2015

Boundary Work in Environmental Law

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ARTICLE

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*Gregg P. Macey**

ABSTRACT

This Article introduces a new approach to environmental law, which I refer to as "boundary work." Legal scholars organize environmental law around a series of boundary disputes. These include: federalism, beginning with the matching principle and the appropriate scale of response to pollution; statutory interpretation, including federal power to regulate "waters of the United States" and air emissions beyond a facility; and the balance of equity and efficiency, often through critiques of risk borne by "fenceline" or environmental justice communities. These areas of inquiry focus on decisions that agencies make as they struggle with governable commons, protectable waters and habitats, controllable emissions, and manageable risks. Yet they are unable to resolve enduring puzzles in environmental protection. Among them: the failure of Title VI of the Civil Rights Act of 1964 to improve environmental quality in low-income and minority communities forty years after the Environmental Protection Agency adopted implementing regulations; the inability of state and federal agencies to determine air quality near hydraulic fracturing ("fracking") and other unconventional oil and gas sites;

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* Associate Professor of Law, Brooklyn Law School. I am indebted to Bill Araiza, Chris Beauchamp, Jon Cannon, Jim Chen, Eileen Gauna, Sheila Jasanoff, Orr Karassin, Brian Lee, Orly Lobel, Michael Madison, Jonathan Nash, Brent Newell, Oren Perez, and Robert Verchick; participants of the Democratization of Risk Governance international workshop at Tel Aviv University, Hydraulic Fracturing: A Comparative Assessment research workshop at the IUCN Academy of Law 12th Annual Colloquium, and a faculty workshop at the University of San Diego School of Law; and staff at Earthjustice for input and comments. I am grateful to the Dean's Summer Research Stipend Program for financial support. Sam Wright provided excellent research assistance. This article is dedicated to the memory of my father, Arthur Alan Macey.

and the limited ability of agencies to police entire categories of risk, such as the impacts of radioactive waste disposed in municipal landfills. These and other puzzles persist because the literature lacks a framework for the study of environmental law as it is performed—not at the level of agencies or market actors, but at a wholly distinct unit of analysis. "Boundary work" provides such a framework. Its unit of analysis is the community of practice, through which boundaries of protectable places and publics are regularly redrawn. I introduce the concept of boundary work and apply it to longstanding challenges in the areas of environmental justice, oil and gas development and production, and waste disposal. Boundary work, and the practice-oriented perspective that underlies it, points to institutional arrangements that construct, shift, and move boundaries so that they are beyond the reach of existing legal authority, irrespective of rulemaking or the settled scope of regulatory power. Boundary work's attention to institutional change sheds light on central issues in administrative law, including the persistence of regulatory commons. It also suggests a workable application of the precautionary principle in domestic environmental law.

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INTRODUCTION

Environmental law is organized around boundary disputes. The lines are pitched along three disparate battlefields.

The first is conceptual. Legal scholars vie for an elusive theory of federalism,[1] the appropriate geographic scale of regulation that will deftly balance everything from local emissions standards and national clean air caps[2] to the pace of permafrost cratering in Siberia and the price of carbon in Carbondale.[3] The most influential concepts in environmental law seek better division of labor among government entities. The widely cited "matching principle" tried to short-circuit a turn to federal, command-based rules that began in the early 1970s.[4] It offers a simple rubric: the appropriate scale of response to pollution is "the size of the geographic area affected by a specific pollution source."[5]

Proponents of the matching principle argue that responses to air, water, and waste challenges risk "jurisdictional mismatch."[6] They are not attuned to the scale of the ecological system or externality at issue (think local greenhouse gas initiatives or federal cleanup standards for a single, isolated site). They weigh the wrong mix of costs and benefits, thereby offering "too little or too much environmental protection."[7] And they squander resources and stifle innovation, treading on areas where an agency lacks institutional advantage.[8] Responses to the problem of mismatch run the gamut, from a rebuttable presumption of decentralized lawmaking[9] to

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1. *See generally* Robert V. Percival, *Environmental Federalism: Historical Roots and Contemporary Models*, 54 MD. L. REV. 1141 (1995).

2. *See, e.g.*, Engine Mfrs. Ass'n v. S. Coast Air Quality Mgmt. Dist., 541 U.S. 246, 258–59 (2004).

3. *See* Katia Moskvitch, *Mysterious Siberian Crater Attributed to Methane*, NATURE (July 31, 2014), http://www.nature.com/news/mysterious-siberian-crater-attributed-to-methane-1.15649.

4. Daniel H. Cole & Peter Z. Grossman, *When is Command-and-Control Efficient? Institutions, Technology, and the Comparative Efficiency of Alternative Regulatory Regimes for Environmental Protection*, 1999 WIS. L. REV. 887, 909–14.

5. Henry N. Butler & Jonathan R. Macey, *Externalities and the Matching Principle: The Case for Reallocating Environmental Regulatory Authority*, 14 YALE L. & POL'Y REV. & YALE J. ON REG. 23, 25 (1996).

6. Jonathan H. Adler, *Jurisdictional Mismatch in Environmental Federalism*, 14 N.Y.U. ENVTL. L.J. 130, 157 (2005).

7. Daniel C. Esty, *Revitalizing Environmental Federalism*, 95 MICH. L. REV. 570, 587 (1996).

8. Butler & Macey, *supra* note 5, at 28; *see also* Adler, *supra* note 6, at 130 (discussing how jurisdictional mismatch plagues contemporary environmental law and policy, producing sub-optimal levels of environmental protection, wasting regulatory resources, and discouraging innovation).

9. Richard L. Revesz, *The Race to the Bottom and Federal Environmental Regulation: A Response to Critics*, 82 MINN. L. REV. 535, 536–38 (1997).

stronger federal initiatives to cure symptoms of the "regulatory commons."[10] Climate change and ecological collapse have brought environmental federalism to a theoretical no man's land, blurring the cooperative compromises[11] of old beyond recognition. "Adaptive,"[12] "scalar,"[13] and "social-ecological"[14] models vie for attention, concerned with multiple geographic and temporal scales but lacking the elegance of earlier arguments based on spillovers, economies of scale, and comparative competence.[15]

Other boundary disputes are statutory. They are prominent in debates over federal power to regulate "waters of the United States" or air emissions impacts "beyond the fenceline." The Clean Water Act (CWA) defines "navigable waters" vaguely as "waters of the United States,"[16] leaving agencies such as the U.S. Army Corps of Engineers to clarify the scope of federal protection. The rules date back to 1973.[17] They stretched federal control beyond interstate waters to intrastate rivers, streams, mudflats, sloughs, and other waters as well as "tributaries of [these] waters" and "wetlands adjacent to" them.[18] The Supreme Court reined in early definitions of statutory waters in 2001,[19] although a plurality decision in *Rapanos v. United States* confused the extent to which

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10. William W. Buzbee, *Recognizing the Regulatory Commons: A Theory of Regulatory Gaps*, 89 IOWA L. REV. 1, 62–63 (2003).

11. The modern use of cooperative federalism in environmental law can be traced to Jane Clark's work in the 1930s. *See* Jane Perry Clark, *Interdependent Federal and State Law as a Form of Federal-State Cooperation*, 23 IOWA L. REV. 539, 539 (1938); *see also* Philip J. Weiser, *Towards a Constitutional Architecture for Cooperative Federalism*, 79 N.C. L. REV. 663, 668 (2001) (highlighting how Congress favors cooperative federalism programs that combine federal and state authority in creative ways, and rejects the dual federalism model of regulation).

12. *See, e.g.*, David E. Adelman & Kirsten H. Engel, *Adaptive Federalism: The Case Against Reallocating Environmental Regulatory Authority*, 92 MINN. L. REV. 1796 (2008); Kirsten H. Engel, *Harnessing the Benefits of Dynamic Federalism in Environmental Law*, 56 EMORY L.J. 159 (2006).

13. *See, e.g.*, Robin Kundis Craig, *Climate Change, Regulatory Fragmentation, and Water Triage*, 79 U. COLO. L. REV. 825, 893–98 (2008); Hari M. Osofsky, *The Geography of Climate Change Litigation: Implications for Transnational Regulatory Governance*, 83 WASH. U. L.Q. 1789 (2005).

14. *See, e.g.*, Jonas Ebbesson & Carl Folke, *Matching Scales of Law with Social-Ecological Contexts to Promote Resilience*, *in* SOCIAL-ECOLOGICAL RESILIENCE AND LAW 265 (Ahjond S. Garmestani & Craig R. Allen eds., 2014).

15. *See, e.g.*, Esty, *supra* note 7, at 614–15; Thomas W. Merrill, *Golden Rules for Transboundary Pollution*, 46 DUKE L.J. 931, 968–69 (1997); Richard L. Revesz, *Federalism and Environmental Regulation: A Public Choice Analysis*, 115 HARV. L. REV. 553, 582 (2001).

16. 33 U.S.C. § 1362(7) (2012).

17. Definition of Navigable Waters of the United States, 33 C.F.R. § 209.260(c) (1973).

18. Definition of Waters of the United States, 33 C.F.R. § 328.3(a) (2014).

19. *See* Solid Waste Agency v. U.S. Army Corps of Eng'rs, 531 U.S. 159, 171–72 (2001).

covered waters must fall within a category of water ("relatively permanent" bodies "adjacent to" navigable waters and wetlands by "continuous surface connection")[20] or enjoy a "significant nexus" to traditional navigable waters.[21] EPA and the Corps proposed new rules, arguing that they have discretion to determine significant nexus between the water at issue and navigable or interstate waters.[22] The physical extent of federal regulation receives a great deal of attention by legal scholars.[23]

A similar showdown concerns the geographic extent of point source regulation under the Clean Air Act (CAA), the centerpiece of the Obama Administration's Climate Action Plan.[24] As is the case with "waters of the United States," the provisions leave the reach of federal power beyond a certain point (i.e., navigable water, fenceline of a power plant) unresolved. Section 111 of the CAA authorizes EPA to set performance standards for categories of emissions sources.[25] The Supreme Court again spurred the ongoing boundary dispute. The Court in *Massachusetts v. EPA* held that carbon dioxide, a greenhouse gas, is a "pollutant" that EPA must regulate if it finds emissions "endanger" the environment.[26] EPA issued its finding in 2009.[27] The agency targeted emissions from new (2010)[28] and existing (2014)[29] power plants under Sections 111(b) and (d) of the statute, respectively. The latter requires EPA to issue guidelines for "system[s] of emission[s] reduction" adequately demonstrated to reduce emissions by a certain degree.[30] This raises a legal question: does a "system of emission reduction" concern the performance of a

20. Rapanos v. United States, 547 U.S. 715, 757 (2006) (plurality opinion).

21. *Id.* at 782 (Kennedy, J., concurring).

22. *See* Clean Water Rule: Definition of "Waters of the United States," 80 Fed. Reg. 37054, 37106 (June 29, 2015) (to be codified at 33 C.F.R. pt. 328).

23. *See, e.g.*, William N. Eskridge, Jr. & Lauren E. Baer, *The Continuum of Deference: Supreme Court Treatment of Agency Statutory Interpretations from* Chevron *to* Hamdan, 96 GEO. L.J. 1083 (2008).

24. EXEC. OFFICE OF THE PRESIDENT, THE PRESIDENT'S CLIMATE ACTION PLAN 6 (2013).

25. 42 U.S.C. § 7411(b)(1)(A) (2012).

26. Massachusetts v. EPA, 549 U.S. 497, 528–33 (2007) (quoting 42 U.S.C. § 7521(a)(1)).

27. Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act, 74 Fed. Reg. 66,496 (Dec. 15, 2009) (to be codified at 40 C.F.R. ch. 1).

28. Standards of Performance for Greenhouse Gas Emissions for New Stationary Sources: Electric Utility Generating Units, 79 Fed. Reg. 1430 (proposed Jan. 8, 2014) (to be codified at 40 C.F.R. pt. 60); Proposed Settlement Agreement, Clean Air Act Citizen Suit, 75 Fed. Reg. 82,392 (proposed Dec. 30, 2010).

29. Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, 79 Fed. Reg. 34,830 (proposed June 18, 2014) (to be codified at 40 C.F.R. pt. 60).

30. 42 U.S.C. § 7411(a)(1), (d).

facility and upgrades within its fenceline, or wider changes power companies should make beyond the fenceline, such as participation in energy efficiency or cap-and-trade programs?[31] The CAA's reach beyond the fenceline will help determine the nation's ability to meet emissions reduction targets, whether domestic or as part of agreed-to international frameworks.[32]

A third set of boundary disputes concerns the distribution of costs and benefits in a risk society.[33] The environmental justice movement is at the forefront of this dispute. It offers a critique of the law's inability to protect vulnerable communities, inform them of risks, and ensure that they can influence the rules and public funds that shape risks.[34] The "fenceline" is a powerful metaphor and organizing principle for the movement. First, it is used to point out the colocation of "locally undesirable land uses" and homes, schools, and playgrounds, a product of poor planning and exclusionary or expulsive zoning.[35] A common narrative begins with the depiction of homes that, by accident or design, are a disturbingly small number of steps from the edge of a chemical process or storage vessel.[36] The metaphor is then put to use. It reveals the law's blindness to sub-local risks, the need to revise health-based standards, the role of accidents and fugitive emissions in determining a community's risk profile, and the

31. Megan Ceronsky et al., Dialogue, *Resolved: EPA and States Can Regulate Emissions Outside the Facility Fence Line Under Clean Air Act § 111*, 44 ENVTL. L. REP. 10255 (2014); Robert M. Sussman, *Power Plant Regulation Under the Clean Air Act: A Breakthrough Moment for U.S. Climate Policy?*, 32 VA. ENVTL. L.J. 97, 119–22 (2014).

32. *See, e.g.*, U.N. Framework Convention on Climate Change, *Copenhagen Accord*, app. I (Jan. 28, 2010), http://www.unfccc.int/meetings/Copenhagen_dec_2009/items/5264.php (pledging to reduce greenhouse gas emissions to seventeen percent below 2005 levels by 2020).

33. ULRICH BECK, RISK SOCIETY: TOWARDS A NEW MODERNITY 70–72, 90–93 (Mike Featherstone ed., Mark Ritter, trans., 1992).

34. Sheila Foster, *Justice from the Ground Up: Distributive Inequities, Grassroots Resistance, and the Transformative Politics of the Environmental Justice Movement*, 86 CAL. L. REV. 775, 821 (1998); Richard J. Lazarus, *Pursuing "Environmental Justice": The Distributional Effects of Environmental Protection*, 87 NW. U. L. REV. 787, 810, 857 (1993).

35. For an early treatment of this issue, see Omar Saleem, *Overcoming Environmental Discrimination: The Need for a Disparate Impact Test and Improved Notice Requirements in Facility Siting Decisions*, 19 COLUM. J. ENVTL. L. 211, 213–16 (1994) (describing the growth of the environmental justice movement following reports of the disproportionate siting of locally undesirable land uses in low-income and racial minority communities). *See also* Vicki Been, *Locally Undesirable Land Uses in Minority Neighborhoods: Disproportionate Siting or Market Dynamics?*, 103 YALE L.J. 1383, 1388–92 (1994) (arguing that the problem of disproportionate siting of locally undesirable land uses may be a function of free market forces rather than racial discrimination).

36. *See, e.g.*, Robert D. Bullard & Beverly Wright, *Disastrous Response to Natural and Man-made Disasters: An Environmental Justice Analysis Twenty-Five Years After Warren County*, 26 UCLA J. ENVTL. L. & POL'Y 217 (2008). For detailed maps depicting the gradual displacement of communities along the Mississippi River by petrochemical plants, see RICHARD MISRACH & KATE ORFF, PETROCHEMICAL AMERICA 116, 157–67 (2012).

failure of monitoring to detect and track chemical mixtures along residential blocks.[37] Fenceline risks reveal a need to reorient risk assessment, from a single chemical and the stubbornness with which it reveals itself to statisticians, to a specific place and its many stressors.[38] The fenceline is also used to second-guess the continued existence of a facility, the conditions for which are reduced to good neighbor, community benefits, and other agreements.[39]

The reach of this metaphor is considerable in legal scholarship. Distance to the fenceline, "fenceline levels," and "fenceline concentrations" are metrics that drive proposals to regulate pollutants, locate monitoring equipment, and estimate emissions from major sources.[40] A classic example is EPA's use of predictive models to calculate the "maximally exposed individual" (MEI).[41] This mythical person signals whether technology-based standards are sufficient when applied to a facility: "[A] mathematical dispersion model might estimate the air concentration of [a] carcinogen two hundred meters from the source."[42] EPA is now open to air quality monitoring at the fenceline, including it as part of rules governing refinery emissions that it proposed in 2014.[43] Fenceline monitoring is a cottage

37. Bullard & Wright, *supra* note 36.

38. *See, e.g.*, Jody Freeman & Daniel A. Farber, *Modular Environmental Regulation*, 54 DUKE L.J. 795 (2005) (proposing a "modular" conception of environmental regulation and natural resource management as an alternative to traditional approaches); Wendy E. Wagner, *The Science Charade in Toxic Risk Regulation*, 95 COLUM. L. REV. 1613, 1619 (1995) ("[C]ontempory science is incapable of completely resolving the level at which a chemical will pose some specified, quantitative risk to humans.").

39. *See, e.g.*, Thalia Gonzalez & Giovanni Saarman, *Regulating Pollutants, Negative Externalities, and Good Neighbor Agreements: Who Bears the Burden of Protecting Communities?*, 41 ECOLOGY L.Q. 37 (2014) (addressing the increased need for the study of community environmental policing and air quality monitoring); Ehud Guttel & Shmuel Leshem, *Buying the Right to Harm*, 86 S. CAL. L. REV. 1195 (2013) (showing that buyouts may be used by injurers to reduce social welfare, avoid taking socially desirable precautions, and adopt a divide-and-conquer strategy among victims).

40. *See, e.g.*, Victor B. Flatt, *Gasping for Breath: The Administrative Flaws of Federal Hazardous Air Pollution Regulation and What We Can Learn from the States*, 34 ECOLOGY L.Q. 107, 149–51 (2007) (discussing North Carolina's use of fenceline levels and fenceline concentrations in its Toxic Air Pollution Procedures); Danielle M. Purifoy, Note, *EPCRA: A Retrospective on the Environmental Right-to-Know Act*, 13 YALE J. HEALTH POL'Y L. & ETHICS 375 (2013) (evaluating the effectiveness of three provisions of the Emergency Planning and Community Right-to-Know Act through a case study of their implementation at a site of an industrial accident).

41. *See* Alon Rosenthal, George M. Gray & John D. Graham, *Legislating Acceptable Cancer Risk from Exposure to Toxic Chemicals*, 19 ECOLOGY L.Q. 269, 290–91 (1992).

42. RICHARD REVESZ, ENVIRONMENTAL LAW AND POLICY 77 (2d ed. 2012).

43. *See* Petroleum Refinery Sector Risk and Technology Review and New Source Performance Standards, 79 Fed. Reg. 36,880, 36,977–79 (proposed June 30, 2014) (to be codified at 40 C.F.R. pts. 60 & 63).

industry. It is used to second-guess safety assurances by state and federal agencies. It is also required in a growing number of consent decrees, the end result of enforcement by those agencies.[44] The "fenceline" guides attempts to increase the sophistication of methods, from site location standards to the estimate of cumulative exposure. It is also used to improve how we identify overburdened communities in the first place. Early reports defined them coarsely, at the level of zip codes, census tracts, and census block groups. Now residents take part in the participatory design of studies, shape hypotheses, and collect data on unique contributors of risk at the level of a neighborhood or even household.[45]

A pervasive and often hidden set of dynamics underlies each of these disputes. In this Article, I introduce the concept of boundary work in environmental law. Agencies struggle to establish the geographic span and distributional effects of governable commons, protectable waters and habitats, controllable emissions, and manageable risks. But within the organizations that police these expanses are dynamics that can increase the scale of an environmental harm, render it invisible, or even explain it away. I refer to the dynamics collectively as "boundary work." Advances in organization theory facilitate their study. The "practice turn" allows us to focus not on decisions that contribute to risk, but practices that accrue within and across organizations and set the terms for its control.[46] When applied to environmental law, the practice turn points to enduring arrangements that construct, shift, and move boundaries so that they are beyond the reach of existing legal authority, irrespective of rulemaking or the settled scope of regulatory power.[47] If we want

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44. *See, e.g.*, Consent Decree at 6, United States v. Flint Hills Res. Port Arthur, LLC, No. 1:14CV169 (E.D. Tex. Feb. 18, 2015) ("FHR has agreed to continue the proactive monitoring of its fence line through implementation of the program in Section X (Fence Line Monitoring Program) . . . .").

45. *Compare* COMM'N FOR RACIAL JUSTICE, UNITED CHURCH OF CHRIST, TOXIC WASTES AND RACE IN THE UNITED STATES (1987) (defining communities using zip codes and census data), *with* ROBERT D. BULLARD ET AL., UNITED CHURCH OF CHRIST, TOXIC WASTES AND RACE AT TWENTY: 1987–2007 (2007) (comparing unit-hazard coincidence and distance-based methods for estimating disparities in hazardous waste facility location).

46. *See, e.g.*, Theodore R. Schatzki, *Introduction* to THE PRACTICE TURN IN CONTEMPORARY THEORY 10–21 (Theodore R. Schatzki et al. eds., 2001); Theodore R. Schatzki, *The Sites of Organizations*, 26 ORG. STUD. 465, 471–73, 475–76 (2005).

47. In this Article, my use of the term "boundary work" differs from its prior use in sociology, where it refers to concerted efforts to, for example, shield a profession from competitors, ensure control over resources, identify socially important categories in a scientific dispute, or encourage coordination across disciplines or groups. *See, e.g.*, ANDREW ABBOTT, THE SYSTEM OF PROFESSIONS 56 (1988); Beth A, Bechky, *Object Lessons: Workplace Artifacts as Representations of Occupational Jurisdiction*, 109 AM. J. SOC. 720 (2003); Sheila Jasanoff, *Constitutional Moments in Governing Science and Technology*, 17 SCI. & ENGINEERING ETHICS

to explain the limits of environmental protection, in areas as disparate as environmental justice, hydraulic fracturing, and residual waste disposal, then federalism, statutory interpretation, and the balance of equity and efficiency will only take us so far.

Apart from these influences, boundary work takes place at a wholly distinct level of analysis: communities of practice.[48] Communities of practice are systems of relationships[49] between people and activities that develop over time, negotiate meaning, and produce "abstractions, tools, symbols, stories, terms, and concepts that reify something of that practice in a congealed form."[50] Examples range from a small research team working in close proximity to a globally distributed network such as Shell Oil Company's Exploration and Product International Ventures group.[51] They share three characteristics: a joint enterprise, mutual engagement (where interaction establishes norms and relationships), and resources such as artifacts, language, and routines.[52] A crucial element of communities of practice is that they emerge through ongoing interaction, as their members adopt local rules and internalize standards. They can be leveraged, or they can lock in knowledge that aligns with ongoing practices and

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621, 625 (2011). My use of the term to explain regulatory practice assumes a more embedded form of agency, where actors are constrained by institutions or enduring social patterns. Only under limited circumstances are actors able to disrupt institutions or create new ones. Thomas B. Lawrence, Roy Suddaby & Bernard Leca, *Introduction: Theorizing and Studying Institutional Work*, *in* INSTITUTIONAL WORK: ACTORS AND AGENCY IN INSTITUTIONAL STUDIES OF ORGANIZATIONS 1, 4–6 (Thomas B. Lawrence et al. eds., 2009).

48. ETIENNE WENGER, COMMUNITIES OF PRACTICE: LEARNING, MEANING, AND IDENTITY (1998). Communities of practice appear in several areas of legal scholarship, often as a metaphor to inform a broad concept (e.g., innovation or creativity), administrative practice (e.g., rulemaking), deliberative body (e.g., the International Criminal Court), or setting in which legal rules or norms are generated or viewed as legitimate (e.g., international relations, employment law). *See, e.g.*, Harlan Grant Cohen, *Finding International Law: Our Fragmenting Legal Community*, 44 N.Y.U. J. INT'L L. & POL. 1049 (2012); Michael Madison, *A Pattern-Oriented Approach to Fair Use*, 45 WM. & MARY L. REV. 1525 (2004); Jens Meirhenrich, *The Practice of International Law: A Theoretical Analysis*, 76 LAW & CONTEMP. PROBS., nos. 3 & 4, 2014, at 1 (2013); Beth Simone Noveck, *The Electronic Revolution in Rulemaking*, 53 EMORY L.J. 433 (2004); Laura Pedraza-Farina, *Patent Law and the Sociology of Innovation*, 2013 WIS. L. REV. 813; Beth Simone Noveck, *The Electronic Revolution in Rulemaking*, 53 EMORY L.J. 433 (2004); Susan Sturm & Howard Gadlin, *Conflict Resolution and Systemic Change*, 2007 J. DISP. RESOL. 1.

49. JEAN LAVE & ETIENNE WENGER, SITUATED LEARNING: LEGITIMATE PERIPHERAL PARTICIPATION 91–93 (1991); *see also* Carsten Østerlund & Paul Carlile, *Relations in Practice: Sorting Through Practice Theories on Knowledge Sharing in Complex Organizations*, 21 INFO. SOC'Y 91, 95 (2005).

50. WENGER, *supra* note 48, at 59.

51. ETIENNE WENGER, RICHARD MCDERMOTT & WILLIAM M. SNYDER, CULTIVATING COMMUNITIES OF PRACTICE: A GUIDE TO MANAGING KNOWLEDGE 113–16, 124–28 (2002).

52. WENGER, *supra* note 48, at 72–84.

identity, stifling innovation.[53] Left unexplored, communities of practice can further path dependence in a regulatory field, channeling the discovery and resolution of issues such as the scope of protectable publics or actionable environmental harms.

Through communities of practice, a regulatory field is queried not for its states of being (comparative competence, existing authority), but the ongoing practices that make do with available resources and carry out situated activity.[54] The emphasis is on Karl Weick's admonition that we study organizing rather than organization,[55] which he accomplished in areas such as industrial safety.[56] A focus on organizing means turning to the practices by which work is actually done.[57] It offers a rejoinder to rational actor models that focus on decision-making, which shrouds key elements of environmental protection in black boxes.[58] The claim is simple: everyday activity (routine and improvised), and the dynamics that explain it, are central to outcomes that we tend to study in isolation.[59] Communities of practice allow us to model the limits of knowledge management in regulation, which, in this Article, involves such wide-ranging issues as quantifying pollution impacts in an "environmental justice community," determining air

53. Joanne Roberts, *Limits to Communities of Practice*, 43 J. MGMT. STUD. 623, 625–26, 630 (2006).

54. The practice perspective thus extends a primary concern of new institutional economics: the costs of exchange and their institutional origins. One such extension is its focus on epistemic as opposed to cost-based limits to knowledge sharing and transfer. *Compare* Oliver E. Williamson, *The Economics of Organization: The Transaction Cost Approach*, 87 AM. J. SOC. 548, 555 (1981), *with* Paul Carlile, *A Pragmatic View of Knowledge and Boundaries: Boundary Objects in New Product Development*, 13 ORG. SCI. 442 (2002), *and* Beth Bechky, *Sharing Meaning Across Occupational Communities: The Transformation of Understanding on a Production Floor*, 14 ORG. SCI. 312 (2003). For a theoretical approach to knowledge sharing limits within and across communities of practice, see John Seely Brown & Paul Duguid, *Knowledge and Organization: A Social-Practice Perspective*, 12 ORG. SCI. 198 (2001).

