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PROBLEMS IN JUDICIAL REVIEW ARISING FROM THE USE OF COMPUTER MODELS AND OTHER QUANTITATIVE METHODOLOGIES IN ENVIRONMENTAL DECISIONMAKING

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I. INTRODUCTION

The increasing use of quantitative models, particularly computer models, has placed a new burden upon the courts in their review of environmental decisions based on those models. This burden is a part of the "new era" in environmental decisionmaking,[1] which arises out of the increasing involvement of scientific and technical issues in legal decisionmaking.[2] Recent cases involving the judicial review of environmental decisions based on models raise questions as to the proper role of judges and courts in such review. In particular, questions are raised as to, first, whether the expertise of judges and resources of courts are sufficient to provide meaningful review of such

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1. *See* Environmental Defense Fund (EDF) v. Ruckelshaus, 439 F.2d 581, 597 (D.C. Cir. 1971). *Accord*, Int'nl Harvester Co. v. Ruckelshaus, 478 F.2d 615, 650, 651 (D.C. Cir. 1973) (Bazelon, C.J., concurring). *See* Leventhal, *Environmental Decisionmaking and the Role of the Courts*, 122 U. PA. L. REV. 509, 511 (1974); Note, *Cost-Benefit Analysis in the Courts: Judicial Review Under NEPA*, 9 GA. L. REV. 417 & n.6 (1975) [hereinafter cited as *Cost-Benefit Analysis*].

2. "During the present century, litigation requiring for its resolution a voluminous evidentiary record of complex and technical data has increased discernibly." Whitney, *Technical and Scientific Evidence in Administrative Decisionmaking*, 45 U. CINN. L. REV. 37 (1976). *See generally*, Mayda, *Conservation, "New Conservation" and Ecomanagement*, 1 ENVT'L L. REV. 21 (1970); Maechling, *Systems Analysis and the Law*, 62 VA. L. REV. 72 (1976); Eastin, *The Use of Models in Litigation: Concise or Contrived?* 52 CHI.-KENT L. REV. 610 (1975); Wilkins, *Computer Impact on Public Decision Making*, 28 PUB. AD. REV. 503, 507-10 (1968).

decisions, and second, whether the "deferential standard of review" used in such cases precludes a meaningful level of judicial review.

Cases dealing with such environmental decisions demonstrate that, although there are problems with judicial expertise, court resources, and appropriate review levels, those problems are not insurmountable. In fact, courts have displayed substantial creativity in developing innovations such as court-retained experts, joint technical appendices, and post-argument explanatory briefs. Additionally, the recent passage of the Magistrate Act[3] offers the potential for even greater flexibility and innovation in dealing with the problems of reviewing environmental decisions based on computer and other mathematical models.

Recent cases have precluded access to federal district courts in certain types of environmental decisions.[4] These developments threaten to exacerbate the problem of assuring an adequate level of judicial review in environmental cases involving models because federal appellate courts, unlike the district courts, "cannot hold evidentiary hearings to answer complicated technical questions involved in each case."[5] Environmental cases involving models must involve such an evidentiary hearing in order to ensure sufficient analysis of the case. More generally, modeling cases demonstrate that a court must have sufficient expertise and resources to enable the court to digest and analyze—and, if need be, supplement—the complicated and technical record which accompanies such environmental decisions involving computer and mathematical models.

The level of judicial review in such environmental decisions involving quantitative models is usually described as the well-known "arbitrary and capricious" or "hard look" standard of review.[6] This arbi-

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3. 28 U.S.C. §§ 631-639 (1977 & Supp. IV 1980). The Federal Magistrate Act of 1979 (Act Oct. 10, 1979, P.L. 96-82, 93 Stat. 643) significantly expanded the duties that may be undertaken by a United States Magistrate. *See* 28 U.S.C. § 636.

4. In Harrison v. P.P.G. Ind., Inc., 446 U.S. 578 (1980), the United States Supreme Court construed broadly the phrase "any other final action" under Section 307(b)(1) of the Clean Air Act, 42 U.S.C. § 7607(b)(1) (1976 & Supp. IV 1980), thus requiring that most challenges to final actions under the Act must be brought in the circuit courts of appeal, rather than the federal district court where a record could be made if needed. *See* Dow Chem. USA v. EPA, 491 F. Supp. 428, 431 (M.D. La. 1980).

5. Kramer, *Air Quality Modeling: Judicial, Legislative and Administrative Reactions*, 5 COLUM. J. ENVT'L L. 236, 249 n.78 (1979) (discussing So. Terminal Corp. v. EPA, 504 F.2d 646, 665 (1st Cir. 1974)). For environmental rulemaking proceedings, courts of appeals have held that federal district courts have jurisdiction to hold hearings to supplement the record where there is no record based on proceedings at the administrative level. EDF v. EPA, 598 F.2d 62, 90-91 (D.C. Cir. 1978). *See* EDF v. EPA, 636 F.2d 1267, 1273-74 (D.C. Cir. 1980).

6. The leading case applying the arbitrary and capricious level of judicial review to environ-

trary and capricious standard of review has not been uniformly applied; thus, environmental decisions based on mathematical models have not always received a uniform, constructive, or meaningful level of judicial scrutiny. The arbitrary and capricious standard of review is usually said to include a thorough, probing level of factual review, but a deferential level of ultimate policy review, to avoid having the court substitute its judgment for the reviewing agency. This creates a tension in the judicial review of those many questions in environmental cases involving both factual and policy determinations. The presence of a computer or mathematical model tends to exaggerate the tension that is inherently felt in accommodating the required probing level of factual review with the deferential level of ultimate review. In particular, the presence of the model makes it more difficult to engage in a thorough inquiry of the factual bases of the environmental decision formed by the model. Perhaps even more importantly, the presence of the mathematical model appears to demand that a reviewing court be prepared, at least in some instances, to accord less deference to the agency's decisions involving the model and even to substitute its judgment for that of the agency, at least to the extent that the decision does not involve inextricable policy decisions.

In order to understand why computer models and other mathematical methodologies have placed these novel strains on judicial expertise, court resources, and the accepted standards of judicial review, this article will examine the nature of a model and its use in environmental decisions. The reasons for using such models in environmental decisions, and the problems inherent in such use will then be examined, along with a more detailed description of the various characterizations of the arbitrary and capricious standard of review normally used in environmental cases involving computer models and mathematical methodologies. This is followed by a discussion of the particular treatment given by courts to the models involved in such environmental decisions as the approval of state im-

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mental decisions is Justice Marshall's opinion in Citizens to Preserve Overton Park, Inc. v. Volpe, 401 U.S. 402 (1971). In *Overton Park*, the Supreme Court stated that the reviewing court should address three questions of whether the agency decision was: (1) within the scope of the agency's authority; (2) in compliance with procedural requirements; and (3) arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with law. *Id.* at 415-17. It is this third part of the *Overton Park* standard of environmental review that involves a substantive review of the environmental decision and its underlying model. Professor Kramer has stated that "[i]n most instances, it is this third inquiry that is the heart of the judicial review process." *Kramer*, *supra* note 5, at 244. This *Overton Park* standard of review was adopted for review of rules in the 1977 amendments to the Clean Air Act. *See* 42 U.S.C. § 7607(d)(9).

plementation plans (SIP), environmental impact statements (EIS), and various other environmental decisions and regulations. Changes are required in such areas as levels of judicial review, structure of the courts, and availability of expertise to address these problems. In so doing, courts will be better able to deal with all cases involving the interrelationship of law and science with technology, which include the environmental cases involving models discussed in this article.

II. Models and Environmental Decisionmaking

A. Introduction to Models

The "model" is an abstract, formal representation of a theory about, or empirical observation of, a defined set of facts or system.[7] Models can range in complexity from a simple mathematical equation or expression to the most complex simulation models requiring computers to run them.[8] The model is a decisionmaking tool which, if applied properly, can greatly assist decisionmakers in dealing with the rising problems of environmental pollution and other technical issues.[9] Since the model is a mathematical representation or embodiment of a theory about a physical system, to be useful, it must act in

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7. "[I]t is the essence of any model to introduce a simplified representation of complex reality. Of course, if the model is too simple in comparison to reality, it is worthless. But that possibility does not constitute an argument against any use of models to gain better understanding of an overly complex reality." Bauer-Bernet, *The Effects of Information Science on the Formation and Drafting of Law*, 14 Jurimetrics 235, 235-36 (1974). *See generally*, Eastin, *supra* note 2, at 618; Mayda, *supra* note 2, at 31; Wilkins, *supra* note 2, at 507-10.

8. "Computer simulation techniques may be said to answer questions of the form, 'What would be likely to happen if . . . ?' Initially it is necessary to formulate some model of the process for which an assessment of variation is required." Wilkins, *supra* note 2, at 507. "Where a simulation model can be constructed, it is not necessary to experiment with the whole system." Using the model, "reasonable statements can be made about the probability of [proposed] modifications of the system itself." *Id.* at 508. *See* McDonnell Douglas Corp. v. United States, 222 Ct. Claims 423 (1980) (allowing inventors to reduce an invention to practice under the Patent Laws by the use of a computer simulation model).

9. As one commentator notes:

> The advantages of the model include its ability to describe and comprehend the facts of the situation better than any verbal description can hope to do. It can uncover relationships between the various aspects of the problem which are not apparent in the verbal description. It also can indicate what data should be collected to deal with the problem quantitatively, establish measures of effectiveness and explain situations that have been left unexplained in the past by giving cause and effect relationships. A mathematical model makes it possible to deal with the problem in its entirety and allow a consideration of all the major variables of the problem simultaneously. It provides for the capability of being enlarged step by step to a more comprehensive model to include factors that are neglected in verbal descriptions. It also uses mathematical techniques that might otherwise appear to have no applicability to the problem. In

a way similar to the physical system being modeled.[10] The model can be used to analyze existing data to gain a greater understanding of a presently existing system.[11] A model can also be used to predict conditions that do not exist and that may never have existed in the past or may never exist in the future.[12]

Models, as broadly defined in this paper, are used in a variety of ways to assist in making decisions in many different areas of the law.[13] This paper focuses on the use of models for environmental decisionmaking. At present, quantitative models are being widely used in the environmental decisionmaking process,[14] and inevitably will be used to a greater extent in the future. Increasing problems of environmental pollution necessitate the use of modeling techniques.[15] Specific statutes or regulations require the use of models in

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addition, a mathematical model frequently leads to a solution that can be adequately described and justified on the basis of verbal descriptions.

Eastin, *supra* note 2, at 618.

10. Models are "quantitative or mathematical representations or simulations which attempt to describe the characteristics in relationship of physical events." U.S. EPA, GUIDELINES ON AIR QUALITY MODELS, A1-A34, 48 (1978) [hereinafter cited as EPA GUIDELINES ON MODELS]. "A model's utility is not determined by truth criteria; rather it is measured with respect to a given set of well-defined purposes and intentions." Brewer & Owen, *Policy Analysis by Computer Simulation: The Need for Appraisal*, 21 PUB. POL. 343, 346 (1973). Neither the results of the models nor the models are "end[s] in themselves but [are] . . . tools that augment existing management techniques." G. HAGEVIK, DECISION-MAKING IN AIR POLLUTION CONTROL 192 (1970). "[A] model is an aid, not a value judge or decision maker . . . ." Mayda, *supra* note 2, at 31. *See* Kramer, *supra* note 5, at 238 n.12.

11. *See, e.g.*, Movement Against Destruction (MAD) v. Trainor, 400 F. Supp. 533, 547-54 (D.Md. 1975) (using models to analyze the relation of present traffic levels to socio-economic variables).

12. *See, e.g., id.* at 562 (using understandings of present relationships of vehicular travel levels to predict future traffic levels). *See also* R. MAYER, R. MORONEY & R. MORRIS, CENTRALLY PLANNED CHANGE 161 (1974).

13. For instance, models are used in policy analysis. *E.g.*, Jones, *Systems Approaches to Multi-Variable Socioeconomic Problems: An Appraisal*, 18 J. PUB. L. 21 (1969); Sarnoff, *The Social Uses of Computer Forecasting*, 17 COMPUTER DIG. 3 (1969). Models are used in more specific policy decisions, such as accident studies on color televisions. *See, e.g.*, GTE Sylvania Incorporated v. Consumer Product Safety Commission, 404 F. Supp. 352, 357, 361 (D.Del. 1975). *See generally* Green, *The Risk-Benefit Calculus in Safety Determinations*, 43 G.W.L. REV. 791 (1975); Handler, *A Rebuttal: The Need for a Sufficient Scientific Base in Government Regulation*, 43 GEO. WASH. L. REV. 808 (1975).

14. Ackerman, Rose-Ackerman & Henderson, *The Uncertain Search for Environmental Policy: The Costs and Benefits of Controlling Pollution Along the Delaware River*, 121 U. PA. L. REV. 1225, 1251 (1973) [hereinafter cited as *Delaware River Costs and Benefits*]; Ackerman & Sawyer, *The Uncertain Search for Environmental Policy: Scientific Factfinding and Rational Decisionmaking Along the Delaware River*, 120 U. PA. L. REV. 419, 472, 543 n.52 (1972) [hereinafter cited as *Delaware River Factfinding*]. *See* W. RAMSAY & G. ANDERSON, MANAGING THE ENVIRONMENT 161 (1972); Note, *Epistemic Ambiguity and the Calculus of Risk:* Ethyl Corporation v. Environmental Protection Agency, 21 S.D. L. REV. 425 (1975).

15. "The ecological crisis calls for some kind of programmatic approach . . . ." W. RAMSAY

the making of an environmental decision in certain situations.[16] Additionally, provisions of the National Environmental Policy Act of 1969 (NEPA),[17] as well as judicial decisions construing NEPA and other environmental statutes, should facilitate the increased use of such models.

Mathematical and computer models are used in the environmental decisionmaking process generally in three ways: (1) to project pollution levels; (2) to evaluate environmental cleanup technologies and predict their effectiveness; and (3) to aid in cost-benefit analysis. A given environmental decision may well involve all three uses of such models. Presented below is a discussion of the three uses of such models in greater detail, followed by a discussion distinguishing between computer models and other quantitative or mathematical methodologies involved in environmental decisionmaking.

B. Use of Mathematical and Quantitative Models in Environmental Decisionmaking

1. Projections of Resulting Levels of Pollution

The primary use of models is to assist in the prediction of the levels of projected pollution given certain polluting and cleanup technologies. For example, a model may be used to test whether proposed new construction would cause a violation of an air quality standard by projecting the quality of the resulting ambient air based on the amount of pollutants assumed to be emitted into the atmosphere by the new construction.[18] Alternatively, the modeler can take as a given the allowable level of pollution and work backwards to calculate the amount by which the pollution must be reduced in order to

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& G. ANDERSON, *supra* note 14, at 217. *See id.* at 156, 219-20; W. MATTHEWS, RESOURCES MATERIALS FOR ENVIRONMENTAL MANAGEMENT AND EDUCATION 214-23 (1976) and authorities cited therein; Faulk, *The Global Environment and International Law: Challenge and Response*, 23 U. KAN. L. REV. 385 (1975); Caldwell, *The Ecosystem as a Criterion for Public Land Policy*, 10 NAT. RES. J. 203, 212-16 (1970).

16. *See, e.g.*, 42 U.S.C.S. §§ 7475(a), (e) (Law. Co-op. 1982), which specifies in part (e)(2) therein the data that can be relied on, in part (e)(3)(B) the factors to be analyzed, and in part (e)(3)(D) the factors to be included in the model and the specified sets of conditions which the model is to be used and that the model is to be described with reasonable particularity; § 7491(a)(3)(B) requires that models be used to project future visibility pollution; and § 7501(2) which allows models to be used to designate nonattainment areas. *See also*, 42 U.S.C. § 7620, which requires the holding of a conference at least every three years to establish appropriate modeling techniques necessary to carry out the prevention of significant deterioration (PSD) provisions of the Clean Air Act, 42 U.S.C.S. §§ 7470-7491 (Supp. IV 1980).

17. 42 U.S.C.S. §§ 4321-4347 (Law. Co-op. 1982).

18. *E.g.*, MAD v. Trainor, 400 F. Supp. 533 (D. Md. 1975).

achieve the required production and pollution. This can be done either by adding more cleanup technology or by altering the pollution sources.[19]

2. Technology Assessment

A second use for models in environmental decisionmaking is the measurement of the efficacy of a particular pollution reduction technology.[20] As described above, the substantive environmental model will have predicted or projected the amount of the substance to be permitted into the environment. A model may be used to test whether a particular cleanup technology or device is capable of achieving that required reduction.[21] Models may also be used to determine whether a technology is "achievable" or "practicable."[22]

3. Cost-Benefit Analysis

A third use for models in environmental decisionmaking is cost-benefit analysis.[23] There are two ways a model may be required for

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19. *E.g.*, So. Terminal v. EPA, 504 F.2d 646 (1st Cir. 1974).

20. *See, e.g.*, Green, *Limitations in the Implementation of Technology Assessment*, 14 ATOM. ENERGY L.J. 59 (1972); Baram, *Technology Assessment and Social Control*, 17 JURIMETRICS 79 (1973); Weinburg, *Technology Assessment Decisions*, 27 SCI. 177 (1972); Green, *The Resolution of Uncertainty*, 12 NAT. RESOURCE J. 182 (1972); Gelpe & Tarlock, *The Uses of Scientific Information in Environmental Decisionmaking*, 48 S. CAL. L. REV. 371, 376 n.13 (1974); Note, *The Role of the Courts in Technology Assessment*, 55 CORNELL L.Q. 861 (1970).

21. *E.g.*, BASF Wyandotte Corp. v. Costle, 598 F.2d 637 (1st Cir. 1979), *cert. denied*, 444 U.S. 1096 (1980); Hercules, Inc. v. EPA, 598 F.2d 91 (D.C. Cir. 1978); Weyerhauser Co. v. Costle, 590 F.2d 1011 (D.C. Cir. 1978); Amoco Oil Co. v. EPA, 501 F.2d 722 (D.C. Cir. 1974); Int'nl Harvester Co. v. Ruckelshaus, 478 F.2d 615 (D.C. Cir. 1973).

22. *E.g.*, Weyerhauser Co. v. Costle, 590 F.2d 1011, 1053-62 (D.C. Cir. 1978). The Supreme Court may have precluded consideration of cost in the evaluation of technologic and economic feasibility. Union Elec. Co. v. EPA, 427 U.S. 246, 256 (1976). *See* EPA v. DuQuesne Power & Light Co., 427 U.S. 902 (1976). Even after *Union Electric*, however, the courts must still review the models and mathematical methodologies which underlie the EPA's determinations of achievable, practicable, or feasible technologies. *E.g.*, Weyerhauser Co. v. Costle, 590 F.2d 1011, 1041, 1056, 1061 (D.C. Cir. 1978); Bunker Hill Co. v. EPA, 572 F.2d 1286, 1293-1301 (9th Cir. 1977). *See* Hercules, Inc. v. EPA, 598 F.2d 91, 114-17 (D.C. Cir. 1978) (technology to meet health related standard). Where a model is speculative in that it is not being based in fact, its results would not be sufficient to support a determination that technology is available. *See* Hooker Chem. & Plastic Corp. v. Train, 537 F.2d 620, 633-34 (2d Cir. 1976).

23. A cost-benefit model for an environmental decision is based on a model of the substantive environmental decision, such as a model predicting the resulting level of pollution or projecting the required level of pollution reduction, as described above. Generally speaking, the "benefits" involved in the cost-benefit analysis are the effects flowing from the pollution reduction; the "cost" involved is normally the increased expense and reduced productivity resulting from the required cleanup efforts. *See generally Cost-Benefit Analysis*, *supra* note 1. The problem in such cost-benefit analysis is that the pollution reduction benefits must be

the comparison of costs and benefits.[24] First, a cost-benefit ratio may be specifically required.[25] Second, a cost-benefit ratio may be mandated either by language requiring that environmental clean-up efforts be "achievable,"[26] "feasible,"[27] or "practicable,"[28] or by language generally requiring the examination or comparison of costs and benefits, such as in the requirement of an EIS in NEPA.[29]

This paper will not focus on the use of cost-benefit analysis in environmental decisionmaking. Nevertheless, those cases concerning cost-benefit analysis and the NEPA impact statements serve as important precedents for later cases involving the substantive environmental models discussed in this paper. Additionally, these cases share with modeling cases such problems in judicial review as lack of judicial expertise and court resources to deal with the technical

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given a monetary value in order that those benefits may be compared in some way to the costs of cleanup. This assignment of value to environmental quality intrinsically involves the arbitrary assignment of values based on subjective estimates of such environmental values as clean air and water, absence of noise, and other aspects of improvements in human environment.

24. See statutes listed in Indus. Union Dep't, AFL-CIO v. Am. Petroleum Inst., 448 U.S. 607, 688, 710 n.27 (1980) (Marshall, Brennan, White and Blackmun, J.J., dissenting).

25. *E.g.*, 33 U.S.C.S. § 701a (Law. Co-op. 1980) (Flood Control Act of 1936); 42 U.S.C.S. § 7545(c)(2)(B) (Law. Co-op. 1982) (Clean Air Act); 33 U.S.C.S. § 1314(b)(4)(B) (Law. Co-op. 1980) (Clean Water Act). These statutes generally specify that a project is to proceed if the benefits outweigh the costs (i.e., if the cost-benefit ratio is less than 1).

26. *E.g.*, 33 U.S.C.S. § 1317(a)(2) (Law. Co-op. 1980) (Federal Water Pollution Control Act Amendments of 1972 [hereinafter cited as FWPCAA]), *discussed in* Hercules, Inc. v. EPA, 598 F.2d 91, 110 nn.36 & 37 (D.C. Cir. 1978) (achievability technology to reduce the reduction of toxaphene and endrin to the environment); 42 U.S.C.S. § 1857c-6(a)(1) (Law. Co-op. 1973), *transferred to* 42 U.S.C.S. § 7411 (Law. Co-op. 1982) (1977 Clean Air Act), *discussed in* Nat'l Asphalt Pavement Ass'n v. Train, 539 F.2d 775, 785-87 (D.C. Cir. 1976) (1972 Act).

27. *E.g.*, 43 U.S.C.S. § 1347(b) (Law. Co-op. 1980) (Outer Continental Shelf Land Act); 42 U.S.C.S. § 6295(a)(4)(D) (Law. Co-op. 1982) (Energy Policy and Conservation Act); 29 U.S.C.S. § 655(b)(5) (Law. Co-op. 1982) (Occupational Safety and Health Act). *See, e.g.*, Indus. Union Dep't v. Am. Petroleum Inst., 448 U.S. 607, 612 (1980); Weyerhauser Co. v. Costle, 590 F.2d 1011, 1031-32, 1041 (D.C. Cir. 1978) (feasibility of best practical control technology currently available for pulp and paper effluent standards promulgated under FWPCAA); Bunker Hill Co. v. EPA, 572 F.2d 1286, 1291, 1301 (9th Cir. 1977) (feasibility of technology for the Idaho SIP under the Clean Air Act). It has been held that such language on feasibility as is contained in FWPCAA does not require the mathematical balancing of quantified values by cost-benefit analysis. *E.g.*, Am. Petroleum Inst. v. EPA, 540 F.2d 1023, 1037-38 (10th Cir. 1976). *See generally* Note, *The Federal Water Pollution Control Act Amendments of 1972: Ambiguity as a Control Device*, 10 HARV. J. LEGIS. 565 (1973) [hereinafter cited as *Ambiguous FWPCAA Control*].

28. 33 U.S.C.S. § 1314(b)(1)(A) (Law. Co-op. 1980) (FWPCAA); 42 U.S.C.S. § 1857c-5(a)(2)(A)(i) (Law. Co-op. 1973), transferred to 42 U.S.C.S. § 7410(a)(2)(A) (Law. Co-op. 1982). *See* BASF Wyandotte Corp. v. Costle, 598 F.2d 637, 656-57 (1st Cir. 1979), *cert. denied*, 444 U.S. 1096 (1980).

29. An EIS is required under § 102 of NEPA, 42 U.S.C.S. § 4332 (Law. Co-op. 1982), but the statute contains no explicit requirement of a cost-benefit ratio. The Fifth Circuit has

issues underlying such cost-benefit analysis, as well as problems in determining the appropriate standard of judicial review. These cost-benefit and EIS cases also involve the additional problem of assigning arbitrary values to unquantifiable environmental amenities as a necessary part of calculating the costs and benefits, thus introducing a further level of complicating issues. This paper will restrict itself largely to substantive environmental models with the observation that the conclusions drawn herein concerning environmental models are applicable to cost-benefit and EIS cases to the extent that those decisions are based on an environmental model.[30]

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recently said that "[u]pon the enactment of NEPA, however, some courts, including this one began to require some judicial review of agency determination of economic benefit . . . . These decisions, however, were rendered before the Supreme Court decision of *Vermont Yankee* [*Nuclear Power Corp. v. NRDC*, 435 U.S. 519 (1978)] and *Strycker's Bay* [*Neighborhood Council, Inc. v. Karlen*, 444 U.S. 223 (1980) (per curiam)]." So. La. Envt'l Council, Inc. v. Sand, 629 F.2d 1005, 1011 (5th Cir. 1980) (citations omitted). This author believes that Justice Marshall's dissent in *Strycker's Bay* is correct to note, 444 U.S. at 228-31, that *Vermont Yankee* should not be read in derogation of the "hard look" preview standard under Citizens to Preserve Overton Park, Inc. v. Volpe, 401 U.S. 402 (1971) and Kleppe v. Sierra Club, 427 U.S. 390 (1976). In fact, the Supreme Court may have applied a cost-benefit test in the recent case involving OSHA standards for benzene, although it declined to admit that it was so acting. *See* Indus. Union Dep't v. Am. Petroleum Inst., 448 U.S. 607, 614-15, 656, 662, 688, 695 n.9, 701-05 (1980) (Marshall, Brennan, White and Blackmun, J.J., dissenting). *But see* Burger's concurrence, *id.* at 662-64. Some analysis is still required under NEPA if such analysis is possible. *Compare* Cal. v. Bergland, 483 F. Supp. 465, 481-84 (E.D. Cal. 1980) *with* Nat'l Wildlife Fed. v. Andrus, 440 F. Supp. 1245 (D. Col. 1977). A mathematically expressed cost-benefit ratio is not required, *e.g.*, EDF v. Costle, 439 F. Supp. 980, 993 (E.D.N.Y. 1977), but, as noted in *South Louisiana*, 629 F. Supp. at 1011, some review of assumptions and procedures is required for other courts to perform the necessary review.

30. The same pressures to improve the quantitative decisionmaking methodologies in substantive environmental decisions will also likely require improved quantitative methodologies in the calculation of cost-benefit ratios. Previous cases, however, have rejected the suggestion that the Flood Control Act or NEPA necessitate the use of computer analysis in calculating cost-benefit ratios. EDF v. Corps of Engineers, 348 F. Supp. 916, 928 (N.D. Miss. 1972), *aff'd on other grounds*, 492 F.2d 1123 (5th Cir. 1974). The court in *EDF* went on to say that "[a]lthough computers may some day be used to quantify ecological elements more precisely, we conclude that at this point in time a valid ecosystems analysis may be achieved by an interdisciplinary team of scientists conducting a rigorous examination of the areas affected by [a proposed] project." 348 F. Supp. at 928.

It has been held that NEPA does not require the use of "an intricate, computerized system of analysis," or even a "formal equation." Columbia Basin Land Protection Assn. v. Kleppe, 417 F. Supp. 46, 50 (E.D. Wash. 1976) (quoting Trout Unlimited v. Morton, 509 F.2d 1276, 1286 n.14 (9th Cir. 1974)). In *Trout Unlimited*, the court noted that progress is "being made in devising techniques which will make cost-benefit analysis more reliable." 509 F.2d at 1286. These opinions imply that better quantitative decisionmaking methodologies such as computer modeling could be required for such cost-benefit analysis in the future if the state of the art permits it. *Accord*, Mon. Wildlife Fed. v. Morton, 406 F. Supp. 489, 491 (D. Mont. 1976) (citing Daly v. Volpe, 514 F.2d 1106, 1112 (9th Cir. 1975)). It is certainly conceivable that the progressing state of the art, together with other factors discussed herein, will allow and mandate the use of computer models in such cost-benefit analysis.

C. Types of Environmental Models

The modeling of an environmental decision may involve the use of computer models or mathematical models or both. A computer may be used to construct a mathematical model in the form of a graph or three-dimensional figure.[31] Conversely, a graph (expressed as a mathematical expression or relation) may be used as an input to a computer model.[32] Finally, the results of one mathematical model may be used as an input to another mathematical model or the results of a computer model may be used as the input to another computer model.[33]

1. Mathematical Models

A mathematical model may consist of an algorithm[34] or other methodology for analyzing large amounts of data, such as by averaging or statistical analysis. The courts have upheld EPA's use of an algorithm to determine "achievable" levels of pollution cleanup calculated by simply averaging the amount of effluent discharge from a number of specially selected model plants.[35] The courts have also upheld the weighted averaging of all data from a number of specially selected plants, even though this overemphasized the data from plants producing the most data.[36] In addition, courts have upheld the

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31. *See, e.g.*, City of Romulus v. County of Wayne, 392 F. Supp. 578, 587, 591-94 (E.D. Mich. 1975) (computer-generated contours); GM Corp. v. Costle, 631 F.2d 466, 469 (6th Cir. 1980) (SYMAP computer graphs of air quality).

32. Texas v. EPA, 499 F.2d 289, 294-95, 300 (5th Cir. 1974) (graph of the functional relationship of hydrocarbon emissions to resulting pollution used in computer model to assist in creation and validation of SIP for Texas). The theoretical relationship of emissions to pollutions is called a reduction model, which the court noted is "normally displayed in graphical form." *Id.* at 294-95.

33. *See, e.g.*, City of Romulus v. County of Wayne, 392 F. Supp. 578 (E.D. Mich. 1975) (results of a computerized traffic model used as an input in the computerized study of resulting noise levels). *See also* MAD v. Trainor, 400 F. Supp. 533 (D. Md. 1975), *on remand from* MAD v. Volpe, 361 F. Supp. 1360 (D. Md.), *aff'd*, 500 F.2d 29 (4th Cir. 1974).

34. The Supreme Court in recent patent cases has defined an algorithm as "a generalized formulation for programs to solve mathematical problems," Gottschalk v. Benson, 409 U.S. 63, 65 (1972), and "[a] procedure for solving a given type of mathematical problem," Parker v. Flook, 437 U.S. 584, 585 n.1 (1978). *See* Diamond v. Diehr, 450 U.S. 175, 186 n.9 (1981); In re Walter, 618 F.2d 758, 764 n.4 (Ct. Cus. & Pat. App. 1980) (algorithms defined as "methods of calculation, mathematical formulas, and mathematical procedures generally"). Each of the foregoing three Supreme Court cases evaluated the patentability of a computer software program. Each program implemented a specific result, such as number conversion in *Gottschalk* and running an industrial process in *Parker* and *Diamond*. Thus, these particular algorithms are not models of reality like the environmental models discussed herein, but both types are structured as algorithms.

35. *See* Hooker Chem. and Plastics Corp. v. Train, 537 F.2d 620, 632 (2d Cir. 1976).

36. In BASF Wyandotte Corp. v. Costle, 598 F.2d 637, 655 (1st Cir. 1979), *cert. denied*, 444

"variability factor"[37] included in point source effluent regulations promulgated under the Federal Water Pollution Control Act Amendments of 1972 (FWPCA) on the basis of statistical analysis.[38] The model can be based on a selection of the organisms most sensitive to a substance to establish a standard for that substance.[39]

Mathematical models in environmental decisionmaking also assume the form of a graph. A graph is a visual representation of a mathematical functional relationship, and as such can be constructed to model a polluting entity. The graph will usually express (or model)

U.S. 1096 (1980), the First Circuit Court of Appeals approved EPA's methodology in demonstrating the practicability of the hydrolysis method of cleanup. The EPA had simply averaged the data from dissimilar plants, giving equal weight to each datum, rather than to each plant. The First Circuit, although noting that the choice of mathematical methodologies or models set the result, stated that it was up to the EPA to choose its own statistical methodologies. *Id.* at 655. Even though some of the data that was averaged came from plants using cleanup technologies (hydrolysis and biological cleanup as opposed to simple hydrolysis) which were different from those allegedly being tested and involved other nonstandard conditions, the methodology was upheld. *Id.* at 654-55. The court noted that, after all, any method of statistical analysis is subject to attack. *Id.* at 655.

37. The variability factor is a number inserted into the regulatory calculation model to account for allowing the effects of worst-case conditions. *See* Am. Petroleum Inst. v. EPA, 540 F.2d 1023, 1035 (10th Cir. 1976). The EPA in its regulations defines this variability factor as "the multiplier by which the long-term achievable values [of permitted effluent pollution] must be multiplied in order to derive the value not permitted to be exceeded [in the short run of one day or 30 days]." *See id.* at 1035 (quoting 40 Fed. Reg. 21941). By that regulation, the daily variability factor was defined as the 99th percentile probability of occurrence value divided by the mean and the 30-day variability factor was chosen as the 98th percentile. EPA had set out in the regulation itself the application of a formula with variability factors to determine long term achievable values.

38. In Am. Petroleum Inst. v. EPA, 540 F.2d 1023 (10th Cir. 1979), the Tenth Circuit rejected the industry's attack on EPA's variability factors used in the setting of point source effluent regulations under FWPCAA. Petitioners had alleged that EPA's statistical analysis was based on insufficient and geographically biased data and irrationally disregarded differences among various sub-categories of regulated refineries. The court engaged in a struggle with a "turmoil of numbers" in trying to sort out the propriety of the variability factors EPA applied in calculating the effluent limitations. The court ultimately deferred to the expertise of the agency saying that "[s]tatistical methodologies are for the experts," *id.* at 1035, and referred the reader to the regulations where those procedures were set out. *See* 40 Fed. Reg. 219.

39. In Hercules, Inc. v. EPA, 598 F.2d 91 (D.C. Cir. 1978), the District of Columbia Court of Appeals upheld the use of the most sensitive test organisms in reviewing the methodology used by EPA in establishing standards for the toxic substances toxaphene and endrin. In setting those dual standards, EPA used a six-step model based on laboratory studies of six aquatic animals, *see id.* at 103-04, 114-15, as follows: (1) six aquatic animal species known to be most sensitive to the substances chosen; (2) short term exposure of those species to large amounts of the substances to establish a short term lethal dosage; (3) use of an extrapolation factor, which EPA had obtained from the National Academy of Sciences, to predict long term lethal dosages based on short term dosages established in laboratory tests; (4) use of a model to set safe ambient standards on the basis of a long term lethal dosage; (5) use of another model to set effluent discharge standards to attain the safe ambient level; and (6) establishment of a

the relationship between the amount of pollutant emitted into the environment and the resulting change in ambient air quality caused thereby.[40] Using such a graph, an environmental decisionmaker can determine the necessary amount of reduction in emitted pollutants required to achieve the mandated improvement in the ambient air.[41] Graphs can also model the efficacy and cost of the treatment technology[42] or the response of an organism exposed to a pollut-

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mass limitation to prevent dilution to evade the effluent discharge standard. EPA's use of the most sensitive organisms was approved based on EPA's making explicit its statistical assumption that although many animals were shown to be less susceptible to the substances, statistics indicate that future study will turn up many animals that are more susceptible to the substances. *Id.* at 106. In the case of endrin, the court in *Hercules* again upheld EPA's choice of sensitive animals, since those reasons were set forth at length and the court further held that "[c]hoice among scientific test data is precisely the type of judgment that must be made by EPA, not this court." *Id.* at 115. In both toxaphene and endrin, EPA's choices were upheld as within the zone of reasonableness allowed under the substantial evidence test. Nevertheless, rather than basing that decision on the discretion accorded to the agency because of its expertise and because of the policy-oriented nature of the choice, the court emphasized that its upholding of the number was justified based on "the scientific uncertainty attending the choice" and "administrative convenience." *See id.* at 107-09, 115-18.

40. *See, e.g.*, Kennecott Copper v. EPA, 526 F.2d 1149, 1152-53 n.16 (9th Cir. 1975), *cert. denied*, 425 U.S. 935 (1976) (graphical rollback model); So. Terminal v. EPA, 504 F.2d 646, 662-63 (1st Cir. 1974) (rollback model); Texas v. EPA, 499 F.2d 289, 294-95, 300 (5th Cir. 1974) (rollback models); MAD v. Trainor, 400 F. Supp. 533, 565 (D.C. Md. 1975) (reduction model relating hydrocarbons to photochemical oxidants).

41. *See, e.g.*, Texas v. EPA, 499 F.2d 289, 295 (5th Cir. 1974) (locating the correct point on the reduction model curve or graph to determine the required hydrocarbon emission control required to effect efficient reduction in photochemical oxidant pollution to meet national air quality standards for that particular air quality control region).

42. In Ass'n of Pacific Fisheries v. EPA, 615 F.2d 794 (9th Cir. 1980), the EPA had utilized financial data to construct a graph to estimate the cost of cleanup for a hypothetical—or model—processing plant. Petitioners in that case challenged the limitations promulgated for those plants using a model plant analysis. Petitioners claimed that, because of the nature of the model and data used, the model plant underestimated the cost of compliance. The Ninth Circuit stated that the complete accuracy of the model was not the question before the court. *Id.* at 809-10. The Ninth Circuit found in determining the model that EPA had engaged in sufficiently "reasoned decisionmaking, adequately supported by information available to the Agency." *Id.* at 809; *accord, id.* at 812. Although the court in *Pacific Fisheries* noted that EPA "itself recognized that its data collection was not as thorough as it otherwise would have been . . . ," the court declined "to second guess the agency's expert determinations as to the model plant, since there is adequate support for those conclusions in the record." *Id.* at 810-11.

Although the court noted that certain post-decisional studies showed "that various statistical and analytical errors by the EPA impugn the validity of the effluent guidelines," *id.* at 811, the court stated that such post-decisional data might be used to overturn a decision only if those studies show that EPA "proceeded upon assumptions that were entirely fictional or utterly without scientific support . . . ." *Id.* at 812 (citation omitted). *See also* Weyerhauser Co. v. Costle, 590 F.2d 1011, 1061 (D.C. Cir. 1978) (upholding EPA's hypothetical model for the dewatering solution to the problem of disposing of sludge bacteria for the dissolving sulfite process); BASF Wyandotte Corp. v. Costle, 598 F.2d 637, 656-57 (1st Cir. 1979) (use of simple model of the cleanup technique in carbon absorption to perform a limited comparison of cost and benefits).

ant.[43] Finally, a graph can serve as a coefficient in a computer model.[44]

Models are often used in environmental decisions to extrapolate from existing data[45] because such decisions must be made on the basis of a sparse data base.[46] For instance, the courts have upheld the extrapolation of test results showing the health effects of one substance to project the health effects of the use of another substance for which there exist no data.[47] The issue of data extrapolation also arises in the environmental field in the area of "technology transfer" where probable cleanup efforts are projected based on the hypothetical application of one cleanup technology from data gathered from the use of a similar technology in another industry.[48]

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43. *See* Ethyl Corp. v. EPA, 541 F.2d 1 (D.C. Cir.) (en banc), *cert. denied*, 426 U.S. 1941 (1976), where the court upheld EPA's use of a theoretical "standard man" to show the functional relationship between air and blood lead levels "to provide a rough estimate of the dangers posed by exposure to various ambient air lead concentrations." *Id.* at 42, 55. The functional relationship was based on absorption figures for ingested lead. EPA then established certain values for the three parameters: (1) air-lead concentration, (2) volume of air inhaled daily, and (3) the percent of inhaled lead absorbed to establish a "standard." *Id.* at 55.

44. *See, e.g.*, Cin. Gas and Elec. Co. v. EPA, 578 F.2d 660, 664 (6th Cir. 1978) (use of a graph in a computer model to represent six sets of coefficients of different weather conditions).

45. A lack of data normally does not permit an administrative agency to defer making an environmental decision. *See* Amoco Oil Co. v. EPA, 501 F.2d 722, 740-42 (D.C. Cir. 1974). As a result, for such technical environmental decisions on the frontiers of scientific knowledge, the court said that it would "demand adequate reasons and explanations, but not 'findings' of the sort familiar from the world of adjudication." *Id.* at 740-41. *See* Indus. Union Dep't v. Am. Petroleum Inst., 448 U.S. 607, 688-724 (1980) (Marshall, Brennan, White and Blackmun, JJ., dissenting).

46. These decisions based on insufficient data necessarily involve policy judgments. *Id.* at 706. In environmental decisionmaking, one cost to be weighed in almost every decision "is the cost of uncertainty—*i.e.*, the cost of proceeding without more and better information." Alaska v. Andrus, 580 F.2d 465, 473 (D.C. Cir.), *rev'd on other grounds*, 439 U.S. 922 (1978).

47. Data for such environmental decisions do not exist because of insufficient time to gather such data, or because of economic or technical contingencies. For instance, the First Circuit in BASF Wyandotte v. Costle, 598 F.2d 637 (1979), upheld the EPA's extrapolation from data relating to 10 pesticides to justify regulations also applicable to 39 other pesticides. The EPA had relied on scientific literature to establish the similarity between the 10 pesticides for which there was data and the 39 pesticides for which there was no data. *Id.* at 655-56 & nn. 27, 34. The First Circuit held that it was within the agency's expertise to use such an extrapolation and noted that the Federal Water Pollution Control Act Amendments (FWPCAA) did not "outlaw scientific deductive reasoning." *Id.* at 655 & n.34. Similarly, the District of Columbia Court of Appeals in Hercules, Inc. v. EPA, 598 F.2d 91 (D.C. Cir. 1978), upheld the EPA's extrapolation from data on the carcinogenicity of strobane to predict the carcinogenicity of toxaphene to justify a regulation promulgated under FWPCAA limiting the discharge of toxaphene into the water. *Id.* at 109. *See also* Int'nl Harvester v. Ruckelshaus, 478 F.2d 615, 642-47 (D.C. Cir. 1973).

48. Recent cases have upheld the application of data from one technology to project the existence of sufficient cleanup technology to meet future, more stringent regulations. *E.g.*,

Environmental cases involving toxic substances often involve the extrapolation from data based on the use of high dosages over extremely short periods of time; in order to establish a reasonable and safe level of ambient exposure, this high-dosage data must be extrapolated to project the effects of a more realistic, lower level of exposure over a longer period of time.[49] As a general matter, the courts have upheld an agency's extrapolations based on limited, or even arguably irrelevant, data bases, and have done so even though such extrapolations are often "quantitatively imprecise."[50]

2. Computer Models

Computer models, which vary widely in their application, are the second major type of environmental decisionmaking model discussed in this paper. Computer models are a type of mathematical model which are used, or "run," on a computer. The speed of the computer permits these computer models to be as complicated or intricate as is necessary for the problem to be solved. As will be discussed in greater detail below, very complicated models are required to assist in thoroughly addressing environmental problems. Consequently, the models used in environmental decisionmaking are most often computer models.

