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Ohio River Basin Energy Study (ORBES): Draft Main Report - Phase II - Part 1

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OHIO RIVER BASIN ENERGY STUDY (ORBES): DRAFT MAIN REPORT Part 1

by

The ORBES Core Team

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PREFACE

Release of this publication concludes the Ohio River Basin Energy Study (ORBES), a research activity undertaken by over 100 university faculty members at eight institutions in the Middle West and the area popularly known as the Ohio River valley. Formally entitled the ORBES Main Report, this document is one of __ issued since the study began in the fall of 1976. Grants from the U.S. Environmental Protection Agency (EPA) funded the project.

The main report is the principal element of the ORBES publication series; it represents the collective end product of a 13-member interdisciplinary faculty group known as the ORBES core team. Its members, the authors of this report, are James J. Stukel, professor of environmental engineering and mechanical engineering and director, Office of Energy Research, University of Illinois at Urbana-Champaign, and Boyd R. Keenan, professor of political science, University of Illinois at Chicago Circle, both of whom also served as co-directors of the project; and (alphabetically) Robert E. Bailey, professor of nuclear engineering and director, Program on Energy Research, Education, and Public Service, The Ohio State University; Donald A. Blome, research scientist, Institute for Mining and Mineral Research, Energy Research Laboratory, University of Kentucky; Vincent P. Cardi, professor of law, West Virginia University; Gary L. Fowler, associate professor of geography and associate director, Energy Resources Center, University of Illinois at Chicago Circle; Steven I. Gordon, assistant professor of city and regional planning, The Ohio State University; James P. Hartnett, professor of energy engineering and director, Energy Resources Center, University of Illinois at Chicago Circle; Walter P. Page, associate professor of economics, West Virginia University; Harry R. Potter, associate professor of sociology, Purdue University; J.C. Randolph, associate professor, School of Public and Environmental Affairs, Indiana University; Maurice A. Shapiro, professor of public health, University of Pittsburgh; and Hugh T. Spencer, associate professor of environmental engineering, University of Louisville. A roster of the core team and rosters of other project entities appear in Appendix A.

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On points of general policy relating to substantive research questions, conflicts were generally resolved by majority vote of the core team. Along with various other groups noted below, individual core team members were invited to comment on the final edited version of this main report. Their statements, each limited to 10 pages, comprise a separate volume. Some core team members chose to use the opportunity to comment upon majority decisions with which they were not in total agreement.

The core team began its work in the fall of 1977 under a series of one-year grants from EPA. In the fall of 1978, the grants were renewed; the entire two-year effort was known as the Ohio River Basin Energy Study Phase II. The first research period, ORBES Phase I, extended from the fall of 1976 through November 1977, when ORBES Phase I: Interim Findings was published. The objective of this publication, authored by professors Stukel and Keenan, was to synthesize findings of the three preliminary research teams that operated independently during Phase I. In keeping with a mandate given to EPA by a congressional committee, portions of Illinois, Indiana, Kentucky, and Ohio were included in the Phase I study region, and researchers were from universities in these states. EPA officials and congressional members and staff agreed that in Phase II the study region should be expanded to include virtually all of West Virginia and the southwestern portion of Pennsylvania.

Core team authors generated far more specialized material for this interdisciplinary report than could be included here. Thus, they were given the opportunity to place their findings in individual core team research reports, which are listed in Appendix B. Core team review committees examined these reports for acceptability for inclusion in the ORBES series. Their review does not represent verification of the contents.

Appendix B also contains a list of the more specialized support research reports, which the core team commissioned. While the main report is written primarily for the lay reader, certain of the support studies are more technical and intended to be of interest to specialists. Whenever possible, support researchers were drawn from the eight institutions with which the core team members themselves were associated. However, in

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several instances, the necessary expertise was provided by other universities or independent research organizations.

For ORBES Phase I, EPA's Office of Research and Development, which administered the grants to ORBES participants, provided the work plan for the researchers. The core team prepared the Phase II work plan. ORBES followed the general format of a technology assessment as part of the EPA-administered Interagency Energy-Environment Research and Development Program. A usual practice in this mode of inquiry is to develop sets of plausible, hypothetical conditions, or scenarios, in which such problems as energy development are examined.

The broad setting for the work of the interdisciplinary, interuniversity core team may be unique in energy-environmental research. A project office was maintained on the University of Illinois campuses at Urbana-Champaign and at Chicago Circle. At least once a month, and sometimes considerably more frequently, the full core team held two- and three-day working sessions on the various campuses and in other locations around the study region.

From the time the core team was organized--indeed from the initiation of the ORBES project in the fall of 1976--all working sessions were open to the public. Early in Phase I, an advisory committee consisting of representatives of government, business, labor, agriculture, public interest, and other sectors, was appointed. Committee membership was expanded throughout Phase II, reaching a total of 45. Committee members had an ongoing invitation to provide written or oral comments on core team research results. They reviewed a preliminary draft of the main report and provided considerable input.

As with core team members themselves, each of the advisory committee members was invited to supply independent comments on the final version of the main report and to contribute these comments to a separate volume, entitled <u>Comments on the Ohio River Basin Energy Study</u>. Support researchers and members of the ORBES management team also contributed.

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If the ORBES experience offers any unique contribution to the process of interdisciplinary research in energy and environmental affairs, it is probably the practice of opening all working sessions to the advisory committee and the general public. The complex nature of project activity produced frequent spirited debate among core team members, and advisory committee members were urged to participate, even in discussions on the merits of core team contributions and the commissioned support studies. Advisory committee members attending ORBES meetings probably were disabused of any persisting notions that all contemporary policy-related university energy and environmental research is carried out in ivory towers.

Indeed, every ORBES function was conducted in an open setting, with the general public welcome to attend sessions of even the smallest groups. The frequency of the core team working sessions made it difficult to publicize them widely. However, in all six states general reports to the public were held throughout the project. They were more widely publicized and well attended. In the summer of 1980, the last series of these general public presentations was held so that interested citizens of the Ohio River Basin Energy Study region could review highlights of this final report before it was submitted to the Environmental Protection Agency.

The core team is indebted to hundreds of citizens and public officials and regrets that space limitations prevent acknowledging all of those people here. Special appreciation must be expressed to a small number of advisory committee members who attended virtually every core team meeting.

The cooperation of Lowell Smith, the EPA project officer for ORBES, also is acknowledged gratefully. His helpful counsel was consistent with the conditions of the individual grants that assured faculty members' independence. Neither he nor other EPA personnel, including the rest of the ORBES management team, made any attempt to exert untoward influence in the preparation of this report; they did, however, make frequent efforts to sensitize the project co-directors and members of the core team

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to the realities of government and its problems. The core team wishes to acknowledge the assistance of these individual members of the management team. They are James H. Phillips, of Region V offices in Chicago, Illinois; Victor F. Jelen, of the Industrial Environmental Research Laboratory, Cincinnati, Ohio; and David Hopkins, of Region IV, Atlanta, Georgia.

The highest quality research and coordinating staff support was provided in the preparation of this report by Stephanie L. Kaylin, ORBES staff associate. Like the ORBES co-directors, she was a key member of the project from start to finish.

The usual authors' acceptance of total responsibility for errors in judgment, omissions, and misinterpretations is difficult to articulate in this instance. It has been necessary for all core team members, as co-authors, to accept on faith much specialized data from their colleagues. In instances where this faith has resulted in substantial misinterpretations or inaccuracies deemed to be of a serious nature, individual core team members have addressed the matters in their independent comments.

These procedures, as well as such unorthodox practices as inviting members of the public to participate in working research sessions, presented unusual problems for university researchers. But we trust that certain frontiers of knowledge and public awareness have been advanced by the experiment.

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Notice

This document is a preliminary draft. It has not been formally released by the Ohio River Basin Energy Study or by the U.S. Environmental Protection Agency and should not at this stage be construed to represent agency policy. It is being circulated for comments on its technical merit and policy implications.

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1. Introduction

1.1 ORBES background and organization

The Ohio River Basin Energy Study (ORBES) began in the fall of 1976, when the U.S. Environmental Protection Agency (EPA) awarded grants for an assessment of potential environmental, social, and economic impacts of a proposed concentration of power plants in a portion of the basin. Initial grants were to faculty members from a group of universities in the basin states of Ohio, Indiana, Illinois, and Kentucky. As the investigation progressed, researchers from universities in Pennsylvania and West Virginia were added to the study group. Experts from outside the academic community also took part throughout the project.

In 1975, the U.S. Senate Appropriations Committee had directed EPA to carry out such a study. It was not long after the Arab oil embargo (1972-73), and a number of electric utilities had announced plans to construct additional generating units in the Ohio River Basin and in nearby areas that share its fuel supply. The Ohio River region offers electric utilities and related industries some of the nation's most suitable power plant sites, within easy reach of coalfields, plus abundant water for cooling. Regional waterways also provide good fuel transportation routes. Finally, there are sparsely populated areas of basin land where plants could be constructed displacing fewer residents than they would in urban areas.

Throughout the Ohio River Basin, however, concern over the effects of energy development had been growing for years. In the fall of 1974 that concern focused on utility plans to locate coal-fired plants on a 100-mile reach of the river from Louisville, Kentucky, northward and eastward to Cincinnati, Ohio, and beyond. Utility planners and observers from related industries, such as coal producers, viewed the plans as consistent with emerging national energy policies for dealing with increased fuel prices and such external disruption of the fuel supply as had just been experienced during the oil embargo. In the midst of this concern about proposed coal-fired power plants, Public Service of Indiana an-

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nounced in late 1974 that it would build a nuclear-fueled facility, the Marble Hill plant, on the Ohio River between Louisville and Cincinnati. Citizen concern intensified. Over the six years since it was announced, controversy has grown over this plant, which now is under construction. Citizens opposing this proposal and others questioned the necessity of locating such a large number of generating facilities on the Ohio River itself. They pointed out that much of the power to be produced by these plants would be transmitted far from the area.

In an effort to identify the implications of locating future energy conversion facilities in this particular part of the Ohio River Basin, the Senate Appropriations Committee directed EPA to conduct a study, "comprehensive in scope, investigating the impacts from air, water, and solid residues on the natural environment and residents of the region. The study should also take into account the availability of coal and other energy sources in this region."[1]

The region dealt with in this report is somewhat different from that studied when the project first got underway. The Senate committee had directed a study of "the proposed concentration of power plants along the Ohio River in Ohio, Kentucky, Indiana, and Illinois." During the first year of the project (1976-77), the focus was on portions of the four states specifically mentioned. It was known as Phase I of the Ohio River Basin Energy Study. Findings were summarized and integrated in a publication entitled ORBES Phase I: Interim Findings."[2]

Although the present report expands on the findings of Phase I, it deals primarily with the second phase of the project. It soon became

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[1] The mandate appears in U.S. Congress, Appropriations Committee, 94th Congress, 1st Session, Senate, Department of Housing and Urban Development-Independent Agencies, Senate Report 940326, 1975.

[2] See U.S. Environmental Protection Agency, ORBES Phase I: Interim Findings, by James J. Stukel and Boyd R. Keenan, Interagency Energy-Environmental Research and Development Program Report, EPA-700/7-77-120, Grant No. EPA R805848 (Washington, D.C.: Environmental Protection Agency, November 1977).

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clear to the Phase I researchers that a study of the "lower Ohio River Basin" in the four states noted in the Senate committee report meant an emphasis on the Eastern Interior Coal Province, approximately located in western and southern Illinois, southern Indiana, and western Kentucky. The boundaries of the ORBES Phase I study region (see figure 1-1) extended northward and westward beyond the Ohio River Basin to include most of the province. The region covered 152,000 square miles, including some coal-laden land actually outside the drainage basin. Excluded was the northern tier of industrial counties in Illinois, Indiana, and Ohio. Only a small portion of the Appalachian Coal Province was included in the region, and this was the principal reason why utility leaders, state and federal government officials, and university researchers alike noted their objections to the Phase I boundaries. They considered these boundaries both artificial and inappropriate for the determination of impacts on the total basin system. It was to eliminate these problems that, at the beginning of the second phase of ORBES, the study region was expanded to include the southwestern portion of Pennsylvania and virtually all of West Virginia (see figure 1-2).

Phase II of the Ohio River Basin Energy Study began in the fall of 1977; its active research was concluded in early 1980. As in Phase I, the project management team included the EPA project officer, other officials of the agency, and two of the university researchers. These two faculty members coordinated the activities of a core team of researchers (on which they also served), the project advisory committee, and support researchers. See Appendix A for rosters of each of these groups.

1.2 Report approach

In accordance with fuel use patterns in the ORBES region, as reflected in the congressional mandate for the study, research during both Phase I and Phase II focused primarily on the use of coal within the region for the generation of electricity. Through the year 2000, coal is expected to continue as the dominant regional fuel. As of 1974 in the ORBES region, coal constituted approximately 95 percent of the total

FIGURE 1-1

OHIO RIVER BASIN ENERGY STUDY REGION
PHASE I

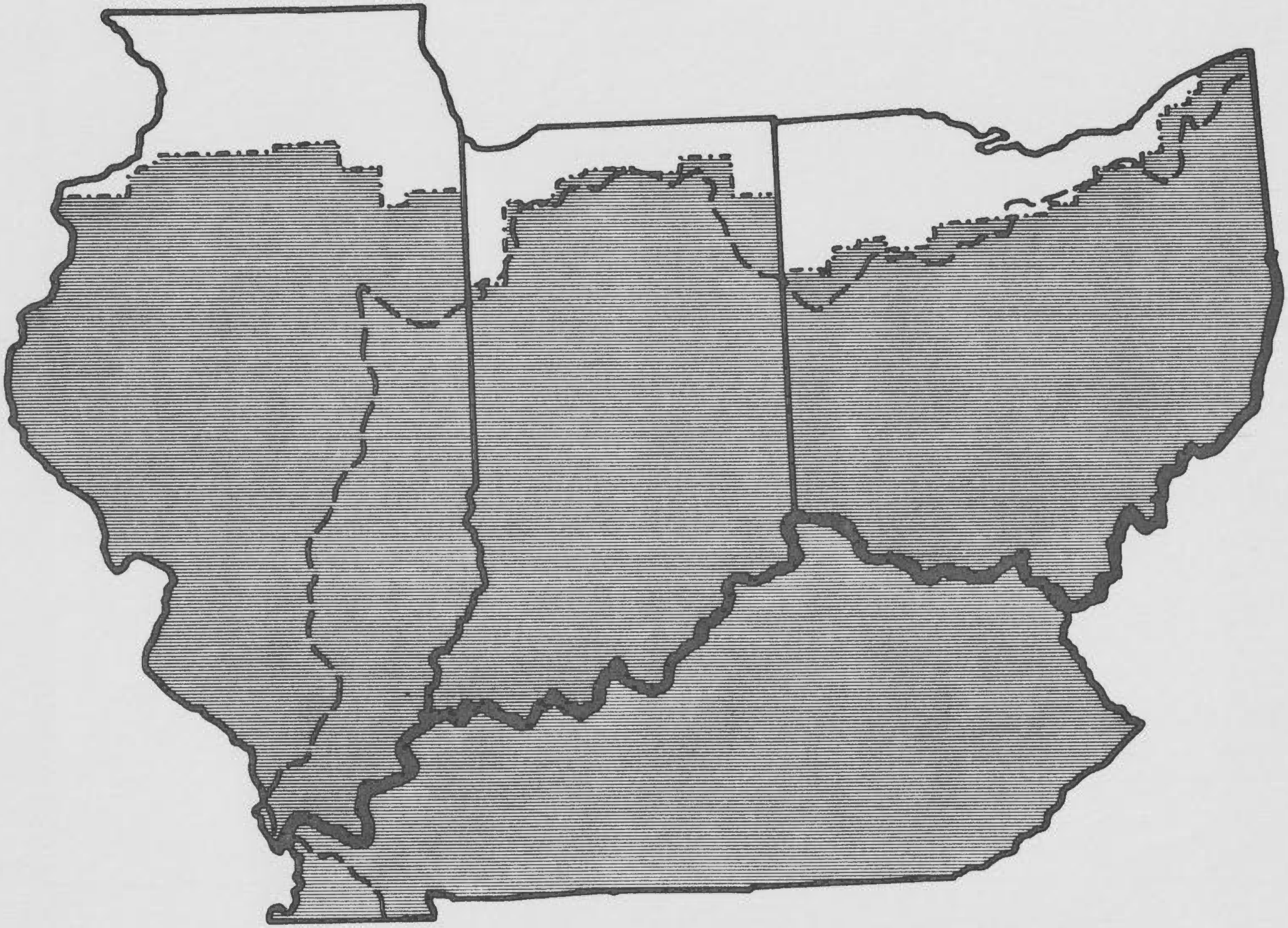

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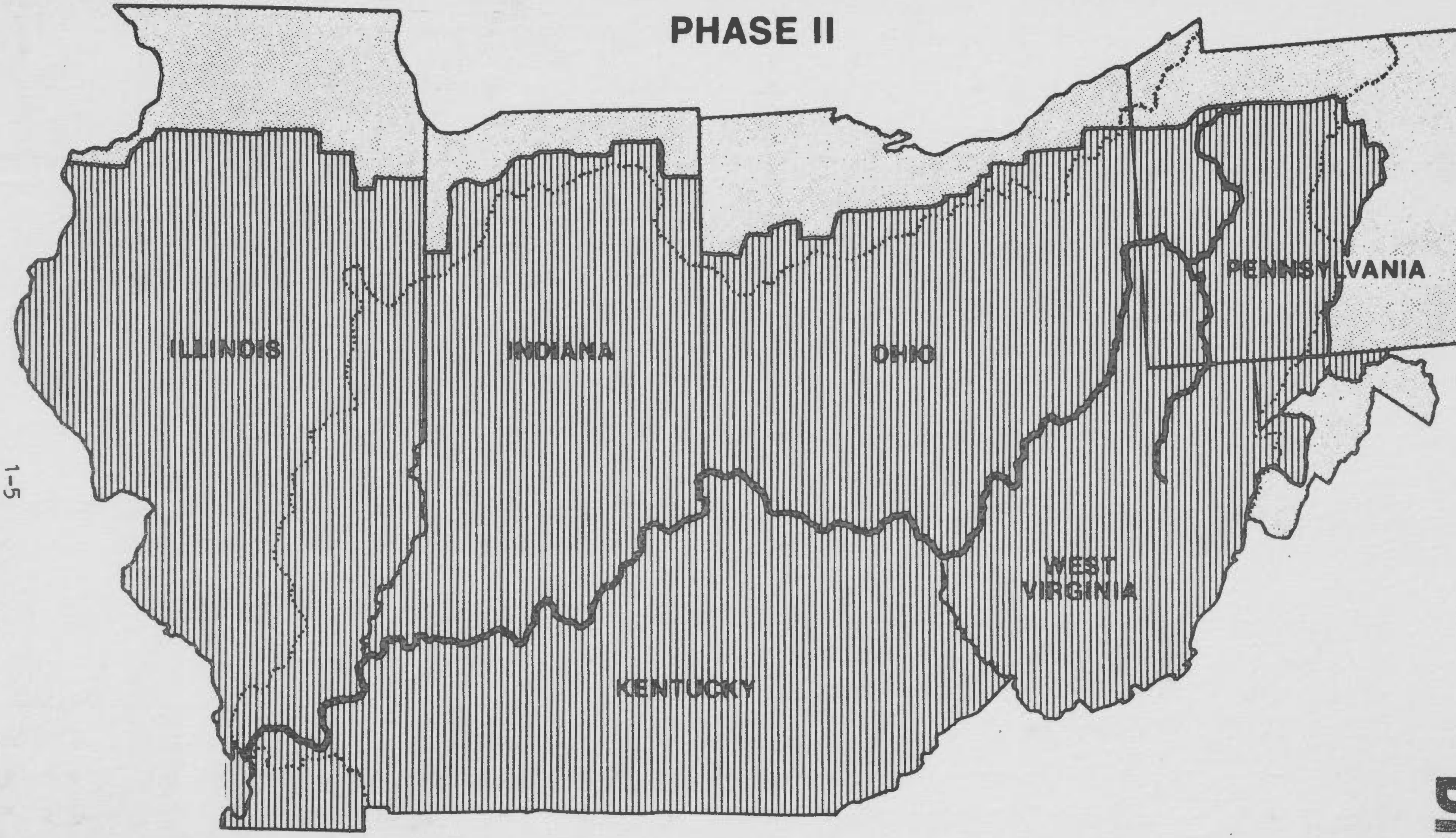
FIGURE 1-2

OHIO RIVER BASIN ENERGY STUDY REGION

PHASE II



··········Ohio River Drainage Region

primary fuels used to generate electricity. In contrast, in the United States as a whole in that year, only 51 percent of primary fuels was used for the generation of electricity. Of the total coal used within the region, 67 percent is used for electrical generation.[3]

Because of the time required to implement policies that would allow other fuels to replace coal, the emphasis on the use of this fuel in the ORBES region is unlikely to change in the next 20 years. As a consequence, most of the policy alternatives considered in the study stress the use of coal for electrical generation. Both the potential impacts of a continued emphasis on coal use in the study region and the institutional implications of this path are highlighted in this report.

It also is important, however, for policymakers to be aware of the consequences for the ORBES region of possible emphases on other fuels. None of the other fuel emphases studied--natural gas, nuclear, and less conventional alternative fuels--could begin to change the domination of coal until the end of the century; none is likely to replace coal totally in the foreseeable future. On the other hand, toward the end of the 1900s and beyond, these fuels may begin to be increasingly important in the ORBES region and elsewhere. Therefore, during the course of the project and as reflected in this report, the impacts of these possible fuel switches were not explored as exhaustively as were the impacts of continued coal use. The institutional barriers associated with these fuel switches, especially alternative energy sources such as solar energy and biomass, were the chief focus of this part of the research.

As implied above, a distinction must be made in regard to the ORBES analyses of the institutional problems associated with the various fuels. The institutional analyses of the impacts of the coal-based futures deal with continuations of or variations on the present situation in the study

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[3] For additional details on regional energy consumption, refer to Walter P. Page, "Energy Consumption in the Ohio River Basin Energy Study Region, 1974, by End User and Fuel Type" (ORBES Phase II, August 1979).

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region. For the other energy and environmental futures, the institutional factors studied are mainly the barriers associated with a shift from coal.

All of the energy-environmental futures, or scenarios, developed during ORBES Phase II are regionally based.[4] That is, whether the distinguishing feature of a scenario is environmental regulations, economic growth rate, energy growth rate, or fuel emphasis, the scenario is cast in terms of the study region, not the United States as a whole or the six ORBES states (Illinois, Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia). It is important to note that the impacts of the various scenarios are not intended to form the basis for regulatory action. Rather, these impacts are discussed in terms of their overall policy implications. The wide range of scenarios is intended to scope out the implications of various regional futures. Thus, even though severe local problems might exist under a given scenario, the analysis emphasizes impacts on a regionwide basis, and the study results cannot be applied directly to such activities as the writing of environmental impact statements.

Not every impact area, however, is presented for every scenario; some scenarios were developed for impact analysis in certain specialized areas. For example, the impacts on water quality are of chief interest for the two scenarios that call for the use of once-through cooling for electrical generating facilities on the Ohio River main stem. It should also be pointed out that only potentially important impacts, both positive and negative, are described in this report. Judgments were made in the course of the research as to which impacts were worthy of analysis and presentation. Because of these judgments and the specialized nature of some scenarios, there is variation among scenarios in the detail in which impacts are presented. Finally, the analysis emphasizes extreme

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[4] "Scenario," a word that may be overused by energy and environmental researchers, means simply a set of plausible, yet hypothetical, conditions for the future. It is a shorthand word without any intrinsic value connotation.

but possible natural conditions--for example, drought, and its effects on water quality, and air pollution episodes, and their effects on air quality.

Each of the scenarios discussed in this report is a hypothetical, yet plausible, energy and environmental future for the ORBES region; each examines impacts that could occur through the year 2000. The impact areas discussed are air quality; water quantity, water quality, and aquatic ecology; land use and terrestrial ecology; public and occupational health; social conditions; and economics. However, as noted above, not all of these impact areas are discussed for all cases.

A model was developed to site electrical generating unit additions in the study region from 1976 through 2000. The objective of this model is to reduce impacts in various areas. For example, with regard to land quality, in some scenarios restrictions are placed on the siting of facilities in counties with high-quality soils. With regard to air quality, no siting is permitted under any scenario in areas that do not attain national air quality standards.[5]

In addition to application of the same siting model for all scenarios (although there are differences based on the megawatts of electricity required and the importance given to various parameters in the model), certain aspects of all the ORBES scenarios are identical. For instance, all fuels were assumed to have the same relative prices throughout the study period as they had in the year 1974. In the siting model itself, certain generating units are assumed in addition to those announced by the electric utilities for the region. These "standard" units are 650

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[5] For a complete description of the siting model and of the energy facility configurations for each scenario, see Gary L. Fowler et al., "The Ohio River Basin Energy Facility Siting Model" (ORBES Phase II, forthcoming).

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megawatts electric for coal-fired units, operating at a 50 percent capacity factor, and 1000 megawatts electric for nuclear-fueled units, operating at a 65 percent capacity factor.[6]

A variety of scenarios are presented and analyzed in this report. Each scenario is an "as if" statement; it represents what <u>one</u> future might be like <u>if</u> assumed conditions are present in the ORBES region. As discussed above, most of these futures emphasize the continued use of coal in the region through the year 2000, but there are a number of variations in the paths entailing coal emphasis.

Among the coal-based scenarios, the conditions emphasized include "business-as-usual" environmental regulatory policies, fuel use patterns, and economic and energy growth rates in the ORBES region; less and more stringent air quality regulations; low and very high regional economic growth; relatively low energy growth; and high electrical energy growth. The alternative fuels emphasized in the remaining scenarios consist of natural gas, nuclear fuel, and less conventional energy sources.

In order to develop the scenarios, it was necessary to delineate current, or "baseline," conditions within the ORBES region. In general, the base period is the mid-1970s. The analysis approach was to compare the baseline conditions to those of the business-as-usual scenario, which in essence is a continuation of present regional conditions. Thus, impacts of the business as usual case in 1985 and 2000 are compared with current conditions. Thereafter, scenario impacts in 1985 and 2000 are compared with each other, not with conditions during the base period.

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[6] Two kinds of generating facility units are sited: (1) through the mid-1980s, those units announced by the electric utility companies (the same for each scenario) and (2) through the year 2000, "standard" units (known as scenario additions) necessary to meet the demand for electricity as projected under each scenario.

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1.3 Report organization

The substantive chapters in this report contain a description of current conditions in the ORBES region, presentations of the various scenarios and their impacts in 1985 and 2000, and discussions of policy considerations associated with the scenarios. Current regional conditions are delineated in nine areas, primarily as they relate to the production and use of electrical energy in the region (chapter 2). The topics covered are laws and institutions (section 2.1), the regional economy (section 2.2), regional energy and fuel use (section 2.3), air quality (section 2.4), water quantity, water quality, and aquatic ecology (section 2.5), land use and terrestrial ecology (section 2.6), public and occupational health (section 2.7), social values and ethics (section 2.8), and social conditions in the region (section 2.9). The presentation of current conditions serves as an introduction to the consideration of the scenarios and their impacts (chapters 3 through 9 and chapter 11).

In chapters 3 through 9, the 16 scenarios that emphasize regional coal use for the generation of electricity are described, and their impacts are contrasted. The parameters that are varied concern environmental regulations, criteria used for siting electrical generating facilities, the export of electricity from the region, overall regional economic growth, overall regional energy growth, and regional electrical energy growth.[7]

Chapter 3 discusses a scenario termed the business-as-usual case (BAU) (scenario 2). As the starting point for most of the other coal-based futures, it is perhaps the richest among all the scenarios analyzed. In terms of environmental regulatory policies, the regional economy, and regional energy and fuel use, the BAU case is essentially a

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[7] For a complete discussion of the study methodology, refer to Walter P. Page and James J. Stukel, "Integrated Technology Assessment Methodology for the Ohio River Basin Energy Study" (ORBES Phase II, forthcoming).

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projection of current conditions in the ORBES region through the year 2000. Therefore, the impacts in the various areas that would arise under BAU conditions in 1985 and 2000 are compared with present conditions.

In chapter 4, the focus is on more stringent environmental regulatory policies than those of the business-as-usual case. Five scenarios are presented and contrasted. The first (scenario 1) assumes that more stringent air, water, and land quality regulations will be in effect in the ORBES region, while the relatively high regional economic growth and coal emphasis of the BAU case are maintained.[8] The impacts of the more stringent case in the years 1985 and 2000 are contrasted with those of the base case.

The question then is asked of what the effects would be of promulgating very strict air quality regulations in the region (scenario 1a). All other conditions of the more stringent case (scenario 1) remain the same. The impacts of very strict air quality regulations are then contrasted with those of the more stringent case. In another variation (scenario 1b), the very strict air quality regulations are assumed to continue, but it is also assumed that electrical generating facilities will be sited in a more concentrated pattern. The object is to examine the adverse environmental impacts that could occur in some localities. The impacts of concentrated siting are compared with those of the very strict air quality case alone. Next, a policy of agricultural land protection is assumed (scenario 1c). The impacts of this scenario are contrasted with those of the more stringent environmental regulations case (scenario 1). The agricultural land protection scenario is then varied under the assumption that concentrated siting of electrical generating

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[8] It must be recognized that the reference point for this "relatively high" growth rate changed during the project period. When the study began, it was necessary to choose the comparisons that would be made in regard to rates of growth. Since that time, of course, growth rates have dropped substantially. Rates that would have been characterized as "low" in 1976 and 1977, when guidelines for the first and second phases of ORBES were established, indeed may appear to be "high" in 1980.

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facilities will take place (scenario 1d). The impacts of this scenario are contrasted with those of the agricultural land protection scenario alone.

In chapter 5, the policies examined concern less stringent environmental regulations and a continued regional emphasis on the use of coal for electrical generation. It is only here that the assumed environmental regulations for air quality are less strict than those of the BAU case. The first scenario to be considered (scenario 2d) assumes a policy of noncompliance with state implementation plans (SIPs). Impacts of the noncompliance case, chiefly on air quality, are contrasted with those of BAU. There also is discussion of a scenario in which once-through cooling of electrical generating facilities on the main stem of the Ohio River is assumed (scenario 2i). (All other scenarios but one (see below) assume that cooling towers will be employed for new electrical generating units.) Impacts of once-through cooling versus cooling towers (as in BAU), chiefly on water quality, are contrasted.

In chapter 6, it is assumed that policies exist to encourage the export of electricity from the ORBES region, all of it generated by coal-fired units (scenario 2a). Impacts of the energy-export scenario are contrasted with those of BAU. In a variation of the export case, once-through cooling of electrical generating facilities located on the Ohio River main stem again is assumed (scenario 2a2). The impacts of once-through cooling versus cooling towers (as in BAU) are compared.

Variations in the overall ORBES-regional economic growth through the year 2000 are the subject of chapter 7. Both scenarios discussed in this chapter are subscenarios of the base case, in which relatively high, or historic, rates of regional economic growth are assumed, while the emphasis on coal-fired electrical generation continues.[9] First, the impacts of a relatively low rate of regional economic growth (scenario 5) are discussed. Second, the impacts of a very high regional economic

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[9] See footnote 8.

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growth rate (scenario 5a) are considered and contrasted with impacts of the low economic growth rate. Impacts of both scenarios also are contrasted with the impacts of historic economic growth (BAU).