55. KARL WEICK, THE SOCIAL PSYCHOLOGY OF ORGANIZING (1969).

56. KARL E. WEICK & KATHLEEN M. SUTCLIFFE, MANAGING THE UNEXPECTED: RESILIENT PERFORMANCE IN AN AGE OF UNCERTAINTY (2d ed. 2007); *see also* Diane Vaughan, *Organizational Rituals of Risk and Error*, *in* ORGANIZATIONAL ENCOUNTERS WITH RISK 33 (Bridget Hutter & Michael Power eds., 2005) (comparing daily encounters with risk for two industrial organizations for which mistakes result in public failures and have high costs: the Federal Aviation Administration's National Air Transportation System and the National Aeronautics and Space Administration's Space Shuttle Program).

57. Brown & Duguid, *supra* note 54, at 200; *see also* Stephen R. Barley & Gideon Kunda, *Bringing Work Back In*, 12 ORG. SCI. 76 (2001) (arguing that organization theory's effort to make sense of post-bureaucratic organizing is hampered by a dearth of detailed studies of work).

58. For a critique of the use of rational choice to explain environmental compliance, see David B. Spence, *The Shadow of the Rational Polluter: Rethinking the Role of Rational Actor Models in Environmental Law*, 89 CAL. L. REV. 917 (2001).

59. *See* Martha S. Feldman & Wanda J. Orlikowski, *Theorizing Practice and Practicing Theory*, 22 ORG. SCI. 1240, 1240–41 (2011).

quality near oil and gas wells, and rationing tens of thousands of tons of residual waste.

To understand the model, we need to define three terms. First are *activities*: "actions and interactions" that take place as individuals perform their daily roles and responsibilities.[60] In the ancient duality of agency and structure in social theory, activities fall furthest toward the pure agency edge of the spectrum. Next are *practices*. These refer to "patterns across actors that are infused with broader meaning" and order our work.[61] Practices are not just routines in which we engage—they are recognized as acceptable forms of activity.[62] For example, employees at a refinery might engage in practices such as inspection, optimization of chemical flows, or investigation of near misses. Here, acts begin to structure the work of, say, an engineering team or department, bringing us closer to the *institutions* that are more enduring frameworks for action in a social setting. Examples of institutions include categories, classifications, rules, and cultural frames.[63] Institutions influence behavior by exerting a mix of pressures—cognitive, normative, and regulative, on patterns of interaction.[64] But the practice perspective suggests that they are not permanent. Change occurs as individuals improvise to make use of scarce resources or innovate in response to local conditions, creating variation among practices.[65] Members of a broader social field, such as a trade association or profession, may identify the anomaly as a problem or possible solution.[66] Change occurs through negotiation among members of the social field, to adopt or prevent the new variation in practice.

Attention to social practices rather than decisions yields insights in fields as diverse as accounting, product innovation, technology adoption, corporate strategy, and international

60. *See* PAULA JARZABKOWSKI, STRATEGY AS PRACTICE: AN ACTIVITY-BASED APPROACH 4 (Charles Baden-Fuller & Richard Whittington eds., 2005).

61. *See* Michael Lounsbury & Ellen T. Crumley, *New Practice Creation: An Institutional Perspective on Innovation*, 28 ORG. STUD. 993, 995–96 (2007) (citing JARZABKOWSKI, *supra* note 60).

62. Richard Whittington, *Completing the Practice Turn in Strategy Research*, 27 ORG. STUD. 613, 619 (2006).

63. Michael Lounsbury, *Institutional Rationality and Practice Variation: New Directions in the Institutional Analysis of Practice*, 33 ACCT. ORGS. & SOC'Y 349, 356 (2008).

64. W. RICHARD SCOTT, INSTITUTIONS AND ORGANIZATIONS 33–34 (1995).

65. Lounsbury & Crumley, *supra* note 61, at 1005. The idiosyncratic enactment of practices, which can lead to deviation and an increase in practice variety, is discussed in Feldman's work. *See, e.g.*, Martha Feldman & Brian Pentland, *Reconceptualizing Organizational Routines as a Source of Stability and Change*, 48 ADMIN. SCI. Q. 94 (2003).

66. *Id.*

relations. Applied to regulatory behavior, the practice perspective offers a framework for the study of environmental law as it is performed—not at the level of market actors or agencies, but where practices and institutions interact on an ongoing basis.[67] Within communities of practice, the boundaries of risk and protectable places and publics are regularly redrawn. Outcomes range from *constructed* boundaries such as the definition of an "overburdened community" (Part I), to *nested* boundaries that limit knowledge management at an appropriate scale of environmental impact (Part II), to *shifting* boundaries where practices and institutional influences render the buildup of risk invisible to regulators (Part III). The practice perspective, and the boundary work it unearths, offers powerful explanations for longstanding, seemingly intractable environmental problems. Its focus on institutional change sheds light on the micro-level persistence of regulatory commons, and offers a workable application of the precautionary principle in domestic environmental law (Part IV).

I. CONSTRUCTED BOUNDARIES

A. Plan EJ 2014: Awareness of Expansive Legal Authority

Our first species of boundary work takes place at the intersection of environmental and civil rights laws. Environmental laws can shift waste streams from one medium to the next and set them on a path of least resistance. They set standards with a coarseness that ignores vulnerable subpopulations. Occasionally, a statute signals its complicity in these results. For example, the Resource Conservation and Recovery Act (RCRA),[68] by virtue of when it was issued, fell third in a sequence by which federal law dealt with air, water, and land-based pollution.[69] Each statute or amendment reallocated the discharge of pollutants from one medium to the next. Scrubbers in

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67. While this Article offers a proof of concept for boundary work in environmental law, its focus on mechanisms by which regulatory work constructs, nests, and shifts the boundaries of future action within the scope of existing authority are likely applicable to a broader set of regulatory problems.

68. Pub. L. No. 94-580, 90 Stat. 2795 (1976) (codified as amended at 42 U.S.C. §§ 6901–6992 (2012)).

69. *Compare* Clean Air Act of 1963, Pub. L. No. 88-206, 77 Stat. 392 (codified as amended at 42 U.S.C. §§ 7401–7671(q)), Clean Water Act of 1972, Pub. L. No. 92-500, 86 Stat. 816 (codified as amended at 33 U.S.C. §§ 1251–1387), *and* Resource Conservation and Recovery Act, Pub. L. No. 98-616, 98 Stat. 3321 (1976) (codified as amended at 42 U.S.C. §§ 6901–6992), *with* Hazardous and Solid Waste Amendments of 1984, Pub. L. No. 98-616, 98 Stat. 3221 (codified as amended at 42 U.S.C. §§ 6901–6992).

smokestacks diverted pollutants to wastewater.[70] The Clean Water Act embraced end-of-pipe controls including filtering systems, oil and water separators, and other layers of control technology that removed wastes from point sources and sent them in search of land disposal.[71] By the time the RCRA amendments banned disposal of hazardous waste on land, we were running out of media to which we could divert it (with notable exceptions including the workplace and consumer products).[72] This is acknowledged in the opening lines of RCRA: "[A]s a result of the Clean Air Act, the Water Pollution Control Act, and other federal and state laws respecting public health and the environment, greater amounts of solid waste . . . have been created."[73] As was true in the past, the new waste streams came to rest in predominantly low-income, minority communities.[74]

RCRA continued to shift waste streams. The new provisions did not limit the amount of hazardous waste that could be produced.[75] RCRA merely set conditions for the handling of waste.[76] They amounted to a tax, hidden within RCRA's broader focus on cradle-to-grave regulation, which increased the cost of treatment and disposal.[77] By calling on EPA to promulgate criteria for acceptable "treatment, storage, and disposal" (TSD),[78] a suddenly more expensive waste stream began its search for the appropriate facility. The stakes were high—the number of landfills fell while the size of remaining facilities grew in size and

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70. Clean Air Act of 1963, Pub. L. No. 88-206, 77 Stat. 392 (1963) (codified as amended at 42 U.S.C. §§ 7401–7671(q)); Clean Water Act of 1972, Pub. L. No. 92-500, 86 Stat. 816 (codified as amended at 33 U.S.C. §§ 1251–1387).

71. 33 U.S.C. § 1311(b)(2)(A) (2012) (requiring application of the best available technology economically achievable); *Water: Total Maximum Daily Loads (303d)*, EPA, http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/intro.cfm#section303 (last visited Sept. 16, 2015) ("The [Clean Water Act] includes two basic approaches for protecting and restoring the nation's waters. One is a technology-based, end-of-pipe approach, whereby EPA promulgates effluent guidelines that rely on technologies available to remove pollutants from waste streams."); *see, e.g.*, Lazarus, *supra* note 34, at 794–95 & n.29.

72. *See, e.g.*, Jason R. Bent, *An Incentive-Based Approach to Regulating Workplace Chemicals*, 73 OHIO ST. L.J. 1389, 1449 (2012) (discussing how the labor market fails to produce efficient levels of precaution against chemical exposures); KATHLEEN CURTIS & BOBBI CHASE WILDING, BODY BURDEN WORK GRP. & COMMONWEAL BIOMONITORING RES. CTR., IS IT IN US? CHEMICAL CONTAMINATION IN OUR BODIES (2007), http://www.isitinus.org/documents/Is It In Us Report.pdf (reporting that participants from seven states were contaminated with three types of toxic chemicals from using common consumer products).

73. 42 U.S.C. § 6901(b)(3) (citations omitted).

74. BULLARD ET AL., *supra* note 45, at 42–45.

75. *See* 42 U.S.C. §§ 6901–6992.

76. *See* 42 U.S.C. §§ 6922–6924.

77. *See* 42 U.S.C. §§ 6921(b), 6922.

78. 42 U.S.C. § 6924.

complexity.[79] RCRA limited the use of a variety of land formations for disposal.[80] Meanwhile, states had to assure that they had adequate storage capacity for twenty years.[81] The classic facility-siting game repeated itself throughout the economy.

But RCRA also contained a tiny and curious set of statements that are pervasive in environmental law. The provisions are referred to as "omnibus clauses." They extend existing authority by referring to a "residuary," or what is not specifically discussed in a statute or agreement. For example, RCRA notes that a TSD permit issued by a state or EPA "shall contain such terms and conditions as the Administrator . . . determines necessary to protect human health and the environment."[82] Richard Lazarus, former EPA General Counsel Gary Guzy, and others noted the existence of omnibus clauses in environmental laws in the late 1990s.[83] In 2000, Guzy issued a memorandum recognizing that omnibus clauses in existing statutes could address environmental justice concerns. Through each clause, statutes could be used to improve quality of life—the relative proximity and clustering of facilities, the prevalence of accidents and unpermitted emissions, and even nuisance-type conditions and social and economic impacts. Statutes regulating air, water, and land disposal made quick nods to EPA's authority to, *inter alia*, condition permits with "such additional measures as the Administrator may reasonably prescribe";[84] ensure that new source performance standards avoid "caus[ing] or contribut[ing] to an unreasonable risk";[85] weigh costs and benefits of proposed facility sitings, including "social costs imposed as a result of . . . location, construction, or modification";[86] incorporate "requirements that minimize, on a site-specific basis . . . potential risks";[87] include the right to "at reasonable

79. David Taylor, *Talking Trash: The Economic and Environmental Issues of Landfills,* 107 ENVTL. HEALTH PERSP. A404, A405 (1999).

80. *See* 42 U.S.C. § 6924(k).

81. 42 U.S.C. § 9604(c)(9)(A).

82. 42 U.S.C. § 6925(c)(3).

83. *See* Richard J. Lazarus & Stephanie Tai, *Integrating Environmental Justice into EPA Permitting Authority*, 26 ECOLOGY L.Q. 617, 660–63, 665–68 (1999); Memorandum from Gary S. Guzy, Gen. Counsel, to certain EPA Assistant Adm'rs (Dec. 1, 2000), http://www.epa.gov/environmentaljustice/resources/policy/ej_permitting_authorities_memo_120100.pdf. For an early argument for more expansive use of existing statutory authories, see Eileen Gauna, *Major Sources of Criteria Pollutants in Nonattainment Areas: Balancing the Goals of Clean Air, Environmental Justice, and Industrial Developments*, 3 HASTINGS W.-N.W. J. ENVTL. L. & POL'Y 379, 392–95 (1996).

84. 42 U.S.C. § 7509(d)(2).

85. 42 U.S.C. § 7411(j)(1)(A)(iii).

86. 42 U.S.C. § 7503(a)(5).

87. 42 U.S.C. § 7429(a)(3).

times have access to and copy any records, [and] inspect";[88] and determine penalties using "such other matters as justice may require."[89] An inventory of these clauses reads like a hidden substrate of environmental law, a blueprint for limiting the law's distributional effects.

The federal government recently finalized such an inventory, *Plan EJ 2014 Legal Tools* (hereinafter *Legal Tools*).[90] It is a companion to EPA's strategic plan, which follows previous administrations in making the pursuit of environmental justice a priority.[91] *Legal Tools* scours federal code for hints of discretion, similar to RCRA's omnibus clause.[92] There continues to be no federal legislation specifically addressed to the distributional effects of environmental law. Therefore, *Legal Tools* is the most thorough answer to date to a question posed by Executive Order 12898 twenty years prior: what is the "greatest extent practicable and permitted by law" to which EPA can mitigate or correct for distributional effects?[93] This question is particularly relevant to fenceline communities. They bear the brunt of disposal practices. They also stand to benefit most from *Legal Tools*, which builds on prior, more modest inventories that sought to influence siting and permitting decisions and conditions near facilities.[94]

This blueprint is the product of a nearly twenty-year effort by EPA, first enshrined in the Executive Order, to exercise existing legal authority, and make environmental justice a part of the mission of federal agencies. The Executive Order sets out numerous goals, chief among them: (1) integrating environmental justice into the core design of agency programs, policies, and activities (PPAs), by adopting strategic plans, identifying disproportionately high and adverse human health and environmental effects on low-income and minority populations, and evaluating the effects of PPAs on those communities;[95] and (2) ensuring that recipients of federal funds comply with Title VI of

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88. 33 U.S.C. § 1318(a)(B)(ii).

89. 33 U.S.C. § 1319(g)(3).

90. U.S. EPA, PLAN EJ 2014: LEGAL TOOLS (Dec. 2011), http://www.epa.gov/environmentaljustice/resources/policy/plan-ej-2014/ej-legal-tools.pdf [hereinafter LEGAL TOOLS].

91. *See, e.g.*, Memorandum from Christine Todd Whitman, EPA Adm'r, to certain EPA Adm'rs, Officers, and Dirs. (Aug. 9, 2001), http://www.mde.state.md.us/assets/document/environmental_justice/ejreport01/ej_2001_Annual_Report_partE.pdf.

92. LEGAL TOOLS, *supra* note 90, at 2.

93. Exec. Order No. 12,898, 59 Fed. Reg. 7,629, 7,629 (Feb. 16, 1994).

94. *See, e.g.*, Lazarus & Tai, *supra* note 83, at 625–26; Memorandum from Guzy to Assistant Adm'rs, *supra* note 83.

95. Exec. Order No. 12,898, 59 Fed. Reg. at 7,629–30.

the Civil Rights Act of 1964.[96] These goals were restated in agency memoranda in 2001 and 2005, along with calls by multiple administrators for senior managers to integrate environmental justice into all PPAs.[97] They were repeated in *Plan EJ 2014*.[98] The first strategic plan appeared shortly after the Executive Order was issued,[99] followed by an implementation plan that quantified some of its goals.[100] Another draft strategic plan was prepared in 2005, responding to the administration's attempts to deemphasize race as a basis for decision-making.[101] EPA's Title VI regulations were adopted in 1973,[102] and hundreds of administrative complaints were filed with the agency in the decades that followed.[103]

These twin objectives received a lot of attention. What is lost in the commentary is an explanation for how, decades after the first Title VI administrative complaint was filed, they failed to improve environmental quality in environmental justice communities. For the remainder of this Part, I complete the evolution of *Plan EJ 2014* from earlier efforts to meet the first goal: making environmental justice a part of core agency missions and considering it as part of PPAs. Then, I look at how EPA recently resolved two Title VI complaints in California. I show that, despite EPA's efforts to better integrate environmental justice into daily operations, there is a greater barrier to meeting the goals of the Executive Order than the extent of agency planning, budgeting, measurement, and evaluation. A community of practice, whose work spans EPA's Office of Civil Rights (OCR) and Office of

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96. *See* Memorandum from President William J. Clinton for the Heads of all Dep'ts and Agencies, 30 Wkly. Compilation of Presidential Documents 279, 279–80 (Feb. 11, 1994).

97. Memorandum from Stephen Johnson, EPA Adm'r, to certain EPA Admr's, Officers, and Dirs. (Nov. 4, 2005), http://www.epa.gov/environmentaljustice/resources/policy/admin-ej-commit-letter-110305.pdf; Memorandum from Christine Todd Whitman, *supra* note 91.

98. U.S. EPA, PLAN EJ 2014, at i (Sept. 2011), http://www.epa.gov/environmentaljustice/resources/policy/plan-ej-2014/plan-ej-2011-09.pdf [hereinafter PLAN EJ 2014].

99. U.S. EPA, THE EPA'S ENVIRONMENTAL JUSTICE STRATEGY (1995), http://www.epa.gov/environmentaljustice/resources/policy/ej_strategy_1995.pdf [hereinafter STRATEGY EJ 1995].

100. U.S. EPA, 1996 ENVIRONMENTAL JUSTICE IMPLEMENTATION PLAN (1996), http://www.epa.gov/compliance/ej/resources/policy/implementation_plan_ej_1996.pdf [hereinafter 1996 IMPLEMENTATION PLAN].

101. *See* Environmental Justice Strategic Plan Framework and Outline, 70 Fed. Reg. 36,168 (June 22, 2005).

102. Nondiscrimination in Programs Receiving Federal Assistance from the EPA—Effectuation of Title VI of the Civil Rights Act of 1964, 38 Fed. Reg. 17,968, 17,968–72 (July 5, 1973) (codified as amended at 40 C.F.R. pt. 7 (2014)).

103. *See* U.S. EPA, TITLE VI COMPLAINTS LISTING PURSUANT TO RNA SETTLEMENT AGREEMENT (2011), http://www.epa.gov/civilrights/docs/extcom/2012_04_title_vi_open-complaints.pdf.

Research and Development (ORD), is organized around an enduring set of procedures that limit the use of existing legal authority when Title VI complaints are processed. These procedures are revealed in agency documents pertaining to complaints such as *Padres Hacia Una Vida Mejor* and *Angelita C.*[104] They influence how EPA determines jurisdiction, prima facie violations, settlement provisions, proposed remedies, and, most importantly, the actual boundaries of the communities that file complaints. This is true despite the fact that EPA is charged with the full "[a]pplication of these existing statutory provisions" to pursue environmental justice.[105]

Plan EJ 2014 caps twenty years of strategic planning at EPA. It speaks to the primary goals of the Executive Order, namely integration of environmental justice concepts and addressing Title VI violations.[106] Underlying an impressive set of documents is an uneasy sense that real environmental improvements remain beyond the reach of programmatic integration or the processing of complaints. This is clear in EPA Office of Inspector General (OIG) reports,[107] and in Government Accountability Office (GAO) evaluations of the plan.[108] Environmental justice cannot be integrated into agency PPAs if EPA has not (a) identified, with some precision, the "low-income, minority" communities it wants to target (leaving inconsistencies across EPA regions and conflicting ways to identify target communities); (b) identified PPAs that are subject to the Executive Order; and (c) agreed on a meaning of "disparate impact" or directed its offices to determine whether PPAs have disproportionately high or adverse effects on low-income, minority communities.[109]

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104. *See* Complaint Under Title VI of the Civil Rights Act of 1964, Padres Hacia Una Vida Mejor v. Laidlaw, Inc., No. 01R-95-R9 (1994) [hereinafter Padres Complaint]; Complaint Under Title VI of the Civil Rights Act of 1964, Angelita C. v. Cal. Dep't of Pesticide Regulation, No. 16R-99-R9 (1999) [hereinafter Angelita C. Complaint].

105. *See* Memorandum from President William J. Clinton for the Heads of all Dep'ts and Agencies, *supra* note 96, at 280.

106. PLAN EJ 2014, *supra* note 98, at i.

107. *See* OFFICE OF THE INSPECTOR GEN., U.S. EPA, REPORT NO. 2004-P-00007, EVALUATION REPORT: EPA NEEDS TO CONSISTENTLY IMPLEMENT THE INTENT OF THE EXECUTIVE ORDER ON ENVIRONMENTAL JUSTICE (2004), http://www.epa.gov/oig/reports/2004/20040301-2004-P-00007.pdf; OFFICE OF THE INSPECTOR GEN., U.S. EPA, REPORT NO. 2006-P-00034, EPA NEEDS TO CONDUCT ENVIRONMENTAL JUSTICE REVIEWS OF ITS PROGRAMS, POLICIES, AND ACTIVITIES (2006), http://www.epa.gov/oig/reports/2006/20060918-2006-P-00034.pdf [hereinafter INSPECTOR GENERAL REPORT].

108. *See, e.g.*, U.S. GOV'T ACCOUNTABILITY OFFICE, ENVIRONMENTAL JUSTICE: EPA NEEDS TO TAKE ADDITIONAL ACTIONS TO HELP ENSURE EFFECTIVE IMPLEMENTATION (2011), http://www.gao.gov/assets/590/585654.pdf.

109. INSPECTOR GENERAL REPORT, *supra* note 107, at 17.

Earlier EPA strategic plans were simpler but more ambitious. For example, the 1996 Environmental Justice Implementation Plan proposed greater use of a national relocation policy as part of remedial actions in fenceline communities.[110] It set a goal of securing wastewater services in twenty-four communities.[111] It included early efforts to assess the cumulative impact of dozens of pollutants across multiple pathways.[112] It called for demographic information gathering near every Superfund site.[113] It focused on how to review community-specific impacts near permitted hazardous waste facilities.[114] It developed an enforcement approach similar to the National Enforcement Initiatives model in *Plan EJ 2014*.[115] It encouraged cross-agency work by setting a goal of routinely reviewing federal actions for compliance under the National Environmental Policy Act and the Clean Air Act.[116] It inventoried major data systems used to identify affected communities in order to find information gaps.[117] It relied on community-based programs to achieve its goals.[118] Perhaps most impressively, the 1996 plan included performance measures. By comparison, *Plan EJ 2014* calls for "deliverables" and "milestones."[119] For example, it might track "completed guidance" rather than whether ideas in the guidance are implemented, their reliability, linkages to PPAs, or other measures. *Plan EJ 2014* uses words such as "incorporating" or "considering" rather than "ensuring" or "evaluating."[120] By comparison, the 1996 plan developed clear measures of progress, such as "10% of the Agency's regulatory packages that identify and address environmental justice concerns" or "reduce complaint processing time by 10%" or "20% of enforcement cases and/or compliance activities that are initiated or completed involve minority communities and/or low-income communities."[121]

This is not to suggest that *Plan EJ 2014* simply repeats the focus of the 1996 plan and other past work. The new plan addresses long-term health, defines "fair treatment" as the distribution of burdens as well as benefits, identifies new areas for

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110. 1996 IMPLEMENTATION PLAN, *supra* note 100, at 6.

111. *Id.* at 8.

112. *Id.* at 13.

113. *Id.* at 7.

114. *Id.* at 11.

115. *Compare id.* at 22, *with* PLAN EJ 2014, *supra* note 98, at 59–60.

116. 1996 IMPLEMENTATION PLAN, *supra* note 100, at 23.

117. *Id.* at 14.

118. *Id.* at 8–9, 11, 13.

119. PLAN EJ 2014, *supra* note 98, at 6.

120. *Compare id.* at 33, 41, *with* 1996 IMPLEMENTATION PLAN, *supra* note 100, at 10, 21–22.

121. *See* 1996 IMPLEMENTATION PLAN, *supra* note 100, at 21, 24–25.

targeted enforcement such as Concentrated Animal Feeding Operations, broadens the definition of "sound science" discussed in the 1996 plan, and reiterates the need to build on the 2003 Framework for Cumulative Risk Assessment.[122] It also rescues projects that were previously lost among broader planning initiatives, such as how to include environmental justice concerns in rulemaking.[123]

Plan EJ 2014's greatest innovation is the simple passage of time: the documents are a study in scaling up, of compiling the agency's prior experience with issues. Literature reviews, lists of "existing and needed tools," and "replicable elements of successful Agency community-based programs" populate its pages.[124] Performance measures are lacking, key terms remain undefined (in fact, EPA had difficulty tracking American Reinvestment and Recovery Act funds used in low-income, minority communities because it could not define them),[125] and the plan does not move appreciably toward understanding the drivers and causes of changes to quality of life. But *Plan EJ 2014* builds on earlier documents and expands their scope. This is particularly true with regards to EPA's legal authority to address community-specific impacts.

Legal Tools goes beyond earlier inventories, such as former General Counsel Gary Guzy's December 2000 memorandum. RCRA's omnibus clause, the Clean Air Act's focus on ambient standards with an "ample margin of safety," and reasonable access and inspection under the Clean Water Act are once again discussed, but so are a wide range of statutes such as the Toxic Substances Control Act, Safe Drinking Water Act, and Federal Insecticide, Fungicide, and Rodenticide Act.[126] *Legal Tools* marks the height of the administrative state's awareness of its ability to pursue environmental justice. How does this awareness inform EPA actions? We turn to the second major goal in the Executive Order: vigorous enforcement of Title VI.

B. Constructing the Fenceline: Title VI Enforcement

EPA's Title VI program is the last line of defense for communities facing the distributional impacts of environmental

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122. PLAN EJ 2014, *supra* note 98, at 3, 12, 108, 116.

123. *See* U.S. EPA, PLAN EJ 2014: INCORPORATING ENVIRONMENTAL JUSTICE INTO RULEMAKING (Sept. 2011), http://www.epa.gov/environmentaljustice/resources/policy/plan-ej-2014/plan-ej-rulemaking-2011-09.pdf.

124. *See* PLAN EJ 2014, *supra* note 98, at 11, 16.

125. OFFICE OF THE INSPECTOR GEN., U.S. EPA, REPORT NO. 11-R-0208, EVALUATION REPORT: EPA FACED MULTIPLE CONSTRAINTS TO TARGETING RECOVERY ACT FUNDS (2011), http://www.epa.gov/oig/reports/2011/20110411-11-R-0208.pdf.

126. LEGAL TOOLS, *supra* note 90, at 7–8, 34, 40, 46–48, 57, 67.

laws. Billions of dollars are distributed to dozens of programs run by thousands of federal fund recipients, including most state and regional siting and permitting agencies. If a community wants to challenge a decision by one of these recipients that leads to discriminatory effects (programmatic challenges are exceedingly difficult),[127] it has few options. Two of them work under narrow, perhaps only theoretical, circumstances: claims regarding violations of the Equal Protection Clause of the U.S. Constitution, and a private right of action under section 601 of Title VI of the Civil Rights Act of 1964.[128] A third option requires submitting an administrative complaint to EPA under regulations issued according to section 602 of Title VI, and showing that actions by a recipient resulted in discriminatory effects.[129] EPA regulations require that it use "any means authorized by law" to obtain compliance with the statute.[130] This is the rare agency mandate to use existing authorities to address conditions at the fenceline. If ever the mass of text gathered in *Legal Tools* would find its expression, it would be in response to administrative complaints filed by representatives of these communities.

