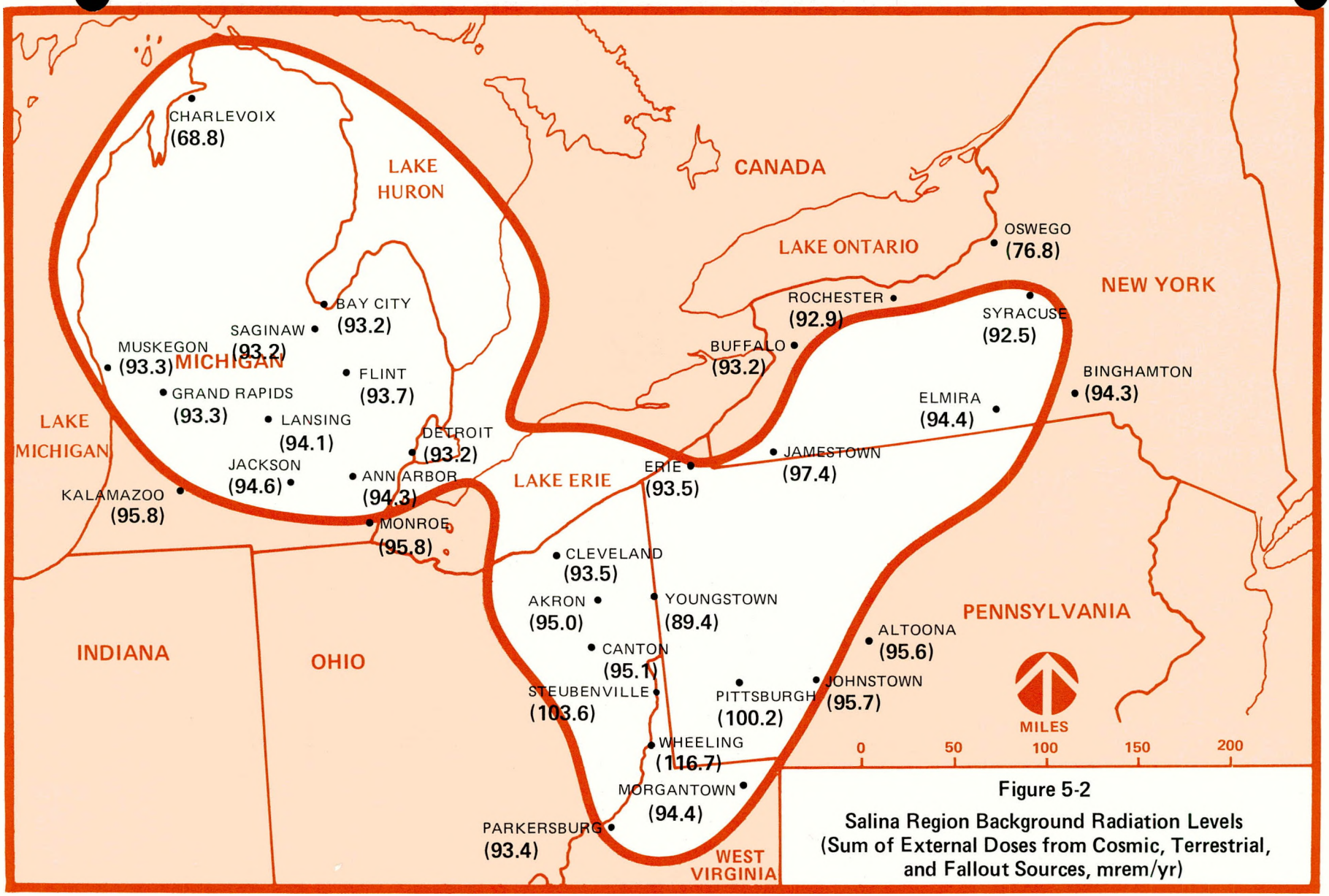


Figure 5-2

Salina Region Background Radiation Levels
(Sum of External Doses from Cosmic, Terrestrial, and Fallout Sources, mrem/yr)

6.0 DEMOGRAPHIC, SOCIOECONOMIC, AND LAND-USE SYSTEMS

The location of a repository will involve an accommodation by the absorbing area of the human and industrial activities associated with the repository. To the extent that local natural and human resources will be drawn upon to create and sustain the repository, demographic, socioeconomic, and land-use changes will occur at the local level and, to a lesser extent, at the regional level.

A regional environmental profile in the form of demographic, socioeconomic, and land-use data summaries provides an important characterization of the people-related elements in the regional setting and a regional context within which localized influences of the repository may be viewed.

6.1 DEMOGRAPHY

The distribution of population is a significant parameter in assessing a variety of potential impacts on people and their activities. For the region, demographic characteristics relative to possible socioeconomic impacts are considered to be represented on an appropriate scale by the number and distribution of major urban places.

6.1.1 URBAN PLACES

Geographers and urban planners have observed that there exists a hierarchy of urban places and the services they offer. For this regional study, demographic characterizations have been developed in terms of major urban places with populations of at least 50,000 persons within or adjacent to the Salina Region. (Urban places with a 1970 population of less than 50,000 inhabitants will be considered at the study- and location-area levels.)

The hierarchy of an urban place with over 50,000 inhabitants includes one or more incorporated places, an urban area, and a Standard Metropolitan Statistical Area (SMSA). These three divisions of an urban place of over 50,000 persons are defined by specific criteria set forth by the Bureau of the Census, U.S. Department of Commerce. The divisions are hierarchical in the sense that an urban area contains at least one incorporated place, and a Standard Metropolitan Statistical Area contains at least one urban area. Incorporated places include political units incorporated as cities, boroughs, towns, and villages.

An urban area consists of an incorporated place, or places, and the surrounding closely settled territory. According to criteria set forth by the Bureau of the Census, an urban area must have an incorporated place of 50,000 or more inhabitants or must contain "twin cities" (two incorporated places with contiguous boundaries) with a combined population of 50,000 or more inhabitants. A Standard Metropolitan Statistical Area is a county or group of contiguous counties that contains at least one urban area. Counties that do not contain an urban area may be included within an SMSA if the counties are contiguous and, according to certain criteria, are socially and economically integrated with the central city, or twin cities, contained within the urban area.

Within or adjacent to the Salina Region there are 30 SMSAs. Of these 30 SMSAs, twenty are located within the boundaries of the Salina Region while ten are located within

50 miles of the Region boundaries. A distance of 50 miles was selected as the criterion for being adjacent to the Region because of the fairly dense population of the Salina Region and because of the corresponding travel time. The 20 SMSAs located within the Salina Region are the following:

SMSA	State	SMSA	State
Ann Arbor	Michigan	Canton	Ohio
Bay City	Michigan	Cleveland	Ohio
Detroit	Michigan	Lorain/Elyria	Ohio
Flint	Michigan	Steubenville/ Weirton	Ohio
Grand Rapids	Michigan	Youngstown/ Warren	Ohio
Jackson	Michigan	Erie	Pennsylvania
Lansing	Michigan	Johnstown	Pennsylvania
Muskegon/Muskegon Heights	Michigan	Pittsburgh	Pennsylvania
Saginaw	Michigan	Wheeling	Pennsylvania
Syracuse	New York		
Akron	Ohio		

The 10 SMSAs located within 50 miles of the Region boundaries are the following:

SMSA	State	SMSA	State
Kalamazoo	Michigan	Toledo	Ohio
Binghamton	New York	Altoona	Pennsylvania
Buffalo	New York	Scranton	Pennsylvania
Rochester	New York	Wilkes-Barre/ Hazleton	Pennsylvania
Utica/Rome	New York		
Mansfield	Ohio		

In some cases the boundaries of the Salina Region cross the SMSA. In these cases a determination was made based on the relation of the urban area to the Salina Region boundaries as to whether or not the SMSA was included within the Region.

Table 6-1 lists the 1970 population of these 30 SMSAs, the counties that are a part of the SMSA area, the urban area associated with each SMSA, and incorporated places with more than 50,000 inhabitants. Figure 6-1 shows the general location and relative size of the urban areas associated with the 30 SMSAs that are in or adjacent to the Salina Region.

As shown on Table 6-1, the largest urban areas and SMSAs within or adjacent to the Salina Region are the Detroit urban area and the Detroit SMSA, with 1970 populations of 3,970,584 and 4,199,931, respectively. The city of Detroit is also the largest incorporated place, with 1,511,482 inhabitants in 1970.

TABLE 6-1

1970 POPULATION OF URBAN PLACES

Place	1970 Population	1960 Population	Change (%)
	MICHIGAN		
Ann Arbor SMSA	234,103	172,440	+35.8
Washtenaw County	234,103	172,440	+35.8
Ann Arbor Urban Area	178,605	115,282	+54.9
City of Ann Arbor	99,797	67,340	+48.2
Bay City SMSA	117,339	107,042	+9.6
Bay County	117,339	107,042	+9.6
Bay City Urban Area	78,097	72,763	+7.3
City of Bay City	49,449	53,604	-7.8
Detroit SMSA	4,199,931	3,762,360	+11.6
Macomb County	625,309	405,804	+54.1
Oakland County	907,871	690,259	+31.5
Wayne County	2,666,751	2,666,297	-0.0
Detroit Urban Area	3,970,584	3,538,495	+12.2
City of Detroit	1,511,482	1,670,144	-9.5
City of Warren	179,260	89,246	+100.9
City of Livonia	110,109	66,702	+65.1
City of Dearborn	104,199	112,007	-7.0
City of St. Clair Shores	88,093	76,657	+14.9
City of Westland	86,749	--	--
City of Royal Oak	85,499	80,612	+6.1
City of Pontiac	85,279	82,233	+3.7
City of Dearborn Heights	80,069	--	--
City of Taylor	70,020	45,118	+55.2
City of Southfield	69,285	31,501	+120.0
City of Sterling Heights	61,365	5,474	+1021.0
City of Roseville	60,529	50,195	+20.6
City of Lincoln Park	52,984	53,933	-1.8
Flint SMSA	496,658	416,239	+19.3
Genesee County	444,341	374,313	+18.7
Lapeer County	52,317	41,926	+24.8
Flint Urban Area	330,128	277,786	+18.8
City of Flint	193,317	196,940	-1.8
Grand Rapids SMSA	539,225	461,906	+16.7
Kent County	411,044	363,187	+13.2
Ottawa County	128,181	98,719	+29.8

TABLE 6-1 (Continued)

Place	1970 Population	1960 Population	Change (%)
	MICHIGAN (continued)		
Grand Rapids Urban Area	352,703	294,230	+19.9
City of Grand Rapids	197,649	177,313	+11.5
City of Wyoming	56,560	45,829	+23.4
Jackson SMSA	143,274	131,994	+8.5
Jackson County	143,274	131,994	+8.5
Jackson Urban Area	78,572	71,412	+10.0
City of Jackson	45,484	50,720	-10.3
Kalamazoo SMSA	201,550	169,712	+18.8
Kalamazoo County	201,550	169,712	+18.8
Kalamazoo Urban Area	152,083	117,224	+29.7
City of Kalamazoo	85,555	82,089	+4.2
Lansing SMSA	378,423	298,949	+26.6
Clinton County	48,492	37,969	+27.7
Eaton County	68,892	49,684	+38.7
Ingham County	261,039	211,296	+23.5
Lansing Urban Area	229,518	169,325	+35.6
City of Lansing	131,546	107,807	+22.0
Muskegon/Muskegon Heights SMSA	157,426	149,943	+5.0
Muskegon County	157,426	149,943	+5.0
Muskegon/Muskegon Heights Urban Area	105,716	95,350	+10.9
City of Muskegon	44,631	46,485	-4.0
Saginaw SMSA	219,743	190,752	+15.2
Saginaw County	219,743	190,752	+15.2
Saginaw Urban Area	147,552	129,215	+14.2
City of Saginaw	91,849	98,265	-6.5
	NEW YORK		
Binghamton SMSA	302,672	283,600	+6.7
Broome County	221,815	212,661	+4.3
Tioga County	46,513	37,802	+23.0
Susquehanna County	34,344	33,137	+3.6
Binghamton Urban Area	167,224	158,141	+5.7
City of Binghamton	64,123	75,941	-15.6

TABLE 6-1 (Continued)

Place	1970 Population	1960 Population	Change (%)
	NEW YORK (continued)		
Buffalo SMSA	1,349,211	1,306,957	+3.2
Erie County	1,113,491	1,064,688	+4.6
Niagara County	235,720	242,269	-2.7
Buffalo Urban Area	1,086,594	1,054,370	+3.1
City of Buffalo	462,768	532,759	-13.1
City of Niagara Falls	85,615	102,394	-16.4
Rochester SMSA	882,667	732,588	+20.5
Livingston County	54,041	44,053	+22.7
Monroe County	711,917	586,387	+21.4
Orleans County	37,305	34,159	+9.2
Wayne County	79,404	67,989	+16.8
Rochester Urban Area	601,361	493,402	+21.9
City of Rochester	296,233	318,611	-7.0
Syracuse SMSA	636,507	563,781	+12.9
Madison County	62,864	54,635	+15.1
Onondaga County	472,746	423,028	+11.8
Oswego County	100,897	86,118	+17.2
Syracuse Urban Area	376,169	334,267	+12.5
City of Syracuse	197,208	216,038	-8.7
Utica/Rome SMSA	340,670	330,771	+3.0
Herkimer County	67,633	66,370	+1.9
Oneida County	273,037	264,401	+3.3
Utica/Rome Urban Area	180,355	187,779	-4.0
City of Utica	91,611	100,410	-8.8
City of Rome (urban part)	47,655	51,646	-7.7
	OHIO		
Akron SMSA	679,239	605,367	+12.2
Portage County	125,868	91,798	+37.1
Summit County	553,371	513,569	+7.8
Akron Urban Area	542,775	458,253	+18.4
City of Akron	275,425	290,351	-5.1
Canton SMSA	372,210	340,345	+9.4
Stark County	372,210	340,345	+9.4

TABLE 6-1 (Continued)

Place	1970 Population	1960 Population	Change (%)
	OHIO (continued)		
Canton Urban Area	244,279	213,574	+14.4
City of Canton	110,053	113,631	-3.2
Cleveland SMSA	2,064,194	1,909,483	+8.1
Cuyahoga County	1,721,300	1,647,895	+4.5
Geauga County	62,977	47,573	+32.4
Lake County	197,200	148,700	+32.6
Medina County	82,717	65,315	+26.6
Cleveland Urban Area	1,959,880	1,783,436	+9.9
City of Cleveland	750,903	876,050	-14.3
City of Parma	100,216	82,845	+20.1
City Euclid	71,552	62,998	+13.6
City Lakewood	70,171	66,154	+6.1
City of Cleveland Heights	60,767	61,813	-1.7
Lorain/Elyria SMSA	256,843	217,500	+18.1
Lorain County	256,843	217,500	+18.1
Lorain/Elyria Urban Area	192,265	149,887	+28.3
City of Lorain	78,185	68,932	+13.4
City of Elyria	53,427	43,782	+22.0
Mansfield SMSA	129,997	117,761	+10.4
Richland County	129,997	117,761	+10.4
Mansfield Urban Area	77,599	--	--
City of Mansfield	55,047	--	--
Steubenville/Weirton SMSA	165,627	167,756	-1.3
Jefferson County, Ohio	96,193	99,201	-3.0
Brooke County, W. Va.	29,685	28,940	+2.6
Hancock County, W. Va.	39,749	39,615	+0.3
Steubenville/Weirton Urban Area	85,492	81,613	+4.8
Steubenville, Ohio	30,771	32,495	-5.3
Weirton, W. Va.	27,131	28,201	-3.8
Toledo SMSA	692,571	630,647	+9.8
Lucas County, Ohio	484,370	456,931	+6.0
Wood County, Ohio	89,722	72,586	+23.6
Monroe County, Michigan	118,479	101,120	+17.2
Toledo Urban Area	487,789	438,283	+11.3
City of Toledo, Ohio	383,818	318,003	+20.7

TABLE 6-1 (Continued)

Place	1970 Population	1960 Population	Change (%)
	OHIO (continued)		
Youngstown/Warren SMSA	536,003	509,006	+5.3
Mahoning County	303,424	300,480	+1.0
Trumbull County	232,579	208,526	+11.5
Youngstown/Warren Urban Area	395,540	372,748	+6.1
City of Youngstown	139,788	166,689	+16.1
City of Warren	63,494	59,648	+6.5
	PENNSYLVANIA		
Altoona SMSA	135,356	137,270	-1.4
Blair County	135,356	137,270	-1.4
Altoona Urban Area	81,795	83,058	-1.5
City of Altoona	62,900	69,407	-9.4
Erie SMSA	263,654	250,682	+5.2
Erie County	263,654	250,682	+5.2
Erie Urban Area	175,263	177,433	-1.2
City of Erie	129,231	138,440	-6.7
Johnstown SMSA	262,822	280,733	-6.4
Cambria County	186,785	203,283	-8.1
Somerset County	76,037	77,450	-1.8
Johnstown Urban Area	96,146	96,474	-0.3
City of Johnstown	42,476	53,949	-21.3
Pittsburgh SMSA	2,401,245	2,405,435	-0.2
Allegheny County	1,605,016	1,628,587	-1.4
Beaver County	208,418	206,948	+0.7
Washington County	210,876	217,271	-2.9
Westmoreland County	376,935	352,629	+6.9
Pittsburgh Urban Area	1,846,042	1,805,310	+2.3
City of Pittsburgh	520,117	604,332	-13.9
Scranton SMSA	234,107	234,531	-0.2
Lackawanna County	234,107	234,531	-0.2
Scranton Urban Area	204,205	210,676	-3.1
City of Scranton	103,564	111,443	-7.1
Wilkes-Barre/Hazleton SMSA	342,301	346,972	-1.3
Luzerne County	342,301	346,972	-1.3

TABLE 6-1 (Continued)

Place	1970 Population	1960 Population	Change (%)
PENNSYLVANIA (continued)			
Wilkes-Barre/Hazleton Urban Area	222,830	233,575	-4.6
City of Wilkes-Barre	58,856	63,551	-7.4
WEST VIRGINIA			
Wheeling SMSA	182,712	190,342	-4.0
Belmont County, Ohio	80,917	83,864	-3.5
Marshall County, W. Va.	37,598	38,041	-1.2
Ohio County, W. Va.	64,197	68,437	-6.2
Wheeling Urban Area	92,944	101,071	-8.0
City of Wheeling	48,188	53,400	-9.8

SOURCES: U.S. Department of Commerce, Bureau of the Census, U.S. Census of Population, 1970, Number of Inhabitants, Final Reports: PC(1)-A24, Michigan; PC(1)-A34, New York; PC(1)-A37, Ohio; PC(1)-A40, Pennsylvania; PC(1)-A50, West Virginia, U.S. Government Printing Office, Washington, D.C., 1971.

The following list ranks the urban areas according to size of population as reported in the 1970 census:

Rank	Urban Area	1970 Population
	1,000,000-5,000,000 Inhabitants	
1	Detroit	3,970,584
2	Cleveland	1,959,880
3	Pittsburgh	1,846,042
4	Buffalo	1,086,594
	500,000-999,999 Inhabitants	
5	Rochester	601,361
6	Akron	542,775
	100,000-499,999 Inhabitants	
7	Toledo	487,789
8	Youngstown/Warren	395,540
9	Syracuse	376,169
10	Grand Rapids	352,703
11	Flint	330,128
12	Canton	244,279
13	Lansing	229,518
14	Wilkes-Barre/Hazleton	222,830
15	Scranton	204,205
16	Lorain/Elyria	192,265
17	Utica/Rome	180,355
18	Ann Arbor	178,605
19	Erie	175,263
20	Binghamton	167,224
21	Kalamazoo	152,083
22	Saginaw	147,552
23	Muskegon/Muskegon Heights	105,716
	50,000-99,999 Inhabitants	
24	Johnstown	96,146
25	Wheeling	92,944
26	Steubenville/Weirton	85,492
27	Altoona	81,795
28	Jackson	78,572
29	Bay City	78,097
30	Mansfield	77,599

Table 6-2 shows the 1970 population of the 30 SMSAs according to the Bureau of the Census and the populations projected for the year 2000 by the U.S. Office of Business Economics and the U.S. Office of Economic Research Service (OBERS, Series E Projections). The data in Table 6-2 indicate that 27 SMSAs will increase in size and three will decline. Of the 27 SMSAs that are projected to increase in size, twenty-three are projected to increase by more than 10%.

TABLE 6-2

FUTURE POPULATION OF STANDARD METROPOLITAN STATISTICAL AREAS WITHIN THE SALINA REGION

SMSA	1970 Population[a]	2000 Population[b]	Change (%)
	MICHIGAN		
Ann Arbor	234,103	363,000	+55.1
Bay City	117,339	142,000	+21.0
Detroit	4,199,931	5,322,600	+26.7
Flint	496,658	767,000	+54.4
Grand Rapids	539,225	653,800	+21.3
Jackson	143,274	187,400	+30.8
Kalamazoo	201,550	293,700	+45.7
Lansing	378,423	562,100	+48.5
Muskegon/Muskegon Heights	157,426	180,400	+14.6
Saginaw	219,743	283,200	+28.9
	NEW YORK		
Binghamton (N.Y. and Penn.)	302,672	340,100	+12.4
Buffalo	1,349,211	1,419,600	+5.2
Rochester	882,667	1,412,500	+60.0
Syracuse	636,507	789,700	+24.1
Utica/Rome	340,670	355,900	+4.5
	OHIO		
Akron	679,239	792,300	+16.7
Canton	372,210	404,100	+8.6
Cleveland	2,064,194	2,470,600	+19.7
Lorain/Elyria	256,843	330,400	+28.6
Mansfield	129,997	164,400	+26.5
Steubenville/Weirton (W. Va.)	165,627	146,900	-11.3
Toledo	692,571	900,100	+30.0
Youngstown/Warren	536,003	627,500	+17.1
	PENNSYLVANIA		
Altoona	135,356	159,800	+18.1
Erie	263,654	356,600	+35.3
Johnstown	262,822	246,700	-6.1
Pittsburgh	2,401,245	2,539,000	+5.7
Scranton	234,107	305,100	+30.3
Wilkes-Barre/Hazleton	342,301	458,300	+33.9
	WEST VIRGINIA		
Wheeling (W. Va. and Ohio)	182,712	167,900	-8.1

a. See Table 6-1 for sources of data.

b. U.S. Department of Commerce and U.S. Department of Agriculture, prepared for the U.S. Water Resources Council, 1972 OBERS Projections: Volume 1, Concepts, Methodology and Summary Data, U.S. Government Printing Office, Washington, D.C., 1972.

6.2 SOCIOECONOMICS

Socioeconomic parameters are indicators of the economy of the area and of social patterns. These parameters indicate the capability of the region to meet the needs generated by the construction and operation of an industrial complex such as a repository. At the regional level, the socioeconomic characterization is presented in terms of the four major industrial sectors constituting the region's economic base.

6.2.1 ECONOMIC BASE

The economic base serves as an indicator of the availability and capability of the region's labor pool to meet the needs associated with the development and operation of a repository, which will require a labor force in the range of 1500-3000 persons, including those having skills in extractive and heavy industries.

Earnings for the years 1970 and 2000 have been selected as indicators of employment for the regional economic base characterization. Total earnings for the Region in 1970 amounted to approximately 66 billion dollars; by the year 2000, earnings will be about 181 billion dollars.

The level of economic activity is estimated on the basis of statistics published by the U.S. Water Resources Council (1974). The data, which are presented in Tables 6-3 and 6-4, are broken down according to Economic Areas delineated by the Bureau of Economic Analysis (BEA), U.S. Department of Commerce. The Salina Region contains 14 BEA Economic Areas representing 180 counties.

The BEA Economic Areas that have been selected are those that best approximate the geographical limits of the Salina Region. Figure 6-2 depicts major economic activities in the Salina Region.

6.2.1.1 Manufacturing and Heavy Industry

The major industrial activities in the Salina Region are associated with the manufacturing sector, rather than mining, agriculture and forestry, trade (retail and wholesale), government, or institutions. A heavy concentration of manufacturing is found around the Great Lakes (USDC, 1975). The principal manufacturing activities in the Great Lakes area are the production of primary and fabricated metals (western New York and western Pennsylvania) and motor vehicles (northern Ohio, eastern Michigan, and nearby northern Indiana) (USDC, 1975).

Manufacturing in the Salina Region accounted for approximately 41% of total earnings in 1970. However, its share of total earnings is expected to decline by about 7% by the year 2000 (see Table 6-4). Total earnings from manufacturing are considerably greater than those from any other single sector. Earnings from wholesale and retail trade, government, and services individually are about one-third of those from manufacturing. The major (by employment) manufacturing centers in the Salina Region are Erie, Pennsylvania; Cleveland, Akron, Canton, Steubenville-Weirton, Youngstown-Warren, and Lorain-Elyria, Ohio; Detroit, Flint, Ann Arbor, Lansing, Jackson, Kalamazoo, Grand Rapids, Muskegon-Muskegon Heights, Bay City, and Saginaw, Michigan. In Ontario, Canada, Windsor (adjacent to Detroit), Chatham, and London are major (by employment) manufacturing centers.

TABLE 6-3
1970 AND 2000 TOTAL EARNINGS FOR MAJOR ACTIVITIES
BY BEA ECONOMIC AREA

[Thousands of 1967 Dollars]

Industry	Syracuse, NY (7)		Rochester, NY (8)		Buffalo, NY (9)		Erie, PA (10)	
	1970	2000	1970	2000	1970	2000	1970	2000
Agriculture, forestry, and fisheries	113,107	147,300	71,396	86,600	88,424	113,800	35,108	34,200
Mining	17,807	25,700	8,304	24,600	13,161	12,800	1,984	2,900
Manufacturing	1,106,213	2,269,100	1,467,062	4,209,800	1,929,010	3,570,300	49,592	1,457,500
Other:								
Wholesale and retail trade	563,074	1,376,300	412,933	1,378,100	721,476	1,577,300	160,396	455,900
Government	718,309	2,237,700	422,291	1,773,900	762,422	2,326,400	133,976	492,400
Services	495,741	2,040,200	394,919	2,176,500	602,852	2,268,200	125,837	605,000
Finance, insurance, and real estate	148,762	541,100	107,083	519,600	172,385	558,700	32,735	144,400
Contract construction	200,889	572,900	157,641	613,300	265,618	657,000	60,119	185,100
Transportation, communications, and public utilities	248,649	694,500	132,903	530,700	343,304	732,800	75,335	213,100
TOTAL EARNINGS	3,612,552	9,905,200	3,174,534	11,313,400	4,898,651	11,817,000	1,175,081	3,590,900

TABLE 6-3 (Continued)

Industry	Williamsport, OH (11)		Binghamton, NY (12)		Clarksburg, W.VA (65)		Pittsburgh, PA (66)		Youngstown-Warren, OH (67)	
	1970	2000	1970	2000	1970	2000	1970	2000	1970	2000
Agriculture, forestry, and fisheries	19,862	23,000	82,167	101,200	3,322	3,600	66,081	70,300	17,931	21,200
Mining	21,603	32,900	2,923	6,900	97,064	157,900	341,471	551,000	7,904	8,800
Manufacturing	362,339	835,500	764,017	1,605,900	142,769	416,200	3,600,342	7,007,800	1,065,885	2,491,100
Other:										
Wholesale and retail trade	127,289	324,600	253,305	617,100	84,669	220,600	1,461,167	3,244,200	288,589	694,000
Government	156,081	469,700	294,185	955,800	116,974	355,300	1,055,773	3,147,100	168,485	572,400
Services	105,726	441,500	211,329	844,300	76,893	309,300	1,423,214	5,068,900	254,990	1,013,600
Finance, insurance, and real estate	22,412	89,400	51,071	188,100	16,859	65,400	357,297	1,178,700	56,978	208,600
Contract construction	50,933	144,400	97,209	256,700	39,350	114,500	638,323	1,499,100	136,246	308,500
Transportation, communications, and public utilities	61,157	149,200	105,748	250,900	67,129	140,200	765,506	1,763,900	129,297	330,700
TOTAL EARNINGS	927,404	2,510,800	1,861,953	4,827,100	645,032	1,783,300	9,709,178	23,531,300	2,126,300	5,649,200

TABLE 6-3 (Continued)

Industry	Cleveland, OH (68) 1970	Cleveland, OH (68) 2000	Detroit, MI (71) 1970	Detroit, MI (71) 2000	Saginaw, MI (72) 1970	Saginaw, MI (72) 2000	Grand Rapids, MI (73) 1970	Grand Rapids, MI (73) 2000	Lansing, MI (74) 1970	Lansing, MI (74) 2000
Agriculture, forestry, and fisheries	123,160	152,800	75,942	89,000	61,504	76,600	77,561	85,000	70,505	82,700
Mining	49,291	69,800	14,282	30,500	9,752	35,100	4,339	9,100	3,603	7,300
Manufacturing	5,496,627	11,785,500	7,783,417	18,598,300	722,190	2,013,800	1,067,645	2,456,900	1,144,661	2,974,300
Other:										
Wholesale and retail trade	2,063,970	4,852,100	2,685,468	6,915,500	264,013	709,600	460,026	1,297,600	372,624	1,098,000
Government	1,308,074	4,374,900	2,112,009	7,294,200	319,424	1,064,500	307,666	1,083,700	556,142	2,114,700
Services	1,732,668	6,878,300	2,356,355	9,752,000	191,015	824,800	343,238	1,444,800	313,862	1,541,900
Finance, insurance, and real estate	496,130	1,776,400	684,778	2,570,200	41,411	175,900	82,374	319,700	104,591	428,600
Contract construction	81,986	1,890,400	0,937,689	663,500	2,013	97,600	63,340	469,900	157,069	487,700
Transportation, communications, and public utilities	864,957	2,200,500	931,120	2,758,100	89,389	260,000	155,756	432,400	136,825	431,300
TOTAL EARNINGS	12,916,867	33,981,000	17,581,057	50,671,600	1,810,713	5,458,400	2,661,942	7,599,400	3,571,319	11,763,900

SOURCE: U.S. Water Resources Council, 1972 OBERS Projections, Series E, Population, U.S. Government Printing Office, Washington, D.C., April 1974.

TABLE 6-4

1970 AND 2000 TOTAL EARNINGS BY MAJOR INDUSTRY[a]

[Thousands of 1967 Dollars]

Industry	1970	%	2000	%
Agriculture, forestry, and fisheries	906,070	1	1,087,300	1
Extractive mining	603,488	1	975,300	1
Manufacturing	27,201,769	41	61,692,000	34
Other:				
Wholesale and retail trade	9,918,996		24,760,900	
Government	8,431,811		27,907,400	
Services	8,628,639		35,209,300	
Finance, insurance, and real estate	2,374,866		8,764,800	
Contract construction	3,788,425		10,160,600	
Transportation, communications, and public utilities	4,107,075		10,888,300	
Total other	(37,249,812)	56	(117,691,300)	65
TOTAL EARNINGS	65,961,139	100	181,445,900	100

SOURCE: U.S. Water Resources Council, 1972 OBERS Projections, Series E, Population, U.S. Government Printing Office, Washington, D.C., April 1974.

a. Totals may not add to 100% because of rounding.

6.2.1.2 Agriculture and Forestry

Dairy, general farming, livestock, fruit, truck, and tobacco are the primary agricultural activities in the Salina Region. Although agriculture and forestry are the dominant land uses, earnings from these activities are less than those from most of the other economic sectors (see Table 6-4). Earnings from agriculture, forestry, and fisheries together constitute about 1% of total earnings in the Region. This share is not expected to change significantly by the year 2000. In dollar figures, earnings will increase slightly over this time span.

6.2.1.3 Extractive (Mining) Industries

Bituminous coal, natural gas, oil, gypsum, cement, lime, and stone are the leading mineral resources in the Salina Region. Mining accounted for only 1% of total earnings in the Region in 1970 and is expected to contribute the same percentage by the year 2000. Earnings, however, will increase by approximately 50% during the same period of time (see Table 6-4 and Figure 6-3).

6.2.1.4 Other Economic Activities

Retail and wholesale trade, government, institutions, and other economic activities account for approximately 56% of earnings in the Salina Region. By the year 2000, this percentage will increase to about 65% (see Table 6-4). Services, government, and wholesale and retail trade account for most of the earnings within this economic sector.

6.3 LAND USE

6.3.1 LAND-USE PATTERNS

Existing and projected land uses are important because they indicate the setting into which a repository must be fitted and the competitive uses for the land resources required. In addition, certain land uses, such as transportation, indicate the existing ability to meet needs that may arise from a repository. At the regional level, land uses of 10,000 acres or more and population centers of 50,000 or more people are used to characterize large-area land uses related to a repository. At more detailed levels of study, population centers of less than 50,000 people will be considered as well as land uses of less than 10,000 acres.

Emphasis in this regional characterization is placed on special land uses, lands dedicated to the public, and lands already under intensive use.

Major existing and proposed (where data are available) special land uses within and adjacent to the boundaries of the Salina Region are identified in following subsections: 6.3.2, Indian Reservations; 6.3.3, Recreational and Natural Areas; 6.3.4, Potentially Interactive Uses; and 6.3.5, Transportation Systems. Highlighted information from these sections (with the exception of transportation) is presented in Figure 6-4, which also shows the major urban places.

6.3.2 INDIAN RESERVATIONS

Indian Reservations of 10,000 acres or more account for approximately 51,869 acres, or 0.06% of the total area within the Salina Region. Within the Salina Region, Indian Reservations are found only in the States of Michigan and New York. The only reservation of more than 10,000 acres that is located within the Region is the Allegany Reservation; the Cattaraugus Reservation lies just outside the boundaries of the Region. Both of these reservations are located in western New York and are shown in Figure 6-5.

The Allegany Reservation had a population of 3497 persons in 1972. All of the reservation land is jointly owned by the Seneca Nation. Surface rights are granted to individual members of the tribe. The boundaries of the Seneca Nation, of which the Allegany Nation is a part, were established in 1794 under the Pickering Treaty. The land of the reservation may not be sold without the consent of the United States. The State of New York has responsibility for Indian education, health, welfare, and legal protection.

The Cattaraugus Reservation has 21,680 acres of land and had an estimated population of 2400 persons in January 1973. Like the Allegany Reservation, the land is owned by the Seneca Nation and may not be sold without the consent of the United States. The State of New York has the same responsibilities for the Cattaraugus Reservation as for the Allegany Reservation.

Table 6-5 summarizes some of the important characteristics of these two reservations.

6.3.3 RECREATIONAL AND NATURAL AREAS

American involvement in outdoor recreational activities has significantly increased since World War II. Both the Federal Government and the states are continuing to acquire large land areas to meet this growing demand as well as to preserve scenic and natural sites for future generations.

At the regional characterization level significant recreational and natural areas over 10,000 acres in size are described.

Within and adjacent to the Salina Region, according to available data sources, there are numerous recreational and natural areas of more than 10,000 acres. These recreational and natural areas include national parks, state parks, national forests, wildlife refuges, and recreational areas located in U.S. Army Corps of Engineers projects. The largest of the recreational and natural areas within or adjacent to the Salina Region are the Huron, Manistee, and Allegheny National Forests. Each covers over 400,000 acres.

Table 6-6 summarizes important data on the recreational and natural areas of more than 10,000 acres within the Salina Region, and Figure 6-5 shows the location of these areas. These recreational and natural areas account for approximately 3.5% of the total area of the Salina Region.

6.3.4 POTENTIALLY INTERACTIVE USES

Potentially interactive land and air uses consist of airports, military facilities, and interactive air-space uses. The latter include restricted, alert, and military operations areas, and low-altitude training and all-weather routes.

TABLE 6-5

INDIAN RESERVATIONS

Reservation	Size (acres)	Acres Within Region	Percentage of Region Area	Location	Population (Date)
Allegany	30,189.40	30,189.40	0.06	Cattaraugus County, New York	3497 (1972)
Cattaraugus	21,680	0	0.0	Cattaraugus, Erie, and Chautauqua Counties, New York	2400 (January 1973)
TOTAL	51,869.40	30,189.40	0.06		5897

SOURCES:

U.S. Department of Commerce, Federal and State Indian Reservations and Indian Trust Areas, U.S. Government Printing Office, Washington, D.C., Stock No. 0311-00076.

U.S. Department of the Interior, Bureau of Indian Affairs, Annual Report of Indian Land as of June 30, 1975.

NOTE: Both the Allegany and the Cattaragus Reservations are state reservations belonging to the Seneca Nation.

TABLE 6-6

RECREATIONAL AND NATURAL AREAS 10,000 ACRES OR LARGER[a]

Type/Name	Estimated Total Acreage	Jurisdiction	Location	Estimated Acreage Within Region	Estimated Percentage of Total Region Area
PARKS					
Allegheny State Park	61,204.00	State	New York	61,204.00	0.11
Letchworth State Park	14,344.00	State	New York	14,344.00	0.02
Pymatuning State Park	37,022.00	State	Ohio, Pennsylvania	37,022.00	0.07
Ohiopyle	18,433.34	State	Pennsylvania	18,433.34	0.03
Salt Fork State Park and Wildlife Area	10,952.00	State	Ohio	10,952.00	0.02
Waterloo	17,053.00	State	Michigan	17,053.00	0.03
Cuyahoga Valley National Recreation Area	41,571.66	Federal	Ohio	41,571.66	0.08
Sleeping Bear Dunes National Lake Shore	71,105.00	Federal	Michigan	71,105.00	0.13
Ohio Power Recreation Area	46,000.00	Local	Ohio	46,000.00	0.08
Ricketts Glen	13,050.36	State	Pennsylvania	0.00	--
Subtotal	330,735.36			317,685.00	0.57
FORESTS					
Huron National Forest	420,000.00	Federal	Michigan	420,000.00	0.81
Manistee National Forest	481,000.00	Federal	Michigan	481,000.00	0.93
Wayne National Forest	141,000.00	Federal	Ohio	65,292.00	0.12
Allegheny National Forest	495,000.00	Federal	Pennsylvania	495,000.00	0.96
Coopers Rock Forest	12,698.00	State	West Virginia	12,698.00	0.02
Sugar Hill State Forest ~9,084.97		State	New York		
Coon Hollow State Forest ~2,454.73	13,651.30[b]	State	New York	13,651.30	0.02
Goundry Hill State Forest ~2,111.60		State	New York		
Subtotal	1,563,349.00			1,487,641.30	2.87

TABLE 6-6 (Continued)

Type/Name	Estimated Total Acreage	Jurisdiction	Location	Estimated Acreage Within Region	Estimated Percentage of Total Region Area
WILDLIFE REFUGES					
Iroquois National Wildlife Refuge	10,818.00	Federal	New York	0.00	--
Mosquito Creek Wildlife Area	17,365.00	State	Ohio	17,365.00	0.03
Connecticut Hill Game Management Area	11,610.00	State	New York	11,610.00	0.02
Subtotal	39,793.00			28,975.00	0.05
OTHER					
Recreational Areas on U.S. Army Corps of Engineers Projects					
Allegheny River System (9 areas)	10,303.00	Federal	Pennsylvania	10,030.00	0.01
Kinzua Dam and Allegheny Reservoir	26,541.00	Federal	Pennsylvania	26,541.00	0.05
Monongahela Waterway (12 areas)	11,161.00	Federal	Pennsylvania	11,161.00	0.02
Shenango River and Lake (6 areas)	15,071.00	Federal	Pennsylvania	15,071.00	0.02
Dover Dam	14,571.00	Federal	Ohio	14,571.00	0.02
Mohawk Dam (2 areas)	14,024.00	Federal	Ohio	0.00	--
Willis Creek Lake (2 areas)	20,383.00	Federal	Ohio	0.00	--
Mosquito Creek Lake (3 areas)	11,457.00	Federal	Ohio	11,457.00	0.02
Subtotal	123,511.00			88,831.00	0.14
TOTAL	2,057,388.66			1,923,132.3	3.62

TABLE 6-6 (Continued)

SOURCES:

U.S. Department of Agriculture, Forest Service, National Forests and Forest Service Field Offices, U.S. Government Printing Office, Washington, D.C., 1976, Stock No. 0-221-034.

U.S. Department of Agriculture, Forest Service, National Forest Wilderness and Primitive Areas, U.S. Government Printing Office, Washington, D.C., 1974, Stock No. 0-552-497.

U.S. Department of the Army, Corps of Engineers, Recreation Statistics, 1974, U.S. Government Printing Office, Washington, D.C., 1974, Stock No. 008-022-00098.

U.S. Department of the Interior, Fish and Wildlife Service, Directory of National Wildlife Refuges—1977, U.S. Government Printing Office, Washington, D.C., 1976, Stock No. 916-533.

U.S. Department of the Interior, Geological Survey, United States of America, National Parks and Monuments, National Forests, Indian Reservations, Wildlife Refuges, Public Lands and Historical Boundaries (map), U.S. Government Printing Office, Washington, D.C., 1965.

U.S. Department of the Interior, National Park Service, Index of the National Park System, U.S. Government Printing Office, Washington, D.C., 1975, Stock No. 024-005-00612-5.

Rand McNally and Company, 1977 Campground and Trailer Park Guide.

Ohio Department of Natural Resources, Ohio Fishing and Hunting Areas, Publication 77, Columbus, Ohio.

a. Acreage also includes the acreage of water bodies

b. None of these state forests is 10,000 acres; however they are adjacent to each other in one corner of Schuyler County and aggregated they comprise a substantial state land holding.

6.3.4.1 Airports

Airports include both public and private facilities that may be utilized either by commercial or by general aviation aircraft. Airports or air bases used exclusively or partially by the armed forces and covering 10,000 acres or more are described in Section 6.3.4.2.

Existing airports may be described according to the air traffic hub structure to determine which facilities may be considered as major. The air traffic hub classification is used by the Federal Aviation Administration as a measure of the concentration of all civil air traffic. Although one or more airports may be associated with it, an air traffic hub is not an airport; it is a city or a Standard Metropolitan Statistical Area requiring aviation services. The air traffic hub structure is in essence a consolidation of the socioeconomic factors that influence a community's ability to generate air carrier and general aviation traffic.

Individual areas fall into one of four air traffic hub classifications as determined by each area's percentage of the total enplaned revenue passengers in all services and operations. These four hub classifications and percentages are as follows:

Hub Classification	Percentage of Total Enplaned Passengers
Large hub	1 or more
Medium hub	0.25-0.99
Small hub	0.05-0.24
Nonhub	less than 0.05

Within or in proximity to the Salina Region there are 16 air traffic hubs, which are classified as follows:

Large Hubs

Cleveland, Ohio
Detroit/Ann Arbor, Michigan
Pittsburgh/Wheeling, Pennsylvania and West Virginia

Medium Hubs

Buffalo/Niagara Falls, New York
Rochester, New York
Syracuse, New York

Small Hubs

Akron/Canton, Ohio
Erie, Pennsylvania
Flint, Michigan
Grand Rapids, Michigan
Kalamazoo/Battle Creek, Michigan
Lansing, Michigan
Saginaw/Bay City/Midland, Michigan
Scranton/Wilkes-Barre, Pennsylvania
Toledo, Ohio
Youngstown, Ohio

Of these 16 air traffic hubs, eleven are within the Salina Region, and five (Buffalo/Niagara Falls, Rochester, Kalamazoo/Battle Creek, Scranton/Wilkes-Barre, and Toledo) are outside it.

Figure 6-6 shows the location of the air traffic hubs within or in proximity to the Salina Region. The Cleveland and Detroit air traffic hubs are near the center of the Salina Region. The remainder of the air traffic hubs are scattered throughout the Salina Region. Only the northern portions of Michigan and eastern New York are without air traffic hubs.

Associated with the air traffic hubs are major airport facilities. These are listed in Table 6-7 together with the number of aircraft departures, enplaned passengers, enplaned revenue tons, and acreages. As may be seen from Table 6-7, the Greater Pittsburgh Airport is 10,000 acres; all other major airports are smaller. The total percentage of area occupied by these facilities within the Salina Region is approximately 0.052%.

6.3.4.2 Military Facilities and Reservations

All land occupied by military facilities and reservations, including land used by National Guard and reserve units, is under the control of the Federal Government. Military facilities and reservations consist of Army, Navy, and Air Force installations.

The Salina Region contains numerous military installations, but only two cover 10,000 or more acres. These two installations are the Seneca Army Depot in Seneca County, New York, and the Ravenna Army Ammunition Plant in Portage County, Ohio. A third, the Letterkenny Army Depot in Fulton County, Pennsylvania, is within approximately 50 miles of the boundaries of the Salina Region. The Seneca and Ravenna installations account for 0.09% of the total area within the Region.

