GOOD ENGINEERING PRACTICE AND THE TALL STACK RULES: JUDICIAL DISREGARD OF THE EPA'S DELEGATED DUTIES

The Clean Air Act[1] (Act) seeks to protect individuals near sources of air pollution from excessive doses of certain pollutants.[2] The Act sets ground-level limits, called National Ambient Air Quality Standards (NAAQS), which, if surpassed, violate the Act.[3] Initially, the Act did not limit the height at which industry could build stacks.[4] Although "hot air" generally rises, conditions can arise that push stack emissions down to the ground.[5] The higher the stack, the lower is the possibility

1. Clean Air Act Amendments of 1970, Pub. L. No. 91-604, 84 Stat. 1676 (codified at 42 U.S.C. §§ 7401-7642 (1982)).

2. 42 U.S.C. § 7470 (1) (1982). The statute reads: "The purposes of this part are as follows: to protect public health and welfare from any actual or potential adverse effect which in the Administrator's judgment may reasonably be anticipated to occur from air pollution . . . not withstanding attainment and maintenance of all national ambient air quality standards." *Id.*

3. 42 U.S.C. § 7409 (1982).

4. Industry has used stacks to emit pollutants for many years. R. MELNICK, REGULATION AND THE COURTS: THE CASE OF THE CLEAN AIR ACT 117 (1983). Since 1970, a dispute has raged over the extent to which stationary sources — stacks — may emit pollutants. NRDC v. Thomas, 838 F.2d 1224, 1230 (D.C. Cir. 1988). *See* L. LAVE & G. OMENN, CLEANING THE AIR: REFORMING THE CLEAN AIR ACT 2 (1981) ("Efforts to control air pollution to protect public health and welfare have generated political struggles for decades in this country and for centuries in Great Britain.").

5. ENVIRONMENTAL PROTECTION AGENCY, GUIDE FOR DETERMINATION OF GOOD ENGINEERING PRACTICE STACK HEIGHT 72 (revised 1985) [hereinafter STACK HEIGHT GUIDELINES] (emission temperature and velocity have little effect on ground level conditions when a stack discharges into a region of downwash and turbulence behind a building).

that air currents will sweep stack emissions to the ground.[6] As a result, companies built tall stacks hundreds of feet high so pollution would "disperse" into the atmosphere instead of collecting at the ground.[7]

Congress amended the Act in 1977 and set an additional goal of limiting the amount of air pollution.[8] Congress realized that excessive stack height would not limit the amount of pollution, but would merely disperse the same amount of pollution over a broader area.[9] As a result, Congress mandated a limit on stack height and forced industry to build stacks tall enough, but no taller than necessary, to avoid NAAQS violations.[10] Additional stack height would allow dispersion of additional pollution.[11] Congress based the restrictions on stack height on "good engineering practice" (GEP).[12] A stack taller than GEP height

6. Alabama Power Co. v. Costle, 636 F.2d 323, 388 (D.C. Cir. 1979) (stack height affects ground level concentrations). Companies attempt to build stacks with sufficient height because stagnant weather, smoke, fog, and smog can increase problems. L. LAVE & G. OMENN, *supra* note 4, at 2. Problems can be as severe as those in Glasgow, Scotland, where stagnant weather and coal emissions resulted in more than 1,000 deaths. *Id.* at 3.

7. *See, e.g.*, Temple, *TVA's New Look*, 5 ENVTL. PROTECTION AGENCY J. 17, 17 (April 1979) (TVA exhausted legal options by implementing tall stack compliance).

8. Clean Air Act Amendments of 1977, Pub. L. No. 95-95, 91 Stat. 685 (codified at 42 U.S.C. §§ 7470-79 (1982)); *see also* D. CURRIE, AIR POLLUTION, FEDERAL LAW AND ANALYSIS § 4.6 (1981 & Supp. 1987).

9. NRDC v. EPA, 489 F.2d 390, 403 (5th Cir. 1974). *See* NRDC v. Thomas, 838 F.2d 1224, 1230 (D.C. Cir. 1988), *cert. denied*, 1988 U.S. Lexis 4347 (a source may disperse its pollutants with tall stacks); Sierra Club v. EPA, 719 F.2d 436, 439 (D.C. Cir. 1983), *cert. denied*, 468 U.S. 1204 (1984) (taller stacks tend to disperse pollutants over greater area); Alabama Power Co. v. Costle, 636 F.2d 323, 388 (D.C. Cir. 1979) (tall stacks as a dispersion technique). Many experts attribute significant environmental degradation to dispersion from tall stacks.

10. 42 U.S.C. § 7423 (1982) (forbidding use of tall stacks). *See* 40 C.F.R. § 51.100(hh)(1)(i) (1987) (stacks exceeding GEP height are tall stacks); *Alabama Power Co.*, 636 F.2d at 389 (tall stacks, one form of dispersion technique, actually concern "too tall stacks").

11. *See* NRDC v. EPA, 489 F.2d 390, 403 (5th Cir. 1974), *rev'd on other grounds sub nom.* Train v. NRDC, 421 U.S. 60 (1975) (tall stacks allow height greater than necessary to prevent excessive concentrations of pollutants at ground level); *see also* 40 C.F.R. § 51.100(hh)(1) (1987) ("Dispersion technique is any technique which attempts to affect the concentration of a pollutant in the ambient air.").

12. 42 U.S.C. § 7423(c) (1982). Congress appeared to codify the terminology based on EPA rules allowing GEP stack height. *See* 38 Fed. Reg. 25,700-01 (1973) (original use of GEP language to regulate stack height).

is a forbidden "tall stack" dispersion technique.[13]

Congress realized the cost of lowering existing stacks to GEP height would be excessive.[14] Congress did not require industry to shorten existing tall stacks, but allowed continued use of the stacks by treating them as if they were the shorter GEP height.[15] This imaginary decrease in stack height, called "stack credit,"[16] is the presumed height used when calculating acceptable emission levels.[17] The stack's acceptable emissions rate is then fixed according to this hypothetical height. Engineers determine NAAQS violations based on emissions which would violate the Act if the stack were actually GEP height.[18]

Due to the technical complexity of calculating GEP height,[19] Congress delegated this responsibility to the Environmental Protection Agency (EPA).[20] The EPA has derived several techniques for determining GEP height.[21] Pursuant to the Act, the EPA has commissioned research which formulates[22] and demonstrates[23] GEP stack

13. 42 U.S.C. § 7423(c) (1982); 40 C.F.R. § 51.100(hh)(1) (1987). *See* 44 Fed. Reg. 2,609 (1979) (stacks greater than GEP height are tall stacks).

14. *See* 42 U.S.C. § 7423 (1982) (establishes 1970 for "grandfathering").

15. H.R. REP. No. 294, 95th Cong., 1st Sess. 93 (1977), *reprinted in* 1977 U.S. CODE & ADMIN. NEWS 1070, 1172 (restricting stack height goes only to the amount of credit a stack may receive).

16. Engineers model stacks at varying heights until test results violate the Act. STACK HEIGHT GUIDELINES, *supra* note 5, at 23. Engineers base decisions on whether stack emissions are excessive by mapping their ambient effect on pollution. Sierra Club v. EPA, 719 F.2d 436, 441 (D.C. Cir. 1983). Stack modeling can be small-scale demonstrations or mathematical modeling. *Id.*

17. Alabama Power Co. v. Costle, 636 F.2d 323, 389 (D.C. Cir. 1979) (calculations predicated on false assumption that stack is actually GEP height).

18. NRDC v. Thomas, 838 F.2d 1224, 1232 (D.C. Cir. 1988) (not restricting actual stack height but limiting emission rate).

19. *See generally* ENVIRONMENTAL PROTECTION AGENCY, GUIDELINES FOR FLUID MODELING OF ATMOSPHERIC DIFFUSION (1981) [hereinafter MODELING GUIDELINES] (demonstrating complex nature of research procedures employed by engineers and scientists operating fluid modeling facilities); STACK HEIGHT GUIDELINES, *supra* note 5 (technical basis for GEP stack height).

20. 42 U.S.C. § 7423(c) (1982) (delegating to Administrator the responsibility of defining GEP).

21. 42 U.S.C. § 7423(c) (1982). The statute provides: "[GEP] means, with respect to stack heights, the height necessary to insure that emissions from the stack do not result in excessive concentrations . . . as result of atmospheric downwash, eddies and wakes which may be created by the source itself, nearby structures or nearby terrain obstacles." *Id.*

22. *See* 40 C.F.R. § 51.100(ii) (1987) (de minimis height, formula height).

23. *Id.* (demonstration height).

height.

The United States Court of Appeals for the District of Columbia rejected the EPA's established techniques to determine GEP stack height.[24] The court applied an unduly burdensome standard of review and mandated technical requirements which are arguably beyond the EPA's capabilities. The court rejected the technical analysis which supports the EPA regulations and ignored the tradition of judicial deference to an agency's highly technical rules.

This Note examines both the technical basis for the tall stack rules and the appropriate standard of judicial review for these complex agency decisions. Part I summarizes the development of the EPA's tall stack rules. Part II analyzes the D.C. Circuit's attempts to interpret the rules. Part III outlines the deferential standard the United States Supreme Court traditionally adopts when reviewing highly technical agency decisions, and Part IV suggests that this standard should be applied when courts review the tall stack rules. In addition, an appendix provides and explains the technical basis supporting the EPA's rules.

I. CREATING THE TALL STACK RULES: THE EPA'S INTERPRETATION OF THE CLEAN AIR ACT

A. *The NRDC Trilogy*

Congress enacted the first comprehensive air pollution measures in 1970.[25] The Act's stated purpose was to limit ground level concentrations of specific pollutants.[26] As a result, the central feature of the Clean Air Act Amendments of 1970 is the National Ambient Air Quality Standards (NAAQS).[27] NAAQS require the EPA to set "primary"[28] and "secondary"[29] standards for specified pollutants. The

24. *See* NRDC v. Thomas, 838 F.2d 1224 (D.C. Cir. 1988), *cert. denied*, 1988 U.S. Lexis 4347; Sierra Club v. EPA, 719 F.2d 436 (D.C. Cir. 1983), *cert. denied*, 468 U.S. 1204 (1984).

25. Clean Air Act Amendments of 1970, Pub. L. No. 91-604, 84 Stat. 1676. *See* R. MELNICK, *supra* note 4, at 28 ("1970 brought a year of political watershed for pollution control.").

26. H.R. REP. No. 294, 95th Cong., 1st Sess. 2 (1977), *reprinted in* 1977 U.S. CODE & ADMIN. NEWS 1077, 1080.

27. 42 U.S.C. § 7409 (1982). *See* Alabama Power Co. v. Costle, 636 F.2d 323, 346 (D.C. Cir. 1979) (implementation of National Ambient Air Quality Standards (NAAQS) as the centerpiece of the Clean Air Amendments of 1970).