EPA's program began unceremoniously in 1973 when the agency issued regulations under Title VI prohibiting activities that result in discriminatory effects.[131] The program is routinely criticized for its severe inertia.[132] I will not repeat its history or extensive critiques here. My focus is EPA's recent attempt to reinvigorate a program that lay dormant for twenty years, developed a crushing complaint backlog—some of which floundered (or was lost) in bankers boxes—and failed to make a prima facie finding until 2011. That year, EPA contracted with Deloitte Consulting LLP to evaluate its civil rights programs, "to determine the extent to which the structure, policies, procedures, and resources of [EPA's] Office of Civil Rights facilitate

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127. *See e.g.*, Norton v. S. Utah Wilderness All., 542 U.S. 55, 64–67 (2004); Plaintiffs' Supplemental Brief in Opposition to Defendants' Motion to Dismiss on Mootness Grounds at 6–7, Padres Hacia Una Vida Mejor v. Jackson, No. 1:11-cv-01094-AWI-DLB (E.D. Cal. Apr. 6, 2012).

128. *See, e.g.*, U.S. COMM'N ON CIVIL RIGHTS, NOT IN MY BACKYARD: EXECUTIVE ORDER 12,898 AND TITLE VI AS TOOLS FOR ACHIEVING ENVIRONMENTAL JUSTICE 29 & n.1 (2003), http://www.usccr.gov/pubs/envjust/ej0104.pdf (quoting Goodwin v. Wyman, 330 F. Supp. 1038, 1040 n.3 (S.D.N.Y. 1971)).

129. *See* Civil Rights Act of 1964 § 602, 42 U.S.C. § 2000d-1 (2012); 40 C.F.R. § 7.35(b), (c) (2014).

130. 40 C.F.R. § 7.130(a).

131. U.S. EPA, Effectuation of Title VI of the Civil Rights Act of 1964, 38 Fed. Reg. 17,968 (July 5, 1973) (codified as amended at 40 C.F.R. pt. 7 (2014)).

132. *See, e.g.*, Tseming Yang, *The Form and Substance of Environmental Justice: The Challenge of Title VI of the Civil Rights Act of 1964 for Environmental Regulation*, 29 B.C. ENVTL. AFF. L. REV. 143, 158–61 (2002).

accomplishment of EPA's . . . equal opportunity mission."[133] Having interviewed and focus-grouped more than one hundred agency staff, Deloitte identified several internal management challenges: lack of mission clarity, leadership turnover, poor quality work product, and the need for clearly defined staff positions.[134] In response, EPA developed a Model Civil Rights Program in 2012, keyed to the Deloitte challenges. EPA's proposals mirror the Deloitte report and focus on procedural and structural changes to the Title VI program. In the wake of the report, they are subject to their own implementation plan.[135]

While *Plan EJ 2014* inventories and expands EPA awareness of its authority to address community-specific impacts, the above reforms ignore a longstanding practice-based defect in how EPA responds to disparate impact claims. The history of Title VI is one of citizens filing administrative complaints that, when not dismissed quickly for procedural defects, are stripped of the lived experience of impacts through a series of "step-wise" moves. What remains is scrutinized according to a narrow interpretation of whether the diminished "impact" can be addressed using existing environmental laws.

This approach appears in EPA's *Draft Revised Guidance for Investigating Title VI Administrative Complaints Challenging Permits* (hereinafter *Draft Revised Guidance*), the most recent written guidance on EPA investigation of Title VI complaints.[136] The environmental justice movement is a response to the "success" of environmental laws in shifting risks to fenceline and other vulnerable communities.[137] By comparison, use of the *Draft Revised Guidance* has encouraged strict adherence to the same laws that allowed disparate impacts to accumulate. While EPA strategic planning documents claim that "no segment of the population" should "suffer[ ] disproportionately,"[138] a community of practice that implements the *Draft Revised Guidance* must first construct the geographic extent of that population.[139] In so doing, actions such as siting a facility in an

133. DELOITTE CONSULTING LLP, FINAL REPORT: EVALUATION OF THE EPA OFFICE OF CIVIL RIGHTS 6 (2011).

134. *Id.* at 7, 16–18.

135. CIVIL RIGHTS EXEC. COMM., U.S. EPA, RECOMMENDATIONS FOR DEVELOPING A MODEL CIVIL RIGHTS PROGRAM AT THE ENVIRONMENTAL PROTECTION AGENCY 7 (2012).

136. Draft Revised Guidance for Investigating Title VI Administrative Complaints Challenging Permits (Draft Revised Investigation Guidance), 65 Fed. Reg. 39,650 (proposed June 27, 2000) [hereinafter Draft Revised Guidance].

137. *See* Luke W. Cole, *Empowerment as the Key to Environmental Protection: The Need for Environmental Poverty Law*, 19 ECOLOGY L.Q. 619, 628–30 (1992).

138. STRATEGY EJ 1995, *supra* note 99.

139. Draft Revised Guidance, 65 Fed. Reg. at 39,653.

already overburdened community come to be viewed as acceptable.

The most notorious Title VI complaint to date is the first processed under an early version of the guidance. *Select Steel* involved a steel recycling mini-mill sited near Flint, Michigan. More important for EPA, it was located in "Air Quality Control Region 122."[140] Under the Clean Air Act, criteria air pollutants such as sulfur dioxide are regulated according to national ambient air quality standards, or NAAQS.[141] The states take the lead to meet these requirements, designating air quality control regions (AQCRs) and determining whether each is in attainment with the NAAQS for each pollutant.[142] Within AQCRs that are in "non-attainment" of those standards, facilities are subject to additional controls, such as technology-based and offset requirements, particularly if they emit more than a certain amount of the pollutant each year.[143]

The *Select Steel* decision refers to pollutants that the facility will release as "not significant," because they were not at levels that triggered the additional requirements.[144] A new facility in a fenceline community might release thirty-two tons per year of volatile organic compounds. But because the amount is less than the 100 tons per year that trigger certain requirements, the pollutant is "not significant." Generally, the *Draft Revised Guidance* states that where an area in question attains a NAAQS, "the air quality in the surrounding community will generally be considered presumptively protective" and emissions of that chemical are not treated as "adverse" under Title VI analysis.[145] This presumption ignored the fact that a NAAQS, which is set for an AQCR the size of a county or metropolitan area, can be achieved even though (a) some "hot spots" in the region will experience higher concentrations; (b) there are numerous documented health effects caused by concentrations below the NAAQS; and (c) the standard does not account for accidents and departures from normal operating conditions, or the cumulative risk of the new facility's emissions once they are added to other area facilities.

140. *See* Letter from U.S. EPA, Office of Civil Rights, to Father Phil Schmitter, Co-Dir., St. Francis Prayer Ctr., Sister Joanne Chiaverini, Co-Dir., St. Francis Prayer Ctr., and Russell Harding, Dir., Mich. Dep't of Envtl. Quality 13 (Oct. 30, 1998) [hereinafter Select Steel Decision]. For historical context of the *Select Steel* decision, including the evolution of EPA's *Draft Revised Guidance*, see Eileen Gauna, *EPA at 30: Fairness in Environmental Protection*, 31 ENVTL. L. REP. 10528, 10549–45 (2001).

141. 42 U.S.C. §§ 7401–7431 (2012).

142. 42 U.S.C. § 7407.

143. 42 U.S.C. §§ 7501–7515.

144. *See* Select Steel Decision, *supra* note 140, at 29.

145. Draft Revised Guidance, 65 Fed. Reg. at 39,680.

The *Select Steel* decision also considers dioxin a hazardous air pollutant. Hazardous air pollutants are regulated using a different, technology-based approach under the Clean Air Act.[146] The proposed facility in *Select Steel*, according to the federal fund recipient that issued its operating permit, emits considerable amounts of dioxin.[147] But because steel recycling mini-mills were no longer listed among the facility categories under section 112 of the CAA, dioxin was "not expected to be regulated" under the statute.[148] Therefore, any amount of dioxin dispersed into residential areas could not be "adverse," and therefore could not lead to a Title VI violation.

A third example involves body burden in the form of elevated blood lead levels. The federal fund recipient's own biokinetic model showed that higher blood lead levels would result from Select Steel's operation.[149] But because the concentration of lead in the air, predicted using dispersion models, fell below the existing NAAQS for lead, there was no "adversity," and therefore nothing to remedy under the civil rights statute.[150]

By now, it should be clear that the *Draft Revised Guidance* is far removed from the risks that are imposed on citizens living near the fenceline. Perhaps the most jarring aspect of the analysis is its focus not on *stressors*, broadly defined, that are caused by a facility cluster or the addition of an intensive land use to an existing cluster, but a handful of chemicals and whether they exceed existing (if any) standards. In the case of a new facility in a county that is in attainment with a NAAQS, this can be a theoretical impossibility.

The narrowing of a complaint happens according to a "step-wise" analysis.[151] The step-wise approach makes a series of "cuts" to a complaint, to determine whether there are any "adverse" impacts of a decision, such as the issuance of a permit, made by a federal fund recipient such as a state's Department of Environmental Quality. At each step, a sizable portion of potential Title VI complaints is dismissed for lack of "adversity."[152] Note that the *Draft Revised Guidance* converts disproportionate exposure to environmental harms or risks to "adverse," "disparate" impacts that are "significant" and for which there is no reasonable necessity.[153] Given EPA's focus

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146. *See* 42 U.S.C. § 7408.
147. Select Steel Decision, *supra* note 140, at 24–25.
148. *Id.* at 24.
149. *Id.* at 20, 22.
150. *Id.* at 2, 4, 22.
151. Draft Revised Guidance, 65 Fed. Reg. at 39,676.
152. *Id.* at 39,676–79.
153. *Id.* at 39,676–83.

on a narrow construction of "adversity," complaints are often dismissed before the level of disparity of an impact is considered.

Select Steel was decided more than fifteen years ago. How does EPA process a Title VI complaint today? For evidence, we turn to complaints filed on behalf of communities in central California. The first is *Padres Hacia Una Vida Mejor*, a complaint filed in December 1994 and dismissed in 2012.[154] This is a classic environmental justice complaint, featuring a dozen recipients of federal funds engaged in the facility siting process.[155] The siting system subjects fenceline communities to ongoing discrimination, in the form of, for example, "100% of the toxic waste disposed . . . in landfills in California . . . dumped in or near low-income, Latino communities."[156] The complaint and the EPA OCR Investigative Report paint very different pictures of the risks posed by hazardous waste facilities. The complainants describe existing impacts, which are worsened by each decision to site or allow the operation, modification, or expansion of a facility, including "air pollution, pesticide poisonings, lead poisoning, groundwater contamination" as well as depressed property values and stigma.[157] The impacts are presented in light of the limited coping resources, such as health care and mobility, of residents of Kettleman City, Buttonwillow, and Westmoreland.[158] The pattern of discrimination implicates numerous federal fund recipients that propose, locate, permit, and operate facilities in an "integrated process"[159] that yields a host of impacts as well as risks such as off-site releases, accidental releases on-site, and inadequate emergency response.[160]

EPA's Investigative Report, released eighteen years later, spans 147 pages. Most are devoted to constructing, rather than policing, a fenceline boundary. The report takes the systemic production of risk described in the complaint and, echoing OCR's work in *Select Steel*, recasts it as discrete "acts."[161] Most of the isolated acts are then removed from consideration. While the document begins with a demand that recipients "ensur[e] that the issuance of their environmental permits does not have

154. Padres Complaint, *supra* note 104; *see* Padres Hacia Una Vida Mejor v. Jackson, 922 F. Supp. 2d 1057, 1059 (E.D. Cal. 2013).

155. Padres Complaint, *supra* note 104, at 1–2.

156. *Id.* at 2.

157. *Id.* at 3–4.

158. *Id.* at 5.

159. *Id.* at 6.

160. *See* OFFICE OF CIVIL RIGHTS, U.S. EPA, INVESTIGATIVE REPORT FOR TITLE VI ADMINISTRATIVE COMPLAINT, FILE NO. 01R-95-R9, at 10 (2012).

161. *See id.* at 24–25.

discriminatory effects,"[162] it immediately turns to the relationship between the geographic expansion of risk and its anticipation by "relevant environmental laws."[163] The only party to survive OCR's jurisdictional analysis, the Department of Toxic Substances Control (DTSC), administers a hazardous waste program that "meets minimum federal criteria" under RCRA.[164] Why? Because its permit modifications, which expanded the operational area of landfills hundreds of acres, did so within existing boundaries of the landfills.[165] OCR next considered whether any of the community impacts described in the complaint were "cognizable under a recipient's authority."[166]

OCR asked DTSC to clarify its authority with respect to the alleged impacts, such as nuisances, risks of accidental releases, and increased air pollution on-site and off-site. EPA determined that the impacts were "not within DTSC's authority to regulate," with a small number of exceptions.[167] Modeled health risks from off-site releases relied on "risk management values consistent with prior EPA decisions," meaning "adverse" impacts would require something greater, perhaps much greater, than those values.[168] Some emissions, such as ozone precursors, could not "produce a discernible change in ozone concentrations" unless they substantially increased.[169] A step-wise process similar to the one used in *Select Steel* is introduced and used only in part, because the risk management values calculated by DTSC and reviewed by OCR led it to declare that the recipient's decisions were not "adverse."[170] Disparity, significance of disparity, justification, and other steps were not considered.

Nor were the considerable authorities available under RCRA to address site- and location-specific impacts through the administration of a hazardous waste program considered. Despite OCR's awareness of the provisions, they did not inform its analysis. Hence, the systemic, ongoing introduction of multiple environmental stressors to Latino communities in the form of siting, operation, and expansion of hazardous waste disposal sites was reduced to a handful of modeling exercises regarding acceptable risk at preexisting fencelines at a single moment in time.

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162. *Id.* at 11–12.
163. *Id.* at 12.
164. *Id.* at 12–13.
165. *See id.* at 17.
166. *Id.* at 69.
167. *Id.* at 70.
168. *See id.* at 122.
169. *See id.* at 113.
170. *Id.* at 37–39, 70–122.

Another Title VI complaint, *Angelita C.*, did result in a preliminary finding of adversity.[171] It is unfortunate that a settlement between EPA and the fund recipient did not include a commitment to reduce any of the risks posed by a dangerous pesticide.[172] But the case is instructive. It shows the lengths to which the Center on Race, Poverty, and the Environment and California Rural Legal Assistance had to go to fit their clients' lived experience into a narrative that could survive OCR's boundary work. First, we notice that much is removed from that experience before the complaint is finalized. The complaint singles out one respondent, the California Department of Pesticide Regulation (CDPR).[173] It takes pains to demonstrate that the impacts it describes are "cognizable under the recipient's authority,"[174] including its authority to issue permits for methyl bromide (MeBr), a highly toxic pesticide whose use is banned in many parts of the world. The complaint presents a narrow geographic construction of impacts caused by MeBr and other toxic pesticides, which can volatize and drift beyond restricted application zones to residential areas.[175] It surveys the scientific literature for levels of exposure to MeBr that lead to negative health effects, the range of proposed and established health-protective standards for MeBr exposure, and the range of proposed and established buffer zones for MeBr (the distance between its application and a population that is considered protective).[176] It focuses only on children, due to their increased vulnerability to health effects of MeBr.[177] And it focuses only on MeBr application near the public schools they attend.[178]

The *Angelita C.* complaint is an expert maneuver through the step-wise moves OCR uses to define a potentially "disparately impacted" area and process claims of discriminatory effects. It focuses on a discrete act by one agency involving one pesticide. It defines the impacted population as children attending public

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171. *See* Letter from Rafael DeLeon, Dir., U.S. EPA, Office of Civil Rights, to Christopher Reardon, Acting Dir., Cal. Dep't of Pesticide Regulation (Apr. 22, 2011) [hereinafter Angelita C. Preliminary Finding].

172. *See* Agreement Between Cal. Dep't of Pesticide Regulation and U.S. EPA, Angelita C. v. Cal. Dep't of Pesticide Regulation (Aug. 24, 2011) [hereinafter Angelita C. Settlement].

173. Angelita C. Complaint, *supra* note 104, at 1.

174. *Id.* at 8–13.

175. *See* JILL LINDSEY HARRISON, PESTICIDE DRIFT AND THE PURSUIT OF ENVIRONMENTAL JUSTICE 121–38 (2011) (discussing the effects of pesticide drift on residential areas).

176. Angelita C. Complaint, *supra* note 104, at 19–23, 24–29.

177. *Id.* at 2.

178. *Id.* at 29–30.

schools within 1.5 miles of the application of at least 35,000 pounds of MeBr over the course of a year.[179] And it accounts for the most conservative estimates of acute and chronic health effects and buffer zones necessary to protect children from exposure to MeBr.[180]

In response, after repeating a line from *Select Steel* and other Title VI decisions that "compliance with federal and/or state environmental regulations, does not, by itself, ensure compliance with Title VI," EPA tested the complaint for evidence of an exceedance of existing standards.[181] Its "adversity" analysis is a sprawling exposure assessment, regressing data from fourteen monitoring sites throughout the state, MeBr usage data, local weather patterns, and distance to predict MeBr concentrations over a seven-year period within one-square-mile blocks.[182] Schools with one or more predicted exposures above an existing standard were described as "affected," but not necessarily "adversely" affected.[183] Another, equally sophisticated assessment of "disparity" followed before adverse impacts were found.[184] EPA used algorithms to estimate the number of Latino and non-Latino children present at each school during each exceedance over a seven-year period. EPA then calculated the probability that Latino and non-Latino children would be affected by the exceedances.[185]

OCR issued a preliminary finding of a Title VI violation, the first of its kind, based on its analysis of children at six schools, for a pesticide that by its own analysis affected hundreds of thousands of children.[186] Meetings followed between OCR and CDPR "to discuss potential resolution of this matter."[187] They reached a settlement shortly thereafter. Once again, there is no evidence that OCR applied existing authorities to reduce impacts among an already artificially narrow subset of an impacted population. In fact, the settlement featured a commitment to carry out the same air-monitoring network used in OCR's Investigative Report, with the addition of a single monitoring station that also sampled for MeBr, once a week, through 2013.[188]

179. *Id.* at 29.
180. *Id.* at 34–35.
181. *See* Angelita C. Preliminary Finding, *supra* note 171, at 2.
182. *See* OFFICE OF CIVIL RIGHTS, U.S. EPA, EXPOSURE ASSESSMENT AND DISPARITY ANALYSIS FOR ADMINISTRATIVE COMPLAINT 16R-99-R9, at 10–15 (2011).
183. *See id.* at 52.
184. *See id.* at 25–33.
185. *Id.* at 52–53.
186. *See id.* at 3, 52.
187. *See* Angelita C. Preliminary Finding, *supra* note 171, at 5.
188. Angelita C. Settlement, *supra* note 172, at 3–4.

Together, *Padres* and *Angelita C.* are the "cutting edge" of Title VI administrative enforcement. Yet as EPA's understanding of fenceline risks expands, and awareness of its authority to address them grows, its *Legal Tools* remain idle. This is largely because the extent of a "fenceline community," and its lived experience of a wide range of stressors, are artificially restricted in OCR's analysis before the *Legal Tools* can be usefully applied. Through step-wise analysis carried out by OCR with the help of staff at ORD, EPA has yet to apply discretionary authorities to either expand the number of impacts "cognizable under a recipient's authority" or the agency's available remedies, which its own regulations describe as "any other means authorized by law."[189] Having prioritized environmental justice at the start of the most recent administration, and identified expansive authority to pursue it at the fenceline, EPA remains, in this regard, a timid organization. OCR's step-wise analysis practices, their influence over the construction of "fenceline communities," and the durability of such institutional risk management tools over time, help explain the lack of administrative response to the distributional effects of environmental law over half a century.

II. NESTED BOUNDARIES

A. *Air Quality Near Oil and Gas Development Sites*

> There is a shocking lack of risk-based decision-making in all of this.[190]
>
> There's knowledge of exposure pathways, there's just not knowledge of exposure.[191]

Boundary work is not only the product of a community of practice within a single agency. Communities of practice organize around enduring institutions that span jurisdictions and drive the extent to which issues such as pollution control are pursued at the appropriate geographic scale. Here we consider another seemingly intractable issue, the public health impacts of "fracking." The impacts defy casual summary, despite countless attempts in law review articles.[192] I will not engage in similar back-of-the-envelope

189. 40 C.F.R. § 7.130(a) (2014).

190. Interview with Envtl. Health Scientist (Apr. 7, 2014) (on file with author).

191. Interview with Regulatory Official (Apr. 3, 2014) (on file with author).

192. *See, e.g.*, Thomas W. Merrill & David M. Schizer, *The Shale Oil and Gas Revolution, Hydraulic Fracturing, and Water Contamination: A Regulatory Strategy*, 98 MINN. L. REV. 145, 179 (2013); Hannah Wiseman, *Untested Waters: The Rise of Hydraulic*

cost-benefit balancing here. Rather, I look at a single, central issue in oil and natural gas regions—air quality—to show how the boundary work of multiple communities of practice can limit environmental protection.

"Fracking" and its trade proxy for hydraulic fracturing, "fracing,"[193] are terms that effectively steer debates in the legal literature and popular press. They are not used here. Hydraulic fracturing is a well stimulation technique that accounts for a small portion of the lifecycle of a well.[194] It is not an accurate stand-in for operations that raise concerns about oil and gas, including preemption and local land use controls,[195] exemptions from statutes such as the CWA and the proper balance of cooperative federalism,[196] or available market and ex post liability solutions.[197]

Instead, I refer to unconventional fuels, including shale gas, tight gas, coalbed methane, and oil shale, and the systems that extract them. "Unconventional" reserves do not readily flow to the surface through a wellbore. Instead, they are widely dispersed among pores in tight sandstone, shale, and other geologic strata.[198]

Fracturing in Oil and Gas Production and the Need to Revisit Regulation, 20 FORDHAM ENVTL. L. REV. 115, 134–35 (2009).

193. *See, e.g.*, U.S. Patent No. 7,267,172 col. 10 l. 6 (filed Mar. 15, 2005) ("A method of petroleum production from at least one open hole in at least one petroleum production zone of an oil and/or gas well . . . selectively fracing through said plurality of sliding valves with fracing material . . . .").

194. For an overview of the lifecycle of an oil or gas well, see Christopher W. Moore et al., *Air Impacts of Increased Natural Gas Acquisition, Processing, and Use: A Critical Review*, 48 ENVTL. SCI. & TECH. 8349, 8350 (2014).

195. *See, e.g.*, Robert H. Freilich & Neil M. Popowitz, *Oil and Gas Fracking: State and Federal Regulation Does Not Preempt Needed Local Government Regulation*, 44 URB. LAW. 533 (2012); John R. Nolon & Steven E. Gavin, *Hydrofracking: State Preemption, Local Power, and Cooperative Governance*, 63 CASE W. RES. L. REV. 995 (2013); Hannah Wiseman, *Fracturing Regulation Applied*, 22 DUKE ENVTL. L. & POL'Y F. 361 (2012). In Colorado, preemption is shaped by two 1992 Colorado Supreme Court decisions that encouraged a case-by-case analysis of conflicts between state regulations and local controls. *See* Bd. of Cty. Comm'rs v. Bowen/Edwards Assocs., 830 P.2d 1045, 1060 (Colo. 1992); Voss v. Lundvall Bros., 830 P.2d 1061, 1064 (Colo. 1992).

196. *See, e.g.*, Hari M. Osofsky & Hannah J. Wiseman, *Dynamic Energy Federalism*, 72 MD. L. REV. 773 (2013); David B. Spence, *Federalism, Regulatory Lags, and the Political Economy of Energy Production*, 161 U. PA. L. REV. 431 (2013).

197. *See, e.g.*, David A. Dana & Hannah J. Wiseman, *A Market Approach to Regulating the Energy Revolution: Assurance Bonds, Insurance, and the Certain and Uncertain Risks of Hydraulic Fracturing*, 99 IOWA L. REV. 1523 (2014); Thomas W. Merrill, *Four Questions About Fracking*, 63 CASE W. RES. L. REV. 971 (2013).

198. *Glossary of Terms*, U.S. ENERGY INFO. ADMIN., http://www.eia.gov/tools/glossary/ (last visited Sept. 16, 2015); *see also* Dae Sung Lee et al., *A Critical Evaluation of Unconventional Gas Recovery from the Marcellus Shale, Northeastern United States*, 15 KSCE J. CIV. ENGINEERING 679, 681 (2011) (citing ROBERT C. MILICI & CHRISTOPHER S. SWEZEY, U.S. GEOLOGICAL SURVEY, ASSESSMENT OF APPALACHIAN BASIN OIL AND GAS RESOURCES: DEVONIAN SHALE 38–42 (2006)) (describing Marcellus shale gas as an "unconventional, or continuous, resource" because it "spans a large geographic area" rather than occur in a discrete trap).

They require intensive efforts to retrieve them, such as directional drilling (many kilometers underground and one or more kilometers horizontally through a formation), hydraulic fracturing (the use of millions of gallons of water mixed with sand and proprietary chemicals to open and ensure movement through source rock such as shale), and pyrolysis (underground heating, still largely an experimental practice).[199]

Air quality concerns arise as unconventional oil and gas (hereinafter UOG) drilling takes hold in a region. I focus on the response to this issue in Colorado. My findings are based on interviews with thirty-five federal, state, county, and municipal officials, environmental advocates, and industry representatives with a focus on the oil and gas sector in three areas: the Western Slope, Front Range, and San Juan River regions. The state was chosen for its history rooted in extractive industry,[200] its place among the most important sources of domestic fossil fuel reserves and production,[201] and its first-mover status in terms of research and regulation of UOG impacts.[202] Semi-structured interviews were conducted in person (n=30, average time=1.5 hours), recorded, and supplemented with archival searches and site visits. Interviews were transcribed and coded for regional UOG operations, impacts and potential root causes, past and ongoing

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199. *See* INNOVATIVE TECH., HYDROUS PYROLYSIS OXIDATION/DYNAMIC UNDERGROUND STRIPPING 1 (2000); Madelon L. Finkel & Adam Law, *The Rush to Drill for Natural Gas: A Public Health Cautionary Tale*, 101 AM. J. PUB. HEALTH 784, 784 (2011).

200. SUSAN UBBELOHDE, MAXINE BENSON & DUANE A. SMITH, A COLORADO HISTORY 336–39 (9th ed. 2006); Gary Harmon, *Energy Alley: The Series*, *Road of Riches*, DAILY SENTINEL (Grand Junction), Mar. 14, 2010, at 3.

201. In 2011, Colorado ranked 7th in the country for total energy production (2,747 trillion Btu of energy) and 5th in natural gas marketed production (1,637,576 million cubic feet). INST. ENERGY RESEARCH, COLORADO: AN ENERGY AND ECONOMIC ANALYSIS (2013), http://instituteforenergyresearch.org/wp-content/uploads/2013/09/State-Analysis-Colorado.pdf. The state's Front Range intersects one of the six largest shale plays in the U.S., the Niobrara Formation. *Id.*; ADAM SIEMINSKI, U.S. ENERGY INFO. ADMIN., OUTLOOK FOR U.S. SHALE (2014), http://www.eia.gov/pressroom/presentations/sieminski_01222014.pdf. Its Western Slope intersects the Piceance Basin, which holds one of the world's largest technically recoverable oil shale deposits. *Oil Shale*, INST. ENERGY RES., http://instituteforenergyresearch.org/topics/encyclopedia/oil-shale/ (last visited Sept. 16, 2015).