Ideally, the many possible environmental impacts of a proposed project can be simulated or predicted by the use of a comprehensive computer model. For example, computer models can be used to project levels of automobile traffic on a highway[51] or aircraft traffic on a runway.[52] More importantly, a computer model can project resulting

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Ass'n of Pac. Fisheries v. EPA, 615 F.2d 794, 816-17 (9th Cir. 1980) (considering 1977 and 1983 effluent point source regulations for fish processing plants promulgated under FWPCAA). Courts have also overturned similar effluent limitation guidelines issued under FWPCAA on the basis that the EPA did not sufficiently describe its extrapolation of data to show the efficacy of a cleanup technique (lead filtration). CPC Int'nl, Inc. v. Train, 515 F.2d 1032, 1049 (8th Cir. 1975), *cert. denied*, 430 U.S. 966 (1977).

49. In Hercules, Inc. v. EPA, 598 F.2d 91, 109-10, 155 (D.C. Cir. 1978), the EPA gathered data by exposing the most sensitive known test animals to extremely high dosages over a short period of time, extrapolating the results to project the effects of long term exposure to toxaphene and endrin. The regulations promulgated under the Toxic Substances Control Act (TSCA), 15 U.S.C.S. §§ 2601-2628 (Law. Co-op. 1980), regulating these substances were upheld in the face of significant contradictory evidence.

50. *See, e.g.*, EDF v. EPA, 598 F.2d 62, 87 (D.C. Cir. 1978) (quoting EDF v. EPA, 510 F.2d 1292, 1299 (D.C. Cir. 1975)).

51. *See, e.g.*, MAD v. Trainor, 400 F. Supp. 533, 539-40, 548-56 (D.Md. 1975). *See also* MAD v. Volpe, 361 F. Supp. 1361, 1373-74 (D.Md. 1973), *aff'd*, 500 F.2d 29 (4th Cir. 1974).

52. City of Romulus v. Butterfield, 392 F. Supp. 578, 586-90 (E.D. Mich. 1975).

levels of air pollution,[53] water pollution,[54] or noise pollution[55] from such proposed projects. A computer can also be used to choose the best location for a nuclear power plant,[56] a sewage disposal plant,[57] or an off-shore gas pipeline.[58] Computers may be used in making

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53. *E.g.*, Rep. Steel Corp. v. Costle, 621 F.2d 797 (6th Cir. 1980); Ala. Power Co. v. Costle, 606 F.2d 1068 (D.C. Cir. 1979); Appalachian Power Co. v. EPA, 579 F.2d 846 (4th Cir. 1978); Cin. Gas and Elec. Co. v. EPA, 578 F.2d 660 (6th Cir. 1978); Clev. Elec. Illum. Co. v. EPA, 572 F.2d 1150 (6th Cir. 1978), *aff'd on reh'g*, Cin. Gas and Elec. Co. v. EPA, 578 F.2d 666 (6th Cir. 1978); No. Ohio Lung Ass'n v. EPA, 572 F.2d 1143 (6th Cir. 1978); Mision Indus., Inc. v. EPA, 547 F.2d 123 (1st Cir. 1976); Sierra Club v. EPA, 540 F.2d 1114 (D.C. Cir. 1976); NRDC v. EPA, 529 F.2d 755 (5th Cir. 1976), *on remand from* Train v. NRDC, 421 U.S. 60, *rev'g in part on other grnds, sub nom.*, NRDC v. EPA, 489 F.2d 390; Kennecott Copper Corp. v. Train, 526 F.2d 1149 (9th Cir. 1975), *cert. denied*, 425 U.S. 935 (1976); So. Terminal v. EPA, 504 F.2d 646, 662-64 (1st Cir. 1974); Texas v. EPA, 499 F.2d 289 (5th Cir. 1974); Life of the Land v. Brinegar, 485 F.2d 460, 470 (9th Cir. 1973), *cert. denied*, 415 U.S. 961 (1974); MAD v. Trainor, 400 F. Supp. 533, 561, 572 (D. Md. 1975); MAD v. Volpe, 361 F. Supp. 1360, 1391-93 (D. Md.), *aff'd*, 500 F.2d 29 (4th Cir. 1974). *See also* U.S. DEPARTMENT OF TRANSPORTATION, COMPUTER MODELLING OF TRANSPORTATION-GENERATED AIR POLLUTION: A STATE-OF-THE-ART SURVEY (Darling ed. 1972).

54. *See, e.g.*, CPC Int'nl, Inc. v. Train, 515 F.2d 1032, 1045-46 (8th Cir. 1975); Ohio v. EPA, 460 F. Supp. 248, 251 (S.D. Ohio 1978); Evans v. Train, 460 F. Supp. 237, 243-44 (S.D. Ohio 1978); Conserv. Council of N.C. v. Froehlke, 435 F. Supp. 775, 782-85, 789-92 (M.D.N.C. 1977); EPA, SIMPLIFIED MATHEMATICAL MODELING OF WATER QUALITY (March 1971); EPA, ADDENDUM TO SIMPLIFIED MATHEMATICAL MODELING OF WATER QUALITY (1972); EPA, COSTS AND WATER QUALITY IMPACTS OF REDUCING AGRICULTURAL NINE POINT SOURCE POLLUTION: AN ANALYSIS METHODOLOGY (EPA-600/5-79-009); U.S. DEPARTMENT OF INTERIOR, MULTIPLE REGRESSION MODELING APPROACH FOR REGIONAL WATER QUALITY ASSESSMENT (EPA-600/7-78-198); L. KONIKOW, COMPUTER MODEL OF TWO-DIMENSIONAL TRANSPORT AND DISPERSION IN GROUNDWATER; EPA, ENVIRONMENTAL PATHWAYS OF SELECTED CHEMICALS IN FRESH WATER SYSTEMS (EPA-600/7-77-113 and EPA-600/7-78-074).

55. Life of the Land v. Brinegar, 485 F.2d 460, 472 (9th Cir. 1973), *cert. denied*, 416 U.S. 961 (1974); City of Romulus v. County of Wayne, 392 F. Supp. 578, 591-97 (E.D. Mich. 1975); Sec'y of Envt'l Aff. v. Mass. Port Auth., 366 Mass. 755, 769, 323 N.E.2d 329, 343 (1975). *See generally* Note, *Port Noise Complaint*, 6 Harv. CR-CL L. REV. 61 (1970) [hereinafter cited as *Port Noise Complaint*]. *See also* Donley, Miller & Novikas, *Computer Analysis to the City Noise-Preliminary Algorithm* (83rd Meeting of the Acoustical Society of America, East Hanover, New Jersey, April 21, 1972, by R. Guernensey); U.S. ARGONNE NATIONAL LABORATORY, TRANSPORTATION NOISE: IMPACTS AND ANALYSIS TECHNIQUES (October, 1973).

56. *Compare* Gros, Power Plant Siting: A Parentian Environmental Approach (1974) (Harvard University Environmental Systems Program, Discussion Paper #74-4) *with* Soc. for the Protection of N.H. Forests v. Site Evaluation Comm., 115 N.H. 172, 337 A.2d 778 (1975) (placement of the Seabrook nuclear power plant).

57. *Compare* Thomas, Shapiro & Houghton, Parentian Analysis of Regional Systems for Sewage Disposal (1974) (Harvard University Environmental Systems Program, Discussion Paper (74-2)) *with* Mid-Shiawassee County Concerned Citizens v. Train, 408 F. Supp. 650 (E.D. Mich. 1974); Ohio v. EPA, 460 F. Supp. 248 (S.D. Ohio 1978); Evans v. Train, 460 F. Supp. 237 (S.D. Ohio 1978).

58. The Wall Street J., Oct. 24, 1968, p. 2, col. 3.

more policy oriented, multi-variable decisions, such as the structure of an urban transportation[59] or waste disposal[60] system or a plan of city development[61] or land use.[62] Computer models may also be used to evaluate erosion by river currents,[63] to establish the mean high water line on a piece of property adjoining a watercourse,[64] and to predict the effects of industrial development and other future actions on ground water supplies.[65]

III. JUDICIAL REVIEW OVER AGENCY ACTION

A. An Agency's Obligation to Employ Models in Environmental Decisionmaking

There are a number of reasons for the increasingly widespread use of mathematical and computer models in environmental decisions. First, Congress has mandated the use of computer models in the 1977 amendments to the Clean Air Act.[66] Under the 1977 Amend-

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59. ASSOCIATION FOR COMPUTING MACHINERY, APPLICATION OF COMPUTERS TO THE PROBLEMS OF URBAN SOCIETY, 4th Annual Symposium (1969); C. BERGE, PROGRAMMING, GAMES AND TRANSPORTATION NETWORKS (1965); Thomas & Thompson, *The Value of Time for Commuting Motorists*, 314 HIGHWAY RESEARCH RECORD 1 (1970); Tipping, *Savings in Transport Studies*, 78 ECON. J. 843 (1968); Wohl & Martin, *Methods of Evaluating Alternative Road Projects*, 1 J. TRANSPORT PLAN. AND ECON. 28 (1967).

60. J. Kuhner and J. Harrington, *Towards Planning Models for Evaluating Solid-Waste Resource Recovery Programs* (Harvard Environmental System Program, 1974). *See* D. HENNING, ENVIRONMENTAL POLICY AND ADMINISTRATION 79 (1974).

61. *See* D. HENNING, *supra* note 60, at 79.

62. *See, e.g.*, 42 U.S.C.S. § 1962d-17 (a) (Law. Co-op. 1978). *See also*, Elm, *NEPA's Environmental Impact Statement, Social Impact, and Federally Funded Low Income Housing*, 11 HARV. J. LEGIS. 613, 624-25 (1974); *Cost-Benefit Note*, *supra* note 1, at 424-25; Alabama v. Corps of Engineers, 411 F. Supp. 1261, 1271 (N.D. Ala. 1976) (interest rate used to calculate cost of flood control project).

63. *E.g.*, Petterson v. Froehlke, 354 F. Supp. 45, 49 (D. Or. 1972), *remanded on other grounds*, Citizens Committee for Columbia River v. Callaway, 494 F.2d 124 (9th Cir. 1974).

64. *See, e.g.*, N.J. Sports & Exposition Auth. v. Borough of E. Rutherford (S.Ct. of N.J., Law Div.), *consolidated with* City of Newark v. Natural Resource Council (S.Ct. N.J., App. Div., Docket No. A-3311-72), *as discussed in* A. Porro, *The Lawyer and the Statistical-Computer Expert*, ELEVENTH ANNUAL SYMPOSIUM ON THE INTERFACE BETWEEN COMPUTER SCIENCE AND STATISTICS (Institute of Statistics, North Carolina State University of Raleigh, N.C., March 6 & 7, 1978).

65. EPA, A LINEAR PROGRAMMING MODEL FOR ASSESSING REGIONAL IMPACTS OF THE ENERGY DEVELOPMENT ON WATER RESOURCES (July, 1977); EPA, MATHEMATICAL MODELING OF A SOCIOLOGICAL AND HYDROLOGIC DECISION SYSTEM (June, 1978). The United States Geological Survey of the Department of Interior has undertaken a Southeastern Carbonate Aquifer Study, which will result in "a computer model, or simulation, for the overall aquifer system [of every region in the country and its water supplies], supported by more detailed simulations of local problem areas." Newsletter of the Water Resources Research Institute of the University of North Carolina, No. 159, May, 1979.

66. Clean Air Act Amendments of 1977, Pub. L. No. 95-95, 91 Stat. 712 (1977), *codified at* 42 U.S.C.S. §§ 7401-7428 (Law. Co-op. 1982).

ments models must be used in connection with the prevention of significant deterioration of air quality (PSD)[67] and for designation of nonattainment areas.[68] Under the PSD program enacted in the 1977 Amendments, a major emitting facility in an area subject to PSD regulations must apply for and receive a permit prior to commencing construction,[69] which must be preceded by an analysis of air quality impacts projected for the area as a result of growth associated with such facility.[70] This analysis must be performed using air quality models specified by regulations promulgated by EPA.[71] The 1977 Amendments also require a conference on air quality modeling every three years to ensure that air quality models used in the PSD program reflect the current state of the art in modeling.[72]

The 1977 Amendments also explicitly provide for the use of air quality modeling in the designation of nonattainment areas.[73] The 1977 Amendments define a nonattainment area for any air pollutant as an area "which is shown by monitoring data or which is calculated by air quality modeling (or other methods determined by the administrator to be reliable) to exceed any national ambient air quality standard for such pollutant."[74] Courts have upheld EPA's use of either monitoring or modeling data in nonattainment designations.[75] Further, it is clear that models will be required in the nonattainment permit program. The permit must be applied for and received prior to the construction or operation of a new or modified major stationary source in a nonattainment area.[76] Prior to the issuance of any permit, an analysis must be performed of alternative sites, sizes, production processes, and environmental control techniques for the proposed source, which demonstrates that the benefits of the proposed source significantly outweigh the environmental and social costs resulting from its construction or modification.[77] Additionally,

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67. *See* 42 U.S.C.S. § 7475 (Law. Co-op. 1982). The PSD regulations, including those dealing with models, were upheld by the D.C. Circuit Court of Appeals in Alabama Power Co. v. Costle, 636 F.2d 323, 371-72 (D.C. Cir. 1980). This opinion superseded the prior interim opinion published at 606 F.2d 1068.

68. *See* 42 U.S.C.S. §§ 7501-7508 (Law. Co-op. 1982), especially § 7502.

69. 42 U.S.C.S. § 7475(a) (Law. Co-op. 1982).

70. *Id.* § 7475(a)(2), (6).

71. *Id.* § 7475(e)(3)(D).

72. *See id.* § 7620; *see also* Kramer, *supra* note 5, at 260 n.141.

73. *See* 42 U.S.C.S. §§ 7501-7508 (Law. Co-op. 1982).

74. *Id.* § 7501(2).

75. *See, e.g.*, Rep. Steel Corp. v. Costle, 621 F.2d 797, 805-06 (D.C. Cir. 1980).

76. 42 U.S.C.S. § 7502(b)(6) (Law. Co-op. 1982). *See id.*, §§ 7501(4) (defining "modified"), 7602(j) (defining "major stationary source"), 7503.

77. *Id.* § 7502(b)(11)(A).

prior to granting any permit, this source must demonstrate either (1) that the total emissions from all sources in the nonattainment region will be sufficiently less than total emissions prior to the permit to assure reasonable further progress towards the attainment of applicable and national ambient air quality standards,[78] or (2) that the additional emissions from the source will not be greater than the allowed increase of emissions as calculated under the nonattainment plan.[79] Regulations promulgated by the EPA specify the types of models to be used under the Clean Air Act in predicting ambient levels of air quality for metropolitan areas and the extent to which that level will be affected by proposed projects or pollution reduction efforts.[80]

Other statutes evince a congressional intent that mathematical methodologies be used. For instance, Congress has enacted statutes which require the use of models to show feasibility or to calculate a cost-benefit ratio.[81] Congress has also enacted statutes requiring the use of "the best available evidence" and "the latest available scientific data in the field,"[82] which may be interpreted to require the use of models.

NEPA may also mandate the use of quantitative or computer models under certain circumstances. By the enactment of NEPA Congress has set a high level for the decisionmaker to meet.[83] His

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78. *Id.* § 7503(1)(A). *See id.* § 7501(1) (defining "reasonable further progress").

79. *Id.* § 7503(1)(B). *See id.* § 7502(b)(5), which requires the calculation of allowance for each pollutant.

80. *See* 40 C.F.R. §§ 51.24(k) and (l), 52.21(k) and (l) (1981).

81. *See supra* text at notes 25-29.

82. *See, e.g.*, 29 U.S.C.S. § 655(b)(5) (Law. Co-op. 1982) (provision of the Occupational Safety and Health Act of 1970 specifying requirements for promulgating standards dealing with toxic materials and/or harmful physical agents). In interpreting § 655(b)(5) of that Act, 29 U.S.C. §§ 651-678 (1976 & Supp. IV 1980), the U.S. Supreme Court has interpreted that provision to require that the risk from a toxic substance be quantified sufficiently to enable the secretary to characterize it as significant in any understandable way. Indus. Union Dep't v. Am. Petroleum Inst., 448 U.S. 607 (1980). The Supreme Court specifically stated that the requirement in the act that the risk be significant is not a "mathematical straight jacket," nor does it require OSHA "to calculate the exact probability of harm" or "to support its finding that a significant risk exists with anything approaching scientific certainty." *Id.* at 655. The Supreme Court recognized that it must be tolerable of such findings where they are "made on the frontiers of scientific knowledge," *id.*, and where they necessarily involve the intertwining of factual determinations and policy judgments. *Id.* at n.62.

83. EDF v. Corps of Engineers (Gillham Dam), 470 F.2d 289, 297 n.12 (8th Cir. 1972) (citing Calvert Cliffs' Coordinating Comm. v. AEC, 449 F.2d 1109, 1114 (D.C. Cir. 1971)). *See generally* F. ANDERSON, NEPA IN THE COURTS (1973); *Cost-Benefit Analysis, supra* note 1, at 443-45; Annot., 17 A.L.R. FED. 33 (1973).

decisions must be based upon a "systematic, interdisciplinary approach"[84] that "utilize[s] ecological information in the planning and development of resource-oriented projects"[85] and gives "presently unquantified environmental amenities and values . . . appropriate consideration in decisionmaking along with technical and economic considerations . . . ."[86] This mandate extends beyond merely listing the factors to be considered; it also forcefully states a congressional intent that these factors be considered "to the fullest extent possible"[87] through the use of "all practicable means and measures."[88] The goal that has been set is the attainment and maintenance of a broadly defined, high standard of living[89] and a "healthful environment"[90] for "present and future generations of Americans," as well as other peoples of the world.[91]

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84. 42 U.S.C.S. § 4332(2)(A) (Law. Co-op. 1982).

85. 42 U.S.C.S. § 5332(2)(H) (Law. Co-op. 1982). One of the original purposes of the Act was "to enrich the understanding of ecological systems." *Id.* § 4321 (1970). Courts have said that ecological factors must be considered by the agency under the requirements of NEPA. *See, e.g.*, Zabel v. Tabb, 430 F.2d 199, 211 (5th Cir. 1970), *quoted in* Life of the Land v. Brinegar, 485 F.2d 460, 465 (9th Cir. 1973), *cert. denied*, 416 U.S. 961 (1974).

86. 42 U.S.C.S. § 4332(2)(B) (Law. Co-op. 1982). *See* 40 C.F.R. §§ 1502.6 (interdisciplinary preparation), 1502.23 (cost-benefit analysis) (1980).

87. 42 U.S.C.S. § 4332 (Law. Co-op. 1982). *See* 40 C.F.R. § 1500.1(b) (1975). The regulations formerly stated that "[t]he phrase 'to the fullest extent possible' in section 102 is meant to make clear that each agency of the Federal Government shall comply with the section unless existing law applicable to the agency's operations expressly prohibits or makes compliance impossible." 40 C.F.R. § 1500.4 (1975). The regulations now stress a reduction in paperwork and delay; *see id.* §§ 1500.1(c), 1500.4, 1502.1, 1502.2 and 1502.7; but do require the decisionmaker to specify the extent to which the underlying information is incomplete or unavailable, *id.* § 1502.22. "NEPA was intended to be broad and all inclusive in its concern for the environment. Federal agencies are to apply its provisions to the fullest extent possible." Note, *State Preparation of Environmental Impact Statements for Federally Aided Highway Programs*, 4 FORDHAM URB. L.J. 597, 602 (1976) [hereinafter cited as *Highway Impact Statements*]. *See* Calvert Cliffs' Coord'g Comm., Inc. v. AEC, 449 F.2d 1109 (D.C. Cir. 1971); Bucks County Bd. of Comm'rs v. Interstate Energy Co., 403 F. Supp. 805, 812 (E.D. Pa. 1975); EDF v. Corps of Engineers, 348 F. Supp. 916, 927 (N.D. Miss. 1972), *aff'd*, 492 F.2d 1123 (5th Cir. 1974).

88. 42 U.S.C.S. § 4331(a) (Law. Co-op. 1982) (1970). Subsection (b) of that section directs that "[i]n order to carry out the policy set forth in this Act, it is the continuing responsibility of the Federal Government to use all practicable means . . ." to attain the six specific goals set out in the subsection. The only limitation on this directive is that it be "consistent with other essential considerations of national policy." *Id.*

89. *See id.* § 4331 (Law. Co-op. 1982): § (a) ("fulfill the social, economic, and other requirements of present and future generations of Americans"), § (b)(2) ("safe, healthful, productive, and esthetically and culturally pleasing surroundings"), § (b)(3) ("without . . . risk to health or safety, or other undesirable and unintended consequences"), § (b)(4) (diversity and individual free choice), § (b)(5) ("high standards of living"), § 101(b)(6) (maximum resource use), and § (c) ("that each person should enjoy a healthful environment"); *see also id.* § 4321 (1970) ("stimulate the . . . welfare of man").

90. *Id.* § 4331 ("stimulate the health . . . of man").

91. *See id.* §§ 4331(a), (b)(1); 4332(2)(C)(v), (2)(D)(iv), (2)(E).

As reflected in the policy mandates of NEPA, Congress intends to "force" the use of the best, state-of-the-art methodologies available in the making of environmental decisions.[92] This would seem to impel the use of such mathematical models as those under study here, at least to the greatest extent that this is possible or practicable.[93] In sum, NEPA is a broad statutory precedent for the maximum use of mathematical models in the environmental decisionmaking process.

The regulations (NEPA Regulations) promulgated by the Council on Environmental Quality (CEQ) applying and interpreting NEPA also place at least an indirect duty on the decisionmaker to use quantitative and computer models to the greatest extent possible. The NEPA Regulations are designed to ensure that the information upon which environmental decisions are based "be of high quality," because "[a]ccurate scientific analysis, expert agency comments, and public scrutiny are essential to implementing NEPA."[94] As those provisions note, "[t]he NEPA process is intended to help public officials make decisions that are based on an [sic] understanding of environmental consequences . . . ."[95] Impact statements are to be concise and avoid extraneous data and analysis, but are to "be supported by evidence that agencies have made the necessary environmental analyses."[96] The NEPA Regulations require the gathering and use of all data relevant to the decision, unless its cost is exorbitant, and when the cost is high, requires the inclusion of "a worst case analysis and an indication of the probability or improbability of its occurrence."[97] A model can be used to produce data where monitoring or experimentation is too costly and can also be used for the required worst-case analysis. A model can also be used to predict the environmental consequences of the project,[98] to evaluate the relative

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92. *See* 40 C.F.R. § 1500.1(a)(1981). For cases discussing the concept of state of the art in environmental law, see Kennecott Copper Corp. v. Train, 526 F.2d 1149, 1152 (9th Cir. 1975); So. Terminal v. EPA, 504 F.2d 646, 680 n.37 (1st Cir. 1974); Texas v. EPA, 499 F.2d 289, 295 n.6, 301 n.16 (5th Cir. 1974); Ala. v. Corps of Engineers, 411 F. Supp. 1261, 1268 (N.D. Ala. 1976); MAD v. Trainor, 400 F. Supp. 578, 594 (E.D. Mich. 1975); Sierra Club v. Froehlke, 359 F. Supp. 1289, 1365-66 (S.D. Tex. 1973), *rev'd on other gnds sub nom.* Sierra Club v. Callaway, 499 F.2d 982 (5th Cir. 1974).

93. *See* Am. Iron & Steel Inst. v. EPA, 526 F.2d 1027, 1075-78 (3rd Cir. 1975) (Adams, J., concurring).

94. *See* 40 C.F.R. § 1500.1(a) (1981).

95. *Id.* § 1500.1(b).

96. *Id.* § 1500.2(b). *See id.* §§ 1500.4 (reduce paperwork), 1500.5 (reduce delay), 1502.7 (150-page limit).

97. *Id.* § 1502.22(b) and (c).

98. *See id.* § 1502.16.

merits of the different alternatives,[99] to integrate data from the natural and social sciences and design rates,[100] and to comply with the general statutory mandate of a "systematic, interdisciplinary approach."[101] Models can also be used in the detailed identification and qualification of environmental effects[102] and in the performing of cost-benefit analyses where appropriate.[103] Where the EIS is based on a model, care must be used that the statement is written in analytical but clear fashion, that the format is clear, and that the portions of the model most useful to decisionmaking are pointed out.[104] Information on the model may be attached as an appendix to the EIS.[105]

A number of cases interpreting the Clean Air Act and NEPA establish the principle that the sophistication of the models used on computers must keep up with the current state of the art.[106] EPA, in recognition of the need to apply this ecosystem-oriented approach to environmental decisions, has adopted a policy in air pollution decisions which favors modeling results over monitoring data where the two conflict, at least where there is a question as to the adequacy of the monitoring data.[107] EPA takes the position that modeling data is normally superior to "air quality monitoring data which is usually not sufficiently comprehensive to cover any given area."[108] The use of EPA's models to project future conditions for which no monitoring data can be used has also been upheld.[109]

Beyond these legal mandates, increasingly complicated and intractable environmental problems will compel the greater use of quantitative models by environmental decisionmakers. Many experts

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99. *See id.* §§ 150.214, 1501.2(c).

100. *See id.* §§ 1502.6, 1502.8.

101. *See id.* § 1501.2(a).

102. *See id.* § 1501.2(b).

103. *See id.* § 1502.23.

104. *Id.* § 1500.4(b), (d), (e), (f) and regulations cited therein.

105. *Compare id.* § 1502.18 (appendix) *with id.* § 1502.21 (incorporation by reference).

106. *See supra* cases cited in note 92.

107. 43 Fed. Reg. 45,998 (1978). This regulatory statement of EPA's policy was upheld in Cin. Gas & Elec. Co. v. Costle, 632 F.2d 14, 19 (6th Cir. 1980).

108. Cin. Gas & Elec. Co. v. Costle, 632 F.2d 14, 19 (6th Cir. 1980). The issue in *Cincinnati Gas* was the use of modeling data to classify an area as a nonattainment area under 42 U.S.C. § 7501(2). The Sixth Circuit left open the question of whether it would be arbitrary and capricious for EPA to base the nonattainment designation on *modeling* data in the face of contradictory adequate *monitoring* data.

109. Models must be used to project future air quality when a nonattainment designation under the Clean Air Act is based on future air quality standard violations which do not now exist. *See, e.g.*, Columbus and So. Ohio Elec. Co. v. Costle, 638 F.2d 910, 912 (6th Cir. 1980); P.P.G. Ind. v. Costle, 621 F.2d 462 (6th Cir. 1980).

are of the opinion that, if we are ever to deal with our environmental problems, we are going to have to utilize the information handling capabilities of the more complex of these quantitative models, particularly those run on computers.[110] Computers are used to incorporate large amounts of environmental data into a "simulation model" of an environmental system (an "ecosystem"[111]); such modeling efforts have been referred to generically as "ecomodels."[112] The rising population and standard of living and the cumulative effects of our society's obliviousness to the pollution problem will all make the problem of pollution more severe in the future, thus further increasing the need for quantitative tools to deal with the problem of pollution.[113] Likewise, improvements in data gathering and modeling capabilities will make the use of models increasingly attractive.[114]

The ideal that is pursued has been termed "ecomanagement"[115] or "environmental management"[116] to indicate a level of sophistication in administration of environmental matters that would be commensurate with a hypothetically complete (i.e., perfect) understanding of

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110. "[T]here will be a revolution in the study of ecosystems in the next 150 years due to the use of theoretical ecology, including computer models." Gelpe & Tarlock, *supra* note 20, at 403 n.82 (citing *Theoretical Ecology: Beginnings of a Predictive Science*, 183 SCI. 400 (1974)). *See* M. BUNDY, MANAGING KNOWLEDGE TO SAVE THE ENVIRONMENT 3-4 (1970). Computers are said to be "powerful" by virtue of their capability of handling large amounts of data and variables. Eastin, *supra* note 2, at 610. "[I]t is often the case that the factors entering into [a modeling] problem are so many that only elaborate data processing procedures can yield significant answers. In such case, a mathematical model forms an immediate bridge to the use of large-scale electronic data processors." *Id.* at 619 (citations omitted); Mayda, *supra* note 2, at 27-28.

111. "An ecosystem results from the integration of all of the living and nonliving factors of the environment for a defined segment of space and time. It is a complex of organisms and environment forming a functional whole." D. HENNING, *supra* note 60, at 162. Of course, such a concept and its applications have practical limits. *See id.* at 151.

112. "[A]n ecomodel [is] 'an intelligible statement of the manner in which our observations and [projections] hang together' and make it possible to correct policy propositions not borne out by application . . . ." Mayda, *supra* note 2, at 31 (footnotes omitted). *See supra* text and notes at notes 7-13.

113. W. RAMSAY & G. ANDERSON, *supra* note 14, at 114-16 ("ecological crisis" will precipitate the use of models even in the face of the difficulties in quantifying and environmental amenities).

114. *See, e.g.*, G. HAGEVIK, *supra* note 10, at 192. In addition to providing its own model, the federal government will evaluate a model which it did not itself produce. *See, e.g.*, TRANSPORTATION SYSTEMS CENTER, SYSTEMS ANALYSIS DIVISION, DEPT. OF TRANSPORTATION, EVALUATION OF AIR TRAFFIC CONTROL MODELS AND SIMULATIONS (1971) (Report No. DOT-TSC-FAA-71-7, prepared for the FAA).

115. "The neologism 'ecomanagement' stands for comprehensive management of environment and other resources, based on ecological principles and applying systems analysis and modeling techniques." Mayda, *supra* note 2, at 21 n.1. *See* W. MATTHEWS, *supra* note 15, at 5, 8; D. HENNING, *supra* note 60, at 162; W. RAMSAY & G. ANDERSON, *supra* note 14.

116. *See* Hahn, *Providing Environmental Science Services*, 28 PUB. AD. REV. 326 (1968).

our ecosystem and which would not be achieved to the exclusion of public input.[117] Most commentators agree that this is an unattainable goal, but is one to which our society should aspire in its efforts to deal with environmental problems.[118] These commentators suggest an increasingly interdisciplinary[119] and ecosystem-oriented[120] approach to the increasing problems with pollution. This approach entails the application of systems planning to the environmental decisionmaking process.[121]

B. Problems Presented to the Administrative Decisionmaker by the Use of Quantitative Models

The problem arising from the use of an environmental model is twofold. First, its use may actually increase the likelihood that a

117. Mayda states that:

> a model makes it possible to see graphically even remote cause-effect relationships and to investigate the ramifications when parameters are changed because of changed priorities. Since such a model is constructed in computer terms, all the alternative effects and their total benefit-cost aspect can be rapidly determined and fed back to the policy makers. As distinguished from the crude precept of periodic revision of projections every so many years, which often turns into a political issue with the usual concomitants, a model makes possible the consideration of each program as a step in an ongoing sequence, with a built-in means of evaluation and a continuous opportunity to correct specific projects.

Mayda, *supra* note 2, at 31.

Of particular interest is his implication that his effort will somehow depoliticize the choices made. There exists in such an attitude the danger that the public will come to find such "elitist decision-making . . . inadequate." Baram, *supra* note 20, at 82. This techno-scientific approach is exacerbated by the differences in perceptions between the "general public" and those of "experts." *See* D. HENNING, *supra* note 60, at 102. This tendency led the author to observe that "[a]t present, the environmental agencies appear to be of the management type, on a closed-system basis." *Id.* at 48. However, it is stressed that "an *open* system should be developed." *Id.* (emphasis his).

118. *See* G. HAGEVIK, *supra* note 10, at 179; J. CONNER & E. LOEHMAN, ECONOMICS AND DECISIONMAKING FOR ENVIRONMENTAL QUALITY 215 (1975). These commentators point out that models will likely play a large part in overcoming the present "serious dearth of physical and biological data." *Id.* For instance, satellites "can provide computerized sensory data for classifying, analyzing, inventorying and monitoring photographic images . . . . When such material is combined with other photographs and data in an interdisciplinary approach, it is obvious that new dimensions are added to the understanding of the ecosystem." D. HENNING, *supra* note 60, at 163.

119. *See* D. HENNING, *supra* note 60, at 152. *See also supra* text at note 84.

120. "[T]he ecosystem approach encompasses and changes multiple-use and resource planning by introducing more specific criteria and ecological principles. It places natural resources and environmental manipulation in the proper perspective for more intensive and precise environmental administration and planning." D. HENNING, *supra* note 60, at 165. It "is essentially a total system approach. It therefore includes in its purview many things omitted in a less comprehensive system." Caldwell, *The Ecosystem as a Criterion for Public Land Policy*, 10 NAT. RESOURCES J. 203, 205 (1970).

121. G. HAGEVIK, *supra* note 10, at 192-93; Hahn, *supra* note 116, at 340; Dale, *Systems Analysis and Ecology*, 2 ECOLOGY 52 (1970).

substantively incorrect decision will be reached. This greater probability of error generally can be traced to the inability of environmental decisionmakers to deal with certain aspects of the use of models in making such decisions. Second, the use of a model increases the danger that wrong environmental decisions may not be detected and corrected by the reviewing courts.[122]

Certain intrinsic aspects of environmental decisions, particularly those resting on models, make those decisions especially difficult for a court to review. First, because of the policy choices and uncertainty involved in such decisions, some discretion must necessarily be committed to the decisionmaker under vague statutory standards. Second, the decisions often rest on an inadequate data base. Third, because of the value-laden nature of such environmental data and because of the relative crudeness of scientific ecological knowledge, such decisions necessarily rest on subjective assumptions and methodologies, such as the assignment of value to clean water in a cost-benefit analysis. Fourth, the complexities of the subject matter and the level of expertise of the decisionmaker combine to make it difficult for the decisionmaker to properly interpret the evidence presented (modeling and otherwise) so as to assure that his choices implement the proper environmental policies. Fifth, these decisions are often inadequately presented as numbers or graphs; this manner of presentation discourages examination of the underlying choices that are made. Each of the aspects is discussed in greater detail below.

1. Vague Statutory Standards

The standards contained in environmental statutes are vague and generally do little to specify the methodologies to be used by decisionmakers.[123] For instance, environmental statutes often require only such effort as is "practicable" or "available." The discretion that this ambiguity allows an administrative agency has led courts to hold that such policy decisions are essentially legislative in character.[124]

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122. *See Cost-Benefit Analysis*, *supra* note 1, at 446.

123. *See* D. HENNING, *supra* note 60, at 15, 20, 99-100. *See also* Gelpe & Tarlock, *supra* note 20, at 376; Note, *The Environmental Policy Act and Policy-Level Decisionmaking*, 3 ECOLOGY L.Q. 799, 808 n.42 (1973) [hereinafter cited as *Policy-Level Decisionmaking*].

124. So. Terminal v. EPA, 504 F.2d 646, 670 n.37 (1st Cir. 1974) ("the choice of how to reduce hydrocarbon emissions is a legislative-type judgment"). On the basis of this doctrine, the court upheld the agency's rejection of a particular kind of abatement methodology as being "generally recognized as beyond the current state of the art." *Id. See* Picher, *Alternatives Under NEPA: The Functions of Objectives in an Environmental Impact Statement*, 11 HARV. J. LEGIS. 595, 597-98 (1974). Gelpe & Tarlock, *supra* note 20, at 372 n.4.

2. Inadequate Data Base

Because of the pressing need of our environmental problems and the mandatory, action-forcing nature of many of the environmental statutes, many environmental decisions are made in the face of an insufficient data base.[125] This lack of data can often be attributed in large part to the practical difficulties of data collection.[126] This paucity of data may also be attributed to the relevant newness of the complex field of environmental science and ecology.[127] A computer model can be used to overcome or at least alleviate difficulties in decisionmaking caused by this lack of data.[128] Nonetheless, a lack of data can hamper the accurate application of a model.[129]

3. Complexity of the Underlying Science

The complex nature of environmental science increases the likelihood that a decision will be incorrect.[130] The field is a technical one, calling on such esoteric disciplines as biology, ecology, computer programming, statistics, and social science. An ecosystem-based approach to environmental decisionmaking, also known as environmental management, would involve the correlation and coordination of many diverse fields[131] in much the same way that ecology must encompass the use, correlation, and coordination of more compartmentalized scientific disciplines.[132] The multidisciplinary field of ecology integrates biological data with social science data[133] and

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125. BASF Wyandotte Corp. v. Costle, 598 F.2d 637, 652 (1st Cir. 1979); Hercules, Inc. v. EPA, 598 F.2d 91, 107-08 (D.C. Cir. 1978); Weyerhauser v. Costle, 590 F.2d 1011, 1025-26 (D.C. Cir. 1978); Amoco Oil Co. v. EPA, 501 F.2d 722, 740-42 (D.C. Cir. 1974); MAD v. Trainor, 400 F. Supp. 533, 548 (D.C. Md. 1975). *See* Indus. Union Dep't v. Am. Petroleum Inst., 448 U.S. 607, 688 (Marshall, Brennan, Blackmun, J.J., dissenting) (1980).

126. *See, e.g.*, Ass'n of Pac. Fisheries v. EPA, 615 F.2d 794, 811 (9th Cir. 1980).

127. Cin. Gas & Elec. Co. v. EPA, 578 F.2d 660, 664-65 (6th Cir. 1978).

128. *See, e.g.*, Clev. Elec. Illum. Co. v. EPA, 572 F.2d 1150, 1161 (6th Cir. 1978).

129. Kennecott Copper Corp. v. Train, 526 F.2d 1149, 1152 n.16 (9th Cir. 1979), *cert. denied*, 425 U.S. 935 (1976) (noting that the less sophisticated rollback model was used instead of the more sophisticated dispersion model because of a lack of information). *See also*, Clev. Elec. Illum. Co. v. EPA, 572 F.2d 1150, 1160-61 (6th Cir. 1978) (noting that the increased precision of the more sophisticated RAM model requires tremendous amounts of data).

130. *See generally* D. HENNING, *supra* note 61, at 3-21; Faulk, *The Global Environment and International Law: Challenge and Response*, 23 U. KAN. L. REV. 385 (1975); Gelpe & Tarlock, *supra* note 20.

131. *See supra* text at notes 115-21.

132. *See* W. MATTHEWS, *supra* note 15, at 13. In fact, the decisionmaking process that incorporates this knowledge can itself be characterized as a model. *See* Hufschmidt, *Environmental Planning*, X AMERICAN BEHAVIORAL SCIENTIST 6-8 (1966).

133. *See* D. HENNING, *supra* note 61, at 44; G. HAGEVIK, *supra* note 10, at 33-34; Hahn,

other types of information. This synthesizing effort is necessary to comprehend the complex interrelationships involved in the structure of an ecosystem.[134] Advances in the information-storage and data-analysis capabilities of computers have facilitated this trend, and have thereby made the use of such computers more attractive as a scientific basis upon which to ground an administrative decision. The science underlying a model, such as in the field of ecology, attempts to integrate all of these divergent fields.

4. Limitations of the Environmental Decisionmaker

The environmental decisionmaker is not likely to have received any extensive formal training in the fields involved in ecology or environmental management. Even an environmental specialist with extensive knowledge in one scientific discipline is not likely to be trained to make the value judgments often involved in such decisions, such as the choices involved in fairly allocating the burden of compliance amongst all parties subject to regulation.[135] Thus, environmental decisionmaking requires the involvement of experts.

The very presence of these experts also contributes to the probability of error in the decisionmaking process. There is often a tendency on the part of these experts—whether permanent agency staff, or private contractors hired by the agency, or private parties coming before the agency—to give an inadequate disclosure of the actual methodologies used and the limitations of the results that their studies produce.[136] Such results or conclusions may take the form of a report whose only substance is contained in a single graph or table.[137] Alternatively, the expert's results may be in the form of a voluminous accumulation of statistical data with little explication of

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supra note 116, at 340. *See generally* DIVISION OF BEHAVIORAL SCIENCES, NAT'L RESEARCH COUNCIL, NAT'L ACADEMY OF SCIENCES, ENVIRONMENTAL QUALITY AND SOCIAL BEHAVIOR (1973); Barnett, *Environmental Policy and Management*, SOCIAL SCIENCES AND THE ENVIRONMENT (1967).

134. Caldwell, *supra* note 15, at 218. *See* CONNER & LOEHMAN, *supra* note 118, at 205. It is for this reason that computer ecomodels are employed to help in the effort. *See* Mayda, *supra* note 2, at 31-32.

135. D. HENNING, *supra* note 61, at 54.

136. *See Delaware River Factfinding*, *supra* note 14, at 495.

137. *See, e.g., id.* at 403-31. Of course, a court is normally reviewing the administrative record of which such reports would only be a part. If the administrative agency has taken the results from such a study and incorporated it into a report of its own, then it is difficult for a court to then judge the completeness of the report. In this case, the incompleteness of the expert's reports may well be reflected in the incompleteness of the administrative agencies' reports produced from them. "An independent study which examined EIS's prepared by state

the conclusions to be drawn therefrom or with little explication of how the stated conclusions were reached.[138]

These experts' opinions may be distorted by various biases that affect both their methodologies and opinions. Experts are often hired by parties preparing for an adversary hearing, with the obvious attendant danger that the model's results and the conclusions may be manipulated in order to better support the employer's position.[139] Moreover, this bias need not be intentional or conscious. Indeed, there is a greater likelihood of unintentional bias: in this area of statistical analysis the results are highly susceptible to unconsciously held biases which often take the form of strongly held professional opinions or intellectual outlooks toward a problem.[140] Regulations governing the content of draft and final impact statements require expert analysis be at an understandable level and in an understandable form. It is questionable whether such requirements address the inherent susceptibility of expert opinion to manipulative distortion.

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and local authorities concluded that the main inadequacy was the lack of data . . . ." Note, *State Preparation of Environmental Impact Statements for Federally Aided Highway Programs*, 4 FORDHAM URB. L. J. 597, 606 (1976) (citations omitted). *See, e.g.*, City of Romulus v. County of Wayne, 392 F. Supp. 578, 588-89 and n.6 (E.D. Mich. 1975). This is also true for supporting documents for state implementation plans. *See, e.g.*, Texas v. EPA, 499 F.2d 289, 302, 303 n.20, 308 n.31 (5th Cir. 1974).