28. 42 U.S.C. § 7409(b)(1) (1982). This section grants the Administrator authority to set primary pollutant standards which are necessary to protect the public health. *Id.*

standards identify maximum levels for each pollutant that the public can be exposed to without adverse health effects.[30] States must submit implementation plans (SIPs) that establish a scheme to achieve NAAQS compliance within their jurisdiction.[31] SIPs must include emission limits and a timetable for the attainment and maintenance of NAAQS.[32] The EPA may approve or disapprove the state's plan.[33]

The Clean Air Act Amendments of 1970 did not directly address stack height as a means of complying with NAAQS.[34] In 1972 the EPA approved a Georgia SIP[35] which allowed an indefinite increase in stack height to avoid decreasing emissions.[36] The Natural Resources Defense Counsel (NRDC) brought suit challenging the EPA's approval of the plan.[37] In a landmark decision, the Fifth Circuit Court of Appeals held that the EPA could condone stack height increases only if emission standards are unachievable, infeasible, or insufficient without dispersion techniques.[38] The court relied on section 110 of the Act,

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29. 42 U.S.C. § 7409(b)(2) (1982). This section grants the Administrator authority to set secondary pollutant standards which are necessary to protect the public welfare. *Id.*

30. R. MELNICK, *supra* note 4, at 29. *See* 42 U.S.C. § 7408(a)(1)(A) (1982). The statute provides: "For purposes of establishing national and secondary ambient air quality standards, the Administrator shall . . . publish . . . a list which includes each air pollutant emissions of which, in his judgement, cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare." *See also* 40 C.F.R. § 50 (1987) (specific primary and secondary levels of pollutants measured in terms of hours or days).

31. 42 U.S.C. § 7407(a) (1982) (requiring states to submit SIP specifying scheme for attainment and maintenance of air quality).

32. 42 U.S.C. §§ 7410(a)(2)(B), (D), (E) (1982).

33. 42 U.S.C. § 7410(a)(2) (1982).

34. West Penn. Power Co. v. Train, 522 F.2d 302, 309 (3d Cir. 1975) (Act prescribes air quality standards as opposed to methods for attaining those standards).

35. 37 Fed. Reg. 10,859 (1972).

36. NRDC v. EPA, 489 F.2d 390, 403 (5th Cir. 1974) (Georgia plan for meeting NAAQS for two regulated pollutants rendered amount of allowable emissions dependent on stack height).

37. NRDC v. EPA 489 F.2d 390 (5th Cir. 1974), *rev'd on other grounds sub nom.* Train v. NRDC, 421 U.S. 60 (1975). The NRDC's brief stressed policy arguments against unlimited use of dispersion. R. MELNICK, *supra* note 4, at 130-31. The Fifth Circuit noted, "[W]ith respect to human health, the scientific community increasingly agrees that damage is related more clearly to levels of acid sulfates than to concentrations of sulphur dioxide. . . . Thus any system that does not reduce total sulphur dioxide emissions . . . will be unavailing to protect public health." 489 F.2d at 403.

38. *Id.* at 410. The EPA agreed with the portion of the Fifth Circuit's decision regarding stack height and therefore did not appeal stack height issues to the Supreme

which requires that SIPs include emission limitations to ensure attainment of air quality standards.[39] Industry representatives subsequently brought claims in two other circuit courts and attempted to limit the Fifth Circuit's holding.[40] These decisions affirmed the Fifth Circuit holding.[41] The summation of cases is referred to as the *NRDC Trilogy*.[42]

B. *EPA's Proposed Rules*

Prior to the Fifth Circuit's decision, the EPA had proposed stack height rules[43] which allowed automatic increases in stack height that were "consistent with good engineering practice."[44] The EPA defined GEP height as "sufficiently tall [so] emissions from the stack are unaffected by atmospheric downwash, eddies and wakes . . . created by . . . nearby structures or terrain obstacles."[45] The EPA explained that use of GEP stacks would prevent nuisances[46] and excessive concentra-

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Court. R. Melnick, *supra* note 4, at 114. The decision not to appeal gave notice that the EPA disapproved of dispersion techniques in most situations and "gave the EPA a legal cloak to cover its policy choice." *Id.* at 135. *But see* 41 Fed. Reg. 7,450 (1976) (EPA's proposed required use of the best available control technology (BACT) unless technologically incapable or economically infeasible).

39. *See* 42 U.S.C. § 7410(a)(2)(B) (1982).

40. *See* Kennecott Copper Corp. v. Train, 526 F.2d 1149, 1151 (9th Cir. 1975), *cert. denied*, 425 U.S. 935 (1976); Big Rivers Elec. Corp. v. EPA, 523 F.2d 16, 20 (6th Cir. 1975), *cert. denied*, 425 U.S. 934 (1976).

41. *See Kennecott Copper*, 526 F.2d at 1151 (dispersion techniques allowed to maintain NAAQS); *Big Rivers Elec.*, 523 F.2d at 20 (section 110(a) of the Act requires emission limits).

After judicial rejection of the EPA's approach, the EPA reconsidered its proposed rules. 41 Fed. Reg. 7,450 (1976). The agency then issued guidelines expressly allowing tall stacks where the emitting source implemented BACT or where the technology employed was economically unreasonable or technologically unsound. *Id.* at 7,450-52 (applied reasonably available control technology (RACT) rather than BACT where BACT is economically unreasonable, so long as steps are taken to eventually provide for BACT).

42. NRDC v. Thomas, 838 F.2d 1224, 1232 (1988).

43. 38 Fed. Reg. 25,697 (1973).

44. *Id.* at 25,700-01 (EPA allowed excessive stack height if accompanied by a designated supplementary control system). *But see* 42 U.S.C. § 7423(b) (1982) (declaring supplementary control systems illegal).

45. 38 Fed. Reg. 25,701 (1973).

46. *See* United States v. County Bd., 487 F. Supp. 137, 143 (E.D. Va. 1979) (nuisance is anything which "endangers human life or health, gives offense to the senses, violates the laws of decency, or obstructs the reasonable and comfortable use of property").

tions[47] caused by pollutants drawn down to ground level.[48]

The rules fixed GEP stack height in level terrain at "two and one-half times the height of the facility or nearby structures."[49] The EPA did not mandate destruction of existing stacks which exceeded GEP height;[50] however, a tall stack could only receive credit for GEP stack height.[51]

Before the EPA promulgated final rules, Congress amended the Act[52] and enacted section 123.[53] Congress maintained that the Clean Air Act Amendments' primary goal is to protect the public from health problems caused by air pollution, but also stated a secondary purpose of limiting the amount of pollution.[54] Section 123 codified the *NRDC Trilogy*, but also incorporated much of the language from the EPA's proposed rules.[55] Section 123 defined GEP height as the stack height necessary to ensure "nearby structures or nearby terrain obstacles" do not induce aerodynamic effects which produce excessive concentrations on the ground.[56] In addition, section 123's legislative

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47. *See infra* note 92 and accompanying text for discussion of excessive concentrations.

48. 38 Fed. Reg. 25,700 (1973) (EPA encouraged stack height increases up to GEP height to avoid local nuisances or excessive concentrations; the EPA considers the two as different problems).

49. *Id. See* 38 Fed. Reg. 25,701 (1973) ("2.5 times" rule too simplistic for complex terrain).

50. 38 Fed. Reg. 25,700 (1973) ("EPA will accept existing stacks.").

51. *Id. See supra* notes 16-18 and accompanying text for discussion of means to calculate stack credit.

52. Clean Air Act Amendments of 1977, Pub. L. No. 95-95, 91 Stat. 685 (codified at 42 U.S.C. § 7423 (1982)).

53. 42 U.S.C. § 7423 (1982) (tall stacks).

54. H.R. REP. NO. 294, 95th Cong., 1st Sess. 2 (1977), *reprinted in* 1977 U.S. CODE CONG. & ADMIN. NEWS 1077, 1080 (primary and overriding purpose of the amendments remains the prevention of illness or death related to air pollution).

55. H.R. REP. NO. 294, 95th Cong., 1st Sess. 91-92 (1977), *reprinted in* 1977 U.S. CODE CONG. & ADMIN. NEWS 1077, 1170 (section 123 intended to ratify the general thrust, if not specific holdings, of *NRDC Trilogy*).

56. Section 123 states in pertinent part:

(a) The degree of emission limitation required for control of any air pollutant under an applicable [SIP] . . . shall not be affected in any manner by . . . the stack height of any source [exceeding GEP] (as determined under regulations promulgated by the Administrator). . . .

(c) . . . For purposes of this section, good engineering practice means, with respect to stack heights, the height necessary to insure that emissions from the stack do not result in excessive concentrations of any air pollutant in the immediate vicinity of the source as a result of atmospheric downwash, eddies and wakes which history denounced use of tall stacks in any situation.[57]

C. *EPA's Final Rules*

Following the enactment of section 123, the technical complexity of the tall stack rules became apparent. The EPA, which spent five years detailing final rules,[58] discovered that situations could arise that might require vastly different techniques to calculate GEP height. As a result, the EPA created three methods to calculate GEP height: de minimis height, formula height, and a demonstration technique for complex situations.[59]

To avoid normal ground-level meteorological phenomena,[60] the EPA developed a de minimis stack height.[61] Although tests to formulate de minimis height proved inconclusive,[62] the EPA did establish

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> may be created by the source itself, nearby structures or nearby terrain obstacles (as determined by the Administrator). . . . [The] height shall not exceed two and a half times the height of the source unless the owner or operator of the source demonstrates . . . to the satisfaction of the Administrator, that a greater height is necessary. . . . In no event may the Administrator prohibit any increase in stack height or restrict in any manner the stack height of any source.

42 U.S.C. § 7423 (1982).

57. Sierra Club v. EPA, 719 F.2d 436, 440 (D.C. Cir. 1983) (Congress emphatically rejected the 1976 Guidelines). *See* 42 U.S.C. § 7423 (1982) (codifying GEP, not economic infeasibility, to determine stack height). The use of "tall stacks" as a dispersion technique elicited the expected congressional debate. *See* Strebu, *Reviewing the Clean Air Act*, 4 ECOLOGY L.Q. 583, 585 (1975). "Once minimal emission controls are met, polluters are encouraged to substitute unlimited stack height for any further control of emissions." 123 CONG. REC. S18,027 (daily ed. June 8, 1977) (statement of Sen. Muskie). Congress resolved the problem by proscribing tall stacks as a means to comply with the Act's requirements. 123 CONG. REC. H16,203 (daily ed. May 24, 1977) (statement of Rep. Waxman).

58. Section 123 gave the EPA six months to promulgate rules detailing GEP stack height calculations. 42 U.S.C. § 7423(c) (1982) ("Not later than six months after August 7, 1977, the Administrator shall . . . promulgate regulations to carry out this section."). The EPA promulgated proposed rules one year late. 44 Fed. Reg. 2,608 (1979). After two sets of proposed rules, two comment periods, and extensive conflict among the commentators, the EPA promulgated final rules after five years of consideration. 47 Fed. Reg. 5864 (1982).