202. Proposed and active drilling sites in Colorado are the focus of the nation's first UOG health impact assessment (2009-2010) and peer-reviewed human health risk assessment (2012). Lisa M. McKenzie et al., *Human Health Risk Assessment of Air Emissions from Development of Unconventional Natural Gas Resources*, 424 SCI. TOTAL ENV'T 79, 85–86 (2012). Garfield County is home to one of the nation's most robust UOG air quality monitoring networks. Coalition of Energy Producing Attainment Counties, Rebuttal Statement to the Colorado Air Quality Control Commission on the Proposed Revisions to Regulation Numbers 3, 6, and 7 as It Relates to the Scheduled Oil and Gas Rulemaking Hearing February 19–21, 2014, at 2 (Jan. 30, 2014). Its air rules (2014) arguably lead the nation in terms of the comprehensiveness and stringency with which they address UOG emissions. *Id.*

efforts to characterize the extent of each impact, and attempts to mitigate impacts through technological, regulatory, and other means.

This Part presents the basic finding revealed in interviews: the disconnect between air-related symptoms reported as UOG sites cluster in a region, and the results of state and local efforts to investigate them. In the following Part, I review the work of two communities of practice, informal networks of agency and university atmospheric and environmental health scientists, in light of this tension. Their work includes analysis of monitoring data in the country's first health impact assessment and human health risk assessment devoted to UOG activity. Citizen complaints of acute and subchronic health symptoms and stressors such as noise, light, and vibrations raise a persistent question: does exposure to air emissions constitute a human health hazard for those living near UOG activity? Distinct communities of practice try to answer this question. They work with monitoring networks and emissions inventories to better account for new industry. Together, they limit the scale at which questions regarding air quality are addressed. After ten years and millions of dollars aimed specifically at UOG air emissions, Colorado regulators are still at a loss for what to tell the public.

In regions such as Colorado's Front Range, air quality has surpassed water contamination (e.g., produced water spills, leaks of drilling and hydraulic fracturing fluids, methane migration through cracks in well casings)[203] as a source of public concern.[204] It is among a number of impacts posed by UOG drilling, development, and production.[205] The growth of operations is

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203. For an overview of potential sources of water contamination near UOG operations, see Theo Colborn et al., *Natural Gas Operations from a Public Health Perspective*, 17 HUM. & ECOLOGICAL RISK ASSESSMENT 1039 (2011); Robert Jackson et al., *Increased Stray Gas Abundance in a Subset of Drinking Water Wells Near Marcellus Shale Gas Extraction*, 110 PROC. NAT'L ACAD. SCI. 11250 (2013).

204. Early dominance of water quality as an issue in Colorado was due to a variety of factors, including the secretive nature of drilling and hydraulic fracturing fluids injected underground, the dominance of agriculture in UOG regions and the need to ensure irrigation of ranch lands and healthy livestock, and the frequency of spills that could impact surface or groundwater. Interview with Cty. Official, in Boulder, Colo. (May 5, 2014) (on file with author). For an overview of threats to water quality from well completion at oil and gas sites, see U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-14-555, DRINKING WATER: EPA PROGRAM TO PROTECT UNDERGROUND SOURCES FROM INJECTION OF FLUIDS ASSOCIATED WITH OIL AND GAS PRODUCTION NEEDS IMPROVEMENT (2014), http://www.gao.gov/products/GAO-14-555.

205. UOG operations expose workers and residents to a range of physical (e.g., noise, light, and vibration), chemical (e.g., benzene, constituents in drilling and hydraulic fracturing fluids), radiological (e.g., technologically-enhanced, naturally-occurring radioactive material), and psychosocial stressors. For an overview of these and other stressors, see John L. Adgate, Bernard D. Goldstein & Lisa M. McKenzie, *Potential Public*

substantial. For example, shale gas production in the U.S. is forecast to rise from 5.0 to 13.6 trillion cubic feet by 2035.[206] Unconventional gas is projected to account for 80% of total natural gas production in the U.S. by that time; some of which will be exported.[207] The U.S. will become a net exporter of petroleum liquids by 2030, largely due to unconventional reserves such as tight oil.[208]

UOG sites migrate from one region to the next, driven by market price, accessibility of underground strata, and advances in drilling and well completion technology. The center of production shifts from coal bed methane in the San Juan River region (late '80s)[209] to tight gas in the Piceance Basin along the Western Slope (late '90s to mid-'00s)[210] to tight oil in the Niobrara Shale on the Front Range,[211] where 18,000 wells dot the landscape in Weld County alone (present day).[212] Boom-bust cycles overlay conventional drilling and UOG test sites.[213] The latter include experiments in *in situ* conversion, which speeds geologic time hundreds of years to coax organic material (kerogen) from shale deposits by raising subsurface temperatures hundreds of degrees.[214]

Health Hazards, Exposures and Health Effects from Unconventional Natural Gas Development, 48 ENVTL. SCI. & TECH. 8307, 8307–14 (2014); Seth B.C. Shonkoff, Jake Hays & Madelon L. Finkel, *Environmental Public Health Dimensions of Shale and Tight Gas Development*, 122 ENVTL. HEALTH PERSP. 787, 788–89, 793 (2014). For the need to consider physical and psychosocial stressors in the context of cumulative risk assessment, see Peter L. deFur et al., *Vulnerability as a Function of Individual and Group Resources in Cumulative Risk Assessment*, 115 ENVTL. HEALTH PERSP. 817 (2007).

206. U.S. ENERGY INFO. ADMIN., ANNUAL ENERGY OUTLOOK 2012 WITH PROJECTIONS TO 2035 (2012), http://www.eia.gov/forecasts/aeo/pdf/0383(2012).pdf.

207. U.S. ENERGY INFO. ADMIN., ANNUAL ENERGY OUTLOOK 2013 WITH PROJECTIONS TO 2040 (2013), http://www.eia.gov/forecasts/aeo/pdf/0383(2013).pdf.

208. *Id.*

209. Interview with Former Cty. Comm'r, La Plata Cty., in Durango, Colo. (Apr. 30, 2014) (on file with author).

210. Interview with Dir., Grassroots Org., in Grand Junction, Colo. (Apr. 28, 2014) (on file with author).

211. Interview with Cty. Official, *supra* note 204.

212. Sherilyn A. Gross et al., *Analysis of BTEX Groundwater Concentrations from Surface Spills Associated with Hydraulic Fracturing Operations*, 63 J. AIR & WASTE MGMT. ASSOC. 424, 426 (2013) ("During this time period, there were nearly 18,000 active wells in Weld County.").

213. *See* Jeffrey B. Jacquet & Richard C. Stedman, *The Risk of Social-Psychological Disruption as an Impact of Energy Development and Environmental Change*, 57 J. ENVTL. PLAN. & MGMT. 1285, 1289 (2013); Jeffrey Jacquet, *Energy Boomtowns and Natural Gas: Implications for Marcellus Shale Local Governments and Rural Communities* (Ne. Reg'l Ctr. for Rural Dev., Working Paper No. 43, 2009), http://aese.psu.edu/nercrd /publications/rdp/rdp43/view.

214. Adam R. Brandt, *Converting Oil Shale to Liquid Fuels: Energy Inputs and Greenhouse Gas Emissions of the Shell in Situ Conversion Process*, 42 ENVTL. SCI. TECH. 7489, 7489 (2008). For an earlier, more exuberant treatment of oil shale and its conversion,

Each wave of activity leaves unique artifacts in its wake. In La Plata County, coal seams burn and seeps emit hydrogen sulfide gas more than a decade after the beds were dewatered, which triggered what are now continuous accidents.[215] Battlement Mesa, a subdivision in Garfield County, was a retirement community after Exxon abandoned its race to commercial-scale oil shale production in 1982.[216] Thirty years later, it is the company town Exxon envisioned—tight gas wells at the border, and a proposal to drill 200 wells within the development, caused an exodus of retirees and an influx of workers.[217] As UOG moved from rural, high-desert lands in the west to populous areas along the Front Range near Denver, a diverse mix of cities drafted, and passed, moratoria keyed to the results of air emissions studies.[218]

The legacies differ by region. More common is the onset of intensive industrial activity, which generates a substantial number of citizen complaints:

> When we think of regulating industrial activity, we think of industrial parks and contemplate the best location to site this industry. We do this because we want to make sure that we are protecting people. And you can't do this with natural gas development. Natural gas development occurs wherever the resource is; because of this, we were continually seeing people's

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see Guy Mitchell, *Billions of Barrels of Oil Locked Up In Rocks*, 33 NAT'L GEOGRAPHIC 195 (1918).

215. Interview with Former Cty. Comm'r, *supra* note 209.

> Good luck trying to put out a coal seam fire. Once you pass a point, you're not putting it out. And that point is probably in the first 72 hours, and here we are 18 years later. The hydrogen sulfide seep started because of dewatering the formation; what would have to happen, you would have to re-stabilize or regain that natural equilibrium, so that you would then stop the seep. The same with up at the Pine River Ranches; you took the water off the coal, and gas did what gas does; it followed the path of least resistance up the outcrop to the atmosphere. So you would have to rehydrate the formation to stop the seep. You ought to hear the state's reasons for why they can't do that. One of the main reasons, because there's connectivity between where this is happening and groundwater aquifers, if they were to start reintroducing water at a lower level, that might impact the groundwater aquifers, and so better to let it vent to the air.

Id.

216. Interview with President, Citizens Org., in Parachute, Colo. (Apr. 1, 2014) (on file with author); Arnold Mackley et al., 32nd Annual Oil Shale Symposium: Oil Shale History Revisited (Oct. 15, 2012).

217. Interview with President, Citizens Org., *supra* note 216.

218. *See* Kristen Wyatt, *Three Front Range Cities Ban Hydraulic Fracturing*, DENVER POST (Nov. 6, 2013, 7:58 AM), http://www.denverpost.com/news/ci_24465840/3-front-range-cities-ban-hydraulic-fracturing (describing moratoria in Boulder, Fort Collins, and Lafayette); *Fracking Ban Wins on Recount, But Questions Linger*, DENVER POST (Dec. 4, 2013, 8:41 AM), http://www.denverpost.com/news/ci_24652199/fracking-ban-wins-recount-but-questions-linger (describing moratorium in Broomfield); Interview with President, Citizens Org., in Broomfield, Colo. (May 3, 2014) (on file with author); Interview with President, Envtl. Non-Profit Org., in Fort Collins, Colo. (May 2, 2014) (on file with author).

> homes being impacted. During that period of time such impact was escalating daily. People were reporting health issues such as, coughing up blood, nose bleeds, headaches and fainting, additionally parents were complaining that their kids were getting sick and their wells were being polluted. As an elected official, I recognized that we had a responsibility to really figure out what kind of impact [was] occurring.[219]
>
> Typically what would happen was a valve would stick open on a tank and when the gas is flowing the vent, it would be just venting raw gas—condensate or produced water tanks. And maybe they'd be a quarter mile or several hundred yards from someone's home, but depending on where their home was located, many times, homes were in draws, so the air flow would come down, and this is another thing we learned about the airshed out there was that valley being surrounded by high mountains, the airsheds at night the air would sink into the valleys and come down the river, and during the day the air would move up the river. When things heated up, it would go up toward Glenwood Springs and at night when things cooled down it would drain down to Parachute. The same thing happened coming out of the mountains, so draws, at night, the air would sink down into the draws, and there were people's homes down there, and if there were any issues in terms of emissions upstream, it would flow right to their homes.[220]

These concerns are expressed in citizen complaints to the Colorado Oil and Gas Conservation Commission (COGCC),[221] which holds express authority and numerous additional powers over the state's oil and gas industry.[222]

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219. Interview with Former Cty. Comm'r, Garfield Cty., in Glenwood Springs, Colo. (Apr. 1, 2014) (on file with author).

220. Interview with Regulatory Official, *supra* note 191.

221. For example, Garfield County has records for 370 complaints related to air quality between June 2003 and May 2009. This is notable as the county has little authority over air emissions from UOG activity. *See* CASSIE ARCHULETA & JOE ADLHOCH, AIR RES. SPECIALISTS, INC., DRAFT, AIR QUALITY MANAGEMENT IN GARFIELD COUNTY: COLORADO'S MOST ACTIVE ENERGY DEVELOPMENT REGION 3 (2009), http://www.garfield-county.com/air-quality/documents/ARS-RGI-Task3.pdf (prepared for Garfield County Public Health); GARFIELD CTY. PUB. HEALTH, PUBLIC HEALTH IMPROVEMENT PLAN GARFIELD COUNTY, COLORADO 2013–2017, at 6 (2013), http://garfield-county.granicus.com/MetaViewer.php?view_id=314&meta_id=29114 (discussing the County's lack of authority). Complaints report a variety of health symptoms, including acute and long-term neurological problems, respiratory concerns, headaches, nausea, and fatigue. One estimate from COGCC suggests 2,729 complaints to the agency for six issues related to UOG sites between 2001 and 2012. Matthew Lepore, Dir., Colo. Oil & Gas Conservation Comm'n, Presentation to the Northwest Colorado Oil and Gas Forum: New Setback and Groundwater Rules (Feb. 21, 2013), http://cogcc.state.co.us/Library/Presentations/NWForum20130221/COGCC_NewRules.pdf.

222. COLO. REV. STAT. § 34-60-106 (2013).

A primary response by regulators is to test air quality for a brief period of time. A state might sample ambient air near several wells over a three-month period in Erie, Colorado;[223] in the vicinity of two compressor stations, a tank farm, and a wastewater impoundment site over five weeks in southwestern Pennsylvania;[224] or by a single well in Ohio.[225] States also prepare air emissions inventories, based on estimates provided in minor source permits.[226] To date, the test results are presented as underwhelming. Below are agency findings from Colorado, Pennsylvania, and Arkansas, respectively.

> The air sampling results are consistent with what would be expected. Concentrations of likely oil and gas related compounds such as ethane and propane were found to be slightly higher at the Erie sites than in downtown Denver, but much lower than in Platteville where greater oil and gas activity is taking place. Similarly, methane levels at the Erie sites were consistent with other locations, and were higher than in Denver, and lower than in Platteville. Toluene and benzene levels were higher at one Erie monitor than the other, likely due to emissions from truck traffic. The monitored concentrations of benzene, one of the major risk driving chemicals, are well within acceptable limits to protect public health, as determined by the U.S. Environmental Protection Agency.[227]

> Short-term sampling did detect concentrations of certain natural gas constituents including methane, ethane and propane, and associated compounds such as benzene, in the air near Marcellus Shale drilling operations. Most of the compounds were detected during short-term sampling at two compressor stations in Greene and Washington counties. Certain compounds, mainly methyl mercaptan, were detected at levels which generally produce odors. Results of the limited ambient air sampling initiative conducted in the southwest region did not identify concentrations of any compound that would likely trigger air-related health issues associated with Marcellus Shale drilling activities.[228]

> Air monitoring was performed around the perimeter of six drilling sites, three hydraulic fracturing sites, four compressor

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223. COLO. DEP'T OF PUB. HEALTH & ENV'T, AIR EMISSIONS CASE STUDY RELATED TO OIL AND GAS DEVELOPMENT IN ERIE, COLORADO (2012).

224. PA. DEP'T OF ENVTL. PROT., SOUTHWESTERN PENNSYLVANIA MARCELLUS SHALE SHORT-TERM AMBIENT AIR SAMPLING REPORT (2010).

225. OHIO EPA, HYDRAULIC FRACTURING WELL PRELIMINARY AIR MONITORING ASSESSMENT (2014).

226. ARK. DEP'T OF ENVTL. QUALITY, EMISSIONS INVENTORY AND AMBIENT AIR MONITORING OF NATURAL GAS PRODUCTION IN THE FAYETTEVILLE SHALE REGION (2011).

227. COLO. DEP'T OF PUB. HEALTH & ENV'T, *supra* note 223, at i.

228. PA. DEP'T OF ENVTL. PROT., *supra* note 224, at ii–iii.

> stations, and one control site . . . . At all sites, concentrations of NO and NO_2 rarely exceeded the [monitor] detection limits . . . . The few times NO concentration did exceed the detection limit . . . , quality assurance measures indicated that the readings were erroneous due to instrument failure. At the hydraulic fracturing sites, compressor stations, and control site, VOC concentration was almost always below or near the [monitor] detection limits . . . .[229]

Drab text reveals the tension between citizen complaint and response. I will return to the tests shortly. First, I explore the roots of this tension, based on analysis of interviews with oil and gas officials. The divide between reported symptoms and state findings is a product of two factors: emissions data variability, and the nested communities of practice that use those data.

General knowledge of oil and gas emissions, such as the mass composition of unprocessed natural gas, has existed for some time.[230] Actual UOG emissions exhibit greater complexity. We can parse the life cycle of unconventional extraction as follows, using natural gas as an example: preproduction, natural gas production, transmission, storage, distribution, use, and well end-of-life.[231] Preproduction is further divided into well pad preparation, well drilling, and well completion.[232] Well completion includes completion transitions (concrete plugs installed to create separate hydraulic fracturing stages), hydraulic fracturing (the high-pressure injection of water, chemicals, and sand into a drilled well), and flowback (the return of hydraulic fracturing and geologic fluids, liquid hydrocarbons, and natural gas to the surface).[233]

Emissions vary by life cycle stage, meaning hazardous air pollutants (preproduction, production), volatile organic compounds (preproduction, production), particulate matter (preproduction), hydrogen sulfide (preproduction), methane (all stages), and other chemical concentrations depend on when an agency decides to measure them.[234] Unconventional reserves thus complicate the measurement problem. Some life cycle stages pose greater potential emissions when UOG technologies are employed.

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229. ARK. DEP'T OF ENVTL. QUALITY, *supra* note 226, at 18.

230. *See* TIMOTHY J. SKONE, JAMES LITTLEFIELD & JOE MARRIOTT, U.S. DOE, LIFE CYCLE GREENHOUSE GAS INVENTORY OF NATURAL GAS EXTRACTION, DELIVERY AND ELECTRICITY PRODUCTION 11 (2011), http://www.netl.doe.gov/energy-analyses/pubs/NG-GHG-LCI.pdf.

231. Moore et al., *supra* note 194, at 8350.

232. *Id.* at 8352.

233. *See id.* at 8352–53.

234. *Id.* at 8350–51, 8353, 8355.

The extent to which this is true has not been determined. For example, we do not understand drilling-related air emissions that occur as pockets of methane, propane, and other constituents in the subsurface are disturbed and released to the atmosphere.[235] Emissions during flowback, another operational stage, vary by orders of magnitude in available studies.[236] Emissions from later stages such as transmission and well abandonment are uncertain, as are the precise locations of related emissions points, including tens of thousands of abandoned wells.[237]

In addition, UOG has an experimental quality. Operators test chemical mixtures and drilling approaches in what is described as an adaptive learning process or "flexible factory."[238] Production curves experience greater (at times exponential) decay in UOG fields.[239] During well completion, hydraulic fracturing initiates hundreds of cracks deep underground through which a resource can flow to the surface. The more closely the fractures are spaced, the higher the initial production rate but the quicker interference occurs among them.[240] This means that production at a well can decline roughly eighty percent in five years. Operators try new designs to improve recovery rates. Adding acid and carbon dioxide to rework a well can restore production to initial post-stimulation levels.[241]

> [Operators] on a very kind of ad hoc basis, they make decisions, they kind of work on the fly, depending on, I guess there's lots of things, I understand it from a business perspective, they have different kinds of equipment that they need to allocate in different ways, they have a work force they need to deal with, they have to schedule the subcontractors, there are lots of different things that have to happen. Maybe Halliburton is available this week, but not that week, or Schlumberger, maybe they can do the slickwater frack on Tuesday but not next

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235. *See, e.g.*, Mohan Jiang et al., *Life Cycle Greenhouse Gas Emissions of Marcellus Shale Gas*, ENVTL. RES. LETTERS, July–Sept. 2011, at 5; Moore et al., *supra* note 194, at 8353 ("[L]ittle information exists on the frequency and volume of emissions from these releases . . . .").

236. *See, e.g.*, David T. Allen et al., *Measurements of Methane Emissions at Natural Gas Production Sites in the United States*, 110 PROC. NAT'L. ACAD. SCI. 17768, 17769 (2013).

237. *See, e.g.*, PA. DEP'T OF ENVTL. PROT., DOC. NO. 550-0800-001, PENNSYLVANIA'S PLAN FOR ADDRESSING PROBLEM ABANDONED WELLS AND ORPHANED WELLS 4 (2000) (stating that the status—operating, plugged, or abandoned—of an estimated 184,000 oil and gas wells in the state is unknown).

238. Howard Rogers, *Shale Gas—The Unfolding Story*, 27 OXFORD REV. ECON. POL'Y 117, 128–29 (2011).

239. Tad W. Patzek, Frank Male & Michael Marder, *Gas Production in the Barnett Shale Obeys a Simple Scaling Theory*, 110 PROC. NATL. ACAD. SCI. 19731, 19732 (2013).

240. *Id.*

241. Dae Sung Lee et al., *supra* note 198, at 680, 685.

> Wednesday and that's one of eight different variables that they've got. So, I don't begrudge them for not being able to tell me what they're doing when they're doing it.[242]

Optimization alters conditions at the well pad. The amount of water used in well completion will depend on the "shale gas play, the operator, well depth, number of fracking stages, and length of laterals."[243] Fracture initiation will vary by reservoir type, conditions near the wellbore, and subsurface conditions.[244] Potential fugitive emissions change according to life cycle stage (such as a well completion or workover) or intermittently as safety valves, compressor seals, and other equipment and piping fail.[245] The amount of gas flared differs by location and operator.[246] The nature of drilling and completion techniques, materials, and timing pose a challenge to data gathering, as does a straightforward response to production decay: drilling more wells per well pad.

> What you had was you used to have a drill rig come in, and a one to three acre well pad, drill a well and then you leave, and so that industrial activity lasts for a matter of a few weeks. When you start putting multiple wells on a pad, initially what it meant was the drill rig gets taken down, moved away to drill someplace else. You finish this well, and then when this drill is available you bring it back and drill your next well. And so if you're somebody who lives in the vicinity, instead of it being a couple of weeks and you can put up with that, now, it's coming back to you over multiple years. Still the well's going to be there 30 years, but you're probably talking about every couple of months, the drill rig coming back. They still weren't putting in ten wells on a pad. Putting in 4–6 wells on a pad was a big deal because you couldn't put them very close together yet. Until they built the new rigs, where you could just slide over and you never took them down, you put them on tracks. And you could drill 24, 36 wells without taking the rig down. So what you get is, for the people living in the area, instead of it being like a neighbor working on a car, and then they fix it and the loud noises are gone, you've got an industrial zone in your back yard for months.[247]

Resource, production decay, and remedy influence not only the level and timing of emissions, but also the location and spacing

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242. Interview with Envtl. Health Scientist, *supra* note 190.

243. Jean-Philippe Nicot & Bridget R. Scanlon, *Water Use for Shale-Gas Production in Texas, U.S.*, 46 ENVTL. SCI. & TECH. 3580, 3580 (2012).

244. Yan Tie et al., *An Experimental Study of Fracture Initiation Mechanisms During Hydraulic Fracturing*, 8 PETROLEUM SCI. 87, 91 (2011).

245. *See* Moore et al., *supra* note 194, at 8351–52.

246. *Id.* at 8351.

247. Interview with Regulatory Official (Mar. 31, 2014) (on file with author).

of wells and equipment. Operations shift in response to market conditions, technological improvements, and the composition of a formation and fuel of interest (e.g., tight oil, shale gas).[248] The center of production might move, along with relative unit price of gas and oil and perfection of drilling techniques, from southwest (coal bed methane) to west (tight gas) to east (tight oil) portions of a state in a span of three decades. The same is true for the spacing of well pads. The surge of UOG development in Colorado led to a decline in well spacing from 640 to 320 to 160 acres.[249]

> There were too many wells per section, per 640 acres. So when the Colorado Oil and Gas Conservation Commission was created, in part it said that you could not have too many holes in the ground per legal unit, and eventually it was whittled down from one per 640 to one per 320, and it went from there. So [the organization] was founded because there was not enough spacing, and too much density of oil and gas wells. So that was their first task, was don't have so many wells per quarter section or quarter–quarter section. Interestingly, that notion of setback or buffer around a house or building has been on their table since [the late 1990s]. Just move it further back and you're reducing risk. They've wanted setbacks early on, especially since the density eventually became one per ten acres, which is where we are now in some areas of Colorado.[250]

Shifting regions and collapsed spacing set broad contours for where emissions occur. At well pads and along transmission routes, equipment use lends greater specificity. Equipment use varies in response to challenges such as production decay and life cycle stage. Tweaks in infrastructure and maintenance add flashing, venting, and fugitive releases from production and waste sites to the air quality puzzle.

> It's so easy to have malfunctions with the equipment, it's raw, gritty gas, you have to do a lot to it before it's clean enough to heat up our furnace or turn on our stoves. And so at that stage there's a lot of mechanical pieces that get worn down or pitted, and you can just have gas seeping through it or through stuck open dump valves, so you just have to be ever-vigilant on that. And so how do you be ever vigilant on that? It's challenging, with that temporal variability, even if you had 15,000 inspectors

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248. *See, e.g.*, Interview with Cty. Official, *supra* note 204; Interview with Attorney, Earthjustice Rocky Mountain Office, in Denver, Colo. (May 6, 2014) (on file with author); Interview with Former Cty. Comm'r, in Glenwood Springs, Colo. (Apr. 1, 2014) (on file with author).

249. *See* COLO. OIL AND GAS CONSERVATION COMM'N, COGCC HEARING: WATTENBERG HORIZONTAL RULE MAKING (2011), http://cogcc.state.co.us/rr_docs_new/GWA2011/GwaLand-2-20110808.pdf (discussing COGCC Rule 318A.e).

250. Interview with Dir., Grassroots Org., *supra* note 210.

> and you tried to go to every wellpad or tank battery, you might not be there when there is a maintenance or malfunction problem.[251]
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> We are all learning more and more about oil and gas. Several years ago, we were first learning about the concept of flashing, when pressurized liquids dump to atmospheric storage tanks. Now we understand that flash emissions can be the majority of emissions from storage tanks. So each well will have at least one oil storage tank, or condensate storage tank where that flashing of gases occurs. Up until then we just estimated the working, standing, breathing [emissions] and so we thought, estimating-wise, that the tank emissions are negligible. And so then there was this growing awareness of wow, flash emissions dwarf the others, and so it was how do we estimate those flash emissions.[252]

Regulators take note of emissions sources over time, including condensate storage tanks, produced water ponds, glycol dehydrators, separators, and engines. Local monitoring networks and regional emissions inventories trigger further study.

Air quality monitoring in the U.S. historically targeted criteria pollutants and urban centers.[253] Half a dozen pollutants such as sulfur dioxide and ozone precursors are measured to ensure compliance with NAAQS under the CAA.[254] This limitation repeats itself in state monitoring, given the state's role in achieving NAAQS through enforcement of implementation plans.[255] Colorado is no exception: state agencies took interest in direct measurement of UOG emissions in response to ozone nonattainment along the Front Range.[256] The state heightened VOC data gathering (VOCs include ozone precursors) at a monitoring station in Platteville, using a monitor in downtown Denver for comparison purposes.[257] Apart from occasional pilot tests and the Platteville monitor, county health departments set the course for data gathering near UOG sites. Counties such as

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251. Interview with Envtl. Official (May 2, 2014) (on file with author).

252. *Id.*

253. *See, e.g.*, Ken Sexton & Hal Westberg, *Nonmethane Hydrocarbon Composition of Urban and Rural Atmospheres*, 18 ATMOSPHERIC ENV'T 1125 (1984).