In chapter 8, another variation in regional growth is discussed. This variation calls for low regional economic growth and a continued coal emphasis (scenario 6).[10] The impacts of very low regional economic growth versus those of BAU, historic energy growth are set forth.

In chapter 9, there is discussion of the effects of even higher electrical energy growth than that of BAU, again emphasizing coal-fired electrical generation. Three such scenarios are considered: (1) a high rate of regional electrical energy growth, based on projections of the National Electric Reliability Council (NERC) (scenario 7b); (2) high regional electrical energy growth in the ORBES region, but with a 45-year generating unit life (scenario 7) (in other ORBES scenarios, a 35-year lifetime is assumed); and (3) high regional electrical energy growth, a 45-year lifetime for generating units, and a policy of least sulfur emissions dispatch (scenario 7a). That is, in this third scenario the criterion for the order in which a new generating unit comes on-line, or is dispatched, is on the basis of the unit's expected emissions of sulfur dioxide.

It is clear that the major policy implications of the coal-based futures relate to regional air quality and intergovernmental problems regarding the siting of electrical generating facilities. These considerations are discussed thoroughly in chapter 10.

In chapter 11, the discussion focuses on possible regional emphases on fuels other than coal. These emphases are natural gas, nuclear fuel, and less conventional alternative fuels such as solar energy and biomass (scenarios 4, 2c, and 3). As discussed in section 1.2, these fuels probably will not be of major importance in the ORBES region before the year

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[10] See footnote 8.

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2000, but they could make some inroads before the end of the study period. Impacts of each alternative to coal are contrasted with BAU impacts. Most important, institutional considerations relating to these alternative fuel uses are set forth.

In chapter 12, a concluding note appears on the diverse perspectives in the ORBES region and the relationship of these perspectives to regional economic and environmental problems.

As evident throughout this report, the data and conclusions presented draw on a number of specialized subprojects carried out for the Ohio River Basin Energy Study. The reports of these studies are listed in Appendix B. Some are written chiefly for experts, but the lay reader may be interested in one or more of the reports.

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2. Current conditions in the ORBES region

2.1 Laws and institutions

Like the rest of the United States, the ORBES region is affected by a number of federal laws that relate to energy development and environmental protection. Most notable are the National Environmental Policy Act, the Clean Air Act, the Clean Water Act, the Surface Mining Control and Reclamation Act, the Federal Coal Mine Health and Safety Act, and legislation relating to nuclear energy. There is a strong partnership between the states and the federal government in implementing provisions of three of these laws: the Clean Air Act, the Clean Water Act, and the Surface Mining Control and Reclamation Act. In this implementation process, the varying actions of the six ORBES states reflect the states' distinct political climates. State participation in implementing the other laws discussed here varies in degree and kind, but each piece of legislation affects current energy development and associated considerations of environmental protection in the study region.[1]

The two federal agencies with the most prominent responsibilities of administering these and other environmental and energy laws are the U.S. Environmental Protection Agency and the U.S. Department of Energy. The U.S. Army Corps of Engineers also is among the federal agencies whose role in the study region should be recognized.

Any discussion of the legal and institutional setting of the ORBES region must include at least three regional organizations: the Ohio River Valley Water Sanitation Commission, the Ohio River Basin Commis-

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[1] For details on relevant laws and institutions, see the following forthcoming ORBES Phase II reports: Vincent P. Cardi, "Legal and Institutional Issues in the Ohio River Basin Energy Study," Boyd R. Keenan, "Electric Power Interstate Conflicts in the Ohio River Basin: Options for Cooperation in Facility Siting and Related Functions," and James A. McLaughlin, "Legal and Institutional Aspects of Interstate Power Plant Development in the Ohio River Basin Energy Study Region." See also Nicholas L. White and John F. Fitzgerald, "Legal Analysis of Institutional Accountability for the Ohio River Basin" (ORBES Phase I, May 15, 1977).

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sion, and the Appalachian Regional Commission. It also is useful to contrast the institutional characteristics of the Ohio River valley and the neighboring Tennessee Valley Authority. Finally, both the ORBES-region electric utility industry and the regional coal-mining industry must be considered in terms of their institutional characteristics.

- The National Environmental Policy Act, or NEPA (42 U.S.C. 4321), was passed in 1969 to encourage nondestructive use of the environment in a way that can be maintained for succeeding generations. The act builds into federal decisionmaking processes a continuous awareness of environmental considerations.

    - NEPA is particularly important because of its requirement that an environmental impact statement be prepared on any federal action that affects the human environment significantly. Before each such action, recommendation, or report on legislation, the federal agency or agencies concerned must prepare a statement of its potential impact on the environment. This statement documents the environmental consequences of the proposed action.

- The Clean Air Act (42 U.S.C. 1857), implemented by the U.S. Environmental Protection Agency in cooperation with the states, is a sweeping national approach to the control of air pollution. Passed in 1963, the Clean Air Act was strengthened considerably by the most recent and most important amendments, in 1970 and 1977. Here the salient aspects of the law and of related regulations are presented.

    - The fundamental concept behind the 1970 and 1977 amendments is federal responsibility (assigned to EPA) to set national standards for ambient air quality (NAAQS) and for the control of emissions from new sources of pollution.

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- In partnership with EPA, each state must develop a specific strategy to ensure that federal standards will be achieved in all areas of the state. These strategies are known as state implementation plans (SIPs).

- NAAQS have been set for seven air pollutants (criteria pollutants): total suspended particulates, sulfur dioxide, oxides of nitrogen (expressed as nitrogen dioxide), hydrocarbons, photochemical oxidants, carbon monoxide, and lead. Other potentially harmful compounds such as sulfates, for which no national standards have been set, are formed through chemical transformation of criteria pollutants. Coal-fired power plants and other coal-fired industrial sources emit significant amounts of two criteria pollutants, sulfur dioxide and nitrogen dioxide, as well as an appreciable fraction of fine particulates. The four other criteria pollutants primarily are products of transportation.

- EPA standards for short-term concentrations of criteria pollutants in the ambient air may not legally be exceeded more than once a year at any one location. Each criteria pollutant must meet two types of standards: primary standards, which are intended to protect human health, and secondary standards, which are intended to protect the public welfare (defined as including property, soil, vegetation, animals, visibility, and other effects not related to human health).

- The use of national emission standards for new industrial sources of pollution, including power plants, is intended to bring about improvement beyond that required by the ambient standards. This improvement is to be achieved as new sources replace old ones. New industrial sources of pollution also are required to meet emission standards set for individual industrial source categories, including fossil-fueled power plants. These standards are known as new source performance standards (NSPS); they apply to sources for which construction began be-

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tween 1971 and 1978. Now in force are revised new source performance standards (RNSPS), stricter than the original NSPS; the revised standards apply to sources under construction after August 1978.

- To allow the states to develop and carry out the SIPs in conjunction with EPA, the nation has been divided into 243 air quality control regions (AQCRs). Part or all of an AQCR can be designated a nonattainment area if it does not meet primary and/or secondary standards. Within nonattainment areas, emission offset provisions are in effect. That is, a new source must obtain an offset, equal to or greater than its expected emissions, from existing sources in the AQCR. Thus, over time, attainment status will be achieved and maintained in the area.

- In addition to the requirements set forth in SIPs, the state and federal governments utilize other continuous emission requirements to control emissions on a local scale. One such requirement is known as the prevention of significant deterioration (PSD), under which future air quality in current clean air areas may not be degraded by more than relatively small increments from present conditions. Additional special protection is given to selected federal lands, such as national parks.

- If it is determined that significant economic disruption or unemployment would result from the use of coal than that produced locally or regionally, major fuel-burning sources in the locality or region may be allowed to use high-sulfur coal. However, they still have to comply with SIP emission requirements.

- Under current conditions, an existing electrical generating facility or other industrial source that undergoes modification may not emit more pollutants after the modification than permitted previously.

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- The Clean Water Act (33 U.S.C. 1251) contains numerous provisions that apply to the extraction of fossil fuels and the generation of electricity. The 1972 amendments to the act continued the existing requirement that states establish water quality standards for their interstate waters and broadened this requirement to include intrastate waters.

  - Each state must classify the desirable uses of its waters and set forth the pollutant concentrations that may not be exceeded in order for these desirable uses to continue without hindrance.

  - EPA has established effluent limitations for each category of industrial point sources of discharge. Individual source permits specify effluent limitations by pollutant, derived from the limitations established by EPA or from classifications of desirable use established by the state, whichever is more stringent. The National Pollution Discharge Elimination System (NPDES) is the mechanism for ensuring that individual dischargers comply with effluent limitations. Every facility that discharges effluents into navigable waters must receive a permit that specifies the effluent requirements to be met. EPA has the authority to issue these permits but may delegate it to the states, retaining the authority to review permits. As of March 1980, the ORBES states of Illinois, Indiana, Ohio, and Pennsylvania were responsible for administering their programs, while permits still were issued by EPA in Kentucky and West Virginia. Most of the limitations set forth in the permits require use of the best practicable control technology, to have been achieved by 1977, and the best available technology, to be achieved by 1983. Stricter limitations can be imposed if they are necessary to achieve a state's water quality standards.

  - Among the effluents from energy facilities and other industrial installations regulated under NPDES are total dissolved solids, total suspended solids, and various elements and chemical com-

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pounds, including dissolved oxygen, sulfates, ammonia, and a number of metals.

- Modifications of power plants and other thermal point sources that meet effluent limitations are not subject to more stringent limitations that may be imposed within 10 years after completion of the modification.

- The Surface Mining Control and Reclamation Act (30 U.S.C. 1201) was passed in 1977. The law is based on the premise that mining should be a temporary activity; it is intended to change coal-mining practices that entail severe social and environmental costs and to prohibit mining operations in areas that cannot be reclaimed. However, because of revisions to the regulations promulgated under the law since its enactment, as well as continuing litigation over certain of its aspects, the final way in which this legislation will be enforced is unclear.

  - In accordance with federal regulations, state permits for new coal mines must include comprehensive performance standards for surface mining operations and for the surface effects of underground mining. These standards are intended to prevent adverse effects on the environment, such as subsidence, ground and surface water contamination, and degradation of land quality. Until state permit programs are in force, or in the event of a state's failure to establish an adequate program, the federal government retains regulatory authority.

  - Before a permit can be obtained, the mining operator must demonstrate that the land can be restored to a postmining land use the same as or of higher quality than its premining use.

  - The act establishes a fund for the reclamation of abandoned mines.

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- Except for valid existing rights, surface mining is prohibited on federal land valuable for recreation or other purposes, such as national forests.

- States must institute a planning process for the designation of areas unsuitable for all or certain types of surface mining. Among such areas are those where reclamation would not be technically or economically feasible; where it would not be compatible with existing land use plans; where it would adversely affect important historic, cultural, scientific, or aesthetic values; where it would result in substantial loss of or reduction in long-range productivity of water supplies or food or fiber products; and where it would endanger life or property in areas subject to flooding or unstable geology.

- The Federal Coal Mine Health and Safety Act (30 U.S.C. 801), enacted in 1977, is the most recent expression of congressional intent to remedy unsafe working conditions and practices in mines and to reduce the number of mining fatalities and injuries. The 1977 act is based on the 1969 act of the same name. It incorporates many of the provisions of the 1969 act, but increases the level of protection for miners.

  - The health and safety of all U.S. coal miners are protected under a single comprehensive law. Mandatory health and safety standards are prescribed, and black lung benefits are provided.

  - Standard-setting and enforcement procedures are made uniform throughout the mining industry, while the standards themselves reflect the characteristics of different segments of the indstry. Each step in the standard-setting and revision process requires compliance within a specific period, and enforcement timetables are more rigorous than in previous legislation.

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- The law is administered by the Department of Labor. Due process is provided by the Federal Mine Safety and Health Review Commission, an independent adjudicatory authority. Affected miners or their representatives can participate in the commission's proceedings.

- Provisions are made for training courses for new miners and refresher courses for experienced ones. During these courses, workers receive their normal rate of pay and any costs incurred while attending the training.

- The Atomic Energy Act (42 U.S.C. 2011) was passed in 1946, when it was believed that the only foreseeable realistic use of nuclear energy would be for military purposes. In 1954 the act was amended to allow and encourage private ownership of nuclear energy for the production of electricity; permits were granted and licensees regulated by the Atomic Energy Commission.

  - In 1959, an additional amendment was passed, calling for the discontinuation of the commission's regulatory authority over certain nuclear materials. This authority was to be vested in the states, under a series of "turnover" agreements.

  - In 1974, nder the Energy Reorganization Act (42 U.S.C. 5801), the research and development functions of the commission were transferred to the Energy Research and Development Administration (now in the Department of Energy). Regulation and licensing were transferred to the Nuclear Regulatory Commission (NRC).[2]

  - It is generally agreed that the regulation of nuclear energy has been preempted by the federal government.

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[2] NRC's responsibility to assure that all possible health and safety precautions are taken in the construction and operation of nuclear-fueled facilities has brought the commission into prominence in certain parts of the

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ORBES region. Attention has focused on NRC's ongoing inspection of construction at the site of the Marble Hill nuclear plant, located at Madison, Indiana, about 31 miles up the Ohio River from Louisville. Marble Hill is a facility of Public Service of Indiana (PSI). In August 1979, NRC halted work at the site. Eight days later, it announced that work could not resume until PSI submitted, under oath, a plan on how construction problems would be corrected. A statement outlining a program to correct the problems was offered in February 1980. A month later, NRC officials announced that work on the facility might be permitted to resume in April.

.arble Hill is one of two nuclear facilities on the Ohio River across from Kentucky that have brought NRC into conflict with that state. Since PSI announced plans to construct Marble Hill four years ago, Kentucky officials have sought to intervene in NRC hearings on the licensing of Marble Hill and of the Zimmer installation, located near Moscow, Ohio, about 20 miles upstream from Cincinnati and across the river from Pendleton County, Kentucky. The principal owner is the Cincinnati Gas and Electric Company. In March 1980, the Kentucky attorney general announced that, because of Zimmer's "inherent hazard" to Kentuckians, his state would intervene in NRC hearings on the licensing of the plant.

Because of the political climate in both Kentucky and West Virginia, no nuclear facilities have been built in these states. Units in the ORBES portions of Indiana and Ohio are discussed above. Numerous nuclear units are located in the two remaining ORBES states, Illinois and Pennsylvania. Those facilities in the ORBES-region portions follow:

Illinois

Dresden Station. Commonwealth Edison operates three nuclear units at Dresden, which is near the town of Morris. The oldest of these units, built in 1960, was the nation's first privately financed reactor.

LaSalle County Station. Two Commonwealth Edison nuclear units are under construction at a site in LaSalle County.

Clinton Station. Illinois Power Company is constructing this station near Clinton in DeWitt County.

Pennsylvania

Shippingport Prototype Nuclear Power Plant. In 1957, the Duquesne Light Company constructed the world's first full-scale nuclear-fueled electrical generating facility at Shippingport. Since then, the facility has been operated jointly by the Duquesne utility and the federal government.

Beaver Valley Station. Two units, operated jointly by the Duquesne Light Company and other utilities, also are located at Shippingport.

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The U.S. Environmental Protection Agency was established in 1970 as the federal unit with basic responsibility for environmental matters, including those that relate to energy development. Among the most decentralized of the federal agencies, EPA activity is organized into 10 regions, whose boundaries coincide with those of most major federal departments. These boundaries, which follow state lines, are the source of many of the problems faced by EPA in the ORBES region.

- The ORBES region straddles three EPA regions: (1) Region III, headquartered in Philadelphia, which includes the states of Pennsylvania and West Virginia, (2) Region IV, in Atlanta, which includes Kentucky, and (3) Region V, in Chicago, which includes Illinois, Indiana, and Ohio.

- Provisions of the 1977 amendments to the Clean Air Act have led to major regional organizational problems for EPA. Most of these problems center around the long-range transport of air pollutant emissions from coal-fired electrical generating facilities. The long-range transport issue has led to disputes among ORBES states.

    - To address these questions, EPA has established a tri-regional task force.

- Other ORBES-region issues associated with the long-range transport of air pollutants involve only two states. For example, the level of sulfur dioxide emissions from coal-fired generating units in Indiana and Kentucky is a point of controversy between these two states.

    - Indiana now is seeking approval from EPA Region V for a limitation of 6 pounds of sulfur dioxide per million Btu of heat produced. Kentucky officials claim their state's adherence to the

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1.2 pound limit set by Region IV is discriminatory, because the higher emission levels from Indiana would be transported across the Ohio River into Louisville and the surrounding Kentucky countryside.

The U.S. Department of Energy (DOE) was created in 1977, largely in response to problems associated with the nation's increasingly heavy dependence on foreign oil. The new department inherited responsibility for a number of critical energy installations in the ORBES region. DOE's predecessor agency was the U.S. Energy Research and Development Administration (ERDA), whose predecessor in turn was the U.S. Atomic Energy Commission (AEC).

- Management of the nation's nuclear program was the principal reason for the creation in 1946 of the Atomic Energy Commission. At that time, the program consisted of military efforts evolving from the World War II Manhattan Project, which built the first atomic bomb. As the program expanded to include nonweapon efforts, such as encouraging civilian electric utility companies to construct nuclear-fueled generating plants, AEC was criticized increasingly. These criticisms centered on the agency's conflicting mandates of both promoting nuclear power and regulating its use.

    - Congress responded in 1975 by abolishing AEC and creating two new agencies: ERDA, which was given broad research management functions, and NRC, which was to assure that all possible health and safety precautions were taken in the construction and operation of nuclear-fueled generating facilities and in other uses of nuclear materials.

- ERDA was abolished in 1977, at which time most of its functions were absorbed by the new Department of Energy. Functions of other agencies, including the Federal Power Commission (FPC), also were transferred to DOE.

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- The responsibilities of the former FPC now are carried out by the Federal Energy Regulatory Commission, a relatively independent agency housed in DOE.

- Other DOE units also are important to the electric utility industry in the ORBES region and elsewhere. One such unit is the Economic Regulatory Commission, whose responsibilities include oversight of utility-sector interactions through cooperative bodies (for example, the industry's national and regional electric reliability councils).

- Within the ORBES region, DOE is responsible for a variety of important energy installations.

  - A gaseous diffusion uranium enrichment facility was built at Oak Ridge, Tennessee, in conjunction with the Manhattan Project. Oak Ridge is in the hydrological Ohio River Basin but outside the ORBES study region. In the early 1950s, when additional similar plants were needed, Congress and AEC chose two sites in the Ohio River valley, where coal, water, and electric power are readily available. The electric power for the first facility, near Paducah, Kentucky, is provided by the Tennessee Valley Authority and a consortium of private companies known as Electric Energy, Inc. Power for the second facility, located near Portsmouth, Ohio, is provided by a 15-member private consortium, the Ohio Valley Electric Corporation (OVEC). A major expansion now in progress at Portsmouth, in the form of a unit utilizing a new centrifuge method, is expected to reduce the electricity requirements of the facility.

  - National security considerations led AEC to decide that the electric power supply for the Portsmouth facility should be a considerable distance away from the plant site. OVEC constructed two such facilities: the Kyger Creek plant, near Cheshire in southeastern Ohio, and the Clifty Creek plant, near

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Madison, Indiana. As discussed elsewhere in this report, the Clifty Creek facility sensitized area residents to air quality issues as early as the mid-1950s.

- As the federal agency now responsible for both the Paducah and the Portsmouth plants, DOE contracts for their operation with the Union Carbide Corporation and the Goodyear Corporation.

- Another large-scale uranium-related facility in the ORBES region is the Feed Materials Production Center (FMPC), at Fernald, Ohio, near Cincinnati. FMPC produces uranium metal that is used in the fabrication of fuel and target element cores for DOE-operated nuclear reactors.

The federal government unit that has been most active in the Ohio River valley for the longest period of time is the U.S. Army Corps of Engineers. Its Ohio River Division, headquartered in Cincinnati, Ohio, has jurisdiction throughout the river basin. The division's major responsibility is to provide a system for the transportation of coal on the Ohio River (100 million tons were transported in 1975). The division also is charged with reducing the effects of flooding in the area and with constructing and operating hydroelectric generating facilities.

- The corps has built and maintained a system of locks and dams on the Ohio River. The first such structure was completed in 1885. As of 1920, the navigation system consisted of 50 locks and dams. In 1974, Congress authorized their replacement by 19 larger, more efficient structures; by 1980, this modernization was nearly complete.

- Similar locks and dams are maintained on several tributaries of the Ohio. Sixty installations in all are operated by the Ohio River Division.

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- The corps cooperates with the Tennessee Valley Authority (see below) in the operation of facilities on the Tennessee River near where it empties into the Ohio at Paducah.

Three agencies operating in portions of the ORBES region--the Ohio River Water Sanitation Commission, the Ohio River Basin Commission, and the Appalachian Regional Commission--are charged with certain environmental responsibilities. Each of these bodies could play a significant role in future energy and environmental affairs in the study region.[3]

The Ohio River Valley Water Sanitation Commission (ORSANCO) was formed in 1948 by means of an interstate compact. The use of the interstate compact provision of the U.S. Constitution was a solution to widespread opposition to federal control and the lack of legal and institutional capability by individual states to resolve regional water quality problems.

- ORSANCO conducts a number of water-related activities, including regular monitoring of the water quality of the Ohio River. This monitoring has resulted in data that provide a composite picture of the river and the lower reaches of its major tributaries.

- As a result of ORSANCO activities, substantial abatement of water pollution in the region has been accomplished.

- In the past few years, the organization has demonstrated an increasing interest in being involved in the orderly siting of electrical generating facilities within its region. However, questions have

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[3] For an extensive discussion of these and other regional organizations, refer to Boyd R. Keenan, "Electric Power Interstate Conflicts in the Ohio River Basin: Options for Cooperation in Facility Siting and Related Functions" (ORBES Phase II, forthcoming).

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been raised about ORSANCO's ability to deal with the air quality considerations associated with power plant siting.

- The ORSANCO membership consists of eight Ohio River Basin states: the six ORBES states (Illinois, Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia) plus New York and Virginia.

Like ORSANCO, the Ohio River Basin Commission (ORBC) came into existence because of water-related problems. The commission was created in 1971 under the Water Resources Planning Act of 1965 at the request of the governors of 11 Ohio River Basin states. ORBC is a federal-state agency whose activities concern water and related land resources throughout the basin. It is the principal coordinating agency for regional plans on these topical areas.

- ORBC prepares and updates plans for managing regional water and related land resources, recommends long-range priorities for meeting regional needs for natural resource information planning and management, and conducts studies and makes recommendations on these plans and priorities.

- The membership of ORBC includes the six ORBES states plus Maryland, New York, North Carolina, Tennessee, and Virginia. In addition, nine federal agencies hold ORBC membership.

In both origin and mission, the Appalachian Regional Commission (ARC) is quite different from ORSANCO and ORBC. ARC was created as a program of former President Johnson's Great Society. Its initial projects were intended to stimulate economic development in Appalachia, thus increasing employment and stemming out-migration. Of course, development of coal resources has been of major concern to ARC, a goal that is not shared by many residents in the western part of the ORBES region.

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- Among the ORBES states, all of West Virginia and portions of Kentucky, Ohio, and Pennsylvania are included in the ARC region. Parts or all of nine other states comprise the rest of the region.

Unlike ORSANCO, ORBC, and ARC, the Tennessee Valley Authority (TVA) is a corporation of the federal government, responsible for the production of electricity in its region. Thus, institutional interfaces between the ORBES region and the TVA service area are numerous. (The regions overlap geographically, with the state of Kentucky a part of both.)

- Probably the most important interface between the ORBES region and the TVA area concerns the institutional management of air quality problems that affect both regions.

- Also important to both regions are waterway management, coal supply, the provision of coal-fired electric power to uranium enrichment facilities, and utility rate-making and other financial factors.

Within the context of the Ohio River Basin Energy Study, the various sectors of the electric utility industry in the study region may be among the most important "institutions" to be considered.[4] However, because of rapidly changing conditions, including national and international energy politics, the industry's institutional characteristics are quite fluid. Here the focus is on the region's (and the nation's) largest investor-owned utility holding company, American Electric Power, Inc., as well as on certain conflicts among industry sectors, including the rural electric cooperatives.

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[4] Several ORBES research reports address aspects of these sectors. See, for example, Boyd R. Keenan, "Electric Power Interstate Conflicts in the Ohio River Basin: Options for Cooperation in Facility Siting and Related Functions" (ORBES Phase II, forthcoming), and Jan L. Saper and James P. Hartnett, eds., "The Current Status of the Electric Utility Industry in the Ohio River Basin Energy Study States" (ORBES Phase II, forthcoming).

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- In February 1980, the U.S. Securities and Exchange Commission (SEC) approved purchase by American Electric Power (AEP) of the Columbus and Southern Electric Company, an investor-owned utility that serves over 440,000 customers in a 6200-square-mile area in central and southern Ohio. The proposed acquisition had been studied by several federal agencies, including SEC, for 12 years, reportedly the longest time that such a proposal had pended in the history of the commission.

  - As a holding company, AEP controls electric utility companies with service areas and/or electrical generating facilities in four of the six ORBES states: Indiana, Kentucky, Ohio, and West Virginia. AEP companies also operate in three neighboring states, Michigan, Tennessee, and Virginia.

  - In terms of possible economic impacts on the ORBES region, particularly central Ohio, the proposed acquisition of Columbus and Southern by AEP is more significant than the purchase itself. The AEP corporate offices are in New York City, but for several years company officials have discussed the possibility of moving these offices to Columbus, Ohio. Some of the anagerial, professional, and technical functions of the AEP system already are conducted in the northeastern Ohio city of Canton.

In recent years, cooperation appears to have increased among various sectors of the electric utility industry, including investor-owned companies (such as the operating companies affiliated with AEP), municipal systems, federal corporations (such as TVA), and rural electric cooperatives. Often, the technical interconnections and managerial relations among these sectors cross state lines. Investor- and government-owned entities sell and purchase power in the processes of "pooling" and "wheeling." That is, when needed, electricity generated by one sector is provided to the other. However, such relationships are not always free of conflict.

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- Municipally owned utilities serve about 14 percent of electricity customers nationwide. Most of these utilities buy power in bulk at wholesale prices from investor-owned companies. As government entities, the municipal utilities have no stockholders, nor are they subject to federal, state, or local taxes.

  - In the ORBES region, conflicts have arisen when investor-owned companies have charged municipal utilities more for bulk power than they charge major industrial customers in the same area.

Perhaps the least-known sector in the electric utility industry is the rural electric cooperatives. In the ORBES region and elsewhere, these cooperatives both distribute power to their members and maintain so-called supercooperatives, which build and operate electrical generating facilities. More than 1000 cooperatives across the United States are represented by the National Rural Electric Cooperative Association (NRECA). The cooperatives are supported by loans and loan guarantees from the Rural Electrification Administration (REA), an agency of the U.S. Department of Agriculture.

- The REA program was authorized by Congress in 1936, and in its early years the agency supported only the distribution element of the cooperatives. Recently, however, REA has financed generating and transmission units. This practice has been criticized by environmental groups, who argue that rural electric cooperatives are becoming too big and are losing sight of their original grass-roots functions. They assert that the cooperatives are the fastest growing sector of the electric utility industry and that they have become an extremely influential special interest group in the shaping of national energy policy.

  - Estimates of REA loans and loan guarantees range from $7 billion to $9 billion annually. NRECA states that 4.1 percent of the REA-insured loans are for generation and transmission facilities, while one of the leading critics of REA, the Environmental Policy Institute, states that this figure is about 30 percent.

- The National Rural Utilities Cooperative Financing Corporation, a nonprofit cooperative financing institution established in 1969, provides capital to the rural electrical generation and transmission entities. The purpose is to supplement the government financing available through REA.

For nearly a century, major portions of the ORBES region have constituted the predominant coal-producing area in the United States. Thus, an understanding of this important regional industry is necessary background information for the reader of this report.[5]

As noted in chapter 1, the ORBES region is served by two extensive coal provinces. The Appalachian Province extends from western Pennsylvania and eastern Ohio southwestward through West Virginia and eastern Kentucky into Alabama. The Eastern Interior Province is located in Illinois, western Indiana, and western Kentucky. There are some important differences between the coals found in the two provinces, principally in their sulfur content.

Coal production in the ORBES region has mirrored national production since World War I. During that period, national production exceeded 500 million tons per year, the majority supplied by the Appalachian and Eastern Interior provinces. During the Depression years of the 1930s, coal production, like that of the national economy in general, declined; annual production ranged between 300 and 400 million tons. World War II and the immediate post-war years brought a resurgence to the industry, and national production reached a record 630 million tons in 1947. Then, however, production again declined. After a four-year period of fluctua-

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[5] For more detailed information, consult David S. Walls et al., "A Baseline Assessment of Coal Industry Structure in the Ohio River Basin Ene_gy Study Region" (ORBES Phase II, June 1979).

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tion, the bottom was reached in 1954, when national production was slightly over 391 million tons--a 62 percent decline from the peak year. By the early 1960s, demand and production began to increase; a new national production level of 648 million tons was reached in 1975. Production has increased every year since then.

- From 1970 to the present, there has been a decline in the percentage of U.S. coal production supplied by the ORBES region. This decline is attributable to expanded production in the West.

    - Among the ORBES state portions, coal production has fallen most markedly in West Virginia, due primarily to declining markets for metallurgical coal and labor disputes.

- Until 1974, more U.S. coal was produced by underground mines than by surface mines. Since that year the opposite has been true. In the ORBES region, however, more coal still is produced by underground mines, although the proportion produced by surface mines is increasing.

    - In the ORBES region in 1965, approximately 30 percent of the active mines were surface mines; by 1975, this figure had risen to 63 percent. In terms of numbers of mines, Kentucky, especially the eastern part of the state, contributed most heavily to the increase in surface-mining operations.

    - Despite a 90 percent increase between 1965 and 1975 in the number of ORBES-region surface mines, the percentage of production from these mines rose only 13 percent. The reason is that many of the new surface mines are relatively small operations.

- A probable effect of the Surface Mining Control and Reclamation Act of 1977 will be to reduce both the number of surface mines and the

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amount of regional and national coal production. The 1969 Federal Coal Mine Health and Safety Act has resulted in consistent improvement in coal-mining working conditions in the ORBES region and elsewhere.

- The ORBES-region coal reserve base is immense. To indicate its size, if coal mining in the region were to continue at the record pace of 1976--468.8 million tons--then the reserve base constitutes a 397-year supply. However, the recoverability of the coal is not taken into account in this calculation.

- In general, the coal mined in the Eastern Interior Province has a high sulfur content, while the Appalachian coal of eastern Kentucky and southern West Virginia is low in sulfur. The northwestern Appalachian coal of Ohio and northern West Virginia has a relatively higher sulfur content, similar to that found in the Eastern Interior Province. The sulfur content of most Pennsylvania coal is between those of Eastern Interior and southern Appalachian coals.

    - Similarly, the moisture and ash content of Eastern Interior coals tends to be higher than that of Appalachian coals, and the Btu content tends to be lower. However, great variability exists within both provinces.

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2.2 Economy

The ORBES portion of each of the six study-region states covers at least 79 percent of state land area except in Pennsylvania, where the ORBES portion comprises only 31 percent. However, major sectors of economic activity, especially in Pennsylvania and Illinois, are excluded from the region. In dollar terms, many economic sectors within the ORBES region account for slightly less than half the dollar output of these sectors in the six ORBES states overall. The exceptions are coal mining and agriculture, which are highly concentrated in the region and account for major shares of the dollar output in the six states.