138. For instance, the Texas SIP litigation involved a review of 10,000 pages of material. Texas v. EPA, 499 F.2d 289, 297 & n.8 (5th Cir. 1974). This tendency towards verboseness may be exacerbated by the courts reviewing the modeling effort. As one commentator notes, "it appears that some courts, searching for a yardstick to measure adequacy, have tacitly considered the length of the alternatives section of the impact statement to be an indication of the discussion's comprehensiveness for full disclosure purposes." Chamouis, *The National Environmental Protection Act of 1969: What Alternative Must An Agency Discuss?*, 12 COLUM. J. L. & SOC. PROB. 231, 234 (1976). Of course, the real issue is not the amount of material that is presented, but the way it is presented. This aspect of the process has also been attacked by observers. For instance, the Ackerman study found "that the style of the [expert's] analysis did not invite the policymaker to confront [the] fundamental questions . . . ." *Delaware River Factfinding*, *supra* note 14, at 481.

139. *See* Tribe, *Ways Not to Think About Plastic Trees: New Foundations for Environmental Law*, 83 YALE L.J. 1315, 1318 & n.23 (1974), and sources cited therein; Lanning, *State Management of the Environment Part One: A Continuing Evaluation of the Michigan Experience*, 8 U. MICH. J. L. REFORM 186, 310-311 (1974). See also Part Two of that article, *id.*, at 466 (1975).

140. This problem can arise from the conceptual rigidity that often accompanies the possession of expertise, *see* Freedman, *Expertise and the Administrative Process*, 28 ADMIN. L. REV. 363, 369 (1976), particularly if the expertise in a scientific field, *see* Spengler, *Machine-Made Justice: Some Implications*, 28 L. & CONT. PROB., 36, 40 (1963). The other facet of the problem is that these experts are "frozen" into viewpoints that are very different from the public to which the system is to respond. D. HENNING, *supra* note 61, at 102; Freedman, *supra* note 140, at 370.

5. Inadequate and Unclear Presentation of Data

The effectiveness of environmental models has also been hampered by the difficulties of properly coordinating experts in the modeling effort and in communicating the results of their efforts to the decisionmaker in an understandable form.[141] For example, the results may appear to be unimpeachable because of the expert's failure to articulate underlying principles.[142] The environmental decisionmaker generally does not have the sophistication needed to deal with many of the intricate facts and methodologies upon which the decision is based.[143] He may have some training in one or more of the fields involved in the environmental decision.[144] No decisionmaker, however, can be trained sufficiently to deal with all of the aspects of this technical, complex, and rapidly developing subject.[145]

Therefore, the decisionmaker must rely on his staff of specialists (if he has one) and the parties' experts to "translate"[146] their work into a language that he can intelligently act upon. The result is that the decisionmaker is highly dependent on these experts to master the complexity of the subject matter.[147] Nevertheless, the decision's

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141. *Delaware River Factfinding*, *supra*, note 14, at 481. For instance, the study pointed out that if the experts "had taken pains to articulate the factors that make the achievement of meaningful environmental improvement uncertain, its analysis would have induced decisionmakers to explore the basic premises of pollution control policy in a far more probing way . . . ." *Id.* "The practical use of results from the modeling of environmental systems has always been limited by . . . the difficulty of communicating results of technical analytic efforts in a form understandable by decision-makers." W. MATTHEWS, *supra* note 15, at 61.

142. G. HAGEVIK, *supra* note 10, at 200.

143. See Freedman, *supra* note 140, at 370-71.

144. It has been noted that decisionmakers are more likely to possess "routinized experience . . . than expertness." Freedman, *supra* note 140, at 371. *But see* Soc. for the Protection of N.H. Forests v. Site Evaluation Comm., 115 N.H. 172, 337 A.2d 778 (1975). In this later case, the state's Supreme Court pointed out that "[t]he site evaluation committee is composed of trained professionals who are specifically authorized by statute to facilitate their task with legal and investigative expertise." *Id.* at 115 N.H. 179, 337 A.2d at 786.

145. "Proficiency is not possible in this 'field' [of environmental management] because there is not enough collective knowledge, theory, or wisdom to define or to describe what would have to be mastered." W. MATTHEWS, *supra* note 15, at 5. *See id.* at 14. Since modeling is in itself a highly technical and rapidly developing field, it is unlikely that a generalist decisionmaker could keep abreast of the state-of-the-art developments in the field. *See id.* at 189; Wilkins, *supra* note 2, at 507-10; D. HENNING, *supra* note 60, at 321; Gelpe & Tarlock, *supra* note 20, at 396-406.

146. *See Delaware River Factfinding*, *supra* note 14, at 480. *See also* M. BUNDY, *supra* note 110, at 18.

147. Professor Freedman speaks of the "danger in excessive reliance upon experts" by administrative decisionmakers. Freedman, *supra* note 140, at 366. Nevertheless, the technical nature of the environmental subject matter—particularly when coupled with that of mathematical modeling and electronic data processing—may lead to a "strengthening" of the

scientific basis, although apparently a source of potential detriment to the decisionmaking process, is often one of the primary factors used in justifying the correctness of the agency's action by the reviewing court.[148] Even though the decisionmaker may not understand the expert's explanation of the workings of an environmental model, often he is nonetheless reassured by simplistic explanations of the model's results, supported by inadequate documentation.[149] This tendency of experts to underdocument is matched by the tendency of decisionmakers to overgeneralize and to avoid stating explicitly the bases of their decision, relying instead on volumes of data and statistics.[150] Consequently, a reviewing court will be faced in this situation with too little documentation and explanation for proper review, although it may have a voluminous record before it.

Moreover, environmental decisions are often "masked" by the numbers which embody the decision.[151] This masking phenomenon makes it difficult for the decisionmaker and later the reviewing court to establish clearly how the numbers embodying the environmental decision (as, for instance, the allowable ambient level or discharge) implements or fails to implement the policy of the applicable statutes or regulations. For example, it is difficult, although not impossible, to establish the concentration of pollutants allowable in water clean enough to meet the "fishable" or "swimmable" requirement of the FWPCAA (Clean Water Act)[152]: it is difficult to conceptualize an environmental result from such a number. This problem of translating environmental policy choices into actual ecological results is

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expert's position in the decisionmaking structure. J. PFIFFNER & H. PRESTUS, PUBLIC ADMINISTRATION 247 (1967); D. HENNING, *supra* note 61, at 57.

148. *Id.* at 54. See *Delaware River Factfinding*, *supra* note 14, at 490 (the decisionmaker often deemphasizes the uncertainties underlying its decision).

149. *See Delaware River Factfinding*, *supra* note 14, at 429.

150. As Professor Baram has stated the problem:

> [f]ormal computer models appear to be quite scientific. Without adequate understanding of the empirical context, without full realization of the embedded assumptions, and without appreciation of the exclusions and omissions, a potential user is easily led down the garden path. The enormous difficulty of specifying a model is not to be lightly dismissed by the so-called "system engineer" who can model anything, any time, any place, for anyone.

Baram, *supra* note 20, at 347.

151. "Dependence on . . . quantification [methodologies] creates an aura of rationality which hides the difficult value judgments which ought to be explicit so that they can be debated on their merits." *Policy-Level Decisionmaking*, *supra* note 123, at 819-20.

152. 33 U.S.C.S. §§ 1251-1376 (Law. Co-op. 1982). *See, e.g.*, Int'l Harvester Co. v. Ruckelshaus, 478 F.2d 615, 630, 648 (D.C. Cir. 1973); City of Romulus v. County of Wayne, 392 F. Supp. 578 (E.D. Mich. 1975). The courts' efforts to pierce this inability to conceptualize the level of environmental quality represented by a decision led the Fourth Circuit to note:

compounded by the uncertainties and inexactitudes associated with predictions, particularly those involving environmental decisions. The ability of decisionmakers conceptually to link the environmental policy choices with the data or numbers forming these decisions, and the communication of this linkage to the public, affects the ability of the public to visualize and respond to the decisions. This ability of the public to understand the choices made by its decisionmakers is a crucial prerequisite to the public input process in environmental decisionmaking, because the decisionmaker often must draw on the data of public opinion in making his decision.[153]

Environmental decisions involving the use of models are often challenged, both as to the broad policy choices made and to the particular application of those choices. Yet, these challenges often are not ostensibly directed at the policy resolution reached by the decisionmaker so much as at its deceptively neutral manifestations: the environmental model. The result is that the resolution of these challenges does not address the political and subjective nature of the decisionmaking process, but instead turns on the evaluation of the appropriateness of the scientific data and methodology relied upon, which appear to be accurately and exactly defined.[154] Fundamentally, the nature of the decision is still political and subjective, regardless of the methodologies used, or the form of presentation of those methodologies. Courts, when presented with the use of mathematical methodologies or computer models in such environmental decisions face the interrelated problems of (1) the roles that courts should play in reviewing the use of these models by administrative decisionmakers; and (2) the standards and scope of review that have

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> [c]ourts require that administrative agencies 'articulate the criteria' employed in reaching their result and are no longer content with bare administrative *ipse dixits* based on supposed administrative expertise . . . . While an agency may have discretion to decide, '[D]iscretion to decide does not include a right to act perfunctorily or arbitrarily' and the agency must in its decision 'explicate fully its course of inquiry, its analysis and its reasoning.'

Appalachian Power Co. v. EPA, 477 F.2d 495, 507 (4th Cir. 1973) (citations omitted).

153. Gelpe & Tarlock, *supra* note 20, at 372-73. These problems intrinsic to environmental predictions are unavoidable and are no reason to not use predictive methodologies in an effort to make the best guess possible. *See* Texas v. EPA, 499 F.2d 289, 319 (5th Cir. 1974).

154. "Often the conflicts among broad alternatives . . . are not amenable to resolution by gathering technical information. The choice may rest on subjective interpretation of the broad policy directives highlighted in NEPA's Section 101, and may be *essentially political* . . . . [I]t is in these fundamental areas that environmentalists often challenge agency action." *Policy-Level Decisionmaking, supra* note 123, at 814-85 (emphasis added). *See* Maechling, *supra* note 2, at 728; Day, *Technology Assessment and the Legal Profession*, 14 JURIMETRICS 67, 75 (1973). *But see* Cape May County Chapter, Inc. v. Macchia, 329 F. Supp. 504 (D.N.J. 1971).

been and should be applied by those courts, which will be collectively referred to as the appropriate "level" of judicial review. The search for the proper judicial role and level of review are reexamined below in eight of the traditional levels of judicial review for environment decisions, and their evolution and development are traced in general terms.

C. Standards and Scope of Judicial Review in Environmental Decisionmaking

1. The *Overton Park* Standard

The level of judicial review which the courts state they apply to environmental decisions based on models is the level of review as formulated in the benchmark case of environmental law, *Citizens to Preserve Overton Park, Inc. v. Volpe*.[155] The fact that courts always recite they are applying the *Overton Park* standard of review does not ensure a uniformity in the level of review applied, however, because the *Overton Park* standard is an ambiguous one. In *Overton Park*, the United States Supreme Court held that a reviewing court should determine whether the environmental action was (1) within the scope of the agency's authority; (2) in conformance with the statute's procedural requirements; or (3) arbitrary, capricious, an abuse of discretion or otherwise not in accordance with law.[156]

The problems of review of environmental decisions based on models as described in part III.B., above, exacerbate the variability of the level of judicial review said to be applied under the *Overton Park* rubric. Problems in judicial review of environmental decisions involving models can be reduced to a question of explicitly defining the proper level of judicial review to be applied when courts recite they are applying the *Overton Park* standard. Most of the cases concerning the validity of environmental models involve substantive review under the arbitrary and capricious standard of the third prong of the *Overton Park* test.[157] The arbitrary and capricious standard of review has not been consistently applied to produce the

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155. 401 U.S. 402 (1971). The approach taken in *Overton Park* was foreshadowed by the decision of the Second Circuit Court of Appeals in Scenic Hudson Preserv. Conf. v. FPC, 354 F.2d 608 (1965), *cert. denied*, 384 U.S. 941 (1966), *aff'd on remand* 453 F.2d 463 (1971). *See* W. RODGERS, HANDBOOK ON ENVIRONMENTAL LAW 20 (1977).

156. Citizens to Preserve Overton Park, Inc. v. Volpe, 401 U.S. 402, 415-17 (1971).

157. Professor Kramer has stated that this third inquiry of substantive review under the arbitrary and capricious standard in most cases constitutes "the heart of the judicial review process." Kramer, *supra* note 5, at 244.

same scope and standards of judicial review, particularly when applied to environmental decisions involving models.

2. Ambiguity and Internal Inconsistency in the Arbitrary and Capricious Level of Substantive Judicial Review

The arbitrary and capricious portion of the *Overton Park* standard is an ambiguous one. Although the phrase "arbitrary and capricious" is a term of art in judicial review, it does little to assist the court in determining the proper scope or standards of judicial review. This is reflected in the numerous different synonyms or characterizations which have been used in the judicial review of environmental decisions.[158] Determining the proper scope and standards under the arbitrary and capricious level of judicial review is also complicated by the fact that the arbitrary and capricious standard actually is composed of a number of differing sub-levels of review, some of which are mutually contradictory.

Under *Overton Park*, the level of factual inquiry is to be searching, probing and careful. Courts seem unable to resist intermingling substantive review under the arbitrary and capricious prong of the *Overton Park* test with procedural review under that standard, although in theory those substantive and procedural review levels are very different. Courts consistently hold agencies to strict compliance with procedural requirements.[159] In contrast, the ultimate level of substantive review is deferential and forbids the reviewing court from substituting its judgment for that of the agency, as discussed further below.

In order to examine the proper scope and standards of judicial review of environmental decisions, this article will examine the statutes upon which such review is based, and will outline the development of the review of such environmental decisions. In order to illustrate the diverse formulations of the current level of substantive review of environmental decisions, the various synonyms and other reformulations used in attempting to describe the level of judicial review used in environmental decisions involving models are examined in part III.C.5., below. This discussion will provide a perspective for the detailed discussion of some of those cases which follows in part IV.

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158. *See infra* text and notes at notes 183-205.

159. As the First Circuit has said, "[t]hough our review of an agency's final decision is a common one, we must be strict in reviewing an agency's compliance with procedural rules." BASF Wyandotte Corp. v. Costle, 598 F.2d 637, 641 (1979); Weyerhauser v. Costle, 590 F.2d 1011, 1027-28 (D.C. Cir. 1978).

3. Statutory Bases for Judicial Review

There are three statutory sources for the scope and standard of judicial review of environmental decisions: (1) the federal Administrative Procedure Act (APA);[160] (2) NEPA;[161] and (3) specific statutes relating to environmental pollution.[162] Oftentimes, more than one of the foregoing statutes must be considered in reviewing an environmental decision, because these review provisions generally are not exclusive of one another.[163] There are exceptions to this rule of

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160. 5 U.S.C.S. §§ 101, 551-559, 701-706 (Law. Co-op. 1980). The provisions most relevant to judicial review of environmental decisions are the provisions of the Administrative Procedure Act (APA) relating to administrative procedure, *id.* §§ 551-559, and the provisions of the APA relating to judicial review, *id.* §§ 701-706. The provisions which are most relevant to the establishment of standards under APA, *id.* §§ 553, 554, 556, 706, have not changed in any substantial respect since those provisions were first codified in 1966 by Public Law 89-554, 80 Stat. 378, as amended by Pub. L. 90-23, 81 Stat. 54 (June 5, 1967). In fact, the basic structure of the APA has changed very little since its original enactment in 1946. *Compare* Pub. L. 404-79th Congress, approved June 11, 1946, 60 Stat. 237-244 §§ 4 (rulemaking, now § 553), 5 (adjudication, now § 554), and 10(e) (scope of review, now § 706).

161. 42 U.S.C.S. §§ 4321-4370 (Law. Co-op. 1982). The original version of NEPA was effective January 1, 1970, *see* Pub. L. 91-190, 83 Stat. 853, and was amended in minor ways effective August 9, 1975, *see* Pub. L. 94-83, 89 Stat. 424. *See generally* Annot., *Construction and Application of §§ 101-105 of National Environmental Policy Act of 1969* (42 *U.S.C.S. §§ 4331, 4335*) *Requiring All Federal Agencies to Consider Environmental Factors in their Planning and Decisionmaking*, 17 A.L.R. FED. 33 (1973); H. GREEN, THE NATIONAL ENVIRONMENTAL POLICY ACT IN THE COURTS (1972).

162. *E.g.*, Clean Air Act, as amended, 42 U.S.C.S. §§ 7401-7642 (Law. Co-op. 1982) [hereinafter cited as CAA]; Federal Water Pollution Control Act, as amended (FWPCAA), 33 U.S.C.S. §§ 1251-1376 (Law. Co-op. 1980); Toxic Substances Control Act, 15 U.S.C.S. §§ 2601-2629 (Law. Co-op. 1982) [hereinafter cited as TSCA]; Solid Waste Disposal Act, as amended, 42 U.S.C.S. §§ 6901-6987 (Law. Co-op. 1982); Noise Control Act of 1972, 42 U.S.C.S. §§ 4901-4918 (Law. Co-op. 1982); Safe Drinking Water Act, 42 U.S.C.S. §§ 300f-300j-10 (Law. Co-op. 1978); Federal Insecticide, Fungicide, and Rodenticide Act, as amended, 7 U.S.C.S. §§ 136-136y (Law. Co-op. 1980 Supp.) [hereinafter cited as FIFRA]; Federal Hazardous Substances Act, 15 U.S.C.S. §§ 1261-1275 (Law. Co-op. 1982); Energy Policy and Conservation Act, 42 U.S.C.S. §§ 6201-6422 (Law. Co-op. 1982); Outer Continental Shelf Land Act, 43 U.S.C.S. § 1347 (Law. Co-op. 1980); 33 U.S.C.S. §§ 1901-1911 (Law. Co-op. 1982 Supp.) (ocean oil pollution); Department of Energy Organization Act, 42 U.S.C.S. §§ 7101-7375 (Law. Co-op. 1982); Emergency Energy Conservation Act of 1979, 42 U.S.C.S. §§ 8501-8541 (Law. Co-op. 1982); Uranium Mill Tailings Radiation Control Act of 1978, 42 U.S.C.S. §§ 7911-7942 (Law. Co-op. 1982); Water Resources Planning Act, 42 U.S.C.S. §§ 1962-1962d-18 (Law. Co-op. 1978); Marine Protection, Research, and Sanctuary Act of 1972, as amended, 33 U.S.C.S. §§ 401-467(e) (Law. Co-op. 1980), and 16 U.S.C.S. §§ 1431-1434 (Law. Co-op. 1982 Supp.). *See also* W. RODGERS, *supra* note 155, at 822-34 (listing other substantive environmental laws which supplement NEPA).

163. *See, e.g.*, Mont. Power Co. v. EPA, 429 F. Supp. 683 (D. Mont. 1977) (applying both the APA and the citizen suit provision of the Clean Air Act); NRDC v. Callaway, 524 F.2d 79 (2d Cir. 1975) (applying both the APA and the citizen suit provision of FWPCAA). Judicial review is available under the APA and applicable substantive environmental laws, unless the substantive laws are exclusive in their jurisdiction, *see infra* text and notes at 164-69, or unless there

nonexclusivity to be found in the judicial review provisions of such statutes as the Clean Air Act,[164] the Federal Water Pollution Control Act (FWPCA) (now the Clean Water Act as of amendment in 1977),[165] the Toxic Substances Control Act (TSCA),[166] the Resource Conservation and Recovery Act (RCRA),[167] the Noise Control Act of 1972,[168] and the Safe Drinking Water Act.[169] Only the FWPCA has been amended to exclude most actions taken thereunder from the coverage of NEPA.[170] In any event, the particular statute relied on is likely to be irrelevant in determining the proper scope and standards of review: *Overton Park* is said to have established for environmental cases the appropriate level of *judicial* review, regardless of the specific statutes or reformulations relied on.[171] Nearly all cases cite *Overton Park* as authority. Because of this claimed uniformity one should be able to speak of a single level of judicial review for such cases without regard for the specific statutes being applied,[172] although this generalization does little to encompass the variety of characterizations given that level of review, as discussed in part III.C.5., below.

4. Evolution of Judicial Review Standards

Problems as to the proper standard of judicial review arose in the earliest environmental cases because of a lack of explicit provisions regarding judicial review and substantive inquiry.[173] As a result, the

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exists another "adequate remedy in a court," 5 U.S.C.S. § 704 (Law. Co-op. 1980). *See* W. Penn. Power Co. v. Train, 538 F.2d 1020 (3d Cir.), *cert. denied*, 429 U.S. 1091 (1976); GM Corp. v. Volpe, 321 F. Supp. 1112 (D. Del.), *aff'd*, 457 F.2d 922 (3d Cir. 1970).

164. 42 U.S.C.S. § 7607(b) (Law. Co-op. 1982). *See* Harrison v. PPG Ind., Inc., 446 U.S. 578 (1980).

165. 33 U.S.C.S. § 1369(b) (Law. Co-op. 1980).

166. 15 U.S.C.S. § 2618(a)(1) (Law. Co-op. 1982).

167. 42 U.S.C.S. § 6976(1) (Law. Co-op. 1982).

168. 42 U.S.C.S. § 4915(a) (Law. Co-op. 1982).

169. 42 U.S.C.S. § 300j-7(a)(1) (Law. Co-op. 1978).

170. *See* 33 U.S.C.S. § 1371(c) (Law. Co-op. 1980).

171. Commentators suggest that the *Overton Park* case may have abolished any distinctions that may have existed between the substantial evidence level of review and the arbitrary and capricious standard of review. *See* Sive, *Some Thoughts of an Environmental Lawyer in the Wilderness of Administrative Law*, 70 COLUM. L. REV. 612 (1970). It is also suggested that NEPA may impose more stringent standards of review—or at least additional standards of review—than do those other statutes. W. RODGERS, *supra* note 155, at 716-17.

172. This claimed uniformity in formulation of the appropriate scope and standards of judicial review does not mean that courts have uniformly applied those standards. In fact, courts have not uniformly applied those standards, particularly in cases involving models. *See infra* notes 198-205 and cases cited therein. Such nonuniformity cannot be explained by the differing statutes involved.

173. *See* Note, *The Least Adverse Alternative Approach to Substantive Review under*

level of judicial review for environmental decisions went through an evolutionary process, particularly during the first few years after the implementation of NEPA. Initially, review was limited to issues that were "solely procedural."[174] As time passed, courts began to realize that it was necessary to engage in some level of substantive review.[175]

This evolution of the concept of substantive review was paralleled by the evolution of meanings of the phrases "arbitrary and capricious" and "substantial evidence": the differences in the meanings of the phrases diminished over time.[176] These two standards of substantive review are contained in § 706 of the APA which defines the scope of review to be applied under that Act.[177] The Supreme Court in *Overton Park* held that the substantial evidence test was to be ap-

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NEPA, 88 HARV. L. REV. 735, 736 (1975) (citation omitted) [hereinafter cited as *Least Adverse Alternative*]; *Cost-Benefit Analysis*, *supra* note 1, at 449.

174. *See Least Adverse Alternative*, *supra* note 173, at 735 n.2, 742-47; Wharton, *Judicially Enforceable Substantive Rights Under NEPA*, 10 U.S.F.L. REV. 415, 423-34 (1976); Note, *The Judicial Role in Defining Procedural Requirements for Agency Rulemaking*, 87 HARV. L. REV. 782 (1974) [hereinafter cited as *Agency Rulemaking Procedural Requirements*]; Yarrington, *Judicial Review of Substantive Agency Decisions: A Second Generation of Cases Under the National Environmental Policy Act*, 19 S.D.L. REV. 279 (1974).

175. *See Least Adverse Alternative*, *supra* note 173, at 735.

176. *See* Comment, *Judicial Review of the Facts in Informal Rulemaking: A Proposed Standard*, 84 YALE L.J. 1750 (1950). *See also* F. ANDERSON, NEPA IN THE COURTS 3 (1973).

177. The two so-called substantive review provisions of APA are contained in subparagraphs (2)(A) and (2)(E) of § 706 of the Act, 5 U.S.C.A. § 706(2)(A), (2)(E), which states in full:

> To the extent necessary to decision and when presented, the reviewing court shall decide all relevant questions of law, interpret constitutional and statutory provisions, and determine the meaning or applicability of the terms of an agency action. The reviewing court shall—
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> (1) compel agency action unlawfully withheld or unreasonably delayed; and
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> (2) hold unlawful and set aside agency action, findings, and conclusions found to be—
>
> (A) arbitrary, capricious, and abuse of discretion, or otherwise not in accordance with law;
>
> (B) contrary to constitutional right, power, privilege, or immunity;
>
> (C) in excess of statutory jurisdiction, authority, or limitations, or short of statutory right;
>
> (D) without observance of procedure required by law;
>
> (E) unsupported by substantial evidence in a case subject to sections 556 and 557 of this title [5 U.S.C.S. §§ 556 and 557] or otherwise reviewed on the record of an agency hearing provided by statute; or
>
> (F) unwarranted by the facts to the extent that the facts are subject to trial de novo by the reviewing court.
>
> In making the foregoing determinations, the court shall review the whole record or those parts of it cited by a party, and due account shall be taken of the rule of prejudicial error.

Id. § 706.

plied only in narrow, specifically limited situations, which the Court restricted to certain informal rulemaking proceedings or public adjudicatory hearings.[178] As a general matter, the substantial evidence standard applies if an agency action (either an adjudication or a rule) is required by statute to be made on the record after an opportunity for an agency hearing.[179] This substantial evidence test has been held applicable to some environmental decisions, such as cases involving "scientific rulemaking"[180] and permits issued under the National Pollutant Discharge Elimination System.[181] Currently, however, there is little difference in review under the arbitrary and capricious standard and the substantial evidence test.

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178. Citizens to Preserve Overton Park v. Volpe, 401 U.S. 402, 414 (1971). The Court said that "[r]eview under the substantial-evidence test is authorized only when the agency action is taken pursuant to rulemaking provisions of the Administrative Procedure Act itself, 5 U.S.C. § 553 . . . , or when the agency action is based on a public adjudicatory hearing. *See* 5 U.S.C. §§ 556, 557 . . . ." *Id.* The substantial evidence test is sometimes known as the *Universal Camera* standard, as named after one of the earliest leading cases defining substantial evidence in the area of review of administrative decisions. Universal Camera Corp. v. NLRB, 340 U.S. 474 (1951). *See generally* Jaffe, *Judicial Review: "Substantial Evidence on the Whole Record,"* 64 HARV. L. REV. 1233 (1951). Some environmental cases involving scientific rulemaking have applied the substantial evidence test. *See infra* note 180 and cases cited therein.

179. *See*, 5 U.S.C.A. §§ 553(c) (rulemaking), 554(a) (adjudications) (Law. Co-op. 1980), both of which use the language "required by statute to be determined on the record after opportunity for an agency hearing." *See also id.* § 706(2)(E), *quoted supra* note 171, and § 556(d) (forbidding the imposition of a sanction unless "supported by and in accordance with the reliable, probative, and substantial evidence"). As the Supreme Court stated, "the basic requirement for substantial-evidence review" is that the relevant statute require a hearing "designed to produce a record that is to be the basis for agency action." Citizens to Preserve Overton Park, Inc. v. Volpe, 401 U.S. 402, 415 (1971).

180. *See, e.g.*, EDF v. EPA, 598 F.2d 62, 82, 85, 89-90 (D.C. Cir. 1978) (citing Indus. Union Dep't v. Hodgson, 499 F.2d 467 (D.C. Cir. 1974)). The *EDF* opinion listed the characteristic of scientific rulemaking as involving extensive and often conflicting evidence, issues on the frontier of scientific knowledge and limited knowledge and much uncertainty, thus necessitating a policy judgment by the agency. In *EDF*, the District of Columbia Court of Appeals held that the substantial evidence test required that EPA's conclusions must be such that, in light of all the evidence of the record as a whole, a reasonable mind might accept it as adequate to support the conclusion. 598 F.2d at 82. The court held that the agency must justify the rule by the "weight of the evidence." *Id.* at 90. Other courts have upheld the application of the substantial evidence rule to scientific rulemaking. *See, e.g.*, Hercules, Inc. v. EPA, 598 F.2d 91, 106-07, 109 (D.C. Cir. 1978). *But see* Ass'n of Pac. Fisheries v. EPA, 615 F.2d 794, 812 (9th Cir. 1980) (effluent limitations under FWPCA; most upheld, but some remanded for use of inapplicable data); Weyerhauser Co. v. Costle, 590 F.2d 1011, 1024-27 (D.C. Cir. 1978); Ethyl Corp. v. EPA, 541 F.2d 1, 31 & n.26, 43, 53 n.124 (D.C. Cir.), *cert. denied*, 426 U.S. 941 (1976) (upholding EPA's rejection of non-catalysts control technologies for automobile emissions).

The United States Supreme Court has in dicta in a recent case endorsed this substantial evidence standard for scientific rulemaking. *See* Indus. Union v. Am. Petroleum Inst., 448 U.S. 607, 655-56 n.62 (1980); *accord, id.* at 666-67 (Powell, J., concurring in part and in the judgment); *id.* at 706 (Marshall, Brennan, White, and Blackmun, J.J., dissenting).

181. *E.g.*, Steel Corp. v. Train, 556 F.2d 822 (7th Cir. 1977). In that case, the Seventh Cir-

Several recent cases by the United States Supreme Court may have cast doubt on the continued viability of substantive review under NEPA,[182] although *Overton Park* will likely continue to be cited as the standard for the judicial review of environmental decisions. The problem will remain of extracting the appropriate scope and standards of judicial review for environmental decisions from the plethora of the descriptive phrases used by the courts to attempt to describe that standard of review.

5. The Differing Reformulations of the *Overton Park* Standard of Review as Applied to Environmental Models

The various reformulations or characterizations of the different aspects of the appropriate level of judicial review can be divided into three groups: (1) what to look for; (2) how deep to look; and (3) how far the decisionmaker should be permitted to stray from statutory standards before being returned. As stated in other terms, the first group of characterizations of the judicial review standard conceptually relates to an examination of the mental processes of the decisionmaking agency. The second group of these characterizations attempts to delineate the extent of the factual examination that a reviewing court should undertake, both within and outside of the record. The third group of those characterizations is composed of attempts by courts to further describe the ultimate level of judicial review which is appropriate to maintain the proper relationship between the court and the administrative agency.

a. The Mental Process Reformulations

In the first group of characterizations of the standard of review are reformulations which examine the mental processes of the administrative decisionmaker. This is not likely to be an examination of the mental processes of a real person, because under normal circumstances such mental processes cannot be inquired into.[183] Courts examine the "whole record"[184] to ensure that the administrative deci-

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cuit held that a permit should be classified as a license under the APA, which would subject it to special review provisions under that Act. *See* 5 U.S.C.S. §§ 551(8), (9) and 558(c) (Law. Co-op. 1980). *But see* Taylor v. District Engineer, U.S. Army Corps of Engineers, 567 F.2d 1332, 1337 (5th Cir. 1978) (the proper standard is whether the decision was "arbitrary, capricious, or an abuse of discretion").

182. *See* Strycker's Bay Neighborhood Council, Inc. v. Karlen, 444 U.S. 223 (1980); Vermont Yankee Nuclear Power Corp. v. NRDC, 435 U.S. 519 (1978).

183. *See, e.g.*, Citizens to Preserve Overton Park v. Volpe, 401 U.S. 402, 420 (1971).

184. The "whole record" requirement of the APA rises from the final sentence of the

sionmaker has engaged in "reasoned decisionmaking"[185] and exercised "reasoned discretion."[186] The court will also look to ensure that there was a rational basis or reasoned scientific basis to substantiate a "rational decision"[187] and that the agency has provided an adequate, satisfactory, or reasoned explanation for its decision.[188] If such an explanation is not provided by the agency, the court will further examine the whole record to see if a course of reasoning or

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review statute, which states that in making the determinations of arbitrariness, capriciousness, or the like, "the court shall review the whole record or those parts of its cited by a party . . . ." 5 U.S.C.S. § 706 (Law. Co-op. 1980).

185. *See, e.g.*, Ass'n of Pac. Fisheries v. EPA, 615 F.2d 794, 803, 812 (9th Cir. 1980) (overturn if based on facts "entirely fictional or utterly without scientific support"); Bunker Hill v. EPA, 572 F.2d 1286, 1292 (6th Cir. 1977); Mision Indus., Inc. v. EPA, 547 F.2d 123, 132 (1st Cir. 1976) ("reasoned determination"); Sierra Club v. EPA, 540 F.2d 1114, 1133 (D.C. Cir. 1976), *vacated as moot*, 434 U.S. 809 (1977); Portland Cement Ass'n v. Ruckelshaus, 486 F.2d 375 (D.C. Cir. 1973), *cert. denied*, 417 U.S. 921 (1974), *aff'd*, 513 F.2d 506 (per curiam), *cert. denied*, 423 U.S. 1025 (1975), *reh'g denied*, 423 U.S. 1092 (1976).

186. *See, e.g.*, Bunker Hill Co. v. EPA, 572 F.2d 1286, 1294 (9th Cir. 1977); Ethyl Corp. v. EPA, 541 F.2d 1, 39 (D.C. Cir.) (*en banc*), *cert. denied*, 426 U.S. 1 (1976); Duquesne Light Co. v. EPA, 522 F.2d 1186, 1192-93 (3d Cir. 1975), *vacated* 427 U.S. 903 (1976); Portland Cement Ass'n v. Ruckelshaus, 486 F.2d 375, 402 (D.C. Cir. 1973), *cert. denied*, 417 U.S. 921 (1974); *aff'd*, 513 F.2d 506 (per curiam), *cert. denied*, 423 U.S. 1025 (1975), *reh'g denied*, 423 U.S. 1092 (1976); Buck County Bd. of Comm'rs v. Interstate Energy Co., 403 F. Supp. 805, 818 (E.D. Pa. 1975).

187. *See, e.g.*, Asarco, Inc. v. EPA, 616 F.2d 1153, 1162-63 (9th Cir. 1980) ("reasoned scientific basis" and "scientific and technical basis"); BASF Wyandotte v. Costle, 598 F.2d 637, 652 (1st Cir. 1977) (facts relied on have some basis in the record); Weyerhauser Co. v. Costle, 590 F.2d 1011, 1026 (D.C. Cir. 1978); Clev. Elec. Illum. Co. v. EPA, 572 F.2d 1150, 1161 (6th Cir. 1978); Mision Indus., Inc. v. EPA, 547 F.2d 123, 130 (1st Cir. 1976) ("informed judgment"); CPC Int'nl, Inc. v. EPA, 515 F.2d 1032, 1048-50 (8th Cir. 1975) (must explain bases); So. Terminal Corp. v. EPA, 504 F.2d 646, 655 & n.5 (1st Cir. 1974) (must be rationally supported); Amoco Oil v. EPA, 501 F.2d 702, 740-41 (D.C. Cir. 1974); MAD v. Train, 400 F. Supp. 533, 563, 574 (D. Md. 1975) (reasonable conclusion in light of present science); *id.* at 564, 574 (rational conclusion).

188. *See, e.g.*, PPG Ind., Inc. v. Costle, 630 F.2d 462, 466 (6th Cir. 1980); Asarco, Inc. v. EPA, 616 F.2d 1153, 1159 (9th Cir. 1980) (satisfactory explanation); BASF Wyandotte Co. v. Costle, 598 F.2d 637, 652 (1st Cir. 1979); Weyerhauser v. Costle, 590 F.2d 1011, 1026, 1054 (D.C. Cir. 1978) (adequate explanation); No. Ohio Lung Ass'n v. EPA, 572 F.2d 1143, 1148 (6th Cir. 1978). As the Sixth Circuit said in *PPG*, the court need not take the agency's word that the agency reasonably analyzed its data. 630 F.2d at 466; Bunker Hill v. EPA, 572 F.2d 1286, 1297 (6th Cir. 1977) (adequate explanation; called the "usual standard"); Appalachian Power Co. v. Train, 545 F.2d 1351, 1356-57 (4th Cir. 1976); FMC Corp. v. Train, 539 F.2d 973, 981 (4th Cir. 1976) (adequate explanation); Hooker Chem. v. Train, 537 F.2d 620, 639 (2d Cir. 1976) (adequate explanation); Am. Iron & Steel Inst. v. EPA, 526 F.2d 1027, 1047 (3d Cir. 1975) (must articulate the standards); CPC Int'nl, Inc. v. EPA, 515 F.2d 1032, 1048-50 (8th Cir. 1975) (must explain relevant factors and bases); Reserve Mining Co. v. EPA, 514 F.2d 492, 507 n.20, 514-20, 529, 535-40 (8th Cir. 1975) (must give adequate reasons and explanations); Amoco Oil Co. v. EPA, 501 F.2d 727, 740-41 (D.C. Cir. 1974) (adequate reasons and explanation). As the Sixth Circuit said in *PPG*, the court need not take the agency's word that the agency reasonably analyzed its data. 630 F.2d at 466.

course of inquiry can be discerned.[189] Courts also have a reasonable man standard for reviewing such technical decisions and making inferences from the administrative record.[190]

Although there may be only subtle semantic differences amongst these phrases, and although the use of any one phrase in the place of another may make no difference as to the ultimate outcome of the case, the phrases implicitly focus on differing aspects of the environmental decision. The reasoned decisionmaking and rational basis reformulations of the standards appear to focus more on the factual portions of a decision, whereas the reasoned discretion and rational decision reformulations of the standard appear to focus more on the policy-type elements of a decision.

The final mental process formulation of the review standard is the "relevant factors" statement of the review standard, which requires the decisionmaker to consider in good faith all relevant factors underlying the decision.[191] The relevant factors formulation appears to be the most substantive of the characterizations because it connotes a more searching review into the various elements (such as data and methodology) of the decision, rather than a broad overview

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189. *See, e.g.*, Asarco, Inc. v. EPA, 616 F.2d 1153, 1161 (9th Cir. 1980) (course of inquiry); BASF Wyandotte v. Costle, 598 F.2d 637, 651-52 (1st Cir. 1979) (explain process); Am. Petroleum Inst. v. EPA, 540 F.2d 1023 (10th Cir. 1976); Am. Iron & Steel Inst. v. EPA, 526 F.2d 1027, 1047 (3d Cir. 1975); Texas v. EPA, 499 F.2d 289, 297 (5th Cir. 1974) (course of inquiry, analysis, and reasoning). Courts held that if the course of reasoning—though unstated—can nonetheless be discerned to be proper then the decision should be upheld. *E.g.*, Am. Iron & Steel Inst. v. EPA, 526 F.2d at 1047 (citing Bowman Transp., Inc. v. Arkansas-Best Freight Sys., Inc., 419 U.S. 281, 286 (1974)).

190. *See, e.g.*, BASF Wyandotte Corp. v. Costle, 598 F.2d 637, 647-48, 651 (1st Cir. 1979) (quoting Weyerhauser Co. v. Costle, 590 F.2d 1011, 1026-27 (D.C. Cir. 1978)); Coal. for Responsible Regional Develop. v. Coleman, 555 F.2d 398, 399-400 (4th Cir. 1977) (rule of reason); Evans v. Train, 460 F. Supp. 237, 247 (S.D. Ohio 1978) (reasonably prepared reader); Conserv. Council of N.C. v. Froehlke, 435 F. Supp. 775, 790 (M.D.N.C. 1977) (responsible executive).

191. *See, e.g.*, Citizens to Preserve Overton Park v. Volpe, 401 U.S. 402, 416 (1970); Asarco, Inc. v. EPA, 616 F.2d 1153, 1160 (9th Cir. 1980); BASF Wyandotte v. Costle, 598 F.2d 637, 558-59 (1st Cir. 1978); Weyerhauser v. Costle, 590 F.2d 1011, 1024-25 (D.C. Cir. 1978); Bunker Hill Co. v. EPA, 572 F.2d 1286, 1294 (9th Cir. 1977); No. Ohio Lung Ass'n v. EPA, 572 F.2d 1143, 1148 (6th Cir. 1978); Coal. for Responsible Regional Develop. v. Coleman, 555 F.2d 298, 299-300 (4th Cir. 1977); FMC Corp. v. Train, 539 F.2d 973 (4th Cir. 1976); Hooker Chem. v. Train, 537 F.2d 620, 639 (2d Cir. 1976); Duquesne Light Co. v. EPA, 526 F.2d 1186, 1192-93 (3d Cir. 1975), *vacated*, 427 U.S. 907 (1976); CPC Int'nl, Inc. v. Train, 515 F.2d 1032, 1048-50 (8th Cir. 1975) (must explain relevant factors); So. Terminal Corp. v. EPA, 504 F.2d 646, 655 (1st Cir. 1974); Texas v. EPA, 499 F.2d 289, 296-97 (1st Cir. 1974); Life of the Land v. Brinegar, 485 F.2d 460, 467-68 (9th Cir. 1974), *cert. denied*, 416 U.S. 961 (1974); Conserv. Council of N.C. v. Froehlke, 435 F. Supp. 775, 783 (M.D.N.C. 1977); MAD v. Trainor, 400 F. Supp. 533, 541, 547, 572, 574 (D. Md. 1975).

of the reasoning used by the agency. Similarly, courts do not allow post hoc rationalizations of agency reasoning from these factors.[192]

b. The Scope-of-Inquiry Characterizations

The second category of formulations of the review standard attempts to characterize the scope of the judicial review effort, in particular, the appropriate extent of factual inquiry. The most common formulations of the various scope formulations of the standard are those which require a "hard look"[193] or "substantial inquiry"[194] of the whole record. Other formulations of the standard require a "rigorous examination" of the decision[195] and a "searching," "thorough," "in-depth," "careful," or "probing" review thereof,[196] although the courts simultaneously note that their inquiry should be a narrow one.[197]

c. The Ultimate-Review-Level Reformulations

The third group of formulations of the standard describes the ultimate level of judicial review. The most common formulation is that

192. *See, e.g.*, Citizens to Preserve Overton Park v. EPA, 401 U.S. 402, 419 (1970); Columbus & So. Ohio Elec. Co. v. EPA, 638 F.2d 910, 912 (6th Cir. 1980); Bunker Hill v. EPA, 572 F.2d 1286, 1292 (6th Cir. 1977); MAD v. Trainor, 400 F. Supp. 533, 574 (D. Md. 1975).

193. *See, e.g.*, Aberdeen and Rockfish R.R. Co. v. Students Challenging Regulatory Procedures, 422 U.S. 289, 322, 326 n.28 (1974) (dictum); Coal. for Responsible Regional Develop. v. Coleman, 555 F.2d 398, 399-400 (4th Cir. 1977); Evans v. Train, 460 F. Supp. 237, 247 (S.D. Ohio 1978); Conserv. Council of N.C. v. Froehlke, 435 F. Supp. 775, 782 (M.D.N.C. 1977); Bucks County Bd. of Comm'rs v. Interstate Energy Co., 403 F. Supp. 805, 813, 818 (E.D. Pa. 1975).