254. 42 U.S.C. § 7408(a) (2012); 40 C.F.R. pt. 50 (2014).

255. 42 U.S.C. § 7410(a); 42 U.S.C. § 7502(c)(3) (requiring a state to maintain an emissions inventory for areas in which it does not meet a NAAQS); 40 C.F.R. § 51.114 (requiring an emissions inventory for attainment regions).

256. Interview with Regulatory Official (May 6, 2014) (on file with author).

257. *See* Gordon Pierce, Colo. Dep't of Pub. Health & Env't, Presentation at COGCC Setbacks Meeting: Monitoring Related to Oil and Gas Development (May 17, 2012), http://cogccuat.state.co.us/library/setbackstakeholdergroup/Presentations/AirMonitoring-20120614.pdf (reviewing ozone precursor studies based on data collected at monitoring stations in Denver and Platteville, Colorado).

Garfield and Boulder recognized a "big gap that the state had and nobody was going to come in and do."[258] Monitoring in Garfield County began as a favorable county commission with a unique source of funding decided to address citizen complaints.[259] The monitoring was funded by oil and gas severance and property taxes, with a state grant to facilitate the stakeholder process. Fourteen monitoring sites dotted the landscape.

Several factors determined monitor location: "access," "power supply," achieving a "good spread across the county from Parachute all the way up past Silt," and capturing "air flow from a number of regions."[260] The network was collapsed over time to improve temporal coverage. It evolved according to the importance of compliance with federal criteria emissions standards (particulate matter, ozone precursors), reasonable access and electrical power sources, and, later, a desire to collect more concentrated data at the urging of agencies such as CDPHE.[261]

By 2008, eight sites gathered VOC data analyzed using EPA method TO-12.[262] Three of the sites gathered particulate matter data (another criteria pollutant). This included 24-hour sampling for $PM_{2.5}$ with state monitoring equipment.[263] Other compounds of interest, including carbonyls like formaldehyde (a suspected human carcinogen released from equipment such as compressor station engines), were analyzed using EPA method TO-11a and collected on a one-in-twelve day basis.[264] A more concentrated network of four sites continues to serve a county of approximately 3,000 square miles of high-desert mountain terrain.[265]

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258. Interview with Regulatory Official (Apr. 28, 2014) (on file with author).

259. Interview with Regulatory Official, *supra* note 191.

260. Interview with Regulatory Official, *supra* note 258.

261. *Compare* COLO. DEP'T OF PUB. HEALTH AND ENV'T, GARFIELD COUNTY AIR TOXICS INHALATION: SCREENING LEVEL HUMAN HEALTH RISK ASSESSMENT 6 (2007) [hereinafter 2007 REPORT], *with* COLO. DEP'T OF PUB. HEALTH AND ENV'T, GARFIELD COUNTY AIR TOXICS INHALATION: SCREENING LEVEL HUMAN HEALTH RISK ASSESSMENT 8 (2010) [hereinafter 2010 REPORT].

262. ALICIA FRAZIER, COLO. DEP'T OF PUB. HEALTH AND ENV'T, ANALYSIS OF DATA OBTAINED FROM THE GARFIELD COUNTY AIR TOXICS STUDY – SUMMER 2008, at 2–3 (2009), http://www.garfield-county.com/air-quality/documents/airquality/2008_Targeted_Oil_and_Gas_Monitoring_Report.pdf.

263. *Id.*

264. 2010 REPORT, *supra* note 261, at 10–11, 15.

265. COLO. DEP'T OF PUB. HEALTH AND ENV'T, QUALITY ASSURANCE PROJECT PLAN FOR THE GARFIELD COUNTY VOLATILE ORGANIC COMPOUNDS MONITORING PROGRAM 10–11 (2011). Each site was strategically placed. For example, Parachute was chosen for its "oil and gas influence"; Battlement Mesa "in response to some citizen concerns and inquiries about air quality"; Rifle with "more of an urban influence"; and Bell Mountain for its "oil and gas influences that didn't have urban impacts." Interview with Regulatory Official, *supra* note 258.

EPA also encouraged the county to move to a more targeted air-monitoring network. EPA's Regional Geographic Initiative (RGI) provided funding for the transition.[266] The RGI was formed to improve a second tool used to track air releases: emissions inventories. Inventories serve several purposes in environmental protection. They assist in permitting compliance assurance and provide inputs for health risk assessment.[267] Federal inventories capture a fraction of oil and gas emissions. EPA's Inspector General reported that only nine states provide well pad emissions data for the National Emissions Inventory.[268] When data are available, they are averaged, most commonly over a one-year period, and reported by source category. UOG equipment often does not meet reporting thresholds when viewed in isolation. The dominance of minor or "area" sources in oil and gas emissions means that inventories can underestimate emissions for a region.[269] Colorado's inventories faced this challenge as UOG sites proliferated along the Western Slope and Front Range.

> Colorado has been inventorying forever, based on reported values in permits. We've got a pretty stringent inventory system where we require any source anywhere in the state for VOCs at least over two tons to report. And in non-attainment areas it's one ton. We get a lot of data. Now, just because we get a lot of data doesn't mean that we're using it. One of the factors behind [the state's rulemaking efforts] was recognizing the fact that our inventories were way too low, because we weren't accounting for the flashing emissions from tanks, primarily. And that was something that wasn't, it's not so much problems with emissions factors, even though those are really old and based on a small sample size of a half-dozen samples that was done in 1975. But I think that we've, it's more being out in the field and discovering new emissions sources.[270]

As states improved their inventories to comply with NAAQS, collect emissions fees, and approve permits, important source categories of VOCs were identified on a regular basis. These

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266. *See* GARFIELD CTY. PUB. HEALTH, WORK PLAN: MANAGING AIR QUALITY IN GARFIELD COUNTY, COLORADO'S MOST ACTIVE ENERGY DEVELOPMENT REGION (2007), http://www.garfield-county.com/air-quality/documents/Revised-Final-Proposal.pdf.

267. *See, e.g.*, U.S. EPA, 2014 NATIONAL EMISSIONS INVENTORY PLAN (2014); U.S. EPA, INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990–2013 (2015), http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2015-Main-Text.pdf.

268. *See* OFFICE OF THE INSPECTOR GEN., U.S. EPA, REPORT NO. 13-P-0161, EPA NEEDS TO IMPROVE AIR EMISSIONS DATA FOR THE OIL AND NATURAL GAS PRODUCTION SECTOR 17 (2013).

269. *Id.*

270. Interview with Regulatory Official, *supra* note 256.

included flash emissions as well as releases from evaporation ponds. Flash emissions, for example, were discovered by an inspector who happened to be standing near a tank when he heard a "brush of sound" that only occurs for several minutes at a time.[271]

Discovering a source category brings the state full circle: to the need to characterize emissions, and ultimately air quality, near a newly identified process, structure, or equipment. Local emissions and concentrations of pollutants are central concerns of residents in UOG regions. Yet once we identify a region, resource, density and stage of adaptive operation, and spacing of well pads in an area of citizen complaints, emissions variance continues to challenge efforts to provide such data.

> Just determining [whether a piece of equipment meets a ton per year reporting threshold] can be very burdensome, for regulators and the regulated community. For tank emissions that would entail collecting a pressurized liquid sample. Flash emissions occur when a pressurized separator periodically dumps that liquid condensate into an atmospheric storage tank and that pressure difference is what releases all the entrained gases, lots of methane, VOCs and a little bit of [hazardous air pollutants]. So you need that pressurized liquid sample before it flashes, and you need to take it to a lab and get it analyzed, and get your extended hydrocarbon analysis and you can plug it into this program that's relatively cheap and widely used by regulators in the regulated community called API E&P TANKS. If you're going to have your gold standard of figuring out what your flash emissions are, it would be using a really sophisticated process simulation software, like ProMax and licenses for those are like $15,000 a year. And you need to know how to use them. But then you have the variability, too, like the temperature of that separator and storage tank, and the pressure of that separator influences what the emissions are. The summer or winter. So it's very complicated.[272]

> Measuring emissions from a car is really easy in the sense that most of it comes out of a tail pipe, you can put a hose over the tailpipe and very accurately measure the exhaust gases, you can put the car in an enclosure. And that's the common method for measuring emission rates, we do this with trees, we do it with corn, it's the enclosure technique, and with that you get really good numbers on that. But oil and gas operations you cannot really put inside an enclosure. You have to put a circus tent over it, with a blower that brings in so many cubic feet per minute and have it leak out on the other side and measure the

271. *Id.* (describing a period between 2002 and 2008 where new, significant emissions sources were discovered on a regular basis).

272. Interview with Envtl. Official, *supra* note 251.

> concentration inside and outside. And you get a really good emission rate. But to do that costs some money. And I haven't seen that type of study. But that would be one way to do this. Still, then the problem is, the big problem is, you could do this on one well, one tank, and you have 50,000 of these, and you have ten different [operators that have different crews and different] standards and rigor and how they train and so you have one, how do you now gauge how representative that is? You do it for a week, a month, and everybody knows that you're doing this now so they check it twice a day to make sure, and it's not going to be any operation, it's going to be one observed, watched, so how representative is it? Even if you were going to do this, you'd still have a lot of question marks behind that data.[273]

With these challenges in mind, we can view the state tests in a different light. For example, the Arkansas Department of Environmental Quality (ADEQ) study, while narrow in focus (sampling took place at six drilling sites, three well completion sites, and four compressor stations, each for four to six hours), was technologically ambitious. ADEQ placed multi-gas monitors on five-foot tripods at the midpoint of each side of a well pad.[274] These "AreaRAEs" use electrochemical sensors to measure nitrous oxides and a photoionization detector to determine VOC concentration.[275] They are continuous monitors, wirelessly transmitting data at five-second intervals over a four- to six-hour period. In addition, DEQ personnel carried handheld versions of the AreaRAE along the perimeter of the well pad every one or two hours.[276] DEQ also measured temperature, humidity, wind speed, and wind direction at each site using a Coastal Environmental System Weatherpak.[277] Considerable effort was made to monitor emissions for a brief moment. But consider each monitoring site in ADEQ's report. Well pads are displayed as polygons, the precise location of activity within them obscured. Each aerial map is presented this way, converting complex amalgams of infrastructure into simple, continuous shades.

273. Interview with Atmospheric Scientist, in Boulder, Colo. (Apr. 7, 2014) (on file with author).

274. ARK. DEP'T OF ENVTL. QUALITY, *supra* note 226, at 15.

275. *Id.* at 14.

276. *Id.* at 15.

277. *Id.*

Figure 1. ADEQ Aerial Map of Emissions Test Site.[278]

ADEQ measured several constituents emitted by a diversity of activity underway within each grey polygon. The exercise focused on criteria air pollutants, including ozone precursors. The tests did not identify individual VOC components, such as formaldehyde, benzene, and other toxic air emissions.[279] Still, ADEQ noted that the compressor stations, drilling rigs, pumps, and other equipment at various stages of well production are responsible for different sources (e.g., fugitive emissions, well flowback venting, flaring) and types (e.g., VOCs, PM_{10}, NO_x) of emissions.[280]

The results reveal greater uncertainty than suggested in the executive summary: VOC emissions at the edge of a polygon (well pad perimeter) fluctuated wildly over five-hour time increments. ADEQ concluded, "[T]he spatial and temporal distribution of VOC concentrations at most drilling sites was significantly affected by monitor location, wind direction, and the interaction between location and wind direction."[281] Even as it employed expensive technology, ADEQ could only provide a rough sketch of air quality in the Fayetteville Shale region.

In Colorado, the Agency for Toxic Substances and Disease Registry (ATSDR) reviewed years of monitoring data as part of a health consultation, and took such indeterminacy to its logical conclusion:

> It cannot currently be determined if breathing ambient air in those areas of Garfield County which were monitored could harm people's health.[282]

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278. *Id.* at 42.

279. *Id.* at 12, 14.

280. *Id.* at 2.

281. *Id.* at 18–19.

282. COLO. DEP'T OF PUB. HEALTH & ENV'T & AGENCY FOR TOXIC SUBSTANCES & DISEASE REGISTRY, U.S. DEP'T OF HEALTH & HUMAN SERVS., HEALTH CONSULTATION: PUBLIC HEALTH IMPLICATIONS OF AMBIENT AIR EXPOSURES AS MEASURED IN RURAL AND URBAN OIL AND GAS DEVELOPMENT AREAS—AN ANALYSIS OF 2008 AIR SAMPLING DATA 3 (2010) [hereinafter 2010 CONSULTATION].

What explains this statement? Inventory development and monitoring build-out were proceeding apace. But they are only tools around which broader communities of practice form, as regulators acquire the capacity to respond to resident concerns. In the next Part, I consider two communities of practice that produced one of the most robust bodies of research on UOG emissions in the world. We view their work in light of the central question underlying citizen complaints, and the core of lived experience near unconventional development and production: Are residents in areas near UOG activity exposed to air emissions that constitute a human health hazard (hereinafter Q_1)?

Research in UOG regions proceeds within distinct communities of practice. Each generates work along nested boundaries: inside a well pad, across a set of monitoring sites or emissions source category, and within an airshed. Different research teams pursue work along each boundary, and develop unique responses to the variability problem. The research appears to overlap. In fact, it does not. Sustained investigation at the scale demanded by Q_1 (near-field, discontinuous, peak emissions) does not occur. The build-out of administrative response to citizen complaints, through monitoring networks and inventories, may not resolve this problem. Instead, it may set the context in which regulators ask the wrong questions.

B. Asking the Wrong Questions: Beyond the Collapsed Drill Rig

> The knowledge of these kinds of local, immediate exposures just isn't there like it is with ozone.[283]

> It's not clear to me that we really have a good understanding of the emissions of hazardous air pollutants and the concentration of HAPs in areas near drilling sites.[284]

> I don't think you can say this proximity or that proximity is okay or not okay, because it depends on what is going on. The question that people want to know is the hardest one, the furthest away.[285]

For decades, oil and gas operations in Colorado were limited by a 150-foot setback rule.[286] The logic was simple: a drill rig stood

283. Interview with Regulatory Official, *supra* note 256.

284. Interview with Former City Official, in Boulder, Colo. (Apr. 5, 2014) (on file with author).

285. Interview with Envtl. Eng'r, in Boulder, Colo. (Apr. 3, 2014) (on file with author).

286. COLO. OIL & GAS CONSERVATION COMM'N, STATEMENT OF BASIS, SPECIFIC STATUTORY AUTHORITY, AND PURPOSE, NEW RULES AND AMENDMENTS TO CURRENT RULES

seventy-five feet tall.[287] Regulators doubled the size of the average rig to ensure that if one collapsed, it would not destroy a building.[288] The rule was set with physical safety in mind. It was promulgated before select counties gathered millions of dollars of monitoring data.[289] Inventories were not yet attuned to the range of emissions sources in oil and gas regions.[290] UOG operations themselves were not commercial-scale. They were limited to a number of obscenely intensive experiments, such as nuclear fracturing[291] and *ex situ* oil shale mining in remote parts of the state.[292]

Regulators lacked the data, or even the vocabulary, to consider impacts beyond physical safety that are now common knowledge, including chemical, radiological, ecological, and psychosocial stressors. By 2008, a rudimentary language was in place. Efforts to characterize chemical emissions were underway. The work proceeded in waves that peaked in 2010 and 2013.[293] Conditioned by networks and inventories and the questions they raise, they grew into distinct top-down and bottom-up communities of practice.[294] There was surprisingly little overlap

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OF THE COLORADO OIL AND GAS CONSERVATION COMMISSION, 2 CCR 404-1, at 5, (2012), http://cogccuat.state.co.us/RR_HF2012/setbacks/StatementOfBasisAndPurposeSetbackRules20121109.pdf; *see* Memorandum from Allison Pasternak to Members of the Oil and Gas Interim Comm. (July 27, 1999) (on file with the Houston Law Review).

287. *See* COLO. OIL AND GAS CONSERVATION COMM'N, *supra* note 286, at 5 (explaining that the setback rule required 150 feet or 1.5 times the height of the derrick).

288. COGCC Rule 603(a)(1) (2009) ("At the time of initial drilling of the well, the wellhead shall be located a distance of one hundred fifty (150) feet or one and one-half (1–1/2) times the height of the derrick, whichever is greater . . . ."); Interview with President, Citizens Org., *supra* note 216; *see* Interview with Dir., Grassroots Org., in Grand Junction, Colo. (Apr. 28, 2014) (noting increases in setbacks); Interview with Former Cty. Comm'r, La Plata Cty., *supra* note 209.

289. *See* Setback Stakeholder Group, *COGCC Well to Building Setback Stakeholder Review*, COLO. OIL & GAS CONSERVATION COMM'N (Feb. 14, 2012), http://cogcc.state.co.us/documents/reg/Rules/SetbackStakeholderGroup/StakeholderAnnouncement.pdf (suggesting Rule 603 was promulgated pre-2008).

290. Interview with Regulatory Official, *supra* note 256; Interview with Envt'l Health Scientist, *supra* note 190.

291. DEGOLYER & MCNAUGHTON, REPORT ON INTERPRETATION OF TEST DATA FROM PROJECT RULISON IN THE RULISON FIELD, GARFIELD COUNTY, COLORADO 1 (1971), www.lm.doe.gov/Rulison/RUL000048.pdf ("On September 10, 1969, a nuclear explosive with a nominal yield of 40 kilotons was detonated at Project Rulison 8,246 feet below the surface of the Mesaverde formation . . . . The Rulison R-EX well was directionally drilled to intercept the fracture system created by the nuclear explosive . . . .").

292. *See* ANDREW GULLIFORD, BOOMTOWN BLUES: COLORADO OIL SHALE, 1885–1985, at 46–49 (1989) (detailing the origins of shale oil extraction in Western Colorado).

293. *See* Cathy Proctor, *Encana Will Halt Western Colorado Drilling in 2014*, DENVER BUS. J. (Dec. 16, 2013, 12:56 PM), http://www.bizjournals.com/denver/blog/earth_to_power/2013/12/encana-calls-halt-to-drilling-in.html?page=all.

294. *See* Interview with Envt'l Eng'r, *supra* note 285 (noting attempts to reconcile top-down and bottom-up approaches).

between them, leaving mid-range, discontinuous, peak exposures that generate symptoms and citizen complaints in UOG regions underexplored and unable to inform changes to setback or other rules.

One wave of inquiry peaked in 2010. Its focus was scattered. It was beset by constraints such as the availability of data.[295] Raw data to draft emissions and health-related studies were opportunistic. They were county-based, equipment-based, or monitoring network-based.[296] Studies answered questions confined to these existing, closed sets, such as the importance of an emissions source category or conditions near a handful of sites gathering criteria air pollutant data at predetermined intervals.[297] The greatest cluster of activity made use of Garfield County data as it transitioned from fourteen to a handful of monitoring sites at the suggestion of other agencies.[298]

Four kinds of studies were shaped by these data. CDPHE partnered with Garfield County to complete two risk assessments.[299] ATSDR drafted health consultations with the same data.[300] A research institute at St. Mary's Hospital generated risk factors from the data as part of a community health assessment.[301] And a research team used the data for a health impact assessment, the first of its kind to consider UOG operations.[302] With regards to air emissions, their impacts on human health, and their control through rulemaking, none of the studies gathered new data. Each made artful and sophisticated use of data collected in support of ongoing monitoring and inventory work.

Documents prepared by CDPHE, ATSDR, and the Colorado School of Public Health (CSPH) used the same screening-level risk assessment methodology.[303] CDPHE's risk assessments were

295. 2010 CONSULTATION, *supra* note 282, at 3–4.

296. *See, e.g.*, 2010 REPORT, *supra* note 261, at 8, 10.

297. *See id.*; 2007 REPORT, *supra* note 261, at 9.

298. *See* 2010 CONSULTATION, *supra* note 282, at 5–6; 2010 REPORT, *supra* note 261, at 8; AGENCY FOR TOXIC SUBSTANCES & DISEASE REGISTRY, U.S. DEP'T OF HEALTH & HUMAN SERVS., HEALTH CONSULTATION: GARFIELD COUNTY PUBLIC HEALTH IMPLICATIONS OF AMBIENT AIR EXPOSURES TO VOLATILE ORGANIC COMPOUNDS AS MEASURED IN RURAL, URBAN, AND OIL & GAS DEVELOPMENT AREAS 5 (2008) [hereinafter 2008 CONSULTATION]; 2007 REPORT, *supra* note 261, at 6.

299. 2010 REPORT, *supra* note 261, at 5; 2007 REPORT, *supra* note 261, at 6, 9.

300. 2010 CONSULTATION, *supra* note 282, at 5; 2008 CONSULTATION, *supra* note 298, at 5.

301. *See* TERESA COONS & RUSSELL WALKER, COMMUNITY HEALTH RISK ANALYSIS OF OIL AND GAS INDUSTRY IMPACTS IN GARFIELD COUNTY, at xiv, xvi, xxxvii (2008).

302. WITTER ET AL., HEALTH IMPACT ASSESSMENT FOR BATTLEMENT MESA, GARFIELD COUNTY COLORADO, at ES-page I (2010).

303. Interview with Regulatory Official, *supra* note 258.

drafted in 2007 and 2010, the latter encouraged by "potential cancer and noncancer (short-term) health effects of benzene in the oil and gas development area," and completed after Garfield County revamped its network.[304] The reports are screening-level because they do not investigate risks to an actual population.[305] Rather, they use air concentration data to generate hypothetical risk estimates. They follow the standard, four-step risk assessment process set out in EPA's *Residual Risk* report to Congress,[306] and make clear the limits inherent in available monitoring data and EPA's methodology.[307] Most telling as it relates to Q_1, the question underlying citizen complaints in Colorado, is this admission: the risk assessment "represents a 'snapshot' in time for characterizing health risks . . . . It does not take into account potential changes in emissions over time."[308]

Each report takes pains to explain the uncertainty of its analysis. The first report considered forty-three air pollutants, with no data for some of the most important air toxics.[309] Available data were collected at monitoring stations once a month or once per quarter.[310] The second report was more direct, noting cancer risk and noncancer hazard estimates "are likely to be underestimated," in part because sixty-five of the eighty-six chemicals detected at four active fixed monitoring sites lacked toxicity values.[311] Four sites sampled air every sixth or twelfth day, rendering the data "less than ideal for a robust statistical analysis on a one-year basis," the standard timescale for risk assessment data.[312] A broader constraint is also hinted at: data averaging. It influences practices such as the choice of sample frequency (e.g., one-in-six day monitoring for VOCs) and the calculation of risk and hazard estimates for a hypothetical population across a period of time (e.g., one year).[313] Averaging is

304. 2010 REPORT, *supra* note 261, at 5, 8.

305. *See id.* at 9; 2007 REPORT, *supra* note 261, at 6, 9–10, 37, 39, 42.

306. OFFICE OF AIR QUALITY PLANNING AND STANDARDS, U.S. EPA, EPA-453/R-99-001, RESIDUAL RISK 16 (1999).

307. 2010 REPORT, *supra* note 261, at 9; 2007 REPORT, *supra* note 261, at 6, 9–10, 37, 39, 42.

308. 2010 REPORT, *supra* note 261, at 9.

309. 2007 REPORT, *supra* note 261, at 43.

310. *Id.* at 7.

311. 2010 REPORT, *supra* note 261, at 6.

312. *Id.* at 18–19.

313. Averaging is an important feature of NAAQS under the Clean Air Act. For example, particulate matter standards for $PM_{2.5}$ and PM_{10} have averaging times of one year and twenty-four hours, respectively. Tech. Transfer Network, *Particulate Matter (PM) Standards—Table of Historical PM NAAQS*, U.S. EPA, http://www.epa.gov/ttn/naaqs/standards/pm/s_pm_history.html (last updated Mar. 13, 2015).

helpful when limited data need to be leveraged to make informed policy decisions. But it further limits the extent to which data speaks to a scale of citizen concern.

Two ATSDR reports followed, prepared with the help of CDPHE staff.[314] The purpose of a health consultation is to "focus on health issues associated with specific exposures so that the state or local department of public health can respond quickly to requests from concerned citizens . . . ."[315] The reports made clear that they were drafted under conditions of uncertainty:

> [T]he inability to realistically and continuously monitor ambient air at all places of interest and in the breathing zone of the exposed population, . . . the reality that some of the monitoring locations may detect emissions from sources other than the oil and gas development activities; and . . . the inability to adequately capture intermittent peak exposures . . . .[316]

The data featured weekly samples at four locations.[317] Data were reviewed in light of the risk assessment protocol used by CDPHE for its screening-level reports.[318] The purpose was to set out public health concerns that local jurisdictions could address.[319] None could be adequately discussed: even if monitors were able to collect data on the more than 100 hydrocarbons emitted by UOG sites and spatial coverage were greater than four elevated stations in a 3,000-square-mile region and toxicity data were available for eighty-six rather than twenty-one chemicals,[320] the data were subject to multiple forms of averaging. In the health consultations, this included mean concentrations of chemicals of potential concern used to estimate potential exposure.[321] The "indeterminate public health hazard"[322] identified in the first ATSDR report persisted in the second, particularly as it relates to peak, intermittent exposure.[323]

Independent research paralleled state and federal reports. Two projects are of note: a "health risk analysis" by St. Mary's Saccomanno Research Institute, and a "health impact assessment"

314. 2010 CONSULTATION, *supra* note 282, at 5–6; 2008 CONSULTATION, *supra* note 298, at 5.

315. 2008 CONSULTATION, *supra* note 298, at i.

316. *Id.* at 12.

317. 2010 CONSULTATION, *supra* note 282, at 8.

318. *Id.* at 1, 9.

319. *Id.* at 6.

320. *Id.* at 9.

321. *Id.* at 10–11.

322. 2008 CONSULTATION, *supra* note 298, at 12.

323. 2010 CONSULTATION, *supra* note 282, at 15.

by the CSPH.[324] They were the first of their kind to explore a UOG region.[325] They received considerable input from residents and other stakeholders.[326] St. Mary's responded to a county request for proposals (RFP) after residents demanded that a fine against EnCana Corporation be used to study oil and gas impacts.[327] Environmental scientists at CSPH responded to a county RFP, also after residents demanded a study. Specifically, Battlement Mesa Concerned Citizens petitioned the county to defer approval of an Antero Resources plan to drill 200 wells in Battlement Mesa.[328] The county had special jurisdiction over land use decisions in the unincorporated subdivision, with a population of over 4,200 people.[329] Both research groups had earlier completed literature reviews and white papers on UOG emissions, putting them in a unique position to respond to the RFPs.[330]

The health risk analysis (HRA) and health impact assessment (HIA) served different purposes but relied on similar air quality data. St. Mary's researchers applied a health assessment model developed to study uranium mill workers in New Mexico.[331] The HRA was "not a classical risk assessment"; it gave a "snapshot" of county health indicators such as infectious disease, birth defects, and economic conditions.[332] The study was ambitious, using public meetings, focus groups, surveys, and records to capture diverse health indicators.[333] It compared health conditions according to zip code, a proxy for natural gas versus agricultural development areas.[334] It also compared Garfield County to counties with a similar history of uranium and other mining activity.[335] The HRA touched upon a broad range of issues, but did not include primary care data or other indicators of acute health symptoms.[336] It did

324. COONS & WALKER, *supra* note 301, at xv; Roxana Witter, Univ. Colo. Denver, Grant Request for Health Impact Assessment of Gas Extraction in Colorado, (Feb. 14, 2010) [hereinafter CSPH Assessment] (on file with author).