59. 46 Fed. Reg. 49,817 (1981) (details EPA methods).

60. *See* STACK HEIGHT GUIDELINES, *supra* note 5, at 31 (meteorological phenomena include wind, surface heating and cooling, surface roughness); 47 Fed. Reg. 5,865 (1982) (same).

61. 46 Fed. Reg. 49,820-21 (1981) (proposed a de minimis height of 65 meters). For a discussion of de minimis height, see *infra* notes 230-40 and accompanying text.

62. 46 Fed. Reg. 49,820 (1981) (current modeling may not be accurate for emissions released at less than 50 meters).

that a stack height of sixty-five meters is sufficiently tall to avoid generic atmospheric effects and yet is short enough to prevent the dispersive effect (atmospheric loading) prohibited by section 123.[63]

The EPA also derived an empirical formula to estimate GEP height for stacks which exceed sixty-five meters.[64] The formula applies only within level terrain.[65] The formula states: GEP height is the height (H) of the source or a nearby structure plus one-and-one-half (1.5) times the smaller of the height or width of that structure (L).[66] This formula is known as the "H + 1.5L" rule. Although Congress defined GEP height as two-and-one-half (2.5) times the height (H) of the source ("2.5 times" rule),[67] section 123's legislative history endorses shorter stack height if GEP dictates.[68]

The "H + 1.5L" rule is equivalent to the "2.5 times" rule when a

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63. Although the EPA initially proposed a de minimis height of 30 meters, 44 Fed. Reg. 2,614 (1979), the EPA changed this height to 65 meters. 46 Fed. Reg. 49,815 (1981) (codified at 40 C.F.R. § 51.100(ii)(1) (1987)). The EPA made the change because no significant increase in sulfate transport resulted due to the 35 meter increase in de minimis height. 46 Fed. Reg. 49,821 (1981).

Although the EPA could not determine an exact minimum height, a theoretical de minimis height must extend above the adverse aerodynamic effects naturally within the atmosphere. *See* 42 U.S.C. § 7423(c) (1982). Because an increase in stack height from the theoretical de minimis height to 65 meters should not create any atmospheric loading, the effective increase in height should not change local ground level concentrations. 47 Fed. Reg. 5,865 (1982). Most sources which emit sulphur dioxide can justify a stack height greater than 65 meters; de minimis height, therefore, will have minimal dispersive effect. *Id.* The increase simply protects the public by ensuring the stack extends beyond the point where emissions should be swept down to the ground. *See* STACK HEIGHT GUIDELINES, *supra* note 5, at 31-32 (general de minimis criterion).

64. 40 C.F.R. § 51.1(ii)(2) (1987). *See* 47 Fed. Reg. 5,865 (1982) (to be codified at 40 C.F.R. § 51.100 (1987)) ("2.5 times" rule applies to stacks in existence before January 12, 1979; newer facilities must conform to the H + 1.5L rule); 46 Fed. Reg. 49,818 (1981) (H + 1.5L rule); 44 Fed. Reg. 2,610 (1979) (initial publication of the H + 1.5L rule); 38 Fed. Reg. 25,701 (1973) ("2.5 times" rule).

65. *See* 44 Fed. Reg. 2,610 (1979) (terrain influence on stacks not allowed). The equations are generally not applicable in complex terrain. *See infra* notes 215-29 and accompanying text. Engineers conducted generic wind tunnel tests to determine the upward extension of eddies and wakes created by nearby structures. *See infra* notes 202-07, 210 and accompanying text.

66. 40 C.F.R. § 51.100(ii)(2)(ii) (1987). *See infra* notes 208-14 and accompanying text for a discussion of the H + 1.5L rule.

67. 42 U.S.C. § 7423(c) (1982). *See* H.R. REP. NO. 294, 95th Cong., 1st Sess. 93 (1977), *reprinted in* 1977 U.S. CODE CONG. & ADMIN. NEWS 1077, 1171 (stack height produced by reference to 2.5 times rule is referred to as GEP stack height).

68. 123 CONG. REC. H27,071 (daily ed. Aug. 4, 1977) (Rep. Rogers said, "If it should be determined that downwash, eddies, and wakes can be prevented by stacks of less than [2.5] times facility height, the Administrator's rule should give 'credit' only for

structure's height is less than its width. The "L" parameter is then considered as the height because height is the smaller dimension. The equation becomes "H + 1.5H" or two-and-one-half times the height.[69] The EPA accepted the 2.5 times rule prior to publication of the modified formula.[70] The EPA determined that source owners who could prove reliance upon the 2.5 times rule prior to formal acceptance of the modified formula should receive complete stack credit for that height even though it may exceed the stack height calculated through use of the H + 1.5L rule.[71]

The height of "nearby" structures is also a factor used to calculate GEP stack height.[72] Wind tunnel tests can determine the upward and downwind extension of the eddies and wakes that a structure creates.[73] For most structures, adverse effects dissipate within a distance of five times the smaller of the height or width of that structure (L).[74] The H + 1.5L rule applies this same variable (L) to determine stack height. Nearby structures are those within "5L" but not further than one-half mile from the stack.[75]

The EPA realized that the definition of "nearby" should differ for structures and terrain obstacles.[76] Tests that establish formula height and define "nearby" assume level terrain. Complex terrain introduces new problems which usually justify stack height above formula

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the height needed to avoid these conditions."). *See infra* notes 199-207 and accompanying text for derivation of the 2.5 times rule.

69. If the width is greater than the height, the GEP height is H + 1.5W.

70. *See* 44 Fed. Reg. 2,610 (1979) (initial publication of the H + 1.5L rule); *see also* 38 Fed. Reg. 25,701 (1973).

71. 40 C.F.R. § 51.100(ii)(2)(i) (1987).

72. 42 U.S.C. § 7423(c) (1982).

73. For a discussion of the downwind extension of eddies and wakes, see *infra* notes 193-97 and accompanying text.

74. 44 Fed. Reg. 2,610 (1979). "[F]or all structures with a maximum width less than ten times their height, adverse downwash effects [may] be expected to extend downwind to a distance of five times the height or width of the structure, whichever is less. Structures with maximum widths greater than ten times their height may have significant adverse effects extending farther downwind." *Id.*

75. 40 C.F.R. § 51.1(jj)(1) (1987). *See* 44 Fed. Reg. 2,610 (1979) ("nearby" limited to one-half mile because the EPA interpreted the legislative history of § 123 with one-half mile as the outer limit); H.R. REP. NO. 294, 95th Cong. 1st Sess. 93 (1977), *reprinted in* 1977 U.S. CODE CONG. & ADMIN. NEWS 1077, 1171 (suggested limit of one-fourth to one-half mile from the source).

76. 46 Fed. Reg. 49,819 (1981) (terrain features at greater distances than one-half mile can cause downwash). *See* 40 C.F.R. § 51.1(jj)(2) (1987).

height.[77] Because formula height is inadequate for stacks located in complex terrain, owners of affected sources usually opt to "demonstrate" the actual GEP stack height.[78]

Determinations of stack height by source-specific demonstrations are superior to formulas because GEP stack height determinations depend on experimental, source-specific data rather than generic, empirical data.[79] Source-specific demonstrations allow the EPA to evaluate the adverse effects of all terrain obstacles, not merely nearby ones.[80] The aerodynamic unpredictability of complex terrain, coupled with the ability to more accurately compute GEP height, prompted the EPA to define "nearby" for complex terrain differently than within level terrain.[81]

Source-specific demonstrations[82] include wind tunnel testing and field studies.[83] Field studies, the most accurate method to determine GEP height, evaluate an actual source under a variety of meteorological conditions.[84] Wind tunnel tests, an alternative to field studies, predict GEP height by placing a model of the stack and surrounding obstacles within a test cell.[85] Engineers then imitate severe meterological conditions to determine GEP stack height.[86] Unfortunately, few facilities are able to perform this type of test.[87] The EPA required only

77. STACK HEIGHT GUIDELINES, *supra* note 5, at 28.

78. 42 U.S.C. § 7423(c) (1982). Alternatively, the owner could use formula height and a reduced emission rate to avoid excessive concentrations. *Id.*

79. *See* 46 Fed. Reg. 49,821 (1981) (even computer modeling of a specific facility is subject to substantial error).

80. *See* 46 Fed. Reg. 49,819 (1981) (demonstrations allow a source to consider the downwash effects of an entire terrain feature); *but see* 44 Fed. Reg. 2,611 (1979) (proposed "nearby" definition identical for terrain obstacles and structures).

81. *See* 46 Fed. Reg. 49,821 (1981) (because complex flow patterns are unpredictable, demonstrations are the best means to determine GEP stack height).

82. 42 U S.C. § 7423(c) (1982). *See* 40 C.F.R. § 51.100(ii)(3) (1987).

83. STACK HEIGHT GUIDELINES, *supra* note 5, at 7-8.

84. *Id.* (field studies are the best source of information).

85. ENVIRONMENTAL PROTECTION AGENCY, GUIDELINE FOR USE OF FLUID MODELING TO DETERMINE GOOD ENGINEERING PRACTICE STACK HEIGHT 5 (1981) [hereinafter FLUID MODELING GUIDELINE]. The aim of fluid modeling is to produce an accurate representation of the atmosphere using flow of air or water in a test facility. *Id.* Wind tunnel testing is the preferred method because it is easier to perform.

86. For the procedures necessary to demonstrate GEP height, see *infra* notes 241-50 and accompanying text.

87. *See* 49 Fed. Reg. 1,267 (1984) (fewer than 10 facilities nationwide); *but see* 46 Fed. Reg. 49,821 (1981) (facilities are reasonably available).

those sources seeking to increase stack height above formula height to conduct source-specific demonstrations.[88]

Section 123 defines GEP stack height as a theoretical precaution against excessive concentrations of pollutants. NAAQS set absolute levels for pollutants determined to be dangerous to human health.[89] NAAQS are measured in terms of hours or years;[90] however, aerodynamic downwash can create temporary, high pollutant concentrations that do not violate the NAAQS.[91] To protect the public from short-term, high-pollutant exposure, the EPA defined "excessive concentrations" as a forty percent increase in a specific pollutant due to downwash, eddies, and wakes.[92] Thus, the EPA developed a relative definition of excessive concentrations which was independent of the NAAQS.[93]

NAAQS violations also result from "plume impaction."[94] Plume impaction, which occurs when the plume from a stack hits an obstacle such as a mountain, manifests before any dispersive effect occurs.[95] Therefore, excessive concentrations arise near the obstacle even without eddy, wake, or downwash effects.[96] The EPA determined that

88. 46 Fed. Reg. 49,821 (1981).