Table 6-8 summarizes data on the military facilities and reservations of 10,000 acres or more within the Salina Region, and Figure 6-7 shows their locations.

6.3.4.3 Restricted and Military Operations Areas

An estimated total of 969,920 acres (1515.5 square miles) of land area is covered by restricted or military operations areas (MOAs) that individually are 10,000 acres or larger. All of these areas are located in the central and northeastern portion of Michigan. Together these areas account for approximately 1.89% of the total land area within the Salina Region.

Aircraft activities are not totally prohibited within restricted areas. Certain aircraft activities are restricted, either because of their nature or because of limitations imposed on aircraft operations that are not a part of normal activities occurring within the area. Restricted areas denote the existence of unusual, often invisible, hazards to aircraft, such as artillery firing, aerial gunnery, or guided missiles. Military operations areas are air spaces that have been established for the purpose of segregating certain military training activities from air spaces used by aircraft operating under instrument flight rules (IFR). Aircraft operating under visual flight rules (VFR) are to exercise extreme caution while flying within a military operations area.

Table 6-9 lists the restricted and military operations areas that are 10,000 acres or larger and are located within the Salina Region, and Figure 6-7 shows the locations of these areas. Restricted or military operations areas that lie totally over the Great Lakes are not included.

TABLE 6-7

AIRCRAFT DEPARTURES, ENPLANED REVENUE PASSENGERS, ENPLANED REVENUE TONS, AND AREA OF AIR FACILITIES[a]
[12 Months Ended June 30, 1975]

Community (Airport Name) Percent of Enplanements	Total Aircraft Departures	Enplaned Passengers	Total Enplaned Revenue (tons)	Estimated Size (acres)[b]	Percent of Region Area
Cleveland, Ohio					
(Hopkins International Airport)					
0.39	57,914	2,699,465	62,224.67	1,492	0.003
(Burke Lakefront Airport)					
0.01	1,729	30,162	502.90	450	0.001
Detroit and Ann Arbor, Mich.					
(Detroit City Airport)					
0.01	1,562	28,240	338.01	264	0.000
(Detroit Metropolitan Wayne City)					
1.88	79,950	3,636,453	106,271.54	4,800	0.009
Pittsburgh, Pa./Wheeling, W. Va.					
(Greater Pittsburgh)					
1.81	87,947	3,498,323	35,540.68	10,000	0.019
Buffalo and Niagara Falls, N.Y.					
(Greater Buffalo International)					
0.69	35,791	1,335,864	20,086.43	1,000	0.000
Rochester, N.Y.					
(Rochester-Monroe County)					
0.39	22,921	758,710	8,272.57	1,083	0.000

TABLE 6-7 (Continued)

Community (Airport Name) Percent of Enplanements	Total Aircraft Departures	Enplaned Passengers	Total Enplaned Revenue (tons)	Estimated Size (acres)	Percent of Region Area
Syracuse, N.Y. (Clarence E. Hancock) 0.34	15,941	662,967	11,267.14	1,600	0.003
Akron/Canton, Ohio (Akron-Canton) 0.11	6,613	226,680	1,984.80	1,520	0.003
Erie, Pa. (Erie International) 0.06	4,626	122,213	908.68	400	0.001
Flint, Mich. (Bishop) 0.05	4,351	97,083	441.06	1,130	0.002
Grand Rapids, Mich. (Kent County) 0.14	11,181	280,668	2,519.33	1,745	0.003
Kalamazoo/Battle Creek, Mich. (Kalamazoo Municipal) 0.05	5,628	97,428	1,051.97	628	0.001
Lansing, Mich. (Capital City) 0.08	7,845	161,295	794.52	1,200	0.002

TABLE 6-7 (Continued)

Community (Airport Name) Percent of Enplanements	Total Aircraft Departures	Enplaned Passengers	Total Enplaned Revenue (tons)	Estimated Size (acres)	Percent of Region Area
Saginaw/Bay City/Midland, Mich. (Tri City) 0.08	4,761	166,680	677.02	1,600	0.003
Scranton/Wilkes-Barre, Pa. (Wilkes-Barre/Scranton) 0.06	2,912	124,872	508.11	980	0.000
Toledo, Ohio (Toledo Express) 0.13	8,234	252,431	2,063.22	1,500	0.000
Youngstown, Ohio (Youngstown Municipal) 0.06	3,513	126,142	498.15	901	0.002
TOTAL	363,419	14,305,676	255,950.80	32,293	0.052

a. Federal Aviation Administration and Civil Aeronautics Board, Airport Activity Statistics of Certificated Route Air Carriers, 12 Months Ended June 30, 1975, National Technical Information Service, Springfield, Va., June 30, 1975.

b. National Flight Data Center, Federal Aviation Administration (source of information for estimated acreages).

TABLE 6-8

MILITARY INSTALLATIONS[a] 10,000 ACRES OR LARGER

Name of Installation	General Location	Size of Installation (acres)	Percentage of Total Acres in Region
Seneca Army Depot	Seneca County, N.Y.	10,587	0.021
Ravenna Army Ammunition Plant	Portage County, Ohio	35,405	0.069
Letterkenny Army Depot	Fulton County, Pa.	19,457	0.0 [b]
TOTAL		65,449	0.09

SOURCES:

General Services Administration, Office of Administration, Detailed Listing of Department of Defense (Military Functions) as of September 30, 1976.

Air Force Association, Air Force Magazine, Annual Air Force Almanac Issue, May 1977, Vol. 60, No. 5.

Department of Defense, Defense Mapping Agency Topographic Center, Major Army, Navy and Air Force Installations in the United States (map), February 1975, Series 8205, Edition 39-DMATC.

a. No military installations 10,000 acres or larger are located in the Michigan and West Virginia portions of the Salina Region. All military installations listed here are U.S. Army installations.

b. Installation not in Region.

TABLE 6-9

RESTRICTED AND MILITARY OPERATIONS AREAS
LARGER THAN 10,000 ACRES

Reference Number or Name	Estimated Land Area Covered (acres)	Percent of Total Acres in Region	General Location
R-4201A	53,760	0.1	Camp Grayling, Mich.
R-4201B	36,160	0.07	Camp Grayling, Mich.
Collins MOA	304,000	0.59	Alpena County, Mich.
Peck MOA	576,000	1.12	Huron County, Mich.
TOTAL	969,920	1.88	

SOURCES:

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Chicago Sectional Aeronautical Chart, 14th Edition, May 19, 1977, Washington, D.C.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Green Bay Sectional Aeronautical Chart, 14th Edition, August 11, 1977, Washington, D.C.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Detroit Sectional Aeronautical Chart, 14th Edition, May 19, 1977, Washington, D.C.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, New York Sectional Aeronautical Chart, 15th Edition, June 16, 1977, Washington, D.C.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Lake Huron Sectional Aeronautical Chart, 13th Edition, May 19, 1977, Washington, D.C.

NOTE: Acreage includes MOA area over land only.

Restricted, alert, and military operations areas are updated on a continual basis by the Departments of Defense and Commerce and the Federal Aviation Administration. Revised sectional aeronautical charts showing these air spaces are published approximately every 6 months.

6.3.4.4 Low-Altitude Air Routes

Low-altitude air routes consist of all-weather low-altitude routes and VFR (visual flight rules) low-altitude training routes. All-weather low-altitude routes (AWLAR) are established for low-altitude airborne radar navigation training and radar bomb scoring training; VFR low-altitude training routes are established for low-altitude navigational training, tactical training, and military/civil flight testing. Within the Salina Region there are no all-weather low-altitude routes over land areas. There is one all-weather low-altitude route over Lake Michigan, just off northwestern Michigan. The VFR low-altitude training routes within the Salina Region consist of both SR and TR routes (i.e., routes with air speeds below or above 250 knots, respectively). There are several VFR low-altitude training routes that are located throughout the entire Salina Region. Only the east-central portion of Michigan and the eastern Ohio-western Pennsylvania areas within the Region are without VFR low-altitude training routes.

Table 6-10 summarizes the mileage and general location of these low-altitude routes, and Figure 6-7 shows their locations.

6.3.5 TRANSPORTATION SYSTEMS

The type and predominant modes of transportation determine an area's accessibility for the movement of materials and labor. The transportation modes within the Salina Region consist of highways, railroads, and navigable waterways. (Air transportation facilities have been described in Section 6.3.4.1.)

6.3.5.1 Highway System

The Salina Region is traversed by several interstate, U.S., and state highways. Interstates 90, 80, 70, 94, and 96 cross the Region in an east-west direction, while Interstates 75, 69, 71, 77, 79, and 81 cross the Region in a north-south direction. Portions of Interstate 69 within the Region have yet to be completed.

Some of the major north-south U.S. highways include 27, 127, 31, 23, 119, 15 and 19. Major U.S. highways in an east-west direction include 10, 6, 30, 42, and 20.

Within the Salina Region there are at present an estimated total of 2400 route miles of interstate highways, 4600 route miles of U.S. highways, and approximately 12,000 route miles of state highways, or a total of approximately 19,000 miles. (Note: route miles include a double counting of a common road by different routes.)

The predominant mode of transportation is the highway system. It provides not only direct location-to-location access but also an interconnecting system of linkages with other modes of transportation. The highway system within an area may be characterized in terms of the actual physical facilities that exist and/or the functions that these physical facilities serve.

The most familiar system of describing the highway system is to classify roads as interstate highways, U.S. highways, state highways, or other local roads. Generally, the interstate highways, most U.S. highways, and certain state highways (particularly those of

TABLE 6-10

MILEAGE OF LOW-ALTITUDE AIR ROUTES

Route Type and Number	Estimated Length of Route[a][b] Within Region (nautical miles)	General Location of Route by a Point (City, State) Near Route
SR ROUTES--AIR SPEED 250 KNOTS OR LESS		
SR 701	170 (45 with SR 703)	Detroit, Michigan
SR 702	160	Detroit, Michigan
SR 703	75 (45 with SR 701)	Detroit, Michigan
SR 707	85	Columbus, Ohio
SR 708	10 (10 with SR 712)	Columbus, Ohio
SR 710	55	Columbus, Ohio
SR 712	10 (10 with SR 708)	Columbus, Ohio
SR 713	45	Columbus, Ohio
SR 746	75	Jackson, Michigan
SR 747	75	Saginaw, Michigan
SR 748	85	Traverse City, Michigan
SR 749	95	Saginaw, Michigan
SR 781	115 (15 with SR 782)	Pellston, Michigan
SR 782	145 (15 with SR 781)	Pellston, Michigan
SR 815	42 (40 with SR 816)	Pittsburgh, Pennsylvania
SR 816	45 (40 with SR 815)	Pittsburgh, Pennsylvania
SR 817	155 (10 with SR 818)	Pittsburgh, Pennsylvania
SR 818	75 (10 with SR 817)	Pittsburgh, Pennsylvania
SR 823	145	Buffalo, New York
SR 824	55 (10 with SR 825 and 826)	Buffalo, New York
SR 825	110 (10 with SR 824 and 826, 20 with SR 826)	Buffalo, New York

TABLE 6-10 (Continued)

Route Type and Number	Estimated Length of Route[a][b] Within Region (nautical miles)	General Location of Route by a Point (City, State) Near Route
SR 826	20 (20 with SR 825)	Buffalo, New York
	TR ROUTES--AIR SPEEDS 250 KNOTS AND ABOVE	
TR 720	50 (25 with TR 766)	Pellston, Michigan
TR 743	190	Saginaw, Michigan
TR 753	115	Saginaw, Michigan
TR 766	145 (25 with TR 720)	Saginaw, Michigan
TR 828	160 (35 with TR 855)	Wilkes-Barre, Pennsylvania
TR 855	130 (35 with TR 828)	Harrisburg, Pennsylvania
TR 856	60	Harrisburg, Pennsylvania
TR 890	75	Elkins, West Virginia

SOURCE: Department of Defense, Defense Mapping Agency, Area Planning Military Training Routes, North and South America, Defense Mapping Agency Aerospace Center, St. Louis Air Force Station, Missouri, October 6, 1977.

a. Estimate of mileage only includes mileage of routes within the Region and mileage of multiple routes within the Region. Estimated mileage does not include mileage of routes over the Great Lakes.

b. Total mileage shown first; portions of total mileage shared with other air routes shown in parentheses.

interstate quality) are considered to constitute the arterial system. The arterial system may generally be described as the system of roads that services major population nodes, or major centers of activities in urban areas, and has a travel density indicative of substantial statewide or interstate travel.

At the regional characterization level importance is placed on interstate and U.S. highways since they make up most of the arterial system. At subsequent levels of characterization greater emphasis will be placed on the functional characterization of roads within the area of study.

Table 6-11 summarizes the interstate and U.S. highways found within the Salina Region. Figure 6-8 shows the positions of the interstate, U.S., and state highways within the Region.

6.3.5.2 Railroads

The railroad system within the Salina Region involves several large, medium, and small hubs within and outside the Region. Most of the trackage within the Region radiates from these hubs. Some of the major rail hubs within or in close proximity to the Salina Region are Buffalo, Rochester, and Syracuse, New York; Pittsburgh, Pennsylvania; Cleveland, Toledo, Akron, Canton, and Youngstown, Ohio; and Detroit, Saginaw, Kalamazoo, Grand Rapids, and Jackson, Michigan. Most are located near the Great Lakes. Only the northern part of Michigan and the midwestern portion of West Virginia are devoid of rail facilities. Figure 6-9 shows the major railroad network trackage within the Salina Region.

The railroad network in the Salina Region consists of an estimated total of 10,573 miles of track, owned by 43 different railroad companies, the U.S. Government, and the states of Michigan and Pennsylvania. This estimated total of 10,573 miles of track includes an estimated total of 1337 miles of track available for subsidy as of April 1, 1976, under the Railroad Revitalization and Regulatory Reform Act of 1976. Table 6-12 summarizes the railroad companies and associated trackage estimates within the Salina Region.

6.3.5.3 Navigable Waterways

Within the Salina Region there are slightly over 500 nautical miles of navigable waterways, exclusive of the Great Lakes. The water transportation system within and adjacent to the Salina Region may be viewed as being oriented in three major directions: the Great Lakes, the Ohio River basin, and the Atlantic coast. The principal inland waterways within the Region include the Ohio, Monongahela, and Allegheny Rivers, all of which are part of the Ohio River system. In addition to these inland waterways, there are four major waterways that are part of the Great Lakes navigation system: the St. Clair River and the Detroit River, which together connect Lake Huron to Lake Erie; St. Mary's River, which connects Lake Superior to Lake Huron; and the Niagara River, which connects Lake Ontario to Lake Erie. Only the St. Clair River and the Detroit River are contained within the Salina Region. In addition to these waterways associated with the Ohio River and the Great Lakes system, the New York Barge Canal provides access from the Niagara River to the Hudson River and thence to the Atlantic Ocean.

TABLE 6-11

INTERSTATE AND U.S. HIGHWAYS

Route Type and Number	Estimated Total Mileage in Region	General Orientation	General Origin and Terminus
		MICHIGAN[a-c]	
Interstate Highways	860		
I-75	300	N-S	Mackinaw City to S. of Detroit
I-94	180	E-W	W. of Battle Creek to Port Huron
I-96	180	E-W	Muskegon to Detroit
I-69	90	N-S	S. of Marshall to Flint (includes temporary road)
I-196	20	N-S	N.E. of Holland to Grand Rapids
Other Interstates (urban)	90		
U.S. Highways	1405		
U.S. 31	260	N-S	Mackinaw City to Grand Haven
U.S. 131	190	N-S	Petosky to S. of Bradley
U.S. 10	270	E-W	Ludington to Detroit
U.S. 23	340	N-S	Mackinaw City to N. of Milan
U.S. 127	50	N-S	S. of Jackson to N. of Lansing
U.S. 27	180	N-S	S. of Marshall to S. of Grayling
U.S. 12	50	E-W	N.E. of Clinton to Detroit
U.S. 24	35	N-S	Rockwood to Pontiac
Other U.S. Highways (urban)	30		
		NEW YORK[b,c]	
Interstate Highways	235		
I-90	130	E-W	N. of Batavia to W. of Canastota
I-81	70	N-S	N. of Syracuse to N. of Binghamton
I-390	20	E-W	(Portions only)
Other Interstates (urban)	15		

TABLE 6-11 (Continued)

Route Type and Number	Estimated Total Mileage in Region	General Orientation	General Origin and Terminus
		NEW YORK[b,c] (continued)	
U.S. Highways	390		
U.S. 62	32		S. New York border to Leon
U.S. 219	45	N-S	S. New York border to S. of Boston
U.S. 15	15	N-S	S. New York border to State Highway 17
U.S. 11	70	N-S	N. of Syracuse to N. of Binghamton
U.S. 20	158	E-W	Alden to Pine Woods
U.S. Alt. 20	70	E-W	East Aurora to U.S. 20
		OHIO[b-d]	
Interstate Highways	647		
I-77	160	N-S	Ohio border to Cleveland
I-70	47	E-W	E. Ohio border to Cambridge
I-80	105	E-W	E. Ohio border to W. of Elyria
I-90	110	E-W	E. Ohio border to W. of Elyria
I-271	42	N-S	I-71 to I-90
I-480	18	E-W	I-80 to I-80 (portions)
I-76	95	E-W	E. Ohio border to Lodi
I-71	50	N-S	Cleveland to Redhaw
Other Interstates (urban)	20		
U.S. Highways	930		
U.S. 62	98	E-W	E. Ohio border to Berlin
U.S. 250	95	E-W	E. Ohio border to W. of Wooster
U.S. 22	60	E-W	E. Ohio border to I-77
U.S. 30	83	E-W	E. Ohio border to W. of Wooster
U.S. 422	75	E-W	E. Ohio border to Cleveland
U.S. 6	125	E-W	E. Ohio border to W. of Lorain
U.S. 322	61	E-W	E. Ohio border to Cleveland
U.S. 20	115	E-W	E. Ohio border to E. of Norwalk
U.S. 42	55	E-W	Cleveland to S.W. of Lodi
U.S. 224	98	E-W	E. Ohio border to Nova
U.S. 36	18	E-W	Dennison to W. of I-77
U.S. 40	47	E-W	E. Ohio border to Cambridge

TABLE 6-11 (Continued)

Route Type and Number	Estimated Total Mileage in Region	General Orientation	General Origin and Terminus
		PENNSYLVANIA[b,c,e]	
Interstate Highways	566		
I-79	180	N-S	S. Pennsylvania border to Erie
I-90	32	E-W	W. Pennsylvania border to S.E. of Erie
I-80	132	E-W	W. Pennsylvania border to Kylertown
I-76	108	E-W	W. Pennsylvania border to Somerset
I-70	94	N-S	W. Pennsylvania border to Somerset
Other Interstates (urban)	20		
U.S. Highways	1658		
U.S. 15	48	N-S	N. Pennsylvania border to S. of Buttonwood
U.S. 6	285	E-W	E. of Towanda to W. Pennsylvania border
U.S. 220	28	E-W	N. Pennsylvania border to Powell
U.S. 20	46	E-W	Ohio border to Pennsylvania border
U.S. 22	104	E-W	W. Pennsylvania border to Ebensburg
U.S. 6N	33	E-W	U.S. 6 to U.S. 20
U.S. 322	160	E-W	Decatur to W. Pennsylvania border
U.S. 62	123	E-W	N. Pennsylvania border to W. Pennsylvania border
U.S. 219	175	N-S	N. Pennsylvania border to Ebensburg
U.S. 119	130	N-S	Sandy to S. Pennsylvania border
U.S. 422	120	E-W	W. Pennsylvania border to Ebensburg
U.S. 30	100	E-W	W. Pennsylvania border to Jenners
U.S. 40	80	E-W	S. Pennsylvania border to W. Pennsylvania border
U.S. 19	206	N-S	S. Pennsylvania border to Erie
Other U.S. Highways (urban)	20		
		WEST VIRGINIA[b,c,f]	
Interstate Highways	65		
I-79	50	N-S	W. Virginia border to S. of Anmoore
I-70	12	E-W	Pennsylvania border to Ohio border
I-77	3	N-S	Ohio border to N. of Parkersburg

TABLE 6-11 (Continued)

Route Type and Number	Estimated Total Mileage in Region	General Orientation	General Origin and Terminus
	WEST VIRGINIA[b,c,f] (continued)		
U.S. Highways	211		
U.S. 22	8	E-W	Pennsylvania border to Ohio border
U.S. 40	12	E-W	Pennsylvania border to Ohio border
U.S. 19	55	N-S	Pennsylvania border to Ohio border
U.S. 50	70	E-W	Pennsylvania border to S. of Clarksburg
U.S. 250	95	E-W	E. of Parkersburg to E. of I-79
U.S. 48	27	E-W	E. of I-79 to Ohio border
U.S. 119	31	N-S	W. of Maryland border to Morgantown
U.S. 30	3	E-W	Pennsylvania border to Grafton
Total Interstate	2373		
Total U.S.	4594		
TOTAL	6961		

a. Data from Michigan Department of State Highways and Transportation, 1976/1977 Official Transportation Map.

b. Data from U.S. Department of Transportation, Federal Highway Administration, The National System of Interstate and Defense Highways, 1977, Washington, D.C., 1977.

c. Data from Rand McNally and Company, Road Atlas, 1977.

d. Data from Ohio Department of Transportation, Official Highway Map, 1977 edition.

e. Data from Pennsylvania Department of Transportation, 1977 Official Transportation Map.

f. Data from West Virginia Department of Highways, 1976 Official West Virginia Highway Map.

TABLE 6-12

RAILROADS AND TRACKAGE

Railroad	Estimated Miles of Single Track	Estimated Miles of Double Track	Estimated Miles of Track with Trackage Rights by Another Railroad	Estimated Total Miles of Track
		MICHIGAN		
Ann Arbor (leased by State of Michigan)	106			106
Boyne City	6			6
Cadillac & Lake City	5			5
Chesapeake & Ohio	1041	21		1,062
Consolidated Rail Corp. (Conrail)	127	120		247
Detroit & Mackinac	281			281
Detroit, Toledo & Ironton	10	7		17
Detroit, Toledo & Shore Line	15	15		30
Grand Trunk Western	590	92		682
Ludington & Northern	2			2
Michigan Northern	243			243
Michigan (acquired by State)	125			125
Norfolk and Western	--	29		29
Port Huron & Detroit	17			17
Available for subsidy	370			370
		NEW YORK		
Arcade & Attica	13			13
Baltimore & Ohio	121		10	131
Bath & Hammondsport	8			8
Consolidated Rail Corp. (Conrail)	536	152	195	883
Dansville & Mount Morris	10			10
Genesee & Wyoming	11			11
Livonia, Avon & Lakeville	11			11
Skaneateles Short Line	3			3
Available for subsidy	392			392

TABLE 6-12 (Continued)

Railroad	Estimated Miles of Single Track	Estimated Miles of Double Track	Estimated Miles of Track with Trackage Rights by Another Railroad	Estimated Total Miles of Track
		OHIO		
Akron & Barberton Belt	15			15
Akron, Canton & Youngstown	53			53
Bessemer & Lake Erie	2			2
Baltimore & Ohio	315	79	31	425
Consolidated Rail Corp. (Conrail)	324	420	143	887
Fairport, Painesville & Eastern	5			5
Lorain & West Virginia	19			19
Lake Erie & Eastern			4	4
Lake Terminal	5			5
Norfolk & Western	258	49	27	334
Pittsburgh & Lake Erie	5		2	7
U.S. Government	30			30
Youngstown & Southern	33			33
Available for subsidy	189			189
		PENNSYLVANIA		
Bessemer & Lake Erie	165	11		176
Baltimore & Ohio	340	140	124	604
Cambria & Indiana	8			8
Consolidated Rail Corp. (Conrail)	1188	403		1591
East Erie Commercial	6			6
Lake Erie, Franklin & Clarion	14			14
Monongahela	108			108
Montour	47			47
Norfolk & Western	106	8	12	126
Pennsylvania (acquired by Commonwealth)	28			28

TABLE 6-12 (Continued)

Railroad	Estimated Miles of Single Track	Estimated Miles of Double Track	Estimated Miles of Track with Trackage Rights by Another Railroad	Estimated Total Miles of Track
	PENNSYLVANIA (continued)			
Pittsburgh & Lake Erie	78	3	52	133
Pittsburgh & Ohio Valley	7			7
Pittsburgh & Shawmut	87			87
Unity	4			4
Wellsville, Addison & Galeton	32			32
Winfield	7			7
Youngstown & Southern	9			9
Union	15			15
Conemaugh & Black Lick	4			4
Monongahela Connecting	5			5
Available for subsidy	366	20		386
	WEST VIRGINIA			
Baltimore & Ohio	321	19	20	360
Consolidated Rail Corp. (Conrail)	57	7		64
Monongahela	52			52
Norfolk & Western	4			4
Western Maryland	4			4
TOTAL	8358	1595	620	10,573

SOURCE: U.S. Department of the Interior, Geological Survey, for the Federal Railroad Administration, State Transportation Maps, Michigan, New York, Ohio, Pennsylvania, West Virginia, U.S. Government Printing Office, Washington, D.C., 1975 (five separate maps).

Associated with the waterways are the following major and minor ports within the Salina Region:

Ohio River System

Pittsburgh, Pennsylvania
Aliquippa-Rochester, Pennsylvania
Clairton-Elizabeth, Pennsylvania

Great Lakes

Lake Michigan:

Grand Haven Harbor, Michigan
Muskegon Harbor, Michigan
Ludington Harbor, Michigan
Manistee Harbor, Michigan
Frankfort Harbor, Michigan
Grand Traverse, Michigan
Mackinaw Harbor, Michigan

Lake Huron, including the Detroit and St. Clair Rivers:

Cheboygan Harbor, Michigan
Saginaw, Michigan
Port Huron, Michigan
Marysville, Michigan
Port of Detroit, Michigan

Lake Erie:

Ecorse, Michigan
Wyandotte, Michigan
Trenton, Michigan
Lorain Harbor, Ohio
Cleveland Harbor, Ohio
Fairport Harbor, Ohio
Ashtabula Harbor, Ohio
Conneaut Harbor, Ohio

The major navigable waterways within the Salina Region are summarized in Table 6-13 and are shown, together with the harbors and ports, on Figure 6-10.

TABLE 6-13

MAJOR NAVIGABLE WATERWAYS

Navigable Waterway	Origin and Terminus Within Region	Estimated Distance Within Region (nautical miles)
OHIO RIVER BASIN		
Ohio River	Pittsburgh, Pa., to Parkersburg, W. Va.	160.0
Monongahela River	Pittsburgh, Pa., to Fairmont, W. Va.	128.7
Allegheny River	Pittsburgh, Pa., to above E. Brady, Pa.	72.0
GREAT LAKES		
St. Clair River	Lake Huron to Lake St. Clair	52.0
Detroit River	Lake St. Clair to Lake Erie	36.0
ATLANTIC		
New York Barge Canal	W. of Newark to N.W. of Syracuse	65.0
TOTAL		513.7

SOURCE: U.S. Department of the Army, Corps of Engineers, Waterborne Commerce of the United States, Calendar Year 1976, Parts 1, 2, and 3, New Orleans, Louisiana (three separate volumes).

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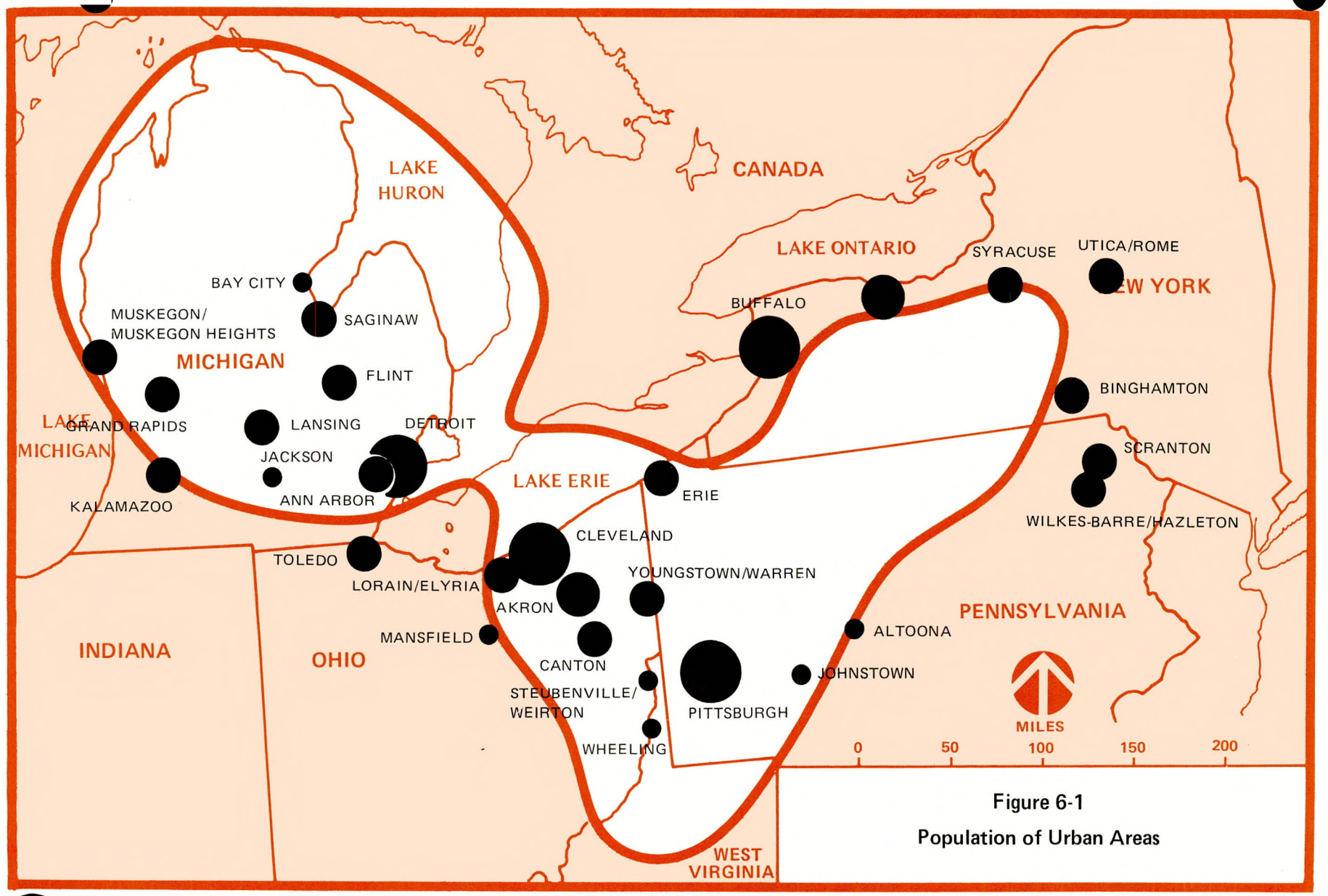


Figure 6-1

Population of Urban Areas

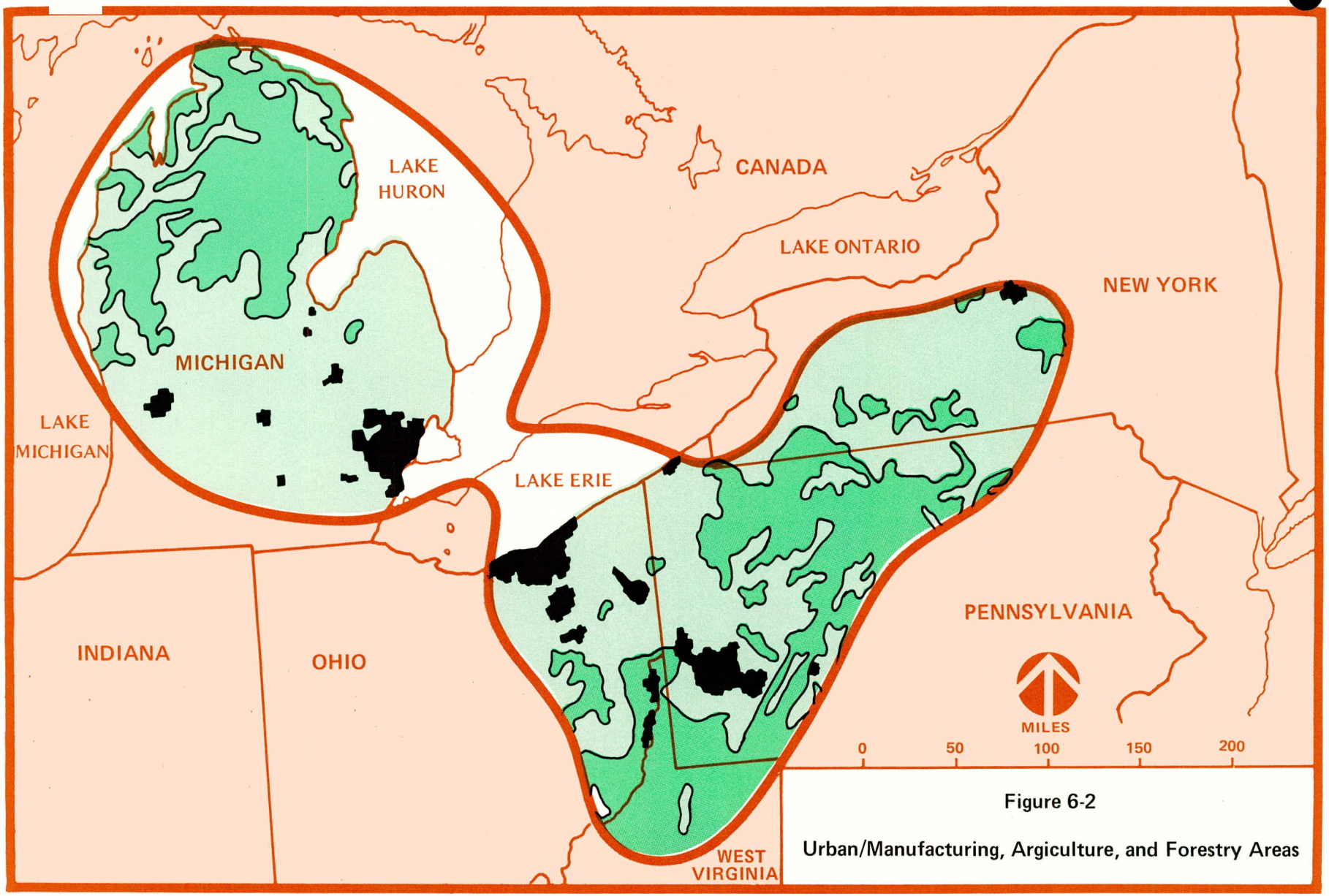


Figure 6-2

Urban/Manufacturing, Argiculture, and Forestry Areas

URBAN/MANUFACTURING CENTERS
CROPLAND, PASTURE, GRAZING LAND
FOREST AND WOODLAND

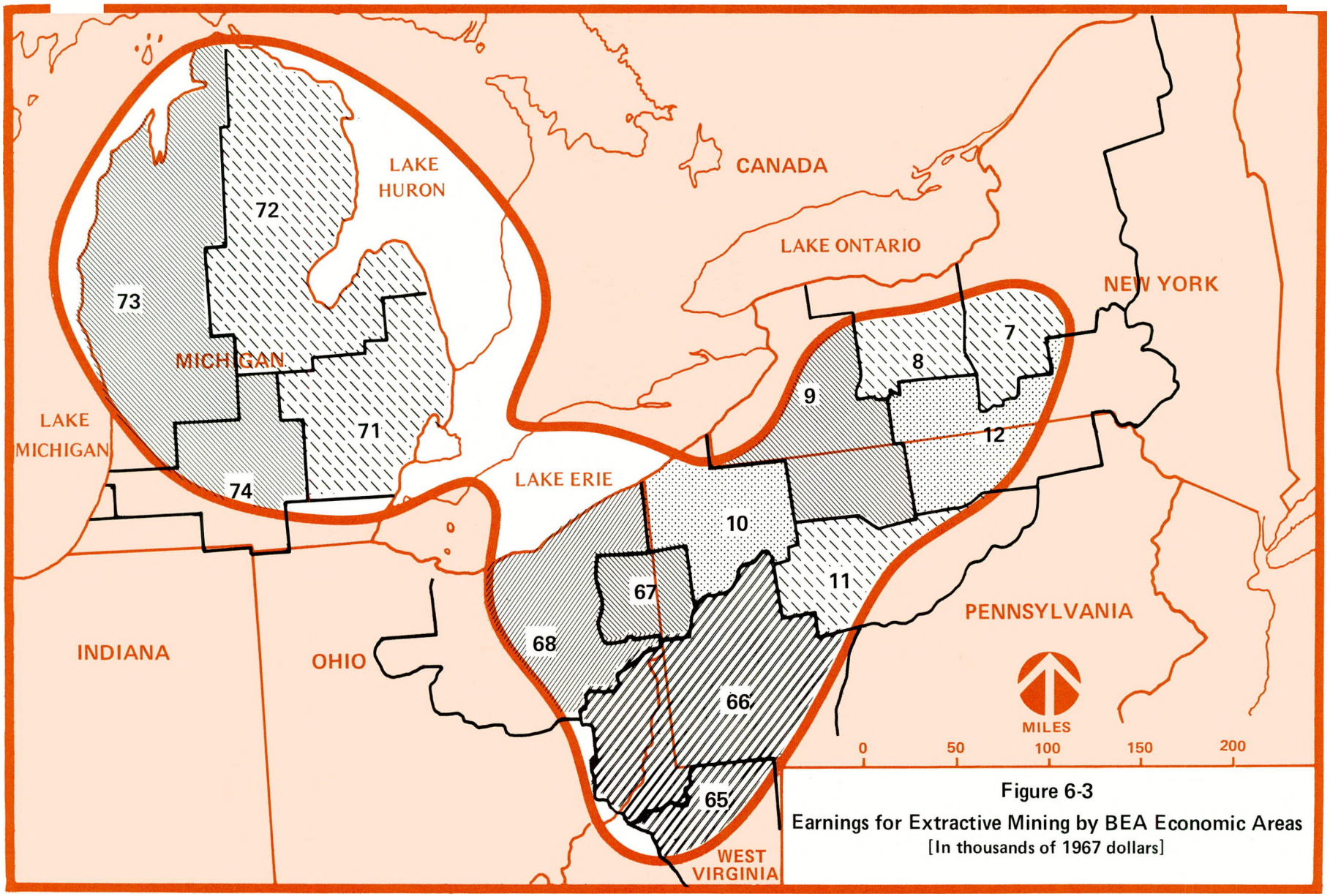


Figure 6-3

Earnings for Extractive Mining by BEA Economic Areas

[In thousands of 1967 dollars]

NOTE: See Table 6-3 for identification of BEA Economic Areas.

- UNDER $5,000
- $5,000-$15,000
- $15,000-$40,000
- $50,000-$100,000
- OVER $100,000

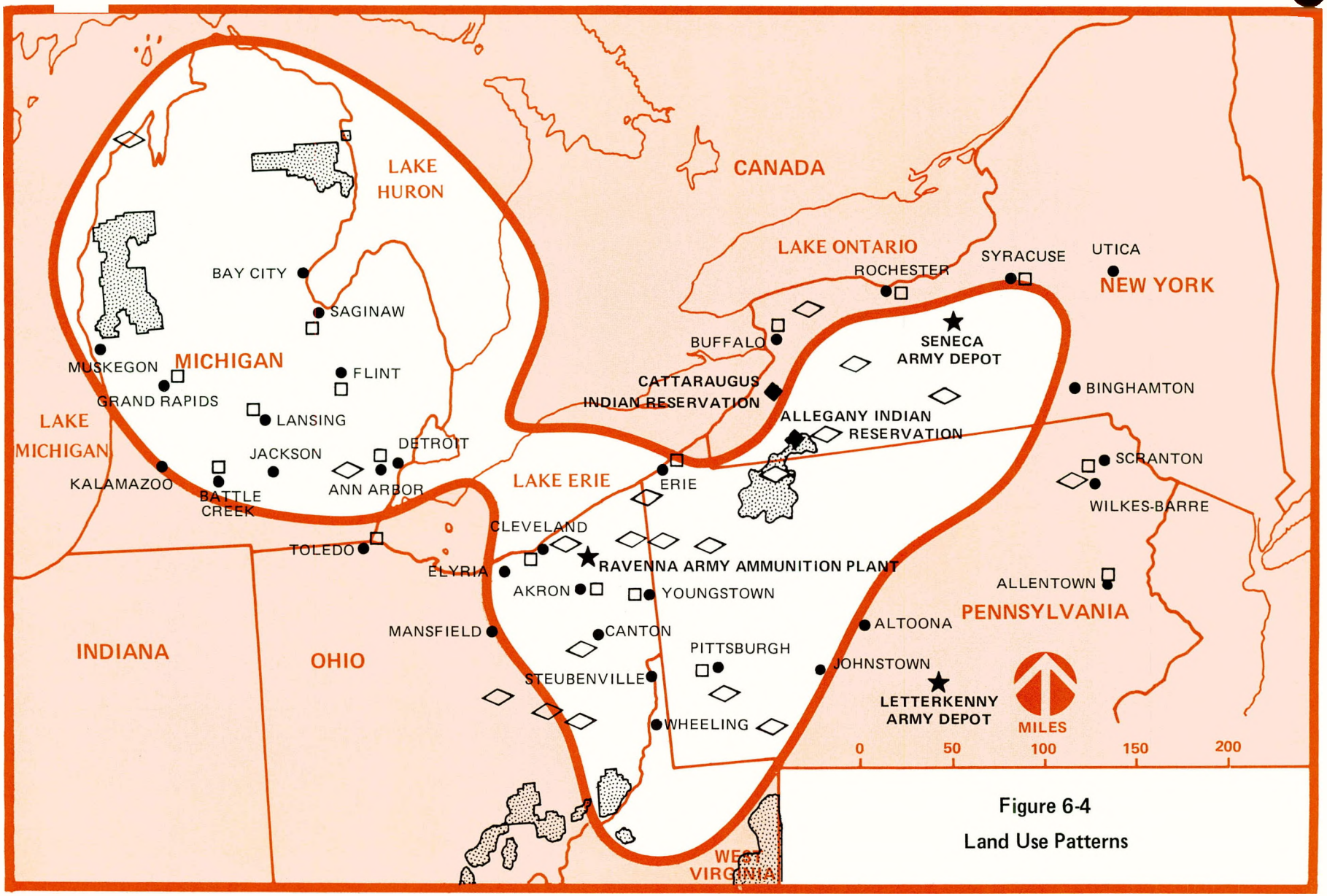


Figure 6-4

Land Use Patterns

- URBAN PLACES
- MILITARY BASES
- INDIAN RESERVATIONS
- AIRPORTS (MAJOR AIR TRAFFIC HUBS)
- RECREATIONAL & NATURAL AREAS
- NATIONAL/STATE FORESTS

NOTE: Only subject areas larger than 10,000 acres are shown.