There are substantial differences among the shares of the six ORBES-region state portions in the gross product of the region. From 1960 through 1975, gross regional product grew more slowly than did the six-state and national gross products. Over this same period, structural characteristics of the ORBES-region economy remained stable.

In this section, ORBES-regional characteristics are presented and contrasted with characteristics in the six ORBES states and in the United States as a whole.[6] All monetary values are expressed in constant 1972 dollars.

- In 1975, gross product in the ORBES region was approximately 48 percent of the gross product in the six ORBES states. Most of this difference is explained by the exclusion from the region of major centers of economic activity, especially in Illinois and Pennsylvania.

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[6] For further information on the ORBES-region economy, refer to Walter P. Page and John Gowdy, "Gross Regional Product in the Ohio River Basin Energy Study Region, 1960-1975" (ORBES Phase II, April 1979).

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- Gross product in the ORBES region was $122.3 billion in 1975, compared with a gross product of $252.3 billion in the six ORBES states in that year.

- While in 1975 most economic sectors in the ORBES region constituted approximately 48 percent of activity in corresponding sectors in the six ORBES states, coal mining and agricultural activity were highly concentrated within the region. Gross product from mining in the ORBES region accounted for 84 percent of mining activity in the six states; gross product from agriculture, 77 percent.

  - Mining activity in the ORBES region contributed $3.6 billion to gross regional product, while agriculture contributed $6.6 billion.

- Tertiary economic activities consist of trade, finance, and service industries. In 1975, tertiary economic activities in the ORBES region contributed less to gross regional product (37 percent) than these sectors contributed in the six ORBES states or the United States as a whole (41 and 46 percent, respectively).

- Manufacturing activity in the ORBES region and the six ORBES states contributed equal percentages to the gross products of these areas in 1975. In the nation as a whole, manufacturing contributed a much smaller percentage.

  - The contribution of manufacturing to the regional and six-state gross products was 31 percent in 1975. The contribution of this sector to U.S. gross product was 23 percent in that year.

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- Among eight major economic sectors, the ORBES-region share of six-state gross product ranged from 42 to 53 percent in 1975.

    - The regional share of the 1975 gross product of the six ORBES states was 42 percent for the finance sector (consisting of finance, insurance, and real estate); 43 percent for the service sector (consisting of services and other); 47 percent each for the nonfarm, trade, and transportation sectors; 48 percent for the manufacturing sector; 49 percent for the construction sector; and 53 percent for the government sector.

- Among the ORBES state portions, the regional share of gross state product in 1975 varied widely--from 100 percent in Kentucky to 25 percent in the ORBES portion of Illinois. (All of Kentucky is within the region.) The relatively small percentage shares for Illinois, Pennsylvania, and, to a certain extent, Ohio, are explained by the fact that large metropolitan areas of these states are excluded from the region.

    - In ascending order, the ORBES-region shares of 1975 gross state product were 25 percent in Illinois, 28 percent in Pennsylvania, 65 percent in Ohio, 76 percent in Indiana, 93 percent in West Virginia, and 100 percent in Kentucky.

- In 1975, per capita gross product in the ORBES region was 8.6 percent less than per capita gross product in the six ORBES states and 6.7 percent less than per capita gross product in the nation as a whole.

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- Per capita gross product in 1975 in the ORBES region was $5205; in the six ORBES states, $5695; and in the United States, $5578.

- The contributions of the individual ORBES states to the 1975 six-state gross product contrast with the shares of the ORBES state portions in gross regional product. The state contributions are considerably higher than the regional contributions in Illinois and Pennsylvania but considerably lower than the regional contributions in Kentucky and West Virginia. Again, these differences arise from the exclusion from the ORBES region of primary centers of economic activity in Illinois and Pennsylvania. These major differences are summarized below.

  - In 1975, the share of the state of Illinois in six-state gross product was 29.4 percent (compared with a share of 15.4 percent of the ORBES portion of the state in gross regional product). The six-state share of Indiana was 11.6 percent, versus a share of 18.1 percent in gross regional product. The corresponding shares for Kentucky were 6.4 percent versus 13.3 percent; for Ohio, 23.8 percent versus 31.9 percent; for Pennsylvania, 25.5 percent versus 15 percent; and for West Virginia, 3.3 percent versus 6.3 percent.

- The growth in gross product in the ORBES region between 1960 and 1975 was substantially less than the growth in the gross products of the six ORBES states and the United States in the same period.

  - The ORBES-region gross product grew at an average annual compounded rate of 2.47 percent ($83.8 billion in 1960, $94.8 billion in 1965, $113.3 billion in 1970, and $122.3 billion in 1970).

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- The gross product of the six ORBES states grew at an average annual compounded rate of 2.82 percent ($166.2 billion in 1960, $202 billion in 1965, $230.3 billion in 1970, and $252.3 billion in 1975).

- Gross national product grew at an average annual compounded rate of 3.26 percent ($736.8 billion in 1960, $925.8 billion in 1965, $1.1 trillion in 1970, and $1.2 trillion in 1975).

- Over the period from 1960 through 1975, structural characteristics of the ORBES-region economy remained stable. The largest percentage increase of a sector's contribution to gross regional product was only 2 percent (in the government sector), as was the largest decrease (in the construction sector).

  - Between 1960 and 1975, the contribution of the government sector to gross regional product rose from 10 percent in 1960 to 12 percent in 1975, while that of construction declined from 6 to 4 percent.

  - The activity of tertiary sectors in the ORBES region increased by only 1 percentage point (from 36 to 37 percent) between 1960 and 1975. The corresponding increases of these sectors in the six ORBES states and the United States were 3 percent and 4 percent, respectively.

- Between 1960 and 1975, the most rapidly growing economic sectors in the ORBES region were government, transportation-communication-utilities, and finance-insurance-real estate.

  - During this period, the government sector in the ORBES region grew by 3.43 percent; the transportation-communication-utilities sector, also by 3.43 percent; and the finance-insurance-real estate sector, by 3.41 percent. These growth rates were

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significantly higher than those of the remaining sectors, the highest of which, the trade sector, grew by 2.80 percent.

- These four relatively high-growth sectors, plus mining (which grew by 2.49 percent), experienced growth rates higher than the regional gross product growth rate of 2.47 percent.

- There were marked differences between 1960 and 1975 in the growth of various sectors in the ORBES region as compared with their growth in the six ORBES states.

  - In the six-state area between 1960 and 1975, the government sector grew more slowly than in the ORBES region (2.84 percent and 3.43 percent, respectively). The private nonfarm sector as a whole, however, grew more rapidly in the six states overall (2.88 percent, compared with 2.41 percent in the region). Within the private nonfarm sector, the six states experienced significantly higher rates of growth in manufacturing (2.97 percent, compared with 2.15 percent in the region), finance-insurance-real estate (3.83 percent, compared with 3.41 percent), and services and other (2.41 percent, compared with 2.08 percent).

- Major differences also were present between sectoral growth rates in the ORBES region and the United States as a whole between 1960 and 1975. The nation experienced markedly higher growth rates in every sector but government, farm, and mining.

  - Eighty-seven percent of the growth in gross national product was accounted for by the private nonfarm sector, while only 83 percent of gross regional product was associated with this sector.

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- The private nonfarm sector grew by 3.44 percent in the nation and by 2.41 percent in the region between 1960 and 1975.

- Other sectors that exhibited important differences in growth rates were manufacturing (3.05 percent in the nation, compared with 2.15 percent in the region), trade (3.96 percent, compared with 2.80 percent), transportation-communication-utilities (4.45 percent, compared with 3.43 percent), and services and other (3.73 percent, compared with 2.08 percent).

- Particularly significant for energy utilization are the higher national sectoral growth rates for manufacturing and transportation-communication-utilities.

- Between 1960 and 1975, the contributions of various sectors to overall economic growth differed in the ORBES region, the six ORBES states, and the United States as a whole.

  - The major differences between the region and the six states were in manufacturing (accounting for 27 percent of the growth in the ORBES-regional gross product and 32 percent of the growth in the gross product in the six ORBES states), mining (3 percent in the region and 1 percent in the six states), and government (15 percent in the region and 10 percent in the six states).

  - Comparing the region with the nation, the major differences were in finance-insurance-real estate (contributing 14 percent of the growth in gross regional product and 17 percent of the growth in gross national product), services (9 percent in the region and 14 percent in the nation), government (15 percent in the region and 12 percent in the nation), mining (3 percent in the region and 1 percent in the nation), and farming (2 percent in the region and 1 percent in the nation).

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2.3 Energy and fuel use

The ORBES region has been characterized as of 1974 in terms of fuel and energy use by end use. The end-use sectors consist of residential and commercial, industrial, transportation, and miscellaneous, as well as the use of fuels for the generation of electricity.

The ORBES-region share of total consumption of primary fuels for all uses is almost 60 percent of consumption in the six ORBES states as a whole.[7] In the use of fuels for the generation of electricity, however, the region accounts for about three-quarters of primary fuel consumption in the six states for this purpose. About 80 percent of the electricity generated in the six states is produced in the region. It is clear from the analysis that relative to the six ORBES states, as well as the nation, the ORBES region is concentrated in the use of energy for electrical generation.

Except for coal, the amount of primary fuel used in the region for all end-use sectors, including electric power generation, is approximately half of that used in the six-state area. In the case of coal, however, the region uses about 72 percent of that used in the six states. Relative to both the six ORBES states and the nation, the region makes heavy use of coal as a primary fuel.

The ORBES region is a large net "exporter" of electricity. While more than 90 percent of the electricity generated in the six states is used within their borders, only about three-quarters of that generated in

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[7] In this analysis, primary fuels are defined as coal, petroleum products, natural gas (all uses), plus hydroelectric and nuclear power for the generation of electricity. Total final consumption is defined as consumption in the residential-commercial, industrial, transportation, and miscellaneous sectors, plus the use of energy and fuels for electric power generation (including losses and omissions).

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the region is used locally. Finally, nonfossil fuels play a conspicuously smaller role in the ORBES region than in either the six ORBES states or the nation as a whole.[8]

In terms of installed electrical generating capacity, in 1976 slightly over 83,000 megawatts electric were on-line in the ORBES region. Of this total, almost 90 percent consisted of coal-fired capacity. Nuclear-fueled capacity accounted for only a little more than 2 percent of the total megawattage. Much of the regional capacity is located along the Ohio River.[9]

- Total energy consumed in electric power in the ORBES region is relatively greater than in the six ORBES states overall; regional consumption of energy for electrical generation is approximately 77 percent of consumption in the six states. In almost every other sector, the total energy consumed in the region is approximately 50 percent of that consumed in the six states.

- Relative to both the six ORBES states and the United States, the ORBES region is highly concentrated in the use of energy for the generation of electricity.

    - In the case of total energy use for electrical generation, the percentage of total energy consumed in the ORBES region is substantially greater (24 percent) than in the six ORBES states

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[8] For further details on regional energy and fuel use, see Walter P. Page, "Energy Consumption in the Ohio River Basin Energy Study Region, 1974, by End User and Fuel Type" (ORBES Phase II, August 1979).

[9] See Steven D. Jansen, "Electrical Generating Unit Inventory, 1976-1986: Illinois, Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia" (ORBES Phase II, November 1978).

(18 percent). The difference is even greater when regional figures are contrasted with figures for the nation as a whole: 24 percent in the region and 15 percent in the nation.

- The ORBES region uses approximately 50 percent as much primary fuels for total consumption as do the six ORBES states. In the case of coal, however, the region uses 72 percent as much.

  - The region uses approximately 34 percent of total primary fuels for the generation of electricity, compared with 27 percent in the six ORBES states and 24 percent in the United States.

- Relative to the six ORBES states and the United States, the ORBES region makes heavy use of coal as a primary fuel. Coal use accounts for about 49 percent of total primary fuel use in the region but only 40 percent in the six states and 19 percent in the nation.

  - Coal constitutes 95 percent of total primary fuel use for electrical generation in the ORBES region, compared with 90 percent in the six states and 51 percent in the United States.

  - The distribution of total coal used in the ORBES region reflects the relative concentration of its use for the generation of electricity. Sixty-seven percent of the total coal used in the region is for electrical generation, as contrasted with 60 percent in the six ORBES states and 64 percent in the nation.

- The ORBES region exports a large amount of electricity. Net regional exports in 1974 totalled about 276 trillion Btu, compared with about 112 trillion Btu exported from the six ORBES states and about 43 trillion Btu imported by the United States. No ORBES investigation was conducted on the destination of electricity exports. It appears, however, that much of the electricity exported from the

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study region is used in the northern portions of Illinois, Indiana, and Ohio; central and eastern Pennsylvania; and Maryland and other east coast states.

- Ninety-three percent of the electricity generated in the six states is used within state boundaries, compared with only 74 percent used locally in the region.

- In 1974, nonfossil fuels played an insignificant role in the nation overall. Their role was even less significant in the six ORBES states and the ORBES region.

    - These fuels constituted about 2 percent of total primary fuel use in the United States as a whole (1435 trillion Btu), about 1 percent in the six ORBES states (113 trillion Btu), and even less than 1 percent in the region (36 trillion Btu).

- In 1976, there were 83,125 megawatts electric of installed generating capacity in the ORBES region. Of this total, 73,449 megawatts were accounted for by coal-fired facilities and only 1865 megawatts were accounted for by nuclear-fueled facilities. Oil-fired units accounted for 4828 megawatts; hydroelectric units, for 1972 megawatts; natural gas units, for 292 megawatts; and multifueled units, for 97 megawatts. The fuel types of the remaining 1384 megawatts electric are unknown.

    - Installed capacity in the ORBES state portions in 1976 was as follows: 14,376 megawatts electric in Illinois; 12,322, in Indiana; 12,002, in Kentucky; 19,504, in Ohio; 12,081, in Pennsylvania; and 12,840, in West Virginia.

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2.4 Air quality

Air quality standards are not being met at several locations in the ORBES region. A number of pollutants violate national ambient air quality standards (NAAQS) and prevention of significant deterioration (PSD) standards (see section 2.1 for a discussion of these standards). However, principally because it is a study of the effects of electrical generation, ORBES focuses on sulfur dioxide, sulfates, total suspended particulates (TSP), and oxides of nitrogen.[10] First, current concentrations, emission sources and their impacts, meteorological effects on concentrations, and concentration effects are discussed in regard to each of these pollutants. An examination then follows of the major source contributors to subregional and regional concentrations under episodic conditions; this examination relies on the use of mathematical models.

Currently, elevated sulfur dioxide concentrations are present in many parts of the ORBES region.

- In 32 ORBES-region counties, the full, 24-hour PSD increment for sulfur dioxide is not available to accommodate new sources, and in several counties in the region, particularly a cluster on the Ohio-Pennsylvania-West Virginia border, NAAQS for sulfur dioxide are violated.

- Data from the 67 American Electric Power (AEP) plants and sulfur dioxide monitors indicate that about half the available annual air resource--80 micrograms per cubic meter (NAAQS)--has been used up in the lower portion of the Ohio River valley, and all or nearly all has been used up in the upper portion of the valley.

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[10] For a complete discussion of the air quality research carried out for ORBES, see James J. Stukel, "Air Quality Analysis for the Ohio River Basin Energy Study" (ORBES Phase II, forthcoming).

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The ORBES region is an area of very high sulfur dioxide emission density. In fact, there appear to be subregional sulfur dioxide "emission corridors" in the region--in particular, subregions between Paducah, Kentucky, and Rockport, Indiana; Evansville and Terre Haute, Indiana; Louisville, Kentucky, and Cincinnati, Ohio; and Huntington and Wheeling, West Virginia.

- The ORBES states--Illinois, Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia--are 6 of 11 states east of the Mississippi River with sulfur dioxide emissions greater than 1 million tons per year (there are 31 states in this area).

- The primary emission sources within the region are large isolated point sources, which are usually power plants, or complexes of urban and industrial sources, and these sources make significant contributions to both the short-term and the annual average sulfur dioxide concentrations measured in the lower and upper Ohio River Basin.

- A further characterization of these emission sources shows that current sulfur dioxide emissions from electric utilities in the ORBES region are at least four times the sulfur dioxide emissions from nonutility sources.

    - When specific data from the air quality control regions (AQCRs) are evaluated, this ratio increases even more in some areas. There are 15 AQCRs in the ORBES region where the sulfur dioxide emission density is high (greater than 10,000 kilograms per square kilometer). In 9 of these AQCRs, utility sources predominate, accounting for 50 percent or more of the total emissions and having emissions 10 or more times those of nonutility sources.

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- Data from the AEP networks indicate the contribution of large point sources to short-term concentrations. High 3-hour sulfur dioxide concentrations in the vicinity of AEP networks often produce the highest 24-hour concentrations of the year. Thus, the daily sulfur dioxide average can be influenced strongly by relatively few hours.

- The 25 highest daily sulfur dioxide concentrations in a year usually comprise 30 percent or more of the annual average sulfur dioxide concentration. Thus, the annual average can be strongly influenced by relatively few days per year.

High sulfur dioxide emission densities within an AQCR, however, are not solely responsible for high sulfur dioxide concentrations in that region. Moreover, a region without high sulfur dioxide emissions still can experience high concentrations of this pollutant. The explanation for these two observed situations involves the transport of sulfur dioxide emissions.

- Transport of emissions by extremely persistent winds (winds from one direction blowing for extended periods of time) is an important factor in subregional and regional sulfur dioxide and sulfate concentrations.

    - About 30 to 50 percent of the 25 highest daily sulfur dioxide concentrations are associated with transport by extremely persistent winds.

    - Specific data from along the Ohio-Pennsylvania-West Virginia border (where several counties violate NAAQS for sulfur dioxide) reaffirm that transport of sulfur dioxide emissions from local and background (distant) sources in the upper portion of the ORBES region contributes to violations of the 24-hour sulfur dioxide standards along the Ohio-Pennsylvania-West Virginia border.

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- Although 50 percent of excess sulfur dioxide concentrations are attributable to extremely persistent winds, elevated background contributions have been observed under both light and strong wind conditions in high sulfur dioxide emission density areas, such as the upper ORBES region. Thus, a variety of meteorological conditions can contribute to elevated sulfur dioxide concentrations.

- Stagnation conditions also can affect distant and local concentrations.

    - Stagnation conditions created by high pressure systems followed by extremely persistent winds are associated strongly with elevated concentrations in areas removed from any local source contribution. This phenomenon occurs when sulfur dioxide emissions are emitted into stagnant air. The sulfur dioxide concentrations then become quite high in a locality. Frequently, when the high pressure system moves out of an area, strong persistent winds, which exist on the system periphery, distribute the high concentration of sulfur dioxide to other parts of the region.

    - Local stagnation conditions also contribute to high sulfur dioxide concentrations. The highest observed 3-hour sulfur dioxide concentrations in the vicinity of tall stack power plants have been associated with stagnation conditions in which the overnight buildup was brought to the ground the following day in response to the heating of the ground surface.

Some of the same observations made about sulfur dioxide nonattainment, emissions, and transport also can be made about sulfates, total suspended particulates, and oxides of nitrogen.

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- With respect to the nonattainment of sulfate and TSP air quality standards, data from 1960 through 1978 suggest that, in general, the annual average sulfate concentrations over the ORBES region declined over this period, primarily because of a decline in the winter average sulfate concentrations. The summer average sulfate concentrations remained the same during this time because of the shift in major sulfur dioxide emissions from urban areas and short stacks to rural areas and taller stacks.

  - Historic trends for other regions suggest that between 1960 and 1978, most of the annual average sulfate concentrations over areas to the south, northwest, and northeast of the ORBES region remained the same or decreased slightly.

- Despite these trends derived from data, the nonattainment of the standards for TSP (of which sulfates are a part) has been a problem in the ORBES region. Of the counties that had TSP monitoring in 1977 (50 to 66 percent of the 423 counties in the region), 169 violated the NAAQS for this pollutant, and 182 had less than the full PSD increment available.

- In the mid-1970s, power plants in the ORBES counties contributed about 47 percent of regional nitrogen oxide emissions from all sources and about 33 percent of regional TSP emissions.

  - In 1976, nitrogen oxide emissions totaled 1.48 million tons; TSP emissions, 1.38 million tons.

The paradox between declining sulfate concentrations and continued substantial TSP nonattainment can be explained by three factors. First, no air quality standards for sulfates have been set in any ORBES state but Pennsylvania. Pennsylvania also is the only eastern state to implement such standards (a 24-hour standard of 30 micrograms per cubic meter). As a result, sulfate monitoring is not conducted extensively or consistently. Second, although sulfates are considered a part of total suspended particulates, an important sulfate ion is not included in the measurement. Thus, the ratio of sulfates to TSP concentration is actually an underestimation of the sulfate contribution to TSP. Finally, sulfates often are not emitted directly (primary sulfates).

- Within the ORBES region, primary sulfate emissions are highest in the Wheeling, West Virginia, area, yet this area's peak emission density, which occurs in the summer, is only about 0.1 grams per second per square kilometer. Most sulfates are created indirectly from sulfur dioxide under certain temperature conditions. Thus, the contribution of sulfur dioxide emissions to sulfate concentrations is an important one.

When the impact of meteorological conditions on sulfate and TSP concentrations is considered, several trends seem to emerge.

- Frequently, air parcel trajectories for major episodes of sulfates, reduced visibility, and acidic deposition (acid rain) in the northeastern United States and southeastern Canada pass over the ORBES region, strongly implicating it as a source region for these episodes.

- Under strong, extremely persistent winds, the contribution of sulfur dioxide emissions in the lower portion of the ORBES region to the sulfate concentrations in the upper portion of the region is at least 50 percent, representing 25 percent of the 24-hour TSP secondary NAAQS.

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- Long-range transport of emisssions from the upper ORBES region even can produce elevated sulfate concentrations, low visibility episodes, or nonattainment of the 24-hour TSP secondary standard as far south as Florida and as far southwest as Arkansas. However, these episodes occur very infrequently.

- Examination of data at specific sites reveals these same general transport trends. In Pennsylvania, for example, long-range transport of pollutant emissions contributes significantly to violations of the Pennsylvania sulfate standard and to violations of the federal 24-hour TSP secondary standard in that state.

    - Further analysis of data from the southwestern Pennsylvania border area shows that these high sulfate concentrations are associated more often with long-range transport from the west and southwest (that is, the lower ORBES region) than from the opposite directions.

As this discussion of current conditions has shown, nonattainment of air quality standards for these three pollutants is the result of some complex situations, especially complex meteorological conditions. But understanding the causes of these pollutant concentrations is essential since sulfur dioxide emissions, transport, and sulfate concentrations appear to contribute significantly to visibility degradation and to acid rain.

- Frequently, regional-scale sulfate episodes are associated with the co-occurrence of reduced visibility and elevated ozone concentrations.

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- The role of ozone in these regional episodes is unclear. Like sulfates, the ozone simply may be elevated because of meteorological conditions. On the other hand, it may be responsible for the sulfate episode.

- Acidic precipitation is due primarily to the presence of sulfate, nitrate, and ammonium ions. The sulfate ions in particular are primarily of man-made origin. Although data are sketchy for determination of the frequency of acid rain, between November 1978 and May 1979 at least 46 acid rain events were registered at five stations in or near the ORBES region.

  - Precipitation is considered acidic if its pH is less than 5.6. Mean regional pH values are about 4.1. Minimum values are about 3.6. However, at Wheeling, West Virginia, values between 1 and 2 have been measured. In general, a pH value of less than 2 means that the solution is more acidic than vinegar and nearly as acidic as edible limes.

  - Wet sulfur deposition is another parameter often used to characterize acidic deposition. Current annual wet deposition in the ORBES region ranges between 1 and 2 grams of sulfur per square meter per year. The highest measured values occur immediately downwind, in central Pennsylvania. Moreover, a number of wet deposition episodes (low pH and/or high sulfate ion concentrations) appear to be associated with very light rainfall or with rainfall over a limited area at the end of major ambient sulfate episodes.

- The understanding of sulfate episodes--and, thereby, of sulfur dioxide transport--is important if visibility degradation and acidic deposition problems (problems that cause degradation of air, water, and land quality) are to be combated.

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Because over 50 percent of the counties in the ORBES region do not have monitoring facilities for sulfur dioxide concentrations, mathematical modeling is useful to predict current subregional and regional air quality trends. Subregional trends, the trends in regional sulfur dioxide and sulfate episodes, and regional annual concentration trends are presented below.

The principal nonattainment subregions in the ORBES region are (1) along the Ohio-Pennsylvania-West Virginia border for sulfur dioxide and TSP, (2) in southwestern Ohio for TSP, and (3) in the vicinity of Louisville, Kentucky, for sulfur dioxide. There are significant emission sources upwind of each of these areas. In order to determine the impacts of these sources on these subregions (and thus on their nonattainment of air quality standards), the mathematical models were used.

- For the subregion including the Ohio-Pennsylvania-West Virginia border, the models suggest that when extremely persistent wind conditions last for 12 consecutive hours (a likely duration according to meteorological data), then sulfur dioxide and TSP nonattainment is affected significantly along the border on both a 24-hour and an annual basis.

  - The maximum impact of the emissions from just the eight coal-fired generating units along the line from the Kammer-Mitchell units in West Virginia to the New Castle plant in Pennsylvania probably amounts to about one-half the 24-hour sulfur dioxide primary NAAQS (365 micrograms per cubic meter) and about one-third the 24-hour Pennsylvania sulfate standard (30 micrograms per cubic meter) in counties downwind.

- For the subregion from Louisville, Kentucky, to Cincinnati, Ohio, the models suggest that when extremely persistent wind conditions

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last for a 24-hour period (a likely duration according to meteorological data), then the 24-hour and annual sulfur dioxide average concentration in Louisville and, thus, the nonattainment of sulfur dioxide NAAQS in Louisville are affected significantly.

- The maximum impacts on the nine counties to the northeast of Louisville that have high sulfur dioxide emission densities probably are 24-hour sulfur dioxide concentrations of about 90 micrograms per cubic meter and 24-hour sulfate concentrations of about 15 micrograms per cubic meter.

Five regional sulfate episodes were evaluated by a regional transport model to determine their subregional sources and to demonstrate the significant contribution of both simple and complex meteorological conditions to regional trends. These five episodes were selected to provide a representative cross-section of flow patterns, seasons, and special situations. They occurred on August 27, 1974, July 10, 1974, June 11, 1976, June 23, 1975, and January 20-24, 1975.

- The most frequent type of sulfate episode (occurring at least 10 times per year) is evidenced by the August 27, 1974, sulfate episode. This type of episode involves a rather straightforward, simple flow pattern of extremely persistent winds from west to east over the ORBES region for several days. During such an episode, the transport of emissions, particularly utility emissions, from the lower part of the region appears to have a significant impact on concentrations in the upper part of the region.

    - During the August 27 sulfate episode, the sulfur dioxide emissions in the lower ORBES region contributed nearly 90 percent of the sulfate concentrations in the upper region. Nearly 100 percent of the lower region's contribution came from utility emissions.

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- On a state basis, the regional transport model predicts that during the August 27 episode, sulfur dioxide emissions from the ORBES states of Illinois, Indiana, and Kentucky produced sulfate concentrations of about 8, 14, and 25 micrograms per cubic meter, respectively, in the upper portion of the ORBES region.

- The second most frequent type of sulfate episode (at least seven times per year) is exemplified by the July 7-11, 1974, episode. Such an episode includes both a stagnating high pressure system centered over the upper region that slowly moves southward and a quasi-stationary front along the Great Lakes. Long-range transport again plays a significant role in this kind of episode, and the emissions in particular states can contribute substantially to the concentrations in others.

  - On July 10, utility sulfur dioxide emissions from the lower portion of the ORBES region contributed about 60 percent of the sulfate concentrations in West Virginia, while utility sulfur dioxide emissions from the upper region contributed about 50 percent of the sulfate concentrations in Delaware.

  - On July 10, sulfur dioxide emissions from the ORBES states of Indiana and Kentucky made the most significant contribution to the sulfate concentrations in West Virginia, while sulfur dioxide emissions from Ohio made the most significant contribution to the sulfate concentrations in Delaware.

- The next two episodes--one occurred on June 11, 1976, and the other on June 23, 1975--represent the third and fourth types of sulfate episode. These types occur with nearly the same frequency (at least four times a year), are associated with more complex meteorological conditions, and are more difficult to simulate.

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- The sulfate episode on June 11, 1976, constituted just one day of a persistent elevated pollution episode, which lasted from June 8 through 13. This persistent episode was associated with recirculating flow over high emission density areas and with pronounced warm air advection, which accelerated the conversion of sulfur dioxide to sulfate. (Recirculating air flow refers to a pattern in which the air mass trajectories pass over a region and then curl back and retrace their original path.) Chemical transformation of sulfur dioxide to sulfates is an important feature of this episode, and transport of emissions, particularly utility emissions, again contributes significantly to concentration levels.

    - During the June 11 episode, regional sulfate concentrations due to primary sulfate emissions probably were about 2 micrograms per cubic meter, whereas the sulfate concentrations due to chemical transformation of sulfur dioxide emissions probably were 40 micrograms per cubic meter. Sulfate concentrations due to TSP probably also were about 40 micrograms per cubic meter.

    - On June 11, the sulfur dioxide emissions from the lower portion of the ORBES region contributed about 80 percent of the predicted sulfate concentrations in the upper portion of the region.

    - If the contribution of emissions from utilities in the lower region is separated from the contributions of all other point source emissions in the lower basin for this same episode, then about 90 percent of the sulfate concentrations contributed by the lower region's sulfur dioxide emissions to the upper region came from utility emissions.

    - During the June 11 episode, sulfate concentrations at three cities in or near the ORBES region (Columbus, Ohio; Pittsburgh,

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Pennsylvania; and Nashville, Tennessee) probably were 30 to 40 micrograms per cubic meter, and the sulfate concentrations at two cities upwind or downwind of the region (Little Rock, Arkansas, and Syracuse, New York) probably were 10 to 20 micrograms per cubic meter. Utility emissions alone were predicted to contribute about 80 percent of these predicted concentrations.

- During the June 23, 1975, sulfate episode, there was a combination of light recirculating and strongly persistent winds. Moreover, a cold front over Nova Scotia blocked the normal easterly flow and increased the residence time of the air mass over the northeastern subregion. Because of this unusual blocking effect, the contribution of emissions from the upper ORBES region to areas northeast of the region was higher than usual. Also because of the meteorological conditions, there was a wide variation in impacts within the region.

  - During the June 23 episode, utility sulfur dioxide emissions from the upper portion of the ORBES region contributed about 50 percent of the predicted sulfate concentrations northeast of the region. Under normal conditions these emissions would have been transported beyond the region and would have contributed to sulfate concentrations beyond the continental United States.

- During the June 23 episode, sulfur dioxide emissions from all source categories in the ORBES portions of Pennsylvania, Ohio, and West Virginia contributed sulfate concentrations of 18, 12, and 7 micrograms per cubic meter, respectively, to the northeastern subregion.

  - Because of the complex meteorological conditions associated with this episode, the resulting sulfate concentrations at five selected cities show wide variations. During the episode, predicted sulfate concentrations at two cities within the region

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(Columbus, Ohio, and Pittsburgh, Pennsylvania) were about 15 to 20 micrograms per cubic meter; concentrations at two cities upwind (Little Rock, Arkansas, and Nashville, Tennessee) were about 5 to 10 micrograms per cubic meter; and the concentration at one city downwind (Syracuse, New York) of the region was about 40 micrograms per cubic meter. Utility emissions contributed about 50 percent of these totals.