89. 42 U.S.C. § 7409(b)(1) (1982). *See generally* Alabama Power v. Costle, 636 F.2d 323, 346-52 (D.C. Cir. 1979) (general discussion of NAAQS).

90. 46 Fed. Reg. 49,819 (1981). *See* 42 U.S.C. § 7409(b) (1987).

91. 46 Fed. Reg. 49,812 (1981) (little mixing of emissions with ambient air occurs before impaction with the ground).

92. Engineers determined that a 40% ground level increase of a pollutant due to source emissions was a reasonable ceiling on creditable stack height. 44 Fed. Reg. 2,611 (1979). Tests conducted in 1976 and 1979 found the 40% rule conservative because maximum ground level increases at formula height vary between 40% and 80%. STACK HEIGHT GUIDELINES, *supra* note 5, at 23. Engineers settled on 40% because altering the structure's orientation dropped concentrations averages slightly. *Id.* at 23-27. *But see id.* at 16 (the "2.5 times" rule leads to a 20% ground level increase).

93. 46 Fed. Reg. 49,819 (1981). *But see* 44 Fed. Reg. 2,611 (1979) (excessive concentrations required both a 40% increase and a violation of NAAQS).

94. 46 Fed. Reg. 49,820 (1981).

95. *Id.*

96. *Id.* The process of setting emission limitations in areas which may suffer from plume impaction is three-fold:

1. Determination of formula stack height.
2. Modeling the source at formula height including all terrain impacted. Terrain features above the stack height are not considered. From this, researchers determine the maximum concentration levels.
3. Modeling the stack with the full terrain feature while extending the stack until the same concentration level is achieved as in step 2. GEP height is this height.

GEP height should include stack height necessary to avoid plume impaction.[97]

II. The D.C. Circuit's Interpretation of the Tall Stack Rules

After the EPA adopts scientific assessments, the D.C. Circuit has original jurisdiction to determine the soundness of the agency's judgment.[98] Since 1983, the D.C. Circuit has considered two cases on the tall stack rules: *Sierra Club v. EPA*[99] and *NRDC v. Thomas*.[100] In both cases, the court purported to apply standard deferential judicial review of administrative agency decision making, but actually adopted a more burdensome standard.[101]

A. *Defining "Nearby"*

The *Sierra Club* court recognized that only demonstrations accurately predict the precise obstacles which create downwash, and that formula height, which depends upon level terrain, merely approximates the obstacles which cause adverse effects.[102] This distinction, the EPA argued, required defining "nearby" differently with respect to complex and level terrain.[103]

Although the court agreed that the EPA's approach was rational, it believed such an approach was not commanded by section 123,[104] which allows consideration of only the adverse effects caused by

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Id. at 49,815-16.

97. 47 Fed. Reg. 5,869 (1982).

98. 42 U.S.C. § 7607(b)(1) (1982).

99. 719 F.2d 36 (D.C. Cir. 1983), *cert. denied*, 468 U.S. 1204 (1984).

100. 838 F.2d 1223 (D.C. Cir. 1988), *cert. denied*, 1988 U.S. LEXIS 4347. Between the decisions, the EPA conducted another proposed rulemaking, 49 Fed. Reg. 44,878 (1984), and issued a final rule. 50 Fed. Reg. 27,892 (1985).

101. *See* Sierra Club v. EPA, 719 F.2d 436, 439 (D.C. Cir. 1983) (describing application of arbitrary and capricious rule, abuse of discretion doctrine, and question whether the regulatory scheme is contrary to the terms of the statute).

102. *Id.* at 444 ("[D]emonstrations . . . select the obstacles that will be taken into account, because they more accurately tell which will actually cause downwash.").

103. 47 Fed. Reg. 5,869 (1982).

104. 719 F.2d at 444 ("Applying the 'nearby' limitation only to the formula method and not to demonstrations would certainly be rational because . . . the formulas do not otherwise select the obstacles to be taken into account.").

"nearby structures and nearby terrain obstacles."[105] Based on the legislative history, the court reasoned that Congress, realizing the most adversely affected sources were within complex terrain, wanted to discourage sources from locating within them.[106] The court admitted the arbitrariness of its decision and remanded the provision to the EPA with instructions to define "nearby" for demonstrations consistently with the term as defined within formula height.[107]

Upon reconsideration, the EPA qualified the definition of nearby for formula height — "5L" or one-half mile — when applying the term to demonstrations.[108] The EPA allowed consideration of adverse effects produced from terrain obstacles which begin within this range, even if portions of the obstacle extend beyond the formula distance,[109] so long as no effects which occur more than two miles from the source are considered.[110] The *NRDC* court upheld this definition.[111]

B. *Plume Impaction*

The EPA allowed consideration of plume impaction excesses in determining GEP height even though no adverse aerodynamic effects create the problem.[112] The *Sierra Club* court strictly interpreted section 123, which proscribes excessive concentrations due to "downwash, eddies and wakes," and held that this language forbids receipt of additional stack credit for plume impaction.[113]

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105. The statute explicitly places a "nearby" limitation on demonstrations. *Id.* at 445 (citing 42 U.S.C. § 7423(c) (1982)).

106. 719 F.2d at 445. (Congress specifically sought to discourage utilities from locating in hilly terrain because this would lead to increased emissions of pollutants).

107. *Id.* at 470.

108. 49 Fed. Reg. 44,883 (1984) (codified at 40 C.F.R. § 51.100(jj) (1987)).

109. 40 C.F.R. § 51.100(jj) (1987). This provision allows modeling of portions of the terrain when the terrain feature begins within one-half mile and is greater than 40% of GEP stack height. "EPA conservatively estimates that the wake region proposed by a terrain feature extends downwind approximately 10 times the height of the feature." *Id.* As a result, EPA engineers consider terrain features within ten times the stack height or two miles, whichever is less. 40 C.F.R. § 51,100(jj)(z) (1987).

110. 49 Fed. Reg. at 44,883-84 (allowance for terrain features will not justify unnecessary stack height because wind tunnel tests only consider terrain which actually creates downwash).

111. NRDC v. Thomas, 838 F.2d 1224, 1256-57 (D.C. Cir. 1988).

112. 47 Fed. Reg. 5,869 (1982).

113. Sierra Club v. EPA, 719 F.2d 436, 455 (D.C. Cir. 1988). The court noted, "Congress sought to prohibit reliance on stack height to achieve air quality standards except in certain cases that it very specifically defined." *Id.* The EPA's construction of

Citing the legislative history, the court noted that Congress intended section 123 primarily to apply to sources within complex, mountainous terrain.[114] Because plume impaction occurs in such terrain, the court theorized that Congress considered and rejected stack credit for plume impaction.[115] The court did note, however, the positive aspects of the EPA's policy.[116]

C. *Excessive Concentrations*

The EPA defined excessive concentrations as a forty percent ground level increase of a particular pollutant due to source emissions.[117] The *Sierra Club* court dismissed this definition of excessive concentrations as outdated.[118] Instead, the court analyzed section 123's statutory language, which requires application of good engineering practice, and balanced it against the Act's legislative history, which mandates protection of public health.[119] The court determined that Congress mistakenly equated engineering practice with protection of public health.[120] The court held that protecting the public should supersede statutory language apparently drafted in confusion.[121]

Additionally, Congress accepted use of formula height by codifying the "2.5 times" rule.[122] The legislative history, however, mandates using the minimum stack height necessary to protect public health even at the expense of ignoring the "2.5 times" rule. Combining these assertions, the court speculated that Congress actually envisioned a distinction between good engineering practice and protection of public health.[123] The court concluded that protection of public health should

§ 123 was condemned by the judicial doctrine of strict construction: when a statute lists several specific exceptions to the general purpose, others should not be implied. *Id.* at 453.

114. *Id.* at 454-55.

115. *Id.*

116. *Id.* at 456. The court said the statutory construction is "harsh but not utterly irrational." *Id.* The court conceded the EPA's policy prevented discrimination against utilities located within mountainous regions. *Id.* at 455.

117. 47 Fed. Reg. 5,869 (1982).

118. 719 F.2d at 447.

119. *Id.*

120. *Id.* at 448 ("What seems most likely is that Congress thought traditional engineering practice and protection of health were the same thing.").

121. *Id.*

122. 42 U.S.C. § 7423(c) (1982).

123. 719 F.2d at 448. "Thus, development of a standard governing the height of

control even if it meant ignoring good engineering practice.[124]

As a result, the *Sierra Club* court required the EPA to define "excessive concentrations" in accordance with an absolute standard, such as those in the NAAQS, that would ensure against pollution levels that could endanger public health.[125] The court considered the forty percent rule a relativist,[126] conservative engineering estimate that may do nothing to protect public health.[127] The court found the EPA's definition insufficient because it would allow sources to increase stack height without considering public health standards.[128] Unnecessary stack height would allow dispersion of pollutants in violation of section 123.[129]

On remand, the EPA redefined excessive concentrations in accordance with the *Sierra Club* court's requirements.[130] The EPA found that employing an absolute approach, however, created additional problems not present under the relativist approach.[131] For example, absolute values are a function of both stack height and emission rate.[132] Thus, the absolute approach requires determining the appropriate

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stacks by reference solely to what engineers had been doing, with no regard for some real life values, was contrary to the intent of Congress." *Id.* The court failed to realize, however, that tests establishing the H + 1.5L rule existed well before the Clean Air Act Amendments of 1977. *See infra* notes 208-12 and accompanying text. Therefore, combining these assertions could also indicate acceptance of a refined empirical formula to determine GEP height.

124. *Id.* (GEP is merely one method for meeting air quality standards).

125. *Id.* at 450. *See* 40 C.F.R. §§ 50.4, 50.12 (1987) (primary standards set to protect public health); *see also* NRDC v. Thomas, 838 F.2d 1223, 1234 (D.C. Cir. 1988) (absolute approach requires set, absolute pollution levels which a jurisdiction must exceed to constitute a violation).

126. *Id.* at 1234 (relativist approach requires increase in pollution level in relation to initial concentration).

127. *Sierra Club,* 719 F.2d at 450 (the EPA must be strict in preventing stack height increase and must satisfactorily show that more than mere history supports definition of excessive concentrations).

128. *Id.* ("Industry should err on the side of reducing stack height, in keeping with Congress's command that credit for stack heights above the 2.5 rule height be granted with utmost caution.").

129. *Id.* (court remanded with instructions to devise a standard directly related to protection of public health).

130. 50 Fed. Reg. 27,896 (1985).

131. 40 C.F.R. § 51.100(kk)(1) (1987) (offered bifurcated test which represented both relativist and absolute approaches by retaining 40% criterion and requiring conformity with NAAQS).