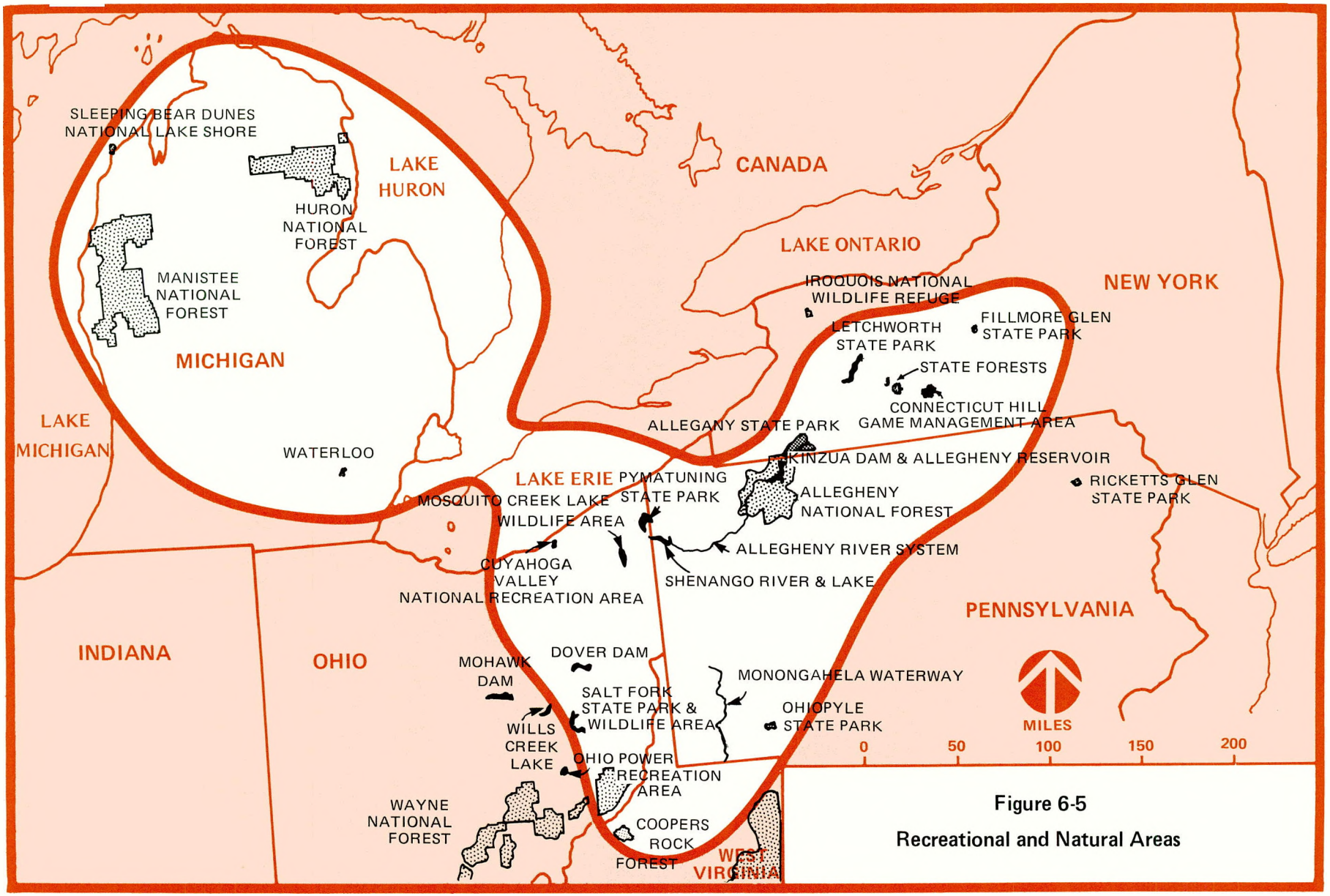


Figure 6-5

Recreational and Natural Areas

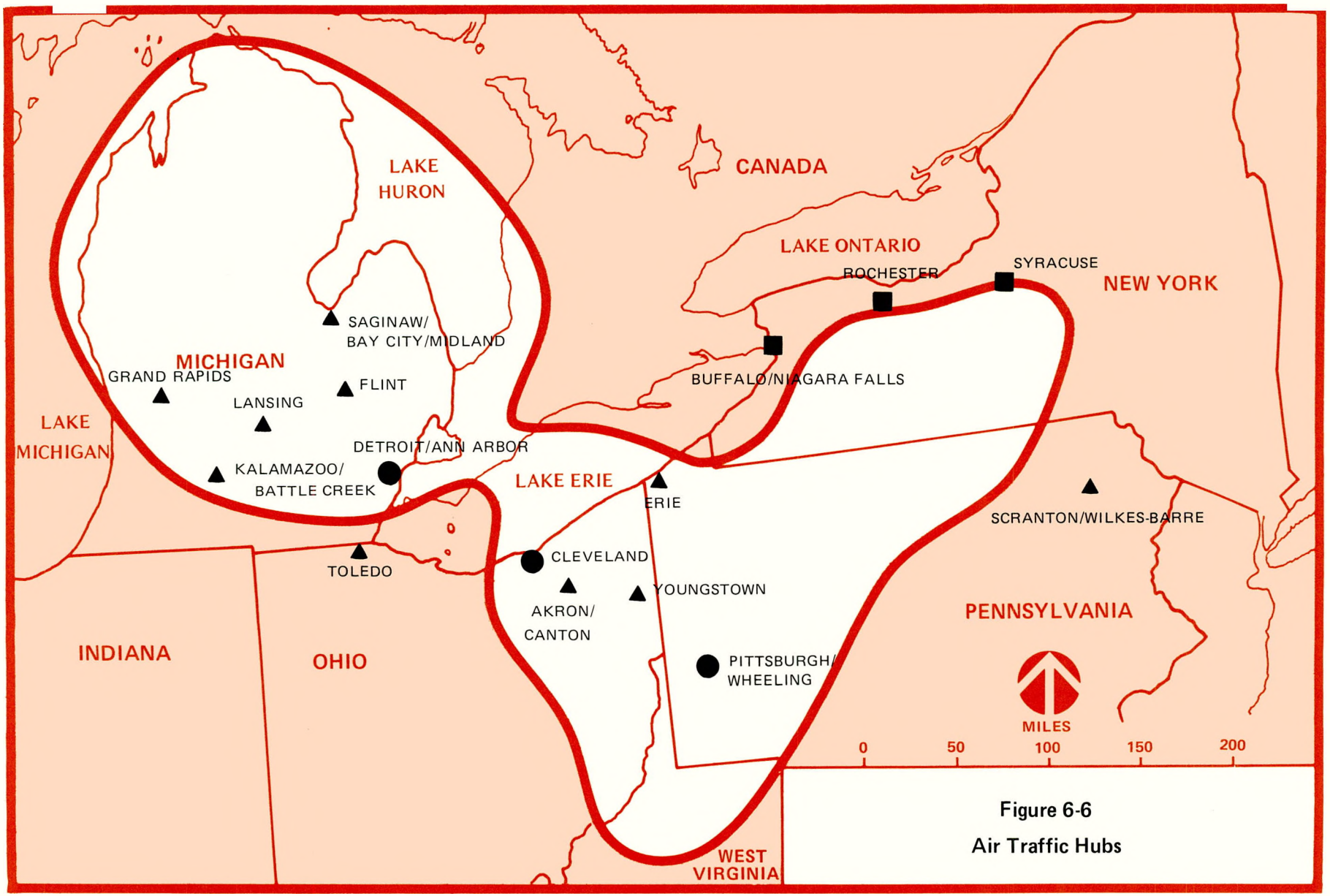


Figure 6-6

Air Traffic Hubs

- LARGE HUBS
- MEDIUM HUBS
- SMALL HUBS

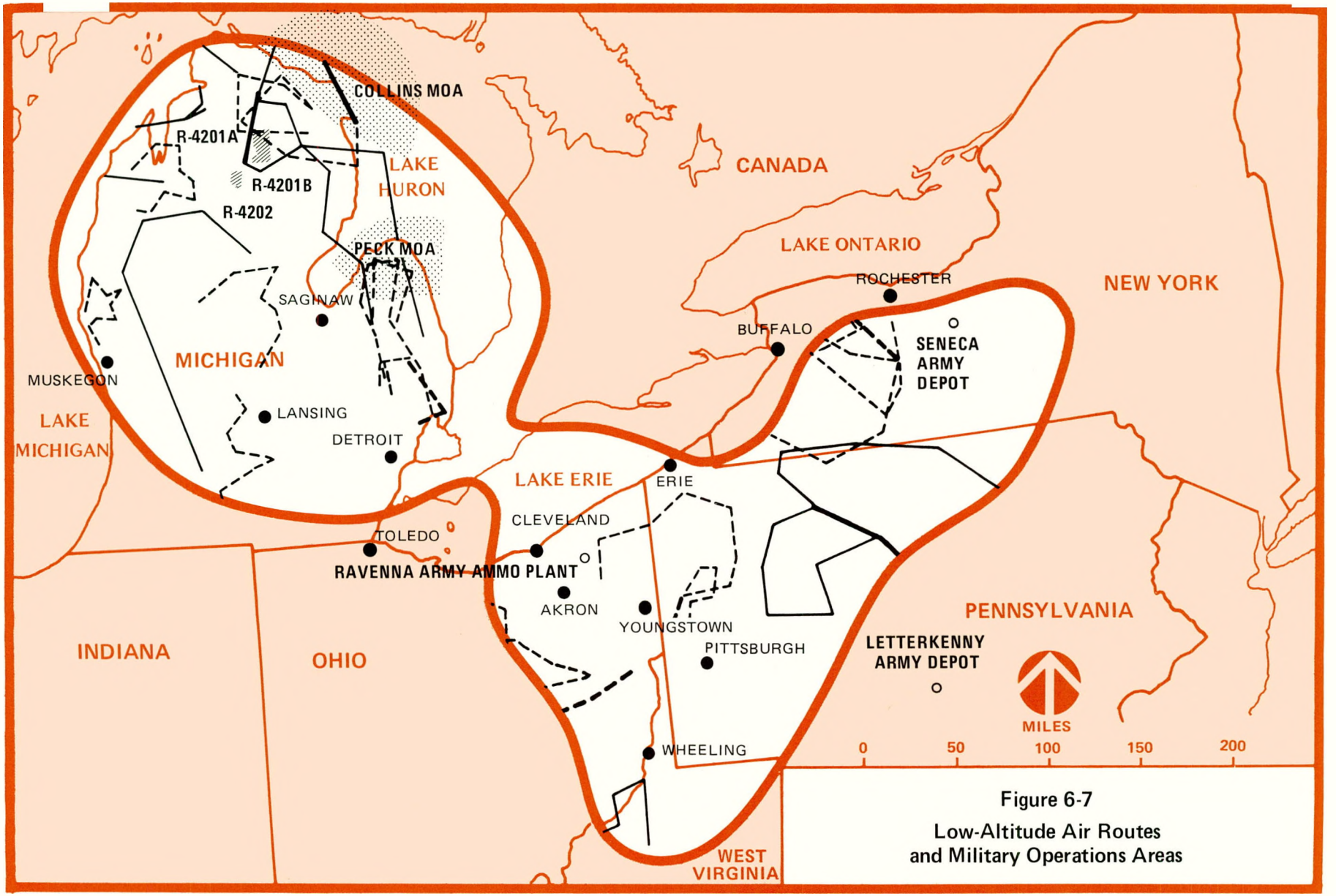


Figure 6-7
Low-Altitude Air Routes
and Military Operations Areas

HIGH-SPEED (>250 KNOTS) LOW-ALTITUDE AIR ROUTES

LOW-SPEED (<250 KNOTS) LOW-ALTITUDE AIR ROUTES

MOA'S (MILITARY OPERATIONS AREAS)

PROHIBITED, RESTRICTED, WARNING , AND ALERT AREAS

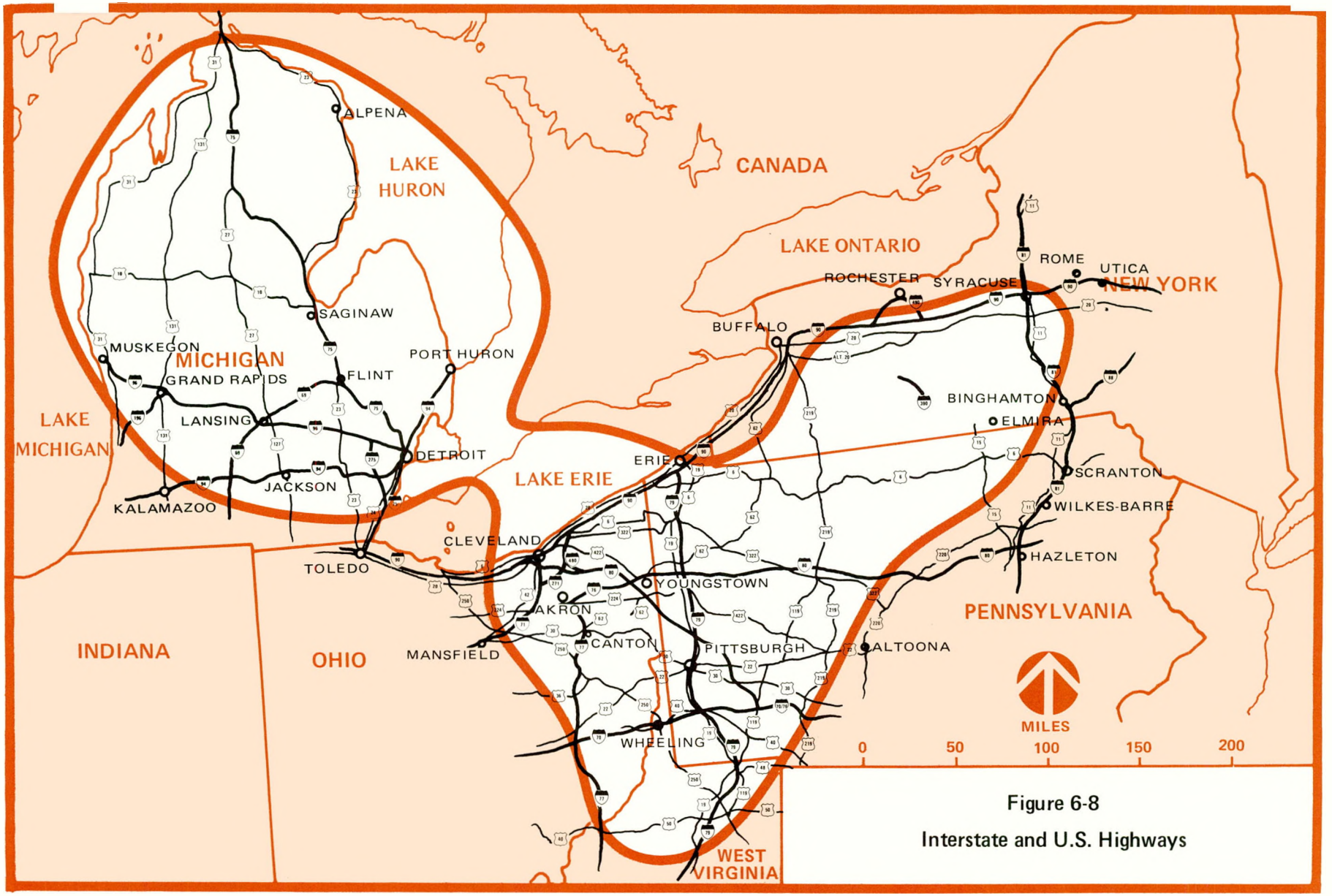


Figure 6-8

Interstate and U.S. Highways

Interstate Highways

U.S. Highways

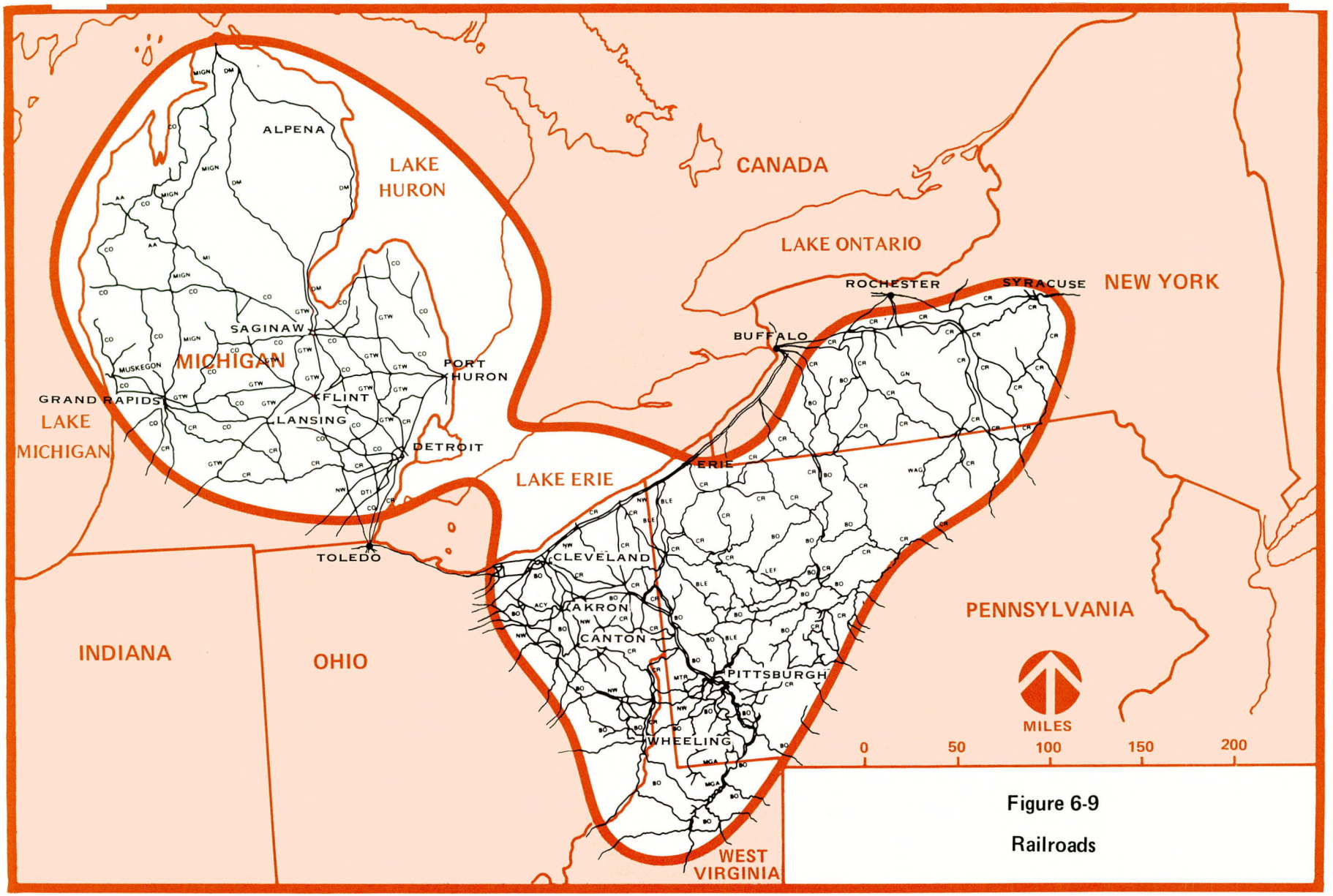


Figure 6-9

Railroads

AA	Ann Arbor	CR	Consolidated Rail Corp. (Conrail)	MGA	Monongahela
ACY	*Akron, Canton & Youngstown*	DM	*Detroit & Mackinac*	MIGN	*Michigan Northern*
BLE	Bessemer & Lake Erie	DTI	Detroit, Toledo & Irontown	MTR	Montour
BO	Baltimore & Ohio	GTW	Grand Trunk Western	NW	Norfolk & Western
CO	Chesapeake & Ohio	LEF	Lake Erie, Franklin & Clarion	WAG	Wellsville, Addison & Galeton

NOTE: See Table 6-12 for names of all railroads.

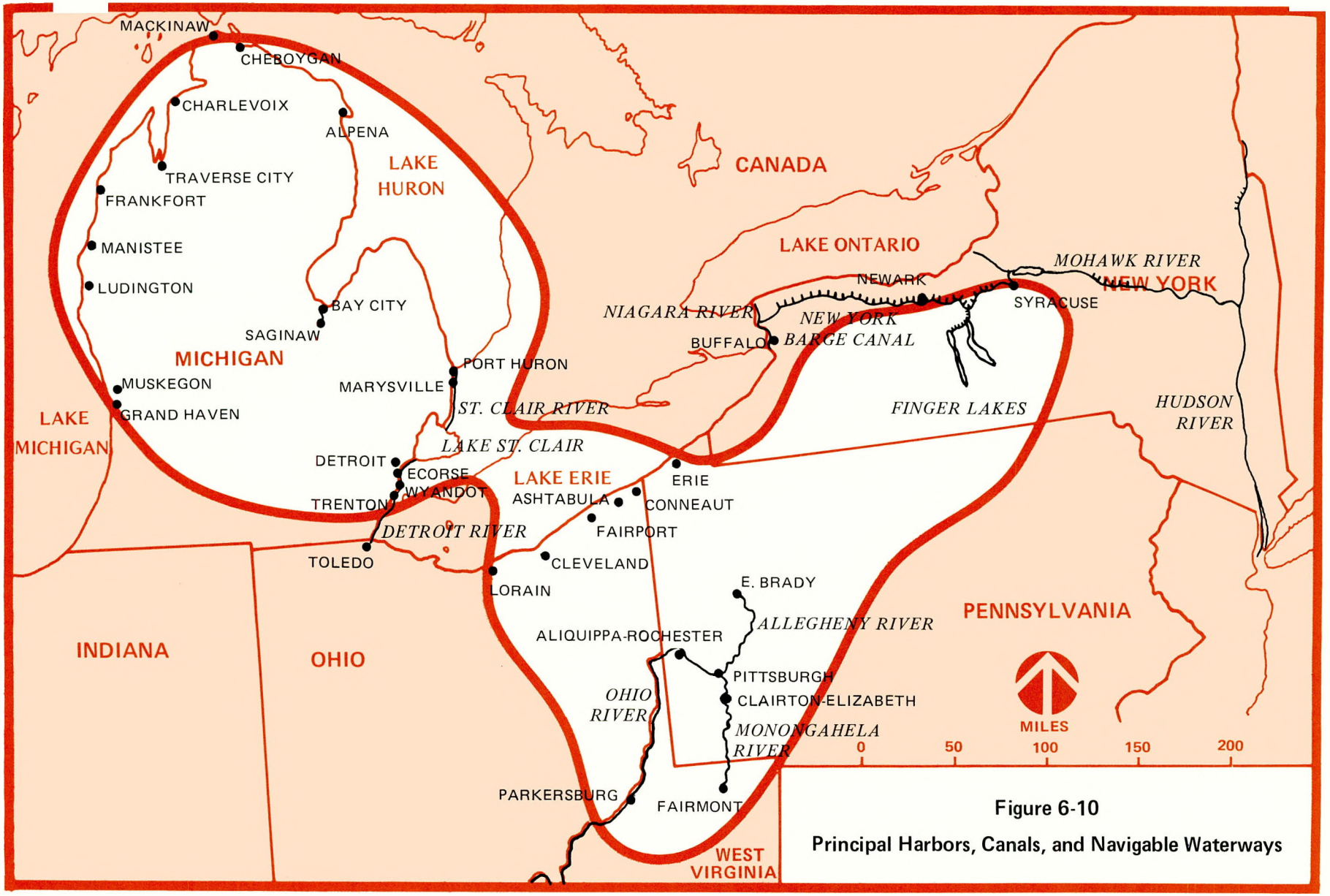


Figure 6-10

Principal Harbors, Canals, and Navigable Waterways

7.0 TERRESTRIAL ECOSYSTEMS

Natural ecosystem components include the indigenous vegetation as influenced by climate, soil, and topographic features, and the fauna associated with various habitat types. Many natural terrestrial systems are important to man as watersheds, as areas for consumptive and nonconsumptive wildlife uses, and as areas to be used for recreation, education, and research purposes. Certain natural habitats are valuable or "critical" ecological areas. The loss of all or part of these important natural features could affect the preservation, production, use, or diversity of existing natural systems. Such a loss of ecological resources could be caused directly by habitat preemption or indirectly by habitat modification caused by the construction or operation of a repository.

For purposes of general description, impact assessment, and natural resource management, natural systems can be classified into units. Natural systems have been categorized into "ecoregions" and into potential natural vegetation types. An ecoregion can be described by its distinctive flora, fauna, climate, land-form, soil, and land-use types; such descriptions provide an overview of the terrestrial biosphere within an area.

Ecoregions and vegetation types are units that have definable biological potential and thus provide a basis for natural resource management considerations. Within a given ecoregion, generalized assessments can also be made of the potential impact of a proposed project on present and future biological characteristics.

Items to be addressed in describing natural systems include:

- Regional vegetation types
- Important timber resources
- Important vegetation features
- Regional fauna and habitat types
- Threatened or endangered fauna and critical habitats.

The construction and operation of a repository in the Salina Region would have some impact on terrestrial ecological resources. Adverse terrestrial impacts would generally be limited to the actual site of the repository and the immediate environs (e.g., loss of terrestrial habitat due to the construction of the repository). The extent of terrestrial impact will depend primarily on the specific location that is chosen. Assessment of the potential impacts of a repository will require detailed studies of terrestrial resources at and near the chosen location. These detailed studies will provide baseline data for the location. A comparison of these baseline conditions with regional characteristics will then provide the basis for determining the relative importance of terrestrial resources at the location and thereby the degree of impact related to the repository.

In this regional report, the ecological information provides a descriptive overview of the important ecological resources in the Salina Region. The information presented is quite general because the Salina Region covers some 80,000 square miles (excluding the Great Lakes and Canada) and includes a variety of soil, topographic, and land-use patterns. About 87% of the Region is classified as forestland (44%) and agricultural land (cropland 31%, pastureland 6%, other rural land 6%); therefore both natural and agricultural systems are included in the discussion of terrestrial ecosystems. Soils, natural vegetation, and wildlife communities are the major categories included under natural systems. Major crops, livestock, and patterns of agricultural activity are discussed in the section on agricultural systems.

For purposes of environmental impact assessment, some terrestrial species are considered to be more "important" than others. The U.S. Nuclear Regulatory Commission (NRC, 1976) defines important species as follows:

a. The species is commercially or recreationally valuable.

b. The species is threatened or endangered (as defined by the Secretaries of the Interior and Commerce).

c. The species affects the well-being of some important species within criterion a or b.

d. The species is critical to the structure and function of the ecological system or is a biological indicator of radionuclides in the environment.

Some states have also designated certain species as threatened or endangered. In response to these guidelines, this report includes sections devoted to important vegetation and wildlife in the Salina Region.

7.1 NATURAL SYSTEMS

7.1.1 SOIL RESOURCES

Soils within the Salina Region are divided into orders and suborders (SCS, 1967). The six orders and nine suborders in the Region are shown in Figure 7-1 and are briefly described in Table 7-1. Three of the six soil orders constitute 92% of the soils in the Region: Inceptisols (42%), Alfisols (30%), and Spodosols (20%). Most of the Inceptisols occur from southeastern Ohio and adjacent West Virginia to western New York. The major crops grown on these soils are silage corn, small grains, and hay. Major areas with Alfisols are southern lower Michigan and northern Ohio. These soils are used as cropland and pastureland; principal crops are row crops and small grains. All Spodosols in the Region occur in northern lower Michigan. These soils are used for woodland, hay, pasture, fruit, and some potatoes and truck crops. The agriculture of the Region is discussed in more detail in Section 7.2.

7.1.2 NATURAL VEGETATION

The description of vegetation in the Salina Region is based primarily on Bailey's (1976) system of classification (see Figure 7-2 and Table 7-2). This hierarchical system consists of four levels:

- Domain, defined by subcontinental areas of related climates
- Division, defined by regional climate
- Province, defined by broad vegetation types
- Section, defined by climax or potential vegetation.

Portions of four of Bailey's sections occur within the Salina Region. The major vegetation patterns for each of these sections are discussed in this section.

Potential vegetation types (Küchler, 1975) represent theoretical climax vegetation (i.e., vegetation that originally occupied the area or vegetation that would be dominant if the land were allowed to revert to forest). However, less than 50% of the Region is

TABLE 7-1

PRINCIPAL SOILS OF THE SALINA REGION[a]

Order and Suborder	Description	Occurrence in Salina Region[b] (% of area)	Contribution by State (%)				
			MI	NY	OH	P	WV
ALFISOLS	Soils that are medium to high in bases (base saturation at pH 8.2) and have gray to brown surface horizons and subsurface horizons of clay accumulation; usually moist, but during the warm season of the year some are dry part of the time.						
Aqualfs (A2)	Seasonally wet Alfisols that have mottles, iron-manganese concretions, or gray colors; used for general crops where drained and for pasture and woodland where undrained.	2	2	0	0	0	0
Boralfs (A5)	Alfisols of cool to cold regions; used for woodland, pasture, and some small grains.	1	1	0	0	0	0
Udalfs (A6, A7)	Alfisols in temperate to tropical regions. Soils usually moist but during the warm season of the year may be intermittently dry in some horizons for short periods; used for row crops, small grains, and pasture.	27	14	5	7	1	0
Total		30	17	5	7	1	0

TABLE 7-1 (Continued)

Order and Suborder	Description	Occurrence in Salina Region[b] (% of area)	Contribution by State (%) MI	NY	OH	PA	WV
ENTISOLS	Soils that have no pedogenic horizons.						
Aquents (E1)	Entisols that are either permanently or seasonally wet and have mottles or gray colors; limited use for pasture.	1	1	0	0	0	0
Psamments (E12)	Entisols that have textures of loamy fine sand or coarser; used for woodland and small grains where warm and moist, and range and irrigated crops where warm and dry.	<1	<1	0	0	0	0
Total		1	1	0	0	0	0
HISTOSOLS (H1)	Wet organic (peat and muck) soils; include soils in which the decomposition of plant residues ranges from highly decomposed to not decomposed; formed in swamps and marshes; used mostly for woodland or lie idle, but some drained areas have truck crops.	1	1	0	0	0	0
Total		1	1	0	0	0	0

TABLE 7-1 (Continued)

Order and Suborder	Description	Occurrence in Salina Region[b] (% of area)	Contribution by State (%) MI	NY	OH	PA	WV
INCEPTISOLS	Soils that have weakly differentiated horizons; materials in soil have been altered or removed but have not accumulated. These soils are usually moist, but during the warm season of the year some are dry part of the time.						
Aquepts (I5)	Seasonally wet Inceptisols that have an organic surface horizon, sodium saturation, mottles or gray colors; used for pasture and hay.	5	5	0	0	0	0
Ochrepts (I8,I10)	Inceptisols that have formed in materials with crystalline clay minerals, have light-colored surface horizons, and have altered subsurface horizons that have lost mineral materials; used for pasture, silage corn, small grains, and hay.	37	0	8	6	18	5
Total		42	5	8	6	18	5

TABLE 7-1 (Continued)

Order and Suborder	Description	Occurrence in Salina Region[b] (% of area)	Contribution by State (%)				
			MI	NY	OH	PA	WV
SPODOSOLS	Soils with low base supply that have an accumulation of amorphous materials consisting of organic matter plus compounds of aluminum and usually iron in subsurface horizons; formed in acid, mainly coarse-textured materials in humid and mostly cool or temperate climates.						
Orthods (S4)	Spodosols that have a horizon in which organic matter plus compounds of iron and aluminum have accumulated; used for woodland, hay, pasture, fruit, and, on gently sloping areas, for potatoes and truck crops.	20	20	0	0	0	0
Total		20	20	0	0	0	0

TABLE 7-1 (Continued)

Order and Suborder	Description	Occurrence in Salina Region[b] (% of area)	Contribution by State (%) MI	NY	OH	PA	WV
ULTISOLS	Soils that are low in bases and have subsurface horizons of clay accumulation; usually moist, but during the warm season of the year, some are dry part of the time.						
Udults (U5)	Ultisols that are usually moist and that are relatively low in organic matter in the subsurface horizons; formed in humid climates that have short or no dry periods during the year; used for general farming, woodland, and pasture, and cotton and tobacco in some parts.	7	0	0	0	6	1
Total		7	0	0	0	6	1
TOTAL ALL ORDERS		101	44	13	13	25	6

a. Soil categories from SCS (1967); presentation of soils is alphabetical by order and suborder; symbols in parentheses correspond to mapping units in Figure 7-1.

b. Total area approximately 80,000 square miles (exclusive of Great Lakes and Canada).

TABLE 7-2

ECOREGIONS OF THE SALINA REGION

Ecoregion [a]	Occurrence in Salina Region[b] (%)	Contribution by State (%) MI	NY	OH	PA	WV
A. Warm Continental Division						
Laurentian Mixed Forest Province						
(2113) Northern Hardwoods Forest Section	51	28	13	<1	9	0
B. Hot Continental Division						
Eastern Deciduous Forest Province						
(2211) Mixed Mesophytic Forest Section	4	0	0	<1	<1	4
(2212) Beech-Maple Forest Section	23	16	0	5	2	0
(2214) Appalachian Oak Forest Section	22	0	0	7	14	1
Total	100	44	13	12	25	5

a. Adapted from Bailey (1976); numbers in parentheses correspond to mapping units in Figure 7-2; all categories shown are within Bailey's Humid Temperate Domain.

b. Total area approximately 80,000 square miles (exclusive of Great Lakes and Canada).

"forested," and it is not likely that a large portion of the nonforested area will be allowed to revert to forest in the near future.

Existing forests in the Salina Region are probably most accurately characterized by the U.S. Forest Service (USFS, 1967), although this classification is based primarily on economic factors (i.e., commercially valuable timber). The major existing forest types include oak-hickory (42%), maple-beech-birch (35%), and aspen-birch (9%). The discussion of major successional vegetation patterns in the Salina Region is based primarily on Braun (1950).

7.1.2.1 Northern Hardwoods Forest Section

Within the Salina Region, the northern half of lower Michigan, Pennsylvania, and nearly all of New York are in the Northern Hardwoods Forest Section (Figure 7-2 and Table 7-2). Potential vegetation in this section is primarily sugar maple-yellow birch-beech-hemlock (Figure 7-3 and Table 7-3). The major existing forest type is classified as maple-beech-birch (Figure 7-4 and Table 7-4). Potential climax vegetation also includes interspersed coniferous forest communities dominated by white pine in northern Michigan and by hemlock and white pine in northwestern Pennsylvania and adjacent New York. Most of the climax vegetation in the Northern Hardwoods Forest Section has been cut, farmed, burned, or otherwise disturbed and transformed into several major secondary or successional forest types (Braun, 1950). In northern lower Michigan, jack pine plains and open aspen stands are prevalent on dry soils. Bogs and muskegs, dominated by black spruce, larch, and arborvitae, are interspersed in poorly drained areas.

In northern Pennsylvania and western New York, open stands of aspen and pin cherry are common in disturbed areas with dry soils (Braun, 1950). Sprout stands of sugar maple and beech are more common in logged-over areas that have not been severely burned than in burned areas (Braun, 1950). Near the southern portion of this hardwoods section, secondary oak or tuliptree (yellow poplar) stands are common.

7.1.2.2 Beech-Maple Forest Section

The potential dominant vegetation of southern lower Michigan and northeastern Ohio is beech-maple forest (Figure 7-3 and Table 7-3). In northeastern Ohio, the major forest type is maple-beech-birch, whereas in southern Michigan the oak-hickory type is dominant (Figure 7-4 and Table 7-4). This latter forest type is now dominant because most of the area classified as beech-maple forest has been cleared for farming (Braun, 1950). In southern Michigan, oak-hickory forests occur primarily on sandy or gravelly soils that are less than optimal for crop production. Other important natural forest types in this forest section include elm-ash-cottonwood forests in low-lying areas of moist soils and remnants of northern coniferous forest on poorly drained soils.

7.1.2.3 Appalachian Oak Forest Section

Southeastern Ohio, northern West Virginia, and most of western Pennsylvania are within the Appalachian Oak Forest Section (Figures 7-2 and 7-3; Tables 7-2 and 7-3). Most of this area has been designated as oak-hickory forest type (Figure 7-4 and Table 7-4). The original vegetation was probably best classified as Mixed Mesophytic Forest because a few remaining undisturbed woodlots and early land surveys indicated a relatively large number of dominants in the tree layer (Braun, 1950).

Existing forests in the Appalachian Oak Forest Section bear little resemblance to the original forest cover. Oak and hickory are common on upper slopes that have well-drained

TABLE 7-3

POTENTIAL NATURAL VEGETATION

Vegetation Type[a]	Dominants	Occurrence in Salina Region[b] (% of area)	Contribution by State (%) MI	NY	OH	PA	WV
Needleleaf Forests							
(94) Conifer Bog	Larch, black spruce, white cedar,	1	1	0	0	0	0
(95) Great Lakes Pine Forest	jack pine, red pine, white pine	12	12	0	0	0	0
Total Needleleaf Forests		13	13	0	0	0	0
Broadleaf Forests							
(100) Oak-Hickory Forest	Bitternut hickory, shagbark hickory, white oak, northern red oak, black oak	12	12	0	0	0	0
(101) Elm-Ash Forest	White ash, American elm	5	4	0	<1	0	0
(102) Beech-Maple Forest	Sugar maple, beech	12	4	1	6	1	0
(103) Mixed Mesophytic Forest	Sugar maple, buckeye, beech, tuliptree, white oak, basswood	4	0	0	1	1	3
(104) Appalachian Oak Forest	White oak, northern red oak	24	0	3	5	14	2
Total Broadleaf Forest		57	20	4	12	16	5
Broadleaf and Needleleaf Forest							
(106) Northern Hardwoods	Sugar maple, yellow birch, beech, hemlock	30	11	9	1	9	<1
TOTAL ALL TYPES		100	44	13	13	25	5

a. From Küchler (1975); numbers in parentheses correspond to mapping units in Figure 7-3; all types shown are within Küchler's Eastern Forests category.

b. Total area approximately 80,000 square miles (exclusive of Great Lakes and Canada).

TABLE 7-4

FOREST TYPES OF THE SALINA REGION

	Forest Type[a]	Occurrence in Salina Region[b] (% of area)	Contribution by State (%) MI	NY	OH	PA	WV
(1)	White-red-jack pine	2	2	<1	0	0	0
(2)	Spruce-fir	<1	<1	0	0	0	0
(4)	Loblolly-shortleaf pine	<1	0	0	0	0	<1
(6)	Oak-hickory	42	14	3	5	15	4
(8)	Elm-ash-cotton-wood	5	3	1	1	<1	0
(9)	Maple-beech-birch	35	11	9	5	10	0
(10)	Aspen-birch	9	9	0	0	0	0
(N)	Nonforest	7	5	0	2	<1	1
	Total	100	44	13	13	25	5

a. Area of forest types calculated from USFS (1967); symbols in parentheses correspond to mapping units in Figure 7-4; all types shown are within USFS' Eastern Forest category.

b. Total area approximately 80,000 square miles (exclusive of Great Lakes and Canada).

soils. Scrub pine communities commonly occur on dry disturbed slopes, and much of the bottomland is being used for agriculture (Braun, 1950). Forest communities on more mesic, less disturbed slopes are dominated by maple, beech, and oak.

7.1.2.4 Mixed Mesophytic Forest Section

The extreme southwestern portion of Pennsylvania and the northern West Virginia Panhandle are in the Mixed Mesophytic Forest Section (Figures 7-2 and 7-3; Tables 7-2 and 7-3). The tree layer in the original climax forests of this forest section was dominated by a relatively large number of species, including maple, buckeye, beech, tuliptree, oak, and basswood. As a result of logging and other disturbances, existing secondary forests are dominated by oak-hickory forest types (Figure 7-4 and Table 7-4). These two dominants are particularly common on upper slopes, ridges, and low hills (Braun, 1950). Maple, tuliptree, and beech are more common on lower slopes and in coves. Farming is mainly concentrated in bottomlands, and riparian forest communities are almost totally absent.

7.1.3 IMPORTANT VEGETATION

Important natural vegetation includes timber resources, wetlands, natural areas, threatened or endangered plant species, and especially valuable wildlife habitats. Timber resources are important because they are commercially valuable and relatively widespread in the Salina Region; other vegetation features discussed here are important because they are relatively rare in the Region.

7.1.3.1 Timber Resources

About 44% of the Salina Region is classified as commercial forest (Table 7-5). Commercial forestland produces, or is capable of producing, crops of merchantable wood (usually sawtimber). Michigan and Pennsylvania contain the largest amount of commercial forestland in the Region. Important forest products include sawlogs, pulpwood, industrial wood (i.e., handle stock, particle board), and veneer. Other products include fuel wood, fence posts, and mine timber. The majority (89%) of the commercial forestland in the Region is in hardwoods. Major commercially valuable hardwoods in the Region are oak-hickory (31%), maple-beech-birch (23%), elm-ash-red maple (17%), and aspen-birch (15%). About 30% of the commercial forestland is classified as sawtimber (Table 7-5).

7.1.3.2 Wetlands

Approximately 2% of the Salina Region is classified as wetlands having some importance to waterfowl (Table 7-6). Wetlands are defined as areas where the water table is near, at, or above the surface of the ground for some portion of the year (Goodwin and Niering, 1975). Areas considered as wetlands include seasonally flooded areas (e.g., river flood plains), marshes, swamps, bogs, riparian areas, and wet meadows.

Some of the better known wetlands that are characteristic of this habitat type in the Salina Region have been identified (Figure 7-5 and Table 7-7). These 28 areas are representative of wetlands within the Region, but not all wetlands in the Region are included in this discussion. Six of these areas, covering about 23,200 acres, occur in Michigan (Table 7-7); wooded swamps, bogs, and fresh marshes are included. None of these areas has been designated as a Registered Natural Landmark, although four areas have been proposed for such a designation. The National Registry of Natural Landmarks is a voluntary public service program administered by the National Park Service (Goodwin

TABLE 7-5

SELECTED FOREST STATISTICS FOR THE SALINA REGION

	Occurrence in Salina Region[a] (% of area)	Contribution by State (%)				
		MI[b]	NY[c]	OH[d]	PA[e]	WV[f]
Commercial forestland	44	18	7	5	11	3
Major forest types (percent of commercial forestland)						
Softwoods (total)	(11)	(6)	(2)	(<1)	(2)	(1)
White pine	2	-	-	-	2	<1
White pine-red pine-hemlock	3	3	-	<1	-	-
Spruce-fir	3	3	-	<1	-	-
Virginia-pitch pine	<1	-	-	<1	<1	-
Loblolly-shortleaf pine	1	-	-	-	-	1
Hardwoods (total)	(89)	(32)	(14)	(10)	(26)	(7)
Oak-pine	2	-	1	1	<1	-
Oak-hickory	31	9	-	4	14	4
Oak-gum	1	-	-	<1	1	-
Maple-beech-birch	23	7	8	2	5	1
Elm-ash-red maple	17	5	4	3	4	1
Aspen-birch	15	10	1	<1	4	-
Stand size class						
Sawtimber	30	9	4	3	11	3
Poletimber	31	19	3	1	7	1
Seedling/sapling	34	13	8	6	5	2
Nonstocked	5	2	2	<1	1	<1
Ownership						
Public	18	13	1	<1	4	<1
Private	82	29	15	11	21	6

a. Total area approximately 80,000 square miles (exclusive of Great Lakes and Canada).

b. Forest statistics adapted from Chase et al. (1970).

c. Adapted from Ferguson (1970).

d. Adapted from Kingsley and Mayer (1970).

e. Adapted from Ferguson (1968).

f. Adapted from Ferguson (1964).

TABLE 7-6

IMPORTANCE OF WETLANDS IN THE SALINA REGION FOR WATERFOWL USE[a]

Importance Category	Total U.S. Acreage	Occurrence in Salina Region[b] (% of U.S. total)	Contribution by State (%)				
			MI	NY	OH	PA	WV
Primary importance	22,440,000	3	3	<1	<1	<1	0
Lesser importance	52,000,000	1	1	0	<1	<1	0
Total wetlands	74,440,000	2	2	<1	<1	<1	0

a. Adapted from Shaw and Fredine (1956).

b. Total area approximately 80,000 square miles (exclusive of Great Lakes and Canada).

TABLE 7-7

REPRESENTATIVE WETLANDS OF THE SALINA REGION[a]

Area Identification[b]		Approximate Extent (acres)	Habitat Type
		MICHIGAN	
(1)	Celeron Island[c]	500-600	Shallow to deep fresh marsh
(2)	Dead Stream Preserve[c]	1,600	Bog
(3)	Dead Stream Swamp[c]	20,000	Wooded swamp, bog
(4)	Proud Lake Bog	100	Bog
(5)	Tobico Marsh[c]	1,000	Fresh marsh, open water, shrub and wooded swamp
(6)	Waterloo Black Spruce Bog	40	Bog
		NEW YORK	
(7)	McLean Swamps and Bogs	2,500	Wooded swamp, bog
(8)	Montezuma Marshes[c]	6,400	Shallow to deep fresh marsh and wooded swamp
(9)	Moss Lake Bog	84	Bog
(10)	Seneca Lake Marsh	500	Shallow to deep fresh marsh
		OHIO	
(11)	Brown's Lake Bog[c]	80	Bog
(12)	Frame Glacial Bog	80	Bog
(13)	Lake Abrams	200-300	Shallow fresh marsh, wooded swamp
(14)	Mantua Swamp[c]	800	Shallow fresh marsh, wooded swamp, bog
(15)	Mentor Marsh[c]	500	Shallow fresh marsh
(16)	Still Fork Swamp[c]	600	Shallow fresh marsh, shrub swamp
(17)	Watercress Marsh[c]	100	Shallow fresh marsh, shrub swamp
		PENNSYLVANIA	
(18)	Boleratz Bog	30	Bog
(19)	Hartstown Bog[c]	3,000	Wooded swamp, bog
(20)	Mercer Bog[c]	50	Bog
(21)	Otter Creek Swamp	350	Wooded swamp, bog
(22)	Pine Swamp[c]	700	Bog
(23)	Plain Grove Bog	Undetermined	Shallow fresh marsh, bog
(24)	Reynolds Spring[c]	100	Bog

TABLE 7-7 (Continued)

Area Identification[b]		Approximate Extent (acres)	Habitat Type
		PENNSYLVANIA (continued)	
(25)	Schollards Run	1,000	Shallow fresh marsh, open fresh water, shrub swamp
(26)	Titus Bog	89	Bog
(27)	Wattsburg Bog	25	Bog
		WEST VIRGINIA	
(28)	Cranesville Swamp Nature Sanctuary[c]	560	Bog

a. Adapted from Goodwin and Niering (1975).

b. Numbers in parentheses correspond to area locations in Figure 7-5.

c. Wetlands of present or potential Registered Natural Landmark status.

and Niering, 1975). There is no legislative authority under this program, but selected areas receive special recognition.