194. *See, e.g.*, Citizens to Preserve Overton Park v. Volpe, 401 U.S. 402, 415 (1970); Asarco, Inc. v. EPA, 616 F.2d 1159, 1160 (9th Cir. 1980); Am. Petroleum Inst. v. EPA, 540 F.2d 1023, 1028 (10th Cir. 1976); Texas v. EPA, 499 F.2d 289, 297 (5th Cir. 1974); Conserv. Council of N.C. v. Froehlke, 435 F. Supp. 775, 781-82 (M.D.N.C. 1977); MAD v. Trainor, 400 F. Supp. 533, 573 (D. Md. 1975); Sierra Club v. Froehlke, 359 F. Supp. 1289 (S.D. Tex. 1973), *rev'd on other gnds. sub nom.* Sierra Club v. Callaway, 499 F.2d 982 (5th Cir. 1974); Cape Henry Bird Club v. Laird, 359 F. Supp. 404, 410-11 (W.D. Va.), *aff'd*, 484 F.2d 453 (4th Cir. 1973).

195. *See, e.g.*, Duquesne Light Co. v. EPA, 522 F.2d 1186, 1192-93 (3d Cir. 1975), *vacated*, 427 U.S. 902 (1976).

196. *See, e.g.*, Citizens to Preserve Overton Park v. Volpe, 401 U.S. 402, 415-16 ("thorough, probing, in-depth review" and "searching and careful," though "narrow"); No. Ohio Lung Ass'n v. EPA, 572 F.2d 1143, 1148 (6th Cir. 1978) (searching and careful, though narrow); Am. Petroleum Inst. v. EPA, 540 F.2d 1023, 1028-29 (10th Cir. 1976) (probing; more so than substantial evidence test); So. Terminal Corp. v. EPA, 504 F.2d 646, 655 (1st Cir. 1974) (inquiries into facts to be searching and careful).

197. *See, e.g.*, Vermont Yankee Nuclear Power Corp. v. NRDC, 437 U.S. 519, 550 (1977); Citizens to Preserve Overton Park v. Volpe, 401 U.S. 402, 416 (1970); BASF Wyandotte v. Costle, 598 F.2d 637, 641 (1st Cir. 1979) (strict procedural review, but narrow substantive review); Appalachian Power Co. v. EPA, 579 F.2d 846, 854 (4th Cir. 1978); No. Ohio Lung Ass'n v. EPA, 572 F.2d 1143, 1148 (6th Cir. 1978) (searching and careful though narrow);

the decision cannot be arbitrary and capricious,[198] which is the language used in the APA[199] and the Clean Air Act.[200] In addition, the courts will overturn an agency decision which embodies an "abuse of discretion,"[201] which the courts appear to equate with the

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Coal. for Responsible Regional Develop. v. Coleman, 555 F.2d 398, 399-400 (4th Cir. 1977); EDF v. Corps of Engineers, 470 F.2d 289, 300 n.17 (8th Cir. 1972), *cert. denied*, 372 U.S. 921 (1973), and authorities therein; Conserv. Council of N.C. v. Froehlke, 435 F. Supp. 775, 782 (M.D.N.C. 1977); Int'nl Harvester Co. v. Ruckelshaus, 478 F.2d 615, 650 (D.C. Cir. 1973) (Bazelon, J., concurring). The *BASF* court expressly affirmed the appropriateness of a narrow standard of substantive review where the case involves numerical and quantitative elements. *See* 598 F.2d at 644-45, 647-48. *Vermont Yankee* established the proposition that, although courts should apply a stringent review of procedural requirements under NEPA, courts are not free to impose additional procedural requirements beyond those provided in the APA. *See* 437 U.S. 519, 524-25, 545-48.

198. *See, e.g.*, Strycker's Bay Neighborhood Council v. Karlen, 444 U.S. 223, 228 n.8 (1979) (per curiam); Citizens to Preserve Overton Park v. Volpe, 401 U.S. 402, 414, 416 (1970); Asarco, Inc. v. EPA, 616 F.2d 1153, 1155, 1159-61 (9th Cir. 1980); Ohio Envt'l Council v. EPA, 593 F.2d 24, 32 (6th Cir. 1979); Weyerhauser Co. v. Costle, 590 F.2d 1011, 1024-25 (D.C. Cir. 1978); Bunker Hill Co. v. EPA, 572 F.2d 1286, 1294 (9th Cir. 1977) (SIP); Clev. Elec. Co. v. EPA, 572 F.2d 1150, 1161 (6th Cir. 1978); No. Ohio Lung Ass'n v. EPA, 572 F.2d 1143, 1148 (6th Cir. 1978) (SIP); Coal. for Responsible Regional Develop. v. Coleman, 555 F.2d 398, 399-400 (4th Cir. 1977); Mision Indus., Inc. v. EPA, 547 F.2d 123, 128-29 (1st Cir. 1976) (SIP); Ethyl Corp. v. EPA, 541 F.2d 1, 34-35 and n.74, 37 and n.79 (D.C. Cir.) (en banc), *cert. denied*, 426 U.S. 941 (1976); Sierra Club v. EPA, 540 F.2d 1114, 1123, 1135-36 and n.58 (D.C. Cir. 1976), *vacated as moot*, 434 U.S. 809 (1977); Am. Petroleum Inst. v. EPA, 540 F.2d 1023, 1028 (10th Cir. 1976) (by implication); Nat. Asphalt Pavement Ass'n v. Train, 539 F.2d 775, 787 (D.C. Cir. 1976); City of Santa Rosa v. EPA, 534 F.2d 150, 154 (9th Cir. 1976); NRDC v. EPA, 529 F.2d 755, 760 (5th Cir. 1976) (SIP); Kennecott Copper Corp. v. Train, 526 F.2d 1149-53 and n.16 (9th Cir. 1975), *cert. denied*, 425 U.S. 935 (1976); Am. Iron & Steel Inst. v. EPA, 526 F.2d 1027, 1047 (3d Cir. 1975); Am. Meat Inst. v. EPA, 526 F.2d 442, 452-53 (7th Cir. 1975); Duquesne Light Co. v. EPA, 522 F.2d 1186, 1192, 1199 (3d Cir. 1975) (SIP), *vacated on other gnds*, 427 U.S. 902; CPC Int'nl, Inc. v. Train, 515 F.2d 1032, 1044 (8th Cir. 1975); So. Terminal Corp. v. EPA, 504 F.2d 646, 655 (1st Cir. 1974); Amoco Oil Company v. EPA, 501 F.2d 727, 739 (D.C. Cir. 1974); Texas v. EPA, 499 F.2d 289, 296-97, 299 n.13, 301, 306, 308, 313-15, 318 (5th Cir. 1974); Life of the Land v. Brinegar, 485 F.2d 460, 469 (9th Cir. 1973), *cert. denied*, 416 U.S. 961 (1974) (clearly insufficient weight to environmental values); Del. Citizens for Clean Air, Inc. v. Admin., 480 F.2d 972, 975-76 (3d Cir. 1973); Evans v. Train, 460 F. Supp. 237 (S.D. Ohio 1978); Ohio v. EPA, 460 F. Supp. 248, 254 (S.D. Ohio 1978); Conserv. Council of N.C. v. Froehlke, 435 F. Supp. 775, 781-82, 792 (M.D.N.C. 1977); Mid-Shiawassee County Concerned Citizens v. Train, 408 F. Supp. 650, 653 (rejecting the reasonableness standard), 660 (D. Mich. 1976); Grain Processing Corp. v. Train, 407 F. Supp. 96, 98-99 (S.D. Iowa 1976); Mont. Wildlife Fed. v. Morton, 406 F. Supp. 489, 490 (D. Mont. 1976); Buck's County Bd. of Comm'rs v. Interstate Energy Co., 403 F. Supp. 805, 812-13 (E.D. Pa. 1975); MAD v. Trainor, 400 F. Supp. 533, 547 (D. Md. 1975) (demonstrably capricious); Cape Henry Bird Club v. Laird, 359 F. Supp. 404, 409 (W.D. Va.), *aff'd*, 484 F.2d 453 (4th Cir. 1973); Concerned about Trident v. Schlesinger, 400 F. Supp. 454 (D.C. Cir. 1976).

199. 5 U.S.C.S. § 706(2)(A) (Law. Co-op. 1980).

200. 42 U.S.C.S. § 7607(d)(9)(A) (Law. Co-op. 1982), which applies to such actions by EPA as rules, regulations, or SIP's. This subparagraph (d) implies that review under the subparagraph (A) arbitrary and capricious standard is *substantive* because it contains a separate provision for overturning arbitrary or capricious *procedural* errors.

201. *See, e.g.*, Citizens to Preserve Overton Park v. Volpe, 401 U.S. 402, 414, 416 (1970);

APA standard. Courts recite that they defer to the decision of the agency to ensure that the court not risk substituting its judgment for that of the agency.[202] One phrase sometimes used speaks in terms of ensuring a "minimal level of meaningful review."[203] As discussed further below, this latter phrase of a minimal level of meaningful review best describes the most appropriate level of judicial review.

Although the cases do not make the differentiation, the language of arbitrariness or capriciousness is most often used for the review of factual elements and bases of a decision, whereas the abuse of discretion standard is most often applied to portions of a decision which entail discretionary, policy-type aspects of the decision. This conclusion is supported by the language of the APA and the Clean Air Act, both

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BASF Wyandotte v. Costle, 598 F.2d 637, 641, 644, 648, 652 (1st Cir. 1979); Ohio Envt'l Coun. v. EPA, 593 F.2d 24, 32 (6th Cir. 1979); Weyerhauser Co. v. Costle, 590 F.2d 1011, 1024-25, 1053, 1060-61 (D.C. Cir. 1978); Clev. Elec. Illum. Co. v. EPA, 572 F.2d 1150, 1161 (6th Cir. 1978); No. Ohio Lung Ass'n v. EPA, 572 F.2d 1143, 1148 (6th Cir. 1978); Ethyl Corp. v. EPA, 541 F.2d 1, 34 (D.C. Cir.) (en banc), *cert. denied*, 426 U.S. 941 (1976); Del. Citizens for Clean Air, Inc. v. Admin., 480 F.2d 972, 975-76 (3d Cir. 1973); Evans v. Train, 460 F. Supp. 237, 241 (S.D. Ohio 1978); Ohio v. EPA, 460 F. Supp. 248, 250 (S.D. Ohio 1978); Bucks County Bd. of Comm'rs v. Interstate Energy Co., 403 F. Supp. 808, 812-13 (E.D. Pa. 1975).

202. For instances of judicial deference *see, e.g.*, Union Elec. Co. v. EPA, 427 U.S. 246, 255 (1976); Train v. NRDC, 421 U.S. 60, 75, 87 (1975); BASF Wyandotte Co. v. Costle, 598 F.2d 637, 655 (1st Cir. 1979), and cases cited therein, *id.* at 647; EDF v. EPA, 598 F.2d 62, 80 (D.C. Cir. 1978); Weyerhauser v. Costle, 590 F.2d 1011, 1026 (D.C. Cir. 1978); Indus. Union Dep't v. Hodgson, 499 F.2d 467, 474-75 n.18 (1974). The decision is entitled to a "presumption of regularity." Citizens to Preserve Overton Park v. Volpe, 401 U.S. 402, 415 (1970); Am. Iron & Steel Inst. v. EPA, 526 F.2d 1027, 1047 (3d Cir. 1975); Duquesne Light Co. v. EPA, 522 F.2d 1186, 1192 (3d Cir. 1975); So. Terminal Corp. v. EPA, 504 F.2d 646, 655 (1st Cir. 1974) (discretion to choose is EPA's). *See also infra* text and notes at notes 225-48 dealing with the bases for this judicial deference to agencies' decisions.

Courts are sensitive to the need to accord legislative-like decisions of agencies a strong presumption of validity and regularity. *See, e.g.*, Vermont Yankee Nuclear Power Corp. v. NRDC, 435 U.S. 519, 555 (1977); Citizens to Preserve Overton Park v. Volpe, 401 U.S. 402, 416 (1970), Alaska v. Andrews, 580 F.2d 465, 473-74 (D.C. Cir. 1978); Clev. Elec. Illum. Co. v. EPA, 572 F.2d 1150, 1161 (6th Cir. 1978); No. Ohio Lung Ass'n v. EPA, 572 F.2d 1143, 1148 (6th Cir. 1978); Coal. for Responsible Develop. v. Coleman, 555 F.2d 398, 399-400 (4th Cir. 1977); Mision Indus., Inc. v. EPA, 547 F.2d 123, 129 (1st Cir. 1976); Duquesne Light Co. v. EPA, 526 F.2d 1186, 1192 (3d Cir. 1975) (not "substitute its evaluation"); So. Terminal Corp. v. EPA, 504 F.2d 646, 655 (1st Cir. 1974); Bucks County Bd. of Comm'rs v. Interstate Energy Co., 403 F. Supp. 805, 812-13 (E.D. Pa. 1975); Conserv. Council of N.C. v. Froehlke, 435 F. Supp. 775, 782 (M.D.N.C. 1977). One court has noted that courts must "substitute their judgment" for that of the decisionmaker in some aspect of the environmental decision. Asarco, Inc. v. EPA, 616 F.2d 1153, 1160 (9th Cir. 1980).

203. *See, e.g.*, Texas v. EPA, 498 F.2d 299, 321-22 (5th Cir. 1974) (Clark, Boyle, JJ., concurring). *See also* Am. Iron & Steel Inst. v. EPA, 526 F.2d 1027, 1063 (3d Cir. 1975); EDF v. Corps of Engineers, 492 F.2d 1123, 1138-40 (5th Cir. 1974); Mision Indus., Inc. v. EPA, 547 F.2d 123, 131 (1st Cir. 1976) (not "clearly wrong"); Ethyl Corp. v. EPA, 541 F.2d 1, 34 n.74 (D.C. Cir.) (en banc), *cert. denied*, 426 U.S. 941 (1976); Reserve Mining Co. v. EPA, 514 F.2d 492, 507 n.20, 514-20, 529, 535-40 (8th Cir. 1975).

of which use the phrase "arbitrary, capricious, or an abuse of discretion."[204] The logical conclusion to be drawn from this language is that the different words were inserted by Congress to express different approaches to substantive review by the courts. This semantic distinction is important in environmental decisions, especially those involving models, where fact and policy are inextricably intertwined, because a court's use of emphasis of one formulation over another reflects the part of the decision—fact or policy—which the court examined. The other ultimate level characterizations of the appropriate level of review is that the decision not be "clearly erroneous," or involve "clear error" or "clear errors of judgment."[205]

D. Problems Presented to the Reviewing Court by the Use of Environmental Models

As discussed in Part III.B., above, the use of environmental models creates a number of problems for the administrative decisionmaker which are carried forward as added difficulties for a reviewing court. Additionally, there are aspects of the institutions of the environmental agencies and the courts and their relationship that further contribute to the difficulties of judicial review in cases relying on environmental models, thereby making them "hard cases" to review.[206] Such institutional problems include the self-perceived lack of scientific expertise on the part of judges, the lack of judicial access to technical resources to assist in the analysis of the technical issues involved in such decisions, the limits on the court's ability to supplement or go outside the record, and the traditional deference which the courts give to administrative decisions.

1. Judges' Lack of Scientific Expertise

One problem in attempting to find an appropriate level of judicial review for environmental decisions is the limited scientific training or expertise of judges hearing the case, whether such limit is actual

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204. Administrative Procedure Act, 5 U.S.C.S. § 706(2)(A) (Law. Co-op. 1980); Clean Air Act, 42 U.S.C.S. § 7607(b), (c), (d) (Law. Co-op. 1980).

205. *See, e.g.*, Citizens to Preserve Overton Park v. Volpe, 401 U.S. 402, 416 (1970); Weyerhauser v. Costle, 590 F.2d 1011, 1024-25 (D.C. Cir. 1978); Bunker Hill Co. v. EPA, 572 F.2d 1286, 1294 (9th Cir. 1977); No. Ohio Lung Ass'n v. EPA, 572 F.2d 1143, 1148 (6th Cir. 1978); Sierra Club v. EPA, 540 F.2d 1114, 1123 (D.C. Cir. 1976), *vacated as moot*, 434 U.S. 809 (1977); So. Terminal Corp. v. EPA, 544 F.2d 646, 655, 662-67 (1st Cir. 1974); Conserv. Council of N.C. v. Froehlke, 435 F. Supp. 775, 782, 792-97 (M.D.N.C. 1977); MAD v. Train, 400 F. Supp. 533, 541, 547, 570, 572, 574 (D. Md. 1975).

206. Kramer, *supra* note 5, at 264.

or merely perceived. Judges often note that the issues involved in such cases are beyond the limits of their training or expertise,[207] and usually refer to themselves as "generalists."[208] The review of environmental decisions involving the use of computer models is particularly difficult for the typical judge, who "looks at the prospect of manipulating a computer program with undisguised terror."[209] In order to engage in a minimal level of meaningful judicial review, however, it is necessary for judges to acquire a reasonable level of understanding of the state of scientific knowledge upon which a decision is based.[210]

2. Judges' Lack of Access to Scientific Resources

Related to the problem of the judges' lack of scientific expertise is their lack of access to adequate scientific resources. Courts have noted that they do not yet have access to scientific aids.[211] In similar cases courts have also noted that they could have made good use of the services of a special master in sorting out the voluminous records and technical issues involved,[212] although this problem may have been alleviated, at least in part, by the recent passage of the

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207. *See, e.g.*, Indus. Union Dep't v. Am. Petroleum Inst., 448 U.S. 607, 688, 705-06 (Marshall, Brennan, Blackmun, JJ., dissenting) ("Courts are ill-equipped to resolve" such issues involving a "high level of technical complexity" involving the judges "in matters to which they are unaccustomed by training or experience"); BASF Wyandotte Corp. v. Costle, 598 F.2d 637, 648 (1st Cir. 1979) (judges are not lab technicians and "cannot play the role of Superchemist"); Ethyl Corp. v. EPA, 541 F.2d 1, 36 (judges generally are not trained as chemists, biologists, or statisticians) (D.C. Cir. 1976) (en banc); *id.* at 66-67 & n.7 (Bazelon, C.J., and McGowan, J., concurring) ("substantive review of mathematical and scientific evidence by technically illiterate judges is dangerously unreliable," resulting in "homespun scientific aphorisms"); *id.* at 70, 104-10, 110 (Wilkey, Jamuss, Robb, JJ., dissenting) (judges' lack of scientific background or access to expertise, such as court-appointed expert); Duquesne Light Co. v. EPA, 522 F.2d 1186, 1193 (3d Cir.), *vacated on other grounds*, 427 U.S. 902 (1975) (expertise to assimilate and understand all of the technical information underlying clean-up technology assessment); Texas v. EPA, 499 F.2d 289, 306-08 nn.27, 30 (5th Cir. 1974) (applicability of data derived from industries is complex matter "beyond our ken, absent the assistance of the parties"); Int'nl Harvester Co. v. Ruckelshaus, 478 F.2d 615, 622, 645 n.112 (Court's lack of understanding might relate to the judges' lack of scientific training), 647-48 (complexity of the technical matters involved) (D.C. Cir. 1973); *id.* at 650-52 (Bazelon, C.J., concurring) (court's lack of scientific knowledge). *See also infra* cases cited in notes 230, 231.

208. *See, e.g.*, Weyerhauser Co. v. Costle, 590 F.2d 1011, 1026 (D.C. Cir. 1978); Ethyl Corp. v. EPA, 541 F.2d 1, 68-69 (D.C. Cir.) (Leventhal, J., concurring), *cert. denied*, 426 U.S. 941 (1976).

209. *Delaware River Factfinding*, *supra* note 14, at 428; *accord*, *id.* at 496; Leventhal, *supra*, note 1, at 511-12, 532. *See also* Int'nl Harvester Co. v. Ruckelshaus, 478 F.2d 615, 647 (D.C. Cir. 1973).

210. *See, e.g.*, Reserve Mining Co. v. EPA, 514 F.2d 492, 507 n.20 (8th Cir. 1975) (en banc).

211. *See* Int'nl Harvester Co. v. Ruckelshaus, 478 F.2d 615, 641 (D.C. Cir. 1973).

212. *See* Texas v. EPA, 499 F.2d 289, 307-08 n.30 (5th Cir. 1974).

Magistrate's Act.[213] The courts have already made use of appointed experts to assist them in the evaluation of voluminous, technical evidence.[214]

3. Voluminous Records

In reviewing environmental decisions judges are also often presented with a record which is either so voluminous[215] or so meager[216] as not to be useful. Frequently, the record is unclear and badly organized as well.[217] The courts have attempted to deal with the problems by methods such as the use of condensed or technical appendices.[218] As will be discussed below, the use of such condensed reports is not only indicative of the complexity of such cases, it actually serves to preclude a meaningful level of review by masking basic flaws in methodology by simplifying results.

4. Judges' Inability to Supplement the Record

A related problem is the lack of flexibility given to judges in supplementing and going outside the record. Normally, courts are confined to examining the administrative record before the decisionmaker at the time of the decision.[219] Nevertheless, reviewing courts have acknowledged that it is proper to go outside of the record to examine the decisionmaking methodologies used, "especially when highly

213. *See supra* note 3. *See also* Note, *Masters and Magistrates in the Federal Courts*, 88 HARV. L. REV. 779 (1975). Judge Leventhal's seminal article in 1974 took the form of much of the earlier approaches to environmental decisionmaking in techno-environmental cases. *See* Leventhal, *supra*, note 1.

214. *See, e.g.*, Ethyl Corp. v. EPA, 541 F.2d 1, 104-05 (D.C. Cir.) (en banc), *cert. denied*, 426 U.S. 941 (1976) (citing Reserve Mining Co. v. EPA, 514 F.2d 492 (8th Cir. 1975) (en banc)).

215. *See, e.g.*, BASF Wyandotte Corp. v. Costle, 598 F.2d 637, 646 (1st Cir. 1979) (2,000-page record and three briefings); Hercules, Inc. v. EPA, 598 F.2d 91, 121, 126 n.63, 129 (D.C. Cir. 1978) ("loosely organized rulemaking record of enormous detail and staggering complexity—thousands of pages of highly technical testimony"); Texas v. EPA, 499 F.2d 289, 297 (5th Cir. 1974) ("the record's length is on the order of 10,000 pages, and is both technical and poorly organized"); Life of the Land v. Brinegar, 485 F.2d 460, 468 (9th Cir. 1973), *cert. denied*, 416 U.S. 961 (1964) (record of 2,000 pages of technical material). This problem with the record on review parallels the similar problem fixed by the administrative decisionmakers of voluminous and loosely organized records. *See supra* text and notes at notes 141-50.

216. *See, e.g.*, Texas v. EPA, 499 F.2d 289, 303 n.20, 304 n.23, 308 n.31, 321-22 (5th Cir. 1974) (Clark, Boyle, JJ., concurring).

217. *See, e.g.*, BASF Wyandotte Corp. v. Costle, 598 F.2d 637, 658 (1st Cir. 1979); Mision Indus., Inc. v. EPA, 547 F.2d 123, 126 n.2 (1st Cir. 1976); Texas v. EPA, 499 F.2d 289, 303 n.21 (5th Cir. 1974).

218. *See, e.g.*, Bunker Hill Co. v. EPA, 572 F.2d 1286, 1295 n.16 (9th Cir. 1977); Clev. Elec. Illum. Co. v. EPA, 572 F.2d 1150, 1163 (6th Cir. 1978); Int'nl Harvester v. Ruckelshaus, 478 F.2d 615, 624 (D.C. Cir. 1973).

219. *See* Asarco, Inc. v. EPA, 616 F.2d 1153, 1159-60 (9th Cir. 1980). The *Asarco* court, in

technical matters are involved."[220] This examination beyond the review record may sometimes be necessitated by the normal inability of the reviewing court to examine the mental process by which the decisionmaker reached his decision,[221] although such inquiry may be permitted under certain rare circumstances for "effective judicial review."[222] Reviewing courts at present have no ability to gather any necessary extra facts on their own, although the passage of the Magistrates Act[223] may have alleviated this problem, at least in part. Additionally, the first court that reviews many environmental decisions is the circuit court of appeals, with no intermediate court between it and the administrative decisionmaker to help alleviate this paucity of facts by a remand for further factfinding.[224] Further, the courts usually have no staff to assist them in the gathering or analysis of the facts when analyzing the problem.[225]

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discussing *Overton Park* noted that the reviewing court is permitted to go outside the record, because:

> [a] satisfactory explanation of agency action is essential for adequate judicial review, because the focus of judicial review is not on the wisdom of the agency's decision, but on whether the process employed by the agency to reach its decision took into consideration all relevant factors.
>
> [J]udicial consideration of evidence relevant to the substantive merits of the agency action but not included in the administrative record raises fundamentally different concerns. When a reviewing court considers evidence that was not before the agency, it inevitably leads the reviewing court to substitute its judgment for that of the agency. This is true even if such judicial review is not strictly de novo in the sense that the court also considers the administrative record. Nevertheless, . . . it is both unrealistic and unwise to 'straightjacket' the reviewing court with the administrative record. It will often be impossible, especially when highly technical matters are involved, for the court to determine whether the agency took into consideration all relevant factors unless it looks outside the record to determine what matters the agency should have considered but did not. The court cannot adequately discharge its duty to engage in a 'substantial inquiry' if it is required to take the agency's word that it considered all relevant matters.

616 F.2d at 1159-60. *Accord* Cin. Gas and Elec. Co. v. EPA, 578 F.2d 660, 664 (6th Cir. 1978); Life of the Land v. Brinegar, 485 F.2d 460, 473 n.14 (9th Cir. 1973), *cert. denied*, 416 U.S. 961 (1974); Appalachian Power Co. v. EPA, 477 F.2d 495, 506-08 (4th Cir. 1973).

220. *See, e.g.*, Asarco, Inc. v. EPA, 616 F.2d 1153, 1159-60 (9th Cir. 1980). *Accord*, Duquesne Light Co. v. EPA, 522 F.2d 1186, 1193 (3d Cir.), *vacated on other gnds*, 427 U.S. 902 (1975); Texas v. EPA, 499 F.2d 289, 297 (5th Cir. 1974).

221. "Possibly barring fraud and other extreme circumstances, the mental process by which the Administrator reaches his decision, if it is explained in the record, is not a proper subject for discovery." So. Terminal v. EPA, 504 F.2d 646, 675 (1st Cir. 1974) (citing United States v. Morgan, 313 U.S. 409, 422 (1941)).

222. Citizens to Preserve Overton Park v. Volpe, 401 U.S. 402, 420 (1971) (citing Shaughnessy v. Accardi, 349 U.S. 280 (1955)).

223. *See supra* text at note 3.

224. *E.g.*, So. Terminal Corp. v. EPA, 504 F.2d 646, 665 (1st Cir. 1974).

225. *See, e.g.*, Leventhal, *supra* note 1; Whitney, *The Case for Creating a Special Environmental Court System—A Further Comment*, 15 WM. & MARY L. REV. 33 (1973).

5. Judicial Deference to Administrative Expertise

A final problem presented to a court reviewing an environmental decision arises from the legal doctrine which requires courts to defer to agency expertise. This doctrine of deference is more than simply a formulation of one aspect of the appropriate scope and standards of judicial review.[226] As found in the relevant statutes,[227] it also reflects the judicial policy decision to maintain the proper relationship and role of the reviewing court vis-a-vis the administrative agency. Two sources of the court's deference to administrative decisions have already been mentioned: (1) the comparative scientific expertise of the administrative decisionmaker and the reviewing judge;[228] and (2) the complex, technical nature of the environmental subject matter being reviewed.[229] Additional justifications for the judicial deference accorded administrative decisions in environmental law are administrative convenience and the discretion which must be accorded administrative decisionmakers to deal with the problems of environmental pollution. These four bases for judicial deference to administrative decisions are briefly discussed further below.

Traditionally, reviewing courts justify judicial deference to administrative decisions based on the demonstrated or presumed expertise of the administrative agency,[230] as well as the judges' perception of their own lack of expertise.[231] As previously discussed, however, the administrative decisionmakers may not be as "expert," nor

226. *Compare supra* cases cited at note 202.

227. *See supra* statutes cited at notes 160-69, 199, 200.

228. *Compare supra* text and note at note 135 (dealing with the scientific expertise of the administrative decisionmakers), *with* text and notes at notes 207-09 (dealing with the scientific expertise of judges).

229. *See supra* text and notes at notes 130-34 (relating to the complicated nature of the sciences involved in environmental decisionmaking); text and notes at notes 110-14 (relating to the need to apply even more sophisticated scientific methodologies to the problem of environmental pollution).

230. *See, e.g.*, Mision Indus., Inc. v. EPA, 547 F.2d 123, 127, 129 (1st Cir. 1976) (rebuttable presumption of regularity, based on use of a computer model involved "an area where EPA's 'expertise is heavily implicated' ") (D.C. Cir. 1976), *vacated as moot*, 434 U.S. 809 (1977); FMC Corp. v. Train, 539 F.2d 973, 986 (4th Cir. 1976) (choice of statistical methodologies up to EPA); AFL-CIO v. Hodgson, 499 F.2d 467, 474-75 (D.C. Cir. 1974). *See supra* note 202 (cases cited for proposition that agencies are entitled to deference on review).

231. *See* Strycker's Bay Neighborhood Council v. Karlen, 444 U.S. 223, 22528 (per curiam), 228, 229-30 (Marshall, J., dissenting) (1980); Vermont Yankee Nuclear Power Corp. v. NRDC, 435 U.S. 519 (1978); Hercules, Inc. v. EPA, 598 F.2d 91, 115 (D.C. Cir. 1978) (deferring to EPA's choice of scientific test data); EDF v. EPA, 590 F.2d 62, 78 (D.C. Cir. 1978) (court must venture into the realm of science to decide issues); Weyerhauser Co. v. Costle, 590 F.2d 1011, 1024-25 & n.11 (D.C. Cir. 1978) (ensuring scientific evidence supports conclusions drawn); *id.* at 1026 n.13 (judges' lack of scientific training); *id.* at 1031 (notwithstanding lack of training, judges cannot ignore errors); Cin. Gas and Elec. Co. v. EPA, 578 F.2d 1286, 1292 (9th Cir.

the judges so lacking in expertise, as to justify more than a minimal amount of judicial deference. This is particularly true for environmental decisions based on computer models and other mathematical methodologies, which will likely involve the use of experts.[232] A reviewing court is no less able than an administrative agency to communicate with the experts involved in the environmental decision (including the modeling experts) and to evaluate independently the work and conclusions of those experts if the reviewing court feels the case so demands, although this statement must be qualified somewhat.[233]

The second source of the courts' institutional deference to environmental decisions is the complex nature of the environmental decision and its underlying bases, such as a model.[234] It is necessarily a risky and uncertain business to use modeling projections to make and justify an environmental decision.[235] This uncertainty is exacerbated by a lack of sufficient monitoring and laboratory data[236] to justify a

1977) (lack of expertise in a technical subject and a limited authority, but nonetheless remanding for lack of reasoned discretion); Am. Petroleum Inst. v. EPA, 540 F.2d 1023, 1028 (10th Cir. 1976); Nat. Asphalt Paving Ass'n v. Train, 539 F.2d 775, 783-86 (D.C. Cir. 1976); Am. Iron & Steel Inst. v. EPA, 526 F.2d 1027, 1047, 1050, 1055, 1075-77 (3d Cir. 1975) (Adams, J., concurring); Am. Meat Inst. v. EPA, 526 F.2d 442, 452-53 (7th Cir. 1975); Reserve Mining Co. v. EPA, 514 F.2d 492, 507 n.20 (8th Cir. 1975); Soc. of Plastics Ind. v. OSHA, 509 F.2d 1301, 1308 (D.C. Cir.) *cert. denied*, 421 U.S. 992 (1975) (deferred to agency for new science); So. Terminal v. EPA, 504 F.2d 646, 655-56; Int'nl Harvester Co. v. Ruckelshaus, 478 F.2d 615, 647-49, 650-51 (D.C. Cir. 1973) (Bazelon, C.J., concurring in the result). *See also supra* cases cited at notes 207, 230.

232. *See supra* text and notes at notes 135-40.

233. *See, e.g.*, 5 U.S.C.S. § 706 (Law. Co-op. 1980), which provides for judicial review of "the whole record or those parts of it cited by a party." The Supreme Court has formulated this whole record test generally to limit review to the administrative record already in existence, and not some new record made initially in the reviewing court. Camp v. Pitts, 411 U.S. 138, 142 (1973) (decisionmaker's failure to adequately explain his decision "is not a deficiency in factfinding procedures such as to warrant the *de novo* hearing ordered in this case"). By contrast, where the factual record is inadequate, or where no record is made, the court may supplement the administrative record by obtaining "from the agency, either by affidavits or testimony, such additional explanation of the reasons for the agency decision as may prove necessary." *Id.* at 143. Under the APA, where the agency's decision arises out of an adjudicatory proceeding but is based on inadequate factfinding procedures and is thus "unwarranted by the facts," 5 U.S.C.S. § 706(2)(F), the court may engage in de novo review of the decision and its underlying data. There are also specific statutory provisions allowing the introduction of additional evidence in the review of certain environmental decisions by a party desiring to do so. *See, e.g.*, 42 U.S.C.S. § 7607(c) (Law. Co-op. 1981); 33 U.S.C.S. § 1369(c) (Law. Co-op. 1980); 15 U.S.C.S. § 2618(b) (Law. Co-op. 1982); 42 U.S.C.S. § 6976(2) (Law. Co-op. 1982); 42 U.S.C.S. § 4915(b) (Law. Co-op. 1982); 42 U.S.C.S. § 300j-7(c) (Law. Co-op. 1981). These statutes only allow such showings at the request of a party and do not grant any power to the court to do so on its own motion.

234. *See supra* text and notes at notes 130-34.

235. *See supra* text and notes at notes 106-21.

236. *See supra* text and notes at notes 125-29.

decision to a scientific certainty.[237] In such an apparently arcane area judges are even more willing to defer to the administrator: the correlation appears to be, the more complex or technical the subject, the more likely judges are to defer any in-depth review, at least in the area of the cases reviewed in this article.

The third basis for judicial deference to administrative decisions is based on considerations of administrative convenience.[238] Courts are not equipped to attempt to manage environmental problems and

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237. *See* Ethyl Corp. v. EPA, 541 F.2d 1, 28 n.58 (D.C. Cir.) (en banc), *cert. denied*, 426 U.S. 941 (1976) (distinguishing between scientific and legal certainty and scientific and legal facts). In his opinion, Judge Wright stated that it is inherent in the nature of legal factfinding that the decisionmaker does not have to rely solely on proved scientific fact, which he defined as one that "is at least 95 percent certain," that is, a fact that a scientist will certify that "the probability of error, by standard statistical measurement, is less than 5 percent." *Id.* Environmental decisionmaking agencies must operate under a flexible decisionmaking standard that will allow the agency "to assess risk, to measure probabilities [and] to make subjective judgments." *Id.* Judge Wright stated that courts have at least the same factfinding powers as a jury, particularly when they are engaged in rulemaking and contrasted this with the "beyond a reasonable doubt" standard of criminal law, which he observed may demand a scientific-like 95 percent certainty. *Id.* Judge Wright stated that the decisionmaker "may apply his expertise to draw conclusions from suspected, but not completely substantiated, relationships between facts, from trends among facts, from theoretical projections from imperfect data, from probative preliminary data not yet certifiable as 'fact,' and the like." *Id.* at 28.

The deferential standard of proof arose, at least in part, out of a particular language of the "will endanger" language of the applicable provision of the Clean Air Act. Judge Wright also based the deferential non-scientific fact standard on the nature of the problems underlying techno-environmental decisions where "questions are particularly prone to uncertainty," and where "speculation, conflicts in evidence, and theoretical extrapolation typify their very action." *Id.* Judge Wright extended his deferential standard in the environmental field to other cases involving scientific and technological issues similar to those involved in techno-environmental decisions, the characteristics of which are that they are (1) based on a statute that is "precautionary in nature" or "mandatory in its command to act;" (2) based on a statute that is designed to protect the public health; (3) is necessarily based upon evidence that is "difficult to come by, uncertain, or conflicting because it is on the frontiers of scientific nature;" and (4) the decision is made by an "expert administrator." *Id.* at 24 & nn. 56, 57. In such cases, Judge Wright states that legal proof is less rigorous than scientific proof, and that in such cases the courts "will not demand rigorous step-by-step proof of cause and effect." *Id.*

238. *E.g.*, Hercules, Inc. v. EPA, 598 F.2d 91, 116 (D.C. Cir. 1978) (upheld EPA's approach to the problem as a rational, reasonable compromise based on "administrative convenience"). *See also id.* at 106-10; Ass'n of Pac. Fisheries v. EPA, 615 F.2d 794, 812 (9th Cir. 1980); BASF Wyandotte Corp. v. Costle, 598 F.2d 637, 644, 654, 655-56, 659-61 (1st Cir. 1979); EDF v. EPA, 598 F.2d 62, 68 n.17, 72-73, 78-80, 85, 88, 89 n.100 (D.C. Cir. 1978); Ethyl Corp. v. EPA, 541 F.2d 1, 37, 49 n.102, 104-05 (D.C. Cir. 1976); Cin. Gas & Elec. Co. v. EPA, 578 F.2d 660-664-66 (6th Cir. 1978); Clev. Elec. Illum. Co. v. EPA, 572 F.2d 1150, 1160-61 (6th Cir. 1978); NRDC v. EPA, 529 F.2d 755, 760 (5th Cir. 1976); Ohio v. EPA, 460 F. Supp. 248, 251 (S.D. Ohio 1978); Evans v. Train, 460 F. Supp. 233, 244 (S.D. Ohio 1978); Conserv. Council of N.C. v. Froehlke, 435 F. Supp. 775, 783, 791-92 (M.D.N.C. 1977); Mid-Shiawassee County Concerned Citizens v. Train, 408 F. Supp. 650, 656-60 (D.C. Mich. 1976); Buck County v. Del. River Basin Comm'n, 403 F. Supp. 805, 818-19 (E.D. Pa. 1975); MAD v. Trainor, 400 F. Supp. 533, 538-40, 547-55, 559-68, 570-72, 574 (D. Md. 1975); EDF v. Corps of Engineers, 358 F. Supp. 916, 927-30 (N.D. Miss. 1972), *aff'd*, 492 F.2d 1123 (5th Cir. 1974).

are, thus, wary of interfering with the work of existing environmental agencies. This institutionally based deference has been used to overlook such administrative errors as the use of an uncalibrated model,[239] insufficient data,[240] and the use of a questionable methodology.[241]

The fourth source of institutional judicial discretion accorded to environmental decisions is the omnipresence of policy questions in such decisions.[242] These policy questions involved in environmental decisions are "legislative-type judgments,"[243] which "are not susceptible to the same type of identification or refutation by reference to the record as are some factual questions."[244] The factual issues involved in environmental decisions "are frequently not subject to any definitive resolution."[245] In such decisions, the policy judgments are inextricably intertwined with factual issues surrounding the decisionmaking methodologies, thus making it difficult to determine what is properly reviewable by the court and what is nonreviewable.[246] Policy judgments are intertwined, both because of the

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239. *E.g.*, Mision Indus., Inc. v. EPA, 547 F.2d 123, 128-29 (1st Cir. 1976).

240. *E.g.*, Weyerhauser Co. v. Costle, 590 F.2d 1011, 1054 n.70 (D.C. Cir. 1978); Nat. Asphalt Pavement Ass'n v. Train, 539 F.2d 775, 786-87 (D.C. Cir. 1976); Int'nl Harvester v. Ruckelshaus, 478 F.2d 615, 624-26, 642-51 (D.C. Cir. 1973).

241. *E.g.*, Hercules, Inc. v. EPA, 598 F.2d 91, 116 (D.C. Cir. 1978).

242. *See, e.g.*, Hercules, Inc. v. EPA, 598 F.2d 91, 108 (D.C. Cir. 1978) (stating that such decisions on the frontiers of scientific knowledge involve "a quintessential policy judgment within the EPA's discretion"). *See also* Superior Oil Co. v. FERC, 563 F.2d 191, 201 (5th Cir. 1977) (areas of new scientific knowledge necessarily involve greater policy choices); Nat'l Asphalt Pavement Ass'n v. Train, 539 F.2d 775, 783 (D.C. Cir. 1976); Soc. of Plastics Ind. v. OSHA, 509 F.2d 1301, 1308 (D.C. Cir.), *cert. denied*, 421 U.S. 992 (1975) (new scientific area requires greater policymaking deference); Reserve Mining Co. v. EPA, 514 F.2d 494, 507 n.20 (8th Cir. 1975); MAD v. Trainor, 400 F. Supp. 533 (D. Md. 1975).

243. *See, e.g.*, So. Terminal v. EPA, 504 F.2d 646, 680 n.37 (1st Cir. 1974). *Accord*, Ethyl Corp. v. EPA, 541 F.2d 1, 20-21 (D.C. Cir.) (en banc) *cert. denied*, 426 U.S. 941 (1976).

244. Ind. Union Dep't v. Hodgson, 449 F.2d 467, 475 (1974), *quoted in* Nat. Asphalt Pavement Ass'n v. Train, 539 F.2d 775, 783 (D.C. Cir. 1976).

245. Ind. Union Dep't v. Am. Petroleum Inst., 448 U.S. 607 (1980) (Marshall, Brennan, Blackmun, JJ., dissenting). In that dissent, Justice Marshall quoted Mr. Justice Clark's statement that in such cases, "[o]ften 'the factual finger points, it does not conclude.' " *Id.* (quoting Soc. of Plastics Ind., Inc. v. OSHA, 509 F.2d 1301, 1308 (2d Cir.) *cert. denied*, 421 U.S. 992 (1975)).

246. As stated by the District of Columbia Court of Appeals:

> Looking to the future, and commanded by Congress to make policy, a rule-making agency necessarily deals less with 'evidentiary' disputes, than with normative conflicts, projections from imperfect data, experiments and simulations, educated predictions, differing assessments of possible risks, and the like. The process is quasi-legislative in character, and one will search it in vain for those intermediate 'findings' of fact which mark the midway point in an adjudicator's linear march from raw evidence to single, ultimate conclusion.

lack of adequate data underlying those decisions,[247] as well as by the recognition that environmental decisions often involve technologies and methodologies on the "frontiers of scientific knowledge."[248]

A great deal of discretionary authority is normally granted by statute to agencies making environmental decisions. Under the legislative history of the APA, if a statute is "drawn in such broad terms that in a given case there is no law to apply . . . ," then there is only limited review under the APA.[249] Under section 701 of the APA, that Act does not apply to the extent that the statute under which the decision is made precludes judicial review or the agency action is committed to agency discretion by law.[250] If a decision is committed to agency discretion under section 702 of the APA, judicial review is not precluded entirely, but still exists only for an abuse of discretion or fundamental jurisdictional or constitutional problems.[251] Moreover, if Congress attempts to delegate too much discretionary authority in such environmental decisions, the United States Supreme Court has intimated that such an attempt would be unconstitutional.[252] Thus, the discretion that can be accorded to en-

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Amoco Oil Co. v. EPA, 501 F.2d 772, 734-35 (D.C. Cir. 1974), *quoted in* So. Terminal v. EPA, 504 F.2d 646, 655 n.6 (1st Cir. 1974).