132. 49 Fed. Reg. 44,882 (1984).

emission rate prior to beginning a demonstration.[133]

Most states specify allowable emission rates for each source located within their jurisdiction in their SIP.[134] The EPA modified regulations for excessive concentrations to allow use of the SIP emission rate for any source seeking to increase stack height up to formula height.[135] The EPA required use of the New Source Performance Standards (NSPS)[136] emission rates, the lowest feasible emission rates, for sources seeking to demonstrate a need for stack height in excess of formula height.[137] The *NRDC* court upheld the EPA's new method to determine excessive concentrations.[138]

D. *Justification of Formula Height*

The *Sierra Club* court also expressed misgivings about the EPA's reliance on formula height.[139] The court noted the interdependency of formula height and the forty percent criterion in the context of excessive concentrations.[140] The court also cited EPA technical support documents which considered formula height an imperfect method to determine GEP height.[141] The combination of these two factors led

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133. *Id.* The regulation provides that it is not necessary under the relativist approach to establish a source emission limitation prior to conducting wind tunnel testing because the definition required only that sources show an increase in concentration. *Id.* One must determine correct emission rate, technology-based limitations, or GEP stack height emissions before assessing whether excessive concentrations exist. *Id.*

134. 42 U.S.C. § 7410(a)(2)(B) (1982).

135. 40 C.F.R. § 51.100(kk)(1) (1987).

136. 42 U.S.C. § 7411(a) (1982) (emission limitation achievable through application of best available control technology to reduce continuous emissions).

137. 40 C.F.R. § 51.100(kk)(1) (1987). In NRDC v. Thomas, 838 F.2d 1224, 1233-39 (D.C. Cir. 1988), environmental groups strongly advocated requiring all demonstrations use the NSPS emission rate. The public interest groups also argued that the *NRDC Trilogy* mandated this more stringent approach, but the court rejected this argument. *Id.* Accordingly, the court rejected this "control first approach" after bitter debate and affirmed the rules promulgated by the EPA. *Id.* at 1239. The control first analysis requires a baseline emission rate which results from a source determined by applying all available methods. *Id.* at 1235.

138. *Id.* at 1239.

139. Sierra Club v. EPA, 719 F.2d 436, 457-58 (D.C. Cir. 1983) (potential for inconsistencies sufficient to require remand).

140. *Id.* at 458 (court had already dismissed EPA's definition of excessive concentrations as "traditional" engineering practice).

141. *Id.* at 450 (because 40% measure is subjective, actual studies may indicate need for much higher or lower stack height). *See* STACK HEIGHT GUIDELINES, *supra*

the court to question the accuracy of the formula height method.[142]

The court found improper the EPA's allowance of stack height increases up to formula height without a demonstration.[143] The court theorized that existing sources probably built their stacks sufficiently high to avoid contemplated nuisances from excessive concentrations.[144] An increase in stack height up to formula height would, therefore, make the stack a tall stack.[145] In light of the court's new definition of excessive concentrations, the court remanded the issue with instructions to demonstrate the formula's accuracy.[146]

On remand, the EPA analyzed data from five plants that had conducted demonstrations to increase stack height.[147] In four of five cases, formula height led to ground level concentrations exceeding both the forty percent criterion and the NAAQS standard.[148] Test engineers increased stack height until the emissions met the forty percent criterion.[149] At this height, further reduction in emissions were necessary to prevent NAAQS violations.[150] In the fifth case, formula height was within ten percent of GEP height.[151] The EPA used the data to conclude that formula height represents the minimum height necessary to avoid excessive concentrations.[152] The agency also adopted a pro-

note 5, at 22 (disclaims formula height as perfect rule, despite scientific community's endorsement of its use).

142. 719 F.2d at 458 (EPA failed to consider formula height with data which would provide accurate measure of protection against health problems).

143. *Id.*

144. *Id.* at 459.

145. *See* H.R. REP. NO. 294, 95th Cong., 1st Sess. 93, *reprinted in* 1977 U.S. CODE CONG. & ADMIN. NEWS 1077, 1171.

146. *Sierra Club*, 719 F.2d at 459-60.

147. 49 Fed. Reg. 44,882 (1984).

148. *Id. See supra* notes 16-18 and accompanying text for a discussion of modeling creditable stack height.

149. 49 Fed. Reg. 44,882 (1984).

150. *Id.* This also shows the appropriateness of EPA's initial definition because the NAAQS standard must always be met.

151. *Id.*

152. *Id.* at 44,883. The EPA also offered the following testimony on formula height:

1. Formula height developed is a function of simple, level terrain;
2. Complex structures produce increased downwash;
3. There are fewer than 10 fluid modeling facilities and requiring all sources to complete demonstrations would overtax the few facilities available; and
4. Modelers often use formula height in demonstrations as a starting point because it minimizes iteration time.

spective rule requiring demonstrations for all increases in stack height.[153]

The *NRDC* court merely glossed over the demonstration data the EPA offered as support for the H + 1.5L rule[154] because the NRDC argued that the EPA inappropriately analyzed the data.[155] The court concluded that the EPA's findings failed to support the H + 1.5L rule[156] and admonished the EPA for developing only a prospective requirement that demonstrations accompany stack height increases.[157] The court then gave the agency the option of requiring demonstrations for all stack height increases or "adopting a formula clearly valid enough to dispense with demonstrations altogether."[158]

III. JUDICIAL REVIEW OF SCIENTIFIC FACTS

Engineering and other scientific fields introduce increasingly technical issues in the federal courts, particularly in the D.C. Circuit.[159] The courts initial duty is to determine the proper standard of review.[160]

Id. at 44,882-83.

153. 40 C.F.R. § 51.1(kk)(2) (1987).

154. The court stated that the EPA did not attempt to justify formula height. NRDC v. Thomas, 838 F.2d 1224, 1244 (D.C. Cir. 1988). The demonstration data is somewhat persuasive, but it is placed in the preamble of the Federal Register rather than the main text. *Id.*

155. *Id.* at 1244 n.16 (NRDC argued that EPA failed to employ the standard engineering multiplication factor used to extrapolate data equivalent to three hour steady state averages required by NAAQS regulations).

156. *Id.* at 1247-48.

157. *Id.* at 1246 (EPA rule allowed most sources affected to bypass easily the demonstration requirement). *See id.* at 1244-46 (court assumed that EPA thought the *Sierra Club* court required a grandfathering requirement).

158. *Id.* at 1246.

159. Bazelon, *Coping With Technology Through the Legal Process,* 62 CORNELL L. REV. 817, 817 (1977) (former Chief Judge of D.C. Circuit comments on difficulties the judiciary encounters when coping with complex technological methods). Two-thirds of D.C. Circuit's case load involves administrative agencies. *Id.*

160. *See* Administrative Procedure Act, 5 U.S.C. § 706(2)(A) (1982) ("arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with the law" is the general standard of review for federal agency actions). *See also* F.P.C. v. Florida Power & Light Co., 404 U.S. 453, 463 (1972) ("A court must be reluctant to reverse results supported by such a weight of considered and carefully articulated expert opinion."); R. PIERCE, S. SHAPIRO & P. VERKUIL, ADMINISTRATIVE LAW AND PROCESS 369 (1985) ("When the nature of the fact/policy issue is such that only a limited amount of hard data exists and that data is ambiguous, the reviewing court must defer to the agency's resolution of the issue."). *But see* Wald, *Judicial Review of Economic Analyses,* 1 YALE J. ON REG. 43, 54 (1983) (Chief Judge of the D.C. Circuit stated that "courts must be

The United States Supreme Court has recently detailed the appropriate standard for highly technical agency matters.

In *Baltimore Gas & Electric Co. v. Natural Resources Defense Council,*[161] the United States Supreme Court held that deference to an agency's scientific expertise is appropriate. Pursuant to the requirements of the National Environmental Policy Act (NEPA),[162] the Nuclear Regulatory Commission (NRC) promulgated a rule stating that permanent storage of nuclear waste would create no adverse environmental effects.[163] While it acknowledged the uncertainty of this assertion, the NRC concluded that modern technology could not determine the long-term effects of permanent nuclear storage.[164] The D.C. Circuit found the rule invalid under the arbitrary and capricious standard, holding that the agency failed to factor specific uncertainties into their assumption.[165]

The Supreme Court unanimously reversed, concluding that the NRC had fulfilled its statutory mandate by exploring the uncertainties and making a reasoned decision to confront the risks.[166] The Court found that judicial deference to an agency's expertise is particularly appropriate when the debate is within the "frontier of science."[167] The Court held it inappropriate for the judiciary to replace an agency's decision with its own[168] and confined the court's role to determining

exceedingly careful that judicial review of . . . sophisticated modeling . . . does not turn into rubber-stamping of the outcome chosen by the agency").

161. 462 U.S. 87 (1983).

162. 42 U.S.C. § 4332(c)(i) (1982). NEPA requires federal agencies to consider the environmental impact of any major federal action. *Id.*

163. 462 U.S. at 90 (NRC allowed licensing board to assume permanent storage of nuclear waste would have no adverse long-term effects).

164. *Id.* at 92.

165. NRDC v. NRC, 685 F.2d 459 (D.C. Cir. 1982), *rev'd sub nom.* Baltimore Gas & Electric Co. v. NRDC, 462 U.S. 87 (1983) (by a divided court).

166. 462 U.S. at 98-99. The court concluded that the FPC apparently had carefully considered NEPA's requirements. *Id.* at 98. After confronting the issue, the FPC merely determined that the scientific uncertainty did not outweigh derived benefits. *Id.*

167. *Id.* at 103. *See* Connecticut v. EPA, 696 F.2d 147, 160-61 (D.C. Cir. 1982) (court deferred to the EPA technique that modeled sulfur dioxide emissions from a New York power plant).

168. *See* Vermont Yankee Nuclear Power Comm'n v. NRDC, 435 U.S. 519, 558 ("[A]dministrative decisions should be set aside . . . only for substantive procedural or substantive reasons as mandated by the statute . . .[,] not simply because the court is unhappy with the result reached."); Hercules, Inc. v. EPA, 598 F.2d 91, 108, 115 (D.C. Cir. 1978) (difference among scientific standards is "quintessential policy judgment" of an agency).

whether an agency has considered relevant factors and articulated a "rational" connection between the facts and its decision.[169]

In *Federal Power Commission v. Florida Power and Light Co.*,[170] Florida Power alleged that the FPC formula for calculating electrical flow employed erroneous methodology.[171] Reluctant to overturn a decision squarely within an agency's technical expertise, the Court mandated deference to an agency unless its method of analysis lacked a substantial factual basis.[172]

The D.C. Circuit adopted this Supreme Court precedent in *Motor Vehicle Manufacturers v. Ruckelshaus*.[173] Under the Clean Air Act, Congress delegated responsibility to the EPA to create test procedures for new vehicles to ensure conformity with emission standards.[174] Congress developed a three-step compliance test for the agency to follow which included adherence to good engineering practices.[175] After prolonged rulemaking,[176] the EPA adopted a simplified procedure that could only detect the most flagrant emissions violations, but would prevent further program delay.[177] After testing over 6000 vehicles, the

169. *Baltimore Gas*, 462 U.S. at 105. *See Hercules*, 598 F.2d at 106-07 ("In reviewing a numerical standard, we must ask whether the agency's numbers are within a 'zone of reasonableness,' not whether the numbers are precisely right."); *but see* Zotos Int'l, Inc. v. Young, 830 F.2d 350, 351-52 (D.C. Cir. 1987) (rational standard is appropriate unless the agency's position is implausible or not a reasonable product of agency's expertise).