Four of the 28 wetland areas are in New York and cover approximately 9500 acres. Types of wetlands include wooded swamps, bogs, and fresh marshes. None of these areas has been designated as a Registered Natural Landmark, although the Montezuma Marshes have been proposed for this designation.

Seven of the 28 wetland areas are in Ohio; they cover about 2400 acres. Types of wetlands include shrubby and wooded swamps, fresh marshes, and bogs. Two of the wetlands, Brown's Lake Bog and Mentor Marsh, are Registered Natural Landmarks, and three other areas have been proposed for this designation.

Ten of the 28 wetland areas are in Pennsylvania (Table 7-7). These areas cover more than 5300 acres. Types of wetlands include bogs, shrubby and wooded swamps, fresh marshes, and open fresh water. None of the areas has been designated as a Registered Natural Landmark, although four of the areas have been proposed for this designation.

One wetland area (a bog) is in West Virginia. It covers about 560 acres and has been designated as a Registered Natural Landmark.

The Salina Region contains five National Wildlife Refuges (NWRs) in "wetland" areas covering some 24,000 acres (FWS, 1976a). Three of these are in Michigan: Michigan Islands (Alpena and Charlevoix Counties), Shiawassee (Saginaw County), and Wyandotte (Wayne County). The Shiawassee NWR covers about 8850 acres; the primary species are ducks and geese. Herons, gulls, and terns are the primary species on the 363-acre Michigan Islands NWR. The Wyandotte NWR includes about 31 acres; primary species are redhead, canvasback, and scaups. The Montezuma NWR, in Seneca County, New York, covers about 6400 acres; geese, ducks, muskrats, and deer are the primary species. In Pennsylvania, the Erie NWR in Crawford County covers almost 8000 acres; ducks, geese, other waterbirds, and beaver are listed as the primary species (FWS, 1976a). The Cedar Point, Ottawa, and West Sister Island NWRs are located in Ohio, on the western end of Lake Erie; they are not within the Salina Region.

7.1.3.3 Natural Areas

Natural areas designated by the Society of American Foresters (SAF) are relatively undisturbed areas which are examples of typical or unique vegetation and associated biotic, edaphic, geologic, and aquatic features (Buckman and Quintus, 1972). These areas are set aside for scientific or educational purposes. There are ten SAF-designated natural areas in the Salina Region: two in New York, six in Ohio, and two in Pennsylvania (Figure 7-5 and Table 7-8). These natural areas are all examples of representative climax or subclimax forest vegetation in various portions of the Salina Region.

7.1.3.4 Threatened and Endangered Plants

Pursuant to the Endangered Species Act of 1973, a list of proposed threatened and endangered plant species was issued (FWS, 1976b). This list of approximately 1700 taxa includes 11 taxa from the five states in the Salina Region. Of the 11 taxa, only five are known to occur in the Region (Table 7-9). The Smithsonian Institution (1975) has published a preliminary list of threatened and endangered plants in the United States. This list includes 9 endangered and 35 threatened species from the five states that are in the Salina Region. The endangered species listed by the Smithsonian Institution, included

TABLE 7-8

SAF NATURAL AREAS IN THE SALINA REGION

Natural Area Identification[a]		Extent (acres)	Primary Forest Type(s)
		NEW YORK	
(A)	Beech-Maple Knoll	8	Beech-sugar maple
(B)	Swamp Woods	100	Black ash-American elm-red maple; white oak (swamp)
		OHIO	
(C)	Brown's Lake Bog	80	Black ash-American elm-red maple
(D)	Dysart Woods	43	White oak
(E)	Kimball Woods	50	Beech-sugar maple; silver maple-American elm
(F)	Mentor Marsh	775	Black ash-American elm-red maple
(G)	Sigrist Forest	30	White oak-red oak-hickory
(H)	Stebbin's Gulch	400	Sugar maple-beech-yellow birch
		PENNSYLVANIA	
(I)	Jacob Guy Natural Area	160	Sugar maple-beech-yellow birch
(J)	Tionesta Natural Area	2113	Hemlock

a. Natural areas designated by Society of American Foresters (Buckman and Quintus, 1972); letters in parentheses correspond to area locations in Figure 7-5.

TABLE 7-9

PROPOSED ENDANGERED PLANTS IN THE SALINA REGION

Scientific Name	Common Name	Status[a] MI	NY	OH	PA	WV
Orchidaceae - Orchid Family						
Isotria medeoloides	Small whorled pogonia	FSE	FSE		FSE	
Poaceae - Grass Family						
Calamagrostis perplexa	Reed grass		FSE			
Polygonaceae - Buckwheat Family						
Polygonum pensylvanicum var. *eglandulosum*	Pinkweed		FE			
Polypodiaceae - Fern Family						
Phyllitis scolopendrium var. *americana*	American hartstongue fern	FSE	FSE			
Ranunculaceae - Buttercup Family						
Aconitum noveboracense	Northern wild monkshood		FE	FE[b]		
Trollis laxus	Spreading globeflower	SE	FE	FSE	FSE	

a. Key: FE--proposed for the Federal list of endangered species (FWS, 1976b); FSE--proposed for the Federal list and included in the Smithsonian list; SE--Smithsonian list (Smithsonian Institution, 1975).

b. Proposed for the Federal list of endangered species but not listed for Ohio (FWS, 1976b); listed by the Ohio Natural Heritage Society (personal communication) as occurring in Summit County, Ohio.

on the FWS (1976b) list, and known to occur in the Salina Region are indicated in Table 7-9.

Isotria medeoloides (small whorled pogonia), an orchid, has been reported from about 13 states (FWS, 1976b) in the northeast and midwest, including Michigan, New York, and Pennsylvania. This species occurs locally in small colonies, generally in acid soils within dry woodlands. Calamagrostis perplexa (reed bentgrass) is known only from local populations near West Danby in Tompkins County, New York. It grows in rocky woodlands. Phyllitis scolopendrium var. americana (American hartstongue fern) is highly localized and has been reported from central New York (Onondaga and Madison Counties), Ontario (Gleason and Cronquist, 1963), and Michigan (Wagner et al., 1977). It is found in crevices, on cool slopes, or in limestone sink holes. Aconitum noveboracense (northern wild monkshood) occurs in local populations from southeastern New York to Wisconsin and Iowa. It grows in rich woods, in shaded ravines, and on damp slopes. Polygonum pensylvanicum var. eglandulosum (pinkweed) is endemic to northern Ohio (Fernald, 1970). It occurs along calcareous shorelines on islands in Lake Erie. Trollis laxus (spreading globeflower) is reported in the proposed Federal list (FWS, 1976b) as endangered in eight states in the northeast, including New York, Ohio, and Pennsylvania within the Salina Region. According to R. L. Stuckey of Ohio State University (personal communications, Fall 1977), T. laxus occurs in two Ohio counties (Stark and Columbiana) within the Salina Region, but the Ohio Natural Heritage Society (personal communication, December 13, 1977) has indicated that it probably no longer occurs in these two counties. This species grows in rich wet meadows, wet woods, and swamps.

In response to the Endangered Species Act of 1973 and in an effort to protect and conserve plants, various states have produced their own lists of endangered, threatened, or rare plants.

Michigan enacted its own Endangered Species Act in 1974 (Act No. 203, Public Acts of 1974) (Beaman, 1977). In response to this Act, a list of endangered, threatened, and rare vascular plants was prepared (Wagner et al., 1977). It includes 328 taxa: 16 endangered, 197 threatened, 90 rare, and 25 probably extinct. Only taxa considered to be in the "endangered" category have formal protection under Michigan law, as of December 2, 1976. In addition to this law, certain plants are protected in Michigan by legislation known as the "Christmas Tree Law" (Act 182, Public Acts of 1962) (Wagner et al., 1977). Plants protected under this law include all trees, shrubs, vines, and a number of herbaceous plants that are often overcollected because of their rarity, putative medicinal value, or attractive blossoms.

The State of New York has a list that contains over 35 taxa of protected native plants. Under the legislation protecting these plants, effective September 1, 1974, "no one may knowingly pick, pluck, sever, remove or carry away without the consent of the owner, any protected plant" (Environmental Conservation Law 9-1503). Most plants on this list are protected because they are often overcollected. A second list of plants, divided into two categories (rare plants and commercially vulnerable plants), will probably be available in 1978 (Dr. Stanley Smith, curator of Botany, New York State Museum and Science Service, personal communication, December 7, 1977). The State of New York does not currently have an official list of endangered or threatened plants that are protected under state law.

The Ohio Natural Heritage Society has assembled information (obtained primarily from the Ohio Biological Survey) concerning endangered and rare species in Ohio. Only species on the FWS (1976b) list are considered as endangered by the Ohio Biological Survey. No plants have official status under Ohio law as endangered or threatened. Ohio law prohibits the picking of plants on public lands, state forests, parks of all kinds, and

wildlife areas. On private lands, all plants are under the control of the landowner, and permission is required before picking (Ohio DNR, 1971).

The Pennsylvania Rare and Endangered Wild Plant Act of 1974 was established for the protection of rare and endangered wild plant species. Under this law, all plants in Pennsylvania are protected from collection on publicly owned land, and permission must be obtained to collect any plants on private land. No official state list of rare and endangered plant species has been developed.

No plants are currently protected by the State of West Virginia. A list of rare plant species is available (R. Fortney et al., 1978).

7.1.4 REGIONAL WILDLIFE

Land-use patterns in the Salina Region include forested areas, areas with interspersed forest and agricultural land, and pure agricultural land; urban and built-up areas are concentrated along Lake Erie (Detroit, Michigan; Toledo, Lorain, and Cleveland, Ohio; and Erie, Pennsylvania) and in the Pittsburgh, Pennsylvania; Youngstown, Ohio; and Wheeling, West Virginia, areas. The resulting complex mosaic of land-use patterns has a significant influence on the regional occurrence and abundance of wildlife. A substantial amount of "forest" and "farm" wildlife habitat is found in the Region. Ecotones (edges) between wooded and agricultural land, and early successional woodlands (shrubland) are especially important to wildlife in the Salina Region. Wetlands are relatively uncommon, but their high value as wildlife habitat and relative scarcity magnify the importance of the wetland areas that occur.

7.1.4.1 Mammals

The geographic ranges of about 65 species of mammals include some part of the Salina Region (Burt and Grossenheider, 1976). The major mammalian groups and the number of species of each group that may occur in the Region are as follows:

Major Group	Number of Species
Marsupials	1
Insectivores	10
Bats	12
Lagomorphs	4
Rodents	22
Carnivores	14
Even-toed ungulates	2

Twenty-three mammalian species are considered game species and/or furbearers in the Region. The Indiana myotis (bat) is the only mammal on the Federal endangered species list (FWS, 1977a) that is expected to occur in the Region; six additional species have state threatened or endangered status in the Region.

The diversity and abundance of mammals in the Salina Region are generally highest in areas where forest/woodland, agricultural land, and water/wetland are intermixed. The heterogeneous habitat types in such areas provide food and cover for many mammalian

species. Early successional woodlands in abandoned agricultural and logged areas are especially important to certain mammals. White-tailed deer are often most productive in mixed woodland-shrubland-agricultural land. Many species (e.g., carnivores, bats) feed in a variety of habitat types. Few mammals are restricted to a specific habitat type, although certain species are often more common in a given type or subtype. Typical "forest" mammals include red squirrels, red-backed voles, snowshoe hares, gray squirrels, flying squirrels, porcupines, bobcats, and black bears. The meadow vole, eastern cottontail, woodchuck, and fox squirrel are normally associated with interspersed hedgerows, woodlands, and agricultural land in the Salina Region. Typical "wetlands" mammals in the Region are beaver and muskrat. House mice and Norway rats are most common in or near human habitation.

Brief descriptions of each major group of mammals in the Salina Region are provided in this section. A more detailed discussion of important mammals is presented in Section 7.1.5.

The Virginia opossum is the only marsupial (pouched mammal) that occurs in the Region. This omnivore can be found in nearly all habitats.

Ten insectivores (seven shrews and three moles) may occur in the Region. All 10 species are widely distributed, with five occurring in every state in the Region. Shrews feed primarily on animal matter and are active both above and below the ground. The short-tailed shrew is one of the most common mammals in the Region. Shrews are seldom seen, even though they are extremely active. Moles spend most of their life below the ground. The presence of moles is often indicated by their characteristic runways.

At least 12 species of bats can be expected in the Salina Region. Some of the more common species are the little brown myotis, eastern pipistrelle, big brown bat, red bat, silver-haired bat, and hoary bat. Bats are widespread in the Region, but because they are active at night, their presence often goes undetected. Bats feed on a variety of flying insects and forage over many habitats, including ponds, streams, fields, forests, and urban areas. They rest during the day in caves, tunnels, trees, and buildings. One bat on the Federal endangered species list, the Indiana myotis, occurs in the Region.

Four lagomorphs (rabbits and hares) are found in the Region. The eastern cottontail is the most widespread and abundant lagomorph in the Region; it is generally associated with agricultural or shrub land. The snowshoe hare occurs in all Region states except Ohio but is most common in forested mountains of New York, Pennsylvania, and West Virginia and in the upper Lower Peninsula of Michigan. Another native species (New England cottontail) and an introduced lagomorph (European hare) have limited ranges in the Region.

More species of rodents (22) than of any other group of mammals are found in the Salina Region. Twelve species of "small" rodents occur; the white-footed mouse and meadow vole are two of the most common small mammals. White-footed mice are common in wooded and shrubby areas, while meadow voles are generally associated with grassy areas. Three introduced species, house mouse, black rat, and Norway rat, have become pests and are typically found near human habitation. Most of the other small mammals are either not common, are only locally abundant, or are restricted to specific habitat types within the Region. Several rodents (woodchuck, gray squirrel, fox squirrel, muskrat, and beaver) are considered game species or furbearers.

Thirteen carnivores may occur in the Salina Region; all are considered game species and/or furbearers in at least one of the five states in the Region. Raccoons and striped

skunks are common in all five states and are found in many habitats. Ermine, least weasel, long-tailed weasel, and mink occur in much of the Region, although their presence and abundance are difficult to determine because of their secretive habits. Red and gray foxes are important furbearers that occur throughout the Region. Black bear may occur in all five states but are typically found in remote, forested areas. The coyote is expanding its range eastward and may occur in all states in the Region. The bobcat and the river otter occur in the Region; neither is considered common.

Two-toed ungulates are represented in the Region by the white-tailed deer and elk. Small herds of elk are found in Pennsylvania and Michigan; they are not considered game species at present. White-tailed deer are common in many portions of the Region (especially in Pennsylvania and Michigan). Deer frequent wooded and agricultural areas and thrive where the two habitats are interspersed. White-tailed deer are a very important game species in the Region.

7.1.4.2 Birds

The avifauna of the Salina Region is generally similar to that found in other temperate regions of eastern North America. Several studies suggest that about 400 avian species have recently been observed in the Region. For example, in New York State, 402 species have been collected, and authentic sight records for eight others have been reported (Bull, 1974). Of these 410 species, 228 (56%) were known to nest in the state. Approximately 70 species regularly winter in the Region; the number of wintering species is somewhat greater in the eastern portions of the Region because of a coastal influence (Tramer, 1974). Important resident game birds include the ruffed grouse, bobwhite, ring-necked pheasant, and turkey. Migratory game birds that are hunted in the Region include waterfowl (ducks and geese), the American woodcock, and the mourning dove. Two species on the Federal endangered list, Kirtland's warbler and the peregrine falcon, regularly occur in the Region; the former species nests only in Michigan. The southern bald eagle is also on the Federal endangered species list (FWS, 1977a) and may occasionally wander into the Region. Thirteen additional species of birds are designated as threatened or endangered in at least one state in the Region.

A brief discussion of avian species and their habitats in the Salina Region is provided in this section. More detailed information on important birds is presented in Section 7.1.5.

Avian species typical of coniferous forests are poorly represented in the Salina Region. Boreal species such as the rough-legged hawk, boreal chickadee, and several fringillids (grosbeaks, finches, and sparrows) invade parts of the Region in winter (Boch and Lepthien, 1976).

The families, and occasionally genera, of birds inhabiting deciduous forests are often remarkably similar in different forest types. A "typical" deciduous woodland in the Region might have eight or nine representative species of wood warblers, four woodpeckers, three chickadees and titmice, three flycatchers, two thrushes, two vireos, and one or two tanagers (Kendeigh, 1944 and 1961). Kendeigh (1961) found that the most common birds in mature forests in northern Ohio were, in order of decreasing abundance, the ovenbird, red-eyed vireo, American redstart, wood thrush, and eastern wood peewee. An average of 220 breeding birds per 100 acres of relatively undisturbed forest has been reported (Kendeigh, 1944 and 1961; Ricklefs, 1972). It is well known, however, that the abundance of birds is greater near the margins of forested areas than in the interior.

Generally, the diversity of bird species is greater in open areas than in wooded areas (Kendeigh, 1944). Horned larks are often predominant in treeless areas; such areas are

also used for feeding by some swallows and soaring hawks (buteos). Two exotic species, the house sparrow and starling, are invariably among the most common birds in open country throughout the Salina Region. Other species become more typical in cleared areas that have been abandoned. Marsh hawks, for example, regularly feed over old fields. The red-winged blackbird is often the most common bird around heavily farmed areas. The fringillids, which are virtually absent from forested areas, are well represented in open areas in the Region. Two mimic thrushes, the brown thrasher and the gray catbird, are characteristically found along fencerows and hedgerows. Several upland game birds, especially the bobwhite and ring-necked pheasant, are closely associated with agriculture.

Many waterfowl visit the Salina Region during migration. Most occur on or near Lakes Erie and Huron.

Several typical southern species of birds have recently extended their ranges northward into the Salina Region (e.g., mockingbird, northern oriole, chuck-will's-widow, white-eyed vireo, blue-winged warbler, blue grosbeak). The appearance of these and other species as breeders north of the 40th parallel has not been adequately explained, but changing climate and the availability of food at backyard feeding stations may be among the factors involved (Tramer, 1974).

7.1.4.3 Reptiles and Amphibians

About 73 species of reptiles and amphibians inhabit the Salina Region (Conant, 1975). As many as 45 species could occur at a particular location if habitats are suitable. Amphibians are an important component of many regional ecosystems because they provide food for many other animals. Representative amphibians of the Region include the spotted salamander, red-backed salamander, red-spotted newt, American toad, spring peeper, green frog, northern leopard frog, and bullfrog.

Reptiles constitute a diverse, but relatively unimportant, part of the regional fauna. The black rat snake, racer, and milk snake are sometimes considered beneficial because they prey on rodents. Other typical reptiles in the Salina Region are the painted turtle, stinkpot, snapping turtle, northern water snake, eastern garter snake, and ringnecked snake. The timber rattlesnake is the only poisonous snake expected to occur in substantial numbers in the Region, although the copperhead and the massasauga are also present.

7.1.5 IMPORTANT WILDLIFE

For the purposes of this regional report, important wildlife includes commercially or recreationally valuable species and threatened or endangered species (Federal or state designation). Descriptions of species that affect the well-being of important species and those that might be considered critical to the structure and function of the ecosystem are not within the scope of the regional report. These concerns will be approached in the study-area report and addressed in some detail in the location report.

7.1.5.1 Commercially or Recreationally Valuable Wildlife

Hunting and trapping are both recreationally and commercially important. In 1975, 20.6 million Americans spent an average of $284 and 23.2 days each on hunting (FWS, 1977b).

Hunting is important in all states in the Salina Region; for example, more than one million hunting licenses are sold annually in Pennsylvania. Hunting can be divided into the

following categories: big game, small game, migratory birds, and other game (FWS, 1977b). Within the Salina Region, major species in each category are as follows:

- Big game: white-tailed deer, turkey
- Small game: eastern cottontail, gray and fox squirrels, ring-necked pheasant, bobwhite, and ruffed grouse
- Migratory birds: ducks, geese, mourning dove, and woodcock
- Other game: woodchuck, crow, fox, and raccoon.

The game mammals and game birds of the Salina Region are listed in Tables 7-10 and 7-11, respectively.

7.1.5.1.1 Big Game

White-tailed deer are common throughout the Salina Region. Populations are highest in forested portions (New York, northern Pennsylvania, northern Michigan) but are increasing rapidly in Ohio, West Virginia, and southern Pennsylvania (interspersed forest and agricultural land). Deer are hunted in every state in the Region. In 1970, about 100,000, 69,000, and 65,000 white-tailed deer were taken in Pennsylvania, Michigan, and New York, respectively; these figures ranked second, fifth, and sixth in the United States (FWS, 1971a).

Wild turkeys occur in all five states of the Region. Turkeys typically inhabit large tracts of forestland. Stocking programs (trapping and transplanting wild birds) are being used in an attempt to establish turkeys in suitable range in the Region (e.g., southwestern Pennsylvania, southeastern Ohio, West Virginia). Turkeys are an important game species in Pennsylvania and West Virginia. The highest turkey populations, and the greatest hunting effort, occur in northern Pennsylvania.

Within the Salina Region, black bears are most common in New York, Michigan, and northern Pennsylvania. Bear hunting is not a major recreational activity in the Region, although it may be locally important in some parts of Michigan and New York (there will be open season on bears in Pennsylvania on December 17, 1979).

7.1.5.1.2 Small Game

In terms of hunter effort and total numbers taken, rabbits (eastern cottontail) and squirrels (gray and fox) are the most important small game species in the Salina Region. Cottontails are typically associated with agricultural land and are most common in shrubby old fields, ravines, and hedgerows adjacent to grassy fields and cropland. Fox squirrels are characteristic of farm woodlots and lowland forests. Gray squirrels are most common in larger tracts of mature forest, especially where mature mast-producing trees (e.g., oaks, hickories, beech) are common.

The ring-necked pheasant and bobwhite are "farm-game" species (i.e., they normally inhabit agricultural land). The best pheasant range in the Salina Region is in northern Ohio and southern Michigan, and hunting pressure in these areas is heavy. Cock pheasants are stocked, on a put-and-take basis, in many other parts of the Region; natural reproduction is marginal in most of these areas. Bobwhites are popular game species where they occur in huntable numbers. They are probably most common in the southern Ohio portion of the Region.

TABLE 7-10

GAME MAMMALS OF THE SALINA REGION

Common Name[b]	Scientific Name[b]	Status[a] NY	OH	PA	WV	MI
Virginia opossum	Didelphis virginiana	F	G,F	F	G,F	-
Eastern cottontail	Sylvilagus floridanus	G	G	G	G	G
New England cottontail	Sylvilagus transitionalis	G	-	G	-	-
Snowshoe hare	Lepus americanus	G	-	G	G	G
Woodchuck	Marmota monax	-	G	G	G,F	G
Gray squirrel	Sciurus carolinensis	G	G	G	G	G
Fox squirrel	Sciurus niger	G	G	G	G	G
Beaver	Castor canadensis	F	F	F	F	F
Muskrat	Ondatra zibethicus	F	F	F	F	F
Coyote	Canis latrans	G,F	-	F	-	-
Red fox	Vulpes vulpes	G,F	G,F	F	F	-
Gray fox	Urocyon cinereoargenteus	G,F	G,F	F	F	-
Black bear	Ursus americanus	G	-	G[c]	G	G
Raccoon	Procyon lotor	G,F	G,F	G,F	G,F	G,F
Ermine	Mustela erminea	-	-	F	-	-
Least weasel	Mustela nivalis	-	G,F	F	G,F	-
Long-tailed weasel	Mustela frenata	-	G,F	F	G,F	-
Mink	Mustela vison	F	F	F	F	G,F
Badger	Taxidea taxus	F	F	-	-	F
Striped skunk	Mephitis mephitis	F	G,F	F	G,F	-
River otter	Lutra canadensis	F	-	-	-	F
Bobcat	Felis rufus	G,F	-	-	-	G,F
White-tailed deer	Odocoileus virginianus	G	G	G	G	G

a. Game status from 1977 hunting and trapping regulations for each state. F = furbearer; G = game species; dash (-) = no designation.

b. Nomenclature from Jones et al. (1975).

c. Season closed in 1977.

TABLE 7-11

GAME BIRDS OF THE SALI. IA REGION[a]

Common Name[b]	Scientific Name[b]	Status[c]
Canada goose	Branta canadensis	1
Snow goose	Chen caerulescens	1
Mallard	Anas platyrhynchos	1
Black duck	Anas rubripes	1
Gadwall	Anas strepera	1
Pintail	Anas acuta	1
Green-winged teal	Anas crecca	1
Blue-winged teal	Anas discors	1
American wigeon	Anas americana	1
Northern shoveler	Anas clypeata	1
Wood duck	Aix sponsa	1
Redhead	Aythya americana	1
Ring-necked duck	Aythya collaris	1
Canvasback	Aythya valisineria	1
Greater scaup	Aythya marila	1
Lesser scaup	Aythya affinis	1
Common goldeneye	Bucephala clangula	1
Bufflehead	Bucephala albeola	1
Ruffed grouse	Bonasa umbellus	2
Bobwhite	Colinus virginianus	2
Ring-necked pheasant	Phasianus colchicus	2
Chukar	Alectoris chukar	3
Gray partridge	Perdix perdix	4
Turkey	Meleagris gallopavo	2
Virginia rail	Rallus limicola	1
Sora	Porzana carolina	1
Common gallinule	Gallinula chloropus	1
American coot	Fulica americana	1
American woodcock	Philohela minor	1
Common snipe	Capella gallinago	1
Mourning dove	Zenaida macroura	1

a. Geographic ranges fom Bellrose (1976) and Johnsgard (1975).

b. Nomenclature after the American Ornithologists' Union (1957, 1973, and 1976).

c. Key: 1--Migratory species, hunting regulations controlled by the Federal Government; 2--permanent resident, occurs in all Region states; 3--introduced species, limited hunting in Ohio only; 4--introduced species, limited hunting in Ohio and New York only.

Ruffed grouse are "forest-game" species that occur in suitable habitats throughout the Region. Grouse require early successional forests to sustain high populations; the aspen-birch cover type is especially valuable. Within the Region, grouse are most abundant in New York, northern Michigan, and Pennsylvania, but grouse hunting is popular in all five states.

7.1.5.1.3 Migratory Birds

Migratory birds that are hunted in the Salina Region include waterfowl (ducks and geese), the mourning dove, and the woodcock. Snipe, rails, and gallinules also occur but are not hunted extensively.

At least 18 species of waterfowl that are normally considered game species may occur in the Region (Table 7-11). In general, the Salina Region is not an important waterfowl breeding area, but several species do breed there (Canada goose, mallard, black duck, wood duck, blue-winged teal, hooded merganser, and northern shoveler). The northern Michigan and New York portions of the Region support an estimated breeding density of one to five pairs of ducks per square mile (FWS, 1975).

The western shores of Lake Huron and Lake Erie are important fall migration and wintering areas for waterfowl. Peak waterfowl populations in this area occur in December, with the most common species being Canada geese, greater scaup, common goldeneye, and red-breasted merganser. The western Lake Erie marshes, most of which are not in the Salina Region, are the most important waterfowl area in this part of the United States.

Most waterfowl hunting in the Salina Region is concentrated along the Great Lakes. Duck and goose hunting on and near smaller lakes, ponds, and streams is also locally important, especially in the Michigan and New York portions of the Region. Mallards, black ducks, wood ducks, and Canada geese are among the most common species taken. Waterfowl hunting was permitted on the Shiawassee, Montezuma, and Erie National Wildlife Refuges in 1974 (FWS, 1976a); see Section 7.1.3.2 for additional information on National Wildlife Refuges in the Salina Region.

The mourning dove is found in agricultural land throughout the Region. Ohio, Pennsylvania, and West Virginia had dove hunting seasons in 1976. Mourning dove breeding density indices for 1974 were higher in Ohio than in any other state in the Region (FWS, 1975).

The woodcock breeds in, and migrates through, all states in the Region (Sheldon, 1971). It does not receive heavy hunting pressure, although it may be locally important.

7.1.5.1.4 Other Game

Other wildlife species often receive considerable hunting pressure locally, but are not as popular as the "traditional" game species (FWS, 1977b). The woodchuck, the raccoon, foxes (red and gray), and crows are in the "other game" category in the Salina Region. All of these species are relatively common.

7.1.5.1.5 Furbearers

Fifteen species of mammals in the Salina Region are considered furbearers (Table 7-10). Trapping these animals for their pelts is recreationally and economically important. The economic importance of wild fur sales in the Region is substantial. For example,

the 1974-1975 harvest in Ohio was worth more than five million dollars (Ohio DNR, 1975). The states of Ohio, Michigan, and Pennsylvania have the highest reported fur harvests in the Region (FWS, 1971b).

Important furbearers in the Region include the muskrat, raccoon, red fox, gray fox, beaver, and mink. Individually, muskrats are not especially valuable, but so many are trapped that they account for a substantial part of the money paid for furs (FWS, 1971b). The muskrat is found throughout the Region wherever there is water, but it is most common in marshes, lakes, ponds, streams, and drainage ditches in northern Ohio and Michigan. The prices paid for raccoon and fox (especially red fox) pelts increased substantially between 1970 and 1975 (Ohio DNR, 1975). These furbearers are found throughout the Salina Region; the raccoon and the red fox are most abundant where agricultural and forest lands are interspersed. Beaver, like the muskrat, are generally restricted to water. Within the Region, beaver are probably most common in Michigan and least common in Ohio. Mink occur in all five states but are relatively uncommon.

Several other furbearers (e.g., Virginia opossum, striped skunk, weasels) are common in the Salina Region but are less important because of the low value of their fur.

7.1.5.1.6 Reptiles and Amphibians

Bullfrogs and green frogs are hunted for their legs and are the only economically important amphibians in the Salina Region. Snapping turtles are sometimes taken for food.

7.1.5.2 Threatened or Endangered Wildlife

In compliance with the Endangered Species Act of 1973, the U.S. Fish and Wildlife Service published and periodically updates lists of threatened or endangered species of wildlife. It is also responsible for ascertaining the current status of listed species, preventing any further deterioration of habitats critical to these species, and recommending measures that could improve the status of individual species.

7.1.5.2.1 Mammals

The threatened or endangered mammals of the Salina Region are listed in Table 7-12. The Indiana myotis (bat) is the only mammal on the Federal endangered list (FWS, 1977a) that is expected to occur in the Region. This species is also considered endangered by all states in the Region. Breeding areas for this bat have not been identified, but it may breed in small, localized colonies in forests (Barbour and Davis, 1969). This species is most vulnerable during the winter, when large groups hibernate in a few caves (Mumford, 1974). There are no known wintering areas in the Salina Region, but the Indiana myotis might be found throughout the Region during migration.

The eastern woodrat, river otter, and bobcat are on Ohio's official list of endangered species. No known colonies of eastern woodrats in Ohio are in the Salina Region (G. E. Svendsen, Ohio University, personal communication, October 4, 1977). The bobcat probably occurs in relatively large wooded areas, especially in southern Ohio. The status of the river otter in eastern Ohio is unknown; if it does occur, the otter is very uncommon.

Three small mammals, the least shrew, woodland vole, and bog lemming, are on Michigan's threatened species list. All three may occur in the Michigan portion of the Salina Region, but their presence is difficult to detect.

TABLE 7-12

ENDANGERED OR THREATENED MAMMALS OF THE SALINA REGION[a]

Common Name[c]	Scientific Name[c]	Federal[d]	Status[b]				
			NY	OH	PA	WV	MI
Least shrew	Cryptotis parva						T
Indiana myotis	Myotis sodalis	E	E	E	E	E	E
Eastern woodrat	Neotoma floridana		E				
Woodland vole	Microtus pinetorum					T	
Southern bog lemming	Synaptomys cooperi					T	
River otter	Lutra canadensis		E				
Bobcat	Felis rufus		E				

a. Ranges from Burt and Grossenheider (1976); species with special status in Salina Region states, but not expected to occur in the Region, are not included herein.

b. Key: E = endangered; T = threatened. Status according to the Federal list of endangered species (FWS, 1977a); New York DEC (1977); Ohio DNR (1976); Pennsylvania Game Commission (personal communication, November 1977); J. W. Rawson, Assistant Supervisor, Wildlife Planning, West Virginia Department of Natural Resources (personal communication; November 16, 1977); Michigan DNR (1976).

c. Nomenclature from Jones et al. (1975).

d. The eastern cougar and eastern timber wolf are on the Federal list (for the eastern United States and Michigan, respectively) but are not likely to occur in the Salina Region.

7.1.5.2.2 Birds

The threatened or endangered birds of the Salina Region are listed in Table 7-13.

Kirtland's warbler and the peregrine falcon are the only bird species on the Federal list of endangered and threatened species (FWS, 1977a) that normally occur in the Region. Kirtland's warbler breeds exclusively in a small northern portion of Michigan's Lower Peninsula; it winters in the Bahama Islands and has been observed in southeastern Michigan, northern and central Ohio, and southwestern Pennsylvania during migration (Clench, 1973). Only about 400 of these birds exist, and the species is on endangered lists in all states in the Region except New York.

The peregrine falcon's range includes essentially the entire continental United States. Two races of peregrine breed in treeless areas of Alaska, Canada, and Greenland and are irregular migrants through the Salina Region. A third race, which formerly bred in the eastern United States, is now rarely seen (Snow, 1972; Zimmerman, 1972). A stocking program, designed to reestablish nesting peregrine falcons in the northeastern United States, is being conducted by the Laboratory of Ornithology at Cornell University (Ithaca, New York).

The southern bald eagle is also on the Federal list of endangered species; this eagle may occasionally wander northward into the Salina Region. More importantly, the northern bald eagle may soon be listed as endangered because of its continued scarcity, its morphological similarity to the southern race, and the intermixing of populations of the two races (FWS, 1976c). Breeding populations of northern bald eagles occur along rivers and lake shores in northern Michigan (inland) and in northern Ohio (Sandusky Bay); migrants or nonbreeding adults are apt to be seen throughout the Region. Any bald eagle south of the 40th parallel is considered endangered by the U.S. Fish and Wildlife Service.

The osprey is listed as endangered in two states because of a recent decline in the numbers of this nearly cosmopolitan species. In New York, where it is endangered, the osprey breeds in areas that are not within the Salina Region. In Michigan, where the osprey is threatened, it breeds in several areas in the Lower Peninsula.

7.1.5.2.3 Reptiles and Amphibians

No species of reptiles or amphibians in the region are on the Federal endangered species list. However, eight reptiles and four amphibians are considered threatened or endangered by at least one state in the Region (Table 7-14).

7.2 AGRICULTURAL SYSTEMS

For agricultural planning at the state, regional, and national level, land resource information is generally interpreted from general soil maps (Austin, 1972). Two land resource categories, Major Land Resource Areas and Land Resource Regions, are used to discuss major agricultural resources in the Salina Region.

The Salina Region includes portions of five Land Resource Regions (Figure 7-6). These five regions consist of 13 geographically associated Major Land Resource Areas (Table 7-15), which are characterized by particular soil patterns, climate, water resources, land uses, and types of farming (Austin, 1972). The major crops and livestock produced in the Region are summarized in Table 7-16.

TABLE 7-13

ENDANGERED OR THREATENED BIRDS OF THE SALINA REGION

Common Name[c]	Scientific Name[c]	Federal	Status[a] NY	OH	PA	WV	MI
Double-crested cormorant	Phalacrocorax auritus						T
Sharp-shinned hawk	Accipiter striatus			E			
Cooper's hawk	Accipiter cooperii						T
Red-shouldered hawk	Buteo lineatus						T
Bald eagle	Haliaeetus leucocephalus	E[c]	E	E	E	E	T
Marsh hawk	Circus cyaneus						T
Osprey	Pandion haliaethus		E				T
Peregrine falcon	Falco peregrinus	E	E	E	E	E	E
Greater prairie chicken	Tympanuchus cupido						T
King rail	Rallus elegans			E			
Piping plover	Charadrius melodus						T
Upland sandpiper	Bartramia americana						T
Common tern	Sterna hirundo			E			
Barn owl	Tyto alba						T
Loggerhead shrike	Lanius ludovicianus						T
Kirtland's warbler	Dendroica kirtlandii	E		E	E	E	E

a. Key: E = endangered; T = threatened. Status according to the Federal list of endangered species (FWS, 1977a); New York DEC (1977); Ohio DNR (1976); Pennsylvania Game Commission (personal communication, November 15, 1977); J. W. Rawson, Assistant Supervisor, Wildlife Planning, West Virginia Department of Natural Resources (personal communication, November 16, 1977); Michigan DNR (1976).

b. Nomenclature from the American Ornithologists' Union (1957, 1973, and 1976).

c. The southern bald eagle is endangered; the northern bald eagle is proposed for endangered status (FWS, 1976c); both subspecies are endangered in New York and Ohio.

TABLE 7-14

ENDANGERED OR THREATENED REPTILES AND AMPHIBIANS OF THE SALINA REGION[a]

Common Name	Scientific Name	Status[b,c] NY	OH	PA	WV	MI
Reptiles						
Spotted turtle	Clemmys guttata		E			
Bog turtle	Clemmys muhlenbergi	E		E		
Eastern box turtle	Terrapene carolina					T
Blanding's turtle	Emydoidea blandingi			E		
Smooth softshell	Trionyx muticus			E		
Kirtland's water snake	Natrix kirtlandi					T
Northern copperbelly	Natrix erythrogaster					T
Black rat snake	Elaphe obsoleta					T
Amphibians						
Western lesser siren	Siren intermedia					T
Small-mouthed salamander	Ambystoma texanum					T
Wehrle's salamander	Plethodon wehrlei		E			
Four-toed salamander	Hemidactylum scutatum		E			

a. Ranges and nomenclature from Conant (1975).

b. Species with special status in the state that do not occur in the Region are not included herein.

c. Key: E = endangered; T = threatened. Status according to New York DEC (1977); Ohio DNR (1976); Pennsylvania Fish Commission (1977); J.W. Rawson, Assistant Supervisor, Wildlife Planning, West Virginia Department of Natural Resources (personal communication, November 16, 1977); Michigan DNR (1976).

About 16% of the Salina Region is in the Northern Lake States Forest and Forage Region (Table 7-15). About 20% of this forest forage region is considered cropland (Table 7-17). Agriculture, generally practiced on small farms, is restricted by poor soil and a short, cool growing season. The major soils are Spodosols (Table 7-1). The temperatures of the coldest month average below 0°C, and those of the warmest month average less than 22°C (Bailey, 1976). Rainfall is generally adequate for crop production. The major crops are forage and feed grains for livestock. Major crops in the northern Michigan Sandy Drift resource area are listed in Table 7-17.

About 31% of the Salina Region is within the Lake States Fruit, Truck, and Dairy Region (Table 7-15), which has six Major Land Resource Areas and supports a wide variety of agricultural practices. The extent of cropland varies from nearly 70% in eastern lower Michigan (Erie-Huron Lake Plain) to about 33% in western lower Michigan (Western Michigan Fruit Belt) and northern Ohio (Erie Fruit and Truck Area) (Table 7-17). Leading crops include canning crops, corn, soft winter wheat, beans, and sugar beets. Fruit (e.g., apples, grapes, cherries) is an important crop adjacent to the Great Lakes. The major soils are Alfisols, which are characterized by a gray to brown surface horizon and subsurface horizons with clay accumulations (Table 7-1). The soils are generally dry during part of the year, but during the warm growing season rainfall is sufficient for good crop production. Temperatures average below 0°C in the coldest month and above 22°C in the warmest month (Bailey, 1976).

Less than 1% of the Salina Region is in the Central Feed Grains and Livestock Region (Table 7-15), which has fertile soil and a favorable climate for agriculture and is one of the best grain-producing areas in the world. About 80% of the land is in cropland (Table 7-17). Some of the more important crops are oats, winter wheat, corn, soybeans, and vegetables. The major soils are Alfisols, which are usually moist during the warm growing season (Table 7-1). Temperatures average below 0°C in the coldest month and above 22°C in the warmest month (Bailey, 1976).

About 30% of the Salina Region lies in the East and Central General Farming and Forest Region (Table 7-15). Generally less than 20% of the land is cropland (Table 7-17). Small farms are typical in much of this forest and farming region. Corn, small grains, and hay are the major crops. The major soils are Inceptisols, which have light-colored surface horizons and altered subsurface horizons (Table 7-1). Ultisol soils occur in western Pennsylvania. These soils are usually moist, and their subsurface horizons are generally clayey and low in organic matter. Temperatures average below 0°C in the coldest month and above 22°C in the warmest month (Bailey, 1976).

About 22% of the Salina Region is within the Northeastern Forage and Forest Region (Table 7-15). The extent of cropland varies from about 33% in northeastern Ohio to somewhat less than 50% in western New York (Table 7-17). Most of the farmland is used to raise dairy cattle. Hay, fruits, and potatoes are the major crops. The major soils are Inceptisols. Temperatures average below 0°C in the coldest month and below 22°C in the warmest month (Bailey, 1976).

TABLE 7-15

LAND RESOURCE REGIONS AND MAJOR LAND RESOURCE AREAS IN THE SALINA REGION

Land Resource Category[a]		Occurrence in Salina Region [b] (% of area)	Contribution by State (%) MI	NY	OH	PA	WV
Northern Lake States Forest and Forage Region							
(94)	Northern Michigan Sandy Drift	16	16	0	0	0	0
	Total	16	16	0	0	0	0
Lake States Fruit, Truck, and Dairy Region							
(96)	Western Michigan Fruit Belt	3	3	0	0	0	0
(97)	Southwestern Michigan Fruit and Truck Belt	<1	<1	0	0	0	0
(98)	Southern Michigan Drift Plain	14	14	0	0	0	0
(99)	Erie-Huron Lake Plain	9	9	0	0	0	0
(100)	Erie Fruit and Truck Area	1	0	0	1	<1	0
(101)	Ontario-Mohawk Plain	3	0	3	0	0	0
	Total	30	26	3	1	<1	0
Central Feed Grains and Livestock Region							
(111)	Indiana and Ohio Till Plain	<1	<1	0	0	0	0
	Total	<1	<1	0	0	0	0
East and Central General Farming and Forest Region							
(124)	Western Allegheny Plateau	3	0	0	3	<1	0
(126)	Central Allegheny Plateau	16	0	0	3	9	4
(127)	Eastern Allegheny Plateau and Mountains	11	0	<1	0	10	1
	Total	30	0	<1	6	19	5

TABLE 7-15 (Continued)

Land Resource Category[a]	Occurrence in Salina Region [b] (% of area)	Contribution by State (%) MI	NY	OH	PA	WV
Northeastern Forage and Forest Region						
(139) Eastern Ohio Till Plain	6	0	0	6	1	0
(140) Glaciated Allegheny Plateau and Catskill Mountains	16	0	10	1	6	0
Total	22	0	10	6	6	0
TOTAL FOR ALL REGIONS	98	42	13	13	25	5

a. See Figure 7-6 for location of land-use regions and areas; land resource categories adapted from Austin (1972).

b. Total area approximately 80,000 square miles (exclusive of Great Lakes and Canada).

TABLE 7-16

MAJOR CROPS AND LIVESTOCK OF THE SALINA REGION

Crops and Livestock[a]	Total U.S. Acreage Harvested or Number of Head	Salina Region[b] % of U.S. Total	Contribution by State(%) MI	NY	OH	PA	WV
Crops	Acres Harvested						
Corn (all purposes)	63,514,906	3	2	<1	<1	<1	0
Winter wheat	36,620,469	3	2	<1	<1	<1	0
Oats (for grain)	18,935,713	5	2	1	1	1	0
Hay (all hay cut)	65,294,703	5	2	1	1	1	<1
Apples and peaches	62,529,617[c]	6	3	1	1	<1	<1
Grape vines	287,789,832[d]	7	0	5	1	1	0
Livestock	Number of Head						
Cattle and calves	105,557,830	3	1	<1	<1	1	<1
Milk cows	14,622,604	7	2	2	1	2	<1
Sheep and lambs	25,471,500	2	1	<1	<1	<1	<1
Hogs and pigs	54,080,194	1	1	0	<1	<1	<1

a. Adapted from USGS (1970).

b. Exclusive of Great Lakes and Canada.

c. Number of trees.

d. Number of vines.