325. COONS & WALKER, *supra* note 301, at 1; *see* CSPH Assessment, *supra* note 324 (stating that the study would provide baseline information).

326. COONS & WALKER, *supra* note 301, at 58; CSPH Assessment, *supra* note 324.

327. COONS & WALKER, *supra* note 301, at 1.

328. CSPH Assessment, *supra* note 324.

329. *Id.*

330. *Id.* (referencing WITTER ET AL., UNIV. OF COLO. DENVER, POTENTIAL EXPOSURE-RELATED HUMAN HEALTH EFFECTS OF OIL AND GAS DEVELOPMENT: A WHITE PAPER (2008)).

331. Interview with Envtl. Scientist, in Grand Junction, Colo. (Apr. 1, 2014) (on file with author).

332. COONS & WALKER, *supra* note 301, at 49.

333. *Id.* at 51, 58.

334. *Id.* at 61.

335. *Id.* at 4, 6–7.

336. *Id.* at 142.

revisit the county's monitoring data, with the following caveat: there is "[a] general lack of data on pollution concentrations in the environment."[337] The study used a dispersion model to estimate exposure from several sites, based primarily on 24-hour canister samples.[338] It found "EPA's acceptable value for cancer risk can be exceeded for benzene in air."[339] UOG industry was relatively new in Garfield County, meaning the study was intended to serve as a baseline for future research.[340] Unfortunately, the infrastructure is not in place to revisit its findings.[341] A recent review by CDPHE repeats the study's limitations, including "[l]ack of baseline health data with which to determine trends or changes" and a "relatively new presence of the industry in the region . . . ."[342]

For the Battlement Mesa HIA, residents envisioned a more focused version of the St. Mary's HRA. They asked for the following baseline and ongoing data, specifically as a means to address Q_1:

> The baseline study should be specific to Battlement Mesa and its population[.] Conduct baseline monitoring of air and water quality within the Battlement PUD before any drilling operations continue[.] Conduct a comprehensive and continuous air, water, and soil quality monitoring system at all well sites during all phases of operation[.] Establish a medical monitoring system to identify any changes in baseline data or trends and/or anomalies in medical practices[.] Require full disclosure of materials used in drilling and fracturing processes to health officials and scientists conducting these studies[.] Test whether a buffer zone of not less than one thousand feet between any well operation and any residence, business, or public building will protect health standards[.][343]

HIAs are not designed to meet these goals, nor were their authors given the resources to gather new data.[344] The permit applicant, Antero Resources, withheld plans, requested delays, and submitted hundreds of pages of comments as the report progressed from first to second draft.[345]

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337. *Id.* at xv.

338. *Id.* at 24–25.

339. *Id.* at xv.

340. *Id.* at 3.

341. *Id.*

342. KENT KUSTER, COLO. DEP'T OF PUB. HEALTH & ENV'T, SUMMARY OF COLORADO PUBLIC HEALTH STUDIES 2005–2012, at 3 (2012).

343. Letter from Bob Arrington, Battlement Concerned Citizens, to Jim Rada, Garfield Cty. Dep't of Pub. Health (Nov. 6, 2009) (on file with author).

344. Roxana Z. Witter et al., *The Use of Health Impact Assessment for a Community Undergoing Natural Gas Development*, 103 AM. J. PUB. HEALTH 1002, 1007–08 (2013).

345. *See id.* at 1007 (describing challenges to completing the Battlement Mesa HIA).

The report is another summary of community health based on existing data. Health is broadly defined to include issues raised at meetings facilitated by the county health department.[346] Quantitative (e.g., comparing available monitoring data to health-based standards) and qualitative (e.g., review of traffic studies, historic chemical and waste spill data, and noise monitoring data) indicators are explored.[347] The document is drafted as a decision support tool. It lists mitigations that could be adopted as part of a special use permit.[348] Results are expressed as numeric rankings. For example, air quality is identified as a negative, community-wide impact, of particular concern to vulnerable populations over long periods of time, and "likely" contributing to "moderate to high" health effects. It is given a relative rank of -14.5 out of +/- 15.[349]

The greatest source of contention surrounded the HIA's Appendix D, a human health risk assessment (HHRA) based on county data. The authors relied on county monitoring studies dating back prior to network build out, the state screening-level risk assessments and federal health consultations, the St. Mary's HRA, and data from Olsson Associates, a consulting firm hired by Antero Resources.[350] We can distinguish Appendix D from these materials because it was concerned with a broader range of exposure scenarios, including some that overlap with Q_1. For example, it identifies acute and subchronic exposures for a person living near a well pad as an important scenario to consider.[351]

However, because no data were "collected specifically for this HHRA,"[352] only partial exposure scenarios were assembled. There were no short-term acute or 24-hour data for "chemicals associated with well installation collected at the point of exposure (e.g., direct measurements in the breathing zone and at residences) during all stages of well completion and when odors are noticed."[353] Nor were there data for each stage of well development and completion at "e.g. from 50 to 3,000 feet . . . from the pads," among other missing information.[354] Instead, the authors distinguished between residents "near a well pad" (half a mile away) and those further

346. *Id.* at 1003.
347. WITTER ET AL., *supra* note 302, at 17.
348. *Id.* at ES-page I, ES-page III, 17.
349. *Id.* at 24.
350. *Id.* app. D at 10–11.
351. *Id.* app. D at 46–48.
352. *Id.* app. D at 67.
353. *Id.* app. D at 68.
354. *See id.* app. D at 51 (discussing limitations in the data).

removed.[355] Existing data did not allow for exploration of acute and subchronic health risks at a range of distances from a well pad during different operational stages.[356] Still, the appendix made findings for residents "near," or within half a mile of a well pad that were troubling. The study found that "[c]omparing the risks shows that there is a higher potential for chronic, short term, and subchronic non-cancer health effects and a greater lifetime excess cancer risk for residents living near the well pads compared to baseline and compared to residents not living near the well pads."[357]

The Board of County Commissioners ended the HIA process while the report was still in draft.[358] Nonetheless, the HHRA was modified with stakeholder input and published in a peer-reviewed journal in 2012.[359] By then, distinct communities of practice were devoted to air quality in UOG regions. The first, including HHRA authors, prepares bottom-up air quality studies. They look at a small number of sampling locations within a mile of UOG activity, conditioned by existing data, access to property and electrical power for new data collection, very limited information on scheduled flashing and other releases, and cost. They raise questions such as the relative contributions of drilling versus well completion to VOC concentrations 0.7 miles from a well pad based on weekly samples.[360] Bottom-up studies note the sources of variability in UOG emissions,[361] which they manage by carving out a portion of Q_1 to consider (e.g., emissions during stage x vs. stage y, risk "near" vs. "far" from a well pad). Another response to variability in bottom-up research is to set up short-term monitoring arrays to characterize releases by source category (e.g., produced water ponds).[362] The latter studies are aimed at improving emissions inventories to ensure compliance with state implementation plans. They are not designed to consider human

355. *Id.* app. D at 45, 64.

356. *Id.* app. D at 46–48.

357. *Id.* app. D at 67.

358. Letter from John Martin, Chairman, Garfield Cty. Bd. of Cty. Comm'rs, to Roxana Witter, Colo. Sch. of Pub. Health (June 6, 2011), http://www.garfield-county.com/public-health/documents/BOCC_Letter_6.6.11.pdf (regarding the close of Battlement Mesa Health Impact Assessment).

359. Lisa M. McKenzie et al., *Human Health Risk Assessment of Air Emissions from Development of Unconventional Natural Gas Resources*, 424 SCI. TOTAL ENVT. 79 (2012).

360. Theo Colborn et al., *An Exploratory Study of Air Quality Near Natural Gas Operations*, 20 HUM. & ECOLOGICAL RISK ASSESSMENT 86 (2012).

361. For example, Colborn et al. note the "great deal of variability across sampling dates in the numbers and concentrations of chemicals detected." *Id.*

362. ROBIN SEGALL ET AL., U.S. EPA, UPSTREAM OIL AND GAS EMISSIONS MEASUREMENT PROJECT 1, http://www.epa.gov/ttnchie1/conference/ei18/session5/segall.pdf.

health impacts. The unit of analysis in bottom-up research varies—the focus might be a stage of operation, piece of infrastructure, or broad distance category, explored at one or a small number of sites.[363]

The top-down community of practice works at a different scale: airsheds, which it uses to explore the distribution of ozone precursors and NAAQS compliance.[364] Areas of study include the Uintah Basin in northeastern Utah and the Denver-Julesburg Basin in northeastern Colorado. These efforts rely on airborne and tower measurements, supplemented by ground mobile monitoring. For example, Pétron et al. found a strong alkane signature downwind from the Denver-Julesburg Basin, based on samples taken at a 300-meter tall tower (the National Oceanic and Atmospheric Administration's Boulder Atmospheric Observatory).[365] In the Uintah Basin, where winter ozone levels exceeded the NAAQS sixty-eight times in 2010, Helmig et al. carried out vertical profiling of ozone precursors at a tower at the northern edge of a gas field.[366] They found levels of atmospheric alkanes during temperature inversion events in 2013 that were 200 to 300 times greater than regional background.[367] These and other "top-down" studies can also be used to estimate methane leakage, which is helpful in comparing the climate-forcing impact of UOG activity to coal-fired power plant emissions. Loss rate estimates for methane vary considerably, from 17% (Los Angeles Basin)[368] to 8.9% (Uintah Basin)[369] to 4% (Denver-Julesburg Basin).[370] Some studies find that EPA underestimates methane leakage rates across the life cycle (its estimate was 1.65% in 2013).[371]

Top-down studies are not meant to characterize air quality in residential or publicly accessible areas near UOG operations. In fact, if we align the work of bottom-up and top-down communities

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363. *Id.* at 2.

364. *See, e.g.*, Gabrielle Pétron et al., *Hydrocarbon Emissions Characterization in the Colorado Front Range: A Pilot Study*, 117 J. GEOPHYSICAL RES.: ATMOSPHERES, Feb. 27, 2012, at 3.

365. *Id.* at 1, 4.

366. Detlev Helmig et al., *Highly Elevated Atmospheric Levels of Volatile Organic Compounds in the Uintah Basin, Utah*, 48 ENVTL. SCI. TECH. 4707, 4714 (2014).

367. *Id.* at 4713.

368. J. Peischl et al., *Quantifying Sources of Methane Using Light Alkanes in the Los Angeles Basin, California*, 118 J. GEOPHYSICAL RES.: ATMOSPHERES 4974, 4988 (2013).

369. Anna Karion et al., *Methane Emissions Estimate from Airborne Measurements over a Western United States Natural Gas Field*, 40 GEOPHYSICAL RES. LETTERS 4393, 4396–97 (2013).

370. Pétron et al., *supra* note 364, at 2, 16.

371. Moore et al., *supra* note 194, at 8351.

of practice, we find impacts at certain scales that are ignored.[372] This includes the spatial and temporal scales represented by Q_1: intermittent, peak, and other discontinuous exposure data at varying distances from identifiable clusters of activity at a well pad or along a transmission route.[373] Bottom-up studies pose the problem of extrapolation, with sample sizes as low as a single well pad. Top-down studies are rare, expensive, and shed light on ozone formation, total emissions, or leakage rates for an entire air basin.

> We don't have representative sampling, that's always going to be a problem at the well scale. You could think of that in a general statistical sense of being able to pick sites at random and go out and do it, but that's not the way it works, you have to get some access and permission, and you can imagine there's some built-in bias in doing that. Tend to have better access to the better sites, most likely. So there's work going on at that scale, I think it's advancing but that problem of being able to really sample enough locations and enough times to characterize the overall system is always going to be there.[374]

> Other approaches that work have a number of advantages, aircraft, top-down, fly a plane, zigzag downwind, upwind and get air mixing information at the same time, and use some simple box modeling approaches to calculate emissions rates. There the advantages, you know it captures the vertical and horizontal extent of the plume, it integrates over whatever number of sources, types of sources there are. Still, it's hard to do, and costs money to get a plane and put an instrument in it, and have some good people who know how to do this right. It's been done a few times, and papers are coming out. . . . But there's no more than two or three groups in the U.S. that have the tools and the expertise to do this well.[375]

The challenge posed by non-overlapping communities of practice was made clear in 2012. COGCC revised its setback rule, an issue it tabled when the agency and its mission were overhauled in 2008.[376] Parties presented statements at commission hearings, arguing for setback increases or the status quo. Data from bottom-up and top-down communities of practice were used to support a safe distance between homes and permitted UOG operations, including the HHRA (establishing health

372. *See id.* at 8352.
373. *See id.* at 8353–54.
374. Interview with Envtl. Eng'r, *supra* note 285.
375. Interview with Atmospheric Scientist, *supra* note 273.
376. Setback Stakeholder Group, *supra* note 289 ("During the 2007-2008 rulemaking process, the [COGCC] deferred action on the well to building setback requirements set forth in Rule 603.").

concerns within 0.5 miles of a well pad),[377] Theo Colborn's data 0.7 miles from a well pad in western Colorado (arguing for a one-mile setback),[378] Gabrielle Pétron's work in the Denver-Julesburg basin (showing increased hydrocarbon concentrations in the region with a link to UOG activity),[379] and the only peer-reviewed research completed *within* the boundary of a well pad in Colorado.[380] A team from the National Institute for Occupational Safety and Health determined eight-hour air concentrations of silica at a number of well pads in the region.[381] Silica is used as a proppant during hydraulic fracturing, and has been linked to lung cancer, kidney disease, and other ailments.[382] More than half of their samples exceeded Occupational Safety and Health Administration permissible exposure limits for respirable silica-containing dust.[383]

Of note in the rulemaking is the absence of exposure or health-related data beyond the fenceline but *within* a mile or half-mile of an oil or gas well. Conservation groups argued for a 1,000-foot setback. They cited two kinds of data in support of their proposed setback: affidavits from residents recounting the symptoms they experienced during well pad preparation, drilling, and completion near their homes,[384] and studies from industries other than oil and gas, including peer-reviewed research on factory emissions near schools.[385] The work of two distinct communities of practice, built on established criteria for pollutant monitoring and emissions inventories to ensure NAAQS attainment and federal commitments to limit greenhouse gas emissions such as methane leaks, did not speak to the proper scale of impact. This is the scale of greatest concern for residents—the distance between existing

377. Final Prehearing Statement of Colo. Envtl. Coal. et al., at 10, Changes to the Rules and Regulations of the Oil & Gas Conservation Comm'n of the State of Colo. COGCC Setback Rulemaking 2012, No. 1211-RM-04 (Colo. Oil & Gas Conservation Comm'n Dec. 19, 2012).

378. Letter from Theo Colborn, President, The Endocrine Disruption Exch., and Carol Kwiatkowski, Exec. Dir., The Endocrine Disruption Exch., to the Members of the Colo. Oil & Gas Conservation Comm'n (Nov. 13, 2012), http://cogccuat.state.co.us/RR_HF2012/setbacks/CommentDocs/Public/TEDX%20COGCC%20setback%20comments%20final%2011%2013%2012%20(2).pdf ("Based on the results of our year-long study 0.7 miles from a well pad, TEDX recommends one mile (5,280 feet) as the setback distance needed to protect the health of residents.").

379. Final Prehearing Statement of the Colo. Envtl. Coal. et al., *supra* note 377, at 9–10, Exhibit 8.

380. *See id.* at Exhibit 8.

381. Eric J. Esswein et al., *Occupational Exposures to Respirable Crystalline Silica During Hydraulic Fracturing*, 10 J. OCCUPATIONAL & ENVTL. HYGIENE 347, 349 (2013).

382. *Id.* at 347, 349.

383. *Id.* at 352–53.

384. Final Prehearing Statement of the Colo. Envtl. Coal. et al., *supra* note 377, at Exhibits 3, 4, 6, 7, 10.

385. *Id.* at Exhibit 9.

(150 feet, 350 feet) and proposed (1,000 feet, 5,280 feet) setbacks, the quality of air beyond the imaginary collapsed rig.[386] The setback rule now stands at 500 feet.[387] Residents continue to recount the experience of acute and subchronic health effects during intermittent, peak emissions from UOG equipment and activity at greater distances.[388]

III. SHIFTING BOUNDARIES

A. *Radioactive Materials Unleashed*

Communities of practice build around durable institutions such as analytic frameworks, inventories, and equipment. Their work can limit the use of existing authority to respond to disparate harms or stall its extension to impacts near intensive industrial activities. The constructed and nested boundaries they create explain the limits of environmental protection beyond comparative competence, statutory power, and equity–efficiency tradeoffs. The institutions that serve as focal points for each community of practice influence the pace of their boundary work. In the context of Title VI complaints, the edge of impacted communities in central California was artificially constrained within the life cycle of complaint processing by an EPA office. As shale oil and gas drilling took hold in Colorado, the scale at which regulators could issue health-based standards was limited by the gradual expansion of inventories and monitors and the cycle of response to NAAQS violations. Other institutions invite boundary work in real time. Our case study is a community of practice that formed thirty years after EPA issued an important exemption in oil and gas law: Subtitle C of the RCRA.[389] This community of practice, a small group of chemists, health physicists, environmental managers, and operators, adjusts the daily intake of radioactive materials at municipal landfills. A practice-based understanding of risk allows us to think of "point sources"—from the menacing bulkiness of a petrochemical plant to the deceptive idleness of a landfill—in a new way.

A common narrative in the rise of shale gas and other unconventional fuels begins with the "Halliburton Loophole."[390] It

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386. *See id.* at Exhibit 7.

387. COLO. CODE REGS. § 404-1:604(a)(1) (2015).

388. *See* Final Prehearing Statement of Colo. Envtl. Coal. et al., *supra* note 377, at Exhibits 3, 4, 6.

389. 42 U.S.C. §§ 6921–6939e (2012).

390. 42 U.S.C. § 300h(d)(1)(B)(ii) (2012); Editorial, *The Halliburton Loophole*, N.Y. TIMES, Nov. 3, 2009, at A28.

is a provision in the Energy Policy Act of 2005 that exempted hydraulic fracturing from regulation under the Safe Drinking Water Act.[391] It received a great deal of attention in the legal literature, as it was drafted by order of the Eleventh Circuit,[392] based on a study declared "scientifically unsound" by an EPA whistleblower,[393] and focused on the primal fear of drinking water laced with proprietary chemical blends.[394] But decades before the merger of directional drilling and high-volume fracturing, EPA made another stark choice. It determined the extent to which it would regulate a variety of oil and gas production wastes under RCRA.[395] Oil and gas waste streams include flowback water, which is fracturing fluid that returns to the surface during well stimulation;[396] produced water, which is present in shale and other formations and brought up through the wellbore;[397] and drill cuttings, which are bits of rock loosened by a drill bit that accumulate in substantial quantities.[398] Flowback and produced waters contain a mix of additives, including fracturing fluid and drilling mud chemicals, methane, VOCs, salts, metals, and radioactive material.[399]

391. Energy Policy Act of 2005, Pub. L. No 109-58, § 322, 119 Stat. 594, 694 (amending the Safe Water Drinking Act).

392. *See* Legal Envtl. Assistance Found., Inc. v. U.S. Envtl. Prot. Agency, 118 F.3d 1467, 1475 (11th Cir. 1997) ("Nothing in the statutory definition [of underground injection] suggests that EPA has the authority to exclude from the reach of the regulations an activity (i.e., hydraulic fracturing) which unquestionably falls within the plain meaning of the definition . . . ."). The decision led EPA to evaluate whether high-volume hydraulic fracturing presented a risk to drinking water supplies, and conclude that use of the practice to extract one resource in particular, coalbed methane, "poses little or no threat." OFFICE OF GROUND WATER & DRINKING WATER, U.S. EPA, EPA 816-R-04-003, EVALUATION OF IMPACTS TO UNDERGROUND SOURCES OF DRINKING WATER BY HYDRAULIC FRACTURING OF COALBED METHANE RESERVOIRS (2004), http://water.epa.gov/type/groundwater /uic/class2/hydraulicfracturing/wells_coalbedmethanestudy.cfm.

393. *See* Letter from Weston Wilson, EPA Employee, to Wayne Allard, U.S. Senator, Ben Nighthorse Campbell, U.S. Senator, and Diana DeGette, U.S. Representative (Oct. 8, 2004) (on file with author) (criticizing the EPA study for its narrow focus on coalbed methane, failure to consider surface discharge of fracturing and production fluids and other sources of contamination, and preparation by panel five-sevenths of whom had conflicts of interest).

394. Colborn et al., *supra* note 203, at 1044, 1049.

395. *See* 42 U.S.C. §§ 6901–6992k (2012) (laying out the provisions on regulation of wastes in the codified version of RCRA).

396. Nathaniel R. Warner et al., *Impacts of Shale Gas Wastewater Disposal on Water Quality in Western Pennsylvania*, 47 ENVTL. SCI. TECH. 11849, 11849 (2013).

397. Tieyuan Zhang et al., *Co-Precipitation of Radium with Barium and Strontium Sulfate and its Impact on the Fate of Radium During Treatment of Produced Water from Unconventional Gas Extraction*, 48 ENVTL. SCI. TECH. 4596, 4596 (2014).

398. *Fact Sheet—Beneficial Reuse of Drilling Wastes*, DRILLING WASTE MGMT. INFO. SYS., http://web.ead.anl.gov/dwm/techdesc/reuse/ (last visited Sept. 16, 2015).

399. Erich Schramm, *What is Flowback, and How Does it Differ from Produced Water?*, INST. FOR ENERGY & ENVTL. RES. FOR NE. PA. (Mar. 24, 2011), http://energy.wilkes.edu/ pages/205.asp.

RCRA was passed to address the unregulated disposal of hazardous waste, much of which was disposed in surface waters and unlined, open landfills.[400] Soon thereafter, EPA published a proposed rule that defined "hazardous waste" under the statute.[401] Much was at stake: for oil and gas producers, transporters, and owners of disposal facilities, any "hazardous" waste under the definition triggered expensive treatment, storage, and management controls as well as strict liability.[402] EPA proposed to exempt large-volume exploration and production wastes from the definition.[403] The exemption was adopted in 1980 pending further study.[404] EPA's report focused on the "severe economic impact" of subjecting "billions of barrels of waste to regulation under Subtitle C as hazardous wastes."[405] Following issuance of the report, the exemption was made permanent in 1988.[406] It covered produced water, drilling fluids, and "other wastes associated with" exploration and production of crude oil or natural gas.[407]

Among the drilling fluids, produced water, and other wastes exempted from cradle-to-grave oversight under RCRA were drill cuttings, flowback and produced water, sludge (buildup of waste products in reserve pits), and scale (hard deposits that accumulate in tanks, pipes, and other points of storage and transmission) that contain naturally occurring radioactive materials, or NORM.[408] NORM can be traced to the shale deposits that are fractured under high pressure with water and sand to allow for the free flow of hydrocarbons.[409] Eons ago, the shale was ocean floor, teeming with trilobites and other biomass.[410] A single well completion can return millions of gallons of water to the surface, laced with salts from

400. *See History of RCRA*, U.S. EPA, http://www2.epa.gov/rcra/history-resource-conservation-and-recovery-act-rcra.

401. 45 Fed. Reg. 33,089 (proposed May 18, 1980).

402. *See* 42 U.S.C. §§ 6921–6939d (laying out provisions for hazardous waste management).

403. *See* 43 Fed. Reg. 58,946 (proposed Dec. 18, 1978) (describing how EPA's proposals relate to the criteria for identifying hazardous waste).

404. Solid Waste Disposal Act, Pub. L. No. 96-482, sec. 7, § 3001(b)(2)(A), (B), 94 Stat. 2334, 2336 (1980).

405. 53 Fed. Reg. 25,446 (July 6, 1988).

406. 42 U.S.C. §§ 6921–6939 (2012); U.S. EPA, EXEMPTION OF OIL AND GAS EXPLORATION AND PRODUCTION WASTES FROM FEDERAL HAZARDOUS WASTE REGULATIONS 5 (2002), http://www.epa.gov/osw/nonhaz/industrial/special/oil/oil-gas.pdf.

407. 42 U.S.C. § 6921(b)(2)(A).

408. U.S. EPA, *supra* note 400, at 10.

409. *See* Alisa L. Rich & Ernest C. Crosby, *Analysis of Reserve Pit Sludge from Unconventional Natural Gas Hydraulic Fracturing and Drilling Operations*, 23 NEW SOLUTIONS 117, 118 (2013) (stating that NORM is found in natural geological formations and can be brought to the surface by exploration and mining of oil and gas).

410. *See* 1 J. P. LESLEY, A SUMMARY DESCRIPTION OF THE GEOLOGY OF PENNSYLVANIA 565 (1892).

ancient bits of sea trapped deep underground in pockets of rock.[411] Prior to extraction, the salts interact with rock for millions of years, mobilizing radionuclides such as $radium_{226}$ and other decay products of uranium and thorium.[412] When these isotopes are drawn to the surface, sent along pipelines, stored in open pits or tanks, or pumped through filters at treatment facilities, the concentration of NORM in bulk wastes can increase, along with its potential for dispersion.[413] This technologically enhanced NORM, or TENORM, is subject to minimal federal regulation.

TENORM is not defined as a "source" or "special" or "byproduct" nuclear material under the Atomic Energy Act.[414] It is not subject to control under the Low-Level Radioactive Waste Policy Act.[415] With few exceptions, including National Emissions Standards for Hazardous Air Pollutants (NESHAPs) for uranium mill tailings piles[416] and transportation rules for the shipment of highly radioactive materials by truck or rail,[417] TENORM is a state issue. Should a state concern itself with TENORM in oil and gas waste, it must design its own proxy for the pervasive controls found in statutes such as RCRA, and apply them to a range of disposal practices for isotopes such as $radium_{226}$, which has a half-life of 1,600 years.[418] Over the years, disposal options included land spreading, shallow burial, subsurface injection, beneficial use (e.g., road dust for ice control), treatment and discharge into surface waters, and, recently, storage in solid waste landfills.[419]

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411. C. CLARK ET AL., ARGONNE NAT'L LABS., HYDRAULIC FRACTURING AND SHALE GAS PRODUCTION: TECHNOLOGY, IMPACTS, AND REGULATIONS 9 (2013); Valerie J. Brown, *Radionuclides in Fracking Water: Managing a Toxic Blend*, 122 ENVTL. HEALTH PERSP. A50, A51 (2014).

412. ANSELMO PASCHOA & FRIEDRICH STEINHAUSLER, TECHNOLOGICALLY ENHANCED NATURAL RADIATION 48–49 (2010) (discussing the increase in concentration of NORM above background levels); Brown, *supra* note 411, at A51.

413. *See* U.S. GEOLOGICAL SURVEY, U.S. DEP'T OF THE INTERIOR, NATURALLY-OCCURRING RADIOACTIVE MATERIALS (NORM) IN PRODUCED WATER AND OIL-FIELD EQUIPMENT—AN ISSUE FOR THE ENERGY INDUSTRY 1 (1999), http://www.pubs.usgs.gov/fs/fs-0142-99/fs-0142-99.pdf.

414. *See* 42 U.S.C. §§ 2014, 2077, 2092, 2111 (2012) (defining what constitutes nuclear materials, but lacking explicit inclusion of TENORM); S.Y. Chen et al., *Toward the Framework and Implementation for Clearance of Materials from Regulated Facilities*, 89 HEALTH PHYSICS 115, 115 (2005) (describing the poorly defined framework for regulating TENORM).

415. 42 U.S.C. § 2021b(9).