170. 404 U.S. 453 (1972).

171. *Id.* at 455. Florida Power claimed its theory as superior for measuring electrical flow. The parties agreed that neither theory was scientifically established. *Id.*

172. *Id.* at 463. *See Hercules*, 598 F.2d at 108, 115 ("The issue is not whether [the agency] has substantial evidence from every scientific field, but whether it has substantial evidence on the record as a whole."). In Connecticut v. EPA, 696 F.2d 147, 160-61 (D.C. Cir. 1982) (the court deferred to EPA's calculation of stack height and emissions therefrom. The court then stated: "It is naive . . . to seek absolute certainty when dealing with matters as complex as measures enacted to improve the nation's environment.").

173. 719 F.2d 1159 (D.C. Cir. 1983).

174. 42 U.S.C. § 7541(b) (1982).

175. *Id.* The compliance test provides: 1. available test methods and procedures must detect failure of vehicles to conform to emission standards; 2. tests must be consistent with GEP; and 3. tests must bear a reasonable correlation to federal testing procedures. *Id.* *See Motor Vehicles*, 719 F.2d at 1164-68 (car manufacturers argued that EPA failed to conform with each prong of test).

176. 42 Fed. Reg. 26,742 (1977) (to be codified at 40 C.F.R. pt. 85) (proposed May 6, 1977).

177. 719 F.2d at 1163 (made adjustments reasonably to correlate with federal test procedure).

EPA created a formula to aid in determining violations.[178]

The Administrator considered tests in conformance with GEP if they detected "grossly excessive emissions."[179] Despite numerous inadequacies in the testing,[180] the court upheld the EPA's methodology, noting that a statutory scheme which depends upon detailed technical findings inevitably becomes obsolete as new data become available.[181] Citing the standard of review articulated in *Baltimore Gas,* the court deferred to the EPA.[182]

IV. JUDICIALLY CREATED TALL STACK RULES: DISREGARD FOR GOOD ENGINEERING PRACTICE

The D.C. Circuit failed to examine the tall stack rules under the judicial review standards articulated by the United States Supreme Court in *Baltimore Gas* and *Florida Power.* By failing to adopt a deferential standard of review for highly technical agency decisions and issuing detailed remand instructions, the D.C. Circuit usurped the EPA's delegated duty to promulgate the tall stack rules.

A. *Defining "Nearby"*

The holding in *Baltimore Gas* requires a court to defer to an agency's scientific expertise if the agency articulates a rational reason for its decision. The EPA defined "nearby" for formula height and demonstrations differently because demonstrations can pinpoint those obstacles which create adverse aerodynamic effects, whereas formula height merely approximates these effects. Although the court recognized the rationality of this distinction, it still remanded the issue to the EPA for reconsideration.

In *Baltimore Gas,* the Supreme Court applied deferential review to

178. *Id.* at 1165-66.

179. *Id.* at 1165.

180. *Id.* at 1166-67. The court did not deny the obsolescence of the procedures adopted. The EPA failed to test light-duty trucks and diesels. *Id.* at 1166. Despite inaccurate testing, the court found it adequately representative. *Id.* at 1166-67. *See* Hercules, Inc. v. EPA, 598 F.2d 91, 115, (D.C. Cir. 1978) (scientific knowledge is cumulative; more data increases accuracy).

181. *Motor Vehicles,* 719 F.2d at 1167. The EPA replaced the 2.5 times rule with the H + 1.5L rule as new data became apparent. *See infra* notes 208-12 and accompanying text.

182. *Id.* at 1167 ("[w]e are mindful of the Supreme Court's recent admonition" that a court must defer when reviewing an agency's technical decisions).

an agency's technical decision even though the agency admitted the validity of the technology was uncertain. A demonstration, however, can calculate GEP stack height with precision. If a court should defer to an agency in the absence of scientific certainty, an agency also deserves deference when it relies on precise engineering practices. Thus the D.C. Circuit inappropriately failed to defer to the EPA's definition of "nearby."

B. *Plume Impaction*

The Supreme Court also prohibits a court from replacing an agency's technical judgment with its own.[183] The EPA allowed stack height increases to avoid plume impaction. The D.C. Circuit found that because section 123 did not provide express authority to consider plume impaction, the EPA's decision constituted reversible error. The court noted the positive aspects of the EPA's rule, but, relying on mere speculation as to congressional intent, replaced the EPA's judgment with its own. One can potentially justify the court's decision by arguing that the decision simply involves nontechnical statutory interpretation rather than a mandate to implement judicial technical policy. Regardless of this potential distinction, the court should articulate the basis for a reversal with greater clarity.

C. *Excessive Concentrations*

With regard to a proper definition of excessive concentrations, the D.C. Circuit overruled the EPA's relativist, forty percent rule in favor of an absolute standard. The court bypassed section 123's requirement of good engineering practice by theorizing that Congress intended public health to take precedence. In so doing, the court further violated the *Baltimore Gas* holding.

Current scientific techniques fail to establish specific pollutant levels which unquestionably cause injury.[184] Many experts conclude that any exposure to pollutants defined within NAAQS can cause injury.[185]

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183. For the Supreme Court's rule, see *supra* note 168 and accompanying text.

184. Banks, *EPA Bends to Industry Pressure on Coal NSPS — and Breaks*, 9 ECOLOGY L.Q. 67, 75 (1980) (no one is sure what levels of various pollutions named within NAAQS actually cause injury). Congress also expressed extreme confusion over which pollutants create health problems. H.R. REP. NO. 294, 95th Cong., 1st Sess. 120, *reprinted in* 1977 U.S. CODE CONG. & ADMIN. NEWS 1077, 1188.

185. Senator Muskie stated:

Our public health scientists and doctors have told us that there is no threshold, NAAQS do not account for short-term excessive concentrations. The EPA defined excessive concentrations so as to protect the public from short-term, high-pollutant exposure.

The forty percent criterion is an experimentally determined factor which the EPA admits is grounded on engineering speculation. Because EPA engineers who conduct demonstrations can assess the level of short-term concentrations,[186] courts should defer to the EPA's expertise. The engineer's technical determinations, although not exact, protect the public from short-term, high-exposure health hazards. As the court in *Motor Vehicle* deferred to an obsolete, experimentally determined multiplication factor, the court should also defer to the EPA's experimentally justified definition of excessive concentrations.

D. *Formula Height*

The D.C. Circuit also disregarded Supreme Court precedent and the EPA's technical expertise when it questioned whether the H + 1.5L rule represents an appropriate measure of GEP stack height. In *Motor Vehicle*, however, the D.C. Circuit deferred to the EPA's discretion, despite the EPA's admission that it had not conducted comprehensive testing or created a reliable formula. Since the mid-1950s engineers have conducted hundreds of wind tunnel tests, each composed of many individual "runs."[187] These tests evaluated the adverse aerodynamic effects of a variety of structures and terrain obstacles.[188] The tests universally support the H + 1.5L formula as the minimum stack height necessary to avoid excessive concentrations.

In *Florida Power* the Supreme Court stated that a court confronted with two competing scientific theories should accept the agency's deter-

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> that any air pollution is harmful. The Clean Air Act is based on the assumption, although we knew at the time it was inaccurate, that there is a threshold. When we set the standards, we understood that below the standard that we set there would still be health effects. The standard we picked was simply the best judgment we had on the basis of the available evidence as to what the unacceptable health effects in terms of the country as a whole be.

Clean Air Act Amendments of 1977: Hearing Before the Subcomm. on Environmental Pollution of the Senate Comm. on Environmental and Public Works, 95th Cong., 1st Sess., pt. 3, at 8 (1977).

186. *See* STACKS HEIGHT GUIDELINES, *supra* note 5, at 27 (ground level concentrations will increase from 40% to 80% for stack applying the 2.5 times rule).

187. For a list of some of the tests performed, see *infra* notes 201, 208 and accompanying text.

188. *See generally* B. EVANS, NATURAL AIR FLOW AROUND BUILDINGS (1957) (more than 200 shapes tested and cavity height consistently based on structural height).

mination if there is a substantial factual basis to support it. To further establish the H + 1.5L rule, the EPA analyzed demonstration data from five sources. The data clearly showed that the formula provides a conservative estimate of GEP height. The NRDC claimed, however, the EPA applied improper methods of analysis.

Rather than deferring to the EPA's methodology, the D.C. Circuit held that the EPA failed to prove the reliability of formula height. The court ordered the EPA to create a rule capable of determining GEP height in all situations or to ignore a formula altogether. Complex terrain offers problems which no formula can solve. The essence of the D.C. Circuit's decision is to mandate demonstrations whenever a company wishes to increase stack height. The court's failure to follow the *Florida Power* court's approach for resolving competing theories is unsupportable because much more than a substantial basis in fact exists to support the EPA's use of formula height.

VI. Conclusion

The D.C. Circuit's decision to override the tall stack rules is misguided. Initially the Clean Air Act did not expressly forbid use of tall stacks to avoid NAAQS violations. Nonetheless, the Fifth Circuit construed the Act as forbidding use of tall stacks except in limited circumstances. Congress later enacted section 123, which proscribes use of tall stacks. As a result, the issue now facing courts is whether industry is building stacks to GEP height or whether it is accurately using GEP stack credit for existing stacks. These decisions require detailed engineering analysis which the judiciary is ill-equipped to analyze.

Due to technical complexity of tall stack rules, Congress delegated to the EPA the job of devising methods to calculate GEP height. Engineers knew that conditions can arise which sweep stack emissions to the ground, creating hazardous pollution levels. GEP height, therefore, is the minimum stack height necessary to prevent, in any situation, excessive concentrations of pollutants from stack emissions. EPA engineers eventually codified three methods to determine GEP height: de minimis height, formula height, and demonstration height. Both formula height, and demonstration height depend on whether structures are "nearby" the stack. Demonstration height also depends on whether terrain obstacles disturb stack emissions.

An analysis of *Sierra Club v. EPA* and *NRDC v. Thomas* shows the difficulty the D.C. Circuit has had understanding and interpreting the tall stack rules. The court applied unrealistic standards of review that resulted in detailed remand instructions to the EPA. Fortunately, the court's invalidation of the EPA's definitions of "nearby" and "excessive concentrations" has not undercut the validity of the rules. The EPA redefined the terms to the satisfaction of the court and simultaneously managed to keep the definitions technically quite similar.