247. *See supra* text and notes at notes 141-50.

248. *See, e.g.*, BASF Wyandotte Corp. v. Costle, 598 F.2d 637, 644-45 (1st Cir. 1979); Hercules, Inc. v. EPA, 598 F.2d 91, 106, 108 (D.C. Cir. 1978); EDF v. EPA, 598 F.2d 662, 82 (D.C. Cir. 1978); Ethyl Corp. v. EPA, 541 F.2d 1, 26 (D.C. Cir.) (en banc), *cert. denied*, 426 U.S. 941 (1976); Am. Petroleum Inst. v. EPA, 540 F.2d 1023 (10th Cir. 1976); Soc. of the Plastics Ind. v. OSHA, 509 F.2d 1301, 1308 (2d Cir.) *cert. denied*, 421 U.S. 992 (1975); AFL-CIO v. Hodgson, 499 F.2d 467, 474-75 (D.C. Cir. 1974).

249. Citizens to Preserve Overton Park, Inc. v. Volpe, 401 U.S. 402, 410 (1971) (quoting S. REP. NO. 752, 79th Cong., 1st Sess., 26 (1945)). The Supreme Court called this exemption from judicial review a "very narrow exception." *Id. Accord*, Santa Clara v. Andrus, 572 F.2d 660 (9th Cir. 1978), *cert. denied*, 439 U.S. 859; Save the Bay, Inc. v. EPA, 556 F.2d 1282 (5th Cir. 1977), *reh'g denied*, 560 F.2d 1023 (5th Cir. 1978); Ariz. Power Auth. v. Morton, 549 F.2d 1231 (9th Cir. 1977), *cert. denied*, 434 U.S. 835; Ariz. Power Pooling Assn. v. Morton, 527 F.2d 721 (9th Cir. 1975), *cert. denied*, 425 U.S. 911.

250. 5 U.S.C.S. § 701(a) (Law. Co-op. 1980). There have been several environmental decisions precluding review of discretionary decisions. *E.g.*, Kentucky v. Ruckelshaus, 362 F. Supp. 360, 366 (W.D. Ky.), *aff'd*, 497 F.2d 1171 (6th Cir.), *aff'd*, 462 U.S. 167. However, environmental statutes have not been construed to delegate such discretion so as to preclude review. *See, e.g.*, Citizens to Preserve Overton Park, Inc. v. Volpe, 401 U.S. 402 (1971); EDF v. Corps of Engineers of the U.S. Army, 492 F.2d 1123 (5th Cir. 1974); McDowell v. Schlesinger, 404 F. Supp. 221 (W.D. Mo. 1975). Akers v. Resor, 339 F. Supp. 1375 (W.D. Tenn. 1972).

251. If the action is committed to agency discretion, judicial review is precluded only to the extent that such discretion exists. Jones v. Freeman, 400 F.2d 383, 390 (8th Cir. 1968). Review is still available for arbitrariness or for an abuse of discretion. *See supra* cases cited at notes 200, 201.

252. *See* Ind. Union Dep't v. Am. Petroleum Inst., 448 U.S. 607, 664 n.1 (1980) (Powell, J., concurring in part and in judgment) (citing Schechter Poultry Corp. v. United States, 295 U.S.

vironmental agencies is limited, despite the apparently broad legislative delegation of authority which is granted in practice.

Cases involving challenges to environmental models take the form of allegations of insufficient underlying evidence. The cases normally raise questions of (1) whether the model from the evidence adequately supports the decision; or (2) whether the evidence used in the model justifies the model's use. Oftentimes, the cases involve both questions. The cases involving the Clean Air Act form the largest body of case law concerning environmental models, particularly computer models. The cases involve the use of those models (1) to establish emission limitations as a part of a State Implementation Plan (SIP) (a State Implementation Plan is the method by which a state implements the Clean Air Act); and (2) to designate nonattainment areas within the state. Although there have been opinions from the First, Third, Fourth, Fifth and Ninth Circuit Courts of Appeals, the largest body of case law comes out of the Sixth Circuit. The eleven cases which have come out of the Sixth Circuit to date are all concerned with the Ohio SIP and form a virtual treatise on the use of models in implementation plans. These Sixth Circuit opinions will be treated separately from the cases from other circuits.

Allegations of insufficient underlying evidence in such environmental decisions do not often succeed because of the deference accorded to such decisions under the arbitrary and capricious standard applied to them,[253] as contrasted with the more deferential substantial evidence and "rule of reason" or reasonableness[254] tests. As seen below, cases involving challenges to models often bifurcate the discussion by discussing separately the alleged errors in the methodology of the model and the data used in the model. Nonetheless, both the modeling results and the data used in the model constitute "evidence" to justify the administrative decision. The fundamental questions on judicial review are simply the proper scope of review (how far the court should inquire into alleged errors in modeling methodology or data used in the model) and standards of review (to what extent the court should overlook apparent errors in the underlying data or modeling results). Again, this question of the proper

495 (1935); Panama Refining Co. v. Ryan, 293 U.S. 388 (1935)). *Accord*, 448 U.S. at 671 (Rehnquist, J., concurring in the judgment).

253. *See supra* cases cited at notes 200, 201.

254. *See, e.g.*, EDF v. EPA, 598 F.2d 62, 82-83 (D.C. Cir. 1978) (citing FCC v. Nat'l Citizens Comm. for Broadcasting, 436 U.S. 755 (1978)); United States Steel Corp. v. Train, 556 F.2d 822, 833 (7th Cir. 1977) (NPDES permit); Am. Petroleum Inst. v. EPA, 540 F.2d 1023, 1028 (10th Cir. 1976) (differentiating *Overton Park's* probing standard from *Universal Camera's* substantial evidence standard).

scope and standards of judicial review, as it relates to environmental models, can be reduced to an evaluation of whether valid underlying evidence sufficient to uphold the decision has been produced.

At present, the amount of evidence required to uphold such a decision is comparatively small in light of the complexity of the subject matter. There is authority, however, that environmental models may be successfully challenged based on a showing of insufficient valid evidence and data to underlie the decision.[255] These cases, along with numerous others where substantial but unsuccessful challenges were raised to models, are discussed below to illustrate the varying scopes and standards of review applied to the evaluation of environmental models.

IV. Judicial Treatment of Agency Use of Models Under Established Standards of Review

Cases involving environmental models can be broken down into four categories. The first category is comprised of cases involving emission standards and nonattainment designations under the Clean Air Act. The second category of cases deals with the use of models in the creation of an impact statement under NEPA. The third category of cases consists of regulations promulgated on the basis of the models; these include regulations under the Clean Air Act, FWPCAA, TSCA, OSHA, and other environmental statutes. The fourth category involves more adjudicatory-type cases, such as those involving permits and licenses under the various environmental statutes listed in the preceding category. Because computer models have been more extensively used and judicially reviewed in the Clean Air Act and NEPA cases, this paper will limit its discussion to those two categories.

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255. *See, e.g.*, Ind. Union Dep't v. Am. Petroleum Inst., 448 U.S. 607, 622 n.16, 652-53, 656 (1980); Asarco, Inc. v. EPA, 616 F.2d 1153, 1161-62 (9th Cir. 1980) (EPA failed to show structural deficiencies in the stack and failed to show how the new particulates were being formed in the stack); Ass'n of Pac. Fisheries v. EPA, 615 F.2d 794, 815 (9th Cir. 1980); Appalachian Power Co. v. EPA, 579 F.2d 846, 854 (4th Cir. 1973); Bunker Hill Co. v. EPA, 572 F.2d 1286, 1299 n.26, 301, 1301 and n.31 (9th Cir. 1977); Appalachian Power Co. v. Train, 545 F.2d 1351, 1365 (4th Cir. 1976); Am. Petroleum Inst. v. EPA, 540 F.2d 1023, 1038 (10th Cir. 1976); Hooker Chem. and Plastics Corp. v. Train, 537 F.2d 639, 641 (2d Cir. 1976); Am. Iron & Steel Inst. v. EPA, 526 F.2d 1027, 1062-63 (3d Cir. 1975); *id.*, at 1073, 1076-77 (Adams, J., concurring); So. Terminal v. EPA, 504 F.2d 646, 663 (1st Cir. 1974); Life of the Land v. Brinegar, 45 F.2d 460, 472 (9th Cir. 1973), *cert. denied*, 416 U.S. 961 (1974); Intn'l Harvester Co. v. Ruckelshaus, 478 F.2d 615, 641-49 (D.C. Cir. 1973); Appalachian Power Co. v. EPA, 477 F.2d 495, 506-07 (4th Cir. 1973); City of Romulus v. County of Wayne, 392 F. Supp. 578, 588-89 (E.D. Mich. 1975).

A. Emission Limitations And Nonattainment Designations Under The Clean Air Act

One of the earliest cases that closely evaluates the use of models in environmental decisionmaking is the case of *Texas v. EPA*,[256] which remains perhaps the leading case in the area. In *Texas v. EPA*, the Fifth Circuit upheld EPA's rejection of the SIP[257] proposed by Texas, and upheld the substitute SIP promulgated by EPA to achieve the necessary reduction in hydrocarbon (HC) emission to achieve the ambient air quality standard for photochemical oxidants (i.e., smog) mandated by the Clean Air Act.[258] Although the court upheld EPA's use of a straight rollback model,[259] the court held that the agency's application of the model was defective by virtue of its use of incorrect data, assumptions, and adjustment factors.[260] Consequently, the court held invalid certain parts of EPA's plan and delayed implementation of other portions pending further consideration by the agency.[261] Significantly, the court in several instances performed its own calculations. Based on those calculations, the court established its own requirements based on the figures generally most favorable to Texas' position.[262]

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256. 499 F.2d 289 (1974). The Second Circuit had earlier overturned EPA's refusal of New York's SIP, although EPA had used a computer diffusion model which was more sophisticated than the state's rollback model. NRDC v. EPA, 494 F.2d 519 (2d Cir. 1974). Because EPA failed to explain its actions, the court rejected EPA's conclusions as "unpersuasive and unrealistic." *Id.* at 526.

257. Implementation plans are required under § 7410 of the Clean Air Act. 42 U.S.C.S. § 7410 (Law. Co-op. 1982). The EPA Administrator is directed by § 7410(a)(2) to disapprove the plan if he finds it will not assure the attainment of national ambient air quality standards.

258. 499 F.2d at 301. The EPA's use of this modeling method made the court uneasy even though the methodology appears to have been the best available at the time, largely because it was based on "simplistic assumption[s]" with "a starting point the common-sensical proposition that pollutants will be reduced proportionally to reductions in their chemical precursors." *Id.* Unfortunately, as previously discussed herein, physical relationships are usually not based on such linearities. The shortcomings of the model are discussed in So. Terminal v. EPA, 504 F.2d 646, 662-63 (1st Cir. 1974). *See infra* text and notes at notes 284-307.

259. The straight rollback model is a computer model which predicts reductions in oxidant pollutants based on hypothetical reduction in reactive hydrocarbon emissions. The Fifth Circuit stated that the rollback or reduction models "show for each current maximum level of oxidant pollution, the percentage reduction in hydrocarbon emissions that is necessary to achieve the oxidant air quality standard. These models are normally displayed in graphical form." 499 F.2d 294-95. "The straight rollback model is based on the principal assumption that reductions in oxide pollutants will be proportional to reductions in reactive hydrocarbon emissions. Hence, the name straight rollback model." Kramer, *supra* note 5, at 245. The rollback model is a type of statistical-empirical model for making projections where there is insufficient information for using more accurate Guassian or numerical models. *Id.* at 238 n.13.

260. 499 F.2d at 308-09.

261. *Id.* at 294.

262. *Id.* at 299 nn.12, 14.

The court's review of the plan adopted by EPA and of EPA's rejection of the Texas plan involved two general questions present in judicial review of implementation plans. First, what is the correct method for predicting the extent of the necessary reduction in photochemical oxidants? Second, would the controls chosen result in the necessary reductions of pollution? These two questions were answered through a four-step process using computer models to predict whether proposed pollution controls would produce sufficient reduction to ensure that ambient air quality standards were met.[263] The correctness of the choice of models was "the only source of dispute as to how great are the necessary reductions" in hydrocarbons.[264]

The court discussed three models which can be used for determining the necessary reduction in HC emissions. The first model was a "proportional model," which was defined in the Clean Air Act regulations by an appended graph.[265] The second model was the model used by the state, which it claimed was a modification of and improvement of the proportional model.[266] The third model, which was the one which the court ultimately accepted, was the "straight percentage rollback method" or "rollback method" used by EPA.[267]

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263. *See id.* at 294-95. The first step in the process is to set the ambient air standard to be met. The second step is to determine the functional relationship (i.e., the model) between pollutants emitted (such as unburned hydrocarbons) and the resulting levels of pollution (oxidants or smog). The third step is to apply the model to the particular air quality control region (AQCR) covered by the implementation plan. This is accomplished by locating a point on the graph representing the existing level of oxidant pollution in the particular AQCR being addressed. The fourth and final step is to move a model to evaluate whether the chosen controls will, in fact, produce the desired pollution level.

264. *See* 499 F.2d at 295.

265. *See* 499 F.2d at 298-300. The model used by EPA was contained in Appendix J to 40 C.F.R. § 51.14 (1973) and is reproduced in the opinion at 499 F.2d at 295, 300.

266. 499 F.2d at 298 n.12. The rationale behind the state's modification was that it avoided the necessity for relying on a type of pollution (reactive hydrocarbons) for which there then existed little data. *Id.* at 298-99 & n.10. It was also apparently on the theoretically solid basis that there was no need to take such substances into account because they do not "react" to produce smog the way "reactive" hydrocarbons do. *See id.* at 293 n.1, 298 n.10.

267. *See* 40 C.F.R. §§ 51.13(e)(2), 51.14(c)(2) (1978). This form of the rollback model may be adaptable for use in projecting pollution by setting the background concentration equal to zero. *Id.* at § 51.14(c)(4)(i). This use of the formula was in apparent violation of the regulations, which specifies that the formula is to be used for sulfur oxides and particulates, *id.* § 51.13(e)(1), and CO and NOX, *id.* § 51.14(c)(2), but *not* for hydrocarbons, which were to be determined by the use of a graph reproduced in an appendix to the regulations. *See supra* note 266. Such models are now allowed. *Id.* § 51.14(c)(4). Previously, EPA had permitted the states' use of the less stringent rollback model (instead of the Appendix J proportional model) at the higher levels of pollution (i.e., all above 0.28 ppm of smog), because of a lack of data to justify the harsher and nearly impossible to meet results of Appendix J at those levels.

EPA rejected the Texas model, because the state had not come forward with sufficient evidence to justify the less stringent requirements of the state's plan,[268] and particularly because the state had used incorrect data in attempting to support those requirements.[269] The court was then faced with having to sustain EPA's choice of an admittedly less sophisticated methodology. The court upheld EPA's model as not arbitrary and capricious in light of (1) the necessity of using some kind of model; (2) the lack of sophisticated data; (3) the deference traditionally given to expert agency judgment in such technical fields; (4) the plan's common-sense appeal; and (5) the plan's reliance on public input.[270] The Fifth Circuit, however, issued a clear warning that such a simplistic approach may not suffice in the future and that future efforts will likely receive a stricter level of scrutiny, regardless of their greater level of sophistication.[271] Further, the court, because of the scarcity of data underlying EPA's model, placed a continuing responsibility on the agency to continue to develop newer and more sophisticated information.[272]

In *Texas v. EPA*, the state also asserted that, regardless of the acceptability of EPA's projections, the additional controls required by EPA were unnecessary.[273] This issue concerned the quality of the data base used to set standards for the chemical processing industry.[274] The court, after an in-depth analysis of the agency's proffered "step-by-step explanation . . . complete with the actual

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268. 499 F.2d at 297-98.

269. The state of Texas had incorrectly differentiated between reactive and nonreactive HC. *See id.* at 288 nn. 10-12, 301.

270. 499 F.2d at 301.

271. The Fifth Circuit stated that "[d]ecisions which are not arbitrary and capricious in the light of existing knowledge may become so by reason of scientific advances." *Id.* at 301 n.16, 308 n.31.

272. *Id.* By implication, the duty includes the duty to update and improve both the models and the underlying data used in them.

273. 400 F.2d at 301-12.

274. The dispute in the use of the data base turned on Texas' use of a reactivity factor to differentiate between reactive and unreactive HCs. Reactivity is a measure of the extent to which a pollutant will interact with sunlight to produce a photochemical oxidant. These reactive data were embodied in the choice of a reactivity factor, which "is a number, running from 0 to 1.0, which indicates the degree of reactivity of a source's hydrocarbon emissions." 499 F.2d at 304. The number was derived from studies of pollution from similar industries in other parts of the country. A higher reactivity number would result in class cleanup effort. *Id.* at 304-11. The reactivity figure was not based on Texas industries, both because the comprehensive study that was made was not available to EPA, *id.* at 302 n.19, and because of other deficiencies, both in that report and the less comprehensive report that was available. *Id.* at 302 n.19. Typical problems were insufficient evidentiary support, *id.* at 303, 304 & n.26; contradiction of other similar studies, *id.* at 304; double-counting, *id.* at 303; improper adjustment factors, *id.* at 303 & n.20; and poor presentation, *id.* at 304 & n.24. Yet, the court was still un-

numbers," upheld the agency's choice of the chemical industry reactivity factor because in setting it Texas was given "the benefit of the doubt."[275] By contrast, EPA's data underlying the choice of standards for the petroleum refining industry were found to be insufficient. The court found that EPA did not engage in a sufficiently extensive analysis of the data, based on the court's own review of that data. Consequently, EPA's choice of factors was found to be arbitrary and capricious.[276]

In *Texas v. EPA*, the court applied the traditional *Overton Park* test of a substantial inquiry into the agency's ten-thousand-page record in order to examine "the agency's explication of its course of inquiry, its analysis, and its reasoning" in light of the court's independent evaluation of that record.[277] The court said that it was required to undertake such a time-consuming and difficult task, because "[o]nly by our own study of the record can we resolve the factual disputes between the parties . . . ."[278] The court, however, was very careful to recite its abhorrence for passing on the actual accuracy or reliability of or the justification for the agency's choice, since "[t]hese are complex matters which are beyond our ken, absent the assistance of the parties."[279]

In *Texas v. EPA*, the Fifth Circuit obviously realized that the increased use of, and reliance upon, quantitative models had put a

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willing to find that the Texas figures were incorrect. *Id.* at 304. It is important to note that the Fifth Circuit stood ready to allow the state to show the court to be wrong. *Id.* at n.22.

275. 299 F.2d at 306. The agency's explanation was brought out in post-argument conference with the attorneys, which the court noted was "complete with the actual numbers used at each site," and which "enabled this court to trace back to the origins of the final result." *Id.* The court overlooked some minor errors, *id.* at 306 n.29, based on its self-assurance of their negligible impact, *id.* at 307 n.30, as well as the traditional deference to the agency's expertise, *id.* at 306 n.27.

276. 499 F.2d at 308-11. It was arbitrary and capricious to use data from Louisiana and Los Angeles which were out of date, differed with other similar data, and were based on questionable assumptions. The court noted that the state's objections and questions were not adequately answered and that even a small error could produce a disproportionately large burden on those regulated.

277. *Id.* at 296-97. The court had to get special help in dealing with the complex issues and lengthy record from the parties in the pre-trial and post-trial conferences that were held for that purpose, *id.* at 297 n.8, requiring "scores of hours of [the] court's time and which could have justified the services of a special master." *Id.* at 308 n.31. Although the court tried to prohibit the introduction of new information, *see id.* at 319, it found the effort impossible to maintain, resulting in some judicial hair-splitting in an attempt to justify the necessity of extra-record examination. *See id.* at 307 n.30, 308 n.31. *See also id.* at 321-22 (Clark, Boyle, JJ., concurring). The court's "course of inquiry" standard is taken from Appalachian Power Co. v. EPA, 477 F.2d 495, 507 (4th Cir. 1973), and Ely v. Velde, 451 F.2d 1130, 1138-39 (4th Cir. 1971).

278. 499 F.2d at 297.

279. *Id.* at 306 n.27. *See id.* at 299 n.13, 301, 306 n.27, 308 n.31.

strain on the environmental decisionmaking process which had to be accommodated in the judicial review standards applicable to that process. First of all, the court did not hesitate to make known its feeling that the decisionmaker may not be meeting his duty "to develop, review and apply updated and more sophisticated information" of both a current and predictive nature, and gave fair warning that a failure to meet this duty may merit a reversal: "[d]ecisions which are not arbitrary and capricious in the light of existing knowledge may become so by dint of scientific advances."[280] Further, the court threatened that the special problems presented by the nature of the results and form of presentation of those modeling efforts may force it to withdraw the protection traditionally given to agency decisions by the use of the arbitrary and capricious standard.[281] This significant prospect may be due to the court's feeling that its own expertise in dealing with issues presented in such quantitative model cases had been sufficiently raised by its exposure to the *Texas v. EPA* case that it will be better equipped by "the experience to know in advance what is required to resolve in court the merits of implementation plan disputes."[282] An equally plausible alternative explanation for the threat is that the Fifth Circuit realized in *Texas v. EPA* that in future similar cases it must make such an in-depth and searching analysis in order to ensure a minimal level of meaningful review.[283]

1. The Uneven Progress of Judicial Review

The second major case involving the use of computer models in environmental decisionmaking was the First Circuit's decision in *South Terminal Corp. v. EPA*,[284] which was decided at about the same time

280. *Id.* at 301 n.16.

281. *Id.* at 308 n.31.

282. 499 F.2d at 308 n.31.

283. In reviewing the application of the plan to particular air quality control regions, the court applied the arbitrary and capricious test, which the court equated with the test of reasonableness. *Id.* at 314. Justices Clark and Boyle, in their concurrence, complained that the method of judicial review in such proceedings was deficient in providing no record, since there was no hearing below. *Id.* at 321-22 (Clark, Boyle, JJ., concurring). They felt that some kind of factual record was necessary in order that the court be able to undertake a minimally meaningful review. It appears that Justices Clark and Boyle felt that the court of appeals had an obligation to review the substantive correctness of EPA's decisions—at some level— and that a minimal record was necessary for such review.

In a later case involving the use of a computer diffusion model to establish emission limitations for the Georgia SIP, the Fifth Circuit did not specify the applicable judicial review standard, but implied it was the arbitrary and capricious standard. *See* NRDC v. EPA, 529 F.2d 755, 760 (5th Cir. 1976), *on remand from*, Train v. NRDC, 421 U.S. 60, *rev'g on other gnds, sub nom.* NRDC v. EPA, 489 F.2d 390 (5th Cir. 1975).

284. 504 F.2d 646 (1st Cir. 1974). The case is discussed in Kramer, *supra* note 5, at 248-49;

that the Fifth Circuit handed down *Texas v. EPA*. In *South Terminal*, petitioners successfully challenged certain portions of the Metropolitan Boston Air Quality Transportation Control Plan (Boston Plan) which EPA had promulgated to ensure the area's compliance with the Clean Air Act's ambient air quality standards for smog and carbon monoxide. Petitioners in *South Terminal* challenged the rollback model used, the manner in which the model was applied in the case, and the data used in the model.[285]

The First Circuit was not persuaded by petitioners' attack of the rollback model as unsophisticated based on its purported failure to take into account local topography and meteorology.[286] The court also rejected petitioners' attack on the ratio between amounts of hydrocarbon emissions and resulting smog pollution, because EPA came forward with "plausible reasons" for choosing that ratio.[287]

Silver, *Problems in Attempting to Translate Statutory Standards with Emission Limitations Under Air and Water Pollution Control Legislation*, 22 VILL. L. REV. 1122, 1130, 1132-34 (1976-77). The plaintiffs in the case were adversely affected entities and individuals who objected to the transportation plan proposed for Boston by EPA when Massachusetts failed in its obligation to develop its own plan.

285. The court rejected the procedural challenges raised by petitioners of inadequate notice and inadequate disclosure of technical documents. *See* 504 F.2d at 656-60. The First Circuit later rejected this same claim of lack of access to documents underlying the SIP model. *See* Mision Ind., Inc. v. EPA, 547 F.2d 123 (1st Cir. 1976), discussed *supra* text and notes at notes 326-41.

286. *See* 504 F.2d at 662-63. Because the case was remanded for other reasons, the court did not have to face the question of whether the correct application of the unsophisticated rollback model using adequate data would be arbitrary and capricious, although the court intimated it would not. The court noted that the EPA support document appeared to consider the influences of topography and meteorology. The court discredited the contradictory testimony of petitioner's expert which stressed the unique topography and meteorology of Boston by noting that the expert did not include gasoline in his analysis. The court did not explain what relevance, if any, gasoline had for this issue, nor did it otherwise explain why the court felt able to resolve expert opinion on such a technical subject presenting "peculiar difficulties for nonexperts to evaluate." *Id.* at 665. The court likewise dismissed the petitioner's expert opinions contesting the need for regional controls by noting that a difference of expert opinion does not constitute clear error. *Id.* at 662-63.

287. 504 F.2d at 662. The court did not even briefly describe what those "plausible reasons" were, although they presumably were of the same sort as set forth in the portion of Texas v. EPA, 499 F.2d 299, 306-08 (5th Cir. 1974), which was cited by the First Circuit. The cited portion of the *Texas* opinion dealt with the Fifth Circuit's rejection of petitioner's claim there that the reactivity factor of 0.6 (on a 1.0 maximum scale) had been incorrectly applied to an "inappropriate initial inventory" which excluded nonreactive hydrocarbons. *See id.* at 306. This issue in the *Texas* case was different from the issue of the correctness of EPA's choice of the 0.6 factor by averaging reactivity factors (0.52 and 0.47) for different areas of the country and increasing the average by 20 percent to give Texas the benefit of the doubt. The Fifth Circuit's sketchy description of the EPA's plausible reasons leaves one with the impression that petitioner's challenge in *South Terminal* was more in the nature of the second question (the choice of the factor), rather than the first question (the application of that factor) as implied by the court.

The First Circuit rejected the claim that the model was incorrectly applied,[288] although the court did leave open the possibility of further challenge of the model on that basis.[289]

Petitioners in *South Terminal* were successful, however, in their allegations that there was insufficient evidence to support the controls imposed by EPA. The court held insufficient the datum on smog pollution, which consisted of a single reading from a machine of questionable accuracy.[290] The court also found there was insufficient evidence to support EPA's determination that carbon monoxide ambient air quality standards were not being met in the Boston core.[291] Finally, in what the court termed the best documented challenges to EPA's technical data, petitioners successfully showed that there was insufficient evidence to support EPA's determination of ambient air quality standards in East Boston near Logan Airport.[292]

The court denied petitioners' motion to supplement the record with intra-agency memoranda or oral testimony by EPA officials before a special master.[293] The First Circuit, with an obvious sense of

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288. *See* 504 F.2d at 662 n.20. The claimed error was that EPA used a measuring methodology for smog that differed from that used in initially establishing the national ambient air quality standard. The court rejected this simply by examining the supporting appendix to the standard. *See* 40 C.F.R. § 50.9, App. D, which confirm the court's holding. Assuming that petitioners might have been claiming that the regulations incorrectly stated the measurement methodology upon which the standard was based, the court's answer was that this question was raised too late and in the wrong forum.

289. The court stated that if it were shown that differences between measuring methodologies used in applying the model and in creating the model were substantially different, this would "raise a serious question." 504 F.2d at 662 n.20.

290. *Id.* at 662. The court verified the possibility of inaccuracy by examining certain computer printouts from the monitoring station which showed nonsensical readings. Although EPA attempted to explain these readings away as only the result of instrument calibrations and the like, and not the result of instrument inaccuracy or malfunction, the court was not persuaded.

291. *Id.* at 663. The EPA had based its determination on a single ambient air quality reading obtained from a monitor apparently placed closer to the street curb than allowed by EPA monitoring guidelines.

292. *Id.* at 663-65. The court pointed to three deficiencies: (1) Logan Airport monitoring was performed using the unapproved methodology of grab sampling; (2) petitioners came forward with correctly gathered monitoring data that showed no violation; and (3) because there was no other data available, EPA used the Kenmore Square data, *see supra* note 292, in lieu of actual monitoring for the area. The court feared that East Boston was being subjected to excessive controls based on readings taken in more polluted areas and found this particularly disturbing in light of EPA's failure to show the effect of the airport traffic on East Boston, the limited applicability of the model's results from Kenmore to the East Boston area with its differing topography and other characteristics, and the localized nature of carbon monoxide pollution. *Id.*

293. *Id.* at 675. The court stated that "[p]ossibly barring fraud and other extreme circumstances, the mental process by which the Administrator reached his decision, if explained by the record, is not a proper subject for discovery." *Id.*

frustration, noted its inability to remand to a lower district court for clarifying findings of fact.[294] The court was thus forced to remand to the agency, but laid out some specific directives as to the actions that should be taken there.[295] Among other things, EPA was directed to receive and consider further objections and arguments respecting the technical basis for calculating photochemical and carbon monoxide pollution, thus reinforcing the conclusion that the court continued to leave open the possibility of an attack on the modeling methodology itself.[296] The court stated that such a procedure would allow the court, if necessary, to rule expeditiously on the rationality of the agency's measurements with the assurance that EPA had fully confronted the objections and that its explication would be more than just post hoc rationalization.[297]

The court applied the traditional level of substantive review: whether EPA's approval of the Boston Plan was based on a consideration of relevant factors or involved a clear error of judgment.[298] The court stressed that it could not substitute its judgment for that of the agency, particularly where there are involved "technical decisions (such as determinations of local photochemical oxidant and carbon monoxide levels and the amount of reductions required to meet national standards)" which the court stated are issues that present peculiar difficulties for nonexperts to evaluate.[299] The court's deferential standard of review was justified by the inextricable involvement of policy determinations in EPA's choice of the pollution control techniques to be used.[300] Such policy decisions traditionally involve the granting of more discretion to the agency decisionmaker, and the court's deference to the portion of the agency's decision relating to control technique mix recognized the political conflicts and trade-offs involved in such a decision.

The standard of review applied to the factual data and determinations underlying EPA's decision was less deferential than that applied to policy decisions, although it recognized that those determinations present peculiar difficulties for nonexperts such as judges to

294. *Id.* at 665 (citing Camp v. Pitts, 411 U.S. 138, 143-32 (1972)).

295. 504 F.2d at 666-67, 682. Further hearings were to be held pursuant to the informal rulemaking provision of the APA, 5 U.S.C. § 533 (1976 & Supp. IV 1980).

296. *See id.* at 666 & n.23.

297. *Id.* at 665-66.

298. *Id.* at 665 (citing Citizens to Preserve Overton Park, Inc. v. Volpe, 401 U.S. 402, 416 (1971)).

299. 504 F.2d at 665.

300. *Id.* at 655 & n.6. *See supra* note 246. *See also* Amoco Oil Co. v. EPA, 501 F.2d 722, 734-35 (D.C. Cir. 1974).

evaluate.[301] The First Circuit followed *Overton Park's* mandate that the court's inquiry into the facts should be searching and careful.[302] The court, however, in recognition of the peculiar problems in judicial review presented by the use of environmental models, went further and established a substantive level of judicial review to assure "that the Agency's technical conclusions no less than others are founded on supportable data and methodology and meet minimal standards of rationality."[303] The First Circuit clearly recognized the dilemma presented to judges by the use of models and other quantitative methodologies in environmental decisionmaking:

> As laymen we are in no position to know how much ultimate weight to give to these arguments, based as they are on technical assumptions. We can only say that the objections as to data and methodology seem too serious to us simply to pass by; they demand investigation and answer. While reviewing courts are not to substitute their judgment for an agency's, they are to establish parameters of rationality within which the agency must operate. A court would abdicate its function were it, when confronted with important and seemingly plausible objections going to the near of a key technical determination, to presume that the agency could never behave irrationally. It has a duty to see that the objections are faced in a proper procedural setting and satisfactory answers provided demonstrating careful agency consideration.[304]

The test is only whether the agency behaves rationally, because under the *Overton Park* test applied by the First Circuit, the wisdom of the plan in the ordinary sense is outside of the court's province.[305]

The ambiguity and tension present in the First Circuit's description of the appropriate level of substantive judicial review reflect the unique problems presented to the courts by the agency's reliance on models.[306] The court obviously recognized that there was something different about the decisions involving quantitative models and other similar technical determinations. As a result, the court accepted its

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301. 504 F.2d at 655.

302. *See id.* (quoting Citizens to Preserve Overton Park, Inc. v. Volpe, 401 U.S. 402, 416 (1971)).

303. 504 F.2d at 655 (citing 504 F.2d at 662-67).

304. *Id.* at 655.

305. *Id.* at 655 n.5 (citing United States v. Allegheny-Ludlum Steel Corp., 406 U.S. 742, 749 (1972)).

306. The court's citation of the arbitrary and capricious judicial review provision of the APA implied that the court was applying that standard to all substantive review under the third prong of the *Overton Park* standard. *See* 504 F.2d at 655. Although the court unambiguously held that it had to "decide whether the selected controls are arbitrary or capricious," the court was not so clear as to the standard of review applied to the technical modeling decision.

responsibility that its inquiry into the facts be as searching and careful as is permissible under *Overton Park* and the APA. Although it may be argued that the review standard in *South Terminal* goes further than the usual *Overton Park* test, the First Circuit's concerns in its *South Terminal* opinion certainly show a realization that the change brought about in the environmental decisionmaking process by the use of models may require a stricter ultimate level of substantive review. Nonetheless, later cases by the First Circuit have not yet fulfilled that expectation.[307]

The next year, the Third Circuit, in *Duquesne Light Co. v. EPA*,[308] adopted a limited approach to substantive review of environmental models under the arbitrary and capricious standard. The Third Circuit recited the traditional considerations underlying that standard, including presumptions of the expertise of the agency and the regularity of its decision.[309] The Third Circuit recognized the need for a vigorous level of judicial scrutiny of the technical bases underlying the SIP; yet, the ultimate standard of review was the deferential one in which the court would overturn the agency's decision only if it did not reflect the consideration of relevant factors or represented a clear error of judgment.[310] The ultimate standard of review applied by the Third Circuit went no further than to determine that the agency exercised "reasoned discretion."[311]

The Third Circuit's test of reasoned discretion would be appropriate for policy choices such as the mix of control requirements involved in *South Terminal*. The issue in *Duquesne Light*, however, did not involve such policy questions, but was concerned only with the EPA's determination of the existence of feasible cleanup techniques to allow compliance with sulfur dioxide emission limitations contained in Pennsylvania's implementation plan. Accordingly,

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307. The First Circuit's later opinion in Mision Ind., Inc. v. EPA, 547 F.2d 123 (1976), applied an arbitrary and capricious standard to the review of the model underlying EPA's approval of the SIP for Puerto Rico. *See* Clev. Elec. Illum. Co. v. EPA, 572 F.2d 1150, 1163 (6th Cir. 1978). *See also* Seacoast Anti-Pollution League v. Costle, 572 F.2d 872, 877 (1st Cir. 1978); BASF Wyandotte Corp. v. Costle, 598 F.2d 637, 641, 647-48, 650-52, 655-56, 661 (1st Cir. 1979).

308. 522 F.2d 1186 (3d Cir. 1975), *on remand from*, 427 U.S. 902, *rev'd on other gnds*, 481 F.2d 1 (3d Cir. 1973). The Supreme Court vacated the first opinion in light of Union Elec. Co. v. EPA, 427 U.S. 246 (1976), which rejected the assertion that EPA must consider claims of economic or technical infeasibility when considering proposed implementation plans.

309. 522 F.2d at 1192.

310. *Id.* (citing Essex Chem. Corp. v. Ruckelshaus, 486 F.2d 427 (D.C. Cir. 1973), *cert. denied*, 416 U.S. 969 (1974)).

311. 522 F.2d at 1193 (citing So. Terminal v. EPA, 504 F.2d 646, 661 (1st Cir. 1973)); Int'nl Harvester Co. v. Ruckelshaus, 478 F.2d 615, 648 (D.C. Cir. 1973).

there appeared to be little reason to accord EPA any great amount of discretion in making such determinations. The Third Circuit's reasons for according such discretion, in addition to the presumption of agency expertise and the presumption of the regularity of an agency decision, were the additional usual rationales of lack of judicial expertise and the institutional consideration of the traditional function of the courts.[312] Based on these considerations, the court stated that it would confine its inquiry to the facts available to the administrator at the time of his decision.

The traditional presumptions underlying the Third Circuit's deferential review in *Duquesne Light* fail to ensure, and may interfere with, a minimal level of meaningful review of environmental decisions based on models. The relative differences in expertise and institutional restraints between agency and court often are not as great as is implied by the presumptions used by the Third Circuit. Moreover, even when there do exist significant differences between agency and court caused by deficiencies in the court's expertise or resources in dealing with models, those differences can and should be resolved within the context of the models.

The Third Circuit's approach to judicial review of models in *Duquesne Light* also raises the specter of delay in frustration of the Clean Air Act's mandate of expeditious action. In fact, the remand granted by the Third Circuit in that case was the fourth time the case had been sent back to EPA for further hearings. Examples of the delay due to remands can be seen in later cases decided by the Third Circuit.[313]

A year later, the Ninth Circuit, in *Kennecott Copper Corp. v. Train*,[314] relied on *Texas v. EPA* in upholding the use of a linear

312. The court said that "[s]ince the function of the judiciary is not to derive its own conclusions from the mass of data available at any given time, but only to review the EPA's decision, and since the judiciary generally lacks the expertise necessary to assimilate such information independently, we will confine our inquiry to the facts available to the Administrator at the time of his decision." 522 F.2d at 1993.

313. *See, e.g.*, Am. Iron & Steel Inst. v. EPA, 526 F.2d 1027 (3d Cir. 1975); Am. Iron & Steel Inst. v. OSHA, 577 F.2d 825 (3d Cir. 1978). One district court in the Third Circuit was unable to discern the Circuit's position on substantive review of environmental decisions involving technical issues. *See* Bucks County Bd. of Comm'rs v. Interstate Energy Co., 403 F. Supp. 805, 812-13 (E.D. Pa. 1975), which applied a "hard look" standard of review, but refused to interject itself into the administrative process by resolving differences in expert opinion at the administrative level. *See id.* at 814-18.

314. 526 F.2d 1149 (9th Cir. 1975), *cert. denied*, 425 U.S. 935 (1976). The portion of the Nevada SIP at issue contained Kennecott's smelter plant. Nevada's proposed SIP would have allowed Kennecott to operate the plant intermittently to avoid emissions during adverse weather conditions; such a method would not require a decrease in total emissions. EPA required cleanup technologies which lowered the total emissions from the Kennecott plant.

rollback model to support EPA's rejection of a portion of Nevada's proposed SIP which would have allowed the use of intermittent controls in lieu of continuous emission reduction and dispersal technologies. The court held that the "rollback method [or model] cannot be characterized as arbitrary or capricious in light of existing scientific knowledge."[315] The court also pointed out that the more accurate method of using a dispersion model could not have been used, because adequate meteorological data were not available, and also pointed out that any errors in the rollback model probably favored the polluter.[316] Therefore, the court upheld EPA's rejection of the implementation plan proposed by the state and upheld the substitute plan EPA promulgated for Nevada.[317] The Ninth Circuit's approach in *Kennecott Copper* failed to take sufficient steps to ensure a minimal level of meaningful review of an environmental model. In later cases, however, the Ninth Circuit showed more ingenuity in dealing with the problems of judicial review of environmental decisions based on models.[318]

The Fifth Circuit, in the 1976 case of *NRDC v. EPA (NRDC II)*,[319] reviewed the use and construction of diffusion models that were newer and more sophisticated than the rollback model earlier considered by the Fifth Circuit in *Texas v. EPA*. The issue in *NRDC II* was the propriety of EPA's approval of the Georgia SIP, which included a factor or credit with the model's calculations to reflect the use of tall smokestacks.[320] The model incorporated a factor which gave credit for tall stacks up to two and one-half times the height of the powerhouse building of the polluting facility.[321] This "2.5 rule"

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315. 526 F.2d at 1152 n.16. The court defined "existing scientific knowledge" in terms of a Senate document, Air Quality and Stationary Source and Emissions Control, Report by the Commission on Natural Resources, National Academy of Sciences, National Academy of Engineers, Natural Research Council, prepared for Sen. Comm. on Public Works, SEN. DOC. 94-4, 94th Cong., 1st Sess., at 242-45 (1975).

316. 526 F.2d at 1152 n.16. The court's determination of the inadequacy of the data was apparently based on the court's review of the EPA brief.

317. A part of the court's holding was also that tall stacks and intermittent dispersion techniques are not acceptable alternatives to control technologies that reduce the amount of pollution being emitted into the atmosphere. *See also* Big Rivers Elec. Corp. v. EPA, 523 F.2d 17 (6th Cir. 1975); NRDC v. EPA, 489 F.2d 390 (5th Cir. 1974), *rev'd on other gnds*, 421 U.S. 70 (1975). This issue was similarly determined in the later Ninth Circuit case of Bunker Hill Co. v. EPA, 572 F.2d 1286, 1290 nn. 2 & 3 (9th Cir. 1977), discussed *infra* notes 342-50.

318. *See* Bunker Hill Co. v. EPA, 572 F.2d 1286 (9th Cir. 1977); Asarco, Inc. v. EPA, 616 F.2d 1153 (9th Cir. 1980).

319. 529 F.2d 755 (5th Cir. 1976), *on remand from*, Train v. NRDC, 421 U.S. 60 (1975), *rev'g in part*, NRDC v. EPA, 489 F.2d 390 (1973).

320. 529 F.2d at 758-59.

321. The use of a tall stack coefficient in a model was based on the assumptions that the use

was a compromise adopted by EPA in response to the Fifth Circuit's earlier opinion of *NRDC v. EPA (NRDC I)*,[322] which had disapproved of the use of such a factor in the model underlying the SIP. The Fifth Circuit relied on equitable considerations in upholding EPA's compromise rule to avoid the harsh results of a retroactive application of the earlier decision. The use of this "2.5 rule" was held not to be arbitrary, although NRDC's objections to its use were termed "serious" by the court.[323]

A second issue in *NRDC II* related to the use of computer diffusion models to evaluate the SIP without any consideration of tall stacks. The court held that under the Clean Air Act a SIP could include the use of tall stacks if, and only if, the SIP—absent any "credit" given to the tall stacks in the model—would meet National Air Quality Standards under the Act. In effect, the court required that the model simulate the actual amount of pollutants being emitted into the air without regard for the effect created by a tall stack which has lower measured pollution at ground level. The court necessarily accepted EPA's use of the model, since it ultimately upheld the Georgia SIP, although petitioners may not have actually challenged the construction or use of the model.