416. *See* 51 Fed. Reg. 34,056 (Sept. 24, 1986) (rule establishing NESHAPs for uranium mill tailings governed by EPA).

417. *See* 49 U.S.C. § 5103(a), (b)(1) (regulating transportation of hazardous materials in commerce).

418. Carlyle J. Roberts, *Management and Disposal of Waste from Sites Contaminated by Radioactivity*, 51 RADIATION PHYSICS & CHEMISTRY 579, 582 (1998).

419. Brown, *supra* note 411, at A53.

The volume of waste covered by federal exemption is considerable. Consider data for TENORM produced by a single industry in one state over the course of one year. Pennsylvania defines TENORM as "Technologically Enhanced Naturally Occurring Radioactive Materials" whose "radionuclide concentrations or potential for human exposure have been increased above levels encountered in the natural state by human activities."[420] In 2011, the Pennsylvania Department of Environmental Protection (DEP) asked oil and gas producers to stop sending produced water to wastewater treatment plants, which experienced substantial buildup of radioactive material.[421]

In 2012, landfills in Pennsylvania received more than 19,000 tons of TENORM waste.[422] The waste was shipped via 1,324 truckloads to twenty landfills across the state.[423] DEP regulations require radiation monitoring at solid waste facilities. At each landfill, radiation alarms must be set to trigger at "a level no higher than 10 microroentgens per hour (μR/hr) above the average background at the facility."[424] Exposure or dose is often expressed in microroentgens (μR), and the amount of exposure per hour is a measure of dose rate. Alarms sounded for a variety of oil and gas wastes shipped to landfills, including drilling fluids, brine, fracking fluid waste, and drill cuttings.[425] Over 93% (1,232) of the truckloads exhibited an average dose rate above 10 μR/hr.[426] Approximately 39.65% (525 loads) and 18.2% (241 loads) had an average dose rate above 40 μR/hr and 80 μR/hr, respectively.[427] Somerset County had the highest number of landfills (three) reporting radiation alerts in Pennsylvania. The three landfills

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420. *See* 25 PA. CODE § 271.1 (2015).

421. Press Release, Pa. Dep't of Envtl. Prot., DEP Calls on Natural Gas Drillers to Stop Giving Treatment Facilities Wastewater (Apr. 19, 2011), http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=17071&typeid=1; *see* Warner et al., *supra* note 396, at 11,850 (suggesting buildup of contaminants beyond maximums established by the U.S. EPA at wastewater treatment plants).

422. Pa. Dep't of Envtl. Prot., TENORM Report Buried 2012ver05.xls (no date) (on file with author) [hereinafter TENORM 2012 Report]; E-mail from Christopher Solloway, Solid Waste Specialist, Pa. Dep't of Envtl. Prot., to Kevin Sunday (Apr. 24, 2013, 2:52 PM) (on file with author) (stating that there were 19,125.62 tons of TENORM waste shipped to Pennsylvania landfills in 2012).

423. TENORM 2012 Report, *supra* note 422.

424. 25 PA. CODE § 273.223(c).

425. TENORM 2012 Report, *supra* note 422.

426. *Id.* In 2013, DEP set an interim procedure for the management and disposal of waste derived from oil and gas wells. According to the procedure, if the measured dose rate for a waste load exceeded 80 μR/hr above background, it could not be disposed in Pennsylvania. E-mail from Ali Tarquino Morris, Program Dev. & Support Chief, Bureau of Waste Mgmt, Pa. Dep't of Envtl. Prot., to Richard Croll (Apr. 11, 2013, 11:26 AM) (on file with author).

427. TENORM 2012 Report, *supra* note 422.

with radiation alerts in Somerset County were Southern Alleghenies Landfill (52 alerts), Shade Landfill (53 alerts), and Mostoller Landfill (8 alerts).[428] In 2012, some of the landfills approached their annual allowance of TENORM.[429]

Some landfills turned away shipments for "excess radiation," including a truck that was "impounded due to it being 20,000 lbs overweight" but for which the "source of the material wasn't identified."[430] Other waste never reached in-state disposal facilities. They were deemed "[n]ot acceptable for disposal into PA landfills"[431] because their levels exceeded 270 pCi/g:

> Dan-Pun has finally pulled the trigger on shipping the original filtercake that was Ra 226 at > 270 pCi/g to U.S. Ecology in Idaho as I had arranged. The boxes begin their journey next week. This is good news for all involved.[432]
>
> I talked to Tony Labenne at Veolia [Landfill] this morning. He stated the Ra = 923 pCi/gram result was for waste still at the well pad and he informed them of the ban to bury in PA . . . .[433]

How should we interpret these numbers (expressed in picocuries (a trillionth of a curie) per gram, or the radioactivity concentration of a particular isotope)? Acceptable levels of radioactivity vary by state. For example, Michigan guidelines call for TENORM deposits in municipal solid waste landfills to contain an average concentration of $radium_{226}$ of 50 pCi/g, provided no sample exceeds a concentration greater than 100 pCi/g.[434] Texas permits TENORM burial if concentrations stay within 30 pCi/g for $radium_{226}$ and $radium_{228}$.[435] Wyoming guidelines allow disposal in

428. *Id.*

429. Pa. Dep't of Envtl. Prot., TENORM Report – By Region (Dec. 2012) (on file with author) (Southern Alleghenies Landfill had 2,472 Allowed Source Term Loading (ASTL) Tons remaining for the year, or 4% of its annual allowance; Laurel Highlands Landfill had 1,293 ASTL Tons Remaining, or 1% of its annual allowance).

430. E-mail from Martha Michalek, Pa. Dep't of Envtl. Prot., to EP-SW-Incidents (Dec. 14, 2012, 2:31 PM) (on file with author).

431. Pa. Dep't of Envtl. Prot., Bureau of Waste Mgmt., Draft—Form U/TENORM Submittal Procedures, at 1 (no date) (on file with author) [hereinafter Form U Submittal Procedures]; *see Rejected Tenorm Waste (2).xls*, Pa. Dep't of Envtl. Prot., Bureau of Waste Mgmt. (on file with author) (showing rejected TENORM waste).

432. E-mail from Chris Gerard, Penn Ohio Corp., to Robert Popichak, Envtl. Chemist, Pa. Dep't of Envtl. Prot. (Jan. 25, 2013, 3:38 PM) (on file with author).

433. E-mail from James Barnhart, Radiation Health Physicist, Pa. Dep't of Envtl. Prot., to Deborah Morvay, Envtl. Chemist, Pa. Dep't of Envtl. Prot. (Dec. 10, 2012, 9:33 AM) (on file with author).

434. Andrew J. Kondash et al., *Radium and Barium Removal Through Blending Hydraulic Fracturing Fluids with Acid Mine Drainage*, 48 ENVTL. SCI. TECH. 1334, 1339 (2014); Karen P. Smith et al., *Assessment of the Disposal of Radioactive Petroleum Industry Waste in Nonhazardous Landfills Using Risk-Based Modeling*, 37 ENVTL. SCI. TECH. 2060, 2061 (2003).

435. Rich & Crosby, *supra* note 409, at 131.

solid waste facilities if $radium_{226}$ levels do not exceed 50 pCi/g.[436] Ten cubic yards of waste with concentrations between 30 and 50 pCi/g of $radium_{226}$ may be deposited in Wyoming solid waste facilities, pending approval by the disposal facility.[437] While not directly related to TENORM, Nuclear Regulatory Commission rules for uranium mill tailings limit concentrations of radon, another decay product of uranium, to 5 pCi/g for passive disposal.[438] A Department of Energy-sponsored study reviewed several exposure pathways for TENORM deposited in landfills and recommended disposal of limited quantities in municipal facilities, with levels of up to 50 pCi/g for $radium_{226}$.[439]

Radium and radon emit particles that are dangerous when inhaled or ingested. Regulators at state and federal agencies encourage "all public and facility staff exposure to radiation should be maintained as-low-as-reasonably-achievable (ALARA)."[440] Health effects from exposure to TENORM depend on exposure pathway.[441] They also depend on exposure to several forms of radiation (alpha, beta, gamma) emitted by specific isotopes.[442] State regulations and guidelines are often developed for a subset of isotopes or a single radionuclide, such as radium. Radium, for example, is the focus of drinking water regulations.[443] Exposure to $radium_{226}$ and $radium_{228}$ is linked to chronic (e.g., cancer) and subchronic (e.g., tooth fractures, anemia, cataracts) health effects.[444] Radon, a decay product of radium, is a known human

436. SOLID & HAZARDOUS WASTE DIV., WYO. DEP'T OF ENVTL. QUALITY, GUIDELINE #24: NATURALLY OCCURRING RADIOACTIVE MATERIAL (NORM) MANAGEMENT IN WYOMING 5 (2011), http://deq.wyoming.gov/media/attachments/Solid%20%26%20Hazardous%20Waste/Solid%20Waste/Guidance%20%26%20Standards/SHWD_Solid-Waste_Guidelines-24-Naturally-Occurring-Radioactive-Material-NORM-Management-In-Wyoming_2011-08_BqBJnMq.pdf.

437. *Id.*

438. R. O. Abdel Rahman et al., *Remediation of NORM and TENORM Contaminated Sites*, 33 ENVTL. PROGRESS & SUSTAINABLE ENERGY 588, 589 (2014).

439. COMM. ON EVALUATION OF EPA GUIDELINES FOR EXPOSURE TO NATURALLY OCCURRING RADIOACTIVE MATERIALS, NAT'L RES. COUNCIL, EVALUATION OF GUIDELINES FOR EXPOSURE TO TECHNOLOGICALLY ENHANCED NATURALLY OCCURRING RADIOACTIVE MATERIALS 139 (1999), http://www.nap.edu/openbook.php?record_id=6360&page=R1.

440. BUREAU OF RADIATION PROT. & BUREAU OF LAND RECYCLING AND WASTE MGMT., PA. DEP'T OF ENVTL. PROT., FINAL GUIDANCE DOCUMENT ON RADIOACTIVITY MONITORING AT SOLID WASTE PROCESSING AND DISPOSAL FACILITIES 8 (2004) [hereinafter GUIDANCE DOCUMENT].

441. *See id.* (proposing to study potential exposure pathways as a means of evaluating potential dangers).

442. *Id.* at 3, 37 (explaining all three forms of radiation have adverse health effects).

443. *See* Brown, *supra* note 411, at A54 (mentioning radium in relation to EPA drinking water standards).

444. AGENCY FOR TOXIC SUBSTANCES & DISEASE REGISTRY, U.S. DEP'T OF HEALTH & HUM. SERVS., CAS # 7440-14-4, RADIUM 2 (1999), http://www.atsdr.cdc.gov/toxfaqs/tfacts144.pdf; *see also* Rich & Cosby, *supra* note 409, at 126.

carcinogen, and radionuclides generally follow a no-threshold model of carcinogenicity, meaning they increase cancer risk at even the lowest doses.[445] Other decay products pose their own potential health effects, such as congenital disorders and other types of cancer.[446] Perhaps the greatest health risks are borne by wastewater treatment plant and pipe yard workers, who handle filters and pipes where radioactive scale builds up over time.[447]

High concentrations of radionuclides occur in UOG wastes as a result of human activity—we remove it from kilometers under the surface, collect it in pits and tanks, and concentrate it through treatment and shipment. For example, beta radiation in a sample of reserve pit sludge in Texas measured 1,329 pCi/g, although, tellingly, radionuclides such as radium did not exceed permit guidelines for waste storage (30 pCi/g) when measured individually.[448] In the Marcellus formation, $radium_{226}$ concentrations can exceed 10,000 pCi/L in saltwater (brine) trapped in shale; one study found median activity of 5,350 pCi/L.[449] New York's Department of Environmental Conservation sampled Marcellus Shale waste, finding $radium_{226}$ activity levels thousands of times higher than the limit for safe drinking water.[450] Managing these materials in a municipal landfill poses challenges. For example, radon emissions can significantly increase as waste interacts with gas generated by the decay of organic matter.[451] Keeping exposure to radiation as low as reasonably achievable is a function of several variables, among them radioactivity, distance, shielding, and time. One study made the following assumptions for TENORM exposure assessment: $radium_{226}$ concentrations of 50 pCi/g or less (radioactivity), storage at least three meters below a landfill cap (shielding), and maintenance of the cap's integrity (time).[452] The presence of radionuclides in the Marcellus Shale and other formations, their potential to concentrate during production and waste management, and documented health effects of exposure demonstrate the importance of TENORM waste disposal and governance.

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445. Bob Weinhold, *Unknown Quantity: Regulating Radionuclides in Tap Water*, 120 ENVTL. HEALTH PERSP. A350, A352 (2012).

446. Rich & Crosby, *supra* note 409, at 127.

447. *See id.* at 125 (describing radiation sickness among occupational workers).

448. *Id.* at 131.

449. Brown, *supra* note 411, at A51; Zhang et al., *supra* note 397, at 4596.

450. David M. Kargbo et al., *Natural Gas Plays in the Marcellus Shale: Challenges and Potential Opportunities*, 44 ENVTL. SCI. & TECH. 5679, 5681 (2010).

451. Gary R. Walter et al., *Effect of Biogas Generation on Radon Emissions from Landfills Receiving Radium-Bearing Waste from Shale Gas Development*, 62 J. AIR & WASTE MGMT. ASS'N 1040, 1043 (2012).

452. Smith et al., *supra* note 434, at 2065.

B. TENORM Landfills: Risk as Practice

Pennsylvania's response to TENORM predates the surge of UOG activity in the late aughts. DEP's Bureau of Radiation Protection (BRP) issued joint regulations with the Bureau of Waste Management (BWM), setting radiation monitoring requirements that led to those alarm triggers.[453] Waste disposal facilities must obtain a permit from DEP before they accept waste.[454] Applications for a permit to operate a landfill include a "[r]adiation protection action plan."[455] When TENORM arrives at a landfill, the Action Plan informs its response. An Action Plan details "procedures for monitoring for and responding to radioactive material entering the facility . . . ."[456] In 2004, BRP and BWM issued guidance that outlines the Action Plan, instrumentation, personnel training, and dose limits for workers and the public.[457] The document restates federal and state policy to maintain exposure to radiation "as-low-as-reasonably-achievable."[458]

TENORM may not be deposited at a waste disposal site without preapproval by DEP, in writing.[459] Approval is conditioned on DEP's determination that disposal of the waste at a facility will not endanger public health and safety.[460] The review process begins with completion of a "Form U."[461] A Form U is filled out when radiation levels are known or suspected to exceed 10 μR/hr above background, or when a waste shipment triggers an alarm at a disposal facility. At that point, the container is placed in a holding area or returned to the generator.

The form requires a generator of residual waste to provide landfill operators with a description of the physical, chemical, and radiological characterizations of a waste shipment, manufacturing and/or pollution control processes used during waste production, a schematic of those processes, a confidentiality claim, a source reduction strategy, and other information.[462] Landfill operators

453. *Radioactive Material in Solid Waste Monitoring*, PA. DEP'T OF ENVTL. PROT., http://www.portal.state.pa.us/portal/server.pt/community/radioactive_material_in_solid_waste_monitoring/21933 (last updated 2015).

454. 25 PA. CODE § 271.101(a) (2015).

455. *Id.* § 273.140a.

456. *Id.*

457. GUIDANCE DOCUMENT, *supra* note 440, at 6–7.

458. *Id.* at 8.

459. 25 PA. CODE § 273.201(m).

460. *Id.*

461. Form U Submittal Procedures, *supra* note 431.

462. BUREAU OF WASTE MGMT., PA. DEP'T OF ENVTL. PROT., FORM U REQUEST TO PROCESS OR DISPOSE OF RESIDUAL WASTE APPLICANT'S CHECKLIST (2008), http://www.elibrary.dep.state.pa.us/dsweb/Get/Document70187/03%20Checklist%202540-PM-BWM0395.pdf.

use this information to fill out a Form U and include site information and a proposed disposal method.[463] If the Form U is properly completed, and DEP decides disposal within Pennsylvania will not endanger the health and safety of the public, approval is sent to the waste generator and landfill.[464]

In order to approve a Form U request, a DEP Regional Chemist relies on information contained in the Form U and related documents.[465] Analysis using DEP-approved methods is provided in pCi/g for several isotopes, including radium_{226}, radium_{228}, uranium_{238}, and thorium_{232}.[466] An EPA-approved sampling method is required for "all new sources of wastes with TENORM above action level," including flowback, produced waters, sludge from storage pits and tanks, and filters where TENORM can build up as scale.[467] The Form U Submittal Procedures specify how readings should be taken. The maximum weight for a representative sample is one thousand tons.[468] Once gamma scans are taken and specific activity levels determined for the samples, the Regional Chemist sends the data to the state's BRP for review.[469] BRP has thirty-three days to determine whether to allow disposal of oil and gas waste at a landfill.[470]

Waste exhibiting TENORM concentrations of 15 pCi/g or below is acceptable for disposal.[471] If it is between 15 pCi/g and 270 pCi/g, BRP must review the submission and determine acceptance or rejection based on the landfill in question and the amount of "cold" waste that can be used to offset "hot" (i.e., radioactive) waste and serve as a buffer.[472] BRP's answer takes the form of TENORM tonnage per week that a landfill can accept.[473] Readings above 270 pCi/g indicate that a shipment is "[n]ot acceptable for disposal into PA landfills," and must be "[m]anage[d] as Class 7 Radioactive Materials."[474]

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463. BUREAU OF WASTE MGMT., PA. DEP'T OF ENVTL. PROT., FORM U REQUEST TO PROCESS OR DISPOSE OF RESIDUAL WASTE INSTRUCTIONS 2, 8 (2012), http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-88996/01%20Instructions%202540-PMBWM0395.pdf.

464. *See* 25 PA. CODE § 273.201(m).

465. Form U Submittal Procedures, *supra* note 431, at 1.

466. *Id.*

467. *Id.*

468. *Id.*

469. *Id.*

470. *Id.*

471. *Id.* at 2.

472. *Id.*

473. *Id.*

474. *Id.*

Parties use an Excel spreadsheet, the TENORM Disposal Yearly Balance, to ensure TENORM does not exceed certain risk-based volumes at each landfill.[475] The file automatically converts volume and radioactivity information for a waste load received at a landfill to the facility's capacity to receive further shipments of TENORM:

> [P]lease fill in the cell labeled "2011 Collected Tonnage" with the volume, in tons, of waste received for calendar year 2011 not including the volume of TENORM waste that exceeded the alarm set point in 2011. Beginning January 1, 2012, when you receive TENORM waste above the alarm set point, please fill in the date that the waste was received and complete all information in adjacent columns requested in the spreadsheet except the last column labeled "ALST Tons Remaining." The value in this column will populate automatically and the estimated TENORM waste > 10 μR/hr remaining for the facility for the rest of the calendar year 2012 will be shown.[476]

> Radiological data is reviewed by BRP using a RESRAD model for determining TENORM allocation. Modeling equates TENORM gamma specific activity expressed in pCi/g, accounts for dilution due to landfill cold waste and assuming probability of waste being distributed over certain areas of the landfill, and allocates maximum tonnage of TENORM waste per week the landfill can accept.[477]

The simple spreadsheet, its exposure modeling and other formulae hidden and password protected, shows a division of labor that parties manage in order to ship, approve, and store TENORM at varying tonnages across the state. Their contributions to the waste management process are shared by email, through Form U submissions, requests for resubmission or tracking of denied Form U waste, and exchanges among regional chemists, central office staff, generators, and facility managers. Assuming certain disposal assumptions are met (e.g., homogeneous mixing, one-in-fifty total TENORM input to a landfill), the spreadsheets govern TENORM disposal that "will not exceed public dose limits."[478]

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475. Letter from Stephen Socash, Chief, Div. of Mun. & Residual Waste, Pa. Dep't of Envtl. Prot., to Landfill Operators, Tracking TENORM Waste Above Alarm Set Point (no date) (on file with author).

476. Bureau of Waste Mgmt., Pa. Dep't of Envtl. Prot., TENORM Disposal Yearly Balance Letter (no date) (on file with author).

477. Bureau of Waste Mgmt., Pa. Dep't of Envtl. Prot., Regional Procedure for TENORM Waste Approval (on file with author).

478. *Id.*; E-mail from Kenneth Reisinger, Dir., Pa. Dep't. of Envtl. Prot., Bureau of Waste Mgmt., to David Allard (Mar. 13, 2013, 12:27 PM) (on file with author) ("The big assumption here is that the landfill is appropriately mixing or blending the TENORM with the cold waste.").

Inputs to the spreadsheet are generated by several sets of practices, including waste coding and analysis, monitoring and acceptance of waste influx by landfill operators, and modeling and blanket or conditional approval by DEP. The inputs work their way through the process governing solid waste disposal across the state. In so doing, they shift and concentrate TENORM and related risks across landfills, holding areas, and transit routes.

The shifts begin as generators categorize waste using a numeric coding system: 804, for hydraulic fracturing fluid waste; 810, for drill cuttings; 802, for salt water or "brine"; and so on.[479] Each code represents a distinct type of waste that must be approved prior to disposal.[480] In addition, a waste code can trigger a new set of procedures before a shipment is accepted for landfill disposal. Form Us are approved with oil and gas waste category in mind. Mislabeled waste can send potentially more active sources of TENORM to a facility. The error may persist unless a shipment triggers an alarm or a generator finds an inconsistency between a waste code and activity levels when it later analyzes a waste stream for recertification (e.g., once every five years).[481] The same is true for sampling and analysis of waste streams, which may prove inaccurate upon arrival of a shipment at a landfill.

> There seems to be little understanding of the [Residual Waste Code] 800 series codes by many of the Generators (O&G Industry) and why proper/accurate coding is important.[482]

> Everything on this sheet looks wrong[;] it is all 801 [drilling fluids and residuals] and 810 [drill cuttings]. Bob are these old form U approvals or are they just recording the wrong waste codes?[483]

> Possible reasons for this mis-coding include, but are not limited to: the "cocktailing" of multiple waste streams at the point of generation, mis-interpretation of the current [Residual Waste

479. BUREAU OF WASTE MGMT., PA. DEP'T OF ENVTL. PROT., RESIDUAL WASTE CODES (2010), http://www.lyco.org/Portals/1/ResourceManagementServices/Documents/FormU-Residual%20Waste%20Codes.pdf.

480. *See, e.g.*, E-mail from Robert Popichak, Envtl. Chemist, Pa. Dep't of Envtl. Prot., to John Wakin, Waste Approval Manager, Waste Mgmt. (June 22, 2012, 10:04 AM) (on file with author) ("This waste is RWC 802 Brine Waste, the PA DEP BRP must approve it prior to disposal at a PA landfill. The analytical results will be forwarded to Jim Barnhart for review.").

481. E-mail from Todd Carlson, Program Manager, Pa. Dep't. of Envtl. Prot., to James Barnhart, Radiation Health Physicist, Pa. Dep't Envtl. Prot. (Sept. 5, 2012, 10:59 AM) (on file with author).

482. Pa. Dep't of Envtl. Prot., TENORM DATA—Southwest Region 1 (2012) [hereinafter SW TENORM Data].

483. E-mail from H. Scott Swarm, Envtl. Grp. Manager, Pa. Dep't of Envtl. Prot., to Robert Popichak, Envtl. Chemist, Pa. Dep't of Envtl. Prot. (Sept. 4, 2012, 9:14 AM) (on file with author).

> Code] definitions, and potentially willful mis-coding to avoid potentially costly and time consuming additional sampling.[484]
>
> Scott, can you please send an email out today to the regional chemists asking (1) whether they have received data (on the Form U) on radium 226 and 228 levels and (2) has this been required for Form U's. [T]hanks. Reply: No and No. As I said before, we have not seen the need because the cuttings [code 810] have not set off the landfill detectors. Only brine treatment sludge has set them off and thereby requiring isotopic analysis.[485]
>
> Todd: I checked with the scale operators who verified the 810 code loads that triggered the radiation detectors consisted of drill cuttings only. Reply: Interesting . . . . . any ideas on how we can follow up on this issue as we haven't seen this before. Do you feel confident with the landfill operation and the generator?[486]
>
> For many of these Marcellus wastes[,] there is not a specific code, and people try and pick what they believe is the most logical. . . . Anyway, this demonstrates for the umpteenth time why these Marcellus wastes should be scanned at the generating site with a Ludlum meter before sending this stuff on the road to a disposal or processing facility.[487]

Agency correspondence reveals a struggle to manage variable waste streams and radioactivity levels. The process is handicapped by miscoding and a lack of representative sampling.

> I have to emphasize again the need to representatively sample the roll-off boxes. A single grab sample may be the problem—maybe the solution is to have several [8-10?] grab samples pulled from each box in a three-dimensional grid pattern, composite them to form a homogeneous sample, then pull a sample for analysis from that greater sample.[488]
>
> As for the new box, this brings up the fact that the generator is responsible for representative sampling and analysis for all wastes. Maybe somebody on their end should look into doing

484. SW TENORM Data, *supra* note 482, at 1–2.

485. E-mail from Stephen Socash, Pa. Dep't of Envtl. Prot., to Scott Walters (Mar. 1, 2011, 10:12 AM) (on file with author); E-mail from Richard Marttala, Pa. Dep't of Envtl. Prot., to Scott Walters (Mar. 1, 2011, 10:45 AM) (on file with author).

486. E-mail from Stephen Socash, Pa. Dep't of Envtl. Prot., to Todd Carlson, Waste Prot. Manager, Pa. Dep't of Envtl. Prot. (Mar. 8, 2012, 10:36 AM) (on file with author); E-mail from Max Stanisch, Envtl. Manager, Casella–McLean Cty. Landfill, to Todd Carlson, Waste Prot. Manager, Pa. Dep't of Envtl. Prot. (Mar. 5, 2012, 10:53 AM) (on file with author).

487. E-mail from John Spang, Pa. Dep't of Envtl. Prot., to James Barnhart, Radiation Health Physicist, Pa. Dep't of Envtl. Prot. (Aug. 23, 2012, 9:12 AM) (on file with author).

488. E-mail from Robert Popichak, Envtl. Chemist, Pa. Dep't of Envtl. Prot., to Chris Gerard, Penn Ohio Corp. (Feb. 14, 2013, 7:02 AM) (on file with author).

> multiple analyses on one box to see how truly homogeneous their waste is . . . just a thought . . . it doesn't sound like they have a truly mixed and homogeneous waste in the box.[489]
>
> The waste is too variable as demonstrated by the disposal tracking sheet. We need a better mousetrap. I'm a little bit confused why we would only do a pCi/g only for loads over 40 μR/hr. I thought that was only for drill cuttings? This is a treatment sludge. I can't keep this straight.[490]
>
> The "new" report indicates radium 226 at 431 pCi/g. The original was 109 pCi/g. If this is true, it may indicate how non-homogenous the levels are in one box. This will have to be rejected and sent out of state . . . .[491]
>
> Here is another [Residual Waste Code] 804 [fracking fluid waste] that I'd like you to look at . . . . Please note that the thorium-232 is over 1,300 pCi/g in the analytical but the μR/hr roll-off readings are near background![492]
>
> Bottom line is that no radiological information was included in 2010 when the Form U was approved. Also, the 203 code was the most appropriate code in early 2010, and may still be today (?). I also found it very interesting that this one facility's waste submitted under the same form U approval was below the landfill's rad alarm level for 90% of their loads in 2012 but the remaining loads measured as high as 143 pCi/g in 2012 (and 208 pCi/g in 2013). This seems to be strong evidence that there is too much variability in this waste stream for any form u analysis of radiation to be meaningful.[493]
>
> Form U's are meaningful for a "consistent wastestream." This does not seem to apply to wastes generated from well sites, at least for TENORM. We really need to focus on a strategy based on actual readings on the boxes . . . .[494]

Miscoding and non-representative samples, in addition to the quantity of TENORM produced, strain landfill operators. Their

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489. E-mail from Robert Popichak, Envtl. Chemist, Pa. Dep't of Envtl. Prot., to Chris Gerard, Penn Ohio Corp. (Apr. 23, 2013, 10:47 AM) (on file with author).