TABLE 7-17

MAJOR AGRICULTURAL RESOURCES IN THE SALINA REGION

Land Resource Category[a]		Approximate % Cropland	Major Agricultural Resources
NORTHERN LAKE STATES FOREST AND FORAGE REGION			
(94)	Northern Michigan Sandy Drift	20	Forage and feed grains for dairy cattle and other live stock. Cash crops are potatoes, other vegetables, and fruit.
LAKE STATES FRUIT, TRUCK, AND DAIRY REGION			
(96)	Western Michigan Fruit Belt	33	One of the largest cherry-producing areas in the U.S. Other important crops are forage and feed grains for dairy cattle and potatoes and other vegetables.
(97)	Southwestern Michigan Fruit and Truck Belt	50	Peaches and grapes are important crops near the Lake Michigan shore. Other common crops are vegetables, melons, and forage and feed grains for cattle and other livestock.
(98)	Southern Michigan Drift Plain	50	Corn and forage and feed grains for dairy cattle and other livestock. Cash crops are winter wheat, dry beans, and potatoes. Near major markets, fruits and vegetables are grown.

TABLE 7-17 (Continued)

Land Resource Category[a]		Approximate % Cropland	Major Agricultural Resources
LAKE STATES FRUIT, TRUCK, AND DAIRY REGION (Continued)			
(99)	Erie-Huron Lake Plain	68	One of the most important cash-crop areas in the Salina Region. Major crops include corn, winter wheat, soybeans, sugar beets, canning crops, and hay. Dairy farming is important near the metropolitan areas.
(100)	Erie Fruit and Truck Area	33	Vineyards, orchards, small fruits, canning crops, and truck crops. Dairy farming near major metropolitan areas.
(101)	Ontario-Mohawk Plain	40	Feed and forage crops for dairy cattle are the most important crops. Cash crops include canning and truck crops, various fruits, and winter wheat.
CENTRAL FEED GRAINS AND LIVESTOCK REGION			
(111)	Indiana and Ohio Plain	80	Principal crops are corn, soybeans, and hay and feed grains for livestock. Truck and canning crops are grown extensively in areas of favorable soil.
EAST AND CENTRAL GENERAL FARMING AND FOREST REGION			
(124)	Western Allegheny Plateau	20	Crops include hay and feed grains for livestock. Fruits and vegetable crops are of local importance.

Table 7-17 (Continued)

Land Resource Category[a]		Approximate % Cropland	Major Agricultural Resources
EAST AND CENTRAL GENERAL FARMING AND FOREST REGION (Continued)			
(126)	Central Allegheny Plateau	15	Crops include hay and feed grains for dairy cattle and other livestock. Fruits and vegetables are grown locally.
(127)	Eastern Allegheny Plateau and Mountains	10	Crops include hay and other feed for dairy cattle. Fruits and vegetables are grown mainly for home consumption.
NORTHEASTERN FORAGE AND FOREST REGION.			
(139)	Eastern Ohio Till Plain	33	The main crops are forage and feed grains for dairy cattle.
(140)	Glaciated Allegheny Plateau and Catskill Mountains	50	Principal crops are hay and grain for dairy cattle. Potatoes are important locally and poultry, fruits, and truck crops are produced in many of the narrow valleys.

a. See Figure 7-6 for location of land-use regions and areas; see Table 7-15 for percentage of each resource area in the Salina Region; land resource categories and percent cropland adapted from Austin (1972).

REFERENCES FOR CHAPTER 7

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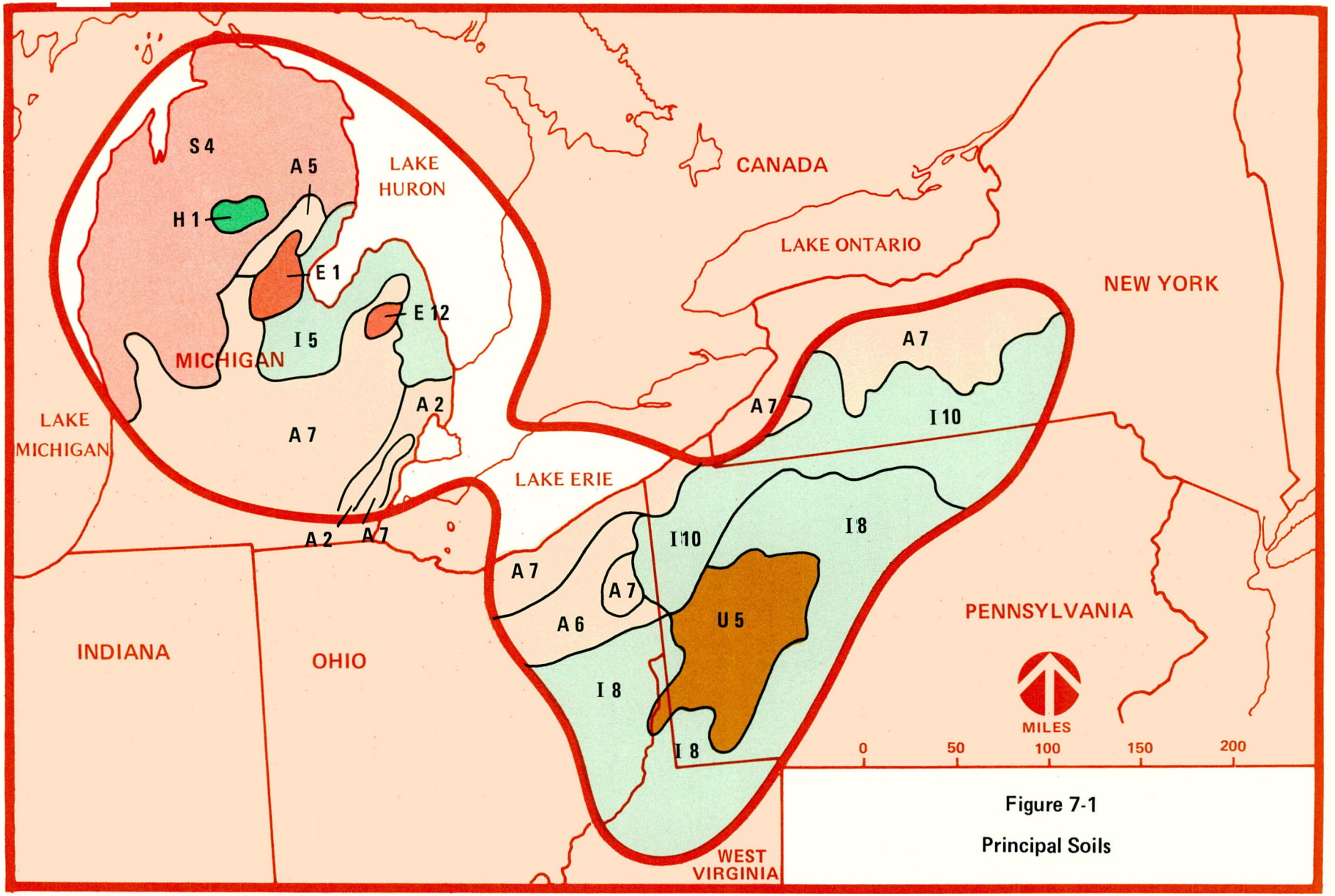


Figure 7-1

Principal Soils

- ALFISOLS
  - A2 AQUALFS
  - A5 BORALFS
  - A6&7 UDALFS
- ENTISOLS
  - E1 AQUENTS
  - E12 PSAMMENTS
- HISTOSOLS (H1)
- INCEPTISOLS
  - I8 & 10 OCHREPTS
  - I5 AQUEPTS
- SPODOSOLS
  - S4 ORTHODS
- ULTISOLS
  - U5 UDULTS

Adapted from SCS (1967).
See Table 7-1 for additional detail.

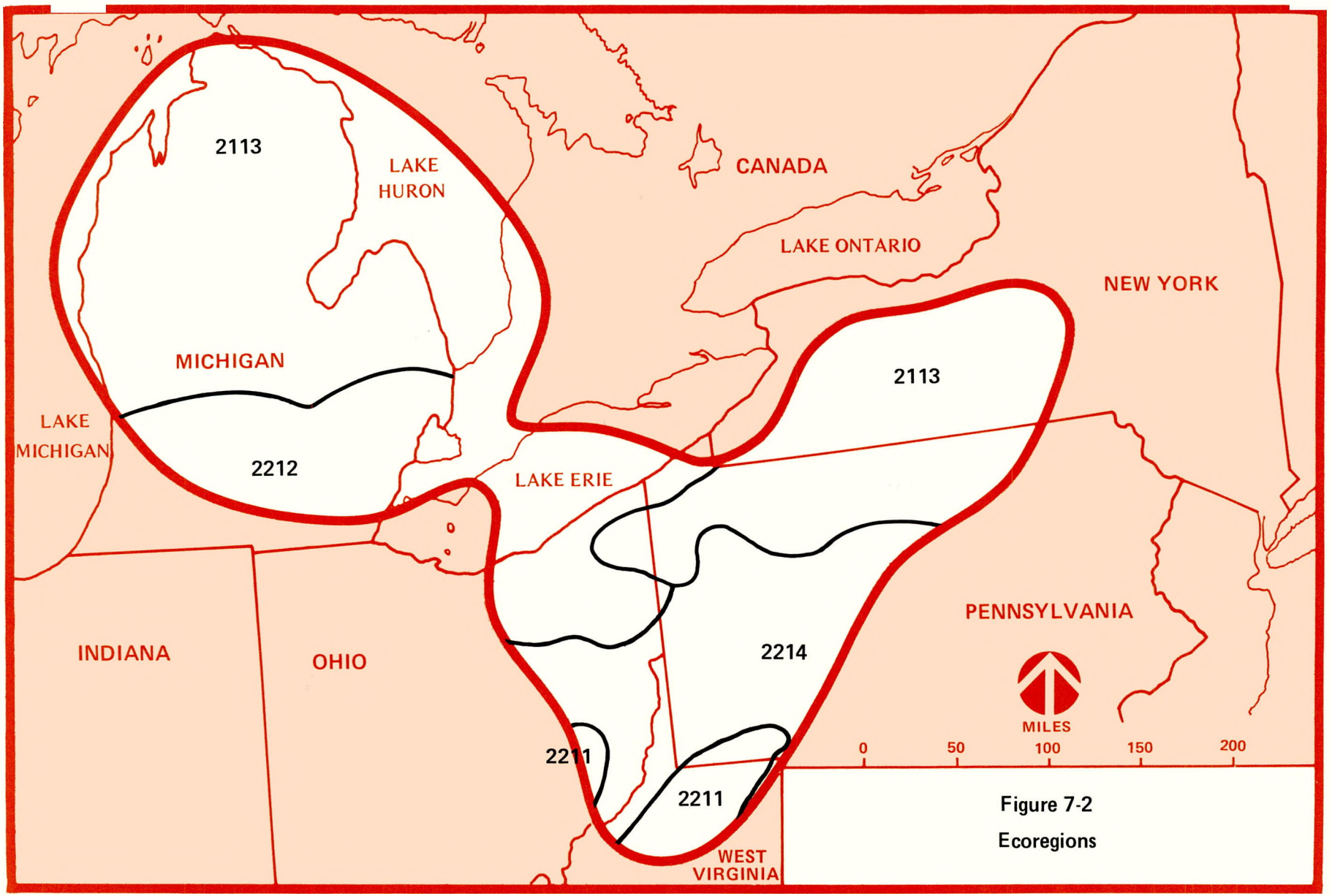


Figure 7-2

Ecoregions

2113 NORTHERN HARDWOODS FOREST SECTION

2212 BEECH-MAPLE FOREST SECTION

2211 MIXED MESOPHYTIC FOREST SECTION

2214 APPALACHIAN OAK FOREST SECTION

Adapted from Bailey (1976).
See Table 7-2 for additional detail

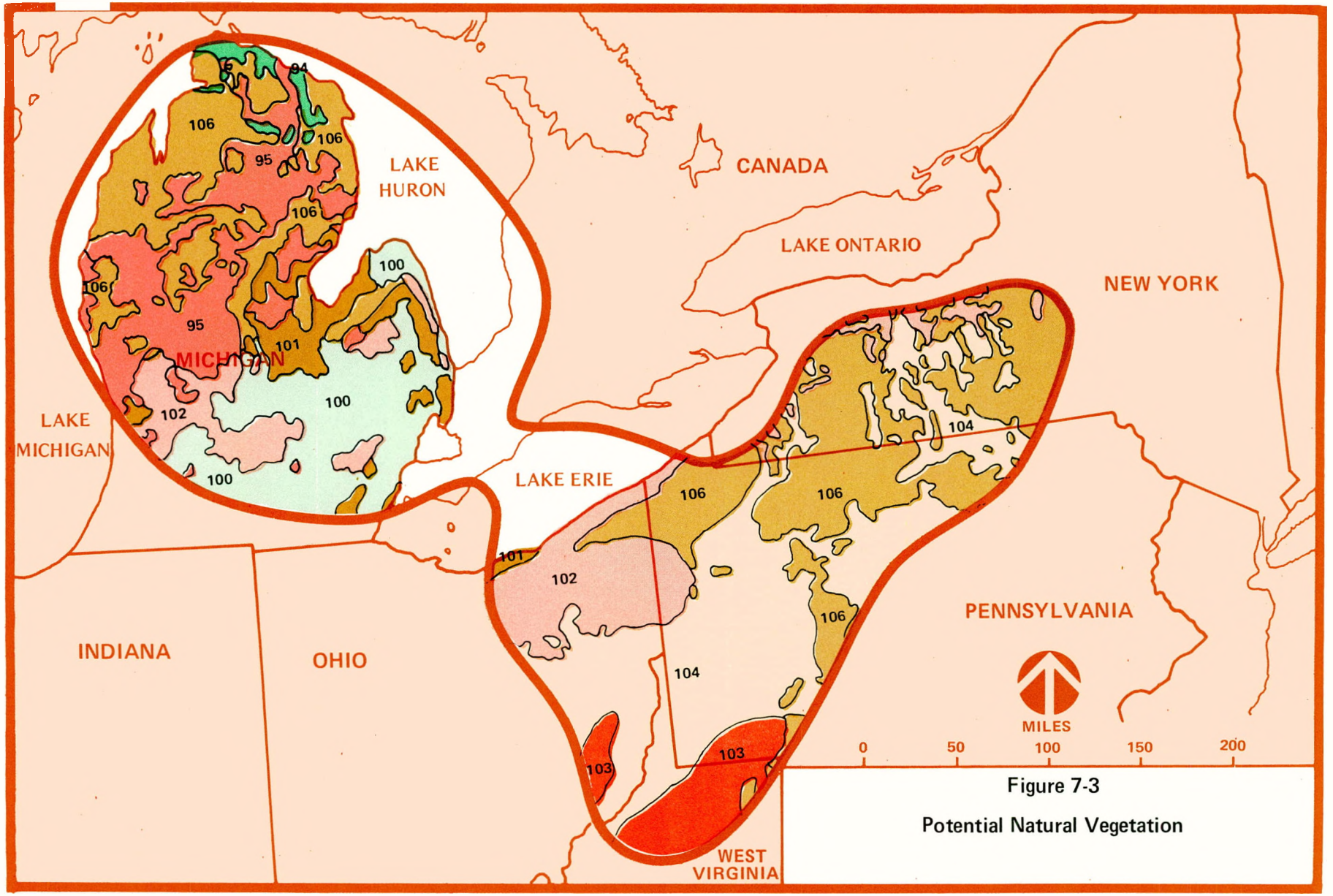


Figure 7-3

Potential Natural Vegetation

94 CONIFER BOG
95 GREAT LAKES PINE FOREST
100 OAK-HICKORY FOREST
101 ELM-ASH FOREST
102 BEECH-MAPLE FOREST
103 MIXED MESOPHYTIC FOREST
104 APPALACHIAN OAK FOREST
106 NORTHERN HARDWOODS

Adapted from Küchler (1975).
See Table 7-3 for additional detail.

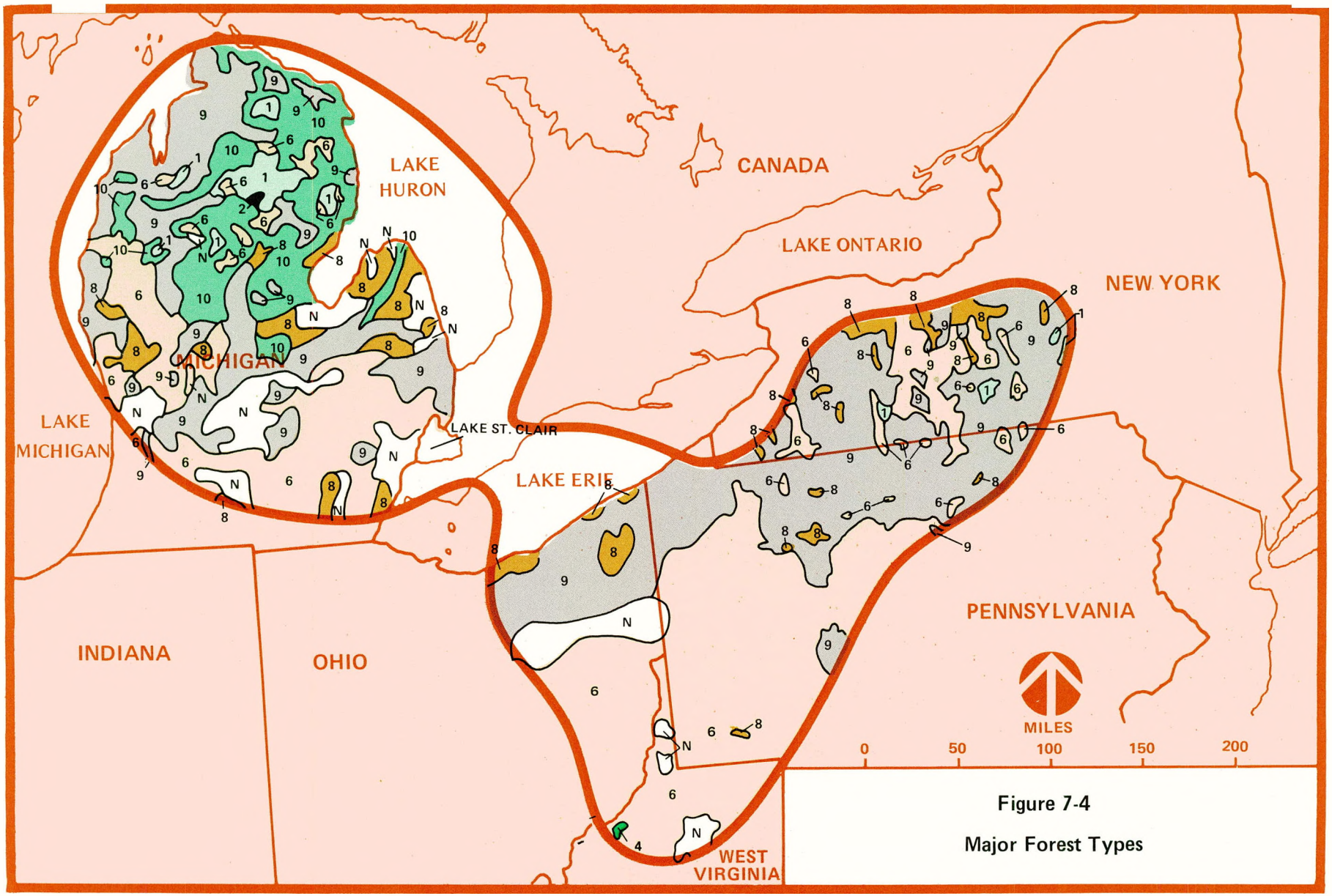


Figure 7-4

Major Forest Types

- 1 WHITE-RED-JACK PINE
- 2 SPRUCE-FIR
- 4 LOBLOLLY-SHORTLEAF PINE
- 6 OAK-HICKORY
- 8 ELM-ASH-COTTONWOOD
- 9 MAPLE-BEECH-BIRCH
- 10 ASPEN-BIRCH
- N NONFOREST

Adapted from USFS (1967).
See Table 7-4 for additional detail.

LEGEND FOR FIGURE 7-5

WETLANDS

1. Celeron Island
2. Dead Stream Preserve
3. Dead Stream Swamp
4. Proud Lake Bog
5. Tobico Marsh
6. Waterloo Black Spruce Bog
7. McLean Swamps and Bogs
8. Montezuma Marshes
9. Moss Lake Bog
10. Seneca Lake Marsh
11. Browns Lake Bog
12. Frame Glacial Bog
13. Lake Abrams
14. Mantua Swamp
15. Mentor Marsh
16. Still Fork Swamp
17. Watercress Marsh
18. Boleratz Bog
19. Hartstown Bog
20. Mercer Bog
21. Otter Creek Swamp
22. Pine Swamp
23. Plain Grove Bog
24. Reynolds Spring
25. Schollards Run
26. Titus Bog
27. Wattsburg Bog
28. Cranesville Swamp Nature Sanctuary

NATURAL AREAS OF THE SOCIETY OF AMERICAN FORESTERS (SAF)

A. Beech-Maple Knoll
B. Swamp Woods
C. Brown's Lake Bog
D. Dysart Woods
E. Kimball Woods
F. Mentor Marsh
G. Sigrist Forest
H. Stebbin's Gulch
I. Jacob Guy Natural Area
J. Tionesta Natural Area

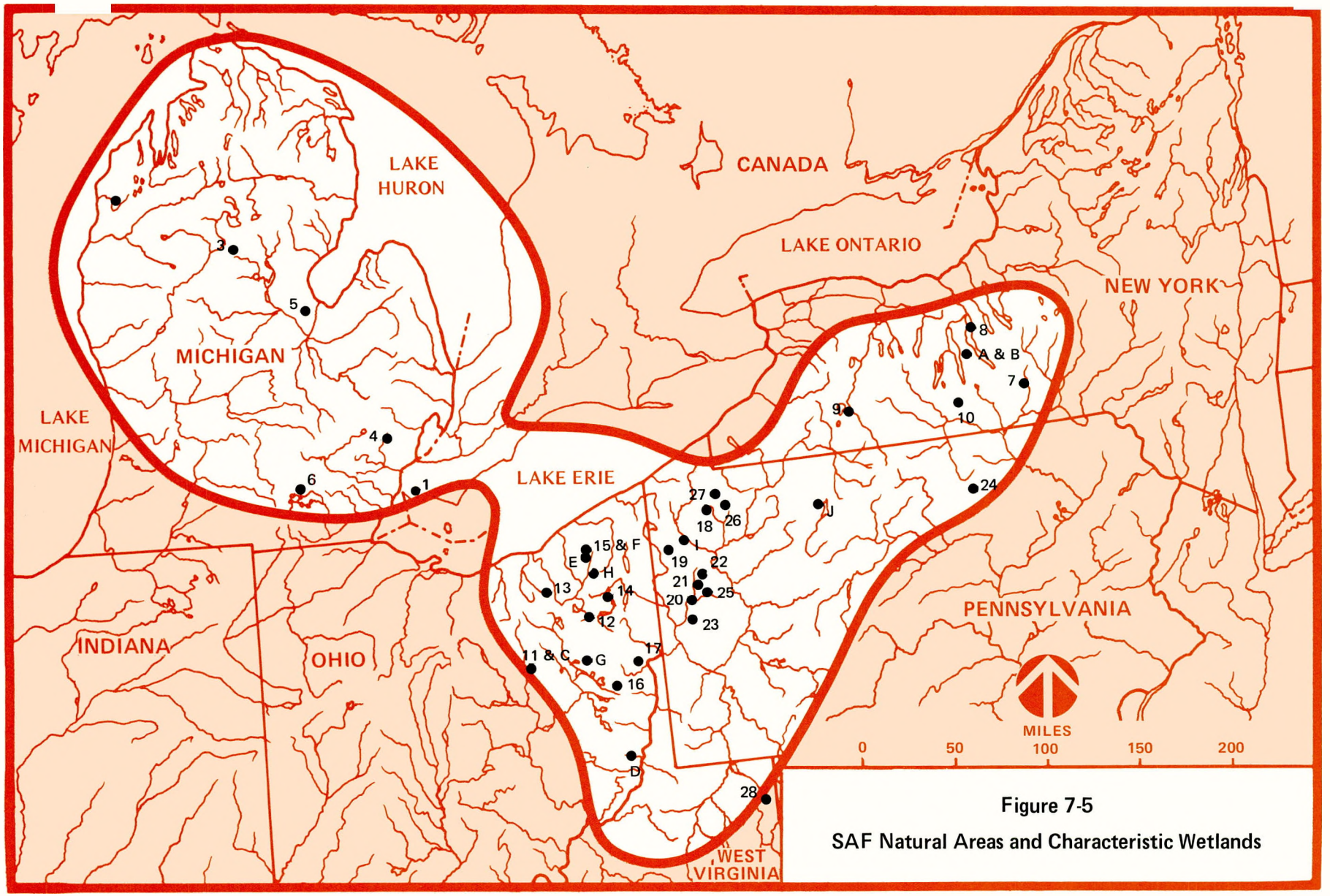


Figure 7-5

SAF Natural Areas and Characteristic Wetlands

NOTE: See preceding page for detailed legend.

Adapted from Buckman and Quintus (1972) and Goodwin and Niering (1975).
See Tables 7-7 and 7-8 for additional detail.

LEGEND FOR FIGURE 7-6

NORTHERN STATES FOREST AND FORAGE REGION

K94 Northern Michigan Sandy Drift

LAKE STATES FRUIT, TRUCK AND DAIRY REGION

L96 Western Michigan Fruit Belt

L97 Southwestern Michigan Fruit and Truck Belt

L98 Southern Michigan Drift Plain

L99 Erie-Huron Lake Plain

L100 Erie Fruit and Truck Belt

L101 Ontario-Mohawk Plain

CENTRAL FEED GRAINS AND LIVESTOCK REGION

M111 Indiana and Ohio Till Plain

EAST AND CENTRAL GENERAL FARMING AND FOREST REGION

N124 Western Allegheny Plateau

N126 Central Allegheny Plateau

N127 Eastern Allegheny Plateau and Mountains

NORTHEASTERN FORAGE AND FOREST REGION

R139 Eastern Ohio Till Plain

R140 Glaciated Allegheny Plateau and Catskill Mountains

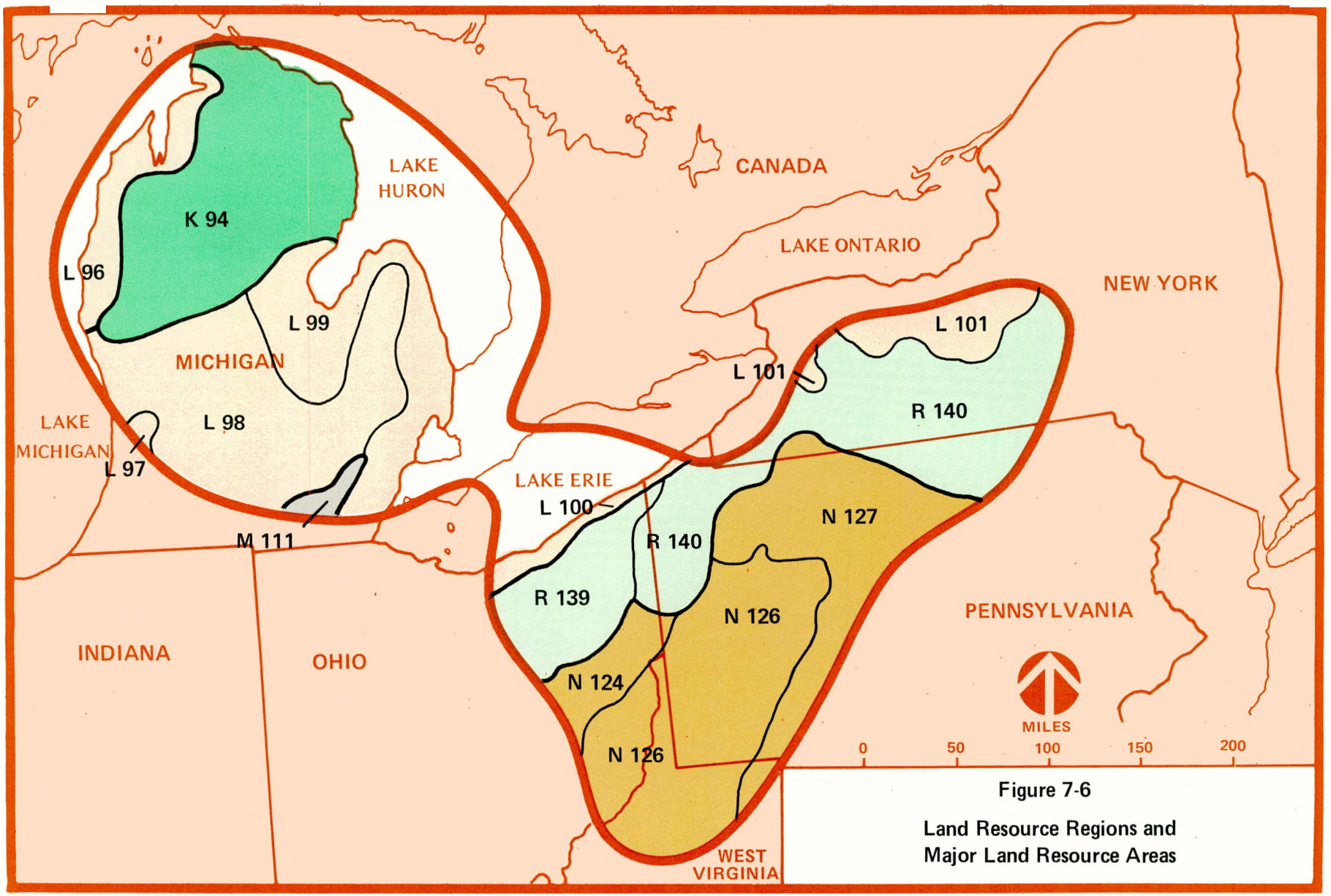


Figure 7-6

Land Resource Regions and Major Land Resource Areas

- NORTHERN LAKE STATES FOREST AND FORAGE REGION
- LAKE STATES FRUIT, TRUCK AND DAIRY REGION
- CENTRAL FEED GRAINS AND LIVESTOCK REGION
- EAST AND CENTRAL GENERAL FARMING AND FOREST REGION
- NORTHEASTERN FORAGE AND FOREST REGION

NOTE: See preceding page for detailed legend.

Adapted from Austin (1972).
See Tables 7-15 and 7-17 for additional detail.

8.0 AQUATIC ECOLOGY

8.1 AQUATIC ECOLOGY

Aquatic ecological regimes are important components of natural ecosystems (see Chapter 7, Terrestrial Ecology). While the water resources represented in these regimes are important in themselves, the habitats they represent are equally important for the webs of ecological life they nurture and sustain. Certain natural habitats are particularly valuable or "critical" ecological areas because of the important food species and valued wildlife they sustain or the recreational and educational values they represent.

The intent of this chapter is to address the pertinent aspects of the aquatic environment and associated biota that may particularly be affected at the regional level. Included is a broad-based identification of major drainage basins, major natural water bodies, and important aquatic species. (The hydrology and general water-quality characteristics of rivers and tributaries within the bounds of the Salina Region are discussed in detail in Chapter 3.)

An aquatic species is considered important if one or more of the following criteria apply:

- The species is of commercial or recreational value.
- The species is endangered or threatened.
- The species clearly and directly affects the well-being of an important species.
- The species is critical to the structure and function of the ecological system.

For purposes of this regional characterization, the aquatic biota of the Salina Region are discussed primarily from the standpoint of (a) the presence or absence of officially recognized endangered or threatened species and (b) the occurrence of commercially and recreationally important species. Because of the very large size of the Salina Region, the analyses in this report are limited to the fish and shellfish of the Region. Emphasis has been placed on commercially and recreationally important species, and on endangered and threatened species.

The Endangered Species Act of 1973 (Public Law 93-205) established a Federal list of endangered and threatened wildlife and plants and required an annual reissue of that list containing species additions, deletions, or other status modifications. In addition, the Act gave individual states the authority to designate and conserve species considered endangered or threatened within their boundaries. As defined in the Act, the term "endangered species" means any species that is in danger of extinction throughout all or a significant portion of its range (other than a species of the Class Insecta determined to constitute a pest whose protection under the provision of the Act would present an overwhelming and overriding risk to man). The term "threatened species" means any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

The extent of commercial and recreational fishing is considered an important attribute of an aquatic ecological characterization because of the direct relationship of these activities to the economic and social characteristics of the area under consideration. The Great Lakes provide an economically important fishery. In 1966, for example, the net value for the commercial fishery operation in the State of Michigan was between 3.1 and 3.6 million dollars (Great Lakes Basin Commission, 1975). A major recreational use of the aquatic environment is the sport fishery. In 1975, 53.9 million Americans went fishing and spent 15.2 billion dollars (FWS, 1977a).

A large number of water bodies, affording a diversity of habitat to aquatic flora and fauna, occur within the Salina Region, which covers portions of five states and the Province of Ontario (Figure 8-1). Standing waters (lakes, ponds, and bogs) provide a very different set of abiotic conditions than do flowing waters (springs, streams, and rivers). The Salina Region contains a wide variety of both standing and flowing water bodies.

Within the Salina Region there are two major drainages: the Ohio River drainage and a portion of the Great Lakes drainage. The Lake Ontario drainage (part of the Great Lakes drainage) includes New York's Finger Lakes and the Genesee River. The headwaters of the Susquehanna River originate within the Salina Region in New York.

The Ohio River drainage includes the Allegheny and Monongahela rivers, which join in western Pennsylvania to form the Ohio River. The major tributaries of the Monongahela River—the Cheat, Tygart, and West Fork rivers--flow northward from West Virginia into Pennsylvania. The high elevation of this region accounts for the steep, unpolluted mountain streams, although acid-mine-drainage problems are known to occur (Tarter, 1976). Rivers within the northwestern panhandle of West Virginia drain into the Ohio River. The West Virginia Panhandle is heavily industrialized, and most waters of the area carry high pollution loads. Eastern river systems in Ohio within the Salina Region drain into the Ohio River.

The Great Lakes drainage within the Salina Region consists of the eastern shore of Lake Michigan, including Grand Traverse Bay; the western shore of Lake Huron, including Saginaw Bay; the central basin of Lake Erie; and many rivers flowing into these lakes. Many northern streams in Ohio belong to the Great Lakes drainage. Most standing and flowing water bodies in the State of Michigan belong to the western Great Lakes drainage, but a few rivers are in the eastern Great Lakes drainage (as defined by Geraghty et al., 1973). Chandler (1966) states that Michigan has 11,000 lakes and 43 river systems in addition to being almost surrounded by the Great Lakes.

The Susquehanna River drainage within the Salina Region includes two major tributaries: the Chemung River in New York and the upper section of the West Branch of the Susquehanna River in Pennsylvania. A small portion of the Susquehanna River proper is in the Salina Region (Figure 8-1). Mine acid has destroyed fish life in the bituminous coal region of the West Branch of the Susquehanna River and the upper Tioga River. A total of 715 miles of streams has been severely affected (Susquehanna River Basin Study, 1970).

A more detailed discussion of the smaller drainages that compose these two large drainages and the Susquehanna River drainage within the Salina Region is presented in Chapter 3, Hydrosphere.

8.2 IMPORTANT SPECIES AND HABITATS

Both of the major drainages (Ohio River and Great Lakes) within the Salina Region provide important commercial and recreational fishery opportunities. The Susquehanna River drainage above the Conowingo Dam, including the sections within the Salina Region, is important as a recreational fishery. A cold-water as well as a warm-water fishery exists in the upper Susquehanna River drainage.

8.2.1 COMMERCIALLY IMPORTANT SPECIES

The Great Lakes drainage provides the most extensive commercial fishery within the Salina Region. Specific areas of the Great Lakes drainage contained in the Salina Region are the eastern shore of Lake Michigan, including Grand Traverse Bay; the western shore of Lake Huron, including Saginaw Bay; the central basin of Lake Erie; and many rivers flowing into these lakes.

Before 1950, U.S. commercial fishing in the Great Lakes relied heavily on 11 fish species: lake sturgeon, lake trout, blue pike, lake herring, chub, lake whitefish, carp, sucker, catfish, yellow perch, and walleye (Great Lakes Basin Commission, 1975). Between 1960 and 1970, only the last seven played a major role in the commercial fishery. Invasion by sea lamprey, smelt, and alewife and, in some cases, overfishing have contributed to the virtual elimination of the first four species from the commercial fishery. Four introduced species (coho, chinook salmon, kokanee salmon, and the splake) are expected to play an important part in future fishery (Great Lakes Basin Commission, 1975).

Lake trout was the primary species in the Lake Michigan commercial fishery until the late 1940s, when the fishing effort shifted to more abundant low-value species. Zarbock (1977) states that the last native lake trout were taken in 1955. Although there has been a significant stocking program (average of 2 million yearlings per year), at present (1977) there is no evidence of successful spawning of lake trout in Lake Michigan (Zarbock, 1977). In 1952, lake herring production reached a high of 9,691,000 pounds, but lake herring is now commercially insignificant and is rapidly approaching extinction (Great Lakes Basin Commission, 1975). Walleye production from Lake Michigan varied from 50,000 to 200,000 pounds annually from the turn of the century to the late 1940s. Walleye presently contributes less than 5000 pounds annually to the commercial catch. Commercial chub production varied between 1.5 and 6.0 million pounds annually between 1900 and 1948. In 1950, it surpassed 10 million pounds for the first time and has remained near 10 million pounds annually since then. However, the diversity of chub species has declined, and now only bloaters (Coregonus hoyi) are taken. The catch of yellow perch doubled in 1961 and reached a peak of 5,835,000 pounds in 1964. In 1968, the catch dropped to 632,000 pounds, an almost tenfold decrease over 4 years. The yellow perch commercial fishery has been closed in the State of Michigan waters of Lake Michigan since 1970 (Zarbock, 1977).

Whitefish is one of the few commercial species that appears to have recovered from the effects of heavy exploitation and sea lamprey predation. The whitefish catch in the mid to late 1960s was approximately 1 million pounds annually. The 1976 commercial catch of whitefish increased by 17% over 1975 (Zarbock, 1977). An increase in fishing effort to collect low-value alewife and smelt was noted after the decline of the high-value species. In the late 1960s and early 1970s, annual alewife and smelt production stabilized at approximately 25 million and 1.5 million pounds (Great Lakes Basin Commission, 1975).

In Lake Huron, commercial landings during 1970-1975 reflect the concentration on medium- and low-value species because of depressed stocks or the near absence of many high-value species such as walleye, lake whitefish, and lake trout. Except for chub and yellow perch, the total average annual values for all commercially important species have followed the general downward trends observed in other Great Lakes before 1965. Chub catches have decreased substantially, resulting in a sharp decrease in total catch value despite increased prices. On the other hand, the total catch of yellow perch increased dramatically through 1966 (Great Lakes Basin Commission, 1975). Zarbock (1977) reports

that, since 1966, yellow perch production has increased in Lake Huron, but walleye production has decreased.

The Lake Erie fishery has accounted for a third of the total Great Lakes fish production annually. The present fishery is made up mainly of walleye, yellow perch, white bass, channel catfish, carp, sheepshead, suckers, and bullhead (Great Lakes Basin Commission, 1975). In 1975, 39,279,000 pounds (i.e., 39% of the total Great Lakes commercial fish production) were taken from Lake Erie (Zarbock, 1977). Because of the high utilization of Lake Erie waters, there has been a noticeable change in the fishery. Sturgeon virtually disappeared from the lake near the turn of the century. Cisco, once dominant in Lake Erie, experienced a sharp decline in 1926 and by 1957 had become insignificant. Whitefish was abundant until 1955, when this species was reduced significantly. Walleye declined in 1957 and has not recovered. The blue pike, nearly extinct in 1958, is now an officially endangered species. The yellow perch population of Lake Erie is also declining. The smelt population remains relatively stable. White bass and channel catfish have been abundant in Lake Erie since the turn of the century, and utilization emphasis has shifted to these species in the past 20 years (Great Lakes Basin Commission, 1975).

A limited amount of commercial fishing was recorded in the Finger Lakes Region of New York in the late nineteenth century (Youngs and Oglesby, 1972), but the harvest in the Finger Lakes is now limited to sport fishing.

The commercial fishery resources of the Ohio River drainage are not as extensive as those of the Great Lakes drainage, but they do constitute a limited fishery resource. The commercial fishery for finfish in the Ohio River drainage was valued in 1969 at less than $1500 in West Virginia, while no catch was reported for Ohio and Pennsylvania (USDC, 1972). Major species were catfish, bullheads, carp, and buffalo. The 1975 Ohio River catch was between 10,000 and 13,000 pounds, valued in Ohio and West Virginia at $5000 to $13,000 (Douthat, 1976). The commercial catch in the Salina Region portion of the Ohio River may be considered negligible.

Another resource that is exploited in the Ohio River basin is that of commercial mussels or clams. These were used mainly in the pearl-button industry, which during the decade preceding World War I was a flourishing multimillion-dollar enterprise. Changing demands, increasing use of synthetic materials, depletion of high-yield mussel beds, pollution of productive streams, and other factors hastened their decline after World War I. From 1908 to 1922, it is estimated that the basin supplied approximately one-third of the total U.S. production of mussel shells (FWS, n.d.). At present, the major use for mussels is as seed in the Japanese cultured pearl industry.

Since 1950, the Tennessee River has been the major source of shells, although the Ohio, White, and Wabash Rivers of the Ohio basin also have provided significant quantities (FWS, n.d.).

Although the 1969 commercial clam catch in Ohio was valued at $55,000 (USDC, 1972), most of the clamming in the Ohio River drainage occurs outside the Salina Region. The major commercial clamming areas on the Ohio River are located between Portsmouth and Cincinnati, Ohio (Stansbery, 1977). The Muskingum River in Ohio also provides an important clamming resource (Clark, 1971); however, most are taken outside the Salina Region (Clark, 1971).

8.2.2 RECREATIONALLY IMPORTANT SPECIES

The Great Lakes basin has numerous inland lakes that support a diverse sport fishery. These lakes, along with the sport fishing derived from the larger Great Lakes, are a valuable recreational resource. The inland waters of lower Michigan and the deeper waters of eastern Lake Michigan and western Lake Huron provide an extensive recreational fishery in the Salina Region.

Yellow perch remains the primary sport fish in Lake Michigan, although other species (e.g., the walleye, smelt, smallmouth bass, and suckers) are of seasonal importance as they move into the rivers or near shore to spawn. Since the mid-1960s, trout and salmon sport fisheries have played a more significant role. Sea lamprey control programs and massive plantings of lake trout, coho salmon, chinook salmon, rainbow trout, brown trout, and steelhead trout have made trout and salmon fishing in Lake Michigan one of the most important sport fisheries in the Great Lakes region (Great Lakes Basin Commission, 1975).

In the Lake Huron drainage of the Great Lakes basin, yellow perch, northern pike, smallmouth bass, walleye, and smelt have been the primary sport fish. Although the walleye, bass, and northern pike fisheries have always been restricted to large protected bays and northern island areas, yellow perch fishing was once good from Port Huron to the Straits of Mackinac. In 1975, 80% of the sport fish catch was yellow perch (Zarbock, 1977).

Salmonid stocking was started by Michigan in 1968, when coho salmon, chinook salmon, and steelhead trout were planted in rivers flowing into Lake Huron. Brown trout and rainbow trout were added to the list of species stocked in 1970. Michigan's 1970 creel census of the Lake Huron sport fishery indicated that smelt ranked first in numbers of warm-water fish caught, followed by yellow perch, centrarchid panfish, suckers, bass, northern pike, and muskellunge. Although fishing interest in catfish remains low, it is gaining in importance to the sport fishery.

Most of the warm-water sport fishing occurs in either Saginaw Bay within the Salina Region or the extreme northern portion of Lake Huron, in the Les Cheneaux and Drummond Island areas. In 1970, the total catch of Lake Huron salmonid species in Michigan waters was 158,600. Trout and salmon fishermen took 76,000 coho salmon, 18,000 chinook salmon, 64,000 steelhead trout, and 600 lake trout in Lake Huron and tributaries during 1970 (Great Lakes Basin Commission, 1975). Zarbock (1977) reports that in the 1975 fishing season 2% of the catch was trout and salmon species.

Sport fishing in Lake Erie during the past decade has been directed primarily at yellow perch, white bass, channel catfish, walleye, and smallmouth bass. Yellow perch is by far the most popular species and is harvested throughout the lake. Angling for white bass and channel catfish is a spring and early summer fishery, mainly confined to the western and central basins. Walleye and smallmouth bass angling is concentrated in the Bass Islands and reef areas of the western basin and along the rocky shorelines of the central and eastern basin.