Although the Fifth Circuit's review in *NRDC II* is considerably less searching than in its earlier opinion in *Texas v. EPA*, the technical issues were less involved. Although the standard of review applied in *NRDC II* was ambiguous,[324] later opinions by the Fifth Circuit have confirmed that the court applied an arbitrary and capricious standard.[325] Later cases in other circuits, however, use deferential review

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of tall stacks would result in measured pollution at ground level. Of course, the use of a tall stack did not reduce the actual pollution being emitted. Tall stacks simply caused the pollution to be dispersed at a higher level and over a larger area. *See generally*, W. RODGERS, *supra* note 155, at 255-56.

The opinion uses the language of "credits" to reflect the assumed pollution reductions from the tall stacks. The "2.5 rule" used by EPA gave only a partial credit to those stacks which exceeded two and one-half times the height of their power houses, because the model likely predicted higher levels of pollution than actually measured by ground-level monitors. Prior to the adoption of the 2.5 rule EPA apparently had allowed full credit for the diluting effect of smoke stacks in existence for the first implementation plans filed in January of 1972. *See* Kennecott Copper Corp. v. Train, 527 F.2d 1149, 1152 n.16 (9th Cir. 1975), *cert. denied*, 425 U.S. 935 (1976). The 2.5 rule was chosen on the basis of the median stack height which existed in the power industry before the passage of the Clean Air Act. NRDC v. EPA, 529 F.2d 755, 760 (5th Cir. 1976).

322. 489 F.2d 390 (5th Cir. 1973), *rev'd in part on other gnds, sub nom.*, Train v. NRDC, 421 U.S. 60 (1975).

323. *See* 529 F.2d at 759-60.

324. *See* 529 F.2d at 760.

325. *See* Taylor v. Dist. Engineer, 567 F.2d 1332, 1337 (5th Cir. 1978). In areas of en-

standards more akin to the standard in *NRDC II* than *Texas v. EPA*. Thus, *Texas v. EPA* may be seen as a high-water mark in the development of the judicial review of environmental models.

The First Circuit, in *Mision Industrial, Inc. v. EPA*,[326] applied a deferential standard of review and declined to apply the more probing standard used by the Fifth Circuit in *Texas v. EPA*. In *Mision*, the court upheld the EPA's use of a computer diffusion model[327] as a "satisfactory predictive tool" on which to base EPA's revision of Puerto Rico's SIP. In *Mision*, petitioners unsuccessfully challenged the revision of the SIP on the "grounds that the predicting methodology used in drafting the plan permitted too great a likelihood for error and that as a result the plan fail[ed] to provide for attainment of national air quality standards."[328] First, petitioners argued that the random error which was an intrinsic part of the model was so great as to prevent its use as a predictive method. The EPA admitted that the model could have a random error as high as 150 percent for annual, and 200 percent for short-term, concentrations of sulfur dioxide. The court accepted the EPA administrator's statements that such errors were extreme and occurred only in isolated instances and were just as likely to result in overprediction as in underprediction.[329]

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vironmental law involving new scientific knowledge, the Fifth Circuit remains willing to defer to the agency's knowledge and expertise. *See, e.g.*, Superior Oil Co. v. FERC, 563 F.2d 111 (5th Cir. 1977). The environmental cases involving technical issues under NEPA decided by district courts in the Fifth Circuit apply a searching and careful version of the arbitrary and capricious standard of judicial review. *See, e.g.*, Inman Park Restoration v. Urban Mass Transp. Ad., 414 F. Supp. 99 (N.D. Ga. 1976); Ala. v. Corps of Engineers, 411 F. Supp. 1261 (N.D. Ala. 1976); City of No. Miami v. Train, 377 F. Supp. 1264 (S.D. Fla. 1974); Sierra Club v. Froehlke, 369 F. Supp. 1289 (S.D. Tex. 1973), *rev'd on other gnds, sub nom.*, Sierra Club v. Callaway, 799 F.2d 982 (5th Cir. 1974).

326. 547 F.2d 123 (1st Cir. 1976). *Mision* is also discussed in Kramer, *supra* note 5, 250-51.

327. Professor Kramer notes that "[d]iffusion models attempt to describe and predict the physical and chemical behavior of pollutants in the ambient air. A computer diffusion model is merely a mathematical model which has been placed on a computer program that describes the 'spatial and temporal history of contaminants released into the atmosphere.' " Kramer, *supra* note 5, at 242 n.36 (quoting J. SEINFELD, AIR POLLUTION 260, 261-351 (1975)). *See* U.S. EPA, GUIDELINES ON AIR QUALITY MODELS, A1-A34 (1978). The District of Columbia Court of Appeals has stated that diffusion models required to be used in the PSD program are "mathematical techniques for simulating the diffusion into the atmosphere of a new source's emissions under various meteorological conditions and operating levels. The purpose of such models is to predict pollutant concentrations at any point in the neighborhood of the source." Ala. Power Co. v. EPA, 636 F.2d 323, 348 (D.C. Cir. 1980) (footnote omitted) (citing EPA, TECHNICAL SUPPORT DOCUMENT—EPA REGULATIONS FOR PREVENTING THE SIGNIFICANT DETERIORATION OF AIR QUALITY, 29-30 (1975)).

328. *See* 529 F.2d at 760.

329. 547 F.2d at 128-29.

Second, petitioners pointed out that the SIP failed to take into account sulfur pollution from sources other than the industrial plants covered in the plan. If that were true, petitioners in effect would have to bear the burden of cleaning pollution from those other sources. Without pointing to any substantiating data, the court accepted the administrator's representation that such sources were adequately compensated for by the 20 percent margin for error built into the model. The court did not attempt to reconcile the fact that such error could just as easily work to petitioners' disadvantage and would, therefore, not offset any such inadequacies in the data base.[330]

The third alleged deficiency in the diffusion model used to create the Puerto Rican SIP was that the model did not accurately portray actual Puerto Rican meteorological conditions. Petitioners contended that the rough terrain of Puerto Rico resulted in greater turbulence than was assumed in the construction of the model. If the petitioners' claim were true, the model apparently would underestimate the dispersal of pollutants due to such turbulence. The EPA did not directly dispute that allegation, but answered that the model was applied more conservatively than if terrain turbulence had somehow been compensated for.[331]

The fourth alleged deficiency was that the model did not use on-site weather conditions as a basis for its projection, but instead used weather data gathered at only three locations on the island. In effect, the Puerto Rican agency assumed that the data acquired at these three sites was representative of the island and extrapolated from that data based on worst-case assumptions. The court noted that EPA took an active role in assuring that the weather data was properly applied, although the court gave as its only example of such review EPA's request for an explanation of how the worst-case condition was derived.[332]

The final, and apparently most serious attack on the model was petitioners' allegation that it was not calibrated, in that no monitoring data had been used to ensure the accuracy of the predictive relationship between sulfur content in the air and air quality.[333] The EPA admitted that such calibration based on incomplete data is not good practice, but stated that conservative assumptions and calcula-

330. 547 F.2d at 128 n.4.

331. *Id.* at 128. *See supra* text and note at note 292 (First Circuit's treatment of this question in *South Terminal*).

332. *See supra* note 331.

333. 547 F.2d at 128-29.

tions were applied to compensate for lack of precision.[334] The First Circuit in *Mision* relied on *Sierra Club v. EPA*[335] to hold that the court should defer to EPA's expertise in choosing the computer model used, since this was an area where EPA's "expertise is heavily implicated."[336] Without refuting any of the serious challenges to the model, the First Circuit recited the litany that the court could not substitute its judgment for that of the administrator. Although the court did not explicitly recite its standard of review, later opinions have stated that the First Circuit was applying the arbitrary and capricious standard in *Mision*.[337]

The First Circuit bolstered its decision in *Mision* by noting that petitioners' criticisms as to the substance of the methodology used were communicated in detail to the EPA administrator during the federal comment period.[338] This recitation by the court is not convincing in light of the deficiencies in the petitioners' access to usable materials.[339] In particular, the court noted that there was some force to the petitioners' complaint that the materials made available prior to the hearings were self-serving rhetoric and confused compilations of additions and deletions to the original plan. The most serious omission from the record was the computer printout showing the basis for the sulfur-in-fuel limitations assigned to each source under the model. The court accepted the necessity of timely access to that printout in order to verify that the sulfur-in-fuel content limitations applied to each individual source were necessary to meet applicable ambient air quality standards under the computer model.

The issue of verification of the underlying model is central to the larger issue of review of the SIP to assure its substantial correctness. Since courts of appeals usually recite that they cannot independently verify the model's correctness, it is vital that petitioners be able to perform such verification themselves. The First Circuit in *Mision* held that the presumption of regularity normally accorded to administrative decisions is rebuttable.[340] Even so, the court found no

334. 547 F.2d at 129.

335. 540 F.2d 1114, *vacated as moot*, 434 U.S. 809 (1977).

336. 547 F.2d at 129.

337. *See* Clev. Elec. Illum. Co. v. EPA, 572 F.2d 1150, 1163 (6th Cir. 1978).

338. 547 F.2d at 129.

339. *Id.* at 126.

340. *Id.* at 127. The issue in *Mision* was whether the presumption was rebutted by procedural errors. That is, the court examined whether petitioners were so prejudiced by the "run around" they received in attempting to gain access to necessary, but unavailable, computer printouts that it "materially impair[ed] their ability to comment at the public hearing [on the cost], and the ability of the hearing itself to serve the purpose Congress intended." *Id.*

basis in the record for any alleged prejudice to petitioners by virtue of the unavailability of the computer printout and dismissed the shortcoming as harmless error.[341]

In 1977, the Ninth Circuit, in *Bunker Hill Co. v. EPA*,[342] rejected the SIP promulgated by EPA after the agency had rejected the plan proposed by the State of Idaho. The Ninth Circuit held that EPA failed to show that the control technology necessary to meet the requirements of the EPA plan was feasible as required by the Clean Air Act.[343] The court reached a differing conclusion from EPA's resolution of the conflict between experts, although the agency's resolution of the differences in expert opinion may be based on EPA's exclusive reliance on expert testimony as opposed to actual data from operating examples from cleanup technology.[344] The court held that if EPA relies only on expert testimony to demonstrate technological feasibility the agency bears a significant burden of proof, in that the expert testimony must clearly demonstrate that

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Although the court appeared to have found such prejudice, the court held that the presumption of regularity was not rebutted, because the prejudice was harmless. *See infra* note 341.

341. *See* 547 F.2d 127-28. The court noted that the petitioners were provided prior to the hearing with the formulas used in the computer diffusion model and appendix listing the maximum allowed percentage of sulfur-in-fuel for each regulated source, together with the control technique (variation in permitted sulfur-in-fuel limitations at each source) and the ultimate results (the numerical results) from the application of the model. The court held that petitioners were not prejudiced by their inability to verify the application of the results of the model. Petitioners did not contend that the results of the application of the model were inconsistent with model used, but it is clear from the opinion the lack of inconsistency was shown in facts learned after the hearings. The court further noted that, because the data turned out to be a useless "miscollated mass stack of papers," petitioners could have gleaned nothing from the data which would have been useful to them in examining EPA's choices. *Id.*

342. 572 F.2d 1286 (9th Cir. 1977). For a discussion of the Ninth Circuit's earlier opinion in *Kennecott Copper* see *supra* text at notes 314-18.

343. *See* 572 F.2d at 1302-03. At the very least, EPA failed to explain adequately the data and methodology it relied on. *See id.* at 1302 n.36, 1291, 1293 n.11, 1295.

344. The court stated that EPA's expert witness "failed to respond fully and satisfactorily" to the objections raised by petitioner's experts. *Id.* at 1291 n.8. Additionally, the court noted several instances where EPA failed to contradict statements by the petitioner's experts that cleanup methodologies were not technically acceptable in that EPA failed to explain significant apparent discrepancies in its data relating to that technological sufficiency. *See id.* at 1296-97. Apparently the EPA did not satisfactorily respond to the eight questions presented to it by the court. *See id.* at 1299 n.26. As a result, significant doubt was cast on the feasibility of the cleanup technologies. *Id.* at 1300. The court rejected attacks made by EPA on the evidence, based on assertion that the petitioner's evidence was based on incorrect assumptions. *Id.* at 1301 n.31. In sum, the court appeared to be resolving disputes between experts, at least in some sense of that word, although most courts hold that it is not proper for judges to engage in such activities. Apparently relying on the doctrine of deference, the Ninth Circuit stated that on the record it was impossible to resolve the controversies involved and, therefore, it had to remand further hearings. *Id.* at 1301.

the technology is available and must convincingly answer any cogent criticism by opposing experts.[345]

In remanding the case for further hearings, the Ninth Circuit in *Bunker Hill* applied *Overton Park* in holding that EPA had failed to exercise the required "reasoned discretion."[346] The court rejected the requirement of a full-fledged evidentiary hearing and stated that the decision could not be based on post hoc rationalization.[347] In spite of this standard of review, the court displayed considerable willingness to explore and supplement the administrative record, to which it is normally bound.[348] The court also held that, although cross-examination is not always required, petitioners would be allowed, based on the court's review of the data and methodology, to cross-examine the experts of EPA.[349] One wonders whether the future will find the Ninth Circuit willing to tolerate such "knowledgeable blunders"[350] in the models and other technical bases underlying such environmental decisions.

The Fourth Circuit's decision in *Appalachian Power Co. v. EPA*,[351] further demonstrates the uneven progress of the courts in responding to the special problems created by the use of models in en-

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345. EPA's expert evidence had been drawn in large part from the Browder's Study, which the court found met the requirement that it be more than "purely theoretical or experimental." *Id.*

346. *Id.* The court felt constrained to note that applying this standard of review did not shift the ultimate burden of proof to EPA. *Id.* at 1305-06.

347. Such post hoc rationalizations were condemned in Citizens to Preserve Overton Park, Inc. v. Volpe, 401 U.S. 402, 419 (1971). *See supra* cases cited at note 192. In *Overton Park* the Supreme Court held that affidavits presented after the close of the administrative hearing record were improperly considered by the lower courts, because they were not included in the record to be reviewed under the APA. In Columbus & So. Ohio Elec. Co. v. Costle, 638 F.2d 910, 912 (6th Cir. 1980), the Sixth Circuit refused to allow EPA to publish technical documents to correct errors found in an earlier Sixth Circuit opinion, Cin. Gas & Elec. Co. v. EPA, 578 F.2d 660, 662-65 (6th Cir.), *cert. denied*, 439 U.S. 1114 (1978), as discussed *infra* text and notes at notes 384-85, stating that such a post hoc attempt to justify EPA's action was improper under the APA. However, the Fifth Circuit in Texas v. EPA, 499 F.2d 299, 307 n.30 (5th Cir. 1974), relied on *Overton Park* in stating it felt constrained to consider EPA's explanations, as opposed to justifications, because "they are not the post hoc *rationalizations* of agency actions which 'have traditionally been found to be an inadequate basis for review.' " *Id.* (emphasis in original.) *Accord* Cin. Gas & Elec. Co. v. EPA, 572 F.2d 1150, 1163 n.4 (6th Cir. 1978).

348. This willingness was based on the "considerable doubt" raised in the court's mind by its full review of the record. 572 F.2d at 1291, 1302. The court presented questions to EPA, to which EPA and the petitioners responded in supplemental briefs and a supplemental record. *Id.* at 1291 n.8, 1299 n.26. The court also allowed the use of a joint condensed appendix. *Id.* at 1295 n.16. The court even looked to a telegram not admitted into the record. *Id.* at 1299 n.25.

349. *Id.* at 1305.

350. *See* Matsumoto v. Brinegar, 568 F.2d 1289 (9th Cir. 1978).

351. 579 F.2d 846 (4th Cir. 1978).

vironmental decisionmaking. In *Appalachian Power*, petitioners unsuccessfully argued that the emission standards established in the West Virginia SIP were unnecessarily stringent in that they reflected a "worst-case approach"[352] and because the controls were applied selectively to only a few regions.[353] The Fourth Circuit properly gave short shrift to petitioner's argument that certain areas were being burdened to a greater extent than others, noting that courts should not interfere in this kind of policy judgment.[354] Unfortunately, the court's formulation of the standards of judicial review to be applied to the technical bases underlying EPA's decision fails to ensure a minimal level of meaningful review.[355] The Fourth Circuit's level of review required only a statement of reasons underlying the decision, such that the rationale of the agency's decision may be reasonably discerned.[356] This statement of review applied in *Appalachian Power* appears more deferential than the standard established under *Overton Park* and is, in any event, far too deferential without further justifying circumstances.

2. Cases Reviewing Ohio's SIP

The much-beleaguered Ohio SIP has to date resulted in a total of thirteen opinions by the Sixth Circuit Court of Appeals, eight of

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352. *Id.* at 853-54. This worst case attack by petitioners refers to the modeling technique of looking for violations of ambient air quality standards by using as data inputs for the model those data (such as plant operating conditions, wind conditions, and terrain) which the modeler suspects (or has shown) to give the highest projected levels of pollution. The term "worst case" is somewhat of a misnomer, because it is the accepted better practice to ignore the highest level of projected pollution by the model. Instead, the modeler uses the model's results "based upon full capacity operational data of all emissions sources in a given area on a hypothetical second-worst day in the year," a practice which the Sixth Circuit has held not to be arbitrary and capricious in itself. Republic Steel Corp. v. Costle, 621 F.2d 797, 801 (6th Cir. 1980) and cases cited therein. *Accord* NRDC v. EPA, 529 F.2d 755 (5th Cir. 1976); MAD v. Trainor, 400 F. Supp. 533 (D. Md. 1975), *aff'd*, 500 F.2d 29 (4th Cir. 1974). The model is used to set the applicable emission limitation "according to the predicted second-worst day in terms of pollution results shown." Clev. Elec. Illum. Co. v. EPA, 572 F.2d 1150, 1160 (6th Cir. 1978). Typically, the highest reading from a monitor for a given period is also disregarded because of the potential for an occasional erroneous reading. *See* So. Terminal v. EPA, 504 F.2d 646, 662 (1st Cir. 1974). *See also* Envt'l Study & Protection v. PAC, 464 F. Supp. 143, 147 (D. Conn. 1978).

353. 579 F.2d at 854.

354. *Id. See supra* text at note 313.

355. The court's response to petitioner's "worst case" objections was: "[i]t is unnecessary for us to pass on the validity of [petitioner's] objections to the assumptions made from the data on which [the state agency] relied; it is sufficient for purposes of our review that the petitioners demonstrated indisputably their understanding of agency's methodology, basis and data used in formulating its plan and of what the regulations in the proposed plan, if adopted, provided, so far as their operations were concerned." 578 F.2d at 854.

356. 579 F.2d at 854 (citing United States v. Allegheny-Ludlum Steel, 406 U.S. 742, 758

which involve challenges to the use of models in environmental decisionmaking.[357] Two types of computer models were used to establish emission limitations for the Ohio SIP because no single model could be applied to all areas of the country regardless of topography or meteorology. One model, the MAXT-24 model,[358] was used to simulate isolated sources in rural and complex-terrain areas. Another model, the RAM model,[359] was used to simulate multiple sources located in relatively close proximity to one another, as would commonly be found in an urban area. A third type of model, called SYMAP, was also involved in the creation of the SIP. The SYMAP program was used to correlate monitoring data to produce a graphical representation of that data to assist in delineating the boundaries of nonattainment areas.[360]

Although there are some differences between the construction and use of the MAXT-24 and RAM models as discussed below, the models in many respects strongly resemble one another and contrast sharply with earlier relatively simplistic models previously used to esti-

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(1972); Ethyl Corp. v. EPA, 541 F.2d 1, 34, 73, *cert. denied*, 426 U.S. 941 (1976)).

357. *See* Columbus & So. Ohio Elec. Co. v. Costle, 638 F.2d 920 (6th Cir. 1980); Cin. Gas & Elec. Co. v. Costle (CGE III), 632 F.2d 14 (6th Cir. 1980); GM Corp. v. Costle, 631 F.2d 466 (6th Cir. 1980); PPG Ind. v. Costle, 630 F.2d 462 (6th Cir. 1980); Rep. Steel Corp. v. Costle, 621 F.2d 797 (6th Cir. 1980); Ohio Envt'l Council v. EPA, 593 F.2d 24 (6th Cir. 1979); Cin. Gas & Elec. Co. v. EPA (CGE II), 578 F.2d 660 (6th Cir. 1978), *cert. denied*, 439 U.S. 1114 (1979); Clev. Elec. Illum. Co. v. EPA, 572 F.2d 1150 (6th Cir.) *clarified*, Cin. Gas & Elec. Illum. Co. v. EPA (CGE I), 578 F.2d 666 (6th Cir.), *cert. denied*, 439 U.S. 910 (1978). *See also* No. Ohio Lung Ass'n v. EPA, 572 F.2d 1143 (6th Cir. 1978); Buckeye Power Co. v. EPA, 525 F.2d 80 (6th Cir. 1975); Buckeye Power Co. v. EPA, 481 F.2d 162 (6th Cir. 1962). In a related case, the Sixth Circuit upheld the right of EPA to proceed directly against Ohio to require enforcement of an EPA-promulgated provision added to the Ohio SIP requiring that automobiles not be registered if they have not passed mandated inspection and maintenance tests. United States v. Ohio Dep't of Highway Safety, 635 F.2d 1195 (6th Cir. 1980).

358. MAXT-24 is an abbreviation for Second Maximum Twenty-Four Hour Dispersion Model with Terrain Adjustments. Another abbreviation applied to such a model is CRSTER. *See* Cin. Gas & Elec. Co. v. EPA, 578 F.2d 660, 663 (6th Cir. 1978).

359. RAM is an abbreviation for Real-Time Air-Quality-Simulation Model.

360. The use of the SYMAP program was upheld in GM Corp. v. Costle, 631 F.2d 466 (6th Cir. 1980), as discussed *infra* text and notes at notes 414-15. The graph of monitoring data produced by SYMAP was used to delineate the boundaries of designated nonattainment areas by using "actual monitored air quality data to produce isopleths which represent the cut points between levels of TSP (total suspended particulate) concentrations. The isopleths are then roughly conformed to geographic or political boundaries and the proper designations are applied to each area." *Id.* at 469. An isopleth is "a graph showing variations in occurrence or frequency of a phenomenon, especially in meteorology, with reference to two variables, such as time and space." 1 WORLD BOOK DICTIONARY 1111 (1973). In non-scientific terms, the SYMAP model performs certain calculations on the monitoring data to draw a line (the isopleth) through data points with equal value in the same way that a person creates a picture by drawing lines between numbered dots in a dot puzzle.

mate ambient air quality standards for air quality control regions.[361] Both MAXT-24 and RAM models are so-called Gaussian models that must be run on a computer.[362] Both models incorporate a solid ascertainable data base composed of the established design capacity of the power plants, sulfur content of the fuel used in those plants, height of the plant's smokestack, weather data, and the nature of the surrounding terrain. The computers are required to perform the "massive analytical task" of performing calculations on the "[t]remendous amounts of data" on each source "so that the computer analysis reflects actual conditions."[363] Both the RAM and MAXT-24 models are run based on the assumptions that the plants being modeled operate at full capacity twenty-four hours a day. Based on these conditions and the factors used in the model,[364] computer runs are made for each day of the year, and the ultimate standards are set according to the predicted second-worst day in terms of pollution results shown.[365]

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361. *See* Kramer, *supra* note 5 at 240 n.23, 242 n.36.

362. A Gaussian model is so called because it relies on a Gaussian plume dispersal, which is a mathematical formula to describe how a cylindrical discharge of pollutant (a plume) will disperse when emitted from a tall, cylindrical source like a smokestack. *See id.* at 238 n.13, 254 n.104 & sources cited therein. Both the RAM and MAXT-24 models assumed "vertical and horizontal dispersion of the pollution plume." Cin. Gas & Elec. v. Costle, 632 F.2d 14, 18 (6th Cir. 1980). The model assumed both that the pollutant would disperse upwards out of the smokestack and disperse laterally as predicted by the laws of fluid dynamics. Such a model is also known as a diffusion model. *See id.* at 242 n.36, 254 n.103 & sources cited therein. *See, e.g.*, Cin. Gas & Elec. Co. v. Costle, 632 F.2d 14, 18 (6th Cir. 1980); Clev. Elec. Illum. Co. v. EPA, 572 F.2d 1150, 1160, 1162-63 (6th Cir. 1960). *See also* Kramer, *supra* note 5, at 254. Diffusion models were described by the District of Columbia Court of Appeals as "mathematical techniques for simulating the diffusion into the atmosphere of a new source's emissions under various meteorological conditions and operating levels. The purpose of such models is to predict pollutant concentrations at any point in the neighborhood of the source." Ala. Power Co. v. Costle, 636 F.2d 323, 348 (D.C. Cir. 1980).

363. Clev. Elec. Illum. Co. v. EPA, 572 F.2d 1150, 1161 (6th Cir. 1978) (quoting from the EPA Brief). The court then used the example cited in EPA's Brief:

> For example, a gaseous pollutant emitted over a grassy field will disperse much differently than if the pollutant is emitted over a large urban area. There the dispersion will be affected not only by the local weather conditions but also by the greater turbulence caused by the different types of surface areas and hot sources throughout a city.

Id.

The court concluded that the RAM employed "a wider, more complete and more accurate data base than any prior model yet employed in devising a sulfur dioxide control strategy for a state or county." *Id.* at 1162, *quoted in* Rep. Steel Corp. v. Costle, 621 F.2d 797, 805 (6th Cir. 1980). The court concluded that the same was true for the MAXT-24 model. *See* Cin. Gas & Elec. Co. v. EPA, 632 F.2d 14, 18 (6th Cir. 1980).

364. *See supra* text and note at note 336.

365. Clev. Elec. Illum. Co. v. EPA, 572 F.2d 1150, 1160 (6th Cir. 1980). *Accord* Cin. Gas & Elec. Co. v. Costle, 632 F.2d 14, 17 (6th Cir. 1980). *See also supra* text and note at note 325

There are, however, some important differences between the RAM and MAXT-24 models. As noted above, the MAXT-24 model is designed for use in predicting pollution from single sources in rural areas,[366] whereas the RAM model can be applied to any individual sources of pollution to derive specific estimates of permissible pollutant emission rates for each.[367] The MAXT-24 cannot be used to provide estimates of comparative contributions of pollutants from each of the individual plants.[368] By contrast, the RAM model can derive specific estimates of comparative amounts of pollutants from each of a number of multiple sources.[369] Both the MAXT-24 and RAM models, however, establish with some degree of certainty the amount of pollutants that an individual source contributes to the ambient air.[370]

Thus, more sophisticated models such as RAM and MAXT-24 provide a solution—with some degree of certainty—to the problem of determining the relative contribution of pollutants to the ambient air by a single source.[371] This is a necessary factual determination which must be made prior to the policy decision determining the amount of cleanup that an individual source must make vis-a-vis other sources in its area. The issue may also become an important one to the extent that a state air pollution authority may attempt to charge individual sources with violations of ambient air quality standards,[372] which would raise substantial questions regarding the ability of such

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(discussion of the worst case approach typically taken by modelers).

366. Cin. Gas & Elec. Co. v. Costle, 632 F.2d 14, 18 (6th Cir. 1980) (quoting Cin. Gas & Elec. Co. v. EPA, 578 F.2d 660, 661-62 (6th Cir. 1978)).

367. Rep. Steel Corp. v. Costle, 621 F.2d 797, 805 (6th Cir. 1980) (quoting Clev. Elec. Illum. Co. v. EPA, 572 F.2d 1150, 1162 (6th Cir. 1978)).

368. Cin. Gas & Elec. Co. v. Costle, 632 F.2d 14, 18 (6th Cir. 1980) (quoting Cin. Gas & Elec. Co. v. EPA, 578 F.2d 660, 661-62 (6th Cir. 1978)).

369. Cin. Gas & Elec. Co. v. Costle, 632 F.2d 14, 18 (6th Cir. 1980) (quoting Cin. Gas & Elec. Co. v. EPA, 578 F.2d 660, 661-62 (6th Cir. 1978)).

370. The inability of the MAXT-24 model to provide relative contributions from multiple sources does not reflect on its ability to demonstrate causation when properly applied to an isolated source. By definition, the MAXT-24 projects only the pollution from the source being modeled, with any pollution from other sources being subsumed into the background pollution factored into the model.

371. *See* Kramer, *supra* note 5, at 239-43.

372. The EPA may not enforce an ambient air quality standard against a private party because such a standard is not a "requirement of an applicable implementation," as required under the federal enforcement statute, 42 U.S.C. § 7413(c)(1)(A). *See* 42 U.S.C. § 7413(a)(1), (b)(1). *Accord* Currie, *Federal Air-Quality Standards and Their Implementation*, 1976 AM. B. F. J., 365, 399-400. If ambient air quality standards are being violated, the appropriate course is for EPA to give notice and, if necessary, initiate an action against the state under 42 U.S.C. § 7413(a)(2). *See* United States v. Ohio Dep't of Highway Safety, 635 F.2d 1195 (6th Cir. 1980).

models to demonstrate causation with sufficient certainty to uphold any enforcement action.[373]

The opinions by the Sixth Circuit Court concerning the Ohio SIP and nonattainment designations based on models constitute a substantial body of law on the issues of the general validity of the models used; the correctness of adjustments made in the models to reflect the terrain being modeled; the extent to which the model can be relied on without calibration; and the ways in which monitoring data can be used to support or discredit modeling data. The Sixth Circuit modeling cases clearly and uniformly hold that, because the Clean Air Act authorizes the use of computer modeling, the use of such models is not per se arbitrary and capricious.[374] Nevertheless, while rejecting "general objections to the procedures and formulas [i.e., models] employed by the EPA," those courts "reserve[d] for later decision those attacks . . . wherein petitioners assert that the agency has made specific mistakes or arrived at results claimed to be demonstrably erroneous."[375] That is, the Sixth Circuit has indicated it will be less deferential in examining the particular method of applying those models.

The first of the Sixth Circuit opinions dealing with modeling, *Cleveland Electric Illuminating Co. v. EPA*,[376] addressed the question of whether EPA erred in designating certain power plants as urban rather than rural. The correctness of that designation is vital in determining whether it is appropriate to use the RAM model, which is designed to be employed in urban areas, or the MAXT-24 model,

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373. If an attempt were made to enforce ambient air quality standards against private parties by the use of modeling or monitoring data a substantial causation question would arise. *See supra* note 372. Although the new MAXT-24 and RAM models do allow the establishment of some degree of causation, it is unlikely that such models could be shown to be sufficiently reliable to justify the finding of a violation of such standard under the Act. After all, "the content of the standards cannot be divorced from the methodology by which compliance is adjudged." W. RODGERS, *supra* note 155, at 297. Certainly, the present state of the art in modeling or monitoring will not allow violations to be established beyond a reasonable doubt, as would be required to uphold a criminal violation. *See, e.g.*, 42 U.S.C. § 7413(c).

374. Columbus & So. Ohio Elec. Co. v. Costle, 638 F.2d 910, 912 (6th Cir. 1980); Cin. Gas & Elec. Co. v. Costle, 632 F.2d 14, 18 (6th Cir. 1980); PPG Ind., Inc. v. Costle, 630 F.2d 462, 464-65 (6th Cir. 1980); Rep. Steel Corp. v. Costle, 621 F.2d 797, 805-06 (6th Cir. 1980); Cin. Gas & Elec. Co. v. EPA, 578 F.2d 660, 662 (6th Cir. 1978); Clev. Elec. Illum. Co. v. EPA, 572 F.2d 1150, 1161 (6th Cir. 1978). *Accord* No. Ohio Lung Ass'n v. EPA, 572 F.2d 1143, 1149 (6th Cir. 1978). *See also* GM Corp. v. Costle, 631 F.2d 466, 469 (6th Cir. 1980), which held that the use of the SYMAP model to designate nonattainment areas was not arbitrary or capricious in itself.

375. Rep. Steel Corp. v. Costle, 621 F.2d 797, 806 (6th Cir. 1980).

376. 572 F.2d 1150 (6th Cir.), *clarified in* Cin. Gas & Elec. Co. v. EPA, 578 F.2d 666 (6th Cir.), *cert. denied*, 439 U.S. 910 (1978).

which is designed to be used in rural areas.[377] The Sixth Circuit in *Cleveland Electric* inspected the geographical location of the plants in question and the population distribution in the nearby vicinity and upheld the urban designation.[378] The court also rejected petitioners' challenge to the RAM model's urban dispersion coefficients,[379] which are multiplying numbers used in the mathematical formula for the Gaussian plume dispersion being modeled.[380]

Petitioners in *Cleveland Electric* did, however, successfully challenge the coefficients used in the models to represent the assumed weather conditions.[381] The EPA had chosen the set of assumptions representing the least stable weather conditions.[382] The court was not persuaded to force EPA to use the less burdensome Class B set of coefficients;[383] the court remanded the issue to EPA for further

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377. *See supra* text and notes at notes 366-69.

378. 572 F.2d at 1165 (6th Cir. 1978). *See* Cin. Gas & Elec. Co. v. Costle, 578 F.2d at 667 (6th Cir. 1978).

379. *See* 572 F.2d at 1165; 578 F.2d at 667.

380. *See supra* note 362 describing the Gaussian mathematical formula. A coefficient is defined as "a number . . . put before and multiplying another. In $3x$, 3 is the coefficient of x . . . ." 1 WORLD BOOK DICTIONARY 405 (1973).

381. This success came on petition for review. *See* Cin. Gas & Elec. Co. v. EPA, 578 F.2d 666, 667 (6th Cir. 1978) (citing Cin. Gas & Elec. Co. v. EPA, 578 F.2d 660, 662-63 (6th Cir. 1978)). These coefficients were a set of coefficients representing assumed weather conditions. The set of coefficients used was one of six sets labeled "Class A" through "Class F," each representing different assumed weather conditions, with Class A representing the least stable conditions, collectively referred to as Pasquill-Gifford Coefficients. *See* Kramer, *supra* note 5, at 254-55.

382. The court in Cin. Gas & Elec. Co. v. EPA, 578 F.2d 662 (6th Cir. 1978), stated that such Class A coefficients are associated with gusty winds and are part of "the set of assumptions which is based on the most direct and quickest impact of the pollution plume upon ground level with the least prior dispersal." *Id.* at 662. EPA's choice of these Class A coefficients represented the worst case assumptions for the regulated facilities, in the sense that those coefficients result in the highest levels of projected pollution for any given set of data. This worst case is to be distinguished from the practice of choosing the second highest of the model's results (produced by choosing the appropriate model, adjusting it for assumed terrain and weather conditions, and plugging in emission data, done for every day of the year) as a basis for setting emission limitations. *See supra* note 325.

383. The court stated that:

> petitioners in this instance (contrary to the general attack on the six coefficients employed in RAM [as involved in *Cleveland Electric*]) are not objecting to the use of the coefficients; they are attacking the accuracy of one set of them—the Class A set associated with the 'gusty winds.' Specifically they claim that the Class A assumption is fallacious in that it assumes a longer period of downward draft than occurs in fact and fails to make allowance for the lateral dispersal which would accompany such a vertical wind at the point of impact.

578 F.2d at 662.

Petitioners then supported the challenge with studies of their own, directed the court's attention to a conference launched by EPA, and pointed out the importance of the issue in determining the emission limits for one-third of the affected power plants.

study.[384] The court, however, recited an impressive array of criteria and authorities rejecting the appropriateness of the Class A coefficients used by EPA,[385] clearly indicating that the court felt petitioners had carried the day; yet the court was careful to note that its remand did not mandate the use of the less burdensome Class B coefficients.[386]

This holding as to the appropriate weather coefficients was reaffirmed in the most recent of the Ohio SIP cases, *Columbus and Southern Ohio Electric Co. v. Costle*.[387] The EPA had studied the points raised in *Cleveland Electric* and concluded that the Class B coefficients would underproject future amounts of pollutants. Thus, EPA published a notice in the Federal Register that the agency proposed to re-adopt the Class A coefficients, unless public comments could demonstrate otherwise.[388] The EPA informed the court that it intended to place the comments and EPA's response to them in the record before the court.[389] The court in *Columbus and Southern* obviously felt that its remand in *Cleveland Electric* mandated an entirely new monitoring effort. The Sixth Circuit in *Columbus and Southern* noted with disapproval that the decision addressed therein was based "on the same modeling which this court has already found to be unsupported by the EPA's own records."[390] The court condemned EPA's efforts as an invalid attempt at post hoc rationaliza-

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384. *See id.* at 664.

385. The court's willingness to reject the use of the coefficient was based on the number of factors: (1) the particular coefficient chosen was very important because it was a determining factor in establishing emission limits for almost one-third of the plants in Ohio, *id.* at 662; (2) three private consultants recommended the use of a Class B coefficient in its place, *id.* at 663; (3) the conference called at EPA's request recommended the adoption of the Class B coefficient, *id.*; and (4) EPA admitted "that there was a growing concern among atmospheric modeling scientists about the issue" of the use of coefficients for those conditions, *id.* at 663. In so holding, the court rejected suggestions that the coefficients were useful under all circumstances because they were based on a now "time-tested" study from the 1950's, *id.* at 662; rejected the lack of experimental or field data to justify changing the dispersion curve coefficient, *id.* at 663; rejected the defense of petitioners' failure to submit any data to justify the change in coefficients, *id.*; and rejected the claim that EPA should be allowed to use the coefficient until newly filed data prove them incorrect. *Id.*

386. *Id.* at 664.

387. 638 F.2d 910, 911-12 (6th Cir. 1980). It is interesting to note that the Sixth Circuit here said it found the coefficients to "lack a rational basis in the administrative record," *id.* at 911, whereas it earlier used the phrase "arbitrary and capricious." *See* Cin. Gas & Elec. Co. v. Costle, 632 F.2d 14, 18 (6th Cir. 1980) (citing, Cin. Gas & Elec. Co. v. Costle, 578 F.2d 660, 663-64 (6th Cir. 1980)).

388. *See* 44 Fed. Reg. 7798, discussed in Kramer, *supra* note 5, at 255 n.110.

389. *See* 638 F.2d at 911-12 (quoting the EPA Brief).

390. 638 F.2d at 911. The court also stated that "[t]he present record gives no indication that the reconsideration mandated by this Court has ever been undertaken." *Id.*

tion for its actions, although the opinion did not set forth clearly the reasons for this harsh condemnation.[391]

In *Columbus and Southern*, the Sixth Circuit allowed attacks on nonattainment designations "only by showing that EPA's prediction of future levels of pollution [using models] are unsupported by the record."[392] The court, however, did not specify acceptable data, nor did it specify the appropriate burden of proof, but stated only that "[m]onitoring data tending to show past attainment of air quality standards without an air quality control region do not per se show the unreliability of EPA's predictions, although such data might show EPA's modeling techniques were flawed."[393] That is, the Sixth Circuit stated, without benefit of technical support, that a model can be shown to be "flawed" (in that it has in the past given incorrect predictions, as measured against actual monitored conditions), and yet still be considered "reliable." For most models, this statement is most likely incorrect: inaccurate predictions do and should be sufficient to show the model's unreliability, at least until its reliability is demonstrated in some other way.

As a technical matter, this holding is correct, in the sense that models are "reliable" (i.e., are giving predictions likely to be correct) only within certain defined ranges. As an example, a dispersion model may give correct readings for a breezeless day, but it is incapable of predicting the dispersion for very high wind conditions. The statement by the Sixth Circuit can be taken to mean that, all other things being equal, a petitioner must show more than a divergence of past predictions and results; yet, it should be enough if that petitioner shows that such divergence is or will be repeated in the future and that this "flaw" will be relied on in the agency's decision.

In *Cincinnati Gas and Electric v. EPA II*,[394] petitioners also challenged the adjustments in the model, purportedly for the purpose of

391. Obviously, EPA (as well as this author) had understood that the earlier remand was to examine further the technical bases underlying the Class A coefficients. The court did not dispute the fact that EPA was studying those bases further, nor could it have been evaluating the extent of that further study since EPA's statements make clear that the results of that study were not yet before the court. *See supra* note 364. It thus appears that the Sixth Circuit felt that it had mandated a completely new modeling effort by its holding in *CGE II*. *See* Cin. Gas & Elec. Co. v. EPA, 578 F.2d 666, 667 (6th Cir. 1978).

392. 638 F.2d at 912.

393. *Id.*

394. 578 F.2d 660 (6th Cir. 1978). EPA had refused to accept the alternative adjustment method suggested by petitioners (the so-called "half grounded displacement theory" which petitioners characterized as a widely recognized means of accounting for such a situation). EPA's method of adjustment, rather than using a generally accepted method of adjustment,

making the models more accurately reflect actual conditions in hilly terrain in areas where the models tended to underpredict. The court noted that, while the record before the court did not establish conclusively that the terrain adjustment was a satisfactory solution, the record did not offer any evidence to the contrary; therefore, the court held that it could not find the terrain adjustment to be arbitrary or capricious.[395]

The Sixth Circuit Ohio SIP cases also address the proper use of monitoring data to calibrate, validate, or discredit modeling results. The resolution of the interplay between monitoring data and modeling results takes on new importance in light of recent court decisions approving their interchangeable use in the PSD[396] and nonattainment[397] programs under the 1977 Amendments to the Clean Air Act, and to the establishment of emission limitations under the Act.[398]

The issue of relating monitoring data to modeling results for the Ohio SIP was first raised in the *Cleveland Electric* case.[399] The EPA's monitoring data for the affected areas in Ohio were higher than the results predicted by the RAM model. Petitioners unsuccessfully attempted to use this data to demonstrate the inaccuracies of

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was composed of a validation study comparing modeling results to actual monitoring data. *See id.* at 664-65. As the court said, the "validation studies compared model predictions of SO_2 ground level concentrations to actual air quality monitoring data." *Id.* at 665. EPA's adjustment was to assume that the terrain features were always no higher than the stack height of the source stack in question, which is the effective stack height of the MAXT-24 model. *Id.* at 664-65. EPA explained its course of reasoning by noting that the terrain data was limited based on the observation that the model overpredicted "when air quality monitors were at elevations higher than the top of the stack." *Id.* at 665. After the model was adjusted based on particular data used, "[t]his was deemed to be appropriate adjustment because the validation studies showed a high degree of correlation between model predictions and sample readouts from monitors positioned on terrain lower than stack height in elevation . . . ," and "the model accurately predicted the ground level concentrations observed by the monitors." *Id.*

395. *See id.* at 665. The court quoted from the EPA Brief to the effect that petitioners did not provide any validation studies for their proposed terrain adjustment for the model, but also noted that EPA had been forced to admit that it likewise had not performed any validation studies and had to disown a statement in an earlier brief that had implied that EPA had performed such studies.