- The final type of sulfate episode occurs very infrequently and is represented by the episode of January 20-24, 1975. This winter episode was characterized by a sequence of recirculating winds and quasi-straight trajectories. The subregional portion of this episode was associated with generally subfreezing temperatures and light fog in the northern part of the Tennessee valley. As a result of these conditions, sulfate concentrations from the sulfur dioxide emissions of the main 201-county portion of the TVA service region probably were about 8 micrograms per cubic meter in the upper ORBES region on January 24, 1975, whereas the concentrations from the emissions of the entire 640-county TVA service region probably were 25 micrograms per cubic meter in the upper ORBES region on the same date.

Sulfur dioxide and sulfate concentrations of longer duration also were calculated. While the regional transport model predicts the impacts of short-term episodes, the simple annual dispersion model predicts utility contributions to annual averages, transport contributions to subregional annual concentrations, and state contributions to state annual concentrations.

- Utility sulfur dioxide emissions in the ORBES region contribute about 75 percent of the annual regional sulfur dioxide and sulfate concentrations.

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- In the industrialized areas of the upper ORBES region, transport contributes about 30 percent of the observed annual sulfur dioxide concentration, and subregional and local scale dispersion contributes about 70 percent.

- Of the sulfur dioxide emissions greater than 1 million tons per year in 11 eastern states, the sulfur dioxide emissions from Ohio have the greatest impact on sulfate concentrations in the states of Pennsylvania (3.6 micrograms per cubic meter), Maryland (3.2 micrograms per cubic meter), West Virginia (3.3 micrograms per cubic meter), and Ohio itself (4.1 micrograms per cubic meter).

The simple annual dispersion model also was used to assess the relationship between the United States and southeastern Canada in regard to sulfur dioxide emissions, pollutant concentrations, and transport impacts.

- The total sulfur dioxide emission rate from eastern Canadian sources (east of 105 degrees west longitude) is about 4.6 million tons per year. In comparison, Ohio, the state with the greatest sulfur dioxide emissions in the United States, has sulfur dioxide emissions of about 3.45 million tons per year.

- Despite these high emissions, sulfur dioxide emissions from eastern Canada contribute only about 2 micrograms per cubic meter to the annual sulfur dioxide and sulfate concentrations in the northeastern United States. However, sulfur dioxide emissions from the eastern United States contribute about 9 to 14 micrograms per cubic meter to the annual sulfur dioxide and sulfate concentrations in southeastern Canada.

- The latter predictions, however, are slightly higher than the observed sulfur dioxide and sulfate concentrations at rural monitors in the province of Ontario.

- Utility sulfur dioxide emissions in the six ORBES states contribute about 50 percent of the sulfur dioxide and sulfate concentrations predicted to occur in southeastern Canada from all eastern U.S. sulfur dioxide emissions.

- The Ontario Hydro monitors in the vicinity of that utility's Nanticoke generating plant, on the north shore of Lake Erie, suggest that transport of sulfur dioxide from the northeastern section of the ORBES region and from sources in the industrialized area along the southern shore of Lake Erie is an important factor in Canadian concentrations.

    - In 1977, 30 percent of the 25 highest daily sulfur dioxide concentrations in the Ontario Hydro Nanticoke monitoring network were associated with extremely persistent winds from the south.

    - In the Nanticoke network during 1976 and 1977, the maximum daily sulfur dioxide concentrations associated with transport of sulfur dioxide from sources to the south were about 225 micrograms per cubic meter.

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2.5 Water quantity, water quality, and aquatic ecology

The ORBES region encompasses most of the Ohio River Basin, the portion of the Mississippi River Basin that borders the states of Illinois and Kentucky, and the southern periphery of some Great Lakes drainage. Consequently, the water systems in the ORBES region and the aquatic life they support currently are as diverse as can be found in the United States. These waterways, their aquatic habitats, and the water supply that supports them first are examined. The effect of current pollution levels is then outlined, and the impact of a severe drought under these current pollution levels is estimated.

- The ORBES region has 11 navigable rivers; numerous tributaries ranging from small streams to large rivers; many long, flowing pools, called impoundments, created by locks and dams; varied lake systems; a number of accidental lakes created by abundant rainfall in combination with poor farming, foresting, and mining practices; and many warm-water sloughs, marshes, and wetlands.
    - The navigable rivers, which drain most of the region and have been made navigable by the construction of locks and dams, are the Ohio, Mississippi, Illinois, Tennessee, Cumberland, Green, Kentucky, Kanawha, Monongahela, Allegheny, and Kaskaskia rivers.
    - The Wabash is the only major nonnavigable river in the region.
    - The eastern tributaries of the Ohio include those of the Appalachian Mountains in West Virginia, Pennsylvania, and Kentucky; these tributaries are of a higher gradient than those to the west.

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- The western Ohio River tributaries include those of glaciated areas to the north of the river in Illinois, Indiana, and Ohio; these tributaries cover an extensive and relatively flat terrain.

- Where the Ohio joins the Mississippi River, numerous low-gradient streams with slow-flowing pools are found.

- Lake Barkley and Kentucky Lake are the largest lakes in the region.

These water systems support a diverse and nationally important aquatic habitat. The bank systems of the region's navigable waterways, in particular, are the ecological mainstay of these diverse habitats.

- The diversity of the region's aquatic ecology can be seen in the size and habitats of its fish species. Of the 258 fish species in the ORBES region, 25 are regionally ubiquitous (occurring in 60 of the 70 ORBES-region waterways), 102 are dispersed (occurring in 11 to 59 of the 70 waterways), 97 are limited (occurring in 2 to 12), and 34 are isolated (occurring in a single waterway). Nearly half the 70 study-region streams contain species not found elsewhere in the region.

- The lower Ohio River (from Cincinnati, Ohio, to Cairo, Illinois) holds some 90 species of fish, including many important game species. It also is frequented by the American bald eagle, the osprey, several species of terns, millions of ducks, and numerous buzzards.

- All 11 ORBES-region navigable waterways have rich fauna and are considered ecologically significant and deserving of the maximum protection possible. Like the lower Ohio River, the Tennessee, the Cumberland, and the Mississippi rivers each contain more than 90 aquatic species.

- The ORBES-region tributaries are considerably more varied than are the navigable waterways and contain even more varied and site-specific ecosystems. Some entirely unique systems, which are protected to a degree, are evident in the tributaries.

    - The most outstanding, ecologically rich stream system in the ORBES region is the small system of sluggish streams and wetlands known as the Bayou de Chien-Obion Creek system, which is located in Kentucky. One hundred and eight species live there, and the system contains eight isolated species, the most in any ORBES-region stream system.

- The ORBES-region lake systems also have diverse ecologies. For example, Lake Barkley, part of the Cumberland River system, contains 128 species--the most of any lake system in the region. Kentucky Lake, part of the Tennessee River system, contains 101 species--the second highest number in the region.

The water resources that support these systems and their habitats come from both within and outside of the region. Within the region, stream flow is aided by precipitation runoff, groundwater, and reservoirs. River inflows from outside the region also make major contribitions to regional water supply.

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- The average rainfall in the ORBES region results in a potential water supply to the region of 584,302 cubic feet per second.

- However, the runoff that actually reaches the region's streams is, under average conditions, 216,627 cubic feet per second.

- The inflow under average conditions is 256,958 cubic feet per second.

- Thus, the total water supply in the ORBES region under average conditions is 473,585 cubic feet per second.

Besides supporting the waterways and the aquatic life of the region, this water supply also is heavily used by industries, municipalities, and and electric utility companies.

- Water withdrawal rates in 1970 in the ORBES region for each major user were: municipalities, 3,907 cubic feet per second; industries, 11,812 cubic feet per second; and utility companies, __ cubic feet per second.

- Thus, the total water withdrawal rate in the region is __ cubic feet per second.

- Water consumption rates in 1970 in the ORBES region for each major user were: municipalities, 774 cubic feet per second; industries, 1,120 cubic feet per second; and utility companies, __ cubic feet per second.

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- Thus, the total water consumption rate in the region is __ cubic feet per second.

As can be imagined, seasonal low flow and unexpected drought conditions represent critical periods for water supply and quality. These conditions produce water quality impacts by further concentrating existing pollutants in the region's waterways.

- During seasonal periods of low flow, the total water supply for the ORBES region is, on the average, 87,578 cubic feet per second. Of this amount, runoff represents 12,978 cubic feet per second, and inflow, 74,600 cubic feet per second.

- Currently all ORBES-region navigable waterways and their major tributaries are in violation of important water quality criteria at seasonal low flow.

- Although regionwide drought conditions have occurred many times in the last 50 years, no truly serious drought has occurred at current pollutant loading levels. Thus, the impact that such a drought would have is unknown.

    - The most recent extensive drought period occurred in 1930. At that time, flow did not exceed 15,000 cubic feet per second for 143 consecutive days.

Despite the nonoccurrence of severe drought conditions, seasonal low flow already has had a negative effect on regional water quality. During seasonal low-flow conditions--usually in late summer--dissolved oxygen levels drop in the water, in some instances to near zero. Algal growth begins to appear, reducing the penetration of light; this reduction discourages the growth of some aquatic plants. If stream nutrients subsequently become too abundant, which they usually do under low-flow conditions, an algal bloom occurs and depletes even more dissolved oxygen

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during night-phase metabolism. This continuous depletion of the dissolved oxygen required by fish and aquatic life is called eutrophication, and it can be irreversible. At present, however, ORBES-region streams are in balance in regard to eutrophication, although they exhibit high stream-nutrient concentrations under low-flow conditions.

A rise in water temperature also aids algal growth. In late summer, navigable pools on the Ohio main stem suffer temperatures of 86 degrees Fahrenheit, which is 2 degrees above the temperature deemed acceptable by reference standards. Dissolved oxygen levels at this time drop below 5 milligrams per liter, the level required by the reference standards and necessary to maintain a system's balance.

Besides the reference standards for temperature and dissolved oxygen, water quality reference standards also exist for total dissolved solids, total suspended solids, sulfates, ammonia, arsenic, barium, cadmium, chloride, chromium, phosphorus, selenium, silver, copper, iron, lead, manganese, nickel, mercury, zinc, and boron.

Some conditions that exist under current low flow are as follows.

- At seasonal low flow, most ORBES-region navigable waterways and their major tributaries currently violate of at least 2 of the 20 pollutant reference standards, especially since background levels of dissolved material also exceed standards on many of those waterways. For these systems, water consumption alone will cause serious problems because of the concentration of conservative agents (agents that do not change form in water).
    - The conservative agents in most frequent violation at low flow are phosphorus, iron, manganese, copper, and chromium.
    - During low flow at one point on the upper Ohio River, a maximum temperature rise of 4.5 degrees Fahrenheit is experienced across the river. This rise comes close to the maximum 5 degrees Fahrenheit rise permitted under ORSANCO standards.

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- Of the 24 navigable waterways and major tributaries selected for specific analysis, most cannot experience stress without undergoing a structural change in the direction of degradation. Such streams receive an aquatic habitat ranking of "A" and are considered high-quality streams. Eighteen of the 24 streams have this ranking. The other 8 have a ranking of "B," which designates that they are in a transitional state between high and low ranking. A ranking of "C" indicates the same, while a ranking of "D" designates low-quality streams that are already degraded and have a fauna tolerant to pollutants.

- Of the 24 navigable waterways and tributaries in the ORBES region selected for specific analysis, 6 are in Kentucky, 5 in Illinois, 4 in Ohio, 3 in Pennsylvania, 2 in West Virginia, and 2 in Indiana. One of the two remaining rivers, the Wabash, borders Indiana and Illinois; the other, the Ohio, borders all six ORBES state portions.

- The current ranking of each stream in Kentucky or bordering only that state is indicated below, along with the number of reaches in the stream (which usually indicate the river's length) and the pollutants that currently are in violation under low-flow conditions.

    - Big Sandy River. Class A stream with 2 reaches. At present, suspended solids, chromium, phosphorus, copper, iron, lead, manganese, mercury, nickel, and boron are in violation of reference standards at low flow.

    - Licking River. Class A stream with 1 reach. Suspended solids, chromium, phosphorus, selenium, copper, iron, manganese, and mercury are in current violation of reference standards at low flow.

- Salt River. Class A stream with 1 reach. No violations of reference standards occur at present.

- Cumberland River. Class A stream with 3 reaches. At present, cadmium, phosphorus, silver, iron, manganese, and mercury are in violation of reference standards at low flow.

- Green River. Class A stream with 2 reaches. Suspended solids, chromium, phosphorus, silver, iron, lead, manganese, and mercury currently violate reference standards at low flow.

- Kentucky River. Class A stream with 3 reaches. No violations of reference standards occur at present.

- The current ranking of each stream in or bordering only the ORBES portion of Illinois is indicated below, along with the number of reaches in the stream and the pollutants that are in current violation under low-flow conditions.

  - Illinois River. Class A stream with 9 reaches. At present, ammonia, phosphorus, copper, iron, lead, manganese, and mercury are in violation of reference standards under low flow conditions.

  - The Big Muddy and Kaskaskia rivers. In each of these Class A streams with 1 reach, phosphorus, iron, and manganese currently are in violation of reference standards at low flow.

  - Rock River. Class B stream with 1 reach. At present no violations of reference standards occur.

  - Mississippi River. Class A stream with 7 reaches. Currently, phosphorus, copper, iron, manganese, and mercury are in violation of reference standards at low flow.

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- The current ranking of each stream in or bordering only the Ohio ORBES portion is indicated below, along with the number of reaches in the stream and the pollutants that at present are in violation under low flow conditions.

  - Scioto River. Class A stream with 4 reaches. Suspended solids, ammonia, chromium, phosphorus, selenium, silver, iron, lead, manganese, and mercury are in violation of reference standards at low flow at present.

  - Muskingum River. Class B stream with 2 reaches. Currently, suspended solids, cadmium, chromium, phosphorus, silver, iron, lead, manganese, and mercury are in violation of reference standards at low flow.

  - Great Miami River. Class A stream with 4 reaches. Suspended solids, cadmium, chromium, phosphorus, silver, copper, iron, lead, manganese, mercury, and zinc are in present violation of reference standards at low flow.

  - Little Miami River. Class B stream with 1 reach. At present, suspended solids, cadmium, chromium, phosphorus, copper, iron, lead, manganese, and mercury are in violation of reference standards at low flow.

- The current ranking of each stream in or bordering only the ORBES portion of Pennsylvania is indicated below, along with the number of reaches in the stream and the pollutants that currently are in violation under low-flow conditions.

  - Beaver River. Class B stream with 2 reaches. Ammonia, chromium, phosphorus, silver, copper, iron, manganese, mercury, and zinc are in current violation of reference standards at low flow.

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- Allegheny River. Class A stream with 4 reaches. At present, total dissolved solids, arsenic, chromium, phosphorus, iron, lead, manganese, and mercury are in violation of reference standards at low flow.

- Susquehanna River. Class A stream with 1 reach. No violations of reference standards occur at present.

- The current ranking of each stream in or bordering only the West Virginia ORBES portion is indicated below, along with the number of reaches in the stream and the pollutants that currently are in violation under low-flow conditions.

  - Monongahela River. Class A stream with 3 reaches. At present, chromium, phosphorus, iron, manganese, mercury, and nickel are in violation of reference standards at low flow.

  - Kanawha River. Class A stream with 2 reaches. Chromium, phosphorus, iron, lead, manganese, mercury, and nickel are in current violation of reference standards at low flow.

- The current ranking of each stream in or bordering only the ORBES portion of Indiana is indicated below, along with the number of reaches in the stream and the pollutants that are currently in violation under low-flow conditions.

  - White River. Class B stream with 6 reaches. At present, suspended solids, ammonia, phosphorus, copper, iron, manganese, and mercury are in violation of reference standards at low flow.

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- Whitewater River. Class B stream with 1 reach. Suspended solids and phosphorus are in current violation of reference standards at low flow.

- The Wabash River, a Class A stream with 10 reaches, borders the ORBES portions of both Indiana and Illinois. Suspended solids, phosphorus, copper, iron, mercury, and nickel are in present violation of reference standards.

- The Ohio River borders all six ORBES state portions; it is a Class A stream with 32 reaches. At present, suspended solids, cadmium, chromium, phosphorus, silver, copper, iron, lead, manganese, mercury, and nickel are in violation of reference standards at low flow. In the upper Ohio, the standard for dissolved oxygen also is violated.

There are sources of these pollutants that are in violation of reference standards during persistent low flow.

- Navigable waterways draining into the Ohio carry primarily industrial and organic pollutants. Those navigable waterways draining into the Mississippi carry primarily agricultural pollutants.

  - The operation of impoundments and of the locks and dams could help lessen the impact of pollutant concentrations on navigable waterways by maintaining dissolved oxygen levels at or above 5 milligrams per liter through reaeration.

- Siltation and stream dessication--primarily from farming and mining rather than from industrial development--are the major factors that affect tributary habitats. For example, orphan mined land in both the Appalachian and Eastern Interior coal provinces is the major source of water quality problems for many ORBES-region tributaries. However, some tributaries do receive substantial quantities of organic waste, and a few small streams are threatened directly by acid precipitation.

- Acid precipitation also is becoming a threat to those protected lakes and streams in wilderness areas, state parks, and private land that until the last 20 years did not receive a pollutant load above the natural inflow. Acid mine drainage and the pollutants created by the washing of coal are affecting many of the small accidental lakes created by surface mining and rainfall.

Although a prolonged drought or period of persistent low flow has not occurred at current pollution levels, mathematical models can project what would occur through the use of past drought conditions and current pollution data. Such projections suggest that the impacts could be severe on certain waterways. For example:

- Under a period of persistent low flow at current pollution levels, it might not be possible to purify the water needed for human consumption at the necessary levels of both quality and quantity.

- During periods of extended drought under existing conditions, temperature standards would be violated at 10 points along the Ohio River main stem. Two points that would be in extreme violation are close together in the first 100 miles of the river.

- Given current levels of nitrates, phosphates, and heavy metal salts, it seems certain that a prolonged drought would have a devastating effect on the region's aquatic biota.

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- Depending on the land use patterns around each waterway in the ORBES region, with existing concentrations aquatic biota would experience minor to severe impacts under a prolonged drought.

- Aquatic biota in the Illinois, White, Big Sandy, Scioto, Beaver, and Ohio rivers would be affected severely under persistent low flow conditions, each by a different pollutant source or combination of sources.

The impacts on each river under a period of prolonged drought or persistent low flow are as follows. These impacts are projected using current pollution levels.

- The impacts of persistent low flow on four ORBES-region rivers are difficult to quantify due to the lack of recent data. However, impacts probably would be minor. These rivers (and their current rankings) are the Rock River (protection level B), the Kentucky River (protection level A), the Salt River (protection level A), and the Susquehanna River (protection level A).

    - A possibility exists that moderate impacts would occur at some localities on the Salt River due to poorly treated sewage effluents.

- Persistent low flow would have only minor impacts on five rivers. These rivers (and their current rankings) are: the Big Muddy River (protection level A); the Kaskaskia River (protection level A); the Mississippi River (protection level A); the Cumberland River (protection level A); and the Whitewater River (protection level B).

    - On the Mississippi River, concentrations of copper and mercury salts to toxic levels, as well as local eutrophication and dis-

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solved oxygen problems, could occur. However, the current ranking of the Mississippi would be maintained since overall impacts would be minor.

- Under persistent low flow, nine rivers would experience overall moderate impacts and some degradation. These rivers (and their current rankings) are the Wabash River (protection level A), the Green River (protection level A), the Licking River (protection level A), the Great Miami River (protection level A), the Muskingum River (protection level B), the Little Miami River (protection level B), the Monongahela River (protection level A), the Allegheny River (protection level A), and the Kanawha River (protection level A).

    - On the Wabash River, concentrations of copper and mercury salts to toxic levels could occur, along with some evident siltation, suspended solids problems, localized eutrophication, and dissolved oxygen depletion. Degradation to protection level B would occur.

    - On both the Licking and the Green rivers, the impacts would entail concentration of heavy metal salts to a toxic level, local eutrophication with nightly dissolved oxygen sags, and local kills of adult fish and probably of embryonic fishes throughout the lower reaches. Degradation to protection level B would occur.

    - On the Great Miami River, the impacts on the Green River would be duplicated, except that degradation to protection level C would occur.

    - On the Muskingum River, there would be probable eutrophication, some siltation, heavy metal salt concentrations to a toxic level, embryonic fish losses, and local adult fish kills. Degradation to protection level C would occur.

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- On the Little Miami River, the impacts would entail probable concentration of heavy metal salts to a toxic level, local eutrophication with nightly dissolved oxygen sags, possible complete systemwide loss of embryonic fishes, and local adult fish kills. Degradation to protection level D would occur.

- On the Allegheny River, concentration of heavy metal salts and dissolved solids to a toxic level would occur, along with the probable loss of some embryonic fishes and limited adult fish kills due to eutrophication and dissolved oxygen sags. Degradation to protection level C would be expected.

- On the Monongahela River, there would be probable concentration of heavy metal salts to toxic levels--leading to the death of some embryonic fishes--and limited eutrophication with minor adult fish kills. Degradation to protection level B would occur.

- On the Kanawha River, there would be probable concentration of heavy metal salts to toxic levels--leading to the death of some embryonic fishes--and limited eutrophication below Charleston, West Virginia, with minor adult fish kills. Degradation to protection level B would occur.

- Persistent low flow would have severe overall impacts on six rivers. These rivers (and their current rankings) are: the Illinois River (protection level A), the White River (protection level B), the Big Sandy River (protection level A), the Scioto River (protection level A), the Beaver River (protection level B), and the Ohio River (protection level A). Degradation to protection level D would occur for the first five of these rivers. On the Ohio, degradation to protection level C would occur.

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- On the Illinois River, these impacts would entail probable eutrophication with subsequent algal blooms and nightly dissolved oxygen sags, concentrations of heavy metal copper and mercury salts to toxic levels, and massive fish kills along the entire river.

- On the White River, there would be probable eutrophication with subsequent algal blooms and nightly dissolved oxygen sags, concentrations of silt, mercury, and copper to toxic levels, massive fish kills, and impacts on the Wabash River, of which the White is a tributary.

- On the Big Sandy River, numerous heavy metal salts, silt, and suspended solids probably would be concentrated to toxic levels, and local eutrophication and nightly dissolved oxygen sags, systemwide death of embryonic fishes, and local adult fish kills would occur.

- On the Scioto River, eutrophication with nightly dissolved oxygen sags and concentrations of heavy metal salts to toxic levels would occur. These conditions probably would result in extensive loss of the aquatic fauna, notably of the region's only endangered species, the Scioto madtom.

- On the Beaver River, there would be probable eutrophication with nightly dissolved oxygen sags, concentration of heavy metal salts to a toxic level, complete loss of embryonic fishes, and extensive adult fish kills.

- On the Ohio River, these impacts would entail probable concentration of heavy metal salts to toxic levels--leading to serious loss of embryonic and young adult fishes--as well as local eutrophication and massive fish kills below major cities.

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2.6 Land use and terrestrial ecology

An understanding of general land use patterns within the ORBES region is critical for the analysis of potential conversions of land use from present to energy-related ones. A regional analysis of major land use types indicates interrelationships among climate, physiography, soils, vegetation, and the history of human development, as well as possible constraints on future uses of land.[11]

- The ORBES region covers 121,841,104 acres of land. Of this regional land area, the Illinois portion comprises 27 percent; the Kentucky portion, 21 percent; the Indiana portion, 17 percent; the Ohio portion, 17 percent; the West Virginia portion, 11 percent; and the Pennsylvania portion, 7 percent.

    - The ORBES state portion of Illinois comprises 92 percent of all land in Illinois; the ORBES portion of Indiana, 89 percent of all land in the state; the ORBES portion of Ohio, 79 percent of all Ohio land; the ORBES portion of Pennsylvania, 31 percent of all land in the state; and the ORBES portion of West Virginia, 87 percent of all West Virginia land. One hundred percent of Kentucky land is included in the study region.

- Agriculture represents the primary land use in the ORBES region (about 54 percent of the regional total). Agricultural land use is the most important land use in the Eastern Interior Coal Province but is relatively unimportant in the Appalachian Province.

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[11] For specific details regarding land use in the ORBES region, see two forthcoming ORBES Phase II repots: J.C. Randolph and Bill Jones, "Ohio River Basin Energy Study: Land Use and Terrestrial Ecology," and Daniel E. Willard et al., "A Land Use Analysis of Existing and Potential Coal Surface Mining Areas in the Ohio River Basin Energy Study Region."

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- Of the ORBES state portions, Illinois has the highest total agricultural land use (23.2 million acres, or 71 percent of the ORBES portion of the state) and West Virginia has the lowest (2.4 million acres, or 18 percent of the ORBES state portion).

- Forests constitute the second most common land use in the ORBES region (about 37 percent of the regional total). Forests are the most common land use in the Appalachian Coal Province and are relatively unimportant in the Eastern Interior Province.

  - Of the ORBES state portions, Kentucky has the highest total forest acreage (11 million acres, or 43 percent of the state land area), whereas West Virginia has the highest proportion of land in forest use (69 percent of the ORBES state portion, or 9.3 million acres).

  - Of the ORBES state portions, Illinois has the least amount (3.3 million acres) and lowest proportion (10 percent) of forested land, due to both limited natural forests and extensive conversion to agriculture.

- Public lands constitute only about 4 percent of the region (5 million acres) and include some forest areas, while urban lands constitute about 6 percent of the region (6.8 million acres).

- In the ORBES region, approximately 1.6 million acres have been affected by the surface mining of coal, although only 18 percent of the total surface-minable reserves has been mined.

  - Surface-minable reserves constitute only about 17 percent of the total coal reserve base in the ORBES region.

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- Two acres of land must be displaced in the Appalachian Coal Province to yield the same amount of coal as one acre in the Eastern Interior Province.

- In the ORBES region, the greatest potential for conflict between agricultural and surface mining land use occurs in Illinois, and the greatest potential for conflict between forestry and surface mining occurs in central and southern West Virginia.

- Reclaimed surface-mined land can serve a number of uses, but reclamation is a slow process. It has been and can be accomplished throughout the region with varying degrees of success.

    - Old surface-mined land has a number of potential uses; for example, it can be used for recreation, wildlife habitats, water supply, forests, pasture, and commercial and residential development.

    - However, reclamation for permanent land use usually takes more than two years after mining operations cease. In fact, of the total regional area affected by surface mining, about 400,000 acres (25 percent) have been affected for at least 10 years and have been reclaimed only partially. (Data for the remaining 75 percent are incomplete, and an accurate assessment of their status cannot be made at this time.)

    - In the Appalachian Province, the amount of time and money necessary to restore a site according to the Permanent Regulatory Program of the Surface Mining Control and Reclamation Act of 1977 could be quite substantial.

    - During the 1970s, reclamation to tillable cropland became increasingly important in Illinois and Indiana. It now constitutes a major intended postmining land use in these areas.

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- Present land use by electrical generating facilities in the ORBES region is estimated to be 140,700 acres, ranging among the state portions from 33,000 acres in Ohio to 20,300 acres in Kentucky.

  - The average land ownership at six selected electrical generating facilities using cooling towers is 1100 acres per 650 megawatts electric; of this, 400 acres are affected directly and 700 acres are affected indirectly.

  - In general, the 400 affected acres are comprised of building sites (approximately 6 percent), fuel and waste storage areas (approximately 44 percent), and roads, parking lots, and miscellaneous uses (50 percent).

  - In cases where surface water resources are insufficient to meet cooling requirements and cooling reservoirs are needed, land use is assumed to total 975 acres per 650 megawatts electric.

A definition of land quality is not as explicitly obvious as definitions of air or water quality. Because of this problem of evaluation, it is difficult to make an objective comparison of lands in different use categories. A land use model was developed to assess the impacts of various siting configurations on land use conversion. The land use criteria chosen for analysis are those for which reliable data exist for all six ORBES states. The four land use categories selected for analysis are agriculture, forest, urban, and public. Using the standardized land use requirements for a 650 megawatts electric generating facility outlined above, total land use conversions were calculated for each affected county under various scenarios; these results are discussed in the scenario comparisons.

Displacement and the effects of pollutant transport are the two major impacts of energy development upon the ecological environment of the ORBES region. Electrical generating units, transmission lines, and coal-mining operations displace the more mobile wildlife and unintentionally destroy the less mobile wildlife, typically amphibians, reptiles, fossorial mammals, and many types of young animals. The impacts are most severe where unusual, rare, or critical habitats are displaced, such as wetlands or isolated habitats at the edge of their geographic range. In these cases, the displaced, mobile animals sometimes do not find suitable alternative habitats.

Little is known about the effects of air pollutant emissions on animals, but sufficient evidence exists to indicate that certain species of plants in the ORBES region are susceptible to some levels of sulfur oxides. The magnitude of their susceptibility varies by species, pollutant type and quantity, and climatic conditions. For example, the catalpa, the Alerican elm, the eastern white pine, the maple, and the Lombardy poplar are the trees most susceptible to visible injury from current sulfur dioxide levels, while oaks and sassafras show relative resistance to such levels.

Available data describing the terrestrial features of the ORBES region vary greatly in both quantity and quality. As no standardized sets of variables are monitored and reported routinely on either an interstate or an intrastate basis, the type of information varies from extremely detailed, site-specific data to very generalized, nonquantitative overviews. For purposes of this analysis, the integrative concept of a biome was used. A biome is any area where regional climates and substrates interact with regional biota to form large, recognizable, geographically based units.[12]

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[12] For specific details regarding terrestrial ecology in the ORBES region, see Indiana University, The Ohio State University, Purdue University, "Preliminary Technology Assessment Study," (vol. II-a, ORBES Phase I, May 15, 1977), and the following forthcoming Phase II reports: J.C. Randolph and Bill Jones, "Ohio River Basin Energy Study: Land Use and Terrestrial Ecology"; Daniel E. Willard et al., "A Land Use Analysis of Existing and Potential Coal Surface Mining Areas in the Ohio River Basin Energy Study Region"; and Orie Loucks et al., "Sub-Injurious Effects of Gaseous Sulfur and Nitrogen Emissions and Their Conversion Products on Crops and Forests in the Ohio River Basin States."

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- Climate in the ORBES region is fairly uniform, although there is a pattern of decreasing precipitation from east to west across the region. Annual solar radiation and mean annual precipitation patterns are fairly similar throughout the region.

- The primary physiographic subdivisions of the ORBES region are the Appalachian highlands of West Virginia, Pennsylvania, southeastern Ohio and eastern Kentucky; the eastern interior uplands of western Kentucky, southern Indiana, and southern Illinois; and the central lowlands of western Ohio, northern Indiana, and most of Illinois.

- There are three major soil classes in the ORBES region: inceptisols (usually light, thin soils with low organic matter on gently sloping to steep terrain), in the Appalachian highlands; mollisols (deep, nearly black, organic-rich soils), in the eastern interior uplands; and alfisols (gray-brown, podzolic, moist mineral soils), in the central lowlands.

- Soil capability varies within each of these major soil classes and is also identified by soil capability classes. The most productive soils are those within capability classes I and II. These soils have few limitations and are suitable for a wide range of vegetation.

    - Of the ORBES state portions, Illinois has the greatest total acres in Class I and II soils (18.3 million acres, or 56 percent of the ORBES portion of the state), while Indiana has the highest proportion of these soils within one state (58 percent of the state portion, or 12 million acres). The ORBES portion of West Virginia has the smallest land area and the lowest percentage in Class I and II soils (756,000 acres, or 6 percent of the West Virginia total).