The court's recent decision that the H + 1.5L formula is an inappropriate method to calculate GEP height and the resulting mandate to perform demonstrations has severe ramifications. Formula height is a conservative estimate of GEP height that usually requires decreased emissions to avoid a NAAQS violation. On the other hand, demonstrations usually allow increased stack height and, hence, increased emissions. The decision to require demonstrations may benefit the environment in the near future because an insufficient number of facilities can perform the requisite wind tunnel testing. But requiring demonstrations will have a long-term deleterious effect on the environment.[189] The resulting increased stack height, which allows greater pollution, will create greater environmental degradation.

Section 123 expressly delegates to the EPA responsibility for promulgating rules to determine GEP stack height. The EPA used its engineering expertise to define good engineering practice. The D.C. Circuit, however, rejected an engineer's definition of good engineering practices and substituted its own judicial interpretation. Supreme Court precedent expressly forbids such judicial activism in regard to an agency's highly technical decisions. Because the tall stack rules are highly technical, the D.C. Circuit should apply a deferential standard of review concerning this agency decision.

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189. ENVIRONMENTAL PROTECTION AGENCY, FLUID MODELING DEMONSTRATION OF GOOD ENGINEERING PRACTICE STACK HEIGHT IN COMPLEX TERRAIN 32 (1985) [hereinafter COMPLEX TERRAIN] (increased stack height from formula height of 132 meters to GEP height of 326 meters due to terrain effects).

APPENDIX: TECHNICAL BASIS FOR THE TALL STACK RULES

This appendix summarizes technical and empirical data that support the EPA tall stack rules. Each method of determining GEP stack height — de minimus height, formula height and demonstration height — is analyzed. The appendix will help predict possible problems and their underlying causes.

A complete understanding of the tall stack rules requires, at a minimum, exposure to the underlying engineering concepts. Courts that subsequently apply the final tall stack rules will confront issues whose technical bases are summarized in this appendix. In addition, the appendix may be an initial planning device useful to industries considering plant modification or relocation.

A. *Formula Stack Height*

When wind approaches a building, aerodynamic forces disrupt normal atmospheric flow.[190] The building obstructs the wind, preventing normal flow around the building. The wind accelerates around the structure.[191] The blocked wind, coupled with the accelerated flow around the structure, form an adverse pressure gradient just behind the structure.[192] This creates highly turbulent eddies and wakes.[193]

As a result, eddies, the most turbulent air, are directly behind the building within a "cavity region."[194] The cavity region extends beyond the building and reattaches the normal flow downwind.[195] The wake encompasses any additional flow disruption created by the building

190. STACK HEIGHT GUIDELINES, *supra* note 5, at 9.

191. *Id.* at 12 (diagram of flow accelerating around rectangular block). *See* A. KUETHE & C. CHOW, FOUNDATIONS OF AERODYNAMICS: BASES OF AERODYNAMIC DESIGN 63-66 (3d ed. 1976) (incompressible flow wind velocity increases as amount of area decreases).

192. STACK HEIGHT GUIDELINES, *supra* note 5, at 9. *See* A. KUETHE & C. CHOW, *supra* note 191, at 315 (adverse pressure gradient develops within retarded flow).

193. "[S]urface friction and pressure gradients combine to retard the atmospheric surface layer flow enough to produce regions where the flow is locally distorted, causing an area of stagnation cavity to develop." STACK HEIGHT GUIDELINES, *supra* note 5, at 9. "[A]erodynamic influences and the extent of the wake are highly dependent on the particular shape and design of the obstruction. The extent of the wake also depends on the characteristics of the approaching atmospheric flow." *Id.* at 11.

194. *Id.* at 9 (eddies exist within cavity region and are highly turbulent).

195. STACK HEIGHT GUIDELINES, *supra* note 5, at 9. *See Id.* at 73 (downwind cavity extends until air particles close to the ground stop to flow upwind toward the building).

and continues downwind beyond the cavity region.[196] Turbulent flow increases downwash and potentially creates excessive concentrations of pollutants at ground level.[197]

GEP height must extend beyond adverse aerodynamic eddies and wakes created behind a building to avoid excessive downwash.[198] The "2.5 times" rule emerged in the mid-1950s as the stack height necessary to avoid these difficulties.[199]

$$\text{GEP height} = 2.5 \times H$$

$$H = \text{the height of nearby structure(s)}$$ [200]

Engineers continue to perform wind tunnel tests to verify the historical height.[201]

Experimental data show that the cavity region generally extends upward one-and-one-half building heights from ground level.[202] Determination of additional height necessary to avoid the loftier wake effects is more difficult.[203] Frictional effects dissipate with altitude and distance from the building, making detection of wake height difficult.[204]

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196. STACK HEIGHT GUIDELINES, *supra* note 5, at 9 (wakes encompass entire region of disturbed flow and extend beyond cavity region).

197. STACK HEIGHT GUIDELINES, *supra* note 5, at 9.

198. 42 U.S.C. § 7423(c) (1982). *See* STACK HEIGHT GUIDELINES, *supra* note 5, at 72 (dispersion into turbulent air causes immediate downwash of emissions).

199. From the mid-1950s until the late 1970s, engineers conducted hundreds of wind tunnel tests to determine principles which govern stack height. *See* STACK HEIGHT GUIDELINES, *supra* note 5, at 68-94. The tests concluded that stacks applying the 2.5 times rule escape excessive concentrations due to building influences. *Id.* at 11. The British used the 2.5 times rule successfully as far back as the early 1900s. *Id.*

200. 40 C.F.R. § 51.100(ii)(2)(i) (1987). *See* STACK HEIGHT GUIDELINES, *supra* note 5, at 6 (both height and width of structure are determined from structure's frontal area and projected onto plane perpendicular to wind direction; asymmetrical structures tested with orientation allowing greatest possible stack height).

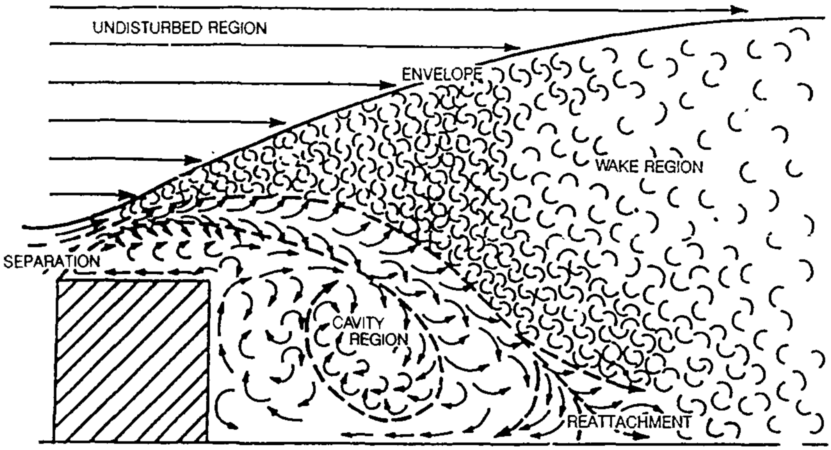
201. *See* STACK HEIGHT GUIDELINES, *supra* note 5, at 80 (2.5 times requirement diminishes downwash significantly); *but see* STACK HEIGHT GUIDELINES, *supra* note 5, at 76 (citing Scorer & Barret, 6 INT. J. OF AIR AND WATER POLLUTION, 49-63 (1963)) (stack height of 2.25 times building height appropriate).

202. *See* STACK HEIGHT GUIDELINES, *supra* note 5, at 16; *but see id.* at 73 (citing B. EVANS, NATURAL AIR FLOW AROUND BUILDINGS (1957)) (in over two-hundred building shapes tested, regardless of building height, cavity region is same function of building height).

203. STACK HEIGHT GUIDELINES, *supra* note 5, at 16. Tests evaluating wake effects must consider the atmospheric boundary layer. *Id.* These considerations blur wake height which can extend up to five times the building's height. *Id.* at 87.

204. *See* A. KUETHE & C. CHOW, *supra* note 191, at 299 (greatest amount of turbulence is at point of separation). *See* Diagram 1.

DIAGRAM I



Wake height, therefore, is the height at which the plume initially becomes disturbed.[205] Estimating wake height as 2.5 times building height is a conservative estimate based on highly variable experimental data.[206] Although not absolutely established, the 2.5 times rule evolved experimentally as the height necessary to avoid adverse wake effects.[207]

Continued scientific testing has refined the 2.5 times rule into the H + 1.5L rule.[208] More recent wind tunnel tests determine requisite cavity height, and, therefore, stack height depends on both the structure's height and width.[209] Cavity height extends above the top of the building by one-half the smaller of the building's height or width[210] and downwind approximately five times the smaller of the height or

205. STACKS HEIGHT GUIDELINES, *supra* note 5, at 19. *See* Sierra Club v. EPA, 769 F.2d 796 (D.C. Cir. 1985) (as wind speed increases, plume near the stack . . . is generally small even though the plume's rise downwind may be significant).

206. STACK HEIGHT GUIDELINES, *supra* note 5, at 21.

207. *Id.* at 13. *See id.* at 11-13 (citing generally BAUMEISTER, MARK'S STANDARD HANDBOOK FOR MECHANICAL ENGINEERS (1978)) (ratio of 2.5 to 1 used to avoid plume entrapment); STACK HEIGHT GUIDELINES, *supra* note 5, at 15 (1973 test found significant difference between stacks two times and two-and-one-half times building heights).

208. STACK HEIGHT GUIDELINES, *supra* note 5, at 17 (2.5 times rule is inappropriate for tall, thin structures); *id.* at 85.

209. STACK HEIGHT GUIDELINES, *supra* note 5, at 19.

210. *Id.* (equation to predict upward extension of the cavity region is H + .5L).

width.[211] The new formula is:

GEP height = H + 1.5L

H = the height of nearby structure(s).

L = lesser of the height or width of the structure(s).[212]

Tests establishing the derivation of formula height are dependent on specific testing conditions.[213] Primary test conditions consist of simple structures, level terrain, and known placement of the cavity regions.[214] Tests apply generic conditions to compile a data base from which engineers can develop a general rule for stack height.

Engineers recognize that complex matters require individual attention.[215] Complex structures pose the least difficult problem with respect to formula height.[216] Engineers model tiered structures as a series of stacked quadrilaterals.[217] Engineers merely apply the formula to each individual tier and then aggregate the results to determine total stack height.[218]

Rounded or sloping structures present more difficult problems.[219]

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211. *Id.* at 17 (most applicable for structures whose width is less than ten times height). *See id.* at 15 (1976 test which found that cavity extension diminishes within three to five times building height for tall narrow structures); *Id.* at 15-16 (1977 test concurs that regardless of structure orientation, cavity region extends downwind approximately five times building height).