396. The District of Columbia Circuit Court of Appeals upheld EPA's "discretion in the choice of methodology—either monitoring or modeling—to be employed in fulfilling" the requirement of performing an air quality projection prior to receiving a permit under 42 U.S.C.S. § 7475(a)(1) (Law. Co-op. 1982). Ala. Power Co. v. Costle, 636 F.2d 323, 371-72 (D.C. Cir. 1980). *See id.* at 350-51.

397. Cin. Gas & Elec. Co. v. Costle, 632 F.2d 14, 19 (6th Cir. 1980) (citing EPA's published regulatory policy favoring modeling results over monitoring data, unless there is available relevant monitoring data meeting high standards of quality assurance). *See* 43 Fed. Reg. 45,998 (1980).

398. *See* Cin. Gas & Elec. Co. v. EPA, 578 F.2d 660 (6th Cir. 1978).

399. *See* Clev. Elec. Illum. Co. v. EPA, 572 F.2d 1150, 1163-64 (6th Cir. 1978).

RAM. The court examined the EPA data, noted that the data fell short of showing "predictive perfection," but held "that the EPA's use of RAM, if conservative, cannot be held to be arbitrary and capricious."[400] A different result might be likely if EPA's figures tended to show that the model overpredicted. Petitioners in *Cleveland Electric* came forward with two reports, one of which purported to show "gross overpredictions by RAM"; however, the court remained unconvinced of the model's inaccuracy.[401]

A related but much more disturbing holding in *CGE II* was the Sixth Circuit finding of "no merit to objections based on failure to calibrate the MAXT-24 model."[402] If this holding by the Sixth Circuit means what it literally says, then the court has ignored the necessity of using monitoring data to initially calibrate, maintain and apply the model.[403] This holding by the Sixth Circuit is also in conflict with the intent of Congress in passing the 1977 Amendments to the Clean Air Act, which was described by the District of Columbia Circuit Court of Appeals as follows:

> Congress intended that monitoring would impose a certain discipline on the use of modeling techniques, which would be the prin-

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400. 572 F.2d at 1163 (citing Mision Ind., Inc. v. EPA, 547 F.2d 123, 128-29 (1st Cir. 1976); Sierra Club v. EPA, 540 F.2d 1114, 1136 (D.C. Cir. 1976), *vacated on other gnds*, 434 U.S. 809 (1977)). Presumably, the court meant that the model was conservative in arguably requiring less stringent cleanup efforts than if it were not so conservative. The court's point was that less than absolute accuracy in the model's results did not invalidate reliance upon it, particularly when such inaccuracies work to the benefit of those regulated.

401. *See id.* at 1163-64. One report was discredited by the court based on undescribed data errors found by a "[r]eevaluation" of the model by an unnamed party, which may have been the court, or may have been an EPA document submitted after the close of the hearing record and strenuously objected to by petitioners. *See id.* at 1164, 1163 n.4. The other study was similarly discredited. In fact, as to it, the court resolved this controversy by weighing the monitoring evidence before it and ultimately upholding EPA's data and position. The Sixth Circuit later cited in *CGE II* this portion of *Cleveland Electric*, holding that it found "no merit to objections based on . . . failure to reject [the model's] results because of claims of overprediction as demonstrated by some monitor readings." 578 F.2d at 665-66. Presumably this statement of no merit refers only to the facts in *CGE II* and would not preclude an attack on the model's results by the use of monitoring data. *Accord* Columbus & So. Ohio Elec. Co. v. Costle, 638 F.2d 910, 912 (6th Cir. 1980). This conclusion appears to be borne out in the Sixth Circuit's later statement that these arguments in *Cleveland Electric* and *CGE II* were "rejected in those cases as to the monitoring systems there and then in place." Rep. Steel Corp. v. Costle, 621 F.2d 797, 805 (6th Cir. 1980). *See also* Cin. Gas & Elec. Co. v. Costle, 632 F.2d 14, 17-19 (6th Cir. 1980).

402. 578 F.2d at 665-666 (citing Clev. Elec. Illum. Co. v. EPA, 572 F.2d 1150, 1163-64 (6th Cir. 1978) (numbered paragraph 7)).

403. However, as Professor Silver notes, "[b]efore and after emission reduction models are applied, the amount of pollutant in the ambient air must be measured. Such measurement is essential for proper application of the model and for enforcement of the limitations set for individual polluters." Silver, *supra* note 284, at 1132.

> cipal device relied upon for the projection of the impact on air quality of emissions from a regulated source. This projects that the employment of modeling techniques be held to earth by a continual process of confirmation and reassessment, a process that enhances confidence in modeling, as a means for realistic projection of air quality.[404]

The failure to calibrate a model with relevant monitoring data fatally undermines the model's credibility and should result in a finding of arbitrariness and capriciousness (for an EPA model) or serve as adequate basis for disregarding the model (for a private party's model). Assuming that valid monitoring data is essential to accurate modeling results, one must then focus on a determination of the proper nature, number, and location of the monitors.

In *Ohio Environmental Council v. EPA*,[405] the Sixth Circuit considered yet another challenge to the modeling air quality dispersion analysis used in the Ohio SIP. The court upheld the revision of the SIP in the face of purported violations caused by two specific sources in part on the basis that the previously approved MAXT-24 model took individual sources into account.[406] The court also based its decision on EPA's verification of certain assumptions underlying the model.[407] In light of the modeling analysis used and the temporary nature of the revision, EPA's action was found not to be arbitrary or capricious.[408]

In *Republic Steel Corp. v. Costle*,[409] the Sixth Circuit considered the quality of the monitoring data which a private party must submit to overcome EPA's designation of a nonattainment area by the use

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404. Ala. Power Co. v. Costle, 636 F.2d 323, 372 (D.C. Cir. 1980). The court said that it was for this reason that the Clean Air Act's 1977 amendments incorporate a technology forcing objective of furthering "the development of sophisticated monitoring techniques, and the collection of the data base that would result from monitoring's widespread use." *Id.*

405. Ohio Envt'l Council v. EPA, 593 F.2d 24, 27 (6th Cir. 1979). The court described the analysis in a footnote:

> Dispersion modeling studies consist of two steps. First, an approved device is used to monitor the actual effect of emissions from a given source into the ambient air. Next a computer calculation is obtained which is a prediction of the effect the emissions from the source in light of known facts and verified assumptions concerning plant design, emission rates, surrounding terrain, atmospheric conditions and other factors which influence the total effect on air quality of the emissions from a given stationary source.

Id. at 30 n.4.

406. *Id.* at 30 (citing Clev. Elec. Illum. Co. v. EPA, 572 F.2d 1150 (6th Cir.), *clarified*, 578 F.2d 666 (6th Cir.), *cert. denied*, 439 U.S. 910 (1978); Cin. Gas & Elec. Co. v. EPA, 578 F.2d 660 (6th Cir. 1978)).

407. 593 F.2d at 30.

408. *Id.* at 32.

409. 621 F.2d 797 (6th Cir. 1980).

of a computer model. The State of Ohio had earlier designated the attainment area, but was overridden by EPA using modeling results.[410] The EPA's policy of preferring modeling results to monitoring data was said to be based on the assumption that monitoring networks are "usually not sufficiently comprehensive to cover any given area."[411] The court in *Republic Steel*, however, observed that "[t]heoretically, of course, actual air quality tests would have to be superior to modeling assumptions if there were sufficient monitors to constitute a fair test of the ambient air in a county."[412] The Sixth Circuit in *Republic Steel* raised the question of the minimum number of monitors which would be needed for a meaningful sample of the ambient air of a county, but held that such a determination could not be made from the record before it. Consequently, the court affirmed EPA's nonattainment designation involved in *Republic Steel*.[413]

In *General Motors v. Costle*,[414] the court held that EPA properly determined that GM had failed to come forward with adequate monitoring data, although the three monitors surrounding the General Motors plant showed no violations of ambient air quality standards. The EPA ignored these data because the agency concluded that the data were not quality assured. The court also noted that EPA's monitors located throughout the county *did* show a violation of ambient air quality standards. Therefore, the court held that EPA's designation of the county as a nonattainment area was not arbitrary and capricious.[415]

In order for a monitoring network to produce quality assured data, its monitors, in addition to meeting the technical specifications contained in federal regulations,[416] must be of sufficient number, and must be placed in correct locations. As for the proper location of monitors to ensure the production of quality assured data, the monitors should be placed at the locations which the computer has predicted to have the highest levels of pollution, the so-called "hot

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410. *See* 40 C.F.R. §§ 81.301-81.356 (1981); 43 Fed. Reg. 46,000 (1978); 45 Fed. Reg. 17,597 (1980).

411. 43 Fed. Reg. 45,998, *quoted in* Cin. Gas & Elec. Co. v. Costle, 632 F.2d 14, 19 (6th Cir. 1980).

412. 621 F.2d 797, 805 (6th Cir. 1980). This is recognized in the EPA guidelines to Air Branch Chiefs of EPA regional offices, which states that "[i]f there is a conflict between *adequate* monitoring data and modeling results, monitoring values should be used." Cin. Gas & Elec. Co. v. Costle, 632 F.2d 14, 19 (6th Cir. 1980) (emphasis in the original).

413. 621 F.2d 797, 805 (6th Cir. 1980).

414. 631 F.2d 463 (6th Cir. 1980).

415. *Id.* at 468.

416. *See, e.g.*, 40 C.F.R., Part 51, Appendix P (1981).

spots."[417] The Sixth Circuit held in *Columbus and Southern* that "polluters in a currently 'clean' region can substantively attack a nonattainment designation of their region only by a showing that EPA's predictions of future pollution levels are unsupported by the record . . . ," and, thus, are arbitrary and capricious.[418] Again, the court did not specify the extent of the showing other than to state that if EPA fails to reveal the site of the model's receptors and disregards the petitioners' data, then the Sixth Circuit would hold this to be "peremptory and arbitrary."[419] The court had earlier held that a bare allegation that petitioners' monitors were placed at the model's hot spots "is insufficient to establish that the monitoring data is 'adequate' in the sense that it should prevail over the modeling results."[420]

Thus, although EPA's monitoring results may be accorded little respect by courts,[421] even less credence is given to the monitoring results produced by private parties. Therefore, any petitioner, in order to contest a nonattainment designation, must be prepared to engage in a lengthy, carefully constructed, and expensive monitoring effort without any assurance that the court will be convinced by its results, no matter how dramatic.

The holdings of the Sixth Circuit cases on the Ohio SIP generally demonstrate that EPA can base nonattainment designations on predictions of future violations of air quality standards.[422] This holding will further facilitate the use of models. Obviously, such future violations can be shown by EPA only with a computer; no

417. *See* 632 F.2d at 16, 19. The model is not designed to give readings at all points in its coverage, but only certain receptor sites, which are the points in the model where it does produce data. As the court had earlier noted, in order to try to insure that the model's results have some reasonable relationship with the physical system being monitored, "the monitor locations and the receptor sites for the [model's] predictions must correspond." Clev. Elec. Illum. Co. v. EPA, 572 F.2d 1150, 1163 (6th Cir. 1978). For a pictorial comparison in monitoring sites and hypothetical receptor sites, see Columbus & So. Ohio Electric Co. v. EPA, 638 F.2d 910, 913-14 (6th Cir. 1980).

418. Columbus & So. Ohio Elec. Co. v. Costle, 638 F.2d 910, 912 (6th Cir. 1980).

419. *Id.* The court did not say whether the petitioner would have to establish that its monitors were, in fact, placed at the monitor's receptors, but the court implied that petitioners would not need to make such a showing. If such is the case, the court should, at a minimum, require a standard of good faith effort by petitioners and a showing by them that their monitoring network displays substantial compliance with good engineering practice.

420. Cin. Gas & Elec. Co. v. Costle, 632 F.2d 14, 19 (6th Cir. 1980). Thereafter, the court, as it did in *Cleveland Electric*, noted that the court was unable to inform itself of the nature of petitioners' monitoring network, because of the petitioners' consultant's refusal to provide such information based on proprietary interests.

421. *See* Silver, *supra* note 284, at 1132-37.

422. *E.g.*, Columbus & So. Ohio Elec. Co. v. Costle, 638 F.2d 910, 912 (6th Cir. 1980) (citing PPG Ind. v. Costle, 630 F.2d 462 (6th Cir. 1980)).

monitor can record data on hypothetical future conditions. Likewise, petitioners must be prepared to use such models because of the limited usefulness of monitoring data under *Columbus and Southern*. In *Columbus and Southern*, the court held that monitoring data could be used to show that EPA's modeling techniques were flawed, but noted that the mere fact that such monitoring data show past attainment of air quality standards does not per se show the unreliability of EPA's projected violations based on models.[423]

The Sixth Circuit cases on the Ohio SIP models will likely serve as precedent for many cases involving models under the Prevention of Significant Deterioration (PSD) and nonattainment programs of the Clean Air Act, and may well serve as general authority for other cases involving environmental models. The level of judicial review employed in these seven Ohio SIP cases appears to show less variation than previous cases. This may reflect the Sixth Circuit's adjustment to the problems of reviewing environmental models. More likely, this decrease in variation can be attributed to the court's repeated exposure to the same basic case. In either event, the arbitrary and capricious level of review applied by the Sixth Circuit in these Ohio SIP cases appears too deferential to ensure a minimal level of meaningful review. Thus, the Sixth Circuit's sophistication from repeated exposure to the Ohio SIP models failed to move the Sixth Circuit beyond the shortcomings shown in the SIP cases previously discussed from the Fifth, First, Third, Ninth, Fourth, and District of Columbia Circuit Courts of Appeals. The Sixth Circuit cases also fail to show any significantly greater level of sophistication over those earlier cases.

One final Clean Air Act SIP case of note involving an environmental model is *Environmental Study & Protection v. Pac*,[424] in which petitioners unsuccessfully challenged a model used for indirect source review.[425] Petitioners sought to force the rescinding of an indirect source permit issued by the state environmental agency. Petitioners there urged that the model used to describe a highway project underpredicted probable pollution levels, both by virtue of the model's construction and its failure to take into account certain factors, such as background pollution and the effects of nearby automobiles on roads adjacent to the highway being modeled. The district court in *Environmental Study* upheld the state's use of the

423. 638 F.2d at 912.

424. 464 F. Supp. 143 (D. Conn. 1978), which is discussed in greater detail in Kramer, *supra* note 5, at 263 n.164.

425. *See* 42 U.S.C.S. § 7410(a)(5)(A) (Law. Co-op. 1982), which precludes EPA from requir-

model because it used "worst case" conditions, and EPA later used the same model, and also because of the lack of an explicit requirement of any model in the process. Professor Kramer has opined that *Environmental Study* "placed a heavy burden of proof on petitioners to show that the use of [the] model was arbitrary," and that the case represents "a much less active role in reviewing discretionary agency decisionmaking" than that exercised by the Sixth Circuit in the Ohio SIP cases, and that such an approach "may reflect a future trend."[426]

B. Cases Under NEPA and Similar Environmental Statutes

The *Overton Park* standard applied in environmental models decisions had its roots in earlier cases under NEPA.[427] Early NEPA cases established that the technical analysis contained in an EIS must be readable by a layman.[428] These early NEPA cases also established that the environmental agency was not required to engage in a "crystal ball inquiry" in making environmental decisions based on projections of future conditions,[429] but that a governmental action not supported by sufficient, reliable scientific data would be held invalid under the arbitrary and capricious standard of substantive judicial review.[430] Courts were not then inclined to inquire in detail into the technical analyses involved in these early NEPA cases, both because the methodology was specified by Congress and because the

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ing such indirect source review of facilities which may attract mobile sources of pollution.

426. Kramer, *supra* note 5, at 264 n.164.

427. *E.g.*, Scenic Hudson Preservation Conf. v. FPC, 453 F.2d 463 (2d Cir. 1971), *cert. denied*, 407 U.S. 926 (1972); Comm. for Nuclear Responsibility, Inc. v. Seaborg, 463 F.2d 783 (D.C. Cir. 1971).

428. *E.g.*, EDF v. TVA, 339 F. Supp. 806, 809 (E.D. Tenn.), *aff'd*, 468 F.2d 1164 (6th Cir. 1972), *dissolved*, 371 F. Supp. 1004 (E.D. Tenn. 1973), *aff'd* 492 F.2d 466 (6th Cir.) (per curiam), *application for stay denied*, 414 U.S. 1036 (1974).

429. *E.g.*, NRDC v. Morton, 458 F.2d 827, 837 (D.C. Cir. 1972).

430. *E.g.*, Lanthan v. Volpe, 350 F. Supp. 262 (W.D. Wash. 1972). *See* NRDC v. Grant, 355 F. Supp. 280 (E.D.N.C. 1973); Cape Henry Bird Club v. Laird, 359 F. Supp. 404, 410-11, 423 (W.D. Va. 1973), *aff'd* 484 F.2d 453 (4th Cir. 1973). *Cape Henry* applied a similar standard of arbitrary and capricious review, as the court stated:

> The [c]ourt believes that its role under NEPA is not only to see that government agencies have complied with all the procedural requirements, but also to engage in 'substantial inquiry' to determine 'whether there has been a clear error of judgment.' Courts are allowed to delve into the decisionmaking process on their own to determine if the agency's decision was arbitrary and capricious when viewed in terms of the data and information supplied and set forth in the EIS.

359 F. Supp. at 410. The model that the *Cape Henry* court was examining was the cost-benefit ratio required to be applied to a flood control project which was contained in the EIS for the project. *See id.* 412-14.

methodologies' crudeness limited the degree to which decisionmakers could rely upon them.[431]

Perhaps the earliest review of an environmental decision based on a model was the case of *Petterson v. Froehlke*,[432] which was decided before any of the cases discussed above involving the Clean Air Act. NEPA became effective after the start of the project involved in *Petterson* and was thus held inapplicable to the ongoing project.[433] The issue in *Petterson* was whether the Corps of Engineers violated its own dredging regulations and erred in projecting probable erosion and other environmental consequences of a dredging project by the use of a mathematical simulation of river currents. Plaintiff unsuccessfully urged that it was necessary to model the erosion by a physical model[434] called a hydraulic simulation. Although perhaps not squarely presented with the question of the validity of the methodology used in the mathematical model, the court summarily dismissed plaintiff's objection to the dredge and fill permit, noting that applicable statutes and regulations did not require detailed reports in the manner that NEPA required.[435]

Early opinions stated that the purpose of judicial review under NEPA was not to ensure a "correct" environmental decision, although the courts did acknowledge their responsibilities to review substantively the technical methodologies underlying those decisions.[436] Courts displayed apparent frustration at having to review early crude methodologies: as they said, the more one examined the methodologies, the more deficiencies one could find.[437] The courts

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431. *See, e.g.*, Cape Henry Bird Club v. Laird, 359 F. Supp. 404, 414, 419, 422 (W.D. Va. 1973). The court noted that Congress specified the model to be used (the cost-benefit method) and the coefficients to be used in it (the discount rate, which was used to calculate the cost of the project). The court also noted that the Corps of Engineers' failure to quantify environmental values was not fatal because at that time there was no method of calculating such values. *Id.* at 414. Ultimately, the court in *Cape Henry* placed more emphasis on the judgment and expertise of the decisionmaker, holding that if the decision "is made in good faith and without bias, then the collection of voluminous amount of data is unnecessary." *Id.* at 422.

432. 354 F. Supp. 45 (D. Or. 1970), *remanded on other gnds*, Citizens Comm. for Columbia River v. Callaway, 494 F.2d 124 (9th Cir. 1972) (mootness).

433. 354 F. Supp. at 48-49.

434. The physical model is a physically constructed model, usually on a reduced and simplified scale, of the conditions being studied, based upon the assumption that this miniature reproduction or approximation will act similarly to the actual condition. *Cf.* Kramer, *supra* note 5, at 238 (describing an atmospheric physical model).

435. 354 F. Supp. at 49.

436. *See, e.g.*, EDF v. Froehlke, 473 F.2d 346, 351-53 (8th Cir.), *inj. denied*, 409 U.S. 1072 (1972) (Brennan, Douglas, JJ., would grant).

437. *E.g.*, EDF v. Corps of Engineers (Gilham Dam), 342 F. Supp. 1211, 1217 (E.D. Ark. 1972), *aff'd*, 470 F.2d 289 (8th Cir.), *inj. denied*, 409 U.S. 1072 (Blackmun, Douglas, JJ., would

were not in a position to expect perfection in the impact statement, but only a sufficiently detailed document created with good faith objectivity.[438]

The second NEPA case apparently involving models, *Life of the Land v. Brinegar*,[439] affirmed a lower court's denial of plaintiff's request for an injunction against the proposed expansion of the Honolulu, Hawaii International Airport. Plaintiffs had alleged, among other things, that the noise prediction methodologies used in the airport EIS were inadequate because they did not use "on-sight" noise measurement techniques to gather monitoring data. The court pointed out that, in lieu of monitoring data, the Federal Aviation Administration utilized a modeling technique characterized by the court as a "well recognized scientific technique, which renders 'on-sight' measurement techniques unnecessary."[440] The court cited *Overton Park* in upholding the sufficiency of the EIS, while pointing out that "[u]ndoubtedly, there exists a plethora of scientific studies which could have been used, but were not. . . ."[441] *Life of the Land* stands as an early example of courts' unwillingness to hold that NEPA required that predictive techniques be based on models.

Courts continued to hold that the failure of the EIS to discuss the scientific bases for certain socioeconomic, recreational, and other environmental data and statements was not fatal to the adequacy of the impact statement under NEPA.[442] If the record contained adequate but conflicting data, courts declined to interject themselves into the decisionmaking process, stating that it was not within their purview to resolve conflicts in expert opinion.[443] If the agency demonstrated a hard look at relevant factors, then it was the

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grant), *cert. denied*, 412 U.S. 931 (1973) (Douglas, J., dissenting). The district court opinion, however, contained a very well documented holding in favor of substantive review under NEPA. *See* 342 F. Supp. at 298-301.

438. *See, e.g.*, Sierra Club v. Froehlke, 486 F.2d 946, 950-51 (7th Cir. 1973). Again, the court reaffirmed its duty to review substantive merits of the decision, but noted it could not substitute its judgment for that of the agency. *Id.* at 952-53. It was about this time that the first of the cases involving the Baltimore expressway was decided. See MAD v. Volpe, 361 F. Supp. 1360 (D. Md.), *aff'd*, 500 F. 2d 29 (4th Cir. 1974).

439. 485 F.2d 460 (9th Cir. 1973), *cert. denied*, 416 U.S. 961 (1974) (Douglas, J., dissenting).

440. 485 F.2d at 472.

441. *Id.*

442. *E.g.*, EDF v. Froehlke, 368 F. Supp. 231, 235 (W.D. Mo. 1973), *aff'd sub nom.* EDF v. Callaway; 497 F.2d 1340 (8th Cir. 1974). *See* EDF v. Froehlke, 477 F.2d 1033 (8th Cir. 1973) (related case).

443. *E.g.*, City of No. Miami v. Train, 377 F. Supp. 1264, 1273 (S.D. Fla. 1974), *cited in* Evans v. Train, 460 F. Supp. 237, 243 (S.D. Ohio 1978). *Accord*, Bucks County Bd. of Comm'rs v. Interstate Energy Co., 403 F. Supp. 805, 815 (E.D. Pa. 1975).

agency's prerogative to resolve the scientific disputes as the agency saw fit.[444]

Cases under NEPA have rejected the suggestion that Section 102(1)(B) of NEPA[445] mandates the development of methods and procedures to permit the calculation and comparison of environmental amenities, and have held that NEPA does not mandate the use of computers in the preparation of an impact statement.[446] Those cases, however, are not authority that NEPA requires of administrative agencies less than the best decisionmaking methodology. Those cases (largely involving flood control projects) present a different problem from the typical environmental data problem, in that the decisionmaker in such cases was Congress, not an administrative agency. In those cases, Congress established with some degree of specificity the algorithm to be used (the cost-benefit ratio), as well as the specific value of some of the values of the variable to be applied.

This specification of methodology by Congress in cost-benefit ratios distinguishes them from the usual environmental modeling situation in which the model and its variables' values are set by the agency or persons working for the agency. This distinction is important for judicial review: obviously, when Congress explicitly defines the methodology and makes the concomitant policy changes, judicial review should be very deferential, at least as to those portions of the decisionmaking process. Where Congress is not the decisionmaker, plaintiff should be allowed an opportunity to tender evidence to discredit the environmental decisionmaking methodology underlying the decision by showing the questionableness of the assumptions and mathematics underlying the agency decision. Although courts may not yet be ready to require that a computer be used to prepare NEPA impact statements, computers were in fact being so employed. Therefore, courts have had to face the question of the appropriate standards and level of judicial review of those models under NEPA.

The first case under NEPA to examine in detail some of the underlying assumptions and data of an environmental model was the case of *City of Romulus v. County of Wayne*.[447] At issue in the *Romulus*

444. *E.g.*, Coal. for Responsible Regional Develop. v. Coleman, 555 F.2d 398, 400 (4th Cir. 1977).

445. *See supra* text and notes at notes 83-94.

446. EDF v. Corps of Engineers (Tennessee-Tombigbee waterway), 348 F. Supp. 916, 928 (N.D. Miss. 1972), *aff'd*, 492 F.2d 1123 (5th Cir. 1974). *Accord*, Daly v. Volpe, 514 F.2d 1106, 1111-12 (9th Cir. 1975); Trout Unlimited v. Morton, 509 F.2d 1276, 1286-87 & n.14 (9th Cir. 1974).

447. 392 F. Supp. 578 (E.D. Mich. 1975). *See id.* at 585-89. Although the Eastern District of

case was the use of an environmental model to predict air and noise pollution levels resulting from the expansion of the Detroit Metropolitan Wayne County Airport. Petitioners in *Romulus* alleged there were errors in the data and methodology used in the models, as well as problems in interpreting the meaning of the model's results, because of the ambiguity present in the noise contours resulting from the model. The first challenged modeling effort purported to predict the added delay time that an air traveler would encounter in waiting to fly out of the airport if the proposed runway were not constructed.[448] The second modeling effort attempted to predict the resulting changes in noise level impacts on the surrounding areas if the new runway were or were not built.[449] Applying the *Overton Park* arbitrary and capricious standard of review, the court found in *City of Romulus* that the EIS did not meet the full and fair disclosure requirements of NEPA.[450] Consequently, the court issued a preliminary injunction against the further use of federal funds on the project.[451]

In the first modeling effort, future passenger air traveler delay times were quantitatively predicted for the purpose of calculating the benefits of the project as proposed, which were to be weighed against its costs (environmental and otherwise) as required under NEPA. The benefit to be measured was the reduction in delay time that would accrue to future air travelers coming into and leaving the airport by virtue of the airport's improved facilities.[452] The predictions as to delay times were found to be deficient because of inadequacies in the data and in the application of the computer models used. The data and models were found to be deficient for four general reasons. First, the data used was not the best then avail-

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Michigan is in the Sixth Circuit, the court in *Romulus* did not cite any prior Sixth Circuit NEPA cases, *e.g.*, EDF v. TVA, 492 F.2d 466 (6th Cir. 1974), nor did it cite the case involving the Ohio SIP which the Sixth Circuit had already handed down, Buckeye Power v. EPA, 481 F.2d 162 (6th Cir. 1973). Instead, the court looked to the District of Columbia Circuit Court of Appeals' opinion in Greater Boston Television Corp. v. FCC, 444 F.2d 841 (D.C. Cir. 1970), *cert. denied*, 403 U.S. 923 (1971), as authority for the hard look standard applied in the *Romulus* case. *See* 392 F. Supp. at 590.

448. 392 F. Supp. at 585-88.

449. *Id.* at 591-94.

450. *See id.* at 584, 587. The court said it was applying a procedural review of the contents of an EIS under the standards of § 102(2)(C) of NEPA and § 706(A) of the APA as delineated by the *Overton Park* case. *Id.* at 583. Although plaintiffs did not request substantive review of the decision, *id.* at 583 n.1, the court felt constrained to note that some courts have "found mandate for review of the ultimate substantive agency decision under the sweeping language of Section 101 of [NEPA]." *Id.* at 583.

451. *See id.* at 584-86, 589 n.7.

452. *See id.* at 584-86.

able.[453] Second, the data used was based on unsupported (and unsupportable) assumptions.[454] Third, the terms that expressed and embodied the model's results were not adequately defined.[455]

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453. The data used were not actual measurements of present air traffic levels as determined from recent tower counts. *Id.* at 587. Instead, present traffic levels were assumed to be the same as those earlier predicted by the Air Transportation Association. The court failed to specify how old the predictions were, and cast no light on why the authorities failed "to include figures *then* available as to actual operations . . . ." *Id.* at 588 (emphasis in original). The court found that the failure to include figures then available in October of 1973, when the EIS was submitted, was potentially misleading to the agency decisionmakers, other reviewing agencies, and the public. *Id.* at 588. Although this failure was said to violate NEPA's purpose of making the EIS a complete source or document, the decision can also be attributed to the court's realization of the importance of data as a corroboration of the model's results.

454. The court pointed out at least three incorrect assumptions in the model. First, it questioned the modeler's assumptions as to a stable "fleet mix" for the years covered by the model. *Id.* at 588. Fleet mix gives a profile of the kinds of planes using the airport according to the number of passengers carried. This assumption was of vital importance in calculating the total hours of annual delay and the dollar cost of that delay, both of which the model claimed to be predicting quantitatively. It appears that delay was calculated on a per-passenger basis as opposed to a per-plane basis, since the court found that the fleet mix assumed by the modelers "produce[d] a greater dollar delay savings . . . ." *Id.* at 588-89. The court condemned this assumption, not because it was wrong, but because the court concluded it was inconsistent with other data used in the same modeling effort (i.e., the fleet mix of general aviation aircraft). *See id.* at 588. The court may have accused the modelers wrongly, if the facts stand as the court states them. The fact that categories of non-carrier, general aviation aircraft, and carrier aircraft are assumed to change drastically in their composition is not, contrary to the court's statements, necessarily inconsistent with a constant percentage of general aviation aircraft as assumed. *See id.* at 588.

The second piece of data that the court found wrongfully assumed or relied on was the number of annual operations in the years which were modeled. *Id.* The third inaccurate, or at least inadequately supported assumption found by the court was that the landing strip was nearing saturation of its capacity. *Id.* at 589. The court noted there was evidence that the runway was not yet nearing load saturation. *Id.* at 589. It was not even clear that the administrative decisionmakers were aware of, or were sensitive to the assumptions made or their importance to the model's results. *See id.* at 585 n.2. The court solved this problem by imputing knowledge of these problems to the decisionmakers: since "[t]he alleged deficiencies of omission were known to the staff preparers of the EIS, [they were] presumably [known] to the agency decision-makers . . . ." *Id.* at 585. The court placed this burden on the decisionmakers in spite of the fact that it recognized that "[w]hether agency decision-makers are aware of technical deficiencies known to staff preparers of an EIS is open to question." *Id.* at n.2. This response was not only to ensure that the decision was an "informed choice," *id.* at 585 (citing Comm. for Nuclear Responsibility, Inc. v. Seaborg, 463 F.2d 783, 787 (D.C. Cir. 1971)), but also to overcome any biases that might be inherent in expert presentations. The court said that "[i]t is axiomatic, however, that for an agency review of staff recommendations to be *truly independent*, deficiencies which may undermine the conclusions reached in the draft EIS should be known to the ultimate decisionmaker." 392 F. Supp. at 585 n.2 (emphasis added).

455. The EIS contained four inadequately defined terms or phrases: "delay," "acceptable levels of delay," "Practical Hourly Capacity" (PHC), and "saturation." 392 F. Supp. at 589. The court noted that the EIS did not make clear "[w]hether delay, for instance, includes taxi delay, as well as delay once an aircraft is in position for take-off, or delay in clearance for landing . . . ." *Id.* Second, it was not clear whether delay was a self-contained and absolute measure of this time or whether it was dependent on the definition of acceptable levels of

Fourth, the EIS failed to delineate exactly how the modeling methodologies were applied,[456] particularly in view of the inconsistencies between the model's assumptions and results.[457]

The second modeling effort was designed to predict the resulting sound levels in surrounding areas to be caused by future air traffic levels. These predictions were made, first assuming no runway would be built, and then assuming that the new runway would be constructed.[458] The results of these two modeling efforts were compared in an attempt to evaluate the effect of the new runway in terms of noise. Generally speaking, the court did not question the application of the methodologies used to reach the results except insofar as they relied upon data that the court had already found to be unacceptable in its discussion of delay time predictions.[459] The

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delay, as implied by counsel for the agency. *See id.* at 589 n.6. Third, although the court felt it was obvious that the term saturation would be defined with reference to peak hour traffic levels, it found fatal the impact statement's failure to so state. *Id.* at 589 n.7. Fourth, although PHC was apparently defined in the EIS as the maximum number of aircraft that the airport could accommodate without violating the criterion "than an acceptable level of delay is four minutes per operation," the obvious problem with this definition was that it was not clear whether this acceptable level of delay was to be judged on an average basis, or whether it was a worst-case maximum not to be exceeded. The exact definition of each and every term employed in a modeling effort is important, not only because they are usually mutually interdependent, but "[m]ore fundamentally, . . . [they are of] pivotal importance to the conclusions reached." *Id.* This is because the definitions used, like any other assumptions made in the modeling effort, are inextricably intertwined with the validity of the computations made in the application of the model.

456. The EIS did not indicate how delay was computed. *Id.* at 589. The court said that "[a]lthough there is reference to delay [in a section of the EIS unrelated to this methodology] neither the information nor the figures there presented explain how the delay has been calculated." *Id.* at 589 n.6. It is not clear whether the court was concluding that the information was not included in the EIS, or saying that the decisionmaker and public could not understand the information contained in the report.

457. In assessing the methodology used to conclude "that the existing runway configuration is rapidly approaching saturation," 392 F. Supp. at 589, and that this would be alleviated by the fact that "hourly capacity [would] be increased by 50% . . . by the addition of the new runway," *id.* at 588, the court found that the conclusions were "not accompanied by supporting data," *id.* at 589, in light of the fact that "much of the data that can be assembled from the EIS supports the opposite conclusion." *Id.* The court made its own calculations to see if the modeler's discussion of delay time in total hours on an annual basis could really be related to the per-operation delay constraint as the modeler claimed. *Id.* at 589 (acceptable level of delay of four minutes). The court took the level of traffic used by the modelers (which the court found to be unsupported) and multiplied it by the acceptable level of delay (four minutes) to see what the resulting annual total delay would be. *Id.* at 589. Such an approach is inconsistent with the interrelated nature of variable and function that is embodied in the exponential relationship, such as the one here for relating traffic levels and delay time. *See id.* at 586.

458. 392 F. Supp. at 591-94. *See id.* at 585.

459. The court apparently felt that the agency had applied a state-of-the-art technology. The court said that that, although the systems used were not perfect in every respect, the decisionmakers were faced with the problems for which "no single method [had] yet been

court's real objection to the modeling effort was to the form in which the model's results were presented, which the court felt obscured or masked the environmental decision.[460] That is, the numerical and graphical forms of the model's results hindered, rather than facilitated, an understanding by the decisionmaker of the environmental quality to result from the decision based on the model. This masking effect also hindered the public's understanding of the decision.

The term "masking" as used herein refers to the fact that environmental decisions are often expressed in numerical or graphical terms that are difficult to interpret and understand. For instance, in *Romulus*, the predicted numerical noise levels and the graphical representations of those noise levels were difficult to translate into the resulting environmental quality. As a result, it was difficult for the decisionmaker to evaluate properly the correctness of its decision from a common sense point of view. It is similarly difficult for the parties to evaluate and respond to the considerations raised by such decisions, and even more difficult for the public to do so. Finally, this masking effect presents a similar hindrance to a reviewing court's attempt to engage in even a nominal level of meaningful substantive review. As an example, in *Romulus*, it is unlikely that anyone other

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agreed upon to answer all relevant noise questions." *Id.* at 594. The ASDS (Aircrafts Sound Description System) system was said to be "a major improvement over the abstractness" of the old system, *id.*, which had been "misunderstood and misapplied." *Id.* at 592. ASDS was also said to be understandable to the layman. *Id.* at 594.

The court claimed that it was not resolving conflicts in expert opinion, because "[t]he criticism of ASDS expressed by [plaintiff's expert witness, the Director of Sensory Sciences at the Stanford Research Institute], and accepted by the Court, *goes beyond a mere difference of opinion between groups of scientists* as to what noise description methodology is more revealing." *Id.* at 594 (emphasis added). That is, the court must have found some part of the facts that mooted its observation that there were more established composite noise level measurements than ASDS (and, by implication, CNR). *Id.* at 593. The court was referring to yet a third sound measurement methodology, Noise Exposure Forecast (NEF), that the EPA views as a better indicator of what actual noise levels will be produced and which EPA used to convert the FAA's results into what it viewed to be a more understandable form. It is interesting to observe that, in comparing the two methodologies as applied, the court noted that "the CNR system *itself* is not subject to the same criticisms as the ASDS . . . ," for reasons which are discussed *infra*. *Id.* at 594 (emphasis added). By virtue of the court's ambiguous language on the subject, it is unclear to what extent it did actually resolve expert opinions without so explicitly stating.

Other commentators have disagreed with the court's conclusion and have stated that "[t]he best method now available for describing noise around airports and of predicting human response is the Noise Exposure Forecast (NEF)." *Port Noise Complaint*, *supra* note 55, at 70, 72. They note that such a study had already been prepared for the Detroit Wayne Airport at the time of the 1970 article. *Id.* at 72 n.48. *See* Bishop & Simpson, Noise Exposure Forecast Contours for 1967, 1970, and 1975 Operations at Selected Airports (Final Report) (Rep. No. FAA NO-70-0 (1970), prepared for the FAA.

460. *See* 392 F. Supp. at 593 at n.14.

than a fairly sophisticated reader would have been alerted by the numerical results to the fact that the models actually predicted noise levels that would result in violations of noise guidelines established by other federal agencies.[461]

In *Romulus*, the EIS, as required by FAA regulations, presented its sound modeling results using two methods: the Aircraft Sound Description System (ASDS) and the Composite Noise Rating (CNR) system.[462] These results were presented in the form of (1) contour maps[463] that purported to express the degree to which the surrounding areas would be affected by noise levels from the airport; and (2) a tabulated summary gleaned from the contour maps and aerial photographs which outlined the noise levels to which structures within the contours would be subjected. The court held that deficiencies in these methods used to present the results of the modeling efforts invalidated the EIS, although the court found that the models and data using the contours and tabulated summary were "correct" when considered alone.[464]

The court characterized the computer-generated noise contours as "meaningless numbers to the nonscientist with no guidelines to analyze the data presented in terms of acceptability for a human environment."[465] Such ambiguity was held to prevent reviewing parties from ensuring that the actual noise levels that would result would be acceptable, in the sense that they would properly correspond to the political choices that had already been embodied in environmental policy. In *Romulus*, "significant noise levels" were ignored, even though they would occur over a "long cumulate dura-

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461. *Id.* at 594 & n.15.

462. *Id.* at 591.

463. For an example of such a contour map using the NEF System see *Port Noise Complaint, supra* note 55, at 75.

464. The court might be interposing an objection that no quantitative cost-benefit analysis was made, as some courts have indicated is required under NEPA. *See, e.g.*, Boxley v. Corps of Engineers, 411 F. Supp. 1261, 1269 (N.D. Ala. 1976). The attempt would be one that would use land-use and other information on the "sensitivity of the recipient" to particular noise levels, *see* 392 F. Supp. at 592 n.12, and value the cost of the calculated level that is predicted to accrue. The weighing of nighttime exposure levels is one step in this direction. This sort of effort is exemplifies of the trend towards sophistication in environmental mathematical efforts and may be mandated by NEPA and the Airport and Airway Development Act of 1970, 49 U.S.C.S. §§ 1701-1720 (Law. Co-op. 1980). The Airway Development Act requires prior to runway construction that the agency include and assess "the economic, social and environmental effects of the airport location and its consistency with goals and objectives of environmental urban planning as have been carried out by the community." *See Port Noise Complaint, supra* note 55, at 95-98.

465. 392 F. Supp. at 594.

tion" involving a wide area that included some areas not subjected to such levels previously.[466]

This masking of such serious consequences was attributable in some degree to the non-linear nature of the system being modeled. That is, the algorithmic nature of noise measurement techniques (like the exponential nature of the delay time functions previously discussed)[467] made the conceptualization of the resulting environmental changes all the more difficult. This problem of the non-linearity of the noise measurement technique is typical of models: often, a small error at an early stage of the modeling process can produce unexpectedly large differences in the model's predictions. These differences can be so large as to entirely alter the conclusions to be drawn from the modeling effort. For instance, in the case of the delay time predictions, a different assumption as to what constituted delay could have led to the conclusion that the new runway should not be built.[468] The court in *Romulus* also noted that the 85 decibel A-weighted (85dB(A)) noise level used in the methodology appeared to have been chosen to fit the particular situation involved.[469]

The *Romulus* court adopted the view that NEPA requirements of full and fair disclosures are "procedural duties [under] Section 102" of the Act; however, the court applied those duties as though they

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466. *See id.* at 593.

467. *See id.* The "failure to disclose noise levels above 85dB(A) is the most serious deficiency in the EIS." *Id.* The ASDS methodology registered whether the sound level exceeded 85dB(A), and if it did, the length of time of such excess for a given day. The ASDS methodology did not measure the extent by which the noise level exceeded 85dB(A). Thus, the model failed to differentiate between noise levels which were merely bothersome and those which could have serious health consequences. This deficiency could have been cured by the use of the CNR methodology, *id.* at 594, which was not used because the court expressed doubt that the lay reader would get any more information if the CNR technique was used. *See id.* at 593-94.

468. *See id.* at 589, 593. Similar problems were incurred with the non-linear reduction model. *See* Texas v. EPA 285, 295 (5th Cir. 1974); MAD v. Trainor, 400 F. Supp. 533, 565 (D. Md. 1975).