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- The primary vegetation patterns of the ORBES region are (1) northern hardwoods of eastern West Virginia, (2) mixed mesophytic forests of western West Virginia, southeastern Ohio, and western Kentucky, (3) Appalachian oak forests of western Pennsylvania, northern West Virginia, and eastern Ohio, (4) beech-maple forests of northern and western Ohio and northern and central Indiana, (5) oak-hickory forests of central and western Kentucky, southern Indiana, and southern Illinois, and (6) bluestem prairie of central and northern Illinois. The first five of these are a part of a larger, recognizable unit referred to as the eastern deciduous forest biome.

  - The conversion of forests and prairie into agricultural land in the ORBES region is the major change that human settlement has made on the original vegetation. Less of this deforestation is evident along the Ohio River and in the Appalachian highlands than in other parts of the region.

  - Of the ORBES state portions, Kentucky has the highest total forest acreage, and Illinois has the least amount of forested land, due to both limited natural forests and extensive conversion to agriculture.

- The conversion of rather substantial acreages of native vegetation in the ORBES region currently occurs due to the surface mining of coal. This conversion causes greater ecological disruption in the Appalachian Coal Province than in the Eastern Interior Province because of higher acreage-to-tonnage relationships required for production, the longer time required for the regrowth of forests in contrast to meadow, and the abandonment of native forest for meadow/pasture as an endpoint of reclamation.

  - The landscapes of the ORBES states differ in their physiographic and ecological ability to recover from surface mining operations, both with and without human assistance.

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- Recently mined or recently reclaimed spoils from old mining operations in the ORBES region have extensively graded topography and relatively uniform vegetation dominated by herbaceous plants and grasses, in contrast to the trees and other woody plants that predominate on older surface-mined land.

- Both natural and agricultural vegetation in the ORBES region are undergoing physiological changes due to present levels of air pollutants; even low levels of sulfur dioxide and nitrogen oxide emissions affect plant growth negatively.

    - In combination with moderate background oxidant levels, sulfur dioxide and nitrogen oxide emissions produce significant negative effects on photosynthesis and other metabolic processes of many plant species, at one-fifth to one-tenth the secondary standards for sulfur dioxide.

    - Oxidants--and, locally, sulfur dioxide--result in reduced vigor and diameter increment for several important forest species in the ORBES region. Insect damage also may be attributable, in part, to the presence of atmospheric toxicants at currently observed concentrations, since the affected forest species are too weak to resist. If all these impacts are considered, total forest losses due to coal-fired utility emissions approach 5 percent of total annual growth.

    - Reduced growth rate and early mortality have been observed for a sensitive conifer, white pine, in both rural and urban areas. These serious symptoms appear to be the direct result of air pollution.

    - Up to 10 percent of the ORBES portion of Illinois and 7 percent of the total region experience sulfur dioxide concentrations significant for crop losses in the presence of episodic oxidant levels.

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- Significant horticultural and garden planting losses are occurring throughout the ORBES region.

- For most crops, background ozone and associated oxidant levels produce the greatest reductions in yields--3 percent to 14 percent for the ozone levels observed at present.

- Sulfur dioxide at the levels commonly found downwind of coal-fired electrical generating facilities can produce additional crop losses of up to 12 percent, depending on the species.

- The original fauna of the ORBES region was predominantly a deciduous woodland fauna. Wetland fauna were well represented, and other localized faunas included those dwelling in prairies, caves, and rock outcroppings. The only fauna that was, and is, largely endemic to the ORBES region, and thus unique, is the karst (cave) fauna, which is especially well represented in southern Indiana, Kentucky, and southeastern West Virginia.

  - The Indiana bat, a cave fauna, is the only fedrally recognized endangered species that is essentially restricted to the ORBES region.

- With human settlement of the ORBES region, the larger animals of the original fauna were eliminated selectively, but the return of deer, beavers, and wild turkeys then was assisted by human beings.

  - Patchwork clearing of forests increased the numbers of certain prairie and forest-edge species at the expense of the species of the forest proper. For example, for squirrels, opossums, and raccoons became more numerous, and bobcats became rarer.

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- In general, the most widely abundant game species today are those that can inhabit hedgerows and woodlots on farms. The most common of these species are the cottontail rabbit, the bobwhite quail, the fox squirrel, the raccoon, the woodchuck, the red fox, the striped skunk, and the opossum.

- Currently, riparian habitats (those bordering water) support the greatest number of unique species. More specifically, the preferred habitat type is a meandering river bordered by a southern flood plain forest. However, 12 of the 19 unique species in the ORBES region require a terrestrial phase in their life cycles.

- Natural areas can contain unique biological, geological, or scenic features. In their distribution and abundance, these areas can serve as overall indicators of environmental quality in the ORBES region.

    - However, because of different emphases placed on natural areas programs by the ORBES states, the number of natural areas within the state portions varies considerably. For example, Illinois has the greatest number of recognized natural areas (426); Kentucky, the lowest (67).

A terrestrial ecosystem assessment model was used to evaluate the impacts of various siting configurations for future energy scenarios on terrestrial ecosystems in the ORBES region. County-level data for four terrestrial ecosystem variables (class I and II soils, forest lands, natural areas, and endangered species) were collected. Values for each variable were indexed by terrestrial ecosystem assessment units ranging in value from 1 (low) to 10 (high); the units were weighted equally. For each 650 megawatts electric sited within a given county, that county's total assessment units were added to the state totals.

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State totals then were used to evaluate the various siting configurations represented in the scenarios. States having higher terrestrial ecosystem assessment unit totals for a given scenario would have a higher probability of increased ecological impact under that scenario. No absolute threshold values for assessment unit totals indicate "good" or "poor" ecological quality. Therefore, only relative increases or decreases in ecological impacts can be ascertained from the model by making scenario comparisons, particularly with the business-as-usual case. Since the data base is state dependent, assessment units can be compared across scenarios only for a given ORBES state portion, not across states.

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2.7 Public and occupational health

Estimates were made on current deaths and diseases attributable to the extraction and transportation of coal in the ORBES region. No comparisons were made with national statistics, although most of the fatalities and injuries associated with coal-cleaning operations in the United States did occur in the region. One conclusion is that, as in the nation as a whole, high-population ORBES-region counties tend to have more health services available.[13]

- In the ORBES region in 1975, approximately 5 excess deaths can be attributed to the extraction of coal used by electrical generating facilities in the region.

- In terms of disability due to occupational disease, 284 cases in 1975 can be attributed to deep-mined coal purchases in the ORBES region.

- The following costs to human health in 1975 can be attributed to coal extraction for electrical generation in the ORBES region: 37 accidental deaths, 2656 nonfatal disabling injuries, 2198 nondisabling injuries, 6 excess deaths due to disease, and 284 disease disabilities.

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[13] For further information on public and occupational health in the region, see two forthcoming ORBES Phase II reports: Edward P. Radford, "A Study of Health Effects Related to Energy Conversion Facility Sitings in the Ohio River Basin Energy Study Region," and Maurice A. Shapiro, "Ohio River Basin Energy Study: Health Effects."

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- In general, the injuries reported for coal cleaning by mechanical plants in are higher in the ORBES region than those reported nationally. All of the 1974 and 1976 fatalities reported at mechanical coal-cleaning plants occurred in the study region, and the disabling injuries included in the statistics were reported mainly in ORBES-region plants.

    - Three ORBES states--Kentucky, Pennsylvania, and West Virginia--account consistently for most of the fatalities and the major share of the disabling injuries in the study area.

    - Why the ORBES portions of Illinois, Indiana, and Ohio report few such injuries is not clear, although part of the explanation may be the level of mining operation and production in those areas.

    - Within the ORBES region, the accident rates associated with coal cleaning are higher than those associated with strip mining but lower than those associated with deep mining.

    - From 1972 through 1976 in the ORBES region, about 14 fatalities and 1504 disabling injuries were attibutable to coal-cleaning operations. From 1972 through 1976, there was a yearly average of about 198 disabling injuries and 3 accidental deaths attributable to coal preparation in the region.

- Among the areas of the United States, the ORBES region is the major user of trucks to transport coal. The study-region portions of Pennsylvania and Ohio are the major shippers and receivers, followed by Kentucky, West Virginia, Indiana, and Illinois, in that order.

    - The six ORBES states originated 78.2 percent of the coal moved by truck from mines to final destinations in 1975.

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- Truck transportation resulted in an estimated 1 to 7 deaths and an estimated 3 to 20 injuries in 1975.

- In 1975 the total number of deaths associated with coal transportation to ORBES-region power plants was between 12 and 51. The number of injuries was between 48 and 209.

- Transportation of coal within the ORBES region in 1975 included 3.08 million train-miles to regional power plants.

  - An estimated 10 to 43 deaths and 44 to 88 injuries can be attributed to regional railroad transportation of coal in that year. In contrast, transportation of this fuel on regional waterways accounted for only about 1 death that same year.

- All 423 ORBES-region counties were ranked in terms of the availability of health services. Those counties with larger populations tend to score higher in this regard, while less populated counties often score much lower.

  - Often, high- and low-scoring counties are close geographically. Large metropolitan areas tend to be ranked high in terms of health services, while immediately surrounding and nearby counties tend to be ranked much lower. Certain exceptions exist; they tend to be clustered (for example, the higher availability of health services in western Pennsylvania and their lower availability in northeastern Kentucky and north central West Virginia).

  - The availability of physicians is much higher in the more populated counties.

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- The availability of dentists and pharmacists tends to be higher in many smaller, less populated counties; their distribution does not necessarily follow the availability of physicians in larger, more populated counties.

- The availability of nurses varies by county and by state portion, but there is a positive correlation with the availability of physicians and hospital beds.

- An exceptional number of ORBES-region counties have a relatively low availability of nurses and hospital beds.

- Counties with the lowest availability of health services tend to be located south of the Ohio River through the states of Kentucky and West Virginia. These counties usually are less populated and/or are located in or near mountainous areas.

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2.8 Society: values and ethics

2.8.1 Values

The values and attitudes relating to energy policy of the residents of the six ORBES states differ in several important respects from those of the U.S. population as a whole. Based on recent survey data from the six states and the nation, comparisons were made in regard to seven key values that relate to energy: conservation/preservation, economic benefit, equity, freedom and governmental activity, health/safety, material comfort, and progress/growth. (Illinois data were available for the ORBES portion of the state; Pennsylvania data, for counties in the southwestern part of the state. For the four other ORBES states, data were statewide.)[14]

It was found that no one value has predominant importance over all others in either the region or the nation. Rather, people strive to achieve a balance between competing values when confronted with difficult choices. Also, when asked to choose among energy policies, people do not necessarily choose those that would be in their own self-interest. For example, although the majority favor policies that provide financial rewards for insulation and oppose policies that would increase fuel taxes, they also favor conservation and equity, even though these may lead to increased costs.

Conservation/preservation implies "doing more with less." The objective is to use more energy-efficient technologies to produce the same output of goods, or simply to use or produce less energy, with resulting changes in lifestyle. A majority in both the six ORBES states and in the nation as a whole express support for this value.

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[14] For details on the methodology and data employed in the analysis of values, see Harry R. Potter and Heather Norville, "Ohio River Basin Energy Study: Social Values and Energy Policy" (ORBES Phase II, forthcoming).

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- In the ORBES states and the United States, a majority of persons surveyed favor the conservation of both natural resources and energy resources.

  - In a West Virginia study, 87 percent of the respondents agree that "Americans are using too much energy; now is the time to conserve our energy resources for future generations."

  - A Kentucky study found that the majority support recycling (91 percent), traveling less (88 percent), and turning down the heat in winter (86 percent).

  - Respondents to an Illinois survey favor improvement of home insulation (68 percent) and using fewer electrical appliances (60 percent).

- In the ORBES states, what people say they are doing to conserve energy is related to their age, sex, income, and education.

  - In Illinois, older persons more often reported that they were using fewer appliances and living in a small house or apartment to conserve energy than those in the same age group nationwide. Also, they were as likely as younger people to approve home insulation. In general, Illinois respondents with higher incomes were less likely to say they are conserving, and female respondents were more likely to say they are conserving.

  - In Kentucky, opposition was found to a policy that would ration the amount of gasoline, oil, or electricity each family could use and then let each family decide how to cut down. However, a slight majority of respondents with incomes below $7000 favored this policy, as did slight majorities of blacks and farmers.

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- The importance of conservation/preservation to respondents in the ORBES states is also apparent in the support shown for several government policies.

  - A majority of the Kentucky residents surveyed favor stricter regulations requiring industries to use less fuel (71 percent) and to pollute less even though products might cost more (85 percent).

- Overall, in the nation and the region, the majority support the general concept of conservation/preservation by indicating their willingness to act in ways consistent with conserving energy, although actual behavior does not always match that stated willingness.

  - Conservation/preservation appears to be an important value even when it conflicts with the value of governmental activity.

  - Support for conservation/preservation is divided when the values of freedom, material comfort, or economic benefit are seriously threatened.

- These findings show support for government policies aimed at achieving conservation/preservation through positive rewards for conservation. However, opposing policies that have negative sanctions for not conserving, such as rationing and higher fuel prices, are not supported.

Economic benefit refers to the tendency to evaluate things and people in monetary terms. Most of the available data are based on tradeoffs between this value and others. The data indicate the importance of economic benefit as a value, but the data also indicate that it is not the single criterion people use in choosing among policies.

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- Most of the existing state and national data on economic benefit as a value involve tradeoff situations. In many instances, respondents are willing to endorse certain costs when the choice is posed against other values, such as governmental activity, health/safety, and conservation/preservation.

    - In Kentucky, respondents express strong support for governmental spending for the development of new energy sources (85 percent state that government should spend more) and for governmental control of industrial pollution, even if products cost slightly more (also 85 percent in favor).

Equity stresses the degree of fairness and social justice associated with the distribution of costs and benefits. The implication is that some segments of society, notably the poor and the elderly, often pay larger proportions of their incomes, and at higher rates, than do the affluent for essentials like energy and food, whose prices are increasing rapidly. Within the ORBES region, equity as a value has varied support.

- Although data on the value equity are limited, they indicate that social class factors and age relate quite consistently to views on equity issues. In general, persons with lower status occupations, less education, and lower incomes place greater importance on equity than those with higher status occupations, college degrees, and higher incomes.

    - In Illinois about 75 percent of the respondents with annual incomes below $7000 favor spending tax money to help low-income people with heating bills, compared with only 51 percent with incomes of $25,000 to $39,999 and 43 percent with annual incomes of $40,000 or more.

- In Illinois older persons favor the "equity" answer (that is, providing tax dollars to low income people) more than younger persons do. These responses appear to differ only slightly from nationwide attitudes.

- Enforcement of a policy returning the coal severance tax to coal-producing counties is strongly favored by Kentuckians (82 percent of those surveyed), with only small variations across the social and demographic factors studied.

- In general, it is not those in higher status positions who are the predominant advocates of equity but, rather, those toward the lower end of the class structure who more often express support of this principle.

- Concern is indicated for those in disadvantaged situations, such as the poor or elderly. Some policies designed to conserve energy do so through increased prices, for example, price deregulation and increased taxes. Such policies can affect the disadvantaged most severely. Data indicate that the public would support policies to help compensate the disadvantaged for added energy costs.

    - In Illinois, 62 percent of respondents are willing to see tax money spent to help pay the heating bills of low-income people.

The preferences Americans have for the sometimes conflicting values of freedom and governmental activity illustrate the complexity of values and attitudes. Freedom refers to allowing a person maximum choices with only limited control over what he or she may do, with that control operating through group norms rather than formal laws. In contrast, governmental activity is intervention by government to facilitate, inhibit, or regulate certain decisions and actions through policies and regulations. Freedom and governmental activity are discussed here not as separate values, but as opposite ends of a continuum.

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- In general, Americans value both freedom and governmental activity. Of particular importance for policy choices is that support for governmental activity is strong when it provides direct benefits to people, not to industry, and when it promotes equity, progress/growth, and health/safety.

  - While 53 percent of respondents in Kentucky oppose regulations to make certain that less fuel is used by consumers, 72 percent favor such regulations for industry. Eighty-five percent of respondents in the state also strongly favor the spending of more money by state government to develop new sources of energy.

  - In Ohio a majority of respondents (65 percent) oppose deregulation of natural gas because it would lead to major cost increases. In addition, a majority of respondents in Illinois (70 percent) oppose a coal severance tax.

  - National studies show people to be quite divided, with no clear majority, about price regulation versus free competition with regard to energy production and incentives for oil exploration.

  - In Kentucky there is substantial regional variation, as well as variation by social class, in the use of taxes to attract new industry to respondents' areas. Most respondents who reside in rural areas and towns with populations under 10,000 favor using more tax money for this purpose, compared with only about one-third of those in the larger urban areas in the state. In Illinois, older persons also are more likely to favor the use of tax dollars to attract new industry and to assist low-income persons with their heating bills.

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The value of health/safety implies giving high priority to citizens' health, possibly emphasizing preventive medicine and devoting resources to ensure good health for as many people as possible. It also includes the desire for healthful and safe surroundings. Both regionally and nationally, health/safety is of major importance.

- Concern is evident for the value of health/safety in the ORBES states.
    - A majority of Indiana residents surveyed rank health as extremely important to their quality of life. They also indicate that they do not want to depend on neighboring communities for health services.

- Nationally, a majority of respondents indicate strong concern about the effects on health and safety of industrial installations and power plants, both coal fired and nuclear fueled. Even though many favor new industry and new energy sources, they do not accept such development without qualification when there are associated risks to health and safety. A majority are willing to pay $30 more per year to cut down on air pollution caused by power plants.

Material comfort involves an orientation toward the acquisition of goods and/or the concept that self-esteem is linked to material worth. The American standard of living sometimes is described as emphasizing passive gratification by such means as spectator sports and products and services that provide satisfaction and pleasure with minimal effort. In fact, belief in achieving material comfort is an important component of the American value system. Energy use is often thought of as important in achieving this comfort.

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- Nationally, the majority of Americans surveyed (68 percent) feel that allowing the mass of people to share a high standard of living was a major factor in making the nation great.

    - However, people are willing to trade off material comfort for economic benefit. The majority surveyed (72 percent) prefer lowering the heat in their homes to paying $70 more per year for fuel. On the other hand, when asked about ways of reducing air pollution, only 48 percent are willing to have the electricity turned off for five hours per day, rather than pay $30 more per year.

- In the ORBES region, views on the value material comfort vary with income and education.

    - Nationally, those with more education are less willing to lower their thermostat settings in winter. In Illinois and Kentucky, however, the trend is slightly in the opposite direction.

    - In both Illinois and Kentucky, about 70 percent of those with less than a high school education report that they are willing to move to smaller quarters, compared with 50 percent in Illinois and 60 percent in Kentucky of those with a high school education or more.

    - Income is also related to the willingness to live in a smaller house or apartment. In the Illinois and Kentucky surveys, about three-fourths of those with low to modest incomes (less than $10,000 per year) are willing to live in smaller homes, compared with less than half of those with incomes of $20,000 or more.

Progress/growth is an important value with respect to energy development because it emphasizes the future rather than the past or

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present; a receptivity to change is implied. Also implied is a belief that things in general both can and should be made better.

- The positive attitude toward progress/growth as a value is shown quite frequently through the need many people express for new jobs and new industry.
  - In three of five counties in southwestern Pennsylvania, the lack of available employment opportunities is among the most frequently named community problems.
- Support is evident for governmental activity to facilitate progress and growth, including the development of new industry under certain conditions.
  - In Illinois, 73 percent of respondents surveyed are willing to see tax money spent on attracting new industry to the state.
  - In Kentucky, 49 percent of respondents feel that more tax money should be spent to attract and develop industry.
  - Progress/growth is not supported at any cost, because substantial concern also is evidenced for the environmental and inflationary effects of growth.
- ORBES-region residents value progress/growth selectively.
  - Progress and growth appear to be favored under only certain conditions and opposed under others.

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- In Illinois, 62 percent of respondents under the age of 30 state they are willing to have tax dollars used to attract new industry, as do 82 percent of those age 60 and older.

- In Kentucky, only 42 percent of respondents under the age of 40 favor spending more tax dollars to attract new industry, compared with about 55 percent of those age 40 and older.

2.8.2 Ethics

Many of the conflicts over energy issues within societies based on high technology probably can be traced to opposing ethical views and even to the concept of "ethics" itself. Recognizing the probable significance of ethics, almost from the initiation of ORBES, project researchers debated the desirability of addressing the concept as it might relate to energy and environmental matters, particularly to power plant siting, construction, and operation.

As noted in the preface, an unusual practice was followed throughout the study with respect to the participation of the project advisory committee. Members of this committee were invited to attend and participate fully in all core team meetings. During the final year of the project, seceral committee members, notably those representing public interest groups, joined in the ongoing discussion of the ethics matter, and some urged the core team to treat the subject in this report. Like the core team members, however, the overall committee was divided on the issue. Much of the debate involving advisory committee members centered around the concept of growth as it applies both to the electric utility industry and to broader questions of economic activity. Finally, by a narrow margin the core team voted to include a section on ethics in this report.

During discussion of whether to include such a section, opinion among the 13 core team members ranged across a spectrum from enthusiastic support to strong opposition. Thus, there is no way that a single statement can reflect the views of the entire group. Of course, similar com-

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ments can be made about other topics on which disagreement existed, but in no other single area was there such strong feeling on the part of a sizeable minority that even the inclusion of a section on a particular topic would be inconsistent with the ORBES mandate as they understood it.

To remain faithful to the spirit of the ORBES experiment, the major portion of this section must be based on the sentiments of spokespersons for the core team majority. Any researcher who wishes to disassociate himself from specific points made below may do so in the separate document that will contain individual comments.[15] However, the ORBES co-directors have deemed it necessary to exercise their special prerogative and to emphasize the lack of consensus in this area within the body of the main report--the only instance in the entire report where they felt such an emphasis necessary. Similarly, they have felt it necessary to emphasize several points made by individuals within the core team minority during the debate on the propriety of including a section on ethics. In addition, since it is difficult, if not impossible, to represent any statement concerning ethical issues either as a major finding of the study or in quantitative terms, this section, unlike the other portions of this report, does not contain any visually emphasized statements. Instead, it is presented as a continuous text.

While some within the core team minority may agree in part with the majority perspective, which is presented below, one of their disagreements centers around the question of the usefulness of such a perspective in the context of ORBES. In accordance with the dictionary definition of ethics as "the discipline dealing with what is good and bad and with moral duty and obligation,"[16] the core team minority believe that a person's ethical position is basic both to his or her individual character and the level of civilization to which he or she belongs. They are reluctant to

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[15] See Comments on the Ohio River Basin Energy Study (ORBES Phase II, forthcoming).

[16] This definition is taken from Webster's Seventh New Collegiate Dictionary (Springfield, Mass: G & C Merriam Company, 1969).

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ascribe to the discipline of ethics the capability of determining moral human behavior with the degree of certainty implied in the majority perspective. Some of the minority members also believe that, in the United States, political and governmental institutions, expressed in part by the enactments of elected representatives, represent the framework within which individuals and groups are afforded the opportunity to translate their own ethics into public policy.

Finally, the minority opposition did not appear to stem from any lack of appreciation for the importance of ethical questions in electric power problems. Rather, it resulted from a concern that the core team had not been mandated to explore ethical considerations. The minority also pointed out that the ORBES research group would be unable to make a unique contribution to complex ethical questions at a time when ethicians, philosophers, and theologians devoting their professional lives to the topic remain sharply divided. For example, such religious oriented organizations as the National Council of Churches have long debated the ethical aspects of nuclear energy. In 1960, this group encouraged the use of nuclear technology and spoke of the ingenuity of mankind in bringing it about as a "gift of the Creator." In recent months, however, units of that organization have argued that nuclear energy is not acceptable. A number of other theologians and ethicians have responded negatively to these units' statements. For instance, in arguing for nuclear energy, one bioethician stated that "because of the awesome range and power with which human actions may affect the global environment for generations, traditional neighbor ethics--expressed in such virtues as justice, truthfulness, and respect for individual rights--is simply inadequate to define criteria for the human good."[17] Core team members in the minority on the ethics matter felt that such contradictory positions among specialists in ethics, biology, and philosophy were reason enough to concentrate efforts elsewhere.

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[17] EPRI Journal, November 1978.

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The majority perspective on ethics begins with the view that the ethical conflicts of most concern appear to be those rooted in issues raised by natural laws of thermodynamics and biology. They believe that ethical conflicts arising from debate over what is and what is not moral, though not unrelated to conflicts with nature, are of a different sort. Conflict with nature is not debatable; conflict over the notion of what is (or is not) moral conduct, on the other hand, is open to continuous debate.

Several aspects of the use of thermodynamic processes raise ethical questions.

In theory, heat engines using water as an energy transfer medium (steam power plants, for example) cannot be made more than 65 to 66 percent efficient, given today's materials. In practice, however, typical heat engines function at somewhat less than their theoretically possible efficiency. For example, as a rule, coal-fired steam power plants convert only about 38 percent of the heat value of their fuel to electricity; the same figure for a large nuclear power plant is 33 percent. In comparison, steam locomotives, the devices that led to the current industrial success of high technology societies, converted only 5 percent of their potential heat energy to motion.

As a result of this low conversion rate, proposals to build large heat engines (steam power plants) implicitly entail an enormous waste of limited resources. Moreover, such proposals are inaccurate if they are made on the basis of being in the best interest of all and if "all" is meant to include future generations. It would seem, therefore, that conservation of natural resources, a practice now deemed, by many, essential to the survival of man, cannot be an effective means of solving energy problems unless the dependence of society on large consumptive heat engines is greatly reduced.

Current lifestyles demand a tremendous auxiliary energy input to maintain natural or biological systems in unnatural states. Examples of such attempts are green lawns having a single species of grass, sophisti-

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cated agriculture, year-round supplies of fresh strawberries, biological waste treatment under high oxygen pressure, and highway margins without trees. These systems are supported by an energy network based entirely upon use of large and inefficient heat engines. At best, internal combustion engines convert only 30 percent of their fuels to usable motion. Also, these engines and the industry they support, in addition to consuming resources rapidly and inefficiently, place an ever-increasing pollutant load on the environment.

It has thus become a fact of life that human beings, and all other creatures on this planet, live with and, to a large extent, have come to depend on support systems and institutions that are biologically unnatural. As a result, policymakers who may not endorse this dependence and who may even wish to change the process cannot ignore the reality without ultimately coming into conflice with the majority lifestyle.

Further ethical questions arise over the right and wrong of human conduct in regard to the forecasting of electricity demand, the claiming of eminent domain, and the siting of power plants. The right and power to take land by eminent domain is conceived to be part of the inherent power of a sovereign (the state) and is usually granted to a state in its constitution. The only constitutional limitations are that the taking must be for a public purpose and that the owner of the land taken must be compensated adequately.

State statutes further delegate the eminent domain power to local governments, railroads, and utilities. Thus, the decision to build a new power plant is primarily a determination of the utility, although if the plant is to be located in a service area within another state, then the public service commission of the second state must agree upon review with the determination of public need for the new plant. Yet, experience shows that the utility's decision to build a new plant is the important one and that the burden is on the public service commission to prove it is not needed. An unfair taking of land ultimately results if inflated forecasting of demand occurs and is defended by utilities proclaiming themselves as the only knowledgeable source of information.

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More important, the decision of where a plant should be located really is made by the private-public utility alone. The government reviews are limited to water availability, air pollution effects, and land impacts. Ultimately, therefore, there is a nonpublic determination of public use and of where the public use will be located. This process that allows a public taking to be determined by a private entity seems unfair, especially when it appears that the amount of compensation may be inadequate.

The measure of compensation required by law is the market value, that is, what the owner could expect to receive if he or she were to sell the property on the open market. Yet if the owner wanted to sell it on the market for the market value, he or she already would have done so. Retaining the land may be worth more to the owner than having the market value in cash, but there may not be compensation for this extra value. Forcing the owner to sell land for less than what might be its full value so that it can be used for a public purpose means that the owner could bear a disproportionate share of the cost of generating and distributing electricity. Further, the price the utility pays a landowner is the result of arms-length bargaining (actually an adversary process), which often appears to give more money to the educated, the wealthy, and the politically powerful and less money to the unsophisticated, the uneducated, and the poor. The right to have a jury trial to determine the fair market value only partially corrects this inequality of treatment, since the uneducated are less likely to resort to legal assistance. A related ethical issue involves failure to condemn and pay compensation for neighboring land that will be affected by a new power plant or transmission line but that is not actually appropriated for use.

The debate over the ethics of nuclear power centers on three unresolved issues: reactor safety, waste disposal, and effects on human populations of long-term exposure to low levels of radiation. The fact that these issues are still being debated within the world scientific community brings to the forefront yet another ethical conflict: policymakers in societies based upon high technology often must make decisions knowing that they are in ignorance of the total, long-range human impact of the decision.

The utility industry has produced, as its single most evident product, lights that come on in virtually every home in America 100 percent of the time when a simple switch is thrown. The system seems inexpensive; it is reliable; and it is comforting to have. Yet, there is a growing body of evidence to indicate that the true price of this amenity is not being paid by those who reap its benefits, but that the balance of its cost--our debt to natural resources and to the environment--is being passed on instead to future generations.

Many solutions to this problem have been suggested. For one, a reeducation process could be instituted. For example, science education in public schools could begin to emphasize the world as an interconnected thermodynamic system, or the adoption of a conservation lifestyle as an act of patriotism could be supported more strongly by various levels of government. Another solution could involve a change in design approach. New development plans and technologies could be evaluated in terms of design with nature as an ally instead of as an enemy. Also, the waste of natural resources by large inefficient heat engines (steam power plants) could be reduced. One means of accomplishing this would be to make cogeneration required by law. Finally, as a extreme example, a constitutional amendment even could be ratified that would guarantee each citizen's inalienable right to a healthy environment.

A review of current statutes reveals that action is being taken today to accomplish some of these changes. A few of the more relevant laws are the Wilderness Act of 1964, the Wild and Scenic Rivers Act of 1968, the Endangered Species Conservation Act of 1969, the National Environmental Policy Act of 1969, the Federal Water Pollution Control Act Amendments of 1972 (the Federal Water Pollution Control Act now is known as the Clean Water Act), the Clean Air Act Amendments of 1970, and the Energy Supply and Environmental Coordination Act of 1974.

2.9 Social conditions

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Basic social measurements--of population, schooling, employment, housing, and per capita gross product trends--indicate that in many respects the ORBES region is quite different from the United States as a whole. For example, regional population is growing at a slower rate than is national population, and housing prices are lower in the region than in the nation. Although employment is quite evenly diversified in the ORBES region overall, in some portions is it highly concentrated in coal mining; in other portions, it is concentrated in agriculture. In general, the region is one of contrasts. It contains heavily industrialized metropolitan areas; intensively farmed, low-population sections; and extensive portions with low population and only minimal economic activity.[18]

In 1975, the ORBES region had 23.5 million inhabitants, about 11 percent of the 1975 United States population of 213 million.

- In terms of fertility, population growth in the ORBES region has been slower than in the nation as a whole.

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[18] For details on current social indicators in the study region, see the following ORBES Phase I reports, each dated May 15, 1977: Indiana University, The Ohio State University, and Purdue University, "Preliminary Technology Assessment Report" (vol. II-A); University of Kentucky and University of Louisville, "Preliminary Technology Assessment Report" (vol. II-B); and University of Illinois at Urbana-Champaign and University of Illinois at Chicago Circle, "Preliminary Technology Assessment Report" (vol. II-C). See also U.S. Environmental Protection Agency, ORBES Phase I: Interim Findings, By Janes J. Stukel and Boyd R. Keenan, Interagency Energy-Environment Research and Development Program Report, EPA-700/7-77-120, Grant No. EPA R805848 (Washington, D.C.: U.S. Environmental Protection Agency, November 1977). The following ORBES Phase II reports provide further details: Vincent P. Cardi, ed., "West Virginia Baseline" (November 1979); Maurice A. Shapiro, ed., "Pennsylvania Baseline" (June 1979); and David S. Walls et al., "A Baseline Assessment of Coal Industry Structure in the Ohio River Basin Energy Study Region" (June 1979).