Another area of sport-fishing interest within the Salina Region is the Finger Lakes of New York State. As an example, Cayuga Lake, one of the two largest lakes in the Finger Lakes region, supports both warm-water and cold-water sport fisheries. The introduction of salmonid fishes has contributed substantially to sport fishing in Cayuga Lake. The lake trout fishery is dependent on an annual stocking program. The only definitive creel census of Cayuga Lake fishing, conducted by Miller (1954), showed that the dominant

species were pumpkinseed, brown bullhead, and yellow perch. Other species reported, in decreasing order of abundance, were smallmouth bass, largemouth bass, rock bass, chain pickerel, black crappie, white perch, channel catfish, lake trout, northern pike, and carp. Lake trout is the most important sport fish in Cayuga Lake, although it is maintained by stocking. The composition of sport fish is somewhat similar in other Finger Lakes, except for the minimal lake trout catches in unstocked lakes.

The Fish and Wildlife Service (FWS, n.d.) has presented information on the sport fishery in the Ohio River basin, a portion of which lies within the Salina Region. Cold-water streams capable of producing or sustaining trout fishing are located primarily in the ridge section of the Appalachian region within the Salina Region and are generally associated with forested, mountainous areas. The balance of the Appalachian region within the Salina Region and upland portions of the remaining regions contain the smallmouth bass-rock bass-sucker streams. Certain reaches of these streams support fishable populations of walleye and northern pike. The lower reaches of the upland streams and streams in the lowlands or plateaus produce carp, catfish, largemouth bass, spotted bass, sauger, crappies, and suckers. The basin's major tributary streams contain all of the species mentioned, except trout.

Native fish populations in many natural lakes have been augmented with stocked species (FWS, n.d.). In contrast with natural lakes, located mainly in the Allegheny drainage within the New York and Pennsylvania part of the Salina Region, ponded-water fish populations are generally the result of artificial stocking. Man-made reservoirs and farm ponds are usually stocked with various combinations of largemouth bass, sunfish, crappies, white bass, walleye, yellow perch, catfish, and bullheads. A few cold-water ponds in the Appalachian region within the Salina Region are stocked and managed for trout. Northern pike also have been established in some reservoirs in Pennsylvania and Ohio.

Sport fishing in the Upper Susquehanna drainage within the Salina Region includes both cold-water and warm-water species. The cold-water fishery (mainly trout species) exists in the upper watershed areas in cooler forested portions of the Appalachian Plateaus province (Susquehanna River Basin Study, 1970). The most popular and widely distributed warm-water species is the smallmouth bass. Another popular species is the walleye. The muskellunge, an introduced species, is another important sport fish, with distribution in the main stem and in the lower reaches of the major tributaries. Other species of the warm-water fishery are the bluegill, yellow perch, and catfish (Susquehanna River Basin Study, 1970). Denoncourt and Cooper (1975) report that 87 fish species occur or are expected to occur in the Susquehanna River drainage above Conowingo Dam. There has been a conscientious effort by the Pennsylvania Fish Commission to reestablish fish species in the Susquehanna River drainage above the Conowingo Dam, and Denoncourt et al. (1975) report that 17 fish species have recently been introduced.

8.3 ENDANGERED AND THREATENED SPECIES

The Endangered Species Act of 1973 was passed by the 93rd Congress and signed into law on December 28, 1973 (Public Law 93-205). The Act defines "endangered species" as any species that is in danger of extinction throughout all or a significant portion of its range. A "threatened species" is defined as any species that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range (Public Law 93-205, 1973). The Act provides for an endangered species list and a threatened species

list. These lists, which are regularly reviewed and updated, are published as regulations in the Federal Register by the Secretary of the Interior (for inland water species).

Another important facet of the Act is the provision for cooperative agreements between Federal and state governments. A state that maintains an adequate and active conservation program may set up and define the endangered and threatened species program within its borders. The Federal Government assists in implementing the endangered and threatened species program for each state.

At present, the States of New York, Ohio, Michigan, and Pennsylvania have active programs in the protection of endangered and threatened species that inhabit their waters. The remaining state within the Salina Region, West Virginia, is in the process of completing its list. Because this list is not officially available, use is made of information provided by the State of West Virginia in the form of its scientific collection permit, which lists fish species that may not be taken in West Virginia waters. For purposes of this regional report, it was assumed that these species may be considered endangered.

The aquatic life presently considered endangered or threatened within the Salina Region includes both fish and invertebrates. Many of the species listed as endangered or threatened in the current Federal list (FWS, 1977b) or in the state lists occur within the Salina Region. Information on the status and distribution of endangered and threatened species is provided in Tables 8-1 and 8-2.

8.3.1 ENDANGERED AND THREATENED FISH SPECIES

Fifty-one fish species are considered endangered or threatened in the five states within the Salina Region. Of these, forty-four are believed to occur within the Salina Region.

Five species of lamprey are either endangered or threatened in Ohio. Four species occur within the Salina Region (Ohio Natural Heritage Program, 1977). All five species are reported in the Ohio River drainage, and three of the species (Ichthyomyzon fossor, I. unicuspis, and Lampetra lamottei) are reported in the Great Lakes drainage (Hubbs and Lagler, 1967).

Two species of sturgeon are considered endangered. One species, the shortnose sturgeon, is on the Federal list of endangered species and is also listed as endangered in Pennsylvania and New York. However, it does not occur in the Salina Region. The lake sturgeon is listed as threatened in Michigan and as endangered in the States of Ohio, Pennsylvania, and New York. It occurs within the Salina Region in both major drainages (Trautman, 1957; Hubbs and Lagler, 1967).

The paddlefish family consists of one North American representative. The paddlefish is on the endangered species list of Ohio and may not be taken in West Virginia waters. At one time this species was present in the Great Lakes drainage, where it is now believed to be extinct (Hubbs and Lagler, 1967). In the Ohio River drainage, this species has been most common in the Scioto River and in the Ohio River below Portsmouth, Ohio. It was recorded above Marietta, Ohio, before 1925 (Trautman, 1957). It is believed to still exist in northeastern Ohio within the Salina Region (Ohio Natural Heritage Program, 1977).

The spotted gar and the shortnose gar are listed as endangered in Ohio. The spotted gar occurs in the Great Lakes and the Ohio River drainage and is present in the Salina Region. The shortnose gar probably does not occur within the Region, although Trautman (1957) reports that, before 1925, an occasional specimen was taken by fishermen in the Ohio River between Washington and Jefferson Counties.

TABLE 8-1

SPECIAL-STATUS FISH SPECIES AND THEIR DISTRIBUTIONS WITHIN THE SALINA REGION

Common Name[b]	Scientific Name[b]	Great Lakes Drainage[c]	Ohio River Drainage[d]	Susquehanna River Drainage[e]	Salina Region[f]	Status[a] Federal	MI	NY	OH	PA	WV
Lampreys	Petromyzontidae										
Ohio lamprey	Icthyomyzon bdellium (Jordan)		X								
Northern brook lamprey	I. fossor Reighard and Cummins	X	X		X[f]				E		
Allegheny brook lamprey	I. greeleyi Hubbs and Trautman		X		X[f]				E		
Silver lamprey	I. unicuspis Hubbs and Trautman	X	X		X[f]				E		
American brook lamprey	Lampetra lamottei (Lesueur)	X	X		X[f]				E		
Sturgeons	Acipenseridae										
Short-nose sturgeon	Acipenser brevirostrum Lesueur					E		E		E	
Lake sturgeon	A. fulvescens Rafinesque	X	X		X		T		E	E	
Paddlefishes	Polyodontidae										
Paddlefish	Polyodon spathula (Walbaum)		X		X[g]				E		E
Gars	Lepisosteidae										
Spotted gar	Lepisosteus oculatus (Winchell)	X	X		X				E		
Shortnose gar	L. platostomus Rafinesque		X						E		
Mooneyes	Hiodontidae										
Mooneye	Hiodon tergisus Lesueur	X	X		X				E		E
Trouts	Salmonidae										
Longjaw cisco	Coregonus alpenae (Koelz)	X			X	E	E	E			
Cisco or lake herring	C. artedii Lesueur	X		X	X		T		E		
Bloater	C. hoyi (Gill)	X			X		T				
Deepwater cisco	C. johannae (Wagner)	X			X		E				
Kiyi	C. kiji (Koelz)	X			X		T				
Blackfin cisco	C. nigripinnis (Gill)	X			X		E				
Shortnose cisco	C. reighardi (Koelz)	X			X		E				
Shortjaw cisco	C. zenithicus (Jordan and Evermann)	X			X		E				
Pikes	Esocidae										
Muskellunge	Esox masquinongy Mitchill	X	X	X	X				E		E
Minnows and carps	Cyprinidae										
Redside dace	Clinostomus elongatus (Kirtland)	X	X	X	X		T				
Rosyside dace	C. funduloides Girard		X	X					E		
Tonguetied minnow	Exoglossum laurae (Hubbs)	X	X						E		
Silver chub	Hybopsis storeriana (Kirtland)	X	X		X				E		
Bigeye shiner	N. boops Gilbert		X		X				E		
Ghost shiner	N. buchanani Meek		X		X[g]				E		
Bigmouth shiner	N. dorsalis (Agassiz)	X	X		X[g]				E		
Pugnose minnow	N. emiliae (Hay)	X	X		X[g]				E		
Blacknose shiner	N. heterolepis Eigenmann and Eigenmann	X	X	X	X[g]				E		
Silver shiner	N. photogenis (Cope)	X	X		X		T				

TABLE 8-1 (Continued)

Common Name[b]	Scientific Name[b]	Great Lakes Drainage[c]	Ohio River Drainage[d]	Susquehanna River Drainage[e]	Salina Region[f]	Status[a] Federal	MI	NY	OH	PA	WV
Suckers	Catostomidae										
Longnose sucker	Catostomus catostomus (Forster)	X	X		X				E		
Blue sucker	Cycleptus elongatus (Lesueur)		X		X				E		E
Lake chubsucker	Erimyzon sucetta (Lacepede)	X	X		X[g]				E		
River redhorse	Moxostoma carinatum (Cope)		X		X		T		E		
Greater redhorse	Moxostoma valenciennesi Jordan	X			X				E		
Freshwater catfishes	Ictaluridae										
Mountain madtom	Noturus eleutherus Jordan		X		X				E		
Northern madtom	N. stigmosus Taylor	X	X		X		T		E		
Scioto madtom	N. trautmani Taylor		X			E			E		
Pirate perches	Aphredoderidae										
Pirate perch	Aphredoderas sayanus (Gilliams)	X			X				E		
Codfishes	Gadidae										
Burbot	Lota lota (Linnaeus)	X		X	X				E		
Killifishes	Cyprinodontidae										
Banded killifish	Fundulus diaphanus (Lesueur)	X	X	X	X				E		
Sticklebacks	Gasterosteidae										
Threespine stickleback	Gasterosteus aculeatus Linnaeus								E		
Perches	Percidae										
Eastern sand darter	Ammocrypta pellucida (Putnam)	X	X		X[g]		T		E	T	
Iowa darter	Etheostoma exile (Girard)	X	X		X				E		
Spotted darter	E. maculatum Kirtland		X		X				E		
Tippecanoe darter	E. tippecanoe Jordan and Evermann		X		X				E		
Channel darter	Percina copelandi (Jordan)	X	X		X[g]				E		
Longhead darter	P. macrocephala (Cope)		X		X				E		
Slenderhead darter	P. phoxocephala (Nelson)		X		X				E		
River darter	P. shumardi (Girard)	X	X		X				E		
Blue pike	Stizostedion vitreum glaucum Hubbs	X			X	E		E	E	E	

a. Federal status based on Federal Register, 42(135), 36420-36431, July 1977. State status based on state lists, with the exception of West Virginia, where the status is based on species that may not be taken with scientific collection permit. Key: E = endangered; T = threatened.
b. Nomenclature follows Bailey et al. (1970).
c. Principal data source: Hubbs and Lagler (1967).
d. Principal data source: Trautman (1957).
e. Principal data source: Denoncourt and Cooper (1975).
f. Principal data sources: Trautman (1957), Hubbs and Lagler (1967), and Carlander (1969).
g. Species occurs in the northeastern Ohio portion of the Salina Region (Ohio Natural Heritage Program, 1977).

TABLE 8-2

SPECIAL-STATUS AQUATIC INVERTEBRATES

WITH POTENTIAL DISTRIBUTIONS WITHIN THE SALINA REGION[a]

Common Name[c]	Scientific Name[c]	Great Lakes Drainage[d]	Ohio River Drainage[d]	Status[b] Federal	MI	OH
	Mollusca					
Snails	Gastropoda					
	Lymnaea megasoma (Say)	X			T	
	Amnicola binneyana (Hannibal)	X			T	
	Paludestrina (Fontigens) nicklineana (Lea)	X	X		T	
	Pomatiopsis cincinnatiensis (Lea)	X			T	
Mussels	Pelecypoda					
Long-solid	Fusconaia subrotunda (Lea)		X			E
Cob shell	Quadrula cylindrica (Say)		X			E
Monkeyface	Q. metanevra (Rafinesque)		X			E
Nodule shell	Q. nodulata (Rafinesque)		X			E
Purple pimple-back	Cyclonais tuberculata (Rafinesque)	X	X		T	
	Elliptio complanatus (Dillwyn)	X			T	
Bullhead	Plethobasus cyphyus (Rafinesque)		X			E
Club shell	Pleurobema clava (Lamarck)	X	X		T	E
Ohio pig-tie	P. cordatum (Rafinesque)	X	X			E
	Anodonta subgibbosa (Anthony)	X			T	
Simpson's shell	Simpsonaias ambigua (Say)	X	X		E	E
	Actinonaias ellipsiformis (Conrad)	X			T	
White cat's paw	Epioblasma (= Dysnomia) sulcata perobliqua (Conrad)	X		E		E
Tuberculed-blossom pearly	Epioblasma (= Dysnomia) torulosa torulosa (Rafinesque)		X	E		
Northern riffle shell	Epioblasma (= Dysnomia) torulosa rangiana (Lea)		X			E
	Epioblasma (= Dysnomia) triquetra (Rafinesque)	X	X		T	
Butterfly	Plagiola lineolata (Rafinesque)		X			E
	Lampsilis fasciola (Rafinesque)	X	X		T	
Pink mucket pearly (orb mucket)	L. orbiculata orbiculata (Hildreth)		X	E		E
Ridged pocketbook	L. ovata (Say)	X	X			E
Yellow sandshell	L. teres (Rafinesque)		X			E
Fragile heel-splitter	Potamilus laevissimus (Lea)	X	X			E
Fan shell	Cyprogenia stegaria (Rafinesque)		X			E
	Obovaria leibii (Lea)	X	X		E	
Allegheny crayfish	Arthropoda					
	Crustacea					
	Orconectes obscurus (Hagen)		X			E

a. Pennsylvania (1977) and New York (1977) have no invertebrates listed. West Virginia presently does not have an official list.
b. Federal status based on Federal Register, 42,(135), 36420-36420-36431, July 1977. State status based on current state listings from Michigan (1976) and Ohio (1976). Key: E = endangered; T = threatened.
c. Nomenclature for invertebrates in most cases follows that in Ohio and Michigan listings.
d. Distributions of many invertebrate species not well documented. However, general distributions by Burch (1975) were followed.

The mooneye has been listed as endangered in Ohio and may not be taken in West Virginia waters. It occurs in the Ohio River drainage and the Great Lakes drainage within the Salina Region (Trautman, 1957; Hubbs and Lagler, 1967).

The eight species of Salmonidae (trout and cisco) listed in Table 8-1 as endangered or threatened occur within the Salina Region. These species are all found in the cold, deep waters of the Great Lakes. The longjaw cisco is on the Federal list of endangered species and occurs in Lake Michigan and Lake Huron.

The muskellunge is listed as endangered in Ohio and may not be taken in West Virginia. It occurs in the Great Lakes and in the Ohio River and Susquehanna River drainages, and is present within the Salina Region.

A total of 10 species of Cyprinidae (minnows and carps) are listed as endangered or threatened in Ohio and Michigan. The rosyside dace and the tonguetied minnow are not found in the Salina Region (Trautman, 1957; Hubbs and Lagler, 1967).

Five species of sucker are listed as endangered or threatened in either Michigan or Ohio. All of the species noted in Table 8-1 may occur within the Salina Region. Lack of recent literature on the distributions of several of these species leaves their status in question. For example, Trautman (1957), on the basis of interviews with fishermen, records that occasional blue suckers were taken on the Ohio River in the 1925-1950 period between Marietta, Ohio, and the Pennsylvania state line. It is not known whether the species still occurs in the Salina Region (Trautman, 1957; Hubbs and Lagler, 1967).

Three species of madtom catfish are listed as endangered. The mountain madtom occurs in the Ohio River drainage (Taylor, 1969) and within the Salina Region. The northern madtom is present in the Ohio River drainage and the Great Lakes drainage (Taylor, 1969) within the Salina Region. The Scioto madtom occurs only in the drainage of the Scioto River, a tributary of the Ohio River (Taylor, 1969). Only the Scioto madtom is on the Federal list of endangered species, but it is not found in the Salina Region.

The pirate perch is on the endangered species list of Ohio and is rare in the Great Lakes region (Hubbs and Lagler, 1967). It is found in the Maumee River drainage of Ohio (Trautman, 1957). It may occur within the Salina Region.

The burbot is listed as endangered in the State of Ohio. It occurs in the Great Lakes drainage within the Salina Region (Trautman, 1957).

The banded killifish is on the endangered species list of Ohio. It is found in both the Ohio River drainage and in the Great Lakes drainage, and occurs within the Salina Region (Trautman, 1957; Hubbs and Lagler, 1967).

The threespine stickleback is listed as endangered in Pennsylvania; it most likely does not occur in the Salina Region. However, Scott and Crossman (1973) record its presence in the Lake Ontario basin, a portion of which lies within the Salina Region.

Nine species of Percidae are listed as threatened or endangered in Michigan, Ohio, Pennsylvania, or New York. One of these is on the Federal list of endangered species: the blue pike (Stizostedion vitreum glaucum), which occurs only in the Great Lakes, particularly in Lake Erie. All of the perches listed in Table 8-1 as threatened or endangered species occur within the Salina Region.

8.3.2 ENDANGERED AND THREATENED INVERTEBRATES

Only the States of Michigan and Ohio have included invertebrates in their lists of endangered and threatened species.

Because the distributions of many of these species in most areas are not well known, it is presently impossible to determine whether or not they are found in the Salina Region. Under the Ohio Natural Heritage Program (1977), several of the invertebrates have been documented as being present in the Salina Region. These include Simpson's shell and the Allegheny crayfish. Three species of Pelecypoda included in the Federal list of endangered molluscan species occur in either the Ohio River drainage or the Great Lakes drainage. It is probable that one of these species, the white cat's-paw mussel, does occur within the Salina Region. The tuberculed-blossom pearly mussel most likely does not occur in the Salina Region on the basis of the known distribution pattern (Federal Register, 42(135), July 1977). The third endangered species, the pink mucket pearly mussel, may or may not occur in the Salina Region since it is recorded from the Muskingum River, Ohio. A portion of the upper Muskingum River lies within the Salina Region.

8.4 SUMMARY

The Salina Region includes a wide variety of standing and flowing water bodies. Both the standing waters of the Great Lakes and Finger Lakes and the flowing waters of the Ohio River and certain tributaries such as the Muskingum River have commercial and recreational value. In general, there has been a trend in the Great Lakes for high-value commercial fish species such as lake trout, lake sturgeon, and blue pike to be replaced by low-value species such as alewife and smelt. This change has been brought about mainly by overutilization and sea lamprey invasion.

A total of 44 species of fish are recorded as endangered or threatened by one or more states within the Salina Region. Only two fish species on the Federal list of endangered species occur in the Salina Region. These two, the longjaw cisco and the blue pike, occur in the Great Lakes. One invertebrate on the Federal list of endangered species, the white cat's-paw mussel, is believed to occur in the Great Lakes drainage within the Salina Region.

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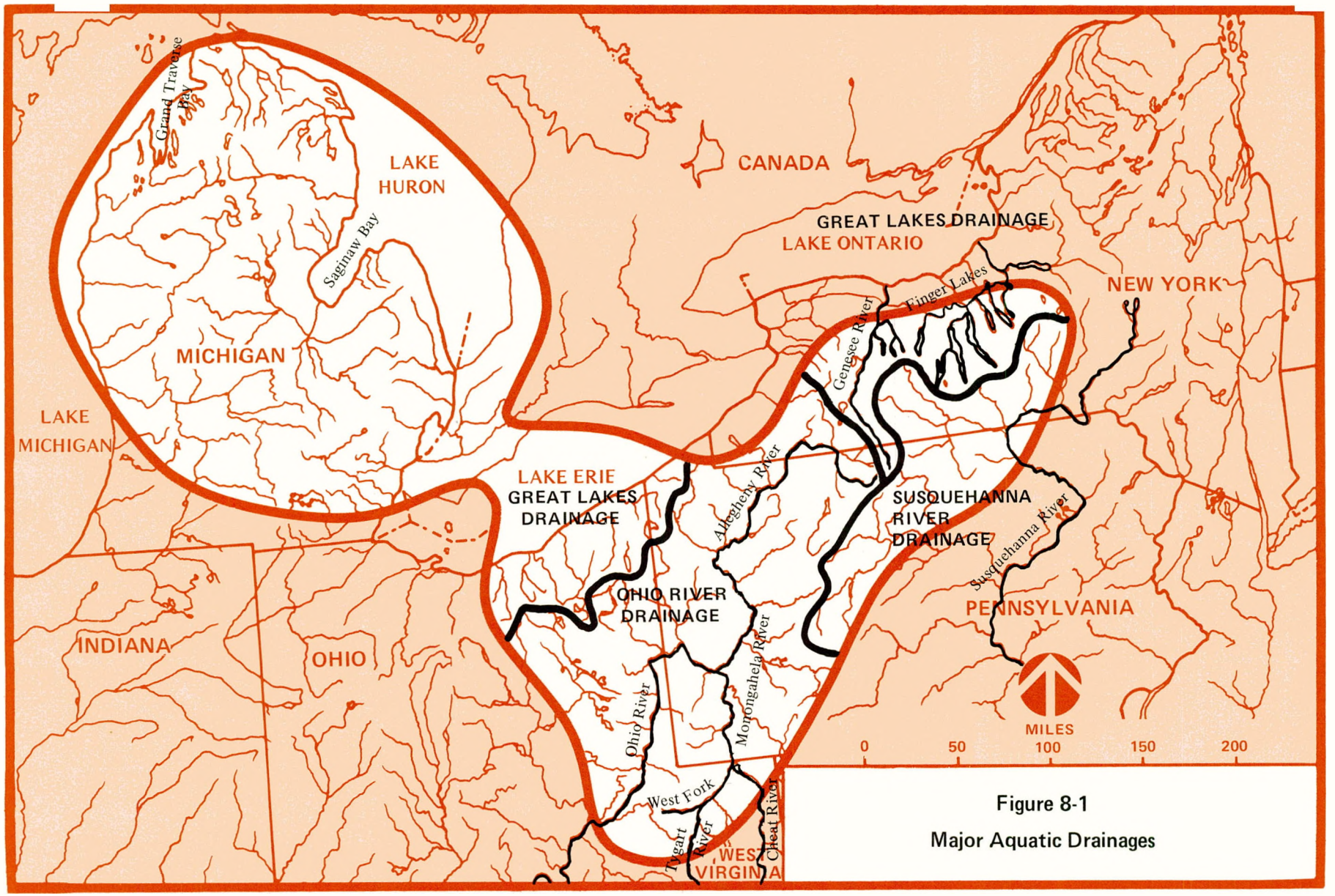


Figure 8-1

Major Aquatic Drainages

9.0 SUMMARY

9.1 GEOSPHERE

The Salina Region includes portions of New York, Pennsylvania, Ohio, Michigan, West Virginia, and Canada. The entire Region encompasses approximately 80,000 square miles of land area in the United States.

About half of the Salina Region is in the Great Lakes section of the Central Lowland physiographic province. The lakes and terrain features, such as moraines and drumlins, reflect the prominent effects of glaciation in this section. The remainder of the Salina Region is a part of the Appalachian Plateaus physiographic province. It is composed of shallow river valleys and broad ridges, with escarpments that provide abrupt changes in elevation. Local elevations generally vary by no more than 300 to 400 feet; however, the elevation increases in going from west to east from about 1000 feet above sea level in Ohio to about 2000 feet above sea level in New York.

The Salina Region lies within two major tectonic divisions: the Central Stable Region in the west and the orogenic belts of the Atlantic margin in the east. The Central Stable Region is founded on Precambrian rocks that compose the stable interior of the North American continent. The eastern areas of the Salina Region contain mountainous areas uplifted and deformed during the Paleozoic Era. Separating the eastern and western portions of the Salina Region are a series of arches--areas that were stable or gently uplifted during the Paleozoic Era, when the Appalachian and Michigan basins were subsiding. It was during these periods of subsidence that salt beds were formed. All these structures are extremely old, with no major movements in the earth's crust for approximately 190 million years. Indeed, the Salina Region has experienced no major internal tectonic activity since Precambrian time (1 billion years ago). Major structural features within the Salina Region are few, uncomplicated, and broad in extent. Minor structures within the region are also relatively few and simple.

The Salina Region is one of low seismicity. Earthquakes in the eastern portion of the region are attributed to readjustment of the earth's crust after the most recent Ice Age. Major surface faulting is uncommon. Several seismic events have occurred in the vicinity of Attica in western New York. These earthquakes have been related to the Clarendon-Linden Fault, a north-south-trending tectonic feature. Several moderate earthquakes (Modified Mercalli intensity of V) have occurred near Cleveland, Ohio. Portions of the Salina Region in Michigan, Pennsylvania, and West Virginia have been virtually earthquake-free.

Oil and gas fields have been developed in all parts of the Salina Region. Primary, secondary, and tertiary recovery efforts, which include water flooding and fracturing, may have affected portions of the Silurian salt layers. The most abundant oil and gas fields are in Pennsylvania, West Virginia, and Ohio. Major bituminous coal reserves occur in Pennsylvania, West Virginia, Ohio, and Michigan. Much of the coal is within 300 feet of the surface, well above the salt beds being considered for a potential repository. Metallic ores in the Salina Region are of low grade and of limited economic importance. Several nonmetallic minerals of economic importance are extracted within the Salina Region: salt, salt brines, silica, and construction materials (sand, gravel, gypsum, etc.). With the exception of salt brines, it is not expected that current or future recovery of these minerals would affect waste repository siting.

9.2 HYDROSPHERE

The Salina Region is subdivided into three Hydrologic Regions (HR): HR I, southeastern Great Lakes basin; HR II, Susquehanna River headwaters; and HR III, northeastern Ohio River basin.

Hydrologic Region I covers the drainage area of Lake Huron, Lake Erie, and Lake Ontario. The terrain is characterized by flat land, lakes, marshes, and peat bogs, reflecting the poor development of regional drainage systems. Streams are relatively short and follow the lows of the glaciated terrain. The terrain is therefore more conducive to infiltration than to direct, rapid surface runoff. Water available for withdrawal and use in HR I comes primarily from precipitation within the area. Annual precipitation ranges from 28 to 37 inches; approximately one-third, nearly 12 inches, becomes runoff. Water quality is generally nonsaline throughout HR I.

Major floods and most damaging floods are usually the result of rain and snowmelt on frozen or nearly saturated ground. Intense summer storms have created destructive floods, but these are ordinarily confined to local areas. Dams are used for flood control and for water resource management. The largest single use of water in the region is for cooling steam-electricity generating plants. Manufacturing facilities and domestic consumption are also major water users.

Although water-bearing formations underlie all of HR I, the depth to the water table varies with the season, local geologic characteristics, and terrain. With the exception of the lower Michigan Peninsula, productive aquifers (yielding to a well at least 50 gpm of water containing not more than 2000 ppm of dissolved solids) are located only along some of the main watercourse alluvial valleys. Because of the abundance of surface-water supplies in HR I, groundwater usage has not been extensively developed and constitutes generally less than 10% of the total water use.

Hydrologic Region II is located in the headwaters area of the Susquehanna River, which flows southeasterly from south-central New York through Pennsylvania and Maryland. The two major tributaries of the Susquehanna River that flow through HR II are the West Branch of the Susquehanna River and the Chemung River. Hydrologic Region II is characterized by deeply eroded, steep-sided, flat-bottomed valleys and flat to gently rolling plateaus varying in relief from several hundred feet in New York to nearly 2000 feet in Pennsylvania. This type of landscape tends to shorten the time for precipitation to run off into streams and consequently promotes the possibility of flooding. Precipitation averaging nearly 38 inches annually in HR II is the major source of water supply. The mean annual runoff varies from about 15 to 25 inches, about half of this occurring during the 3-month period from March through May. Some tributaries of the West Branch of the Susquehanna River are heavily influenced by acid mine drainage. Nevertheless, the dissolved-solids concentration of most streams in HR II seldom exceeds 800 ppm. Generally, floods occur each year in HR II; major flooding can occur in all seasons. Flooding is, however, more frequent in early spring, usually in March. Major floods have been caused by heavy rainfall on top of heavy snowfall and by heavy rainfall on previously saturated ground. Occasionally, local flooding is caused by ice jams or from thunderstorms during the summer months. As in HR I, major water uses are for steam-electricity generation, manufacturing, and domestic consumption.

The abundant water in the Susquehanna River basin is being looked to by communities outside the area as a supply source for the future. Currently significant quantities of water are transmitted by pipeline to Chester, Pennsylvania, and Baltimore, Maryland.

Rural water supply needs will also increase rapidly in the future. This includes rural domestic use, consumption by livestock, and irrigation. The increases are not as dramatic as in the urban areas, but they are nevertheless substantial and must be planned for, particularly where they compete directly with urban needs.

Groundwater in HR II occurs in appreciable quantities in rock strata and is generally of good quality, except near coal mines below Tioga County, Pennsylvania. Deep aquifers in the region may be saline or brackish. Highly permeable glacial deposits along most of the valleys are significant sources of groundwater. These aquifers are very productive and readily recharged. Since most urban communities are situated on the water-bearing glacial deposits in the valleys, groundwater in the rocks has not been widely utilized. Although water-use data are not available for HR II, data for the entire Susquehanna River basin, which includes HR II, indicate that 17% of the total water consumption is supplied by groundwater. Total groundwater use is expected to increase as total water demands grow in the region.

Hydrologic Region III lies in the northeastern section of the Ohio River basin. Major streams in this region are the Allegheny River, Monongahela River, Muskingum River, Beaver River, and the main stem of the Ohio River. Hydrologic Region III is located in the Appalachian Plateaus physiographic province, which is characterized by rugged terrain resulting from the differing resistance of the rock to weathering and runoff. Extensive forest cover, poor-quality soils, narrow valleys, steep stream gradients, and flash floods during the dry seasons are characteristic of this area. Vegetation is generally sufficient to retard runoff and minimize erosion. Precipitation averages about 45 inches annually; runoff ranges from about 11 to 25 inches per year. Many minor tributary streams throughout the area normally cease flowing during the dry season, with drought periods adding to their number. Often during late summer and early fall, stream flow from precipitation is negligible, the only flow being from groundwater seepage. Waters of the region are nonsaline, although some tributaries have high concentrations of dissolved solids. In order of gross consumption, major water uses are for steam-electricity generation, manufacturing, and domestic use.

Valley-fill sediments, consisting both of glacial outwash and recent alluvium, are the most important source of groundwater in HR III. Highest yields occur generally in the valleys of the Ohio River and its north-side tributaries. Most bedrock systems in the area are relatively poor water bearers, although productive aquifers do occur in some limited rock strata that underlie portions of HR III. High iron concentrations are often found in these waters. Groundwater supplies have been developed in the valley-fill sediment aquifers primarily for use at the point of need. Because of the large areas covered by these aquifers, most of the stored water has been untouched by current development.

9.3 ATMOSPHERE

The Salina Region is located primarily within the Great Interior climatic zone. Differences in climate are controlled primarily by latitude, general air mass and storm movements, elevation, and distance from moisture. Modifications to the climatic patterns are introduced by the Great Lakes and by the orographic lifting effects of the Appalachian Mountains. The climate of the Salina Region is generally characterized as cool in the northern section and warm temperate and rainy in the southern section. Wind and precipitation patterns indicate a very low erosion potential in the Region.

Fundamental changes in the climate of the Region have occurred over the last million years (the Pleistocene Epoch). In this period there have been four ice ages during which glaciers covered much of the Salina Region.

The most recent ice age (Wisconsin Glacial) ended about 10,000 years ago, although continuous ice sheets still exist in the polar regions. The current epoch (Holocene), which began 10,000 years ago, is considered to be interglacial. However, there are indications that a long-term global cooling trend is under way at present.

In the Salina Region, severe-weather conditions are rather typical of those occurring in most areas of the contiguous United States. The maximum 24-hour rainfall with a 100-year recurrence interval ranges from 4 to 6 inches. The frequency of tornadoes is noticeably greater in southern Michigan and eastern Ohio than in other sections of the Region. However, the frequency is significantly lower than that in the Central United States. Most of the Salina Region experiences 100-year maximum winds of less than 90 mph, which is typical for most of the continental United States.

Restrictive dispersion conditions are relatively frequent in the extreme southern section of the Salina Region compared to the rest of the region and to the contiguous United States. Sections of the Salina Region experience less than 25 to nearly 40 episode-days in 5 years.

Air quality statutes and regulations restrict development in areas that are not attaining the national ambient air quality standards (unless certain offset criteria are satisfied) or where emissions would result in violations of the standards or would exceed increments established by the Clean Air Act Amendments of 1977. Data indicate that the national ambient air quality secondary standards for particulates are being exceeded around all major cities and in eastern Ohio, southwestern Pennsylvania, and northern West Virginia.

9.4 BACKGROUND RADIATION

Background radiation is ubiquitous, resulting from cosmic, terrestrial, and fallout sources. Limited data available for the Salina Region reveal no anomalous areas. Dose-rate levels range from 68.8 mrem/yr at Charlevoix, Michigan, to 116.7 mrem/yr at Wheeling, West Virginia.

9.5 DEMOGRAPHIC, SOCIOECONOMIC, AND LAND-USE SYSTEMS

Many areas within the Salina Region are highly urbanized. The heaviest concentrations of urban areas (over 50,000 inhabitants) in the Salina Region occur in Ohio, southern Michigan, and western Pennsylvania. The largest urban areas in or near the Region include Detroit (nearly 4 million inhabitants), Cleveland and Pittsburgh (nearly 2 million inhabitants each), and Buffalo (over 1 million inhabitants).

Total earnings for the Salina Region in 1970 amounted to 66 billion dollars; by the year 2000 earnings will be about 181 billion dollars. Manufacturing accounted for approximately 41% of the total earnings in 1970. Although agriculture and forestry are the dominant land uses, they produce, together with fisheries, about 1% of the total earnings of the Region. Mining and other extractive industries likewise account for about 1% of the regional earnings. Retail and wholesale trade, government, institutions, and other

services account for approximately 56% of earnings in the Salina Region. This percentage is expected to increase and the percentage for manufacturing is expected to decrease in the coming decades.

Sensitive or conflicting commitments of land areas larger than 10,000 acres have been identified; these areas consist of the Allegany Indian Reservation, 10 parks, 8 forests, 3 wildlife refuges, 8 recreation projects, 14 airports, 2 military reservations, and 4 military operations areas. The area committed to these activities totaled less than 6% of the Salina Region. The bulk of the remaining land is agricultural and open land, with some areas preempted for urban and residential development and for transportation networks.

The Salina Region is traversed by a well-developed network of highways, rail lines, and waterways used for commercial transportation.

9.6 TERRESTRIAL ECOSYSTEMS

The broad mosaic of land-use patterns in the Salina Region has a significant influence on the distribution and abundance of terrestrial resources. Major land-use patterns in the Salina Region are forestland (44%), cropland (31%), pastureland (6%), and other rural land (6%).

Four ecoregion categories (sections) occur in the Salina Region: Northern Hardwoods, Beech-Maple Forest, Appalachian Oak Forest, and Mixed Mesophytic Forest. Important natural vegetation includes commercially valuable timber, wetlands, natural areas, and proposed endangered plant species. Commercial forestland in the Region is about 90% hardwoods and 10% softwoods. Forestland is about equally divided among sawtimber, poletimber, and seedling/sapling stands. Approximately 2% of the Region is classified as wetlands having some importance to waterfowl. Some 28 representative wetland areas and 5 National Wildlife Refuges (predominantly in wetland areas) are located in the Region.* The Society of American Foresters has identified 10 natural areas in the Region. Five plant species that are proposed for Federal endangered status occur in the Region.

Regional wildlife includes some 65 species of mammals, at least 400 species of birds, and 73 species of amphibians and reptiles. Forestland, shrubland, and openland species are well represented. Important wildlife includes game species, furbearers, and endangered species. At least 31 game birds and 23 game mammals are found in the Region, and hunting and trapping are important. The white-tailed deer is the most important big-game animal; rabbits and tree squirrels are important small-game mammals. Nonmigratory game birds include the ring-necked pheasant, bobwhite, and ruffed grouse; migratory game birds include waterfowl and the mourning dove. Species on the Federal endangered list include the Indiana myotis, Kirtland's warbler, peregrine falcon, and bald eagle.

Farming is important in the Salina Region. Major crops are corn, hay, winter wheat, and oats. Cattle, swine, and sheep are important livestock.

*In Section 9.5, only three wildlife refuges are reported as sensitive or conflicting commitments of land because of the size criterion (10,000 acres or more).

9.7 AQUATIC ECOLOGY

The Great Lakes provide the most extensive commercial fishery within the Salina Region. Although shifts have occurred in the abundance of various species because of fishing pressures, introduction of predators, and pollution, commercial harvesting of fish remains a significant industry in the Great Lakes. The Ohio River drainage presents a more limited fishery resource. The commercial fish harvest in this drainage may be considered negligible, as are the present-day collections of mussels and clams. The Great Lakes and the Finger Lakes in upstate New York support a diverse sport fishery. Appalachian streams offer trout fishing; in many lower stretches of tributaries and in the main stem rivers of the Salina Region a warm-water fishery exists. Many streams and lakes are augmented with stocked species to enhance sport fishing. Only two fish species and one invertebrate on the Federal list of endangered species occur in the Region.

APPENDIX A

REGULATORY REQUIREMENTS AND COMPLIANCE

A.1 FEDERAL REQUIREMENTS AND INSTITUTIONS

A.1.1 INTERDISCIPLINARY APPROACH

In the National Environmental Policy Act (NEPA) of 1969, the Congress directs that all agencies of the Federal Government shall utilize a systematic, interdisciplinary approach to planning and decision-making. This requirement is being met in part with the assessments outlined in Figure 1-1. The Act also requires that each agency, in consultation with the Council on Environmental Quality, identify and develop methods and procedures for ensuring that environmental values are given appropriate consideration in decision-making; include a detailed environmental statement in every recommendation for legislation and other Federal actions significantly affecting the environment; and consult with, and obtain comments from, any Federal agency that has jurisdiction by law or special expertise relative to a detailed environmental statement.

The Council on Environmental Quality (1973) has provided consultation in the form of general guidelines for the preparation and review of impact statements. Areas of environmental impact that may be involved in the development of a national waste terminal storage facility and the Federal agencies and Federal-State agencies with jurisdiction by law or special expertise to comment are outlined in Figure A-1. The Council has the responsibility (Executive Order 11991, 1977) for issuing regulations to Federal agencies for the implementation of NEPA. This will make the environmental impact statement process more useful, will avoid excessive paperwork and the accumulation of extraneous data, will focus on real environmental issues and alternatives, and will refer to the Council conflicts between agencies relative to the implementation of NEPA.

The U.S. Department of Energy (1977) has developed and published methods and procedures for environmental impact assessments of their legislative and other Federal actions.

Also, DOE has memoranda of understanding (MOU) with NRC, EPA, DOT, and DOI in the area of radioactive waste management, with other interagency MOUs being developed. As part of its responsibility for being the lead Federal agency for licensing a waste repository, the NRC will distribute the DOE-prepared environmental report(s) for comment to agencies such as:

- Department of Agriculture
- Department of Defense
- Department of Commerce
- Department of Health, Education and Welfare
- Department of Housing and Urban Development
- Department of Interior
- Department of Transportation
- Environmental Protection Agency
- Department of Labor

A.1.2 AIR

The Clean Air Act directs the U.S. Environmental Protection Agency (EPA) to develop national ambient air quality standards:

- National Primary Ambient Air Quality Standards: requisite to protect public health.
- National Secondary Ambient Air Quality Standards: requisite to protect public welfare.

The Act also requires the states to submit Air Quality Implementation Plans to EPA for approval; it directs that these plans be developed on the basis of Air Quality Control Regions.

Enforcement of the Clean Air Act by the EPA has resulted in the identification of an agency in each state with the responsibility for establishing a state implementation plan and with the authority to enforce it. The state implementation plans are organized, as required, in terms of Air Quality Control Regions and priority classes for each region (EPA, 1972).

The effects of air quality on siting tend to relate either to nonattainment or to nondegradation. Nonattainment refers to Air Quality Control Regions in which some monitoring stations report air quality (e.g., particulate concentrations) that does not attain the air quality standards. Siting of new emission sources in such regions may be allowed in a part of the control region that is within standards or by means of the offset policy in which existing sources are reduced so that the net effect is a reduction in emissions. The nondegradation policy is aimed at avoiding air quality degradation in sensitive land-use areas. For example, National Parks have been classified as (Class I) sensitive. Siting in or near such sensitive land-use areas is not precluded by the air-quality requirements, but the emission allowances are more restrictive.

A.1.3 WATER

The Federal Water Pollution Control Act asserts the following policy objectives relative to liquid effluents:

- By July 1, 1977--effluent limitations for point sources which require Best Practicable Control Technology Currently Available (BPCTCA).
- By July 1, 1983--effluent limitations for point sources which require Best Available Technology Economically Achievable (BATEA).
- By 1985--discharge of pollutants eliminated

This Act empowers EPA to develop effluent limitations for point sources and to issue permits to discharge liquid effluents; this is the National Pollutant Discharge Elimination System (NPDES) (EPA, 1974a). The EPA delegates this authority to issue permits to states that have approved NPDES programs. Approval requires that the state standards for ambient water quality and for liquid effluents be at least as stringent as the Federal guideline values.

The actions of EPA relative to water quality have also resulted in designated agencies in each state with responsibility to develop strategies to ensure pure water and in many states the authority to permit discharges. The essential water quality requirement of a repository (to operate in 1985) will be that of no discharge of pollutants.

A.1.4 LAND USE

The Coastal Zone Management Act is a land-use law administered by the National Oceanic and Atmospheric Administration (NOAA); it provides (somewhat similarly to the Clean Air Act) for the development of state programs "to preserve, protect, develop and where possible to restore or enhance the resources of the Nation's coastal zone for this and succeeding generations." This land-use law has the power to coordinate state-based programs of land-use management and to generate additional permit requirements of activities in coastal zones. This act pertains to lands in 30 states; these include the Atlantic, Pacific, and Gulf coastal states and the states bordering the Great Lakes. All 30 eligible states have initiated programs (Council on Environmental Quality, 1976) under the Coastal Zone Management Act.

The Federal Land Policy and Management Act of 1976 provides a mission statement for the Bureau of Land Management of the Department of Interior, to avoid overlapping and conflicting directives from the almost 3000 public land laws on which its administration of 450 million acres of public lands has been based.

The Forest and Rangeland Renewable Resources Planning Act of 1974 has provided for assessment of use of these renewable resources, for example, by the U.S. Department of Agriculture's Forest Service (USDA, 1975).

The Wilderness and Wild and Scenic Rivers Acts protect certain areas for special recreational uses. The Wilderness Act of 1969 establishes wilderness as a land-use category and gives authority to the Department of Interior under guidelines to establish federally owned land areas as wilderness areas to be preserved in the wild state. The Wild and Scenic Rivers Act provides for the implementation of a national policy to preserve certain selected rivers in a free-flowing condition and to protect their immediate environments. The U.S. Department of the Interior has the responsibility of administering this Act.

Recent executive orders establish certain land-use requirements. All Federal agencies are required to take flood plains into account when evaluating major Federal actions (Executive Order 11988, 1977). Areas of trails on public lands are to be closed to use by off-road vehicles if adverse impacts are (or would be) caused by such use (Executive Order 11989, 1977). New construction in wetlands is to be avoided unless there are no practical alternatives (Executive Order 11990, 1977).