469. 392 F. Supp. at 592. The justifications offered by FAA for their choice of the 85dB(A) level were basically three: (1) it corresponded to an indoor awakening threshold level; (2) it corresponded to the limits of current monitoring capabilities; and (3) it seemed to be particularly well suited for use in this case, "because the 85dB(A) contours [as drawn after the fact] corresponded approximately with both the altitude and the lateral boundaries of airport traffic areas." *Id.* The exact nature of the court's resolution is again not clear. There was no evidence cited in the opinion that contradicted the assertion by FAA that "the quality of noise analysis below [85dB(A)] starts to degrade." *See id.* at 592. Indeed, as the court said, the standard "may have significance as a measuring standard." *Id.* Yet, the court accepted the plaintiff's opinion as to its unsatisfactory scientific justification, and justified that acceptance by saying that "the rationale for its selection as a maximum level of acceptability for the human environment was not demonstrated either in the EIS or the testimony." *Id.*

were also substantive, in that they were intended to affect the substance of the decision by ensuring that "the ultimate project decision would be based on all available information."[470] The court examined whether the EIS failed procedurally to disclose the necessary information so that a reasoned decision could be given, instead of examining whether the facts and evidence set forth in the EIS complied with the substantive requirements of section 101 of NEPA, because plaintiffs did not try to prove that the *substantive* decision to construct a third parallel runway was in error.[471] The court left open the question of the proper parameters of judicial review of agency environmental decision.[472] Nevertheless, at least some of plaintiff's allegations apparently challenged the correctness or "merits" of the environmental decision, prompting the court to address them to the extent the court felt it could and should do so under the arbitrary and capricious standard. The court's application of a substantive level of review was manifested in two ways. First, the court's sensitivity to inadequacies in the underlying data in the record was much greater than a procedural review would require. Second, despite the court's disclaimer, it resolved conflicts in expert opinion; in particular, the court resolved differing expert opinions on the classifications underlying the noise level chosen, which was said to be based on the capability of available monitoring.[473] In *Romulus*, the court's approach to the standards of judicial review appears to reveal the court's feeling that the procedural level of NEPA review was too restrictive upon the court's legitimate need to examine the technical bases underlying the agency decision.

The court's basic rationale for the more stringent judicial review standard used in *Romulus* was the decisionmaker's failure to use the best modeling and graphical display methodologies available to properly inform the decisionmaker and general public of the environmental decision being made.[474] Applying general principles of equity, the

470. 392 F. Supp. at 589.

471. *Id.* at 583.

472. *Id.* at 583 n.1.

473. *See id.* at 586-87, 589 n.7. The court may simply have been judging the credibility of the expert witness, who was an employee of the consulting firm which prepared the capacity section of the EIS. *Id.* at 588. The more likely explanation is that the court accepted the expert's testimony that it was possible for an expert such as himself to analyze data and results, but that the court felt this did not constitute a sufficiently understandable disclosure of the problems involved to alert the layman reading the EIS. *See id.* at 585.

474. The court did not appear to have any problem with the acceptability of noise modeling techniques or the general method of presenting the results in the form of sound contours. *See id.* at 591. It was not fatal that the decisionmaker "admitted that no single method has yet been agreed upon to answer all relevant noise questions." *Id.* at 594, 591 n.10. The court

court issued a preliminary injunction to restrain the decision because the court concluded that the rationale of the decision was inadequately disclosed.[475] Thus, although the *Romulus* court engaged in a form of substantive review of the decision's basic model in the sense of examining some of the technical bases underlying the model, its standard of review still would not ensure that the model's bases were subjected to a minimal level of meaningful review; it would only review the model where necessary to explain or support an eventual decision.

At about the same time that the injunction was granted in *Romulus*, a Maryland district court issued its opinion in litigation concerning a Baltimore freeway, *Movement Against Destruction v. Trainor* (*MAD II*),[476] in which Judge Miller engaged in perhaps the most searching and careful analysis of modeling data and methodology undertaken by a judge to date. *MAD II* was the second of two companion opinions on the subject, with the court's earlier opinion *Movement Against Destruction v. Volpe* (*MAD I*),[477] which also involved lengthy and detailed investigations into the validity of the data base and computer models underlying the pollution projections used in the EIS for the highway. In the context of this central issue the contrast between the opinions in *MAD I* and *MAD II* reveals the developing roles of courts and the evolving levels of judicial review for techno-environmental decisions.

As Judge Miller did in *MAD II*,[478] the per curiam opinion in *MAD I* engaged in a "substantial inquiry"[479] into the actions of the state and federal officials involved to see whether their decisions passed muster under the *Overton Park* test. In both cases, the results were the same: plaintiff's request for an injunction against the construction of the particular highway segment was denied.[480] Yet, the approaches taken in the two opinions written only two years apart appear to be significantly different. The extensive, technical, and rather critical review given to modeling efforts in *MAD II* can be

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stated that it "does not question the underlying concepts of ASDS, [the Aircrafts Sound Description System, *see id.* at 591 n.9.]. It is a system of measuring aircraft noise. It is the implementation of that concept, use of only one threshold, and the choice of 85dB(A) as that threshold that renders that analysis deficient." *Id.* at 594.

475. *Id.*

476. 400 F. Supp. 533 (D. Md. 1975).

477. 361 F. Supp. 1360 (D. Md. 1973), *aff'd*, 500 F.2d 29 (4th Cir. 1974).

478. 400 F. Supp. at 556, 558, 573.

479. 361 F. Supp. at 1396, 1402.

480. *See* 400 F. Supp. at 574; 361 F. Supp. at 1402.

contrasted to the cursory treatment and deference given to similar modeling efforts in the *MAD I* decision.

Both *MAD I* and *MAD II* faced the same two questions.[481] In both cases, plaintiffs alleged that the EIS failed to consider all relevant factors and was based on such "incompetent evidence"[482] that it violated the requirements of NEPA, since it represented a "clear error of judgment."[483] In both cases, the Maryland District Court stated that its level of review was a limited one.[484] In both cases the court engaged in a detailed examination of the data and methodologies used and gave a lengthy explanation[485] of its review of them, but the court ultimately held in *MAD II* that the methodologies were

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481. Two substantive issues involved in the cases were (1) the propriety of the approval of the EIS for the highway (which involved a substantive review of the data and methodology underlying that approval), *see* 400 F. Supp. at 541-43, 557; 361 F. Supp. at 1380, 1382-83, 1385-87, 1388-92; and (2) the alleged failure of the agency to fill the requirements of the 3-C planning process which is designed to ensure that the highway programs are based on a continuing, comprehensive transportation planning process carried on cooperatively by state and local communities. *See* 400 F. Supp. at 538 n.5, 562 n.69, 568-69 & nn. 81, 82, 572-73; 361 F. Supp. at 1370, 1394-96. The *MAD II* opinion also addressed the additional issue of whether the project was correctly found to be consistent with the SIP then in force. *See* 400 F. Supp. at 559-60.

482. 400 F. Supp. at 540-41, 547, 573-74; 361 F. Supp. at 1398-1402. In both *MAD I* and *MAD II*, the Maryland District Court applied *Overton Park* and the APA. 400 F. Supp. at 540; 361 F. Supp. at 1402 (citing 5 U.S.C. § 701). If this threshold question is passed, the court then must engage in a substantial inquiry of the decision, which includes a determination of:

> [w]hether the decisions of the governmental officials involved were 'arbitrary, capricious, or an abuse of discretion,' that is was the decision based upon a good faith consideration of relevant factors and was there no clear error of judgment? While the reviewing court is not permitted to substitute its judgment for that of the agency, the ultimate standard of review being a narrow one, the reviewing court has an obligation to review substantive agency decisions on the merits to determine whether there has been a clear error of judgment.

400 F. Supp. at 541 (citations omitted).

483. Plaintiffs launched a frontal attack on the models used. As the court said:

> Plaintiffs have argued forcefully that the defendants or their agent used scientifically inadequate methodologies and improper factors in the traffic and air quality predictions which form at least part of the foundation for their decisions. Defendants have contended that the techniques, methodologies, and factors utilized by them in the decisions were made at least within the state of the art.

400 F. Supp. at 547.

484. As the court stated:

> It is not the court's function to decide, as a matter of fact, which factor or methodology is the more scientifically correct, but decide whether (1) there is any reasonable ground for the use of the factor or methodology used, (2) the factor or methodology used was used in good faith and not solely for justifying a preconceived result, and (3) the use of the factor or methodology produced a result which could have justified rationally the various decisions required to have been made under law.

400 F. Supp. at 574. *Accord* 361 F. Supp. at 1387, 1396, 1402.

485. The court in both cases engaged in a substantial inquiry. 400 F. Supp. at 540; 361 F. Supp. at 1396, 1402.

"within the state of the art," and, therefore, were proper since they represented no clear error of judgment.[486]

The EIS challenged in *MAD II* was based on an earlier Baltimore Regional Environmental Impact Statement (BREIS). The BREIS was produced using several standardized models based on current data from federal and state agencies and from private contractor reports.[487] The models were used in BREIS and the resulting EIS to project future vehicular travel levels,[488] and expected resulting levels of air pollution.[489] The air pollution model itself relied upon the

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486. 400 F. Supp. at 574. The court acknowledged that there were some errors by its italicization of the word "clear" when it held that the review showed that "there was no *clear* error on the part of the . . . Administrator." *Id.* (emphasis in original).

487. 400 F. Supp. 562-63. *See* Friesema & Culhane, *Social Impacts, Politics and the Environmental Impact Process*, 16 NAT. RESOURCES J. 339, 343 (1976).

BREIS was based on an earlier report by a private contractor (Voorhees). 361 F. Supp. at 1379. That report was divided into seven tasks: (1) gathering land-use data for the target years; (2) adjusting the data to reflect the patterns resulting from the alternatives; (3) travel simulation modeling; (4) quantifying background levels of carbon monoxide (CO), hydrocarbons (HC), nitrogen-oxides (NO_2), photochemical oxidants (POX) (smog), and particulates on a regional basis; (5) using those background levels together with other vehicular travel data, actual and simulated, to run models of expected vehicular pollution (using the BAQC emission model) and the expected resulting air quality using a dispersion model; (6) modeling sewer and storm water run-offs and solid waste disposal problems created by the resulting changes in land-use patterns resulting from each of the alternatives as the secondary effects of the project; and (7) projecting expected noise levels. The results of the various modeling efforts were summarized in such tables as those reproduced by the court. *Id.* at 575-80. The court concluded that "[a]s a gross generalization, it may be said that BREIS concluded that there are economic benefits in the short term and the long term from the construction of the [entire] 3-A highway system and of the other highway and rapid transit improvements contemplated by the GDP [the General Development Plan, *see id.* at 539-40, n.10]. *Id.* at 539-40. It further concluded that "by 1980 and 1995 projected pollutant levels in all categories of pollution will differ only slightly among the transportation alternatives . . . ," *id.* at 540, and that the levels generally will meet the SIP requirement of meeting the primary and secondary national air quality standards. *Id.* at 541.

488. *See* 400 F. Supp. at 548. The court noted that the basic theory of the computer-run equations that composed the model was bottomed upon the proposition that history repeats itself. *Id.* That is, the model took past data and projected the changes that the transportation system would produce, based on several assumptions. *See* 400 F. Supp. at 552-53. The court's own evaluation of the level of sophistication of the model was that it was within the state of the art of travel forecasting. *Id.* at 549, 554. This conclusion was based upn the court's observation that the basic gravity modeling technique was more sophisticated than that which had been utilized in the past and that there then existed no single methodology or technique in prediction of future traffic volumes which had been empirically demonstrated to be an infallible one under all circumstances. *Id.* at 548.

489. *See id.* at 549. The modeling effort to generate the necessary projections of air quality data was a set of procedures involving the use of several models, some of which had as their input the input of other models. *Id.* at 562. This complexity was further compounded by the differing characteristics of the pollutants involved. *Id.* at 561. The effect of CO is largely localized to a particular highway or highway segment. *Id.* at 561 n.66. The result was that the highway segment had to be examined at two levels. "The first deals with the air quality impact of the highway segment alone. The second is the impact of that highway segment, together with the

results of the vehicular traffic model as data inputs, and, therefore, the air pollution model could be no more accurate than the vehicular modeling effort. Plaintiffs' substantive challenge to the vehicular modeling effort can be broken down into three parts: (1) the data used in the model; (2) the structure of the model used; and (3) the assumptions on which the model was based.[490] Plaintiffs alleged that the data used, which was collected in 1962, was so outmoded that the traffic projections included in the BREIS based on that data were sufficiently incompetent as to demonstrate a clear error of judgment by EPA in using them in the final EIS.[491] Before dealing specifically with the allegations, the court initially noted that the agency apparently acted in good faith and noted that the prediction of the future by modeling is necessarily a risky business and necessarily involves a substantial amount of judgment to be exercised by the agency. The court also noted the relative sophistication of the gravity modeling technique employed in the BREIS study to generate these traffic modeling projections.[492] The court refused to find that the use of outmoded data constituted clear error for two reasons: (1) experts doubted the value of another such effort; and (2) the extensive validation checks and adjustments in the model apparently tended to expose and correct any such errors introduced by apparently out-of-date data.[493]

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other transportation facilities, which constitute the urban transportation system as set forth in the urban transportation plan." *Id.* at 561. For the highway segment step, the only pollutant that need be considered was CO; this analysis was the so-called microscale study. *Id.* at 562. This microscale analysis was done with a computer-run mathematical model. The data for that model came from several sources: measurement of present CO levels resulting from that traffic, measurements of present levels of background CO concentration, and predictions of future vehicular traffic levels (which is, itself, the result or output of a model). For a further discussion of the microscale analysis, see *infra* note 505.

The second level of analysis of the highway was required to extend beyond the expected impact of the highway segment alone. *Id.* at 561. This so-called mesoscale analysis considered the impact of the entire GDP on a regional basis as required for finding an EIS consistency. *Id.* at 562 & n.69. The court found that the mesoscale study reached conclusions relating to predicted regional ambient air concentrations in the near and long terms for various alternative transportation systems of HC, POX, NO_2, CO, and particulates. *Id.* at 564. The results of this study were summarized in tables. The mesoscale analysis is discussed *infra* note 505.

490. 400 F. Supp. at 547-56. As the court noted, "[e]ssential to the validity of the conclusions of BREIS is the technical reliability of the projections of traffic volume." 400 F. Supp. at 548. *See id.* at 566. The court in assessing the validity of the air pollution models referred back to discussion of the validity of the vehicular modeling effort. *Id.* at 562.

491. 400 F. Supp. at 548-49.

492. *Id.* at 548. *See supra* note 488.

493. *Id.* at 547-52. This "verification process for the models and submodels used in the BREIS for traffic compared theoretical simulated projection of VMT for 1970 with extrapolated VMT based on actual counts the same year." *Id.* at 549. The process consisted of a cyclical repetition of the following steps: (1) model run; (2) comparison with known results; (3)

The plaintiffs alleged that the structure of the model was defective in its assessment and presentation of the environmental impacts of the planned highway because it failed to contain a factor for "generated" traffic.[494] That is, it was asserted that the change in the road would serve as a "magnet" to attract traffic. The court rejected the challenge on a number of bases. The court noted that the methodology utilized in preparing the traffic projections was within the state of the art; if the state of the art would allow more, the court indicated that it would require more. The court noted that the generated traffic phenomenon was not clearly understood and that there was no clearly accepted methodology for predicting such traffic. The court also noted that the model actually used implicitly took into consideration some of the factors claimed to be involved in the generated traffic phenomenon.[495] Finally, the court noted that the validation checks, which compared predicted results to actual results, would ensure that projections were roughly correct and that any consistent biases in the projections would be revealed and could be corrected or adjusted for in the decisional model.[496]

Plaintiffs' third attack was on the assumptions underlying the model, which the court similarly rejected.[497] The court examined the reasonableness of the assumptions from the perspective of the time in which they were made and held that the test for such assumptions is whether they are "made in good faith and with a rational explanation" even if they are "later proved to be incorrect."[498] In fact, some of the assumptions underlying the study did turn out to be incorrect.

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adjustment of model parameters to make the model a more accurate reproduction or mimic of reality; and (4) adjustment of data to accommodate model adjustments, measurement and collection shortcomings, and inefficiencies in the data base. *See id.* at 550-51.

494. "Generated" traffic is a term utilized by professional planners and transportation analysts to refer to a phenomenon of combined additional trips on an old road and a generally parallel new road which are greater than that additional traffic which can be accounted for simply (1) by diversion of existing traffic from other routes in the general vicinity and (2) from normal growth of traffic in general over time. 400 F. Supp. at 549. Because the phenomenon was not clearly understood and because its use was a matter of reasonable debate among transportation planners and analysts, the court concluded there was no showing of "any generally accepted methodology among transportation planners and analysts for the inclusion of a factor" which would take into account such generated traffic in a manner more explicit than the BREIS approach of building it into the model's assumptions. *Id.* at 549.

495. 400 F. Supp. at 533. *See id.* at 552.

496. *Id.* at 550-52.

497. *Id.* at 552-53. The assumptions were related to the relative cost of mass transit as opposed to automotive traffic, the possibility of transportation controls being imposed, supply relationship to travel cost and time, and the anticipated completion dates of the mass-transit portions of the area-wide transportation plan.

498. *Id.* at 553.

For instance, the assumption of no imposition of transportation restrictions later turned out to be incorrect.[499] Additionally, as other parts of the opinion made clear, some of the data and relationships used in the model turned out in the final analysis not to be entirely accurate, as discussed below. The court did not require that all assumptions turn out to be proven completely accurate; rather, it held only that the use of an assumption must be necessary or desirable and that the agency must undertake a diligent research effort to establish the validity of the assumption to the extent possible under the state of the art at that time, all of which should be done *prior* to the use of the assumption by the decisionmaker.

In substance then, the court in *MAD II* struck a balance between practicality and desirability. The court recognized that modeling results are not that precise since "[p]rediction of the future . . . is necessarily a risky business . . .," particularly since modern knowledge concerning the environment is developing so rapidly.[500] In *MAD II* the court felt that the validation efforts of the EPA were within the state of the art of the relevant scientific discipline because they were more sophisticated than similar efforts utilized in the past.[501] The court deferred to the substantial amount of judgment exercised by those who performed the study and refused to set itself up as a "super professional transportation analyst or planner."[502]

The carbon monoxide (CO) modeling effort was upheld as within the state of the art based on the court's observation that, although the proportional model was the least sophisticated modeling procedure of those used, it appeared to be the best available technique then accepted by EPA.[503] The court, however, found that errors in the reduction model caused the specific predictions for photochemical oxidants (POX) to be subject to doubt.[504] Two possible sources of

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499. *Id.* at 554.

500. *See id.* at 548, 552, 554.

501. *Id.* at 554, 548-49.

502. *Id.* at 548-49.

503. *Id.* at 564. *See id.* at 567-68. As the court predicted, *see id.* at 564 n.74, the EPA now allows demonstration of consistency by means of a proportional rollback model, a photochemical dispersion model, an Empirical Kinetics Modeling Approach (EKMA), or other empirical and statistical models. *See* 40 C.F.R. § 51.14(c)(7) (1981).

504. The reduction model was applied by (1) noting the 1970 observed level of POX; (2) referring to the reduction model curve at the point which represents this value on the horizontal axis; and (3) reading on the vertical axis the percentage reduction in hydrocarbon emissions required to attain the standard. 400 F. Supp. at 566. While there was no direct evidence in the record on the point one way or the other, the court had a strong suspicion that the reduction model could not be utilized in this manner, either through the method of calculation employed in BREIS or through the method of calculation argued for by plaintiff's counsel. *Id.* at 567 &

error in the reduction model as applied were the inaccurate reproduction of the curve's endpoint on the graph which represented the model, and, according to the court, the "improper use" of the reduction model.[505] Additionally, there were errors in the calculations in the final EIS which had the effect of giving the wrong conclusions: as pointed out in the subsequent BREIS on which the decisionmaker relied, the final EIS had been in almost total error in concluding that national standards for hydrocarbon (HC) and photochemical oxidants (POX) would be met; however, the statement by the decisionmaker noted the error.[506] This was apparently enough to satisfy the court.

The standard of review in both *MAD I* and *MAD II* was said to be the arbitrary and capricious standard under *Overton Park*,[507] although the ultimate scope of review appeared more probing in *MAD II* than in *MAD I*. The court concluded that the results of the vehicular modeling effort were of sufficient validity to justify the decisionmakers' reliance on them, in spite of the "pass through" effect by which modeling inaccuracies are compounded by the use of those model's results as data for other models.[508] In *MAD II*, the

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n.79. The court did not specify the source of its suspicions. The ambiguity is not resolved in the relevant regulations. *See* 40 C.F.R. § 51.14 (1981).

In an effort to evaluate the effects of these ostensible serious flaws, the court looked for evidence in the record by which to estimate the reliance which the decisionmaker placed on these specific results. The court noted that the consistency statement made reference to specific numbers, that the agency had been in close contact with the state agency that discovered the error in the EIS, and that the decisionmaker based its conclusions on the estimated reductions in HC emissions predicted in BREIS and other factors to show consistency. *Id.* at 569-70. The other factors that the court cited in making its finding tended to show *inter alia* that the assumptions made were reasonable, that the predictions did not show too serious a violation, and that planned alternative transportation facilities would have a mitigating effect. Likewise, the court cited the inherent uncertainty involved in such efforts, the awareness of the decisionmakers of some of the flaws and shortcomings of the effort, and the fact that the effort was one made in good faith and within "the state of the art." *Id.* at 541.

505. *Id.* at 567.

506. The graph is reproduced in the opinion. *Id.* at 565. The endpoint referred to is the intersection of the nonlinear graphical line with the bottom horizontal forming the boundary of the graph's grid. The court claims to have found this error by comparing the graph to the official example from which it is purportedly taken, *see* 40 C.F.R. Part 51, at 69, App. J. (1976), and by comparing it to "the model's very purpose." 400 F. Supp. at 565-67. The court made this inquiry and drew its own conclusions as to the nature and magnitude of its effect even though "the apparent variance was not even commented upon by plaintiff's counsel or witnesses." *Id.* at 567. *Compare* Texas v. EPA, 497 F.2d 289, 295, 300 (5th Cir. 1974). The supposed shift in endpoint may have some slight effect on the correctness of its application. The effect would likely be negligible in light of the inaccuracy of the plotting or graphical solution technique.

507. 400 F. Supp. at 547, 556, 571-73; 361 F. Supp. at 1387, 1396, 1402.

508. The court noted that "[e]rrors in traffic volume projections most likely would result in errors in conclusions based on traffic volume projections." *Id.* at 548. *See id.* at 562.

predictions of expected levels of traffic were used in other models to predict projected pollution effects on a local basis (by microscale analysis)[509] and on a regional basis (by mesoscale analysis).[510] The substantive correctness of the microscale and mesoscale analyses was at the heart of the propriety of accepting the overall sufficiency of the EIS. Therefore, unless one accepts a purely procedural review as adequate in the case of such environmental decisions, a court must examine in some detail the component parts of such analyses and the models underlying them in order to ensure a minimally acceptable level of substantive correctness for the environmental decision. In this light, the court must be prepared to substitute its judgment for decisions of the agency on all technical matters, excepting those involving strictly policy matters. The court's review in *MAD II*, while thorough and in depth, failed to ensure the correctness of such nonpolicy technical decisions. The court in *MAD II* upheld the validity of all methodologies, except for the reduction model, and overlooked errors introduced into the resulting conclusions based on the decisionmaker's nonreliance on some of the specific numerical levels predicted.[511] Noting that there were only a few instances where the pre-

509. The microscale analysis for the air quality levels at the local level was accomplished by the following steps: (1) actual measurements of present traffic levels were compared by the use of models to derive a functional relationship of CO pollution to traffic levels; (2) assumptions were made as to whether this functional relationship would hold true in the future; and (3) projected levels of ambient CO were predicted using as inputs projected traffic levels, vehicle emission factors (by vehicle and speed), wind speed, wind angle, height of the highway pavement, receptor height and distance from the road's edge, atmospheric stability, and pollutant molecular weight. The theoretical result of the calculations, after adding the appropriate background concentrations, was the predicted one-hour maximum CO concentration at any particular receptor site. Stated more generally, "the CO concentrations from . . . highway generated sources were a factor, i.e., a function of vehicle miles traveled (VMT) multiplied by emission equations in turn applied to a mathematical model intended to predict the diffusion of gaseous CO based upon atmospheric and other relevant conditions." *Id.* at 562-64. The results were predicted maximum worst case levels at CO over one-hour and eight-hour periods. *Id.* at 563-64. *See* 400 F. Supp. 539 n.9. There was a conflict between the modelers and the EPA as to the proper model to be used in this process, although both advocated the use of computer-generated models based on Gaussian diffusion equations. *Id.* at 562-64.

510. The mesoscale analysis was used to project levels of NO, POX, NO_2, CO, and particulates on a regional basis. For the mesoscale analysis, three basic types of modeling efforts were involved, depending on the type of pollution examined. For CO pollution levels at the regional level, a computer diffusion model similar to the one used at the microscale level was employed. A proportional modeling technique was used to predict resulting levels of HC, NO_2, and particulates. In order to predict resulting levels of POX, this proportional modeling approach had to be combined with a reduction model, necessitated by the fact that POX—unlike the other substances—is not emitted directly into the atmosphere, but is produced by the reaction of the HC with ordinary sunlight. 400 F. Supp. at 564-67. The modelers' summaries of results of the various modeling efforts in tables were reproduced at the end of the opinion. *See id.* at 575-79.

511. 400 F. Supp. at 568, 571.

dicted levels of pollution projected by the model exceeded national standards, the court held that the decisionmaker's decision was not arbitrary and capricious,[512] was made in good faith, had considered the relevant factors, and did not constitute a clear error of judgment.

Besides the air and noise pollution cases involving models, courts have also reviewed cases involving models to predict probable water pollution levels. These water pollution cases also reflect the inability and unwillingness of the courts to apply a meaningful level of substantive review to the non-policy portions of model-based agency decisions. Computer models have been used to predict levels of water quality resulting from the damming of a river or the introduction of pollutants into an existing body of water from the polluting source, such as a sewage plant. For example, in *Conservation Council of North Carolina v. Froehlke*,[513] the district court reviewed the decision by the United States Army Corp of Engineers to proceed with the creation of a water reservoir which was based, in part, on mathematical models used to project probable levels of eutrophication of the water caused by excessive levels of phosphorous.[514] This challenge to the phosphorous modeling effort was a part of plaintiffs' challenge to the adequacy of the EIS under NEPA.[515] Plaintiffs in *Conservation Council* generally did not contest the underlying data used in the models.[516] Rather, their objections to the project were directed toward the conclusions reached by the Corps of Engineers, which were based on mathematical models taken from the EPA National Eutrophication Survey.[517]

The court in *Conservation Council* stated that it was applying the *Overton Park* level of substantive review under NEPA to evaluate the merits of the decision.[518] Although the court acknowledged its duty to defer to the discretionary judgment of the decisionmaker, the Corps,[519] the court continued to examine and resolve the conflicts in expert testimony in favor of defendants.[520] In reviewing

512. *Id.* at 556, 571, 572, 574.

513. 435 F. Supp. 775 (M.D.N.C. 1977).

514. *Id.* at 783-84, 792-95.

515. *See id.* at 781-82, 790.

516. *Id.* at 783, 792.

517. *Id.* at 783-84, 792.

518. *Id.* at 781-82, 792-93.

519. *Id.* at 782, 793. The court stated it was not to substitute its judgment for, or make the ultimate decision for the environmental decisionmaker.

520. *Id.* at 793. The court there stated that "disagreement among the experts in the field need not invalidate the EIS or the decision to impound," because NEPA does not require scientific unanimity or scientific perfection in the EIS. *Id.* Similarly, the agency "is not required to accumulate the sum total of scientific knowledge of the environmental elements af-

such evidentiary conflicts, the court placed the burden of proof on the objecting plaintiffs to demonstrate inadequate evidentiary support or insufficient data, which plaintiffs failed to do. The court stated that all of the plaintiffs' objections to the data gathering and modeling methodologies were refuted by the greater weight of the evidence.[521] As the court observed, the Corps apparently used the best methodologies then available to conduct "a thorough interdisciplinary examination of the environmental and economic benefits and detriments of impoundment."[522] In sum, the court left open the possibility that a similar decision by the Corps of Engineers could be shown to be incorrect by some degree of proof, but the court did not explicate what type or magnitude of error was necessary to support a finding of a clear error of judgment by the decisionmaker.

The judicial review of computer models has also been involved in decisions allowing the placement of sewage plants and the permitting of discharges from the plants into waterways. Two cases by the Federal District Court for the Southern District of Ohio[523] upheld the use of admittedly inaccurate computer models on the basis that a reasonable reader of an agency report would not be misled concerning the reliability of the weight to which modeling is entitled for planning purposes.[524] The standard applied in these two cases was based on the amount of disclosure actually made to the decisionmaker and the public,[525] which is similar to the disclosure standard used in *Life of the Land v. Brinegar*.[526] The Ohio cases claimed to be applying the *Overton Park* standard of review,[527] which the district court felt precluded a substantive review of and a significant level of factual inquiry into the data gathering end of the decisionmaking methodologies involved.[528] This approach appears to be ill-founded. Although NEPA may not require scientific perfection, or even the most accu-

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fected by a proposal, because the decision need show only a good faith consideration of relevant factors." *Id.*

521. *Id.*

522. *Id.* at 796.

523. Brown v. EPA, 460 F. Supp. 248 (S.D. Ohio 1978); Evans v. Train, 460 F. Supp. 237 (S.D. Ohio 1978).

524. 460 F. Supp. at 251; *id.* at 242.

525. The district court stated it was applying the arbitrary and capricious standard. *Id.* at 253; *id.* at 243-44.

526. 489 F.2d 460 (9th Cir. 1973), *cert. denied*, 416 U.S. 961 (1974), discussed *supra* text and notes at notes 439-41.

527. *See supra* text and notes at notes 183-205 (discussing the varying formulations of that standard).

528. *See* 460 F. Supp. at 252-53; *id.* at 241, 243-44.

rate stream model then developed,[529] the district court ignored the actual mandates of NEPA[530] in abdicating its judicial role as the supervisor of administrative decisionmaking methodologies by upholding an environmental decision based on an inaccurate computer model which did not even represent a state of the art in the subject area of the decision.

In NEPA cases involving models, the courts' level of review generally is not sound or exact enough to ensure a meaningful review of the underlying methodologies and data. The *MAD II* opinion, although ultimately too deferential, applied a sufficiently detailed inquiry indicative of the more detailed inquiry which should be done by the courts. However, later cases such as *Conservation Council of North Carolina v. Froehlke*, *Brown v. EPA* and *Evans v. Train* demonstrate a continued refusal by courts to engage in the necessary factual inquiry, as well as an overly deferential level of review of model-based agency decisions.

V. A Suggested Approach to Judicial Review of Decisions Based on Models to Ensure a Minimum Level of Meaningful Review

Because of the diversity of cases involving judicial review of models in environmental decisionmaking, it is difficult to draw from them broadly applicable conclusions or solutions. Nevertheless, the cases do generally reveal that: (1) the role of the court in the decisions has been too restricted; and (2) the standards and scope of review applied by the courts has not been sufficiently searching to ensure the correctness of the factual underpinnings of agency decisions, since the methodology and data underlying the model or models used in the decision generally are not scrutinized.

Fundamentally, the court's role in its scope of review must be to correct errors presented in a "wrong decision."[531] The phrase "wrong decision" in the context of an environmental decision based on a mathematical or computer model refers only to the factual underpinnings of the case, that is, the validity of the data and methodology used in the models as well as other factual, non-modeling aspects of the decision. It is important to note that an environmental decision based on a model cannot be said to be reviewable as a "wrong decision" to the extent that it may be based on incorrect policy deci-

529. *See id.* at 251.
530. *See supra* text and notes at notes 83-93.
531. *See* Int'nl Harvester v. Ruckelshaus, 478 F.2d 615, 648 (D.C. Cir. 1973).

sions. The reviewing court must properly discern the line between reviewable factual underpinnings and nonreviewable policy decisions even when both may provide basic assumptions for modeling. It is particularly difficult to discern this line in environmental cases involving models, because facts and policy are quite often inextricably intertwined. As seen in the cases presented, the construction of the model used in the environmental decision invariably involves assumptions, compromises, and adjustments, all of which embody policy decisions by the administrative agency. The same is true for the quality of the data used. For instance, the data may be chosen from the cleanest plant or the most sensitive organisms, thereby likely to reflect a policy requirement of stringent cleanup requirements. To the extent that the policy contained implicitly in such decisions is within the statutory authority of the agency and is in accord with the laws, policy choice should be deferred to. The burden, however, should be on the agency to establish the extent of policy involved in the decision, and *all portions* of the decision, including the model and the basic data comprising the model, should be reviewable with a level of substantial inquiry adequate to ensure a minimum level of meaningful review and a resulting factually correct decision.

As a general matter, most opinions involving the review of environmental decisions based on models have been too deferential to the administrative agency and its expertise. Courts, fearing that they might be accused of substituting their judgment for that of the administrative agency, have accepted too limited a role in reviewing environmental decisions based on models. As seen above, however, it is difficult to formulate a uniformly applicable standard of review for any case. It appears from the cases reviewed here that proper judicial review requires a more flexible approach to such cases than is applied to less technical, less complicated decisions. For a particular case reviewing an environmental decision based on a model, the role of the court and the level of scrutiny applied by it must depend on: (1) the nature of the particular decision at issue; (2) the mandates of the applicable substantive and review statutes; (3) the amount of available data; (4) the quality of that data; (5) the decision-making methodologies available; (6) the quality of the methodologies and data used; (7) the expertise of the administrative agency; (8) the procedural posture of the case; and (9) the technical and scientific resources available to the court.

It may be objected that such a case-by-case approach to judicial review is, in reality, present in every case and that it possesses an inherent tendency to expand judicial inquiry to the eventual arrogation

of agency expertise. In the alternative, it may be objected that such a case-by-case approach to review amounts to no standard of review at all. In either instance it must be remembered that such a flexible approach to judicial review is suggested for application to a very limited class of technical environmental decisions relying on models, and only as to those portions of the decisions involving the intertwining of complex and scientific issues with policy decisions which have generally remained untested by the courts.

The proper role of the court and the appropriate level of judicial review is best expressed in the formulation that the court, given sufficient resources, should sufficiently involve itself in the model data and methodology to ensure a minimal level of meaningful review.[532] This approach must rest on courts' realization that a significant review of the factual record is required for a "substantial inquiry" into an environmental decision based on models.[533] In most environmental cases involving mathematical and computer models, this formulation of the appropriate judicial review standard results in an inquiry somewhat more searching than the *Overton Park* standard presently said to be applied to such decisions. On occasion, the more flexible approach to judicial review suggested herein may require that the court "substitute its judgment" for that of the administrative agency where the inquiry reveals fundamental or uncorrected flaws in the modeling and decisionmaking process.

A court properly may substitute its judgment for the agency's in several instances: (1) where the agency uses an incorrect model or a model that inexplicably falls short of the modeling art; (2) where the agency uses unexplained or unjustified assumptions or adjustments in the model; (3) where the agency uses data shown to be incorrect or inapplicable to the situation; where the agency uses an insufficient data base such as by using inexplicably out-of-date data, failing to validate and explain the procedures applied to ensure that the model was proper for the data base, failing to use monitoring data or other procedures to calibrate and validate the model, failing to cite to supporting technical and scientific literature or failing to distinguish apparently inconsistent technical literature, and failing to explain or correct apparently incorrect or imprecise methodologies or results; (4) where the agency fails to properly structure and summarize the

532. *See* Texas v. EPA, 499 F.2d 289, 321, 322 (5th Cir. 1974) (Clark, Boyle, JJ., concurring). The main opinion applied the arbitrary and capricious standard throughout, *id.* at 296-97, but did so in a way more searching than the typical arbitrary and capricious review case.

533. *See supra* cases cited at note 194.

supporting and nonsupporting data and methodology in an understandable index or appendix; and (5) where the agency fails to provide necessary data at a time at which meaningful comments and challenges to data and methodology could be raised, or fails to provide a realistic opportunity for the presentation of such objections. The flexible formulation of judicial review suggested herein reflects no change from current administrative law doctrines, in that courts should continue to avoid reviewing policymaking decisions by administrative agencies to the greatest extent possible. The suggested standard might be seen as a change, however, to the extent that decisions involving both factual and policy decisions can no longer be insulated from judicial review by the presence of policy decisions intermingled in the environmental decision. To that extent, courts *should* be allowed to "substitute their judgment" for the policy judgment of the administrative agency, where the decision being reviewed involves scientific technical issues, has policy elements inextricably intertwined with those technical issues, and is not a decision primarily of policy.

This suggested minimal level of meaningful review would require limited modifications of traditional court roles and standards of review. Courts should no longer hesitate to resolve scientific controversies or differences of opinion, nor should the courts hesitate to go beyond the record to resolve those controversies. Courts also should not hesitate to go beyond the record where there are readily apparent errors or inconsistencies in the data or methodology used by the decisionmaking body; where contradictory data or methodology is brought to the attention of the court by any opposing party (whether in the record or not); or where accepted scientific technical literature is felt useful or necessary in reviewing the decision. Courts should allow cross-examination of witnesses and should not hesitate to require full adjudicatory evidentiary hearings, particularly where significant errors or deficiencies are present and not explained in the record initially produced by the administrative agency. In particular, where the first level of judicial review occurs in a court of appeals without opportunity for review by a trial court, provision should be made for more formal proceedings before a special master or magistrate, as opposed to remanding to the administrative agency for further proceedings to develop the record.

Where a remand does not appear to be necessary, a court should not hesitate to allow into the record supplemental data, testimony, calculations or other evidence by way of post-argument conferences, supplemental briefs, supplemental appendices, or submissions from

independent technical advisory panels. Where possible, the Magistrate's Act should be used both during any judicial review proceedings and any post-review proceedings to collect, analyze, and evaluate the sufficiency and correctness of the scientific and technical data and methodology involved in the environmental decision, including that involved in the mathematical and computer models. Such supplementation of the courts' resources and expertise could be equally well provided by technical special masters, technical advisors provided by the administrative decisionmaking body, consultants provided by the challenging parties, independent consultants hired by the court, or technically trained staff members hired full-time by the court.

At the present time, the problems of judicial review discussed herein do not warrant the creation of a Science Court or special environmental court, as suggested by a number of commentators,[534] although a number of environmental subject matters, such as hazardous and toxic waste regulation, are so specialized and complex that they may eventually mandate the creation of a special court to deal with problems of insufficiency of data, scientific uncertainty, and contested policy decisions. By contrast, the mere presence of a model in the environmental decisionmaking process is not sufficiently important to require or allow that the decision be reviewed by a special court. Additionally, if one required or allowed only those environmental decisions which relied significantly on models to be reviewed by such a court, it would place the jurisdictional basis of that Science Court on the amorphous jurisdictional footing of determining whether the decisionmaker relied on a model. At the present time, the better solution is to provide reviewing courts with sufficient technical resources and flexibility in review standards to ensure that environmental models involving computer or mathematical models receive a minimum level of meaningful review.

It is recognized that this suggestion flies in the face of the spirit, if not the letter, of traditional judicial interpretations of judicial review statutes, as well as recent Supreme Court opinions.[535] Those cases by the U.S. Supreme Court can be distinguished, in that they address only issues of judicial review under NEPA, arguably only a procedural review statute, and in any event should not be read to preclude

534. *See, e.g.*, Matheny and Williams, *Scientific Disputes and Adversary Procedures in Policy-making: An Evaluation of the Science Court*, 3 LAW & POLICY Q. 341 (1981); Martin, *Procedures for Decisionmaking Under Conditions of Scientific Uncertainty: The Science Court Proposal*, 16 HARV. J. LEG. 443 (1979). *See also* Whitney, *supra* note 225, at 33-35.

535. *E.g.*, Strycker's Bay Neighborhood Council, Inc. v. Karlen, 444 U.S. 223 (1980); Vermont Yankee Nuclear Power Corp. v. NRDC, 435 U.S. 519 (1978).

a meaningful level of review. The Supreme Court in *Strycker's Bay* did reject one of the premises of this paper, that is, that special treatment should be given to administrative decisions that entail "complex or technical factual issues or 'Issues of Great Public Import.' "[536] However, if Justice Marshall is correct in his dissent in *Strycker's Bay* in saying that such a holding limits "the reviewing court to the essentially mindless task of determining whether an agency 'considered' environmental factors even if that agency may have effectively decided to ignore those factors in reaching a conclusion,"[537] then Justice Marshall has the better of the argument. If necessary, an amendment should be made to NEPA, the APA, and the various substantive environmental statutes to allow courts sufficient flexibility to engage in a minimal level of meaningful review.[538]

Courts should be provided with sufficient appropriations to hire, either on a permanent or part-time basis as appropriate, the necessary technical expertise to assist them in analyzing the data and methodology used in environmental models and to establish a training center or program designed to better acquaint judges with the rudiments of the scientific and technical issues underlying environmental decisions based on models. These steps, while less drastic than the creation of a separate Science Court, would allow courts to better address the disputes and questions often involved in environmental decisions based on models and would better equip the courts to ensure that environmental decisions are always of a demonstrable correctness to protect the integrity of the environmental effort and the confidence of the public in it.

VI. Conclusion

The courts in reviewing environmental cases involving computer models and other quantitative methodologies have been constrained to apply too limited and deferential a standard of review in those decisions. As a result, some of those decisions have been upheld, even though the decisions were based upon methodologies and data which were neither conclusive nor shown to be correct. As a corollary result, less confidence can be placed in the correctness of such

536. Vermont Yankee Nuclear Power Corp. v. NRDC, 435 U.S. 519, 545 (1978) (quoting Brief for Respondents).

537. Strycker's Bay Neighborhood Council, Inc. v. Karlen, 444 U.S. 223, 228, 231 (1980) (Marshall, Jr., dissenting).

538. Kennedy, *Bumpers Amendment: Regulating the Regulators*, 67 A.B.A. J. 1639 (1981); O'Reilly, *Deference Makes a Difference: A Study of Impacts of the Bumpers Judicial Review Amendment*, 49 U. Cinn. L. Rev. 739, 772, 778-80 (1980).

decisions where the apparent absence of demonstrated error in methodology or data actually reflects only the limited and deferential nature of judicial review applied by the courts under the *Overton Park* standard. Consequently, the court should apply a sufficiently searching and flexible level of judicial review to ensure a meaningful review of all except the purely policy-related portions of the environmental decision. In particular, a court should take all necessary actions to examine the data and methodologies underlying those decisions, including the use of court appointed experts, supplemental proceedings, supplemental briefs, technical advisory panels, or post-argument conferences or testimony. Above all, courts should use the flexibility under the *Overton Park* standard of review to fashion and apply an explicitly defined scope of review to ensure a minimal level of meaningful review of environmental decisions based on computer models and quantitative methodologies.