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- In 1955, 1960, and 1975, fertility rates in the region were 2.6 percent, 4.1 percent, and 2.6 percent lower than national rates, respectively. According to 1975 U.S. Census estimates, the national fertility rate was less than 2.1 lifetime births per woman, which is considered the population replacement rate.

- The most recently available regional mortality rate is higher than the national rate.

  - In 1955 and 1960, regional mortality rates were only 1.2 percent and 0.1 percent lower than national rates, respectively.

  - In 1965, however, the region averaged an 0.6 percent higher mortality rate than that of the nation. When this rate is age-adjusted, reflecting higher death rates for older age groups, the region still has a higher death rate than the United States overall.

- Between 1965 and 1975, more persons left the ORBES region than migrated to the area. During this period, approximately 147,000 persons left the region.

  - The populations of the ORBES portions of Illinois, Indiana, and Ohio declined, while the population of Kentucky increased. In general, the population increased in the ORBES state portion of West Virginia, but central West Virginia lost more residents than it gained, while northeastern West Virginia experienced a net gain in residents. In the ORBES portion of Pennsylvania, population increased slightly, although it decreased slightly next to the Ohio border.

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- Between 1970 and 1975, however, the Appalachian portions of the region experienced some return migration. While 3.4 percent of the area's residents left during that period, the area acquired 2.4 percent more residents during the same period.

The regional population has less education than the national population. In 1970, the average schooling in the region was 9.7 years per person, compared with 12.2 years in the United States as a whole.

Employment is another important social indicator. ORBES-regional employment was not compared to that of the nation or of other regions. Within the region, employment is quite diversified, reflecting contrasts in other areas.

- In 1970 the ORBES workforce (the number of employed persons) totaled about 1.13 million. The regional unemployment rate was about 5.8 percent, compared with the national rate of 5.4 percent.

- In 1970 over one-third of the 423 ORBES-region counties had fewer than 5000 employees. In the state of Kentucky and in the ORBES portion of West Virginia, a substantial number of counties had fewer than 5000 employees (38 of the 120 counties in Kentucky and 19 of the 48 counties in the ORBES portion of West Virginia).

  - Few counties in Ohio and Pennsylvania had fewer than 500 employees (5 of the 68 counties in the ORBES portion of Ohio and 1 of the 19 counties in the ORBES portion of Pennsylvania). In both these states, a substantial number of ORBES-region counties (37 percent in Ohio and 63 percent in Pennsylvania) had workforces over 25,000 in 1970.

- In 1970 within the ORBES region, over 284,000 people were employed in manufacturing.

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- Among the six state portions in 1970, those of Indiana and Ohio had the highest proportion of counties with economies based on manufacturing (that is, over 40 percent of the workforce was employed in that sector): in Indiana, 23 of the 83 counties, and in Ohio, 22 of the 68 counties.

- In 1970 within the ORBES region, about 275,579 people were employed in agriculture.

  - Among the ORBES state portions, Illinois had the most persons employed in agriculture in 1970 (80,386). Indiana had 54,328; Kentucky, 68,959; Ohio, 52,349; Pennsylvania, 13,283; and West Virginia, 6,274.

- Although only a small proportion of the regional workforce was employed in mining in 1970, 109 of the 423 counties in the region had substantial mining activity. In these counties, a relatively high percentage of the workforce (typically 8 to 20 percent) was composed of coal-mining employees.

- Due to the oil embargo of 1973-74 and the associated increase in coal use in the United States, regional coal-mining employment increased. This rise can be inferred from the increase in coal production during this period.[19]

  - Just before the embargo, in 1971, about 442,000 short tons of coal were produced in the region. In 1972, this figure rose to 463,000 short tons; in 1973, it declined to 452,000 short tons.

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[19] See Donald A. Blome, "Coal Mine Siting for the Ohio River Basin Energy Study" (ORBES Phase II, forthcoming), and Walter P. Page, "An Economic Analysis of Coal Supply in the Ohio River Basin Energy Study Region" (ORBES Phase II, forthcoming).

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- In Kentucky, where most of the coal mined is of low sulfur content, production rose steadily throughout the embargo period.

- In the ORBES portion of Ohio, where predominantly high-sulfur coal is mined and where coal-mining labor problems existed, production declined steadily. Part of the decline in Ohio can be attributed to imports of western coal, which represent a significant percentage of the coal burned by electric utilities in that state.

- Between 1971 and 1975, coal production in the other ORBES state portions was as follows: in Illinois and West Virginia, production rose and then declined; in Indiana, it rose and then leveled off; and in Pennsylvania, it rose steadily but at a slower rate than in Kentucky.

In general, housing rates (prices for both rental and purchase) in the ORBES region are lower than in the rest of the nation.

- In 1970, the average of the median rental among the six ORBES state portions was $85 per month, with a range of $40 to $130 among all ORBES counties.

- In both the ORBES region and the United States, in-migration related to power plant construction creates more housing problems in areas with fewer new units and more older units.

    - In the ORBES region, 48.7 percent of the housing was built before 1939; the comparable figure for the nation is 40.6 percent.

    - Within the region, 22.3 percent of the housing was built after 1959; in the nation, 24.7 percent was built after that year.

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Income is another key social indicator. Compared to the U.S. median income, median income in the ORBES region is low, due in large measure to a number of poverty pockets. However, per capita income is slightly different in the nation and the region. On the other hand, the region has a higher percentage of families below the poverty line than does the nation. Per capita gross regional product also was computed, and it sheds some light on economic conditions in the region as compared with those in the United States as a whole and the six ORBES states overall.[20]

- Across all ORBES counties, the median family income in 1970 was $7672, with a maximum of $11,694 and a minimum of only $2407. The median U.S. family income in 1970 was $10,480.

- Per capita income in the ORBES region also is lower than in the United States as a whole. In 1969, regional mean per capita income was $2422; national mean per capita income, $3119. In 1974, these figures increased to $3719 in the region and $4572 in the nation.

- In 1970, over 16 percent of the families in the average ORBES county were below the poverty level. In comparison, about 11 percent of families in the nation were below the poverty level in that year.

    - Among the 423 ORBES counties, the proportion of families below the poverty level ranged from 2.4 to 61.6 percent.

- In 1975, per capita gross product in the study region was 7 percent lower than in the nation and 8.6 percent lower than in the six ORBES states.

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[20] For details on per capita gross product, see Walter P. Page and John Gowdy, "Gross Regional Product in the Ohio River Basin Energy Study Region, 1960-1975" (ORBES Phase II, April 1979).

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- Per capita gross product in the region was $5240; in the nation, $5593; and in the six ORBES states, $5695 (constant 1972 dollars).

3. Business as usual (scenario 2)

3.1 Description

A variety of alternative plausible futures, or scenarios, were developed for the Ohio River Basin Energy Study. The scenarios are derived from an array of policy assumptions about various conditions in the study region from the base period (the mid-1970s) through the year 2000. These policy assumptions, plus data on current conditions and the use of various scenario models, are the basis for construction of the scenarios themselves. Each scenario analyzed in the project is characterized in terms of basic policy assumptions, exogenous variables (such as the growth in the demand for electricity), energy and fuel use, siting patterns for electrical generating units, sources of coal supply, and underlying dominant social values.[1]

Perhaps the richest among the ORBES scenarios is the business as usual (BAU) case (scenario 2). The assumptions underlying this scenario tend to be relatively conventional in terms of the ORBES study region: the use of coal is emphasized, historic patterns of economic growth are followed, and BAU environmental regulations prevail.

Two major clusters of values are associated with the business as usual case and with all scenarios that assume BAU environmental regulations: (1) economic benefit, material comfort, and progress/growth, which come from policies that promote a high economic growth rate, and (2) governmental activity and nationalism, especially in regard to fuel

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[1] For details on the analysis methodology (including that used for scenario construction), as well as on the assumptions behind all the ORBES scenarios, see Walter P. Page and James J. Stukel, "Integrated Technology Assessment Methodology for the Ohio River Basin Energy Study" (ORBES Phase II, forthcoming).

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policy, since one of the objectives in this scenario is to decrease U.S. dependence on imported oil.[2]

Most of the assumed BAU environmental standards are defined in terms of what currently exists as applied to present and future sources of pollution. For air, controls are defined as the application of current (as of September 1978) state implementation plans (SIPs) in urban areas and current rural SIPs in rural areas under the Clean Air Act (42 U.S.C. 1857). New source performance standards (NSPS) are applied to all new sources of pollution. For water, BAU consists of the existing guidelines for the design, construction, and wasteload management of industrial facilities. The BAU controls for land are derived from federal standards prior to the 1977 Surface Mining Control and Reclamation Act. State standards may exceed federal ones. With regard to environmental protection of all receptors, then, this scenario reflects "current" conditions.

This plausible future is defined by a variety of energy and fuel use characteristics. The push to coal produces a large percentage increase in the use of ORBES-regional coal between 1974 and 2000 (85.2 percent), a modest increase in the use of refined petroleum products (10 percent), and a decrease in the use of natural gas (9.9 percent). Regional demand for electricity, from both regional consumption and export, rises by 123 percent, and total Btu consumption (fossil fuel equivalent) rises by 46.9 percent.[3] In the year 2000, projected installed electrical generating capacity in the ORBES region would be 153,245 megawatts electric, an increase of 81,115 megawatts from installed capacity in 1975. Of the total in 2000, 29.3 percent would be supplied by units that are governed by state implementation plans (SIPs). The remaining 70.7 percent of capacity would be supplied by units governed by new source performance standards (NSPS) or revised new source performance standards (RNSPS).

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[2] A full discussion of values in relation to ORBES can be found in Harry R. Potter and Heather Norville, "Ohio River Basin Energy Study: Social Values and Energy Policy" (ORBES Phase II, forthcoming).

[3] See Walter P. Page, Doug Gilmore, and Geoffrey Hewings, "An Energy and Fuel Demand Model for the Ohio River Basin Energy Study Region" (ORBES Phase II, forthcoming).

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As in all other ORBES scenarios, it is assumed that the coal to supply the electrical generating units comes from Bureau of Mines (BOM) districts in the six ORBES states (districts 1, 2, 3, 4, 6, 9, 10, and 11). In the high-sulfur category, the largest percentage increase between 1974 and 2000 occurs in districts 1 and 3. The percentage change for the production of high-sulfur coal, both underground and surface, is identical, although there are differences between coal regions. As in the base year, districts 7 and 8 provide no high-sulfur coal in the year 2000. In the low-sulfur category, the largest percentage increase between 1975 and 2000 occurs in BOM districts 1 and 3; output in districts 7 and 8 is estimated to increase by a somewhat smaller percentage. In all other ORBES scenarios, the absolute coal tonnages arising from the various groups by districts may vary, but the percentage changes are the same across scenarios. No specific coals are assigned to the specific coal-fired generating units set forth under the various scenarios.[4]

The same annual regional population growth is assumed for all scenarios, including the BAU case. There would be a 15 percent rise in population over the period 1970 to 2000, resulting in an increase from the 1970 ORBES-region population of 23.1 million to a population of 26.6 million in the year 2000. The rise is attributed to in-migration to the region because of power plant construction. For all scenarios, a fertility rate of 2.1 lifetime births per woman is assumed; this is the population replacement rate.

Ninety-five standard 650 megawatt electric coal-fired electrical generating units are sited in the study region after 1985. They are concentrated in counties bordering the Ohio River main stem and its tributaries, particularly in the upper Ohio River Basin along the main stem, in the coalfields of southeastern Ohio, and in counties bordering the

[4] See Donald A. Blome, "Coal Mine Siting for the Ohio River Basin Energy Study" (ORBES Phase II, forthcoming).

Monongahela and Allegheny rivers in Pennsylvania. No nuclear-fueled scenario additions are sited.

Under the BAU case, as well as all other ORBES scenarios, it is assumed that generating unit additions in the region announced by utility companies, including both coal-fired and nuclear-fueled facilities, will be built as planned. The announced fuel type and unit size are assumed to be identical to utility plans.[5] The dates on which these facilities would come on-line also are assumed to be the same as those announced by the utilities.[6]

Between 1976 and 1985, the utilities have scheduled 43,799 megawatts electric of coal-fired and nuclear-fueled capacity additions in the ORBES region. Most of this capacity will be built along the main stem of the Ohio River (about 25,500 megawatts) and its tributaries (about 10,500 megawatts). Nearly 80 percent of the additions scheduled regionwide are coal fired; the remaining additions are nuclear fueled. Among the ORBES state portions, the largest amount of capacity additions is scheduled in Indiana, where over 11,000 megawatts electric are planned, 80 percent coal fired and 20 percent nuclear fueled. Illinois follows, with over 9000 megawatts electric, 55 percent coal fired and 45 percent nuclear fueled. All of the 9000 megawatts electric scheduled for Kentucky are coal fired. The remaining capacity additions are accounted for in Pennsylvania (nearly 8000 megawatts electric, 83 percent coal fired and 17 percent nuclear fueled), Ohio (less than 5000 megawatts electric, 83 percent coal fired and 17 percent nuclear fueled), and West Virginia (2500 megawatts electric, all of it coal fired). Although additions scheduled from 1986 through the year 2000 are less certain, nonetheless they also are assumed to come on-line as planned by the utilities.

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[5] For an inventory of existing and planned electrical generating units in the six ORBES states, see Steven D. Jansen, "Electrical Generating Unit Inventory, 1976-1986: Illinois, Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia" (ORBES Phase II, November 1978).

[6] Exceptions were made in the case of two scenarios. See sections 8.1 and 11.1.1.

3.2 Impacts

In this section, the impacts that would be expected under the business as usual case (scenatio 2) are identified and discussed. Additional contrasts are made between these effects and current conditions in the ORBES study region (see chapter 2).

3.2.1 Air quality

Since current air pollutant emissions in the ORBES states--especially emissions from coal-fired electrical generating units--contribute substantially to pollutant concentrations within the region, estimates were made of emission patterns under BAU (scenario 2).[7] Moreover, since transport of regional emissions is a major factor in concentration levels both within and outside the region, projections were made of the impacts that would occur if the meteorological characteristics of the August 27, 1974, sulfate episode were repeated under BAU.[8] Finally, trends in annual average regional concentrations under BAU were examined.

In the BAU evaluation, the major cluster of planned and scenario addition coal-fired units is projected to occur between Louisville, Kentucky and Cincinnati, Ohio. The most important finding in the BAU evaluation is that in the year 2000 utility emissions in the six ORBES states still would represent a major regional source of emissions, even though

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[7] A discussion of the mathematical models used for the evaluation of the business as usual scenario, as well as the other ORBES scenarios, can be found in James J. Stukel, "Air Quality Analysis for the Ohio River Basin Energy Study" (ORBES Phase II, forthcoming).

[8] This episode, discussed in section 2.3, exemplifies the most frequently occurring type of sulfate episode. Such an episode involves a simple flow pattern of extremely persistent winds blowing from the west to the east over the ORBES region.

emissions from the region's coal-fired plants are projected to decrease from current levels by that year.[9]

- Under BAU in the year 2000, utility sulfur dioxide emissions in the ORBES region still would constitute about one-third of national utility sulfur dioxide emissions.

- Under BAU environmental regulations, sulfur dioxide emissions from SIP-regulated generating units in the ORBES region would decrease to 5.45 million tons in 1985 and to 2.93 million tons in 2000 from the 8.86 million tons emitted in 1976 by coal-fired electrical generating units in the region.

    - Under BAU, SIP-regulated generating units also would emit less sulfur dioxide per megawatt in 2000 than currently. This can be attributed to plant retirements and compliance with SIPs. Specifically, the ratio of annual net generation to sulfur dioxide emissions for these plants would increase from the current ratio by about 30 percent between 1976 and 2000.

- Under BAU, sulfur dioxide emissions from all electrical generating units in the ORBES region--those regulated by SIPs, NSPS, and RNSPS--would decrease to 5.93 million tons in 1985 and to 4.35 million tons in 2000 from the 8.86 million tons generated in 1976 from all units in the region.

    - Under business as usual in the year 2000, RNSPS-regulated generating units would emit less sulfur dioxide per megawatt than

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[9] For projections of air pollutant emissions under BAU, as well as under various other ORBES scenarios, see Andrew J. Van Horn et al., "Selected Impacts of Electric Utility Operations in the Ohio River Basin, 1976-2000: An Application of the Utility Simulation Model" (ORBES Phase II, forthcoming).

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would the SIP plants in operation at that time. In 2000, the ratio of annual net generation to sulfur dioxide emissions for the RNSPS coal plants would be about eight times greater than the above ratio for the SIP coal-fired plants.

- Under BAU, total suspended particulate (TSP) emissions in 1985 and 2000 from all electrical generating units in the ORBES region would decrease to 250,000 tons and 190,000 tons, respectively, from the 1.36 million tons generated in 1976 by all units in the region.

- Similarly, the contribution of utility emissions in the ORBES region to regional sulfur dioxide and sulfate concentrations should decrease in 2000 under BAU from the current contribution.

- By 1985 under BAU, TSP emissions would decrease drastically (82 percent) from the 1976 levels. By 2000, they would decrease 86 percent from the 1976 levels.

- By 1985 under BAU, nitrogen oxide emissions would increase 16 percent over the 1976 levels. By 2000, they would increase 35 percent from the 1976 levels.

- If the same conditions of extremely persistent winds were to occur under BAU as those that occurred during the August 27, 1974, sulfate episode, emission contributions and sulfur dioxide and sulfate concentrations would be lower under BAU than they were during that episode.

- Sulfur dioxide and sulfate concentrations in the upper ORBES region from utility sources in all subregions should be about 50 percent lower in 2000 under BAU than concentrations that occurred under the August 27 episode from the same sources.

- Under BAU, utility emissions from the lower ORBES region in 2000 would contribute only about 40 percent of the sulfate concentrations that they contributed to the upper region under the August 27 episode.

- Annual regional sulfur dioxide and sulfate concentrations also should decrease under BAU from current annual regional concentrations.

    - By 1985 under BAU, the annual regional sulfur dioxide concentration should have decreased about 33 percent and the annual regional sulfate concentration about 29 percent from the 1976 concentrations of 18 and 7 micrograms per cubic meter, respectively.

    - By 2000 under BAU, the annual regional sulfur dioxide concentration should have decreased about 56 percent and the annual regional sulfate concentration about 50 percent from the 1976 concentrations of 18 and 7 micrograms per cubic meter, respectively.

3.2.2 Water quantity, water quality, and aquatic ecology

The water quality impacts that would occur under a combination of business as usual (scenario 2) regulations and severe drought conditions are projected for 24 selected river basins in the region (see section

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2.5) as well as for the region in general.[10] Under BAU conditions, 6 river systems would experience light aquatic habitat impacts; 4 would experience moderate impacts; 10 would experience heavy impacts; and 4 would experience drastic impacts. These degrees of impacts represent the percentage of water quality parameters violated as a result of total installed capacity, and they designate certain occurrences within a river system.

Light impacts represent 1 to 10 percent of the maximum impact. Under these conditions, impacts on a system's biota would likely not be detectable except locally in the vicinity of outfalls. No change in a stream's class is expected to occur.

Moderate impacts represent 10 to 25 percent of the maximum impact. Under these conditions, minor eutrophication with some loss of existing embryonic fishes would be expected. The effects would be noticeable at low flow, but recovery over the next several seasons could also be expected. Stream class would drop one level during the period of recovery.

Heavy impacts represent 25 to 50 percent of the maximum impact. Under these conditions, eutrophication, a concentration of heavy metals, and possible stream dessication would combine to have a marked effect on the stream's biota. The effects would be immediately noticeable with local fish kills. A longer period of recovery, possibly five to seven years, would be required. Stream class would drop two levels for a minimum of five years.

Drastic impacts represent over 50 percent of the maximum impact. Under these conditions, eutrophication, a concentration of heavy metal

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[10] For details on water quantity and water quality impacts under the scenarios, see E. Downey Brill, Jr., et al., "Potential Water Quantity and Quality Impacts of Power Development Scenarios on Major Rivers in the Ohio Basin" (ORBES Phase II, forthcoming). Details on aquatic ecology impacts are provided in Clara Leuthart and Hugh T. Spencer, "Fish Resources of the Ohio River Basin Energy Study Area" (ORBES Phase II, forthcoming).

salts, dissolved oxygen depletion, siltation, and stream dessication would all combine to essentially destroy the existing system. Extensive fish kills would be expected all along the waterway, with nearly complete loss of embryonic fishes. The period of recovery might range up to 20 years depending on the final condition of the watershed. Stream class would drop three levels for at least a 15-year period.

Regionwide impacts projected to occur under BAU are given first. Aquatic habitat impacts, utility-planned units, scenario additions, water withdrawal (the quantity removed from the stream), water consumption (the quantity not returned), and other pertinent information are then given for each river.

- The aquatic systems most affected under BAU, consisting of lakes and streams, would be those with supposedly protected watersheds, in particular, wilderness area networks. Four wilderness areas are present in the ORBES region, and each contains important aquatic habitats.

- In addition to the existing ORBES wilderness areas, certain lands in the Monongahela National Forest, West Virginia, comprising approximately 36,000 acres, also would be affected under BAU.

- At present there are no official "wild and scenic" rivers in the ORBES region, but several are being considered for designation. These are in the eastern ORBES region and would be threatened by acid rain under BAU.

- Systems outside protected watersheds likewise would be affected under BAU, especially in headwater areas where flow tends to be minimal and consists almost entirely of surface runoff. Only those species of fish that inhabit headwaters would be threatened.

- The major cause of BAU impacts on water quality would be consumption that further concentrates the dissolved solutes already present in high concentrations. This situation clearly is aggravated by acid-rain-mobilized toxic metals, both those coming down with the rain itself and those leached from noncalcareous soils.

- River systems that would experience light impacts under BAU conditions are the Kaskaskia, Big Sandy, Licking, Salt, Cumberland, and Little Miami rivers.

- River systems that would experience moderate impacts under BAU conditions are the Rock, Mississippi, Green, and Whitewater rivers.

- River systems that would experience heavy impacts under BAU conditions are the Illinois, Big Muddy, White, Wabash, Kentucky, Scioto, Muskingum, Great Miami, Susquehanna, and Kanawha rivers.

- River systems that would experience drastic impacts under BAU conditions are the Beaver, Allegheny, Monongahela, and Ohio rivers.

- Under BAU, the Big Sandy River would experience light (0 percent) aquatic habitat impacts. Thus, no new violations of standards would be anticipated.

    - No installations are planned for this river, and none would be added under this scenario.

    - Five percent of the water would be withdrawn, and 1 percent would be consumed.

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- Under BAU, the Licking River would experience light (0 percent) aquatic habitat impacts. Thus, no new violations of standards would be anticipated.

  - No installations are planned for this river, and none would be added under this scenario.

  - Thirty-one percent of the water would be withdrawn, and 6 percentwould be consumed.

- Under BAU, the Salt River would experience light (0 percent) aquatic habitat impacts, although entrainment and impingement impacts would be possible. However, no new violations of standards would be anticipated.

  - No installations are planned for this river, and none would be added under this scenario.

  - Ninety-three percent of the water would be withdrawn, and 12 percent would be consumed.

- Under BAU, the Cumberland River would experience light (0 percent) aquatic habitat impacts, and no new violations of standards would be anticipated.

  - No installations are planned for this river, and none would be added under this scenario.

  - Twenty-six percent of the water would be withdrawn, and 4 percent would be consumed.

- Under BAU, the Green River would experience moderate (13 percent) aquatic habitat impacts, and high background levels of manganese and iron could contribute to reference standard violations.

- Installed capacity under this scenario would be 480 megawatts electric (all planned by the utilities).

- Seven percent of the water would be withdrawn, and 1 percent would be consumed.

- Under BAU, the Kentucky River would experience heavy (28 percent) aquatic habitat impacts, with entrainment and impingement contributing to the loss of sensitive species.

  - Installed capacity under this scenario would be 440 megawatts electric (all planned by the utilities).

  - Seventy-nine percent of the water would be withdrawn, and 12 percent would be consumed.

  - Power plant consumption probably would not cause violation of reference standards.

- Under BAU, the Illinois River would experience heavy (43 percent) aquatic habitat impacts, with entrainment and impingement contributing to the loss of sensitive species. Significant increases in certain pollutant concentrations would also result from power plant loadings.

  - Installed capacity under this scenario would be 19,755 megawatts electric (14,955 megawatts of planned units and 5200 of scenario additions).

  - Thirty-nine percent of the water would be withdrawn from the river over all reaches by industries, municipalities, and power plants; 5 percent of this water would be consumed.

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- Power plants would consume the most, with the highest consumption ratio for any of the 9 reaches being 8 percent.

- Significant increases would be registered in iron, manganese, mercury, copper, and lead concentrations because of power plant consumption in combination with existing high backgrounds in some reaches.

- Significant increases in chromium and boron concentrations probably would occur due to power plant loadings.

- No new violations in reference standards would be indicated.

- Under BAU, the Big Muddy River would experience at least heavy (30 percent) aquatic habitat impacts; all of the species sensitive to entrainment and impingement probably would be lost.

  - Installed capacity under this scenario would be 346 megawatts electric (all planned).

  - One hundred and eight percent of the water would be withdrawn, and 12 percent would be consumed.

  - The calculated concentration increases resulting from power plant consumption alone probably would not be enough to cause new violations; the major increases would result primarily from projected municipal and industrial water consumption.

  - The background concentrations of total dissolved solids (484 micrograms per liter) are already high, and very small increases could lead to violations of reference standards (500 micrograms per liter), although such violations are not projected to occur.

- Under BAU, the Kaskaskia River would experience light (0 percent) aquatic habitat impacts with some entrainment and impingement impacts. A significant quantity of water might be withdrawn locally for the purpose of irrigation, resulting in the complete loss of embryonic fishes and eggs.

    - No installations are planned for this river, and none would be added under the BAU scenario.

    - Sixty-two percent of the water would be withdrawn, and 6 percent would be consumed.

- Under BAU, the Rock River would experience moderate (14 percent) aquatic habitat impacts.

    - Installed capacity under this scenario would be 1300 megawatts electric (all scenario additions).

    - Two percent of the water would be withdrawn, and 1 percent would be consumed.

    - The impact of power plants would be small, and the impact of power plant consumption negligible.

- Under BAU, the Mississippi River would experience moderate (13 percent) aquatic habitat impacts, as well as increases in a few background concentrations.

    - Installed capacity under this scenario would be 13,250 megawatts electric (5450 planned and 7800 scenario addition). Of the 7800 megawatts electric of scenario additions, 1300 would be on the Mississippi River main stem and the remaining 6500 on the Rock and Illinois rivers.

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- Six percent of the water would be withdrawn, and 1 percent would be consumed.

- Power plant impacts on water quality would be negligible.

- A significant increase in mercury concentrations might result from the high background levels.

- The Mississippi's water quality would be affected significantly below its confluence with the Ohio River, which would contribute high background levels of mercury, iron, and manganese.

- Under BAU, the Scioto River would experience heavy (39 percent) aquatic habitat impacts, with entrainment and impingement contributing to the loss of sensitive species.

  - Installed capacity under this scenario would be 2200 megawatts electric (90 planned and 1300 scenario addition).

  - One hundred and nineteen percent of the water would be withdrawn, and 23 percent would be consumed.

  - New violations for total dissolved solids might occur as a result of municipal and industrial water consumption in conjunction with high background levels.

  - The concentrations of several metals would increase substantially as a result of power plant consumption.

  - Probable loss of the ORBES region's only endangered fish species (the Scioto madtom) would occur.

- Under BAU, the Muskingum River would experience heavy (48 percent) aquatic habitat impacts, with entrainment and impingement contributing to the loss of sensitive species.

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- Installed capacity under this scenario would be 3776 megawatts electric (1826 planned and 1950 scenario addition).

- Twenty-eight percent of the water would be withdrawn, and 6 percent would be consumed.

- Some increases in background concentrations might occur as a result of power plant consumption, even though the highest power plant consumption for any reach would be only 7 percent.

- Under BAU, the Great Miami River would experience heavy (27 percent) aquatic habitat impacts, with entrainment and impingement contributing to the loss of sensitive species. Significant increases in several metal concentrations would occur as a result of power plant consumption.

  - Installed capacity under this scenario would be 702 megawatts electric (all planned).

  - Thirteen percent of the water would be withdrawn, and 2 percent would be consumed.

- Under BAU, the Little Miami River would experience light (0 percent) aquatic habitat impacts. No new violations of standards would be anticipated.

  - No installations are planned for this river, and none would be added under this scenario.

  - Two percent of the water would be withdrawn, and 0 percent would be consumed.

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- Under BAU, the Beaver River would experience drastic (54 percent) aquatic habitat impacts, with entrainment and impingement contributing to the loss of sensitive species.

  - Installed capacity under this scenario would be 1950 megawatts electric (all scenario additions).

  - One hundred and ninety-one percent of the water would be withdrawn, and 19 percent would be consumed.

  - Significant increases in metal and ammonia concentrations might occur because of power plant, municipal, and industrial consumption.

  - New violations of copper, cadmium, selenium, lead, zinc, and ammonia standards would occur; the violations of the last four would occur because of municipal and industrial consumption.

- Under BAU, the Allegheny River would experience drastic (50 percent) aquatic habitat impacts, with entrainment and impingement contributing to the loss of sensitive species.

  - Installed capacity under this scenario would be 10,209 megawatts electric (5659 planned and 4550 scenario additions).

  - Eighteen percent of the water would be withdrawn, and 9 percent would be consumed.

  - Most of the projected consumption would be due to power plants, and power plant consumption would result in significant increases in total dissolved solids and light metal concentrations.

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- Under BAU, the Susquehanna River would experience heavy (30 percent) aquatic habitat impacts, with entrainment and impingement contributing to the loss of sensitive species.

  - Installed capacity under this scenario would be 650 megawatts electric (one scenario addition).

  - Nine percent of the water would be withdrawn, and 5 percent would be consumed.

  - The impact of power plant consumption probably would be negligible.

- Under BAU, the Monongahela River would experience drastic (51 percent) aquatic habitat impacts, with entrainment and impingement contributing to the loss of sensitive species. The concentration of seven metals that have high background levels could increase significantly.

  - Installed capacity under this scenario would be 4420 megawatts electric (2470 planned and 1950 scenario additions).

  - Fifty-two percent of the water would be withdrawn, and 10 percent would be consumed.

  - Power plant consumption would total approximately half of the total projected consumption.

  - New violations of selenium and lead standards could occur where background concentrations are already equal to the reference standard.

  - Power plant loadings also could increase the cadmium and boron concentrations siginficantly.

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- Under BAU, the Kanawha River would experience heavy (33 percent) aquatic habitat impacts, with entrainment and impingement contributing to the loss of sensitive species. New violations of reference standards could occur for several metals that now are at levels equal to the standards. The concentrations of other metals having high background levels could increase significantly.

  - Installed capacity under this scenario would be 4231 megawatts electric (all planned).

  - Sixty-nine percent of the water would be withdrawn, and 9 percent would be consumed.

- Under BAU, the White River would experience heavy (28 percent) aquatic habitat impacts, with entrainment and impingement contributing to the loss of sensitive species.

  - Installed capacity under this scenario would be 2835 megawatts electric (all planned).