212. 40 C.F.R. § 51.100(ii)(2)(ii) (1987). STACK HEIGHT GUIDELINES, *supra* note 5, at 19 (wake height estimations correspond to H + 1.5L rule); *but see id.* at 22 (studies may eventually show GEP higher or lower than that calculated with the H + 1.5L rule).

213. *See* FLUID MODELING GUIDELINE, *supra* note 85, at 5 (wind tunnel testing requires a fixed flow which accurately reproduces atmospheric phenomena).

214. *See* FLUID MODELING GUIDELINE, *supra* note 85, at 5 (primary factors include surface roughness, terrain, building, structure, and scaled atmospheric phenomena); *see also* ENVIRONMENTAL PROTECTION AGENCY, DETERMINATION OF GOOD ENGINEERING PRACTICE STACK HEIGHT: A FLUID MODEL DEMONSTRATION STUDY FOR A POWER PLANT 4-5 (1983) [hereinafter EPA DEMONSTRATION] (delineating several parameters which engineers used in actual demonstration).

215. STACK HEIGHT GUIDELINES, *supra* note 5, at 5-6 ("Scientific literature in general indicates that a *case specific* review is integral to assuring the prevention of adverse aerodynamic effects near a given source.") (emphasis added).

216. *See id.* at 41-45 (consideration of geometrically complex structures).

217. *Id.* at 42 (diagram analyzing individual quadrilaterals as separate components).

218. *Id.* at 43 (influences of each tier is complimentary); *id.* at 43-45 (treat groups of nearby structures similarly); *id.* at 43 (grouping of nearby structures may create a streamlining effect around lower tiers and reduce necessary stack height).

219. *Id.* at 14 (rounded buildings create smaller cavity regions than sharp-edged structures).

Curved shapes create favorable aerodynamic conditions and, therefore, reduce necessary stack height.[220] Complex terrain creates the most formidable adverse aerodynamic forces because of the obstacle's size and unpredictability.[221] The terrain presents an infinite number of potential geometries, making application of any formula height impossible.[222]

The primary problem created by both rounded structures and complex terrain is defining the placement of a flow separation point, the beginning of a cavity region.[223] A cavity region defines an initial point of turbulent flow. An abrupt change in flow direction usually generates a separation.[224] For instance, flow separates at sharp corners.[225] Therefore, predicting the placement of cavity regions behind a quadrilateral-shaped structure is relatively simple.[226]

Alternatively, the separation point on a curved obstacle can begin anywhere on the slope.[227] Roving terrain may create several cavity regions in a localized area, causing an unpredictable coupling effect.[228] Therefore, determination of GEP height within complex terrain generally requires a source-specific demonstration.[229]

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220. *Id.* at 32.

221. *Id.* at 28.

222. *Id.* at 31. *See id.* at 79 (citing H. MOSES, G. STROM & J. CARSON, NUCLEAR SAFETY 1-19 (1964)) ("Air flow in mountainous areas is . . . quite complicated with terrain irregularities located many stack heights upwind and downwind influencing plume motions.").

223. *See* MODELING GUIDELINES, *supra* note 19, at 141 (flow can separate anywhere on slope because shapes are streamlined).

224. *See* A. KUETHE & C. CHOW, *supra* note 191, at 315 (separation point defines termination of laminar flow and beginning of turbulent flow); STACK HEIGHT GUIDELINES, *supra* note 5, at 28-29 (point of separation is function of flow speed and flow direction).

225. MODELING GUIDELINES, *supra* note 19, at 141. *See* STACK HEIGHT GUIDELINES, *supra* note 5, at 29 (shear features such as cliffs create most distinct cavity regions).

226. STACK HEIGHT GUIDELINES, *supra* note 5, at 9-11 (separation point begins at the sharp forward edge of a quadrilateral). *See* Diagram 1. *See, e.g.*, COMPLEX TERRAIN, *supra* note 189, at 27 (steep obstacles create large area of recirculation).

227. MODELING GUIDELINE, *supra* note 19, at 141.

228. *See* STACK HEIGHT GUIDELINES, *supra* note 5, at 56 (diagram showing potential problems when cavity regions from two terrain obstacles couple to create more severe aerodynamic conditions). *See also* A. KUETHE & C. CHOW, *supra* 191, at 315-16 (potential absorption of cavity region within valley).

229. STACK HEIGHT GUIDELINES, *supra* note 5, at 31.

B. *De Minimis Stack Height*

The earth's atmosphere possesses a unique stratification, the composition of which may affect stack height. A planetary "boundary layer" exists around the earth.[230] Aerodynamic friction[231] with the earth creates a velocity stagnation point[232] at ground level. Wind speed increases asymptotically with distance upward from the stagnation point.[233] The wind speed at the top of the boundary layer is equal to the normal wind speed.[234] Boundary layer height varies from 500 to 2000 meters upward.[235]

The planetary boundary layer contains a "surface layer."[236] Surface layer height varies with meterological phenomena.[237] The surface layer contains the highest turbulence level within the planetary boundary layer. Emission of pollutants into the surface layer can cause immediate downwash.[238] Prevention of plume entrapment within the surface layer requires a "de minimis" stack height of approximately sixty-five meters.[239] Emissions from stacks with a height of sixty-five meters or less also have an insignificant effect on chemical loading of the atmosphere.[240]

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230. The planetary boundary layer contains the portion of the atmosphere where aerodynamic friction due to motion relative to the earth's surface is most acute. MODELING GUIDELINE, *supra* note 19, at 74. *See* A. KUETHE & C. CHOW, *supra* note 191, at 299 ("boundary layer" is a layer near body within which effects of viscosity are most concentrated). *See* Diagram 2.

231. *Id.* Surface temperature changes and surface roughness can generate aerodynamic friction. STACK HEIGHT GUIDELINES, *supra* note 5, at 32. Surface roughness drastically affects the magnitude of the boundary layer. MODELING GUIDELINE, *supra* note 19, at 80.

232. A wind velocity of zero at ground level is a stagnation point. A. KUETHE & C. CHOW, *supra* note 191, at 64. *See* Diagram 2.

233. MODELING GUIDELINE, *supra* note 19, at 72. *See* Diagram 2.

234. A perfect fluid theoretically has no turbulence outside of the boundary layer, thereby making the maximum boundary layer velocity equal to the free speed flow. A. KUETHE & C. CHOW, *supra* note 191, at 299-305. *See* Diagram 2.

235. MODELING GUIDELINE, *supra* note 19, at 74. *See* Diagram 2.

236. MODELING GUIDELINE, *supra* note 19, at 74-75 (surface layer is generally 10% to 20% of the planetary boundary layer). *See* Diagram 2.

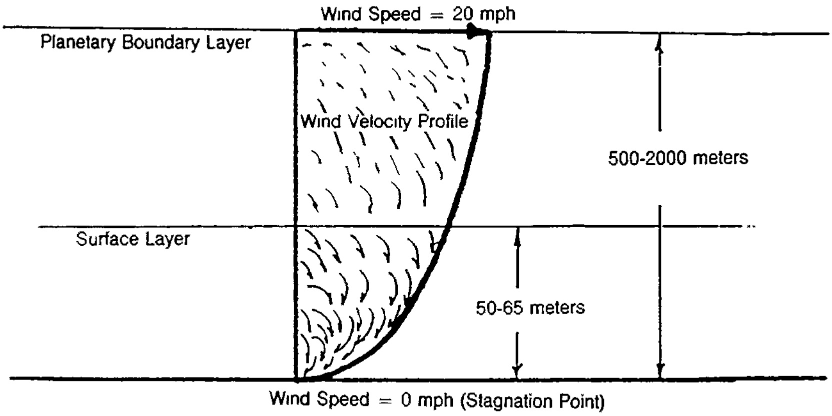
237. *See* STACK HEIGHT GUIDELINES, *supra* note 5, at 31. Determinations of surface layer height vary from 30 to 50 meters or, more generally, from 10% to 20% of planetary boundary layer. MODELING GUIDELINE, *supra* note 19, at 75.

238. STACK HEIGHT GUIDELINES, *supra* note 5, at 32.

239. 40 C.F.R. § 51.100(ii)(1) (1987) (sixty-five-meter height is measured from ground-level elevation at base of stack).

240. STACK HEIGHT GUIDELINES, *supra* note 5, at 32 (sixty-five-meter height will

DIAGRAM 2



C. *Demonstrations*

Section 123 of the Act states that stack height shall not exceed that calculated with the 2.5 times rule unless a demonstration proves a greater stack height is necessary.[241] A fluid model study (wind tunnel test) simulates meterological phenomena on a scaled-down version of a source.[242]

To determine whether pollutant concentrations rise to an excessive level, engineers conduct a series of tests called runs.[243] Each run must take place over a sufficient length of time to determine steady-state average concentrations of pollutants.[244] These averages generally correspond to one-hour average concentrations.[245]

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allow a reasonable dilution to take place in minimal time available before particulate matter settles).

241. 42 U.S.C. § 7423(c) (1982). *See generally* EPA DEMONSTRATION, *supra* note 214 (report calculates GEP height for actual plant with demonstration).

242. Engineers analyze wind records from the past year and test with a wind speed of approximately 98% of maximum wind speed. *See* FLUID MODELING GUIDELINE, *supra* note 85, at 15-16. Occasional high wind speeds will result in significantly reduced plume rise and therefore create the greatest potential for excessive ground-level concentrations. *Id.* at 6.

243. *See id.* at 38-41 (step-by-step instructions necessary to conduct test procedures).

244. *Id.* at 18.

245. *Id.* at 19.

Engineers gather data from each run.[246] To determine the influence of a particular obstacle, engineers remove it from the test cell after a successful run and conduct an additional run.[247] A comparison of the run within a particular obstacle is compared with the run which contained all of the nearby structures and obstacles.[248] From the comparison, engineers can determine the precise aerodynamic effect a particular obstacle creates and, therefore, the actual stack height required to exceed adverse aerodynamic effects.[249] This stack height is the good engineering practice height.[250]

CONCLUSION

Engineers discovered that GEP height depends upon atmospheric conditions and the structures and type of terrain surrounding the stack. GEP height depends on which factor predominates for the specific stack. Atmospheric conditions are paramount when using de minimus height; structural effects are paramount for formula height; and terrain effects dominate demonstration height. Each condition, and hence each method of determining GEP height, presents different complexities. Engineers have conducted wind tunnel tests and have determined an accurate calculation of GEP height for each method. Empirical data support their conclusions.

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246. *Id.* at 41-42 (step one).

247. *Id.* at 42 (step two).

248. *Id.* (step three).

249. *Id.* at 7 (wind tunnel testing provides ideal environment to determine excessive concentrations and GEP height).

250. *Id.* at 42 (height is creditable GEP height). *See id.* at 7 (can determine aerodynamic effects of structure or terrain obstacle on source which is subject of experiment).

* J.D. 1989, Washington University.

COMMENTS