A.1.5 MINING

The Bureau of Land Management (1976) in consultation with the U.S. Geological Survey (USGS) formulates the requirements to be incorporated into leases, permits, and licenses for mining on Federally owned land. Underground mining must be done so that subsidence is prevented or controlled and surface land values and uses are maintained. Surface mine reclamation is required. Water impoundments, water retention facilities, dams, or settling ponds are required as needed. Revegetation is required. Bonds must be furnished in sufficient amount to ensure reclamation. The USGS is responsible for the approval of exploration and mining plans, which must include complete information on

prospecting, exploration, testing, development, mining, preparation, reclamation, and abandonment.

The laws under which the Bureau of Land Management, the USGS, and the Bureau of Indian Affairs have developed rules related to mining are the following: the Mineral Leasing Act of February 25, 1920, the Mineral Leasing Act for Acquired Lands, and certain statutes related to Indian lands.

A.1.6 SOLID WASTE DISPOSAL

The Resource Conservation and Recovery Act of 1976 is the basic law relative to land disposal of solid waste, and this law is administered by EPA (1974b). However, the regulations do not pertain to mined material at present. Sea disposal of solid waste is covered by the Marine Protection, Research, and Sanctuaries Act of 1972, which is also administered by EPA.

A.1.7 RADIOLOGICAL HEALTH AND SAFETY

The responsibility for radiological health and safety in civil nuclear activities is vested in the U.S. Nuclear Regulatory Commision (NRC) by the Atomic Energy Act of 1954. Under this authority, the NRC (1975a,b) has established standards for protection against radiation and for the licensing of production and utilization facilities. Protection standards include the requirement that radiation exposures be maintained at levels that are "as low as reasonably achievable" (ALARA) for both workers and members of the public. Although numerical ALARA goals have been established for LWR effluents (NRC, 1975b) similar goals have not yet been established for other segments of the fuel cycle, including waste-disposal activities. In addition to the requirements outlined above relative to the performance of environmental assessments and preparation and review of a detailed statement by the U.S. Department of Energy, there is expected to be, in accordance with regulations in preparation (Bishop, 1977), the requirement of submittals to, and independent review by, NRC. Present NRC plans are that the licensing process will be sequential in nature and will include a preliminary site review, a site development plan review, construction approval, and operating license.

Reorganization Plan No. 3 of 1970 transferred from the AEC to the EPA the authority to establish "generally applicable environmental standards" for radioactive material, and to provide broad guidance for all aspects of radiation protection formerly a function of the Federal Radiation Council, both deriving from the Atomic Energy Act of 1954. The EPA (1977) has, under this authority, promulgated environmental radiation standards for the uranium fuel cycle. These standards exclude, however, "operations at waste disposal sites" and "transportation of any radioactive material in support of (fuel cycle) operations."

The EPA has indicated (Rowe, 1976) its intent to issue "fundamental environmental criteria under the Federal radiation protection guidance broad enough to address all types of radioactive wastes." These may be followed by general environmental standards for various classes of wastes.

A.1.8 NOISE

The Noise Control Act of 1972 provides criteria for noise abatement and control and is administered by EPA. Regulations relative to construction noise (EPA, 1976) require noise inspection and monitoring.

A.1.9 ECOLOGY

Several of the legal requirements cited under land use (Section A.1.4) are partly based on a national policy to protect natural systems. In addition, there are the following laws that are based specifically on this national policy:

The Endangered Species Act of 1973 provides for the conservation of endangered and threatened species and of ecosystems on which these species depend. The Act is administered by the Secretary of the Interior or the Secretary of Commerce in accordance with program responsibilities. The Secretary of Agriculture is responsible for the enforcement of provisions that pertain to the importation or exportation of terrestrial plants. In accordance with this Act, lists of threatened and of endangered species are maintained, and protective regulations can be issued and enforced. Coordination with other Federal, state, and international agencies is also managed by the Department of the Interior.

The Fish and Wildlife Coordination Act provides the Secretary of the Interior with responsibilities to provide assistance to other Federal as well as state agencies and public or private organizations relative to the protection, stocking, improving the habitat, etc., of wildlife; to make surveys; and to accept donations for such purposes as wildlife protection.

Other acts that have the purpose of protecting habitats or species are the National Wildlife Refuge Act, the Migratory Bird Treaty Act, and Protection of Bald and Golden Eagles.

A.1.10 OTHER

The Rivers and Harbors Act of 1899 is also mentioned; it is the basis of the U.S. Army Corps of Engineers' authority relative to navigable waters. The Corps (1968) requires permits for activities such as dredging and construction in navigable waters.

A.2 INTERNATIONAL REQUIREMENTS AND INSTITUTIONS

The Salina Region includes areas adjacent to Lake Michigan, Lake Erie, and Lake Ontario, which are in the area of concern of the Great Lakes Water Quality Agreement. The basic agreement is articulated in a treaty approved by the U.S. Senate in 1909. In 1972 particular objectives were developed relative to maintenance of good water quality (Agreement with Canada, 1972).

The International Joint Commission, a joint U.S.-Canadian organization established by the 1909 Treaty, is charged with investigating and reporting on the condition of the waters and recommending actions for improving water quality. Specific requirements regarding the monitoring and reporting of radioactive substance concentrations 1 kilometer beyond points of release into the lakes have been established (U.S. Department of State, 1977).

The United States has treaty agreements relative to the conservation of species and habitats: Endangered Species Trade Convention, Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere, and the Migratory Bird Treaty Act. The Endangered Species Act of 1973 gives the U.S. Department of the Interior responsibility for liaison relative to the conservation of endangered and threatened species.

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U.S. Environmental Protection Agency, 1976. "Noise Emission Standards for Construction Equipment," 40 CFR 204.

U.S. Environmental Protection Agency, 1977. "Environmental Standards for the Uranium Fuel Cycle," 40 CFR 190, Subpart B.

U.S. Nuclear Regulatory Commission, 1975a. "Standards for Protection Against Radiation," 10 CFR 20.

U.S. Nuclear Regulatory Commission, 1975b. "Licensing of Production and Utilization Facilities" and Appendix I thereto, 10 CFR 50.

U.S. Department of State, 1977. "Refined Radioactivity Objective for the Great Lakes Water Quality Agreement"; Federal Register, 42, pp. 18171-18172.

Wild and Scenic Rivers Act of 1968, PL 90-54 (16 U.S.C. 1271-1287), as amended by PL 92-560, 1972; PL 93-279, 1979; and PL 93-621m, 1975.

Federal Agency \ Potential Area of Impact	Air Quality	Water Quality	Marine Pollution, Commercial Fishery Conservation and Shellfish Sanitation	Water Regulation and Stream Modification	Fish and Wildlife	Solid Waste	Noise	Radiation	Hazardous Substances Toxic Materials	Transportation and Handling of Hazardous Materials	Energy and Natural Resources Conservation	Land Use Management Land Use Changes, Planning and Regulation of Land Development	Public Land Management	Protection of Environmentally Critical Areas - Floodplains, Wetlands, Beaches and Dunes, Unstable Soil, Steep Slopes, Aquifer Recharge Areas, etc.	Land Use in Coastal Areas	Historic, Architectural, and Archaeological Preservation	Soil and Plant Conservation and Hydrology	Outdoor Recreation
Department of Agriculture	▲	▲			▲						▲	▲	▲	▲	▲		▲	▲
Forest Service		▲		▲	▲				▲		▲			▲	▲		▲	▲
Soil Conservation Service									▲			▲					▲	
Agricultural Research Service														▲				
Agricultural Stabilization and Conservation									▲									
Consumer and Marketing Service									▲									
Department of Health, Education & Welfare	▲	▲	▲			▲	▲	▲	▲								▲	
Department of Commerce							▲	▲		▲	▲							
National Bureau of Standards									▲	▲				▲	▲		▲	
Maritime Administration		▲	▲		▲				▲	▲								
National Oceanic & Atmospheric Adm.													▲					
Department of Defense		▲	▲	▲		▲				▲	▲	▲		▲	▲	▲	▲	▲
Army Corps of Engineers																		
Department of the Navy							▲				▲	▲		▲	▲	▲		▲
Department of Housing & Urban Development																		
Department of Interior	▲					▲		▲			▲							
Bureau of Mines	▲	▲	▲	▲	▲							▲	▲	▲	▲		▲	▲
Bureau of Sport Fisheries & Wildlife	▲	▲	▲	▲	▲							▲	▲	▲	▲		▲	▲
Bureau of Outdoor Recreation	▲	▲	▲			▲						▲		▲	▲	▲	▲	
Bureau of Land Management	▲	▲				▲												
Bureau of Indian Affairs																		
Geological Survey																		
Bureau of Reclamation																		
Office of Saline Water																		
National Park Service																		
Mining Enforcement & Safety Adm.																		
Office of Land Use & Water Planning																		
Office of Energy Conservation																		
Power Marketing Adm.																		
Department of Labor																		
Occupational Safety & Health Adm.																		
Department of Transportation																		
Coast Guard																		
Federal Highway Adm.																		
Federal Railroad Adm.																		
Federal Aviation Adm.																		
Office of Hazardous Materials																		
Assistant Sec. for Systems Development & Technology																		
Environmental Protection Agency																		
Federal Power Commission																		
General Services Adm.																		
National Aeronautics & Space Adm.																		
River Basins Commissions*																		
Water Resources Council																		
Nuclear Regulatory Commission																		
National Endowment for the Arts																		
Advisory Council on Historic Preservation																		

*River Basin Commissions, as geographically appropriate (Delaware, Great Lakes, Missouri, New England, Ohio, Pacific Northwest, Souris-Red-Rainy, Susquehanna, Upper Mississippi) and similar Federal-State agencies should be consulted.

† In all cases where a proposed action will have significant international effects, the Department of State should be consulted.

‡ The Council on Environmental Quality reviews all impact statements.

OWI/ESP-54

Figure A-1

Areas of environmental impact and Federal agencies and Federal -State agencies* with jurisdiction by law or special expertise to comment.†‡

APPENDIX B

COMMENTS RECEIVED ON DRAFT REPORT AND LETTERS SENT IN RESPONSE TO COMMENTS

B.1 INTRODUCTION

Copies of the draft report Environmental Characterization of Bedded Salt Formation and Overlying Areas of the Salina Basin were distributed in June-August 1978 for review and comment. Reports were sent to the New York and Ohio State energy offices, state legislators, regional and state scientific experts, and the Department of Energy. The groups and individuals who were requested to review and comment on the report are listed in Attachment I to this Appendix.

B.1.1 SUMMARY OF RESPONSES

Table 1 provides an index of letters from New York and Ohio organizations and individuals who submitted comments on the draft report, together with the respective responses sent by the Office of Nuclear Waste Isolation (ONWI). Copies of the ONWI responses and the incoming comment letters are included in Attachment II to this Appendix.

TABLE 1

1. Ltr. from T. K. DeBoer, New York State Energy Office, to Colin Heath, U.S. Department of Energy, dated Janury 4, 1979, transmitting comments from New York State agencies; includes correspondence from T. Curran, Director of Environmental Analysis, New York State Department of Environmental Conservation.

2. Ltr. to T. K. DeBoer, from E. S. Pederson, Office of Nuclear Waste Isolation, dated January 22, 1979, transmitting responses to specific comments from New York State agencies.

3. Ltr. from Dr. C. W. Donoho, Jr., Ohio Agricultural Research and Development Center, to Joseph J. DiNunno, NUS Corporation, dated August 16, 1978, transmitting comments on the Salina Region report.

4. Ltr. to Dr. C. W. Donoho, Jr., from E. S. Pederson, Office of Nuclear Waste Isolation, dated January 22, 1979, transmitting responses to Dr. Craig Weidensaul, Head, Laboratory for Environmental Studies, OARDC.

5. Ltr. from Dr. Moid V. Ahmad, Department of Geology, Ohio University, to Joseph J. DiNunno, NUS Corporation, dated September 7, 1978, commenting on the Salina Region report.

6. Ltr. to Dr. Moid V. Ahmad from E. S. Pederson, Office of Nuclear Waste Isolation, dated January 22, 1979, responding to his comments on the Salina Region report.

7. Ltr. from Ms. Ann Clarke, Southern Tier Central Regional Planning and Development Board, to Joseph J. DiNunno, NUS Corporation, dated August 16, 1978, commenting on the Salina Region report.

8. Ltr. to Ms. Ann Clarke, Corning, New York, from E. S. Pederson, Office of Nuclear Waste Isolation, dated January 22, 1979, responding to comments on the Salina Region report.

9. Telecon message, dated December 27, 1978, between W. G. Belter of NUS Corporation and M. Italiano of the Northeast Ohio Areawide Coordinating Agency re receipt of comments from the Agency.

10. Telecon message, dated January 10, 1979, between W. G. Belter of NUS Corporation and E. Johnson of the Ohio Department of Energy, re letter from C. Masoner, Ohio Department of Energy, dated December 26, 1978.

    Ltr. from C. Masoner, dated December 26, 1978, to Mr. Walter Belter, NUS Corporation.

Summaries of two telephone discussions between W. G. Belter, NUS Corporation, and representatives of the Ohio Department of Energy and the Northeast Ohio Areawide Coordinating Agency are included in Table 1 and Attachment 2 because of their relevance to the State of Ohio position on the location of a radioactive waste repository.

In brief, the comments were considered to be generally positive and constructive. Errors in some of the text and certain figures have been corrected in this final report. In a number of instances, the comments requested information, from this broad regional report, that would only become available during the follow-on detailed area and location studies.

APPENDIX B--ATTACHMENT I
DISTRIBUTION LIST FOR SALINA BASIN
ENVIRONMENTAL CHARACTERIZATION REPORT

Mr. T. K. DeBoer, Director
Technological Development Programs
New York State Energy Office
Empire State Plaza
Albany, New York 12223
(Note: 50 copies of report transmitted)

Mr. G. Timothy Guernsey, Deputy Director
Ohio Department of Energy
25th Floor, State Office Building
30 East Broad Street
Columbus, Ohio 43215
(Note: 20 copies of report transmitted)

Honorable Neal Zimmers, Jr.
Chairman
Senate Energy and Public Utilities Committee
1510 Winters Bank Building
Dayton, Ohio 45402

Honorable Stanley Steingut
Speaker of the New York State Assembly
Legislative Office Building
Empire State Plaza
Albany, New York 12223

Honorable Warren M. Anderson
Majority Leader
New York State Senate
Legislative Office Building
Empire State Plaza
Albany, New York 12223

Honorable Bernard C. Smith
Chairman, Conservation and Recreation Committee
Legislative Office Building
Empire State Plaza
Albany, New York 12223

Honorable James Mc Farland
Chairman, Corporation, Authorities, and Public Utilities Committee
Legislative Office Building
Empire State Plaza
Albany, New York 12223

Assemblyman G. Oliver Koppell
Chairman, Environmental Conservation Committee
Legislative Office Building
Empire State Plaza
Albany, New York 12223

Honorable Erwin J. Landes
Chairman, Corporations, Authorities, and Commissions Committee
Legislative Office Building
Empire State Plaza
Albany, New York 12223

Honorable Angelo Orazio
Chairman, Joint Legislative Commission on Energy Systems
Legislative Office Building
Empire State Plaza
Albany, New York 12223

Honorable James McFarland
Vice Chairman, Joint Legislative Commission on Energy Systems
Legislative Office Building
Empire State Plaza
Albany, New York 12223

Representative Thomas J. Carney
Chairman
Energy and Environment Committee
60 Melrose Avenue
Boardman, Ohio 44512

Mr. Critz H. George
Office of Nuclear Waste Management
Department of Energy
Washington, D.C. 20545
(Note: 10 copies of report transmitted)

Ms. Ann Clarke
Southern Tier Central Regional Planning and Development Board
53 1/2 Bridge Street
Corning, New York 13830

Mr. Thomas Neiderkorn
Planning and Environmental Associates
310 West State Street
Ithaca, New York 14850

Dr. Norman Richards
State University of New York
College of Environmental Sciences
and Forestry
Syracuse, New York 13410

Dr. John H. Thompson
Department of Geography
Syracuse University
Syracuse, New York 13210

Dr. Manfred Wolff
Department of Geology
Hofstra University
Hempstead, New York 11550

Environmental Planning Lobby
109 State Street
Albany, New York 12207
Attn: Ms. Marilyn DuBois

Mr. Frank R. Liguori
Commissioner of Planning
Tompkins County Department of Planning
128 East Buffalo Street
Ithaca, New York 14850

Mr. Michael Brown
Seneca County Planning Board
48 West Williams Street
Waterloo, New York 13165

Ms. Rita Frank
Assistant Budget Officer
County of Cortland Court House
Cortland, New York 13405

Assemblyman Melvin Zimmer
841 State Office Building
Syracuse, New York 13202

Dr. Peter Black
State University of New York
College of Environmental Sciences
and Forestry
Syracuse, New York 13210

Dr. Donald Behrend
College of Environmental Sciences
and Forestry
State University of New York
200 Bray Hall
Syracuse, New York 13210

Mr. Lindley V. Pryor
Chief, Physical Planning
Southern Tier West Regional
Planning and Development Board
15 Main Street
Salamanca, New York 14799

Mr. Kevin Byrne
Executive Director
Southern Tier West Regional
Planning and Development Board
15 Main Street
Salamanca, New York 14799

Dr. Alfred Dekin
Director, Public Archaeology Facility
State University of New York
at Binghamton
Binghamton, New York 13901

Dr. Arthur Eschner
State University of New York
College of Environmental Sciences
and Forestry
Syracuse, New York 13210

Dr. Lee Harrington
Marshall Hall
Syracuse University
Syracuse, New York 13210

Mr. Robert Hennigan
College of Environmental Sciences
and Forestry
State University of New York
310 Stadium Place
Syracuse, New York 13210

APPENDIX B - ATTACHMENT II

COPIES OF ONWI RESPONSE LETTERS WITH INCOMING COMMENT LETTERS

Battelle
Project Management Division
Office of Nuclear Waste Isolation
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 424-6424
Telex 24-5454

January 22, 1979

Dr. Clive W. Donoho, Jr.
Associate Director
Ohio Agricultural Research and
Development Center
Wooster, Ohio 44691

Dear Dr. Donoho:

We appreciate the review of Dr. Craig Weidensaul, Head of your Laboratory for Environmental Studies on our report entitled "Environmental Characterization of Bedded Salt Formation and Overlying Areas of the Salina Basin" and his comments as transmitted in your letter of August 16, 1978.

We have followed up your suggestion that the document should be sent to the department heads of agricultural economics at the Land Grant Universities, in the states involved. Copies have been provided to them.

Dr. Weidensaul's thoughtful comments have been carefully analyzed, and it is unfortunate that he believes the regional report to be biased toward the establishment of repositories and also that he feels the authors have ignored, or were ignorant of, important considerations on food and fiber production. We have attempted to stress factual information in the reports to enable the decision makers to have as complete a data base as possible in making evaluations. One of the most difficult aspects of regional report preparation was deciding how much information could be included in order to keep the size of the document to a manageable level. Because of the large area involved, the data and information presented are extremely broad in nature and limited to general regional characterization. Subsequent study reports as they focus on smaller areas, locations or specific sites will address the items questioned by Dr. Weidensaul in considerable detail, and, hopefully, satisfy his concerns.

Dr. Weidensaul's observation that the report did not address potential environmental impacts of repositories is certainly correct. We tried to make clear that this report was not an environmental impact evaluation. The purpose of the regional report is to provide a broad general characterization of regional resources. The report will be one of a number that will provide baseline data to be used if a suitable repository location can be found in the region. Environmental impacts, evaluations and problems associated with repositories for radioactive wastes will be addressed in detail in later reports.

RESPONSES TO SPECIFIC COMMENTS FROM NEW YORK STATE AGENCIES

Section 3.2 - Groundwater

Page 3-24 - Greater emphasis should be placed on the determination of the presence of water in overlying formations and the dynamics of groundwater movement in the areas selected for further study.

Response: - As certain areas are selected for further study within the Salina Basin, it is planned to conduct more detailed geohydrologic studies in the study area(s) to better define the presence and extent of groundwater and the dynamics of groundwater in these areas.

Section 4.7 - Air Quality

Page 4-1 - Add this note: *New York State air quality standards in many areas of the State are more restrictive than the national air quality standards and as such would be of greater significance than the national air quality standards. (See Part 257-3.3 of New York State Air Quality Regulations).

Place asterisk (*) after end of first paragraph and after repository (end of first sentence, second paragraph) to refer to the added note.

Add the following sentence at the end of second paragraph: However, any incremental increase in the annual geometric mean must not be such as to cause the air quality standard to be exceeded.

Response: (1) Since Ohio and Pennsylvania also have State air quality standards, it would be more appropriate to add the following note:

* Various State air quality standards are more restrictive than the national ambient air quality standards in some areas and as such would be of greater significance than the national ambient air quality standards.

(2) The asterisk for the above note will be positioned as the comment indicates in the final report.

(3) An additional sentence is not needed since this point is covered in the second sentence of the referenced paragraph.

Page 4-2 - A table of New York State air quality standards should be listed.

A copy of Part 257 and a copy of Ambient Air Standards - Federal and State are enclosed.

Response: It is considered inappropriate to provide this information for one state and not the others in a regional report. Detailed information on the various State air quality standards will be presented in the follow-on area study(s) as suggested.

Fig. 4-23 - This figure identifies areas exceeding National Secondary Standard for particulates. A similar map shows areas exceeding State standards.

Response: It is planned to provide this level of detail during the next phase "area studies" as they are carried out.

Section 5.0 - Background Radiation

Page 5-1 - Section 5.0 applies to background radiation. Section 5.1.3 refers to fallout radiation. The comment in Section 5.1.3 that Cs-137 is the major source of radiation from long-lived fallout should have the words "external ionizing" inserted in front of radiation to make it clear that the exposure from Sr-90 in milk is not included. This would conform with the interpretation of background radiation in Section 5.1. The definition of background radiation in 5.1 eliminates the food pathway such as Sr-90 in milk and in surface waters used as public water supplies. The definition also eliminates airborne particulates that would result in exposure from the inhalation pathway.

Response: The words "external ionizing" will be inserted in front of "radiation" in Section 5.1.3 of the final version of the report.

Table 5-1 - Table 5-1 listing background radiation levels should be reviewed to determine whether the value of 4.8 millirem per year for fallout should be added to the cosmic rays and terrestrial levels. The terrestrial levels were based on nation-wide aerial surveys. It is expected that these levels would include the background radiation from fallout.

Table 5-1 also has two low terrestrial levels that should have some explanation. These involve the 21.0 mr/yr for Charlevoix, Michigan and the 30.0 mr/yr for Oswego. DEC's 1975 Annual Report of Environmental Radiation in New York State indicates that the average total external radiation on nine locations around the Nine Mile Point station east of Oswego is 78.3 mrem/yr. This is the same as the average external radiation at 13 stations around the RG&E Ginna station east of Rochester. Deducting the value of 42.0 mr/yr for cosmic rays at Oswego in Table 5-1 from the total of 78.3 mr/yr results in a terrestrial reading, including fallout, of 36.3 mrem/yr. Deducting the 4.8 mr/yr for fallout would provide a reasonable verification of the 30.0 mr/hr net terrestrial level in Table 5-1. This verification for Oswego and the measurements around the Ginna plant indicates that the Buffalo, Rochester and Syracuse levels of 44.0-45.6 may be too high. Readings obtained by aerial surveys should be checked by readings of ground surveys at selected points.

Response: Fallout was subtracted from the terrestrial contribution as explained in the reference "National Radiation Exposure in the United States," Donald Oakley, ORP/SID 72-1 USEPA, 1972.

The two terrestrial levels given were taken directly from the NCRP Report #45, "National Background Radiation in the United States," 1975. Any type of field or ground surveys for validation of reported literature values is not planned in the regional studies.

Section 6.0 - Demographic, Socioeconomic and Land-Use Systems

Fig. 6-1 - Population of Urban Areas - The Corning Elmira urban area is not indicated.

Figs. 6-4 and 6-5 - Land Use Pattern - Map is too general in that many recreational, natural areas and state lands are not represented.

Fig. 6-6 - Air Traffic Hubs - Chemung County Airport should be indicated as a small hub.

Fig. 6-8 - Interstate and U.S. Highways - The Genesee Expressway and Southern Tier Expressway are not indicated.

Fig. 6-9 - Railroads - Railroad information may need updating.

Fig. 6-10 - Principal Harbors, Canals and Navigable Waterways - There may be inaccuracies under navigability as indicated on the map. Map too general for specific comment.

The information in Figures 6-6 through 6-10 should be presented more accurately and receive appropriate recognition in that transportation systems would have to be used for nuclear waste transportation.

Response: Your criticism of the above graphics is quite justified and we are updating and revising the figures accordingly. It should be noted, however, that the data were quite limited for use in the initial drafts of the report. Our specific handling of each figure is noted below:

(1) Urban Areas

Corning/Elmira does not fit the 1970 census definition of urban place. No city of over 50,000 is present and Elmira and Corning are not contiguous, hence not "twin cities".

(2) Land Use

More areas have been identified and the map will be more detailed for final report. As stated in the report, however, only land uses of 10,000 acres or more were used in the characterization.

(3) Air Traffic Hubs

Chemung County is not listed as a hub in Airport Activity Statistics, as of June 30, 1975. More recent information is being obtained.

(4) Highways

Neither of these highways is an Interstate or U.S. Highway. Only these roads are being mapped. Other inaccuracies are being corrected.

(5 & 6) Rail and Water Transportation

This information is being updated and revised for final report.

Section 7.0 - Terrestrial Ecosystem

Fig. 7-5 - The wetland section for New York is unacceptable in that there are many more significant wetlands within the area than were identified. Region 8 has some of the best habitat for turkey and pheasant in New York State. Fisheries resources have received little recognition. The above mentioned environmental characteristics should receive appropriate recognition.

Response: We agree that the wetland section for New York is more extensive than those areas depicted on Figure 7-5; the areas presented were those provided by the authorities cited (Buckman and Quintus, 1972, and Goodwin and Niering, 1975).

We also agree with your statement concerning Region 8 having some of the best habitat for turkey and pheasant in New York State and this was verified by discussion with the Dept. of Environmental Conservation (DEC), Delmar, New York. It was further noted that within New York state's portion of the Salina Basin optimum turkey habitat occurs in the lowerhalf and the northern areas contain better pheasant habitat.

It is important to understand that this study was done on a broad regional context, and incorporated only major literature sources. Smaller wetland areas would only be identified in more detailed follow-on area or location studies. Similarly, fisheries resources would be further quantified in area or location studies.

Section 9.4 - Background Radiation

The summary of background radiation in Section 9.4 states that there are no anomalous areas. A review of the data in Table 5-1 shows that there are only two of 37 levels below 89.4 millirem per year. These are 68.8 at Charlevoix and 76.8 at Oswego. Similarly, there are only 2 levels over 100.2. These are 108.6 at Steubenville, Ohio and 116.7 at Wheeling, West Virginia. Thirty-three levels are in the range of 89.4 - 100.2. The two low readings and two high readings are anomalous and require some explanation.

Response: Based on the mean of all measurements given in Table 5.1 of 93.9 mrem/yr, the variations in the results are not statistically significant. Variations resulting from such things as seasonal differences, analytical techniques, and so forth have been found to result in greater differences than those shown in the table.

Appendix A - Regulation, Requirements & Compliance

Appendix A describes federal and international regulatory requirements. Appendix A should also include regulatory requirements for the specific States in the Salina Salt Basin.

Although Figure A-1 illustrates some of H.U.D.'s impact on areas of environmental concerns, it is suggested that a brief description of the Housing and Community Development Act of 1974, as amended be included in Section A.1.4 "Land Use."

Mentioning several Federal Agreements should assure program consistencies e.g., U.S. Department of Housing and Urban Development, U.S. Environmental Protection Agency, U.S. Coastal Zone Management Program, A-95 Program Notification and Review System, etc.

Response: Because this first environmental characterization report is of a broad, regional nature only, it was felt appropriate to include only federal and international requirements as an appendix to the regional report. As the program proceeds to the identification of specific areas in certain states, it is then planned to include state regulatory requirements for the specific state areas under study.

We propose to accomodate your comment on "mentioning several Federal Agreements should assure program consistencies...." by inserting the following as part of the last paragraph of Section A.1.1 ---

'Also, DOE has memoranda of understanding (MOU) with NRC, EPA, DOT, and DOI in the area of radioactive waste management, with other interagency MOU's being developed. As part of their responsibility for being the lead Federal agency for licensing a waste repository, NRC will distribute the DOE prepared environmental report(s) for comment to agencies such as:

- Department of Agriculture
- Department of Defense
- Department of Commerce
- Department of HEW
- Department of Housing and Urban Development
- Department of Interior
- Department of Transportation
- Environmental Protection Agency
- Department of Labor

Concerning your comment on the Housing and Community Development Act of 1974, we have reviewed the Act (42 U.S.C. SS 1411 et seq.) in relationship to a proposed repository. It would appear that HUD's major involvement with the project would most likely occur at the time NRC would be distributing the DOE environmental report(s) for review, as noted above. Compliance with HUD requirements would seem best handled in this fashion.

NEW YORK
STATE ENERGY OFFICE
ROCKEFELLER PLAZA
ALBANY, NEW YORK 12223
JAMES L. LAROCCA, COMMISSIONER

January 4, 1979

Dr. Colin Heath
Director
Division of Waste Isolation B107
U.S. Department of Energy
Washington, DC 20545

Dear Dr. Heath:

The New York State review of NUS's draft reports, "Plans for Environmental Surveys of Bedded Salt Formations and Overlying Areas of the Salina Basin in New York, Volume II", January 1978, and "Environmental Characterization of Bedded Salt Formation and Overlying Areas of the Salina Basin", April 1978, was coordinated by the State Department of Environmental Conservation. Enclosed for your consideration are the State's comments that resulted from this review.

If you have any questions regarding these comments, please call Mr. Thomas J. Cashman, Department of Environmental Conservation, at (518) 457-6600.

New York State appreciates being given the opportunity to review these draft plans.

Sincerely,

T. K. DeBoer
Director of Nuclear Operations

TKD/plc

cc: Joseph J. DiNunno, NUS
Thomas J. Cashman

JAN 8 1979

Joseph J. DiNunno

New York State Department of Environmental Conservation
50 Wolf Road, Albany, New York 12233

Peter A. A. Berle,
Commissioner

December 29, 1978

RECEIVED

JAN - 3 1979

N.Y.S. ENERGY OFFICE
ALBANY, NEW YORK

Mr. Theodore DeBoer
NYS Energy Office
Agency Building #2
Empire State Plaza
Albany, New York 12223

Dear Mr. DeBoer:

Enclosed are New York State's comments on the two additional NUS environmental reports on the NWTS program:

A. "Draft-Plans for Environmental Surveys of Bedded Salt Formations and Overlying Areas of the Salina Basin in New York, Volume II," January 1978. Volume II is the plan for collecting a more extensive environmental data base for potential site locations of approximately 30 square miles.

B. "Draft-Environmental Characterization of Bedded Salt Formation and Overlying Areas of the Salina Basin" April 1978. This report is intended as a general characterization of the present environmental setting of the Salina Region, with emphasis on its land, water and air characteristics and resources, on the plant and animal life, and on man and his industries.

The State commented on the NUS October 1977 draft "Plans for Environmental Surveys of Bedded Salt Formations and Overlying Areas of the Salina Basin in New York-Volume I". The January 11, 1978 letter transmitting the comments identified the State's major concerns. These concerns still apply and a copy of the January 11 transmittal letter is enclosed for ready reference.

The Department of Energy has stated that the further study alluded to in the "Executive Summary of the Draft Report in the Geology and Salt Deposits of the Salina Salt Basin" has been deferred indefinitely. As a result of this indefinite deferment, the review by the State of the two additional NUS reports was not as extensive as the review of the NUS October 1977 draft.

The enclosed comments identify portions of the two additional reports that require clarification by NUS prior to issuing final reports on these subjects.

Very truly yours,

Terence P. Curran, Director
Environmental Analysis

TJC:sl
Enclosures

Note:

Mr. Curran's letter of December 29, 1978 to Mr. T. DeBoer, New York State Energy Office, which transmitted New York State's comments on this draft report, also provided their comments on the "Draft Plans for Environmental Surveys of Bedded Salt Formations and Overlying Areas of the Salina Basin in New York, Volume II, January 1978.

These comments are not related to the regional characterization report and, therefore, are not reproduced here.

New York State's Comments On:

Draft-Environmental Characterization of Bedded Salt Formation and Overlying Areas of the Salina Basin, April 1978

Section 3.2-Groundwater

Page 3-24 - Greater emphasis should be placed on the determination of the presence of water in overlying formations and the dynamics of groundwater movement in the areas selected for further study.

Section 4.7-Air Quality

Page 4-11 - Add this note: *New York State air quality standards in many areas of the State are more restrictive than the national air quality standards and as such would be of greater significance than the national air quality standards. (See Part 257-3.3 of New York State Air Quality Regulations)

Place asterisk (*) after end of first paragraph and after repository (end of first sentence, second paragraph) to refer to the added note.

Add the following sentence at the end of second paragraph: However, any incremental increase in the annual geometric mean must not be such as to cause the air quality standard to be exceeded.

Page 4-12 - A table of New York State air quality standards should be listed.

A copy of Part 257 and a copy of Ambient Air Standards - Federal and State are enclosed.

Fig. 4-23 - This figure identifies areas exceeding National Secondary Standard for particulates. A similar map shows areas exceeding State standards.

Section 5.0-Background Radiation

Page 5-1 - Section 5.0 applies to background radiation. Section 5.1.3 refers to fallout radiation. The comment in Section 5.1.3 that Cs-137 is the major source of radiation from long-lived fallout should have the words "external ionizing" inserted in front of radiation to make it clear that the exposure from Sr-90 in milk is not included. This would conform with the interpretation of background radiation in Section 5.1. The definition of background radiation in 5.1 eliminates the food pathway such as Sr-90 in milk and in surface waters used as public water supplies. The definition also eliminates airborne particulates that would result in exposure from the inhalation pathway.

Table 5-1 - Table 5-1 listing background radiation levels should be reviewed to determine whether the value of 4.8 millirem per year for fallout should be added to the cosmic rays and terrestrial levels. The terrestrial levels were based on nation-wide aerial surveys. It is expected that these levels would include the background radiation from fallout.

Table 5-1 also has two low terrestrial levels that should have some explanation. These involve the 21.0 mr/yr for Charlevoix, Michigan and the 30.0 mr/yr for Oswego. DEC's 1975 Annual Report of Environmental Radiation in New York State indicates that the average total external radiation on nine locations around the Nine Mile Point station east of Oswego is 78.3 mrem/yr. This is the same as the average external radiation at 13 stations around the RG&E Ginna station east of Rochester. Deducting the value of 42.0 mr/yr for cosmic rays at Oswego in Table 5-1 from the total of 78.3 mr/yr results in a terrestrial reading, including fallout, of 36.3 mrem/yr. Deducting the 4.8 mr/yr for fallout would provide a reasonable verification of the 30.0 mr/hr net terrestrial level in Table 5-1. This verification for Oswego and the measurements around the Ginna plant indicates that the Buffalo, Rochester and Syracuse levels of 44.0-45.6 may be too high. Readings obtained by aerial surveys should be checked by readings of ground surveys at selected points.

Section 6.0-Demographic, Socioeconomic and Land-Use Systems

Fig. 6-1 - Population of Urban Areas - The Corning Elmira urban area is not indicated.

Figs. 6-4 and 6-5 - Land Use Pattern - Map is too general in that many recreational, natural areas and state lands are not represented.

Fig. 6-6 - Air Traffic Hubs - Chemung County Airport should be indicated as a small hub.

Fig. 6-8 - Interstate and U.S. Highways - The Genesee Expressway and Southern Tier Expressway are not indicated.

Fig. 6-9 - Railroads - Railroad information may need updating.

Fig. 6-10 - Principal Harbors, Canals and Navigable Waterways - There may be inaccuracies under navigability as indicated on the map. Map too general for specific comment.

The information in Figures 6-6 through 6-10 should be presented more accurately and receive appropriate recognition in that transportation systems would have to be used for nuclear waste transportation.

New York State's Comments On:

Draft-Environmental Characterization of Bedded Salt Formation and Overlying Areas of the Salina Basin, April 1978

Section 7.0-Terrestrial Ecosystem

Fig. 7-5 - The wetland section for New York is unacceptable in that there are many more significant wetlands within the area than were identified. Region 8 has some of the best habitat for turkey and pheasant in New York State. Fisheries resources have received little recognition. The above mentioned environmental characteristics should receive appropriate recognition.

Section 9.4-Background Radiation

The summary of background radiation in Section 9.4 states that there are no anomalous areas. A review of the data in Table 5-1 shows that there are only two of 37 levels below 89.4 millirem per year. These are 68.8 at Charlevoix and 76.8 at Oswego. Similarly, there are only 2 levels over 100.2. These are 108.6 at Steubenville, Ohio and 116.7 at Wheeling, West Virginia. Thirty-three levels are in the range of 89.4 - 100.2. The two low readings and two high readings are anomalous and require some explanation.

Appendix A - Regulation, Requirements & Compliance

Appendix A describes federal and international regulatory requirements. Appendix A should also include regulatory requirements for the specific States in the Salina Salt Basin.

Although Figure A-1 illustrates some of H.U.D.'s impact on areas of environmental concerns, it is suggested that a brief description of the Housing and Community Development Act of 1974, as amended be included in Section A. 1.4 "Land Use."

Mentioning several Federal Agreements should assure program consistencies e.g., U.S. Department of Housing and Urban Development, U.S. Environmental Protection Agency, U.S. Coastal Zone Management Program, A-95 Program Notification and Review System, etc.

TJC:sl
12/29/78

SUMMARY OF AMBIENT AIR STANDARDS - FEDERAL AND STATE

Contaminant (1)	Averaging Period	New York State Standards (IN EFFECT MARCH 1977) Level	Conc.	Units	Statistic (2)	CORRESPONDING Federal Standards PRIMARY Conc.	Units (5)	Stat.	SECONDARY Conc.	Units	Stat.
SULFUR DIOXIDE SO_2	12 Consecutive Months	ALL	0.03	PPM	A.M. (Arith. Mean of 24 hr. avg. conc.)	80	$\mu g/m^3$	A.M.			
	24 - HR.	ALL	0.14 (3)	"	MAX. (2)	365	$\mu g/m^3$	MAX. (2)			
	3 - HR.	ALL	0.50 (4)	"	MAX.				1300	$\mu g/m^3$	MAX.
CARBON MONOXIDE CO	8 - HR.	ALL	9	"	MAX.	10	mg/m^3	MAX.	10	mg/m^3	MAX.
	1 - HR.	ALL	35	"	MAX.	40	mg/m^3	MAX.	40	mg/m^3	MAX.
PHOTOCHEMICAL OXIDANTS	1 - HR.	ALL	0.08	"	MAX.	160	$\mu g/m^3$	MAX.	160	$\mu g/m^3$	MAX.
HYDROCARBONS (NON-METHANE)	3 - HR. (6 - 9 A.M.)	ALL	0.24	"	MAX.	160	$\mu g/m^3$	MAX.	160	$\mu g/m^3$	MAX.
NITROGEN DIOXIDE	12 Consecutive Months	ALL	0.05	"	A.M.	100	$\mu g/m^3$	A.M.	100	$\mu g/m^3$	A.M.
PARTICULATES (SUSPENDED) TSP	12 Consecutive Months	IV	75	$\mu g/m^3$	G.M. (Geometric mean of 24 Hr. average concentrations)	75	$\mu g/m^3$	G.M.	60 (6)	$\mu g/m^3$	G.M.
		III	65	"							
		II	55	"							
		I	45	"							
	24 HR.	ALL	250	"	MAXIMUM	260	$\mu g/m^3$	MAX	150	$\mu g/m^3$	MAX.
	30 DAYS (7)	IV	135	"	A.M.						
		III	115	"	"						
		II	100	"	"						
		I	80	"	"						
	60 DAYS (7)	IV	115	"	A.M.						
		III	95	"	"						
		II	85	"	"						
		I	70	"	"						
	90 DAYS (7)	IV	105	"	A.M.						
		III	90	"	"						
		II	80	"	"						
		I	65	"	"						

(1) N.Y.S. also has standards for Beryllium, Flourides, Hydrogen Sulfide, and Settleable Particulates (Dustfall).

(2) All maximum values are values not to be exceeded more than once a year.

(3) Also during any 12 consecutive months, 99% of the values shall not exceed 0.10 ppm (not necessary to address this standard when predicting future concentrations.

(4) Also during any 12 consecutive months 99% of the values shall not exceed 0.25 ppm (see above).

(5) Gaseous concentrations are corrected to a reference temperature of 25°C and to a reference pressure of 760 millimeters of Mercury.

(6) As a guide to be used in assessing implementation plans to achieve 24 - hour standard.

(7) For enforcement only, monitoring to be done only when required by N.Y.S., (not necessary to address this standard when predicting future concentrations.

PART 257

AIR QUALITY STANDARDS

(Statutory authority: Environmental Conservation Law, § 15)

Subpart 257-1 **Air Quality Standards—General**
Subpart 257-2 **Air Quality Standards—Sulfur Dioxide (SO_2)**
Subpart 257-3 **Air Quality Standards—Particulates**
Subpart 257-4 **Air Quality Standards—Carbon Monoxide (CO)**
Subpart 257-5 **Air Quality Standards—Photochemical Oxidants**
Subpart 257-6 **Ambient Air Quality Standard—Hydrocarbons (Non-Methane)**
Subpart 257-7 **Air Quality Standards—Nitrogen Dioxide (NO_2)**
Subpart 257-8 **Ambient Air Quality Standards—Fluorides**
Subpart 257-9 **Ambient Air Quality Standard—Beryllium**
Subpart 257-10 **Ambient Air Quality Standard—Hydrogen Sulfide (H_2S)**

Historical Note

Part filed June 29, 1961; renum 250.4; new filed Aug. 9, 1963; repealed, new filed May 8, 1969; Dec. 24, 1970; (§§ 257.1—257.11) renum. Part 408, Title 9, filed Sept., 1971; new Subparts 257-1—257-10 filed April 28, 1972 eff. May 1, 1972.

Section 257.1-257.5

Historical Note

Secs. filed June 29, 1961; renum. 250.4; new filed Aug. 9, 1963; repealed, new filed May 8, 1969; Dec. 24, 1970; renum. 408.1—408.5, Title 9, filed Sept., 1971.

257.6-257.11

Historical Note

Secs. filed Dec. 24, 1970; renum. 408.6-408.11, Title 9, filed Sept., 1971.

SUBPART 257-1

AIR QUALITY STANDARDS—GENERAL

Sec.
257-1.1 Foreword
257-1.2 Definitions
257-1.3 Application
257-1.4 Compliance

Historical Note

Subpart (§§ 257-1.1—257-1.4) filed April 28, 1972 eff. May 1, 1972.

Section 257-1.1 Foreword. Air quality standards are designed to provide protection from the adverse health effects of air contamination; and they are intended further to protect and conserve the natural resources and environment and to promote maximum comfort and enjoyment and use of property consistent with the economic and social well-being of the community.

Historical Note

Sec. filed April 28, 1972 eff. May 1, 1972.

257-1.2 Definitions. When used in this Part the following terms shall be interpreted to mean:

(a) *Air quality standard.* A numerically prescribed contaminant level that shall not be exceeded in a specified area of the State. Such contaminant levels may include instantaneous, short term, or long term concentrations of individual contaminants or grouping of contaminants having synergistic effects. Such standards may also be

described in terms of net effects resulting from the occurrence of individual contaminants or grouping of various contaminants.

(b) *Commissioner.* The Commissioner of the New York State Department of Environmental Conservation.

Historical Note

Sec. filed April 28, 1972 eff. May 1, 1972.

257-1.3 Application. (a) The standards shall be applicable, as specified in the individual Subpart, to the levels as described in Part 256 of this Title and as assigned in Subchapter C. In addition, emissions in a classified area shall be controlled to the extent required to be compatible with standards established in other areas.

(b) The procedures and techniques employed to determine ambient air concentrations of contaminants shall be as specified in the standard or in accordance with other methods or techniques acceptable to the commissioner. Acceptable methods may be published from time to time by the commissioner.

Historical Note

Sec. filed April 28, 1972; amd. filed Nov. 27, 1972 eff. immediately. Changed "Part 501" to read "Part 256" in (a).

257-1.4 Compliance. (a) No person shall permit, suffer or allow the emission of contaminants from an emission source which alone or in combination with emissions from other sources cause contravention of air quality standards promulgated in this Part.