  - Thirty-eight percent of the water would be withdrawn, and 6 percent would be consumed.

- Under BAU, the Whitewater River would experience moderate (23 percent) aquatic habitat impacts.

  - Installed capacity under this scenario would be 160 megawatts electric (all planned).

  - Ten percent of the water would be withdrawn, and 3 percent would be consumed.

- Under BAU, the Wabash River would experience heavy (38 percent) aquatic habitat impacts, with entrainment and impingement contribut-

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ing to the loss of sensitive species. Substantial increases in iron and mercury concentrations would result from power plant consumption, although the background levels of both already greatly exceed reference standards.

- Installed capacity under this scenario would be 9532 megawatts electric (6932 planned and 2600 scenario additions).

- Forty-eight percent of the water would be withdrawn, and 5 percent would be consumed.

- Under BAU, the Ohio River would experience drastic (56 percent) aquatic habitat impacts, with entrainment and impingement contributing to the loss of sensitive species. Increased violations of the reference standards also could occur for several heavy metals.

  - Installed capacity under this scenario would be 126,832 megawatts electric (65,732 planned and 61,100 scenario additions). Of the latter, 39,000 megawatts would be on the Ohio River main stem and the remaining 22,100 would be on tributaries, which are discussed above.

  - Forty-four percent of the water would be withdrawn, and 9 percent would be consumed.

  - Most of the water quality effects carried through to the Ohio River main stem would result from power plant consumption, which represents approximately 60 percent of the total projected consumption. Power plant consumption could increase concentration levels from 5.3 to 7.5 percent of the background levels.

  - One new violation of the reference standard for copper would occur in a reach where present levels equal the reference standard. Municipal and industrial consumption alone would cause this violation.

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- New violations for lead and zinc would also occur; these would not be caused entirely by municipal and industrial consumption.

- A dissolved oxygen sag would be evident over the first 50 river miles of the main stem. Beyond that point, dissolved oxygen levels would return to seasonal norms.

3.2.3 Land use and terrestrial ecology

Given the number, geographical distribution, and specifications of the electrical generating facilities projected under business as usual conditions (scenario 2), estimates were made of the land use conversion requirements for the years 1985 and 2000. The land conversions required for all energy uses, including electrical generating facilities, transmission line rights-of-way, and the surface mining of coal, are projected for the ORBES region and the six state portions. The percentage of agricultural and forest lands affected by this land conversion also is estimated. Finally, terrestrial ecology impacts are projected for the region and for the state portions.[11]

The single most important factor in terms of total land use conversion under BAU--and indeed under all scenarios--is the growth rate of generating capacity through the year 2000. In general, land resources probably would meet the demand adequately, although the number of suitable sites for generating facilities could be limited by the year 2000.

- Under BAU, the land conversion required by 2000 for all energy-related uses (generating facilities, transmission line rights-of-

[11] See J.C. Randolph and Bill Jones, "Land Use and Terrestrial Ecology" (ORBES Phase II, forthcoming).

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way, and surface mining for utility coal) might total 991,000 acres (1548 square miles), or 0.8 percent of the total land in the ORBES region.

- Under BAU, the total land use conversion in the ORBES region due to new electrical generating facilities would be 183,869 acres between 1976 and 2000, in addition to the current 140,700 acres used for electrical generating facilities.

    - By 1985, 26,810 acres in the ORBES region would be irreversibly committed to these facilities and 46,492 acres would be reversibly committed; between 1986 and 2000, 40,395 more acres would be irreversibly committed and 70,172 more acres reversibly committed.

    - In the ORBES portion of Indiana, total land use conversion by 2000 would be 39,540 acres, the greatest commitment among the ORBES state portions. Between 1976 and 1985, 6951 acres would be irreversibly committed; between 1986 and 2000, 7468 more acres. Reversible land use conversion between 1976 and 1986 would amount to 12,106 acres; between 1986 and 2000, 13,015 additional acres.

    - In the ORBES portion of Illinois, total land use conversion by 2000 would amount to 28,528 acres. By 1985, 5286 acres would be irreversibly committed; between 1986 and 2000, 5268 additional acres. In terms of reversible commitment, 9003 acres would fall into this category betweem 1976 and 1985; 8971 additional acres, between 1986 and 2000.

    - In the state of Kentucky (all of which is in the ORBES region), total land use conversion by 2000 would be 36,433 acres. Between 1976 and 1985, 5508 acres would be irreversibly committed; between 1986 and 2000, 7782 additional acres. In terms of

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reversible commitment, 9591 acres would fall into this category between 1976 and 1985, and 13,552 additional acres between 1986 and 2000.

- In the ORBES portion of Ohio, total land use conversion by 2000 would be 31,572 acres. Of this total, 2936 acres would be irreversibly committed between 1976 and 1985, and 8576 additional acres between 1986 and 2000. Reversible commitment would amount to 5115 acres between 1976 and 1985 and to 14,945 additional acres between 1986 and 2000.

- In the ORBES portion of West Virginia, total land use conversion by 2000 would amount to 19,806 acres. Between 1976 and 1985, 1582 acres would be irreversibly committed; between 1986 and 2000, 5642 additional acres. Between 1976 and 1985, 2755 acres would be reversibly committed; between 1986 and 2000, 9827 additional acres.

- In the ORBES portion of Pennsylvania, land use conversion by 2000 would total 27,990 acres. Irreversible committment would total 4547 acres between 1976 and 1985 and 5659 additional acres between 1986 and 2000. Reversible commitment would total 7922 acres between 1976 and 1985 and 9862 additional acres between 1986 and 2000.

- Of the total land conversion required for generating facilities by 2000 under BAU, 52 percent would be agricultural lands, 37 percent forest lands, 2 percent public lands, and 9 percent other land uses.

- Under BAU, the estimated land use requirement for new transmission line rights-of-way in the ORBES region would be 73 percent of the potential land use requirements for new energy conversion facilities, or 134,224 acres.

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- By 1985 under BAU, coal tonnage production would increase by 162 million metric tons per year over 1976 levels (439.5 million metric tons per year). As a result, 111 new standard mines (each producing 1.5 million metric tons per year) would be opened; 64 would be underground mines and 47 would be surface mines. By 2000 under BAU, production would increase 376 million metric tons per year over 1976 levels, and 273 new standard mines would be opened (174 underground and 99 surface).

  - By 1985 under BAU, 46 million metric tons of low sulfur coal would be consumed by electrical generating units per year. By 2000, 37.4 million metric tons would be consumed.

- Under BAU, the surface mining of coal for all purposes within the ORBES region would affect 2.33 million acres between 1976 and 2000; this is approximately 1.5 times greater than the total acreage affected by coal surface mining during the past 100 years.

- Under BAU, 673,000 acres (28 percent of the 2.33 million acres) would be affected by the surface mining of coal for electrical power generation during the period 1976 through 2000. Of this, 184,000 acres would be affected in the Eastern Interior Coal Province, and 489,000 acres would be affected in the Appalachian Province.

  - One standard 650 megawatt electric, coal-fired power unit would use 1.14 million tons of coal annually, or 17.1 million tons over the period 1985 through 2000. To meet the coal demand of one standard unit supplied entirely by surface-mined coal, 193 acres per million tons could be affected in Illinois (Eastern Interior Coal Province), and 458 acres per million tons could be affected in eastern Kentucky (Appalachian Province).

- Two scaling factors strongly influence estimates of affected surface mine acreages: acreage-to-tonnage ratios and surface-to-total production ratios.

  - At present, surface mining produces approximately half the ORBES-region coal, while underground mines produce the remainder. Under BAU by the year 2000, the underground portion would increase.

  - Surface-mining production currently ranges from 19 to 98 percent of total production, depending on the geographical location. Under BAU, these proportions would change to 26 to 60 percent of production by the year 2000.

  - Primarily because of the steeper slopes, a given amount of surface-mined coal disturbs 2.4 times as much surface area in eastern Kentucky as in Illinois. In general, this relationship holds between the other Appalachian and Eastern Interior Coal Province states.

- In general, under BAU--as well as under all scenarios--the probability of conflict between prime agricultural land use, steep slope land form, and surface mining would change little from current conditions.

  - Locally, prime farmland conflicts would be more important in Illinois and Indiana and less important in eastern Kentucky and West Virginia; the converse is true of steep slope conflicts.

  - Coal to supply SIP-governed units in the ORBES region originates in the hills of eastern Kentucky, West Virginia, and Pennsylvania; thus, the possibility of conflict with prime farmland is small.

  - Under BAU, the surface mining of coal for scenario units would be 22 percent more likely to affect prime farmland and 6 per-

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cent more likely to affect steep slopes than the mining for existing facilities.

- A minimum of two years from the cessation of mining is required to reclaim the land with quick-growing cover species. At present, 151,000 acres in the ORBES region are undergoing the two-year reclamation process. In 2000 under BAU, 220,000 acres would be undergoing this process.

    - Although the Appalachian region contains more sloping land than does the Eastern Interior coal province, reclaimed ecological productivity and land use would vary only slightly under BAU--and, indeed, under all scenarios.

Displacement and the effects of pollutant transport would be the two major impacts of future energy development upon the ecological environment of the ORBES region under BAU, as well as under all scenarios.

- Under BAU, ecologically related impacts (as measured by terrestrial ecosystem assessment units) would increase from the 1976 total of 1306 units. By 1985, 783 additional units would be expected under BAU (a 60 percent increase). Between 1986 and 2000, 1804 additional units would be expected (a 138 percent increase).

    - Between 1986 and 2000 in the ORBES state portion of West Virginia, a 101 percent increase in ecologically related impacts would result; in Ohio, 103 percent; in Illinois, 123 percent; in Pennsylvania, 141 percent; in Kentucky, 161 percent; and in Indiana, 216 percent. The precise unit values represented by these percentages are 156 units in West Virginia, 305 in Ohio, 356 in Illinois, 270 in Pennsylvania, 266 in Kentucky, and 451 in Indiana.

- Under BAU conditions by the year 2000, a decrease would occur in the area around a coal-fired generating station that would experience significant crop losses due to sulfur dioxide concentrations. Only 6 percent of one state and 2 percent of the total ORBES region would experience concentrations significant enough for crop losses, compared with 10 percent and 7 percent, respectively, under current conditions.

3.2.4 Public and occupational health

Under business as usual conditions (scenario 2) in 1985, about 22 fewer annual deaths would be attributed to sulfate air pollution exposure than could be attributed in 1976. In 2000 under BAU, about 38 fewer annual deaths would be attributed than in 1976. This decrease reflects the decrease in sulfur dioxide emissions that occurs with SIP compliance.

Between 1976 and 2000 under BAU, the cumulative deaths that might be attributed to all emissions from coal-fired electrical generating units could amount to 312,000.

3.2.5 Social conditions

Given the number, geographical distribution, and specifications of the electrical generating facilities projected under business as usual conditions (scenario 2), estimates were made of the population shifts and the labor demand associated with constructing and operating these facilities. Estimates also were made of the shifts and demands associated with supplying coal to these facilities.

In general, power plant construction and operation in the ORBES region do not lead to significant migration into the county in which the plant is sited. Many portions of the region are within commuting distance of major areas of labor supply, and in these areas few new residents would be expected because of power plant construction. In some counties under BAU, however, construction workers would constitute a significant percentage of the labor force. Those areas where more than 5 percent of the labor force is employed in power plant construction derive major benefits from the income generated by these workers.

Estimates were made for three critical construction skill categories: boilermakers, electricians, and pipefitters. Also estimated were total labor demand for power plant construction and operation from 1975 through 1990 (the peak construction year under the BAU case). The most important finding is that, in the peak employment year, no regional labor shortages would exist in any of the skill categories examined. This is not to say, however, that localized shortages might not occur.

- Under BAU, in six groups of contiguous ORBES-region counties, the expected in-migration due to power plant siting would range between 0.3 and 2.2 percent of the 1970 population, with the highest in-migration occurring in 1990, the peak construction year.

- The number of power plant construction workers would range between 0.9 and 9 percent of the labor force in six groups of contiguous ORBES-region counties under BAU. The highest percentage of construction workers would occur in the peak construction year (1990).

- Under BAU, no regional shortages would be expected through the peak construction year, 1990, in three critical skill categories for power plant construction: boilermakers, electricians, and pipefitters.[12]

- The expected labor skill requirements would be approximately 2400 boilermakers, 2300 electricians, and 2600 pipefitters, compared with an anticipated supply in these categories of about 2600, 3600, and 4300, respectively.

- Thus, the supply of boilermakers for power plant construction in the region would be about 8 percent more than the demand for these workers; the supply of electricians, 56 percent more than the demand; and the supply of pipefitters, 65 percent more than the demand.

- The rate of increase in the demand for construction workers would be fairly uniform between 1975 and 1997. This uniform rate implies a minimal potential for short-term labor shortages.

- Between 1975 and 1995 under BAU, about 327,000 person-years would be required for power plant construction and operation in the ORBES region.[13]

Coal mining would increase in most of the 109 counties to meet the demand for additional power plants. As a result, some migration into

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[12] It was assumed that the growth rate in the supply of the three skills examined within the ORBES region would be similar to that of the 1970s and that the proportion of these workers currently employed in power plant construction would remain constant. See two forthcoming ORBES Phase II reports by Steven I. Gordon and Anna S. Graham: "Site-Specific Socioeconomic Impacts: Seven Case Studies in the Ohio River Basin Energy Study Region" and "Regional Socioeconomic Impacts of the Ohio River Basin Energy Study Scenarios."

[13] Because of the scheduling of power plant construction, these requirements were calculated only through 1995 for all ORBES scenarios considered. See Gary L. Fowler et al., "The Ohio River Basin Energy Facility Siting Model" (ORBES Phase II, forthcoming).

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these counties would occur and "boom-town" effects would be expected. In several of these counties under BAU, coal miners would comprise a significant percentage of the labor force.

- In 14 of the 109 coal-producing counties in the ORBES region under BAU, the projected number of new miners through the year 2000 would comprise 10 percent or more of the 1970 population.

  - In 13 of these counties, a total of 5000 new mining jobs would have been created by 2000.

- In only about ___ of the 423 ORBES-region counties might "boom-town" effects (over 200 percent growth) be expected under BAU (scenario 2). In ___ of these counties, the effects would arise from the presence of power plant construction workers; in ___ counties, from the presence of coal miners.

- Of the 423 counties in the ORBES region, 109 have concentrations of coal-mining activity. The increase in mining employment in these 109 counties would be dramatic under BAU.

  - The estimated increase in total regional coal-mining employment between 1970 and 2000 would be between 25 and 169 percent. This range is based on the current productivity of large coal operations in the region.

  - Twenty of the 109 coal-producing counties would experience mining employment growth rates of 200 percent or more; 78 of the counties, rates between 50 and 199 percent.

It was assumed that housing construction rates in the study region through the year 2000 will be the same as they were between 1960 and 1970. Using this assumption, under BAU, 50 percent or more of the fore-

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casted growth in housing stock in 44 of the 423 counties in the region would be absorbed by power plant workers. In these counties, the local housing markets would undergo temporary disruption, resulting in the use of temporary housing and/or the bidding up of rental or purchase prices. In turn, there could be unsightly development in communities with little or no land use regulation or adverse effects on local residents who bid for the same residences as the power plant workers. Although these impacts would be expected to vary according to specific local conditions, no data on these variations are available.

3.2.6 Economics

Between 1976 and 2000 under BAU (scenario 2), the cost of electricity to consumers in the ORBES region would increase by 79.8 percent from the 1976 price of 2.58 cents per kilowatt hour. Total cumulative capital costs for implementation of this scenario also have been calculated, as have cumulative capital costs for the control of sulfur dioxide and total suspended particulates (TSP) from coal-fired generating units.[14]

- Business as usual environmental regulations would lead to a price of 3.87 cents per kilowatt hour in the year 1985 and a price of 4.64 cents per kilowatt hour in the year 2000.

- Excluding pollution control costs, $75.9 billion would be required to achieve the growth in installed electrical generating capacity projected under BAU.

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[14] Electricity prices and capital costs associated with various ORBES scenarios, including BAU, are discussed in Andrew J. Van Horn et al., "Selected Impacts of Electric Utility Operations in the Ohio River Basin, 1976-2000: An Application of the Utility Simulation Model" (ORBES Phase II, forthcoming).

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- Total cumulative capital costs for pollution control through the year 2000 under BAU would be $18.9 billion.

    - Of this total, $12.6 billion would be required for the control of sulfur dioxide emissions; $6.1 billion, for the control of TSP emissions.

- All the above monetary values are expressed in constant 1975 dollars.

Between 1976 and 2000 under BAU, deaths attributable to all emissions from all ORBES-region coal-fired electrical generating units could total about 312,000. The cumulative medical costs to the ORBES region have been calculated based on this mortality rate.

- From 1976 to 2000 under BAU, medical costs due to the deaths attributable to all emissions from coal-fired electrical generating units would total about $16.2 billion (1976 dollars).

    - Cumulative direct medical costs represent about 4.6 percent and cumulative indirect costs (foregone earnings) about 95.4 percent of the total cumulative costs.

Between 1976 and 2000 under BAU (scenario 2), sulfur dioxide and ozone concentrations in the ORBES region would contribute to regional losses in agricultural output. However, these regional losses would not be evenly distributed across the three crops selected for study--soybeans, corn, and wheat. Of the regional loss, soybean losses would represent 56.7 percent; corn losses, 39.9 percent; and wheat losses, 3.4 percent. These percentages would remain about the same for all three crops for the losses attributable to utility operations. The economic impacts of these regional losses, especially the losses due to utility operation, were calculated for the six ORBES state portions as well as for the region.

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- Under BAU between 1976 and 2000, cumulative regional crop losses due to sulfur dioxide and ozone concentrations would have a present discounted value of $6.4 billion.[15] Soybean losses would represent 56.7 percent of this amount; corn losses, 39.9 percent; and wheat losses, 3.4 percent.

  - These total losses would represent 11.9 percent of the discounted present value of the cumulative regional pollution-free crop yield between 1976 and 2000.[16]

- Between 1976 and 2000 under BAU, crop dollar losses attributable to utilities would represent about 40 percent of the regional present discounted dollar losses due to sulfur dioxide and ozone concentrations.

  - Losses attributable to utilities would represent 4.8 percent of the discounted present value of the anticipated cumulative regional pollution-free crop yield between 1976 and 2000.

  - Of the total regional present discounted dollar losses due to utilities, soybean losses due to utilities would represent 59.7 percent; corn losses, 39.9 percent; and wheat losses, 3.4 percent.

- Under BAU between 1976 and 2000, the six ORBES state portions would experience the following present discounted dollar losses from crop losses due to sulfur dioxide and ozone concentrations: the ORBES state portion of Illinois would experience crop dollar losses total-

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[15] Present discounted value represents the cumulative amount between 1976 and 2000 that has been discounted to its value in 1976.

[16] The crop yield that could be anticipated if no pollution impacts occurred is calculated so that the impact of pollution on crop yield can better be seen. This hypothetical figure is the same for all scenarios.

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ling 53.6 percent of the regional present discounted dollar losses; Indiana, 25.1 percent; Ohio, 14 percent; Kentucky, 6.9 percent; Pennsylvania, .04 percent; and West Virginia, 0.6 percent.

- The above losses represent the following percentages anticipated of pollution-free crop yield in each state portion: the Illinois dollar losses would represent 12.2 percent of the possible pollution-free crop value in that state portion; the Indiana losses, 11.5 percent; the Ohio losses, 11.7 percent; the Kentucky losses, 12.3 percent; the Pennsylvania losses, 8.2 percent; and the West Virginia losses, 8.4 percent.

- Under BAU between 1976 and 2000, the percentage of present discounted dollar losses due to utilities alone in each of the six ORBES state portions would be the same for each state portions as the percentages of total regional present discounted dollar losses due to sulfur dioxide and ozone concentrations in the state portions.

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4. More stringent environmental regulations

4.1 Description: more stringent environmental regulations (scenario 1)

An investigation was made of the policy implications for the ORBES region of relatively strict environmental regulations in conjunction with a push to coal and high rates of economic growth in the ORBES region and the United States, as in the business as usual case (scenario 2). The only difference between the two scenarios concerns environmental regulations. Under the strict environmental regulations case (scenario 1), the underlying dominant value is health and safety.

In the case of air, strict regulations mean that the generally stringent pollutant emission standards for urban areas set by current (as of September 1978) SIPs would be applied throughout a state. For water, guidelines were developed under strict controls that would reduce effluents by about 95 percent from BAU conditions. Strict environmental controls on land call for interim and permanent performance standards under the Surface Mining Control and Reclamation Act of 1977, but with strengthening of site-specific applications; state standards may exceed federal ones. Special interim and permanent standards are applied to steep-slope mining, mountaintop removal, the mining of prime farmland, and the surface effects of underground mining.

The energy and fuel use characteristics remain the same as under the BAU case; as under BAU, total regional installed capacity in the year 2000 would be 153,245 megawatts electric. Assumptions about population growth also remain the same. The strict environmental control assumptions lead to a more dispersed siting pattern for post-1985 electrical generating unit additions from that of the base case. Capacity additions along the middle and lower Ohio River main stem are concentrated on the reach from Cincinnati, Ohio, to Louisville, Kentucky, and in southwestern Indiana and southeastern Illinois in counties bordering the Wabash River. Elsewhere they are located on smaller tributaries away from the Ohio main stem. Fifteen reservoirs are required to accommodate the dispersed siting pattern.[1]

The general pattern of coal supply in the strict control case is the same as that in the BAU case. However, the stricter environmental standards imply reduced efficiency in the transformation of coal to electricity, and, as a consequence, a somewhat higher level of coal demand for production of the same anticipated output to supply the demand for electricity.

4.2 Impacts: more stringent versus business as usual environmental regulations (scenario 1 versus scenario 2)

In this section, differences in impacts in the year 2000 stemming from differences between more stringent and BAU environmental regulatory policies are summarized and discussed.

4.2.1 Air quality

Under the more stringent environmental regulations case (scenario 1), there would be a greater decrease in utility sulfur dioxide emissions and annual concentrations than there would be under BAU (scenario 2). Emissions of total suspended particulates (TSP) and nitrogen oxide, however, would be about the same under both scenarios.

- In general, total sulfur dioxide emissions in the ORBES region would be about twice as high in 1985 and 2000 under BAU as they would be under the more stringent environmental regulations case in the same years.

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[1] For details, see E. Downey Brill, Jr., et al., "Potential Water Quantity and Quality Impacts of Power Development Scenarios on Major Rivers in the Ohio Basin" (ORBES Phase II, forthcoming).

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- With more stringent environmental regulations, sulfur dioxide emissions from SIP-regulated coal-fired generating units in the ORBES region would be 52 percent less by 1985 and 61 percent less by 2000 than BAU emission levels for SIP units in those years.

- Under more stringent environmental regulations, sulfur dioxide emissions from all generating units in the ORBES region (SIP, NSPS, and RNSPS units) would be about 50 percent less by 1985 and about 31 percent less by 2000 than BAU emission levels for all units in those years.

- Reductions in emissions of total suspended particulates in the ORBES region would be almost identical in 1985 and 2000 under both the more stringent environmental regulations case and the BAU case.

  - In 1985, regional TSP emissions would total 250,000 tons under both scenarios.

  - In 2000, TSP emissions would total 210,000 tons under the more stringent case and 190,000 tons under BAU. The reason for slightly higher emissions under the more stringent case is that stricter controls on existing plants cause reductions in the megawattage they generate, and eventually this reduction must be compensated for by increased operation of new plants.

- Increases in the emissions of nitrogen oxides in the ORBES region also would be almost identical in 1985 and 2000 under both the more stringent environmental regulations case and BAU.

- Annual regional sulfur dioxide and sulfate concentrations due to utility sulfur dioxide emissions would be substantially less under the more stringent environmental regulations case than they would be under BAU in both 1985 and 2000.

- In 1985, the annual regional sulfur dioxide and sulfate concentrations due to utility sulfur dioxide emissions would be about 10 and 5 micrograms per cubic meter, respectively, under BAU. With the application of more stringent regulations, these concentrations would be about 40 percent less.

- In 2000, the annual regional sulfur dioxide and sulfate concentrations due to utility sulfur dioxide emissions would be about 6 and 3 micrograms per cubic meter, respectively, under BAU and about 33 percent less under the more stringent case.

4.2.2 Water quantity, water quality, and aquatic ecology

The more stringent environmental regulations case (scenario 1) was unique in several respects with regard to water impacts. It was the only scenario in which units (a total of 15) were sited in areas requiring water storage for cooling; it also was one of only two scenarios in which units were sited on relatively small tributaries (the high electrical energy growth case (scenario 7) was the other). Water quality impacts under the more stringent case largely would be due to consumption and the subsequent concentration of dissolved materials already having high background levels. In general, however, water quality impacts would be significantly less under the more stringent case than under BAU.

- The more stringent environmental regulations case is water consumption intensive, as evidenced by the fact that 78.2 percent of the significant increases observed therein would be caused by consumption alone. In comparison, the same figure for BAU would be 41.2 percent.

- Of the 24 streams and rivers modeled for impacts under both the more stringent environmental regulations case and business as usual, a total of 4 would remain unchanged (identical impacts under both scenarios); 17 of the 18 streams significantly affected under BAU would experience fewer impacts under more stringent regulations; and 3 streams would experience greater impacts under more stringent regulations than under business as usual.

  - ⊕ The streams affected more under the more stringent environmental regulations case than under BAU would be the Big Sandy and the Little Miami, both of which would go from light to drastic impacts with the projected siting of a single 650 megawatt electric unit. Impacts on the Allegheny would be slightly worse under more stringent regulations than under BAU, but still drastic in both cases.

  - ⊕ Minor shifts in siting patterns within the more stringent environmental regulations case could reduce most of its serious water quality impacts to a near trivial level. This reduction would require relocating 2 of the 95 units (those on the Big Sandy and the Little Miami).

- ⊕ Many of the region's smaller tributaries, even though they meet criteria for water supply, are probably not suitable for the siting of even small (650 megawatt electric) units under either more stringent environmental regulations or BAU. The Big Sandy and Little Miami rivers are good examples. This unsuitability, which is due to existing high background levels, now includes virtually all small tributaries of the Ohio main stem.

- ⊕ The region's major river, the Ohio main stem itself, and its immediate headwaters (the Allegheny and the Monongahela) would be affected heavily to drastically regardless of scenario. Once again, this impact is due to existing loadings and high backgrounds of pollutants, and the problem would not be solved by imposing more stringent environmental regulations.

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- It is anticipated that acid rain impacts would be less under the more stringent environmental regulations case than under BAU.

- Aquatic habitat impacts, installed capacity, and water withdrawal and consumption would be identical under both BAU and the more stringent environmental regulations case for the Kaskaskia, Licking, Salt, and Cumberland rivers.

- Under the more stringent environmental regulations case, the Big Sandy River would experience drastic (55 percent) aquatic habitat impacts, compared with only light (0 percent) impacts under BAU. With the drastic impacts, entrainment and impingement would occur and contribute to the loss of sensitive species; concentrations also would increase.

  - Under more stringent regulations there would be one additional electrical generating facility (a standard 650 megawatt generating unit) on the Big Sandy than there would be under BAU.

  - As a result of this addition, 32 percent of the water would be withdrawn and 19 percent consumed under more stringent regulations, compared with 5 and 1 percent, respectively, under BAU.

  - Numerous pollutants with already high backgrounds would increase in concentration.

  - Significant increases in boron, chromium, and ammonia concentrations would occur as a result of plant loadings, and a new violation would be observed for selenium.

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- Under more stringent environmental regulations, the Green River would experience light (5 percent) aquatic habitat impacts, compared with moderate (13 percent) impacts under BAU, even though installed capacity and water withdrawal and consumption are the same under both scenarios.

- Under the more stringent environmental regulations case, the Kentucky River would experience light (3 percent) aquatic habitat impacts, compared with heavy (28 percent) impacts under BAU. However, the light impacts probably would entail entrainment and impingement.

  - Installed capacity is the same for both scenarios. Under more stringent regulations, however, 88 percent of the water would be withdrawn and 18 percent consumed, compared with 79 and 12 percent, respectively, under BAU.

- Under the more stringent environmental regulations case, the Illinois River would experience moderate (22 percent) aquatic habitat impacts, compared with heavy (43 percent) impacts under BAU. These moderate impacts still would result in entrainment and impingement and contribute to the loss of sensitive species.

  - Under more stringent regulations there would be fewer standard electrical generating units on the Illinois River than under BAU.

  - Only slightly more water would be withdrawn under more stringent regulations than under BAU, and water consumption would be the same in both situations.

- Under the more stringent environmental regulations case, the Big Muddy River would experience light (9 percent) aquatic habitat im-

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pacts, compared with heavy (30 percent) impacts under BAU. Installed capacity and water withdrawal and consumption are the same under both scenarios.

- Under the more stringent environmental regulations case, the Rock River would experience light (0 percent) aquatic habitat impacts, compared with moderate (14 percent) impacts under BAU. Installed capacity and water withdrawal and consumption are the same for both scenarios.

- Under the more stringent environmental regulations case, the Mississippi River would experience light (5 percent) aquatic habitat impacts, compared with moderate (13 percent) impacts under BAU.

    - Under the more stringent regulations case, there would be five fewer standard generating unit additions on the Mississippi than under BAU. Of the seven units to be added under more stringent regulations, two would be on the Mississippi main stem, three on the Illinois, and two on the Rock.

    - Water withdrawal and consumption would be the same under both scenarios.

- Under the more stringent environmental regulations case, the Scioto River would experience moderate (26 percent) aquatic habitat impacts, compared with heavy (39 percent) impacts under BAU. The moderate impacts still would entail entrainment and impingement, which would contribute to the loss of sensitive species. Installed capacity and water withdrawal and consumption would be the same under both scenarios.

- Under the more stringent environmental controls case, the Muskingum River would experience moderate (22 percent) aquatic habitat impacts, compared with heavy (48 percent) impacts under BAU.

  - Under more stringent regulations, there would be three fewer standard electrical generating unit additions on the Muskingum than under BAU.

  - Under more stringent regulations, 24 percent of the water would be withdrawn and 3 percent consumed, compared with 28 and 6 percent, respectively, under BAU.

- Under the more stringent environmental regulations case, the Great Miami River would experience moderate (23 percent) aquatic habitat impacts, compared with heavy (27 percent) impacts under BAU.

  - Under more stringent regulations, there would be one more standard electrical generating unit on the Great Miami than under BAU.

  - Only slightly more water would be withdrawn under more stringent regulations, and water consumption would be the same under both scenarios.

  - Under both BAU and more stringent environmental regulations, significant increases would occur in concentrations of iron, manganese, mercury, and chromium. Under the more stringent case, significant increases in lead and zinc also would occur.

- Under the more stringent environmental regulations case, the Little Miami River would experience drastic (53 percent) aquatic habitat impacts, compared with light (0 percent) impacts under BAU.

  - This change would result from the addition of one standard generating unit on the Little Miami.

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- This one plant would consume 25 percent of the 7-day-10-year low flow and thus cause numerous metals to exceed their reference standards.

- Under more stringent regulations, a new violation for total dissolved solids would be observed.

- Under the more stringent environmental regulations case, the Beaver River would experience light (0 percent) aquatic impacts, compared with drastic (54 percent) impacts under BAU. No new violations thus would be expected under more stringent regulations, although there would be the strong possibility of local entrainment and impingement impacts.

  - Under more stringent regulations, three fewer standard generating units would be added on the Beaver than under BAU.

  - Under more stringent regulations, 179 percent of the water would be withdrawn and 11 percent consumed, compared with 191 and 19 percent, respectively, under BAU.

- Under both the more stringent environmental regulations case and BAU, the Allegheny River would experience drastic impacts--53 and 50 percent, respectively.

  - Under more stringent regulations, there would be four more standard generating units on the Allegheny than under BAU.

  - Under more stringent regulations, 29 percent of the water would be withdrawn and 16 percent consumed, compared with 18 and 9 percent, respectively, under BAU.

  - Power plant consumption alone for any given reach would be 35 percent of the 7-day-10-year low flow. This consumption could

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substantially aggravate existing conditions of high backgrounds.

- Plant pollutant loadings could bring about additional impacts from sulfates, ammonia, and boron.

- Under the more stringent environmental regulations case, the Susquehanna River would experience light (3 percent) aquatic habitat impacts, compared with heavy (30 percent) impacts under BAU. Installed capacity and water withdrawal and consumption would be the same under both scenarios.

- Under the more stringent environmental regulations case, the Monongahela River would experience heavy (30 percent) aquatic habitat impacts, compared with drastic (51 percent) impacts under BAU. Although significant entrainment and impingement impacts would occur under more stringent regulations, scenario-added units are dispersed (one on each reach), thereby reducing overall impacts.

    - Installed capacity would be the same under both scenarios, and water withdrawal and consumption would be only slightly higher under more stringent regulations.

- Under the more stringent environmental regulations case, the Kanawha River would experience moderate (16 percent) aquatic habitat impacts, compared with heavy (33 percent) impacts under BAU. Some entrainment and impingement would be expected under these moderate impacts.

    - Under more stringent regulations, one more standard generating unit would be added on the Kanawha than under BAU.

    - Water withdrawal and consumption would be about the same under both scenarios.

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- Under the more stringent environmental regulations case, the White River would experience moderate (13 percent) aquatic habitat impacts, compared with heavy (28 percent) impacts under BAU. These moderate impacts still would result in significant entrainment and impingement effects and significant increases in iron, manganese, and silver concentrations as a result of consumption by scenario addition power plants. Chromium and boron levels also might be raised to 10 percent of the reference standard or more.

  - Under more stringent environmental regulations, there would be three more standard electrical generating units on the White than under BAU.

  - Forty-one percent of the water would be withdrawn and 8 percent consumed under more stringent regulations, compared with 38 and 6 percent, respectively, under BAU.

- Under both the more stringent environmental regulations case and BAU, the Whitewater River would experience moderate impacts--10 and 23 percent, respectively.

  - Under more stringent environmental regulations, there would be one more standard generating unit on the Whitewater than under BAU.

  - Under more stringent regulations, 21 percent of the water would be withdrawn and 10 percent consumed, compared with 10 and 23 percent, respectively, under BAU.

  - Plant loadings would lead to significant increases in the concentrations of iron, chromium, silver, and boron.

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- Under the more stringent environmental regulations case, the Wabash River would experience moderate (16 percent) aquatic habitat impacts, compared with heavy (38 percent) impacts under BAU. These moderate impacts still would result in significant entrainment and impingement effects and significant increases in iron and silver concentrations.

  - Under more stringent regulations, there would be five more standard generating units on the Wabash than under BAU.

  - Water withdrawal and consumption would be the same under both scenarios.

- Under the more stringent environmental regulations case, the Ohio River would experience heavy (33 percent) aquatic habitat impacts, compared with drastic (56 percent) impacts under BAU. Heavy impacts would entail some entrainment and impingement, and a dissolved oxygen sag would be observed along the first 50 river miles, with levels going to seasonal norms beyond that point.

  - Under more stringent regulations, there would be 15 fewer standard generating units on the Ohio than undr BAU. Of the 79 total units that would be added under the more stringent regulations case, 39 would be added on the Ohio main stem and 40 would be added on the tributaries, which are discussed above.

  - Water withdrawal and consumption would be about the same under both scenarios.

4.2.3 Land use and terrestrial ecology

The land conversion required for all energy-related uses and for electrical generating facilities would increase slightly in the ORBES region under the more stringent environmental regulations case (scenario 1) from the conversion required under business as usual conditions (scenario 2). The acreage required for surface mining, however, would decrease slightly under the more stringent case. Terrestrial ecosystem impacts also would increase slightly under the more stringent case.

- Under the more stringent environmental regulations case, the land conversion required for all energy-related uses (generating facilities, cooling reservoirs, transmission line rights-of-way, and utility coal surface mining) would be approximately 1 percent higher in 2000 than under BAU.

- The more stringent environmental regulations case would require about 10 percent more land for generating facilities between 1976 and 2000 than would BAU.

  - Approximately forty standard 650 megawatts electric generating units would be distributed to more central locations under the more stringent case than under BAU.

  - If an average-sized cooling reservoir (975 acres) were to be built for each of the 15 Ohio sites dispersed away from major water sources, an additional 14,600 acres would be required.

  - The more stringent case would result in a 6 percent increase in agricultural land conversion for generating facilities from the conversion required under BAU.

The increased use of scrubbers by electrical generating facilities under the more stringent case would result in a decrease in thermal efficiency. Thus, electrical generating facilities would have to burn more coal to produce the same megawattage as under BAU. To meet the increased needs of these facilities, coal production would be expected to increase slightly under the more stringent case. However, it is not anticipated that any more new standard mines would be opened under the more stringent case than under BAU, and, in fact, the total acreage needed for surface mining of land actually would decrease by the year 2000.

- By 2000 under the more stringent environmental regulations case, only slightly more coal would be produced per year than under BAU; the same number of standard mines would be opened up under each scenario between 1976 and 2000; and electrical generating units would consume substantially more coal under the more stringent case than they would under BAU.
  - By 2000 under the more stringent case, only 15.1 million more metric tons of coal would be produced than under BAU.
  - Under the more stringent case, the same number of new standard mines (273) would be opened as under BAU between 1976 and 2000, although two fewer underground mines and two more surface mines would be opened than under BAU.
  - By 2000 under the more stringent case, electrical generating units would consume 31 million more metric tons per year than they would under BAU.

- The cumulative acreage that would be affected by surface mining for utility coal for the period 1976 to 2000 would decrease slightly under the more stringent environmental regulations case--to 665,000 acres, compared with 673,000 acres under BAU.
  - Under the more stringent case, the land use requirements of state coal-mining regions for surface mining of utility coal would decrease slightly from BAU requirements: in eastern Kentucky, 27 percent; in Ohio, 24 percent; in western Pennsylvania, 14 percent; in western Kentucky, 10 percent; in Indiana, 10 percent; in West Virginia, 9 percent; and in Illinois, 6 percent.

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- In the ORBES region in 2000, terrestrial ecosystem impacts would be greater under the more stringent case (1857 units) than under BAU (1804 units). This increase suggests that counties located inland from the Ohio River corridor generally would have higher ecological assessments (as defined in the model) than counties bordering the river.

  - In 2000, terrestrial ecosystem impacts would be less in the ORBES portion of Ohio under the more stringent case (300 units) than under BAU (305 units). In all other ORBES state portions, however, the impacts of more stringent case impacts would be slightly to significantly more than those of BAU: in Illinois, 9 percent (390 terrestrial ecosystem units); in Indiana, 2 percent (458 units); in Kentucky, 1 percent (368 units); in Pennsylvania, 3 percent (277 units); and in West Virginia, 5 percent (164 units).

4.2.4 Public and occupational health

Under the more stringent environmental regulations case (scenario 1), the concentrations of sulfur oxides and other pollutants would approach the threshold dose levels. Thus, public and occupational health impacts are difficult to estimate.

4.2.5 Social conditions

More in-migration would be expected under the more stringent environmental regulations case (scenario 1) than under business as usual conditions (scenario 2). This is due to the fact that strict controls

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entail the inclusion of flue-gas desulfurization systems (scrubbers) in all new coal-fired generating facilities, and the building of scrubbers requires more workers. Nevertheless, the number of in-migrants would not constitute a high percentage of any one community's population. The more stringent case would require slightly higher numbers of power plant construction and operation workers than would BAU in three critical skill categories examined, boilermakers, electricians, and pipefitters. However, overall labor shortages would not be expected under the strict environmental regulations case, although there might be a shortage of boilermakers.

- Under the more stringent environmental regulations case, in 1990 the population increase in six groups of contiguous ORBES-region counties due to power plant siting would range from 0.3 to 3.2 percent of the 1970 population. This compares with a range between 0.3 and 2.2 percent under BAU.

- Under the more stringent case, the number of power plant construction workers would range from 0.6 to 12.7 percent in 1990 of the labor force in six groups of contiguous ORBES-region counties. Three county groups would have increases over 10 percent, indicating greater population impacts in these areas than under BAU. Under BAU, the maximum increase would be only 9 percent.

- In the year 1990 under the more stringent environmental regulations case, about 2600 boilermakers, 2400 electricians, and 2700 pipefitters would be required for power plant construction in the ORBES region; 1990 is the peak construction year under BAU and is used here for purposes of comparison.

    - These requirements represent approximately 200 more boilermakers, 100 more electricians, and 100 more pipefitters than under BAU, but no regional labor shortages would be expected.

- The demand for boilermakers would equal the supply almost exactly, creating the possibility of a shortage in this skill category. However, the supplies of electricians and pipefitters each would be about one-and-one-half times the demand.

- About 349,000 total person-years of labor for power plant construction and operation between 1975 and 1995 are projected under the more stringent environmental regulations case. This represents an increase of 22,000 person-years over BAU requirements.

  - The differences in labor demand would occur primarily because strict environmental controls entail the use of flue-gas desulfurization systems (scrubbers) in all electrical generating units projected under the strict control case, as well as in all units announced by the electric utility companies. Under BAU, however, scrubbers would be required only in the scenario additions. Labor requirements for the construction of facilities with scrubbers are about 16 percent higher than those for similar facilities without scrubbers.

Both the more stringent case and BAU would require essentially the same numbers of coal-mining workers. Moreover, differences in coal-mining employment trends, as well as the geographical distribution of this employment, would be minimal.

- In 13 ORBES-region coal-producing counties under the more stringent environmental regulations case, coal-mining workers would comprise 10 percent or more of the 1970 population. Fourteen counties would be so affected under BAU, only a slight difference from the more stringent case.

  - In 11 of the 109 coal-producing counties, 5000 or more new mining jobs would be created under the more stringent case; in these counties, "boom-town" effects might take place. Under BAU, such effects might occur in only 2 more counties.

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- The more stringent environmental regulations case and BAU assume similar energy input, and thus similar coal-mining employment. There would be only slight differences between the two scenarios in the number and geographical distribution of coal-mining workers.

4.2.6 Economics

The cost of electricity would be only slightly higher under more stringent environmental regulations (scenario 1) than under BAU (scenario 2). However, total cumulative capital costs for pollution control through the year 2000 would be about 20.7 percent higher under the more stringent case. This is due to differences in the cost of controlling sulfur dioxide emissions; the cost of controlling emissions of total suspended particulates (TSP) would be identical under both scenarios.

- In 1985 under the more stringent environmental regulations case, the cost of electricity to the consumer would be 4.21 cents per kilowatt hour, 8.8 percent higher than under BAU. In the year 2000, however, the cost of electricity under the more stringent case would be only 1.5 percent higher (4.71 cents per kilowatt hour) than under BAU.

- Under the more stringent environmental regulations case, cumulative capital costs for pollution control would be $22.53 billion. This is 20.7 percent higher than the cumulative capital costs projected under BAU.

    - The control of sulfur dioxide emissions would account for $16.41 billion of cumulative capital costs under the more stringent case, or 30.8 percent over the BAU cost.

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- Cumulative capital costs for the control of TSP emissions would be $6.12 billion under both the more stringent case and BAU.

- All monetary values are expressed in constant 1975 dollars.

- The greatest difference between the more stringent environmental regulations case and the BAU case lies in total sulfur dioxide emissions. The second-greatest difference is the cumulative costs for pollution abatement, while the smallest difference is in consumer costs (the price of electricity).

4.3 Stricter siting criteria

4.3.1 Description: very stringent air quality regulations (scenario 1a)

A variation of the more stringent environmental control case (scenario 1) was developed in which only air quality standards were changed (scenario 1a). The policy issue being addressed is the change in impacts that might result from more stringent air quality standards. In this variation, in addition to the air quality standards of the more stringent case, a county is excluded as a potential site for a scenario unit addition if, under the 1977 amendments to the Clean Air Act, that county contains a nonattainment area for primary and secondary national ambient air quality standards (NAAQS) and/or less than the full increment for the prevention of significant deterioration (PSD) is available in that county. Also, ambient air quality considerations were given more importance in evaluating the suitability of counties for capacity additions.

The siting pattern for capacity additions after 1985 that results from application of these criteria is more dispersed in the very stringent air quality case. The most significant changes occur in Indiana and Kentucky, where the clusters of "new" units that are located along the middle and lower Ohio River main stem in the more stringent case are dispersed along the major tributaries. In the other ORBES state subregions, changes in siting patterns, relative to the more stringent case, are fairly minor. Energy and fuel characteristics, including installed electrical generating capacity, as well as sources of coal supply, are the same as in the strict control case. As in the more stringent environmental regulations case, health/safety is an underlying dominant value.

4.3.2 Impacts: very stringent air quality regulations versus more stringent environmental regulations (scenario 1a versus scenario 1)

In this section, differences in impacts between the more stringent environmental control case and the very stringent air quality case are discussed.

4.3.2.1 Air quality

The impacts of sulfur dioxide and sulfates on regional air quality should be about the same whether siting of new electrical generating units is allowed with less than the full PSD increment (scenario 1) or not allowed with less than the full increment (scenario 1a). The subregional sulfur dioxide and sulfate impacts, however, could be less in the area between Louisville, Kentucky, and Cincinnati, Ohio, under the very stringent air quality regulations case (scenario 1a) than under the more stringent environmental regulations case (scenario 1) alone. Subregional-scale modeling, which should lead to a more accurate assessment, is now in progress. A comparison of TSP and nitrogen oxide emissions under both scenarios also should be provided by modeling that is now in progress.

4.3.2.2 Water quantity, water quality, and aquatic ecology

Although there might be local water quality and aquatic ecology impacts under the very stringent air quality regulations case (scenario

1a), regional impacts would be about the same as under the more stringent environmental regulations case (scenario 1).

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4.3.2.3 Land use and terrestrial ecology

Under the very stringent air quality regulations case (scenario 1a), land use requirements and terrestrial ecosystem impacts in the ORBES region would not change significantly from those under the more stringent environmental regulations case (scenario 1).

- The very stringent air quality regulations case would not require any more land for electrical generating facilities than would be necessary under the more stringent environmental regulations case.

- Terrestrial ecosystem impacts in the ORBES region in the year 2000 would be only slightly higher under the very stringent air quality regulations case than under the more stringent environmental regulations case because more units are sited in counties off the Ohio River corridor.

  - Under the very stringent air quality case, assessment units would be 4 percent greater (472 units) in the ORBES portion of Indiana and 7 percent greater (320 units) in the ORBES portion of Ohio than under the more stringent case, where the measurements would be 458 and 300 units, respectively. Terrestrial ecosystem impacts would be slightly lower under the former case than under the latter in Illinois (385 versus 390 units), Kentucky (264 versus 268 units), and Pennsylvania (263 versus 277 units).

4.3.2.4 Public and occupational health

Although there may be local conditions under which health impacts would occur under the very stringent air quality regulations case (scenario 1a), regional health impacts would be about the same as under the more stringent environmental regulations case (scenario 1).

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4.3.2.5 Social conditions

With respect to power plant construction and operation, implementation of very stringent air quality regulations (scenario 1a) would lead to slightly greater impacts on population and a slightly higher demand for labor than implementation of more stringent environmental regulations alone (scenario 1). The differences, however, are not significant, and no regional shortages would be expected.

- Under the very stringent air quality regulations case in six groups of contiguous ORBES-region counties, in 1990 power plant construction workers would constitute from 0.2 to 3.6 percent of the 1970 population, slightly greater than the range of 0.3 to 3.2 percent under the more stringent environmental regulations case.

- The very stringent air quality regulations case would require slightly fewer workers in three critical skill areas--boilermakers, electricians, and pipefitters--than would the more stringent environmental regulations case. No shortages thus would be expected in any of these categories.

- The total person-years required for the construction and operation of power plants between 1975 and 1995 would be about 357,000 under the very stringent air quality regulations case. This requirement is about 8000 person-years more than that of the more stringent environmental regulations case.

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- The projection that total person-years would be higher under the very stringent air quality regulations case than under the more stringent environmental regulations case, while at the same time labor skill requirements would be lower, can be attributed to the differences in the siting patterns of the two scenarios. Multiple units require fewer workers than single units.

- Coal-mining employment would be identical under the very stringent air quality regulations case and the more stringent environmental regulations case.

4.3.2.6 Economics

Only the siting patterns, not the total projected levels of air pollutant emissions, differ between the more stringent environmental regulations case (scenario 1) and the very stringent air quality regulations case (scenario 1a). Therefore, the economic impacts of the very stringent case, which stem directly from pollutant levels, would be identical to those of the former scenario.

4.3.3 Description: very stringent air quality regulations with concentrated siting (scenario 1b)

In this case, the question being asked is what impacts would result if very stringent air quality standards were applied, but electrical generating facility additions were sited in a more concentrated pattern (scenario 1b). This is achieved by permitting a greater megawattage of electrical generating capacity to be sited in a candidate county (a maximum of 5200 megawatts electric, compared with a maximum of 2600 in all

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other cases but one, scenario 1d; see section 4.3.7).[2] However, total installed capacity, as well as the number of "new" generating units, is the same as in the more dispersed case. A greater number of scenario unit additions are located in the most suitable counties in each ORBES state portion; in general, the distance between these counties is significantly greater. There are no differences between the two scenarios in regional energy and fuel use patterns or in sources of coal supply.

4.3.4 Impacts: very stringent air quality versus very stringent air quality with concentrated siting (scenario 1a versus scenario 1b)

Differences in impacts arising from the concentrated siting of generating facilities under the very stringent air quality case, as compared with the more dispersed case, are discussed in this section.

4.3.4.1 Air quality

The impacts of sulfur dioxide and sulfates on regional air quality should be about the same whether 2600 megawatts electric (scenario 1a) or 5200 megawatts electric (scenario 1b) are allowed in each county where scenario unit additions are sited. The subregional sulfur dioxide and sulfate impacts, however, could be higher under the concentrated siting case along the southern Indiana-southern Illinois border; between Louisville, Kentucky, and Cincinnati, Ohio; between Huntington and Wheeling, West Virginia; and north of the Pittsburgh, Pennsylvania, area (Allegheny County). Subregional scale modeling now is in progress to allow a more accurate assessment. A comparison of TSP and nitrogen oxide emissions under both scenarios also should be provided by modeling that is now in progress.

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[2] For details on concentrated and dispersed siting criteria and implementation, see Gary L. Fowler et al., "The Ohio River Basin Energy Facility Siting Model" (ORBES Phase II, forthcoming).

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4.3.4.2 Water quantity, water quality, and aquatic ecology

Although there might be local water quality and aquatic ecology impacts under the very stringent air quality regulations with concentrated siting (scenario 1b), regional water quality and aquatic ecology impacts would be about the same as under the very stringent air quality regulations case alone (scenario 1a).

4.3.4.3 Land use and terrestrial ecology

Under very stringent air quality regulations with concentrated siting (scenario 1b), total land use requirements in the ORBES region would not change much from the dispersed siting case (scenario 1a), although fewer counties would be involved and different land types would be affected. Concentrated siting would cause more terrestrial ecosystem impacts, however, than would dispersed siting.

- Policies encouraging concentrated facility siting would not reduce the total land requirements in the ORBES region to any appreciable extent. For example, total land use conversion for generating facilities would be approximately the same under the concentrated siting case and the dispersed siting case. However, because of changes in the geography of the siting patterns, land use conversions within major categories would change.

    - Concentrated siting would result in a small increase (3 percent) in forest land conversion from the conversion required under dispersed siting (64,200 acres). The ORBES state portion requiring the most forest conversion under concentrated siting would be Ohio--a 9 percent increase over the amount required under dispersed siting in that state portion (8,800 acres).

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- Very strict air quality regulations with dispersed siting would require land in 65 counties; very strict air quality regulations with concentrated siting would require land in 29 counties.

- Concentrated siting would result in slightly greater ecological impacts regionwide (1903 units) in 2000 than would more dispersed siting.

  - Terrestrial ecosystem impacts under concentrated siting would be greater than under dispersed siting in four ORBES state portions: Illinois (by 1 percent), Indiana (by 10 percent), Kentucky (by 9 percent), and West Virginia (by 5 percent). These impacts would be less in Ohio (by 8 percent) and Pennsylvania (by 6 percent).

4.3.4.4 Public and occupational health

Although there may be local conditions under which health impacts would occur under the very stringent air quality regulations case with concentrated siting (scenario 1b), regional health impacts would be about the same as under the very stringent air quality regulations case alone (scenario 1a).

4.3.4.5 Social conditions

Concentrated siting of new electrical generating facilities (scenario 1b) would mean greater increases in population in counties where plants are sited than would the very stringent air quality regulations case alone (scenario 1a). However, under very stringent air quality regulations with concentrated siting, less labor demand would occur than under the very stringent air quality regulations case alone. This decrease is attributable to the placement under concentrated siting of up to 5200 megawatts of sited electrical generating capacity in one county. Under the very stringent air quality case alone, as well as under all

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other ORBES scenarios but the agricultural land protection scenario with concentrated siting, a maximum of 2600 megawatts electric per county is permitted. The increased capacity within a county would mean more multiple-unit plants, which can be built with less labor than single-unit facilities. No power plant construction labor shortages would be expected under concentrated siting. County-level impacts on housing, commercial and public services, and so forth also would be magnified.

- Under a concentrated siting pattern in six groups of contiguous ORBES-region counties, in 1990 the increase over 1970 population due to power plant construction would range from 0.3 to 4.9 percent. This compares with a range from 0.2 to 3.6 percent in 1990 under the very stringent air quality regulations case alone.

- In two of the six county groups under the concentrated siting pattern, power plant construction workers would make up more than 10 percent of the county labor force in 1990. The range among the six groups would be from 0.6 to 15.4 percent in that year, compared with a range from 0.2 to 3.6 percent under the very stringent air quality regulations case alone.

- The concentration of generating facilities would result in about a 5.5 percent decrease in the required numbers of boilermakers, electricians, and pipefitters from the very stringent air quality regulations case alone. No shortages in any of these skill categories would be expected.

- There would be a decrease of about 10,000 person-years of effort under concentrated siting from the very stringent air quality regulations case.

- Coal-mining employment would be identical for the very stringent air quality regulations case and the very stringent air quality regulations case with concentrated siting.

4.3.4.6 Economics

The total projected levels of air pollutant emissions would be identical between the very stringent air quality case (scenario 1a) and the very stringent air quality case with concentrated siting (scenario 1b). Therefore, the economic impacts associated with the concentrated siting case would be identical to those associated with the very stringent air quality case alone, as they are identical to the more stringent environmental regulations case (scenario 1).

4.3.5 Description: agricultural land protection (scenario 1c)

In this scenario (scenario 1c), the focus is on the potential change in impacts that would arise from protection of prime agricultural land and the associated dispersion of generating facility sites. A county is excluded as a generating unit site if it has 50 percent or more of its area in Class I and II soils or does not meet the very stringent air quality criteria. In addition, the importance of land use is increased in the determination of site suitability.

The siting pattern for scenario unit additions after 1985 under the agricultural land protection case differs significantly from that of the more stringent environmental regulations case, although total installed capacity remains the same. In general, fewer units are sited in the western part of the study region, primarily in northern Illinois and Indiana into western Ohio. The new units are more concentrated in the coal-producing areas of southern Illinois, southern Indiana, and southeastern Ohio.

4.3.6 Impacts: agricultural land protection versus stringent environmental regulations (scenario 1c versus scenario 1)

Differences in impacts between the strict agricultural land protection case (scenario 1c) and the stringent environmental regulations case (scenario 1) are found in this section.

4.3.6.1 Air quality

The impacts of sulfur dioxide and sulfates on air quality in the ORBES region should be about the same whether counties that have 50 percent or more class I and II soils are excluded as generating unit sites (agricultural land protection; scenario 1c) or not (scenario 1). Subregional sulfur dioxide and sulfate impacts, however, may be less in west-central Ohio and greater in eastern Kentucky under the agricultural land protection scenario than under the more stringent environmental regulations case alone. To arrive at a more accurate measurement, subregional-scale modeling now is being carried out. A comparison of TSP and nitrogen oxide emissions under both scenarios also should be provided by modeling that is now in progress.

4.3.6.2 Water quantity, water quality, and aquatic ecology

Although there might be local water quality and aquatic ecology impacts under the agricultural land protection case (scenario 1c), regional water quality and aquatic ecology impacts would be about the same as under the more stringent environmental regulations case (scenario 1).

4.3.6.3 Land use and terrestrial ecology

Policies protecting prime agricultural lands (scenario 1c) could be effective in preserving these lands, but there would be a corresponding increase in forest land conversion from the conversion required under the

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more stringent environmental regulations case (scenario 1). Regionwide, terrestrial ecosystem impacts would be about the same under both scenarios, although very significant changes would occur in some ORBES state portions.

- Under agricultural land protection, additional energy facilities are sited in West Virginia because of few suitable nonagricultural sites in Ohio. As a result, 46 percent less land would be required for electrical generating facilities in Ohio than would be required under the more stringent environmental regulations case. In West Virginia, however, 67 percent more land would be required under the former scenario than under the latter for electrical generating facilities.

- Under agricultural land protection, less agricultural land (7 percent less, or approximately 17,000 acres) would be required than under the more stringent environmental regulations case.

- Under agricultural land protection, 76,391 acres of forest land would be required, compared with the 66,592 acres required under the more stringent environmental regulations case.

- Although siting impacts on agricultural soil productivity should decrease under the agricultural land protection case, in the ORBES region overall terrestrial ecosystem impacts would be approximately the same as in the more stringent environmental regulations case (1857 units versus 1866 units). The reduction of impacts on agricultural lands in the protection case, however, would cause a shift in impacts by a similar magnitude to the other terrestrial ecosystem variables (forest lands, natural areas, and endangered species).

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- Under agricultural protection, terrestrial ecosystem impacts in Ohio would decrease by 40 percent from the more stringent environmental case, because of the siting shift from Ohio to West Virginia. Consequently, impacts in West Virginia under the agricultural protection case would be 66 percent more than under the more stringent regulations case.

4.3.6.4 Public and occupational health

Although there may be local conditions under which health impacts would occur under the agricultural land protection case (scenario 1c), regional health impacts would be about the same as under the more stringent environmental regulations case (scenario 1).

4.3.6.5 Social conditions

Because energy and fuel use characteristics would be the same under both the agricultural land protection case (scenario 1c) and the more stringent environmental regulations case (scenario 1), total regional power plant and coal-mining employment should be the same for both scenarios. However, because the siting pattern changes under the agricultural land protection case from the case with more stringent regulations, some local power plant employment impacts could occur, resulting in some migration within the region. Local coal-mining employment trends should be the same for both scenarios.

4.3.6.6 Economics

The projected levels of air pollutant emissions would be identical between the agricultural land protection scenario (scenario 1c) and the more stringent environmental regulations scenario (scenario 1), although the siting patterns differ. Therefore, the expected economic impacts, which are related directly to emission levels, would be identical for both scenarios.

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4.3.7 Description: agricultural land protection with concentrated siting (scenario 1d)

This scenario (scenario 1d) differs from the agricultural land protection case only with respect to potential impacts arising from an alteration in the siting pattern from dispersed to concentrated. This is achieved as in the stringent air quality regulations with concentrated siting case (see section 4.3.4). This case was developed because it appeared that a greater concentration of generating units might produce changes in air pollutant emissions and concentrations and their associated impacts.

In this case, generating facility sites are nearer the Ohio River main stem. Sites in the lower part of the ORBES region (that is, southwestern Indiana and southeastern Illinois) are farther apart than in the middle and upper parts of the region, where counties bordering the Ohio main stem become prime candidates for siting.

4.3.8 Impacts: agricultural land protection versus agricultural land protection with concentrated siting (scenaio 1c versus scenario 1d)

Differences in impacts between these two scenarios appear in this section.

4.3.8.1 Air quality

The impacts of sulfur dioxide and sulfates on regional air quality should be about the same whether dispersed (scenario 1c) or concentrated (scenario 1d) siting patterns are employed under a policy of agricultural land protection. The subregional impacts of sulfur dioxide and sulfates, however, might be greater under the concentrated siting case in southwestern Ohio and in the area between Louisville, Kentucky, and Cincinnati, Ohio. A more accurate assessment should be provided by subregional-scale modeling, which is now in progress. A comparison of TSP and nitro-

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gen oxide emissions under both scenarios also should be provided by modeling that is now in progress.

4.3.8.2 Water quantity, water quality, and aquatic ecology

Although there might be local water quality and aquatic ecology impacts under the agricultural land protection case with concentrated siting (scenario 1d), regional water quality and aquatic ecology impacts would be about the same as under agricultural land protection alone (scenario 1c).

4.3.8.3 Land use and terrestrial ecology

The major differences in land use and terrestrial ecosystem impacts between the agricultural land protection case with dispersed siting (scenario 1c) and the same case with concentrated siting (scenario 1d) occur at the state rather than the regional levels.

- The agricultural land protection case with dispersed siting and the case with concentrated siting are very similar in their siting patterns; each would require about 4 percent less land for electrical generating facilities than would be required under the more stringent environmental regulations case (scenario 1) for the entire ORBES region.

  - Scenario addition generating facilities would require land in 29 counties under concentrated siting policies and land in 55 counties under dispersed siting policies.

  - The concentrated siting pattern increases the number of facilities sited in Ohio; thus the land conversion required for electrical generating facilities in that state portion is 58 percent greater than the conversion required under dispersed siting.

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- Within each ORBES state portion except West Virginia and Illinois, more agricultural land would be converted under the agricultural land protection case with concentrated siting than under the same case with dispersed siting.

    - Policies requiring concentrated siting would require 7 percent more agricultural lands for energy facilities regionwide than would dispersed siting.

- The agricultural land protection case with concentrated siting would result in a 3 percent decrease regionwide from the terrestrial impacts associated with a dispersed siting pattern. This decrease is greatest in Kentucky (by 12 percent) and West Virginia (by 30 percent). However, concentrated siting would result in a 35 percent increase in Ohio from those impacts that occur with dispersed siting.

4.3.8.4 Public and occupational health

Although there could be local conditions under which health impacts would occur under the agricultural land protection case with concentrated siting (scenario 1d), regional health impacts would be about the same as under agricultural land protection alone (scenario 1c).

4.3.8.5 Social conditions

Because energy and fuel use characteristics would be the same under both the agricultural land protection case alone (scenario 1c) and the agricultural land protection case with concentrated siting (scenario 1d), total regional power plant and coal mining employment should be the same

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for both scenarios. However, the siting pattern is different in these scenarios, and local power plant employment impacts would be more severe under the concentrated siting case than they would be under the agricultural land protection case alone. These impacts could result in migration within the region. Local coal-mining employment trends should be about the same for both scenarios.

4.3.8.6 Economics

Economic impacts are related directly to the levels of air pollutant emissions projected under each scenario. These levels would be identical in the case of both the agricultural land protection scenario (scenario 1c) and the agricultural land protection scenario with concentrated siting (scenario 1d). Thus, the economic impacts of these two scenarios also are expected to be identical.