(b) Notwithstanding the existence of specific standards, emissions of odorous, toxic, or deleterious substance in concentrations or of such duration that will affect human health or well-being, or unreasonably interfere with the enjoyment of property, or unreasonably and adversely affect plant or animal life shall not be permitted.

Historical Note

Sec. filed April 28, 1972 eff. May 1, 1972.

SUBPART 257-2

AIR QUALITY STANDARDS—SULFUR DIOXIDE (SO_4)

Sec.
257-2.1 Definitions
257-2.2 Objective
257-2.3 Standards (SO_2)
257-2.4 Measurement

Historical Note

Subpart (§§ 257-2.1—257-2.4) filed April 28, 1972 eff. May 1. 1972.

Section 257-2.1 Definitions. (a) *Sulfur dioxide (SO_2).* A nonflammable, nonexplosive, colorless gas, having a pungent, irritating odor. For the purpose of this Subpart, this term shall also include other material that may test as sulfur dioxide by the specified method of measurement.

(b) *Ppm.* Parts of contaminant per million parts of air by volume.

(c) *$\mu g/m^3$.* Micrograms of contaminant per cubic meter of air.

Historical Note

Sec. filed April 28, 1972; amd. filed Feb. 16, 1977 eff. 30 days after filing.

257-2.2 Objective. Sulfur dioxide has been associated with increase in chronic respiratory disease on long term exposures and alteration in lung and other physio-

logical functions on short term exposures. Although plant damage to sensitive vegetation and significant metal corrosion and other effects may occur at other ambient air concentrations, the primary objective of these standards is to prevent adverse health effects.

Historical Note

Sec. filed April 28, 1972 eff. May 1, 1972.

257-2.3 Standards (SO_2). (a) During any 12 consecutive months, 99 percent[1] of the three-hour average concentrations shall not exceed 0.25 ppm[2] and the three-hour average concentration shall not exceed 0.50 ppm[3] more than once a year. (Applicable in all levels).

(b) During any 12 consecutive months, 99 percent[4] of the 24-hour average concentrations shall not exceed 0.10 ppm[5]; and the 24-hour average concentration shall not exceed 0.14 ppm[6] more than once a year. (Applicable in all levels).

(c) During any 12 consecutive months, the annual average of the 24-hour average concentrations shall not exceed 0.03 ppm[7]. (Applicable in all levels.)

Historical Note

Sec. filed April 28, 1972; amd. filed Feb. 16, 1977 eff. 30 days after filing.

257-2.4 Measurement. (a) Sulfur dioxide in air is determined by the West Gaeke method of analysis, or by other methods acceptable to the commissioner.

(b) All measurements are corrected to a reference temperature of 25 degrees Centigrade and to a reference pressure of 760 millimeters of mercury.

Historical Note

Sec. filed April 28, 1972 eff. May 1, 1972.

SUBPART 257-3

AIR QUALITY STANDARDS—PARTICULATES

Sec.		Sec.	
257-3.1	Definition	257-3.4	Standard for settleable particulates (dustfall)
257-3.2	Objective		
257-3.3	Standard for suspended particulates	257-3.5	Measurement

Historical Note

Subpart (§§ 257-3.1—257-3.5) filed April 28, 1972 eff. May 1, 1972.

Section 257-3.1 Definition. *Particulate* is any matter dispersed in the atmosphere, whether solid or liquid, in which the individual particles are larger than single molecules (about 0.0002 μ in diameter), but smaller than about 500 μ. Settleable particulates, or dustfall, is normally in the size range greater than 10 μ, and sus-

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1 For predicting future concentrations, predicted conformity with the 0.50 standard will be sufficient to demonstrate prediction of conformity with the 99 percent standard.

2 Corresponds to Federal standard of 650 μg/m3 (at temperature of 25°C and pressure of 760 mm of mercury).

3 Corresponds to Federal standard of 1300 μg/m3 (at temperature of 25°C and pressure of 760 mm of mercury).

4 For predicting future concentrations, predicted conformity with the 0.14 standard will be sufficient to demonstrate prediction of conformity with the 99 percent standard.

5 Corresponds to Federal standard of 260 μg/m3 (at temperature of 25°C and pressure of 760 mm of mercury).

6 Corresponds to Federal standard of 365 μg/m3 (at temperature of 25°C and pressure of 760 mm of mercury).

7 Corresponds to Federal standard of 80 μg/m3 (at temperature of 25°C and pressure of 760 mm of mercury).

pended particulates range below 10 μ in diameter. For the purpose of this Subpart, the suspended and settleable particulates are as collected and measured by the method specified or other methods acceptable to the commissioner.

Historical Note

Sec. filed April 28, 1972 eff. May 1, 1972.

257-3.2 Objective. (a) For suspended particulates protection from adverse health effects, taking into consideration its synergistic effects.

(b) For settleable particulates to alleviate the nuisance of dustfall and to reduce the economic cost of air pollution.

Historical Note

Sec. filed April 28, 1972 eff. May 1, 1972.

257-3.3 Standard for suspended particulates. (a) 24-hour standard. For any 24-hour period, the average concentration shall not exceed 250 $\mu g/m^3$ more than once a year. (Applicable in all levels.)

(b) *Annual standard.* During any 12 consecutive months, the geometric mean of the 24-hour average concentrations shall not exceed:

Level I	45 $\mu g/m^3$	Level III	65 $\mu g/m^3$
Level II	55 $\mu g/m^3$	Level IV	75 $\mu g/m^3$

(c) *30-day standard.* During any 30 consecutive days, the arithmetic mean of the 24-hour average concentrations, at any location, shall not exceed:

Level I	80 $\mu g/m^3$	Level III	115 $\mu g/m^3$
Level II	100 $\mu g/m^3$	Level IV	135 $\mu g/m^3$

(d) *60-day standard.* During any 60 consecutive days, the arithmetic mean of the 24-hour average concentrations, at any location, shall not exceed:

Level I	70 $\mu g/m^3$	Level III	95 $\mu g/m^3$
Level II	85 $\mu g/m^3$	Level IV	115 $\mu g/m^3$

(e) *90-day standard.* During any 90 consecutive days, the arithmetic mean of the 24-hour average concentrations, at any location, shall not exceed:

Level I	65 $\mu g/m^3$	Level III	90 $\mu g/m^3$
Level II	80 $\mu g/m^3$	Level IV	105 $\mu g/m^3$

(f) The standards in subdivisions (c), (d) and (e) of this section are intended for enforcement purposes, and monitoring will be performed only as required in a particular area. For prediction purposes, prediction of conformity with the annual geometric mean standard shall be sufficient to demonstrate predicted conformity with these standards.

Historical Note

Sec. filed April 28, 1972; amd. filed Feb. 16, 1977 eff. 30 days after filing.

257-3.4 Standard for settleable particulates (dustfall). (a) During any 12 consecutive months, 50 percent of the values of the 30 day average concentrations shall not exceed:

Level I	0.30 $mg/cm^2/mo$	Level III	0.40 $mg/cm^2/mo$
Level II	0.30 $mg/cm^2/mo$	Level IV	0.60 $mg/cm^2/mo$

(b) During any 12 consecutive months, 84 percent of the values of the 30-day average concentrations shall not exceed:

Level I	0.45 $mg/cm^2/mo$	Level III	0.60 $mg/cm^2/mo$
Level II	0.45 $mg/cm^2/mo$	Level IV	0.90 $mg/cm^2/mo$

Historical Note

Sec. filed April 28, 1972 eff. May 1, 1972.

257-3.5 Measurement. (a) Concentration of suspended particulates is determined gravimetrically by the use of high-volume sampling techniques by drawing air through a filter for 24 hours and is expressed in micrograms of suspended particulate per cubic meter of air ($\mu g/m^3$). Specifications for equipment and filter media shall conform to standards acceptable to the commissioner.

(b) Concentration of settleable particulates or dustfall is determined gravimetrically by the collection of the settleable particulate in a one-gallon glass jar without a lid. Area on which the particles have settled is computed from the inside diameter of the jar mouth. The results are expressed as miligrams of settleable particulate per square centimeter per month ($mg/cm^2/mo$).

Historical Note

Sec. filed April 28, 1972; amd. filed Feb. 16, 1977 eff. 30 days after filing.

257-3.6 Sampling frequency. (a) The following guidelines regarding minimum frequency of sampling shall be used to determine compliance with standards.

(b) *Suspended particulate standards.*

(1) Annual standard—every sixth day sampling—minimum of 50 samples.
(2) 24-hour standard—every sixth day sampling—minimum of 50 samples.
(3) 30-day standard—every day sampling—minimum of 24 samples.
(4) 60-day standard—every other day sampling—minimum of 24 samples.
(5) 90-day standard—every other day sampling—minimum of 36 samples.

Historical Note

Sec. filed Feb. 16, 1977 eff. 30 days after filing.

SUBPART 257-4
AIR QUALITY STANDARDS—CARBON MONOXIDE (CO)

Sec.
257-4.1 Definition
257-4.2 Objective
257-4.3 Standard
257-4.4 Measurement

Historical Note

Subpart (§§ 257-4.1—257-4.4) filed April 28, 1972 eff. May 1, 1972.

Section 257-4.1 Definition. *Carbon monoxide (CO).* A colorless, odorless gas, produced by the incomplete combusiton of carbonaceous material, having an effect which is predominantly one causing asphyxia.

Historical Note

Sec. filed April 28, 1972 eff. May 1, 1972.

257-4.2 Objective. Protection from adverse health effects caused by the affinity of hemoglobin for carbon monoxide which is over 200 times greater than that for oxygen, resulting in a decrease of oxygen circulation through the body.

Historical Note

Sec. filed April 28, 1972 eff. May 1, 1972.

257-4.3 Standard. (a) *For all levels* For an eight-hour period, the average concentration of carbon monoxide shall not exceed nine ppm[1] more than once in any 12 consecutive months.

(b) *For all levels.* For a one-hour period, the average concentration of carbon monoxide shall not exceed 35 ppm[2] more than once in any 12 consecutive months.

Historical Note

Sec. filed April 28, 1972; amds. filed: filing. May 19, 1972; Feb. 16, 1977 eff. 30 days after

1 Corresponds to Federal standard of 10 mg/m^3 (at temperature of 25°C and pressure of 760 mm of mercury).

2 Corresponds to Federal standard of 40 mg/m^3 (at temperature of 25°C and pressure of 760 mm of mercury).

257-4.4 Measurement. (a) Carbon monoxide (CO) is determined continuously by the nondispersive infrared spectrometry.

(b) All measurements are corrected to a reference temperature of 25 degrees Centigrade and to a reference pressure of 760 millimeters of mercury.

Historical Note

Sec. filed April 28, 1972 eff. May 1, 1972.

SUBPART 257-5

AIR QUALITY STANDARDS—PHOTOCHEMICAL OXIDANTS

Sec.
257-5.1 Definition
257-5.2 Objective
257-5.3 Standard for all levels
257-5.4 Measurement

Historical Note

Subpart (§§ 257-5.1—257-5.4) filed April 28, 1972 eff. May 1, 1972.

Section 257-5.1 Definition. *Photochemical oxidants* are those substances in the atmosphere which are produced when reactive organic substances, principally hydrocarbons, and nitrogen oxides are exposed to sunlight. For the purpose of this Subpart, they shall include ozone, peroxyacyl nitrates, organic peroxides and other oxidants as measured by the method specified, or by an equivalent method approved by the commissioner.

Historical Note

Sec. filed April 28, 1972 eff. May 1, 1972.

257-5.2 Objective. Photochemical oxidants cause irritation of the mucous membranes, damage to vegetation, and deterioration of materials. They affect the clearance mechanism of the lungs and later resistance to bacterial infection. The objective of these standards is to prevent such effects.

Historical Note

Sec. filed April 28, 1972 eff. May 1, 1972.

257-5.3 Standard for all levels. In any one-hour period, the average concentration of photochemical oxidant shall not exceed 0.08 ppm[1] more than once in any 12 consecutive months.

Historical Note

Sec. filed April 28, 1972; amd. filed Feb. 16, 1977 eff. 30 days after filing.

257-5.4 Measurement. (a) Photochemical oxidant is determined by the liberation of iodine from a buffered, neutral potassium iodide solution, corrected for interferences of sulfur dioxide and oxides of nitrogen and is expressed as photochemical oxidant (ozone equivalent) per million parts of air (ppm) by volume.

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1 Corresponds to Federal standard of 160 $\mu g/m^3$ (at temperature of 25°C and pressure of 760 mm of mercury).

SUBPART 257-7

AIR QUALITY STANDARDS—NITROGEN DIOXIDE (NO_2)

(Statutory authority: Environmental Conservation Law, §§ 15, 77)

Sec.		Sec.	
257-7.1	Characteristics	257-7.3	Standard
257-7.2	Objective	257-7.4	Measurement

Historical Note

Subpart (§§ 257-7.1—257-7.4) added, filed May 19, 1972.

Section 257-7.1 Characteristics. Nitrogen dioxide is a reddish-orange-brown gas with a characteristic pungent odor. The partial pressure of NO_2 in the atmosphere restricts it to the gas phase at usual atmospheric temperatures. It is corrosive and highly oxidizing and may be physiologically irritating. The presence of nitrogen dioxide in ambient air has been associated with a variety of respiratory diseases. NO_2 is essential to the production of photochemical smog. At higher concentrations, its presence has been implicated in the corrosion of electrical components as well as vegetation damage.

Historical Note

Sec. added, filed May 19, 1972.

257-7.2 Objective. The objective of this Subpart is the attainment of the annual average which, with an adequate safety margin, will provide for protection of public health and will protect against known and anticipated adverse effects on public welfare.

Historical Note

Sec. added, filed May 19, 1972.

257-7.3 Standard. During any 12 consecutive months, the annual average of the 24-hour concentrations, shall not exceed 0.05 ppm ($100\mu g/m^3$) in all levels.

Historical Note

Sec. added, filed May 19, 1972.

257-7.4 Measurement. (a) The concentration of NO_2 is determined by the method specified or by an equivalent method approved by the commissioner.

(b) NO_2 is collected in a sodium hydroxide solution and determined colorimetrically by reacting the exposed absorbing reagent with phosphoric acid, sulfanilamide, and N-1-naphthylethylenediamine dihydrochloride.

(c) All measurements are corrected to a reference temperature of 25 degrees Centigrade and to a reference pressure of 760 millimeters of mercury.

Historical Note

Sec. added, filed May 19, 1972.

(b) All measurements are corrected to a reference temperature of 25 degrees Centigrade and to a reference pressure of 760 millimeters of mercury.

Historical Note

Sec. filed April 28, 1972 eff. May 1, 1972.

SUBPART 257-6

AMBIENT AIR QUALITY STANDARD—HYDROCARBONS (NON-METHANE)

Sec.
257-6.1 Definition
257-6.2 Objective
257-6.3 Standard
257-6.4 Measurement

Historical Note

Subpart (§§ 257-6.1—257-6.4 filed April 28, 1972 eff. May 1, 1972.

Section 257-6.1 Definition. *Hydrocarbons* are organic compounds consisting only of hydrogen and carbon. However, for the purpose of this Subpart, *hydrocarbons (non-methane)* shall refer to the total air borne hydrocarbons and other organic compounds excluding methane (CH_4) as measured by the specified technique, or other method acceptable to the commissioner.

Historical Note

Sec. filed April 28, 1972 eff. May 1, 1972.

257-6.2 Objective. Although ambient air concentrations of gaseous hydrocarbons as a group have not been associated with health effects, it has been demonstrated that ambient levels of photochemical oxidant which do have adverse effects on health are associated with the occurrences of concentrations of non-methane hydrocarbons. The objective of this standard is to inhibit such photochemical reactions which lead to photochemical smog formation.

Historical Note

Sec. filed April 28, 1972 eff. May 1, 1972.

257-6.3 Standard. During the three-hour period from 6 to 9 a.m., the average non-methane hydrocarbon concentration must not exceed 0.24 ppm[1] more than once in any 12 consecutive months.

Historical Note

Sec. filed April 28, 1972; amd. Feb. 16, 1977 eff. 30 days after filing.

257-6.4 Measurement. (a) Hydrocarbons (non-methane) is determined by the flame ionization technique with correction for methane by a methane analyzer.

(b) All measurements are corrected to a reference temperature of 25 degrees Centigrade and to a reference pressure of 760 millimeters of mercury.

Historical Note

Sec. filed April 28, 1972 eff. May 1, 1972.

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1 Corresponds to Federal standard of 160 ug/m3 (at temperature of 25°C and pressure of 760 mm of mercury).

SUBPART 257-9

AMBIENT AIR QUALITY STANDARD—BERYLLIUM

Sec.
257-9.1 Definition
257-9.2 Objective
257-9.3 Standard
257-9.4 Measurement

Historical Note

Subpart (§§ 257-9.1—257-9.4) added, filed April 28, 1972 eff. May 1, 1972.

Section 257-9.1 Definition. For the purpose of this Subpart, the term *beryllium* shall include metallic beryllium and all beryllium compounds that may test as beryllium by the acceptable analytical method.

Historical Note

Sec. added, filed April 28, 1972 eff. May 1, 1972.

257-9.2 Objective. Beryllium is extremely toxic in most of its physical and chemical forms, and can result in acute respiratory and skin problems or chronic beryllium disease. While industrial hygiene safety procedures now in effect have minimized the potential for acute effects, long term exposure to relatively low level ambient air concentrations that might occur in proximity to industrial plants still pose a potential for chronic beryllium disease. Compliance with the proposed standard should preclude such effect.

Historical Note

Sec. added, filed April 28, 1972 eff. May 1, 1972.

257-9.3 Standard. Applicable in all levels during any month, the average concentration of beryllium shall not exceed 0.01 $\mu g/m^3$.

Historical Note

Sec. added, filed April 28, 1972 eff. May 1, 1972.

257-9.4 Measurement. Beryllium in air is sampled by filtering through a cellulose or membrane filter at a rate and for a time necessary to meet detection limits. Following acid digestion of the filter, analysis is made for beryllium with the atomic absorption spectrophotometer using an acetylene nitrous oxide flame.

Historical Note

Sec. added, filed April 28, 1972 eff. May 1, 1972.

SUBPART 257-10

AMBIENT AIR QUALITY STANDARD—HYDROGEN SULFIDE (H_2S)

Sec.
257-10.1 Definition
257-10.2 Objective
257-10.3 Standard
257-10.4 Measurement

Historical Note

Subpart (§§ 257-10.1—257-10.4) added, filed April 28, 1972 eff. May 1, 1972.

Section 257-10.1 Definition. *Hydrogen sulfide* (H_2S) is a colorless gas having a characteristic, disagreeable odor often described as that of rotten eggs. For the

SUBPART 257-8

AMBIENT AIR QUALITY STANDARDS—FLUORIDES

Sec.
257-8.1 Definitions
257-8.2 Objectives
257-8.3 Standards
257-8.4 Measurement

Historical Note

Subpart (§§ 257-8.1—257-8.4) added, filed April 28, 1972 eff. May 1, 1972.

Section 257-8.1 Definition. The term *fluorides* refers to a heterogeneous group of compounds formed from the highly reactive, nonmetallic gaseous element known as fluorine. For the purpose of this Subpart the term *fluoride* will include material that tests as fluoride by the method specified or other methods acceptable to the commissioner.

Historical Note

Sec. added, filed April 28, 1972 eff. May 1, 1972.

257-8.2 Objectives. Fluorosis in grazing ruminants has been shown to occur with continuing low level fluoride ingestion. Also excessive atmospheric fluoride concentration has been associated, in varying degrees, with vegetation damage. The objective of the standard for forage is to protect against adverse effects on grazing ruminants while the objective of the standard for total fluorides in air is to provide protection against adverse effects on vegetation.

Historical Note

Sec. added, filed April 28, 1972 eff. May 1, 1972.

257-8.3 Standards. (a) Total fluorides, parts per million (ppm), dry weight basis (as F) in and on forage for consumption by grazing ruminants. Average concentration shall be less than the following in all levels:

(1) For growing season (not to exceed six consectuive months) — 40 ppm
(2) For any 60 day period — 60 ppm
(3) For any 30 day period — 80 ppm

(b) Gaseous fluorides in air (parts per million parts of air) as F—all levels. (25 degrees Centigrade, 760 min. Hg.)

(1) 12 hour averages to be less than 4.5 ppb (3.7 $\mu g/m^3$)
(2) 24 hour averages to be less than 3.5 ppb (2.85 $\mu g/m^3$)
(3) 1 week averages to be less than 2.0 ppb (1.65 $\mu g/m^3$)
(4) 1 month averages to be less than 1.0 ppb (0.8 $\mu g/m^3$)

Historical Note

Sec. added, filed April 28, 1972 eff. May 1, 1972.

257-8.4 Measurement. (a) Total fluorides in and on forage is determined by fusion of a representative sample by the Schoniger flash oxygen combustion method and analysis by specific ion electrode* or other methods acceptable to the commissioner.

(b) Gaseous fluorides in air will be collected and analyzed by methods acceptable to the commissioner.

Historical Note

Sec. added, filed April 28, 1972 eff. May 1, 1972.

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* *Standard Method For Fluorides From Vegetation*, New York State Department of Health, Division of Labs. & Research, August, 1970 (or subsequent revision). ppb = 0.82 $\mu g/m^3$ as F.

purpose of this Subpart the term *hydrogen sulfide* will include hydrogen sulfide and other sulfides as measured by the acceptable analytical method.

Historical Note

Sec. added, filed April 28, 1972 eff. May 1, 1972.

257-10.2 Objective. Hydrogen sulfide can cause odors which unreasonably interfere with the comfortable enjoyment of life and property. Although tarnishing of metals and discoloring of paint may occur at higher ambient air concentrations the primary objective of this standard is to prevent disagreeable odors.

Historical Note

Sec. added, filed April 28, 1972 eff. May 1, 1972.

257-10.3 Standard. Applicable in all levels. In any one-hour period, the average concentration of hydrogren sulfide shall not exceed 0.01 ppm (14 $\mu g/m^3$).

Historical Note

Sec. added, filed April 28, 1972 eff. May 1, 1972.

257-10.4 Measurement. (a) Hydrogen sulfide is determined by the Cadmium Hydroxide-Methylene Blue method and expressed as parts of hydrogen sulfide per million parts of ambient air (ppm) by volume.

(b) All measurements are corrected to a reference temperature of 25 degrees Centigrade and to a reference pressure of 760 millimeters of mercury.

Historical Note

Sec. added, filed April 28, 1972 eff. May 1, 1972.

January 11, ~~1977~~ 1978

Mr. Theodore DeBoer
NYS Energy Office
Agency Building #2
Empire State Plaza
Albany, New York 12223

Dear Mr. DeBoer:

Enclosed are New York State's comments on the NUS October 1977 Draft "Plans for Environmental Surveys of Bedded Salt Formations and Overlying Areas of the Salina Basin in New York - Volume I." We have incorporated the pertinent views of interested New York State agencies in these comments.

The major concerns to New York State in regard to a radioactive waste repository in the Salina Salt Basin are the site integrity, the risk of inadvertent penetration of a repository in the salt bed, the value of the mineral resources affected by such a repository and the potential environmental and health impacts in the relatively densely populated region of New York. The overriding concern is the need for reasonable assurance that any selected site can maintain the site integrity for thousands of years in order to isolate the high level radioactive waste from the environment.

A radioactive waste repository would preclude or jeopardize the use of valuable resources such as salt, oil and gas in a thirty square mile area of the Salina Salt Basin. These same resources also increase the potential hazard of later intrusion into a repository located in the Salina Salt Basin.

The NUS draft plan for environmental surveys is a comprehensive plan and will require a detailed study. Such a survey is essential before selection of any site. It may be more cost-effective, however, to place a priority on resolving the basic issues of site integrity, control of inadvertent drilling or mining into the waste repository and the value of the mineral resources lost to present and future generations prior to the large investment of time and money on the environmental survey. These basic issues may totally negate the waste repository program in the Salina Salt Basin.

We appreciate the opportunity to review this draft plan and hope that the comments will be of assistance to NUS Corporation.

Very truly yours,

/S/

Terence P. Curran, Director
Office of Environmental Analysis

Enclosure

TJC:sl

OARDC

Ohio Agricultural Research and Development Center

WOOSTER, OHIO 44691
TELEPHONE (216) 264-1021

OFFICE OF DIRECTOR

August 16, 1978

Mr. Joseph J. DiNunno
NUS Regulatory Project Manager
NUS Corporation
4 Research Place
Rockville, Maryland 20850

Dear Mr. DiNunno:

Mr. Stephen K. Breslauer has requested an evaluation of the draft of Volume 2 entitled "Environmental Characterization of Bedded Salt Formation and Overlying Areas of the Salina Basin." I asked Dr. Craig Weidensaul, Head of our Laboratory for Environmental Studies, to read and evaluate this document. His comments are enclosed in a letter addressed to me, dated August 10, 1978.

I believe Dr. Weidensaul's concerns revolve primarily around the economic importance of agriculture, forestry, and fisheries in the region under study. I would suggest that you send this document to the head or chairperson for the departments of agricultural economics at the Land Grant Universities in Michigan, Ohio, Pennsylvania and New York. Their names and addresses are as follows:

Dr. H. M. Riley, Chairman
Department of Agricultural Economics
Michigan State University
E. Lansing, Michigan 48824

Dr. D. H. Boyne, Chairman
Department of Agricultural Economics & Rural Sociology
The Ohio State University
Columbus, Ohio 43210

Dr. J. W. Malone, Head
Department of Agricultural Economics & Rural Sociology
The Pennsylvania State University
University Park, Pennsylvania 16802

Dr. O. D. Forker, Chairman
Department of Agricultural Economics
Cornell University
Ithaca, New York 14853

I appreciate the opportunity to review Volume 2 and I hope that the suggestions made by Dr. Weidensaul and my suggestion to contact appropriate departments of agricultural economics to properly assess the impact on agriculture, forestry and fisheries, will be helpful.

Sincerely yours,

Clive W. Donoho, Jr.
Associate Director

CWD:kj
cc: S. K. Breslauer
R. M. Kottman, Dean & Director, College of Agriculture and Home Economics, O.S.U.
T. C. Weidensaul, Head, Laboratory for Environmental Studies, OARDC

OARDC

Ohio Agricultural Research and Development Center

WOOSTER, OHIO 44691
TELEPHONE (216) 264-1021

LABORATORY FOR
ENVIRONMENTAL STUDIES

August 10, 1978

Dr. C. W. Donoho
Associate Director
OARDC

Dear Clive:

I have reviewed the enclosed document as you requested. The three comments I made re Volume I are also applicable to the enclosed, more recent one. In addition, I might make the following remarks re the latest document.

Table 6-3 (page 6-13) takes out of context the importance of agriculture, forestry, and fisheries in terms of environmental impacts and land uses. A similar table should reflect land-use demands and needs for each listed industry when attempting to evaluate the total impact on and importance of a particular industry re the total economy of the Salina Region.

From Table 6-4 (page 6-16) I notice that in 1970 agriculture, forestry, and fisheries total earnings in the Salina Region represent 1.4% of the total earnings and decrease in relative importance to only 0.7% projected for the year 2000. The manufacturing; wholesale and retail trade; government; services; finance, insurance, and real estate; contract construction; and transportation, communications, and public utilities industries have projected increases in total earnings between 1970 and 2000 of 34, 13.6, 15.4, 19.4, 4.8, 5.6, and 6 percent, respectively. These figures imply that throughout the orchard, vineyard, and truck crop areas of Ohio, Pennsylvania, New York, and Michigan that gross income from agriculture, forestry, and fisheries will decrease proportionate to total earnings in all industries and only increase in real dollars to $181,230,000 per year in 2000, this increase requiring 30 years to attain. I personally feel that this is a significant underestimate of the importance of the agri-industries in the Salina Region.

Recreational and Natural Areas are only mentioned for areas exceeding 10,000 acres, but it is a known fact that most of such forested areas are in relatively small private ownerships and account for far more land than the combined totals of the "forested" lands mentioned. Much attention is devoted to airports, highways, navigable waters, and restricted military areas, but no mention is made of the importance of agriculture, forests (other than large single acreages), or fisheries

as land uses in Chapter 6. However, in paragraph 6.2.1.2 agriculture and forestry are recognized as the dominant land uses (44% as forests and 40% as agricultural crop lands). There is a need for a detailed description of the quantity, locations, and specific crops produced. It appears that such areas have been de-emphasized or discounted since they account for the reported relatively small contribution to the total income of the Region.

In paragraph 7.1.2.1 black cherry should be emphasized as it is the single most valuable timber species in the Salina Region. Most of the high quality cherry produced in the U.S. is grown in northwest Pennsylvania. No reference is made anywhere in the report to this important species. Further a statement re this hardwood region being previously cut, burned, farmed, or otherwise disturbed implies timber of lesser quality or possible lack thereof when the black cherry region is one of the most intensively managed and productive hardwood areas in the nation. The authors should consult a more recent timber inventory account and projected timber volume availability than the 28 yr.-old paper by Braun.

Most papers cited re timber are not at all current re actual volumes and species distribution and importance. Further, no consideration is given to forest management and species manipulation. The assumption is implied that the only species present or which will be present are the indigenous species that will gain dominance during successional changes toward a climax forest.

I feel the importance of agriculture is de-emphasized by the statement in line 3 on page 7-34. It is further played down by the way the reference made to small farms is couched. I think the owners of these farms should have been given some consideration re their right to earn a living on the land while they are stewards without fear of land condemnation for access to the public domain. This aspect went untreated in Chapter 6. All discussions involved only money and nothing about people except indian reservations.

On page 7-34 the statement is made that the major crops are forage and feed grains for livestock. The meat and dairy products derived therefrom have not gotten adequate discussion, particularly since 31% of the Salina Region is in the Lake States Fruit, Truck Crop, and Dairy Region. This page has several contradictions re general statements made previously compared to subsequent discussion of crops grown, acreage affected, etc.

In general I feel the entire report is biased toward the establishment of repositories and sidesteps the long-term importance of alternative land uses, particularly that for agriculture and forestry. Many important considerations re food and fiber production have been neglected or glossed over in such a way as to indicate either an intentional bias on the part of the report authors or a lack of familiarity with these subjects. They seemed to have some aversion for more current, sometimes hard-to-find factual information in the extent of detail necessary to make the discussions valuable. Several of the chapters are superficial treatments of the

subjects at hand and never address anything close to environmental impact evaluations or problems associated with repositories for radioactive wastes. Most discussions are oriented around economics and not hazards, people, etc. No recommendations are made re the advisability of establishing repositories in the Salina Region.

If you have any questions, let me know.

Sincerely,

T. Craig Weidensaul

T. Craig Weidensaul
Head, LES and Associate
Professor of Plant Pathology

TCW:mg
enclosure

Battelle
Project Management Division
Office of Nuclear Waste Isolation
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 424-6424
Telex 24-5454

January 22, 1979

Dr. Clive W. Donoho, Jr.
Associate Director
Ohio Agricultural Research and
Development Center
Wooster, Ohio 44691

Dear Dr. Donoho:

We appreciate the review of Dr. Craig Weidensaul, Head of your Laboratory for Environmental Studies on our report entitled "Environmental Characterization of Bedded Salt Formation and Overlying Areas of the Salina Basin" and his comments as transmitted in your letter of August 16, 1978.

We have followed up your suggestion that the document should be sent to the department heads of agricultural economics at the Land Grant Universities, in the states involved. Copies have been provided to them.

Dr. Weidensaul's thoughtful comments have been carefully analyzed, and it is unfortunate that he believes the regional report to be biased toward the establishment of repositories and also that he feels the authors have ignored, or were ignorant of, important considerations on food and fiber production. We have attempted to stress factual information in the reports to enable the decision makers to have as complete a data base as possible in making evaluations. One of the most difficult aspects of regional report preparation was deciding how much information could be included in order to keep the size of the document to a manageable level. Because of the large area involved, the data and information presented are extremely broad in nature and limited to general regional characterization. Subsequent study reports as they focus on smaller areas, locations or specific sites will address the items questioned by Dr. Weidensaul in considerable detail, and, hopefully, satisfy his concerns.

Dr. Weidensaul's observation that the report did not address potential environmental impacts of repositories is certainly correct. We tried to make clear that this report was not an environmental impact evaluation. The purpose of the regional report is to provide a broad general characterization of regional resources. The report will be one of a number that will provide baseline data to be used if a suitable repository location can be found in the region. Environmental impacts, evaluations and problems associated with repositories for radioactive wastes will be addressed in detail in later reports.

Similarly, the long-term importance of alternative uses of the land that may be required for a repository (e.g., food and fiber production) will be addressed in detail once candidate repository locations are identified.

It is agreed that black cherry is an important timber species in northern Pennsylvania. The black cherry and black cherry-sugar maple forest types are within the maple-beech-birch type discussed in the regional report. The maple-beech-birch type portion of the Salina Region constitutes less that six percent of the commercial forest land in the Region. Discussion of individual types within the major forest types of the Salina Region is beyond the scope of the regional report. Growing stock volume, sawtimber volume and average stumpage prices for major timber species in the Pennsylvania portion of the Salina Region are compared in Table 1: black cherry is obviously important but so are several other species or species groups; black walnut is the most valuable species (per board foot).

Timber inventory data used in the regional report were taken from the most recent statewide publications available (i.e., U.S. Forest Service publications on the timber resources of each state in the region). Data for Pennsylvania were adapted from Ferguson (1968). The Forest Service is updating this publication but the new report was not available at the time the regional report was written.

Forest management practices were not discussed in the regional report because of the large number of individual forest types in the Salina Region and the variety of silvicultural techniques that might be applicable. Clearcutting is probably the only feasible management technique for regenerating black cherry commercially in north central Pennsylvania (Marquis, 1973).

The statement that forage and feed grains for livestock are the major crops implies that meat and dairy products derived from the livestock are important.

It is apparent that Dr. Weidensaul recognized several "contradictions" on Page 7-34 of the regional report; no replies can be made without specific information on the alleged "contradictions." As a general comment, no attempt (expressed or implied) was made to de-emphasize the importance of agriculture or the rights of owners of farms (small or large).

We appreciate receiving Dr. Weidensaul's comments on the regional study and look forward to your Center's continued input to the more in-depth follow-on studies as they are carried out. For your information, we have cited below several additional references that you may find helpful in clarifying some of the points that have been raised.

Sincerely,

E. S. Pedersen

Erik S. Pedersen
Project Manager
Site Qualification and
Licensing Department

Enclosure

References Cited

(1) Ferguson, R. H., 1968. The timber resources of Pennsylvania. USDA, Forest Service, Northeastern Forest Experiment Station, USFS Resource Bulletin NE-8, Upper Darby, Pa. 147 pp.

(2) Marquis, D. A., 1973. Cherry-maple. Pp. 78-79. In: Silvicultural systems for the major forest types of the United States, USDA, Forest Service, Agriculture Handbook No. 445, Washington, D.C.

(3) Ohio Crop Reporting Service., 1978. Ohio timber prices. Ohio Crop Reporting Service, Columbus, Ohio (July 6, 1978).

RECEIVED SEP 11 1978
Joseph J. DiNunno

OHIO UNIVERSITY
DEPARTMENT OF GEOLOGY
PORTER HALL
ATHENS, OHIO 45701

September 7, 1978

Mr. Joseph J. DiNunno
NUS Regulatory Project Manager
NUS Corporation
4 Research Place
Rockville, Maryland 20850

Dear Mr. DiNunno:

Mr. Adam Marsh, Manager Ohio University Research Institute has forwarded me the draft report - Environmental Characterization of Bedded Salt Formation and Overlying Areas of the Salina Basin for review and comments. The following are my comments:

1. The hydrological flow regime and the seismic risk are some of key elements in the selection of the site for the waste repository project. I find that both of these topics are not thoroughly investigated in the draft.

2. A generalized deep ground water flow system of the Salina region may be outlined so that the problems encountered at Lyon, Kansas may be avoided.

3. The seismic characterization of the Salina region is superficial. This region was glaciated until 10,000 years ago.

The unloading of the ice is causing the uplift at North Erie Basin. The stability of this region may not be established based on 300 years of seismic data alone. The magnitude of the earthquakes have not been mentioned in Table 2-2. The seismic risks are not evaluated quantitatively.

4. I would recommend that a more detailed analysis of the groundwater flow system and seismic risk should be done for this report.

Yours sincerely,

Moid U. Ahmad

Moid U. Ahmad
Prof. of Hydrology and Geophysics

MUA/eo
cc/Ohio Department of Energy
U.S. Department of Energy (Waste Management)
Mr. Adam Marsh

Battelle
Project Management Division
Office of Nuclear Waste Isolation
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 424-6424
Telex 24-5454

January 22, 1979

Dr. Moid V. Ahmad
Professor of Hydrology and Geophysics
Department of Geology
Porter Hall
Ohio University
Athens, Ohio 45701

We appreciate your review of the draft report on "Environmental Characterization of Bedded Salt Formation and Overlying Areas of the Salina Basin" and the comments provided in your letter of September 7, 1978. Your concern with the need for greater detail in technical areas such as the hydrological flow regime, the groundwater flow system and seismic risk in support of any planned placement of a repository in a geologic unit is appropriate. This information will be developed as the site search program proceeds.

As an aid to your understanding how this kind of information will be developed, it may be helpful to briefly describe the terminal waste storage program for nuclear wastes from commercial facilities. The identification of potential waste storage sites involves two parallel efforts. First of all, geologic studies are being conducted to locate a geological setting that will insure that all public health, safety, and engineering feasibility requirements are met. Concurrent with the geologic studies are a sequence of environmental studies to assure that natural and human values are being properly considered as required by the National Environmental Policy Act (NEPA).

Both types of studies have started with: (1) broad regional, formation-wide surveys with plans to proceed to (2) area-wide surveys (approximately 1,000 square miles in extent), and (3) confirmatory location studies (about 30 square miles in size). The environmental studies are being directed at areas of geologic interest. As you might expect, both the geologic and environmental studies are phased efforts, with review of results and decision-making at the end of each phase regarding: (1) whether to proceed, and (2) the focus of further investigations. In this setting, the report which you reviewed is the Phase I broad regional environmental characterization. Your suggestion for more detail on the hydrological flow regimes would be covered in the Phase 3 locational studies; similarly, the deep groundwater flow system and seismic risk characterization would be assessed in the geologic area-wide and location studies, if a determination is made to proceed with these investigations.

We are grateful for your time and efforts in reviewing the regional environmental report. We believe by the nature of your comments you would be even more interested in results of the geohydrological studies of the Salina Basin. If so, we suggest you contact Mr. Muzaffer Kehnemuyi, Office of Nuclear Waste Isolation, Battelle Memorial Institute, 505 King Avenue, Columbus, Ohio 43201.

Sincerely,

E. S. Pedersen

Erik S. Pedersen
Project Manager
Site Qualification and
Licensing Department

ESP:tam

Southern Tier Central
Regional Planning &
Development Board

53½ Bridge Street
Offices 3, 4, 5
Corning, New York 14830
607/962 3021, 607/962 5092

William D. Hess
Executive Director

August 16, 1978

Mr. Joseph J. DiNunno
NUS Regulatory Project Manager
NUS Corporation
4 Research Place
Rockville, Maryland 20850

Dear Mr. DiNunno:

We appreciate the opportunity given us to review your regional characterization report (Y/OWI/SUB-78/42505/2) dated April, 1978.

We recognize that this report is the first in a series of progressively more detailed environmental reports. As such, the level of detail provided is really too broad for us to be able to comment. That is, the report does not include data specifically pertaining to our three county planning area.

We're sorry that we could not be of any real assistance on this report. However, we are looking forward to reviewing the more detailed studies as they are completed and will undoubtedly be providing comments on these.

Sincerely yours,

Ann Clarke
Environmental Planner

AC/fb

File: 05.2
Corres.
NUS

RECEIVED AUG 21 1978
Joseph J. DiNunno

Battelle
Project Management Division
Office of Nuclear Waste Isolation
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 424-6424
Telex 24-5454

January 22, 1979

Ms. Ann Clarke
Environmental Planner
Southern Tier Central Regional
Planning and Development Board
53-1/2 Bridge Street
Corning, New York 14830

Dear Ms. Clarke:

We appreciate your review of our report entitled "Environmental Characterization of Bedded Salt Formation and Overlying Areas of the Salina Basin" and your comments as provided by letter of August 16, 1978.

We agree with your acknowledgment that this report is the first in a series of progressively more detailed environmental reports. As you have noted, the report, because of its broad regional nature, does not include data on the three counties of specific interest to your Board.

We appreciate your offer to review the more detailed environmental studies as they are completed and will provide you with these anticipated reports as they become available.

Sincerely,

E. S. Pedersen

Erik S. Pedersen
Project Manager
Site Qualification and
Licensing Department

ESP:tam

TELECON NOTE

Date: 12/27/78 Time: 11:00 A.M. File:

Between: M. Italiano of: Northeast Ohio Areawide Coordinating Agency (NOACA)

And: W. G. Belter (NUS)

DISCUSSION:

At the suggestion of DOE, I called NOACA to determine whether they planned to submit any comments on the draft Salina Region environmental characterization report. I indicated that we were trying to ascertain whether any additional comments were to be forthcoming during early January, as we hoped to finalize this report by January 15, 1979. He noted the following items:

1. It was still NOACA's conclusion that selection of any area in Ohio in the Salina Region was infeasible because of population, industrial density, etc.

2. The NOACA Board feels strongly that any further study of the entire state of Ohio should cease; the Federal Government should not spend any money for drilling exploratory holes in Ohio for a repository; these government funds could better be utilized for alleviating economic problems in northeast Ohio.

3. He planned to discuss our request for comments on the characterization report with F. Pizzedaz, their Executive Director, and perhaps several Board members; he was not optimistic about sending us any further comments.

TELECON NOTE

Date: 1/10/79 Time: 8:45 A.M. File: _____

Between: E. Johnson of: Ohio Dept. of Energy

And: W. G. Belter (NUS)

DISCUSSION:

By letter of Dec. 26, 1978, from R. C. Masoner, the Ohio Department of Energy returned nine copies of the NUS Salina Region environmental characterization report. In the letter it was indicated that seven copies of the report had been distributed to various Ohio State agencies and the State legislature. In response to my inquiry as to whether we might expect to receive any technical comments on the report, Johnson noted the following points:

1. By directive from the Governor, no further State funds were to be spent by any State agency on the salt repository project; therefore, it was unlikely that any other State of Ohio responses would be forthcoming.

2. He thought the NUS report was a good technical document from a regional perspective; also that the Stone & Webster geologic reports were very comprehensive.

James A. Rhodes
GOVERNOR

Robert S. Ryan
DIRECTOR

30 East Broad Street 34th Floor
Columbus, Ohio 43215
(614) 466-6797

December 26, 1978

Mr. Walter Belter
NUS Corporation
4 Research Place
Rockville, Maryland 20850

Dear Mr. Belter:

Under separate cover, I am returning nine (9) of the remaining ODOE copies of the NUS report entitled "Environmental Characterization of Bedded Salt Formations and Overlying Areas of the Salina Basin."

Seven (7) copies were sent out to individuals in several State of Ohio agencies including:

Colleen K. Nissl - Ohio Attorney General's Office
Roger Williams - Department of Economic and Community Development
Wayne Nichols - Ohio Department of Natural Resources
Horace Collins - Ohio Geological Survey ODNR
Rex Sprague - Ohio Environment Protection Agency
Neal F. Zimmer, Jr. - The Ohio Senate
Tom J. Carney - The Ohio House of Representatives.

Two (2) copies are retained at ODOE Administration, and two (2) copies are retained in the Research and Development Division of ODOE.

The emotional impact of the prospect for nuclear waste disposal in northeastern Ohio was felt by this department in the resolutions forwarded by 27 communities and associations within the project area. These resolutions were very firm in their resolve to reject any possible or potential siting of nuclear waste disposal in their area. The Governor of Ohio has supported this resolve. The communities which have expressed their feelings are as follows:

Richmond Heights	44143
Lyndhurst	44124
Seven Hills	44131
Bay Village	44140
Solon	44139
Lake County City Association	44077
South Euclid	44123
Lake County Commissioners	44077
Ashtabula County	44047
Shaker Heights	44120
Bedford Heights	44146
Wickliffe	44092
Garfield Heights	44125
Lakewood	44107
Middleburg Heights	44130
Highland Heights	43097
Fairview Park	44126
North Olmsted	44070
Strongsville	44136
Broadview Heights	44147
Rocky River	44116
Parma	44129
Westlake	44145
University Heights	44118
Newburgh Heights	44105
Willoughby Hills	44094
Mayfield Heights	44124

If I can be of any further assistance, please call.

Sincerely,