490. E-mail from Kenneth Reisinger, Dir., Bureau of Waste Mgmt., Pa. Dep't of Envtl. Prot., to Stephen Socash, Pa. Dep't of Envtl. Prot. (Mar. 6, 2013, 3:30 PM) (on file with author).

491. E-mail from Robert Popichak, Envtl. Chemist, Pa. Dep't of Envtl. Prot., to Chris Gerard, Penn Ohio Corp. (Apr. 17, 2013, 10:17 AM) (on file with author).

492. E-mail from Robert Popichak, Envtl. Chemist, Pa. Dep't of Envtl. Prot., to James Barnhart, Radiation Health Physicist, Pa. Dep't Envtl. Prot. (July 9, 2013, 2:17 PM) (on file with author).

493. E-mail from Todd Carlson, Program Manager, Waste Mgmt., Pa. Dep't of Envtl. Prot., to Dwight Shearer, Program Manager, Pa. Dept. of Envtl. Prot. (Apr. 2, 2013, 11:23 AM) (on file with author).

494. E-mail from Todd Carlson, Program Manager, Pa. Dep't of Envtl. Prot., to Dwight Shearer, Pa. Dep't of Envtl. Prot. (Apr. 2, 2013, 10:56 AM) (on file with author).

task is to facilitate waste disposal, or to refuse certain waste loads pending approval. But the variability in dose rates, even "from a single site . . . affect a facility's ability to manage . . . waste."[495] When a shipment arrives and triggers a radiation alarm, landfill operators struggle with the variability of waste as they implement procedures in their Action Plan, such as determining whether waste triggers Action Level 1 (the landfill may reject the shipment and return it to the generator) or 2 (immediately isolate waste, question drivers about origin of waste, scan drivers for exposure, and contact DEP and other appropriate agencies).[496]

State regulations and guidance set out landfill operator activities in response to a radiation alarm. Radiation detectors are placed "as close as practical to the waste load and in an appropriate geometry to monitor the waste."[497] Alarms are set to trigger at a level no higher than 10 μR/hr above average background for a facility.[498] Operators use portable radiation monitors to determine dose rate and presence of certain isotopes on a vehicle that triggers an alarm.[499] When an alarm is triggered, the regulations and guidance recommend the following procedures: reset the alarm and evaluate the vehicle or container again, and if the alarm is triggered a second time, survey the vehicle's surfaces at a distance of five centimeters with a portable meter.[500] If radiation dose rates exceed certain thresholds in the cab or on the outside of the waste transport vehicle, it is moved to a designated area.[501] The landfill contacts a DEP Area Health Physicist. If the landfill seeks to dispose of the waste shipment, the load is kept onsite until the nature of the material and proper actions are determined. The vehicle may not leave the facility until it is issued a form exempting it from DOT restrictions. If a driver leaves without approval, the landfill contacts the state police.[502]

These and other procedures were triggered hundreds of times per year in Pennsylvania. Landfills received waste that was at times miscoded, improperly mixed or sampled, or shipped before a disposal site received Form U approval. For their part, operators, chemists, and health physicists scanned and

495. E-mail from Carl Spadaro, Envtl. Gen. Manager, MAX Envtl. Co., to Michael Forbeck (Jan. 19, 2011, 9:06 AM) (on file with author).

496. GUIDANCE DOCUMENT, *supra* note 440, at 21–23.

497. 25 PA. CODE § 273.223(c) (2015).

498. *Id.*

499. *Id.* § 273.223(d).

500. GUIDANCE DOCUMENT, *supra* note 440, at 22.

501. *Id.* at 8.

502. *Id.* at 23.

rescanned, decided when to process as routine waste, moved certain waste to designated areas, requested authorization to process waste at higher activity levels, rejected loads, and sent them back on the road with appropriate notifications and DOT exemptions.

There are points in the disposal process where a mistake can allow a shipment to be categorized as "routine waste" (if another pass through a fixed monitor does not trigger an alarm)[503] or given "blanket approval," where a waste stream initially found below a certain activity level is accepted to a limit of 0.5, 1.0, or 2.0 percent of the landfill's incoming volume.[504] The latter "is done in lieu of calling Rad Protection each time the alarm goes off when we know the waste is coming from a [certain] facility . . . ."[505] Blanket approval allows landfills to track but otherwise give less focus to certain waste streams when an alarm is triggered.[506]

Coding and sampling errors also affect "conditional approval," which is made with a landfill's TENORM Disposal Yearly Balance in mind.[507] This practice, carried out by DEP staff at regional and/or central offices, is the heart of the Form U process—restricting disposal of TENORM waste to protect occupational and public health.[508] DEP assesses the level of TENORM that a landfill can accept so that it can remain within prescribed activity levels and a recommended 50:1 "cold" (routine) to "hot" (radioactive) waste ratio.[509] Restrictions are made assuming "the landfill is appropriately mixing or blending the TENORM with the cold waste."[510] DEP determines a weekly tonnage that can be disposed

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503. *Flowchart of Recommended Immediate Actions for a Solid Waste Facility Radiation Alarm*, Pa. Dep't of Envtl. Prot., Bureau of Waste Mgmt. (on file with author).

504. E-mail from Joel Fair, Envtl. Eng'r Manager, Pa. Dep't of Envtl. Prot., to Anita Stainbrook, Envtl. Group Manager, Pa. Dep't of Envtl. Prot. (Aug. 25, 2011, 11:57 AM) (on file with author); Memorandum from Ray Urciuolo, Chief, Div. Radiation Control, to Bureau of Radiation Prot. Area Health Physicists (Sept. 10, 2004) (on file with author).

505. E-mail from Joel Fair, Envtl. Eng'r Manager, Pa. Dep't of Envtl. Prot., to Anita Stainbrook (Aug. 25, 2011, 11:57 AM) (on file with author).

506. Rather than call BRP each time an alarm is triggered, when a waste stream frequently sets off alarms, a facility can adjust the proportion of "hot" and "cold" (i.e., non-radioactive) waste that it accepts. *Id.*

507. *See, e.g.*, E-mail from Joel Fair, Envtl. Eng'r Manager., Pa. Dep't of Envtl. Prot., to Tony LaBeene (Dec. 14, 2012, 11:03 AM) (on file with author).

508. *Id.*

509. E-mail from Kenneth Reisinger, Dir., Bureau of Waste Mgmt., Pa. Dep't of Envtl. Prot., to Stephen Socash, Chief, Div. of Mun. & Residual Waste, Bureau of Waste Mgmt., Pa. Dep't of Envtl. Prot. (Mar. 25, 2013, 8:25 PM) (on file with author).

510. E-mail from Kenneth Reisinger, Dir., Bureau of Waste Mgmt., Pa. Dep't of Envtl. Prot., to David Allard, Dir., Bureau of Radiation Prot., Pa. Dep't of Envtl. Prot. (Mar. 13, 2013, 11:27 AM) (on file with author).

at a landfill while maintaining this ratio.[511] It does so under time constraints,[512] often while waste shipments remain idle for days or weeks at the gate.[513] Weekly tonnage disposal limits are added to Form Us before they are approved.[514] The pace of disposal approved can cause shipments to accumulate. Landfill operators and generators express confusion over TENORM allowances, and make decisions unaware of similar restrictions at other sites. The process of approval or individualized allowance can cause TENORM to pile up, cluster at one or more landfills, or return to the roads.

> We're all in the unfortunate position that the generator already staged this at the landfill. Since the landfill has a 60-day limit on holding waste (expiring at the end of this month), they're anxious to have a decision.[515]
>
> This e-mail correspondence deals with 25 roll-offs of O&G waste that were received as "candidate waste" at Greentree LF some time ago. As candidate waste, it was allowed to sit on the landfill site in the boxes while chemical analysis data was being generated . . . . [O]ur Rad Protection staff initially said they could only dispose of one box per week . . . . leaving some of this material sitting at the landfill for up to 24 additional weeks.[516]
>
> Also, per the field scan notes, these three roll offs do not seem to be quarantined or segregated in any way. They[']re located in landfill recycling building, landfill building, and CARES building. Is there a potential hazard to the workers there?[517]
>
> If we are limiting Shallenberger to 20 tons per week at a landfill but the landfill is taking the same amount from RES and IWT[;] the landfill is creating the hot spot DEP is trying to prevent. It is just not [sic] the waste generator who needs to know what they are generating. From a disposal standpoint the landfill

511. Form U Submittal Procedures, *supra* note 431.

512. *Id.*

513. *See, e.g.*, E-mail from Todd Carlson, Program Manager, Waste Mgmt., Pa. Dep't of Envtl. Prot., to James Barnhart, Radiation Health Physicist, Pa. Dep't of Envtl. Prot. (Dec. 12, 2012, 9:24 AM) (on file with author) ("I understand that these 21 loads are currently sitting at the landfills . . . . [S]ome portion of these loads will remain on the landfill property for approximately 20 weeks before disposal.").

514. *See, e.g.*, *Timeline for Approval of Form U # 557388 Arden Landfill*, Pa. Dep't of Envtl. Prot., Bureau of Waste Mgmt. (on file with author).

515. E-mail from Deborah Morvay, Envtl. Chemist, Waste Mgmt., Pa. Dep't of Envtl. Prot., to James Barnhart, Radiation Health Physicist, Pa. Dep't of Envtl. Prot. (Nov. 20, 2012, 9:19 AM) (on file with author).

516. E-mail from Todd Carlson, Program Manager, Waste Mgmt. Program, Pa. Dep't of Envtl. Prot., to Deborah Morvay, Pa. Dep't of Envtl. Prot. (Dec. 19, 2012, 8:46 AM) (on file with author).

517. E-mail from Deborah Morvay, Envtl. Chemist, Waste Mgmt., Pa. Dep't of Envtl. Prot., to James Barnhart, Radiation Health Physicist, Pa. Dep't of Envtl. Prot. (July 18, 2013, 1:14 PM) (on file with author).

> needs to know on a daily, weekly or other basis what their total allocation is at any one time.[518]
>
> This is why we need to have a live database for these form U's and what you approved and any conditions applied to that form U. When a form U is rejected[,] it needs to go out as an alert to all regions and landfills. This is what we were trying to say, by the time the load hits the scale house, all those form U numbers, conditions, etc. are lost.[519]
>
> EC# 599573 was approved 9/6/12 for 85 pCi/gram Ra226 . . . . Levels disposed were up to five times this gamma (90 uR/hr). Therefore Ra226 = ~ 425 pCi/gram at 90 uR/hr. This is actual data (thanks to new tracking and reporting EC#) showing that the front end Form U approval is not working so well for limiting disposal of elevated Ra226 specific activity waste, which we had presumed. In a few cases this month, at this landfill, this TENORM waste would not be allowed in the landfill and possibly violated US DOT statute being transported there . . . . Also and equally important, the amount originally allowed in weekly tonnage disposal restriction (30 tons) is *significantly overestimated*.[520]

The focus on landfill-specific authorization with annual caps based on inputs from a small group of analysts and operators allowed mistakes of identity, radioactivity, and intensity of disposal to accumulate. One program manager at DEP argued: "So as long as the annual allowance based on the TENORM spreadsheet is not violated, anything goes."[521] The yearly allowance spreadsheet shaped practices at the landfill and regional and central offices, while regulators lacked the ability to tend to the "bigger picture":[522] broad patterns of TENORM creation and disposal within the state. Cross-references as basic as TENORM by well number could not be generated.[523] Root causes of high dose rates were the subject of

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518. E-mail from Kenneth Reisinger, Dir., Bureau of Waste Mgmt., Pa. Dep't of Envtl. Prot., to Michael Forbeck (Mar. 7, 2013, 12:16 PM) (on file with author).

519. E-mail from Dwight Shearer, Program Manager, Pa. Dep't of Envtl. Prot., to James Barnhart, Radiation Health Physicist, Pa. Dep't of Envtl. Prot. (Feb. 7, 2013, 8:13 AM) (on file with author).

520. E-mail from James Barnhart, Radiation Health Physicist, Pa. Dep't of Envtl. Prot., to David Allard (Feb. 6, 2013, 3:05 PM) (on file with author) (emphasis added).

521. E-mail from Todd Carlson, Program Manager, Pa. Dep't. of Envtl. Prot., Bureau of Waste Mgmt., to Ali Tarquino Morris, Envtl. Group Manager, Pa. Dep't of Envtl. Prot., Bureau of Waste Mgmt. (Jan. 4, 2013, 2:54 PM) (on file with author).

522. E-mail from James Barnhart, Radiation Health Physicist, Pa. Dep't of Envtl. Prot., to Tony LaBeene, Special Waste Coordinator (Mar. 5, 2013 10:34 AM); E-mail from Tony LaBeene, Special Waste Coordinator, to James Barnhart, Radiation Health Physicist, Pa. Dep't of Envtl. Prot. (Feb. 28, 2013 10:50 AM); E-mail from Kenneth Reisinger, *supra* note 518.

523. PA. DEP'T OF ENVTL. PROT., TENORM DATA- SOUTHWEST REGION (Jan.–Dec. 2012) (on file with author).

speculation.[524] DEP began to engage in retroactive monitoring: they sent letters to facilities linked to rejected Form Us to ask about "the ultimate disposition of the wastes."[525] They could not immediately account for some of the shipments.[526] In 2013, DEP looked into whether landfills "received enough cold waste to allow for proper mixing of the TENORM" in 2012. Three landfills did not.[527] Three others "accepted just enough cold waste to mix with their TENORM."[528] In response to confusion over the relationship between measures of dose rate and radioactivity (e.g., the "need to develop clear criteria for loads > 140 uR/hr [but less than 270 pCi/g]" and "how the limit of 10 uR/h relates to the results we receive in units of pCi/g"),[529] DEP adopted an interim procedure that would have rejected 250 loads for in-state disposal in 2012, "whereas in reality, only six were actually rejected . . . ."[530] These and other adjustments gave rise to practice variation and set the stage for staff to propose further innovations.[531] DEP staff looked beyond the categories of data necessary for annual allocation to improve their handling of TENORM based on the origin of waste as well as a

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524. E-mail from Robert Popichak, Envtl. Chemist, Pa. Dep't of Envtl. Prot., to James Barnhart, Radiation Health Physicist, Pa. Dep't Envtl. Prot. (June 22, 2012, 10:34 AM) (on file with author).

525. *See, e.g.*, E-mail from Jeffrey Olsen, Bureau of Waste Mgmt., Pa. Dep't of Envtl. Prot., to Kenneth Reisinger, Dir., Bureau of Waste Mgmt., Pa. Dep't of Envtl. Prot. (Jan. 28, 2013, 12:07 PM) (on file with author); Letter from Stephen Socash, Chief, Pa. Dep't of Envtl. Prot., Div. of Mun. & Residual Waste, to Doug Kepler, Seneca Res. Corp. (no date) (on file with author).

526. E-mail from Jeffrey Olsen, Bureau of Waste Mgmt., Pa. Dep't of Envtl. Prot., to Kenneth Reisinger, Dir., Bureau of Waste Mgmt., Pa. Dep't of Envtl. Prot. (Jan. 28, 2013, 12:07 PM) (on file with author).

527. E-mail from Christopher Solloway, Solid Waste Specialist, Pa. Dep't. of Envtl. Prot., Waste Mgmt., to David Allard (Apr. 16, 2013, 3:46 PM) (on file with author).

528. *Id.*

529. E-mail from David Allard, Dir., Bureau of Radiation Prot., Pa. Dep't of Envtl. Prot., to Joel Fair, Envtl. Eng'r Manager, Pa. Dep't of Envtl. Prot., Waste Program (May 1, 2012, 12:15 PM) (on file with author); E-mail from Deborah Morvay, Envtl. Chemist, Pa. Dep't of Envtl. Prot., Bureau of Waste Mgmt., to James Barnhart, Radiation Health Physicist, Pa. Dep't of Envtl. Prot. (Mar. 15, 2012, 11:08 AM) (on file with author).

530. E-mail from Ali Tarquino Morris, Chief, Program Dev. & Support, Pa. Dep't of Envtl. Prot., Bureau of Waste Mgmt., to Richard Croll (Apr. 11, 2013, 11:26 AM) (on file with author).

531. *See, e.g.*, E-mail from Bruce Gearhart, Envtl. Prot. Specialist, Bureau of Waste Mgmt., Pa. Dep't of Envtl. Prot., to Jeffrey Olsen, Bureau of Waste Mgmt., Pa. Dep't of Envtl. Prot. (Nov. 7, 2012, 9:05 AM) (on file with author) ("One problem which I recognize is the lack of involvement of the Waste staff on these sites (well locations) and inspecting them as residual waste generators. As I see it, the problem should be dealt with at the point of generation, not the receiving facilities. Verification of the waste type/process versus the approved form U etc. could take place prior to the waste being transported to the landfill and setting off the alarms. I discussed this issue with some of the Oil and Gas folks who don't see it as 'their' problem because the waste is approved by a Waste chemist and sent to Waste facilities where any problems are dealt with.").

broader set of risks posed by landfill disposal.[532] Yet they expressed concern that reduced test frequency would further limit their ability to handle waste that varied by formation, operation, and well.[533]

IV. TOWARD BETTER BOUNDARY WORK IN ENVIRONMENTAL LAW

A. *The Institutional Scale*

Environmental protection is now stretched in two directions: to climate change and transboundary ecosystems that transcend a single system of governance, and to finer delineations of risk such as personal exposure. In response to the former, scholars embrace greater "redundancy, administrative overlap, joint regulation, and mutual dependence" among state and federal actors.[534] They push against neat allocations of responsibility—intrastate groundwater to state and local agencies, climate change to international tribunals, and so on—in the prevailing "static model" of environmental law.[535] They point to a growing number of instances where regulation follows a dynamic path, from the push and pull of state and federal brownfield redevelopment[536] to the flexible, cross-jurisdictional management of watersheds.[537]

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532. *See, e.g.*, PERMA-FIX ENVTL. SERVS., INC., TECHNOLOGICALLY ENHANCED NATURALLY OCCURRING RADIOACTIVE MATERIALS (TENORM) STUDY REPORT 9–8 (2015) (identifying the radiological impacts of spills and long-term storage as areas of concern, including "a radiological environmental impact to soil from the sediments from landfill leachate treatment facilities that treat leachate from landfills"); E-mail from Jeffrey Olsen, Bureau of Waste Mgmt., Pa. Dep't of Envtl. Prot., to Diane McDaniel, Eng'g Manager, Bureau of Waste Mgmt, Pa. Dep't of Envtl. Prot. (Oct. 2, 2012, 11:05 AM) (on file with author) ("[S]tart looking at treatment processes and see if we can't start to recognize patterns based on treatment techniques and origin of waste.").

533. E-mail from Carl Spadaro, Envtl. Gen. Manager, MAX Envtl. Co., to Michael Forbeck, Envtl. Program Manager, Bureau of Waste Mgmt., Pa. Dep't of Envtl. Prot. (Jan. 19, 2011, 9:06 AM) ("The shipment that triggered the alarm was one of several loads accepted by MAX from the same well site. The other loads did not trigger any alarms. This underscores our continuing concerns about further reducing the frequency of chemical and radiation monitoring of these wastes, as there have been differences in the waste from a single site that affect a facility's ability to manage the waste."); E-mail from Carl Spadaro, Envtl. Gen. Manager, MAX Envtl. Co., to Michael Forbeck, Envtl. Program Manager, Bureau of Waste Mgmt., Pa. Dep't of Envtl. Prot. (Jan. 19, 2011, 10:35 AM) ("This still illustrates our concern about reducing the frequencies of testing these wastes, so as to make sure that we are requiring reasonable measures to capture unexpected contamination sources.").

534. Heather K. Gerken, *Federalism As the New Nationalism: An Overview*, 123 YALE L.J. 1889, 1902 (2014).

535. J.B. Ruhl & James Salzman, *Climate Change, Dead Zones, and Massive Problems in the Administrative State: A Guide for Whittling Away*, 98 CAL. L. REV. 59, 104 (2010).

536. William W. Buzbee, *Brownfields, Environmental Federalism, and Institutional Determinism*, 21 WM. & MARY ENVTL. L. & POL'Y REV. 1, 24–25 (1997).

537. Freeman & Farber, *supra* note 38, at 822.

When we recognize the dynamism of regulatory response, its complexity expands exponentially: "the initiative to address environmental problems will originate from more than one level of government based upon a variety of political, socioeconomic, and environmental factors . . . ."[538] There is a yawning gap between initiative (and who should take it) and implementation, which in legal scholarship is often spanned with metaphor rather than mechanism. For example, governance should mirror the characteristics of ecosystems, eliminate "unfit" policy solutions, maintain a "diversity" of ideas, and operate at a variety of scales.[539] The regional or "midlevel" regime figures prominently as a scale where jurisdictional overlap can be managed and coordinated.[540] To ensure diversity of available policy solutions, federal preemption is tweaked, setting regulatory "floors" and "ceilings"[541] that bound multilayered responses as they are negotiated[542] or iteratively play out.[543]

The commons is another metaphor that scholars use to explain fragmented, underprotected policy settings.[544] The common-pool grazing fields and fisheries of Harden's classic treatment are replaced with another scarce resource that is equally prone to non-excludability and free riding: regulatory action itself. Here is how the regulatory commons exhausts itself: an issue such as hydraulic fracturing attracts the attention of several government actors, each with "partial potential jurisdiction" but no primacy over regulatory response. Interest groups concerned with oil and gas development do not know where to turn to address its impacts. They fragment or duplicate their demands, or choose not to act. Regulators do not see their work "inuring sufficiently" to their benefit, or choose not to act.[545] The result is silence in the face of growing intensity of development.

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538. Adelman & Engel, *supra* note 12, at 1799.

539. *Id.* at 1800 n.14. A more technical version of the metaphor is to compare governance to a complex adaptive system. *See, e.g.*, Donald T. Hornstein, *Complexity Theory, Adaptation, and Administrative Law*, 54 DUKE L.J. 913, 914–15 (2005). For an application to energy, see generally Osofsky & Wiseman, *supra* note 196.

540. *See, e.g.*, Freeman & Farber, *supra* note 38, at 840–43 (describing the multiagency regional effort to overcome water resource conflicts in northern California).

541. William W. Buzbee, *Interaction's Promise: Preemption Policy Shifts, Risk Regulation, and Experimentalism Lessons*, 57 EMORY L.J. 145, 147 (2007).

542. *See* Jody Freeman & Jim Rossi, *Agency Coordination in Shared Regulatory Space*, 125 HARV. L. REV. 1131, 1146 (2012); Erin Ryan, *Negotiating Federalism*, 52 B.C. L. REV. 1, 4 (2011).

543. *See generally* Ann E. Carlson, *Iterative Federalism and Climate Change*, 103 NW. U. L. REV. 1097 (2009) (discussing several iterative federalism schemes).

544. Buzbee, *supra* note 10, at 22.

545. William W. Buzbee, *Asymmetrical Regulation: Risk, Preemption, and the Floor/Ceiling Distinction*, 82 N.Y.U. L. REV. 1547, 1605 (2007).

The metaphor is even extended to Heller's "anticommons." For example, multiple parties have the right to exclude from utility-scale lands for wind and solar power, leading to underproduction of renewable energy.[546]

Whether conceived as a complex system or commons, similar governance solutions follow: avoid reductionist assumptions about federal, state, and local government behavior; harness regulatory overlap; strengthen the ability of citizens to push for an appropriate level of response; maintain centralized roles such as information gathering and floor-setting while "tempering uniformity";[547] allow dispersed actors to address problems as they arise; encourage more productive interaction (e.g., coordination, feedback) among levels of government; tend to vertical as well as horizontal relationships among regulatory actors;[548] and strengthen the resilience of social and ecological systems, or their ability to respond to "continuous alterations in baseline conditions."[549]

A sense of reverse engineering pervades these proposals. But just as they derive from concepts whose inner workings remain imprecise,[550] they fall for similar theoretical traps. They assume that the behavioral dynamics at work in a commons will give way when multilevel, overlapping solutions are applied. A rational actor model endures in both the explanation of regulatory commons and proposed fixes based on competition and selection. Proposed solutions take the form of similar regulations at various levels of government, which risks redundancy and squandered resources. Midlevel and regional multi-stakeholder groups invite rent seeking and capture. Casual assumptions about the comparative competence of agencies are repeated, only now at finer scales and horizontally as well as vertically. A strong federal role is championed. But the proper federal response to uncertainty as multiple authorities gain control over an issue remains unclear, in light of the limits inherent in simpler federal–state cooperative divisions. The appropriateness of overlapping authority is assumed; dynamism's compatibility with issues such as acceptable lifetime cancer risk is unclear.

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546. Hannah Wiseman, *Expanding Regional Renewable Governance*, 35 HARV. ENVTL. L. REV. 477, 486, 499–506 (2011).

547. *See* Adelman & Engel, *supra* note 12, at 1839–40.

548. Allan Erbsen, *Horizontal Federalism*, 93 MINN. L. REV. 493, 504 (2008).

549. Robin Kundis Craig, *"Stationarity Is Dead"—Long Live Transformation: Five Principles for Climate Change Adaptation Law*, 34 HARV. ENVTL. L. REV. 9, 21–22 (2010).

550. Commons management, for example, is criticized for its "many variable problem." Arun Agrawal identified thirty-six conditions "that seem relevant to the successful management of common-pool resources." Arun Agrawal, *Common Resources and Institutional Sustainability, in* THE DRAMA OF THE COMMONS 41, 54–55 (Elinor Ostrom et al. eds., 2002).

Nor are the metaphors extended completely. For example, complex adaptive systems involve variation, interaction, mutual adaptation, and selection among diverse actors, under conditions of uncertainty. Scholars who apply complex systems to social settings argue that they cannot be analyzed using deductive models, opting instead for inductive review of large-*n* case studies or computer simulations.[551] Such methods do not abound in legal scholarship. Central to these concerns is the lack of mechanisms by which a regulatory system narrows protection or is able to self-correct. In addition, there is ambiguity over the scale at which commons or adaptive systems exist.

Boundary work offers an analytic approach to regulatory commons, the mechanisms by which they limit environmental protection, and their potential for reform. It reveals a kind of federalism underway, but one that does not follow the neat delineations of federal, state, and local agencies that are preserved in adaptive governance models. Communities of practice can either exist within a regulatory body or span jurisdictional boundaries. Consider how Title VI complaints are processed. An informal network spans EPA's Office of Research and Development (which provides benchmarking and control group analysis), staff in a related EPA region, and case managers in the Office of Civil Rights' External Complaints and Compliance Program. By comparison, air quality near oil and gas sites in Colorado is the focus of two communities of practice. One is a professional network of atmospheric scientists, often at government-sponsored laboratories, who consider air quality at the scale of airsheds. Another involves environmental scientists who rely on opportunistic data to estimate emissions or risk by category of equipment, operation, or monitoring network. TENORM waste disposal in Pennsylvania brings together chemists, health physicists, and environmental managers at well sites, landfills, and regional offices. These communities of practice set the context in which an interplay of institutions (e.g., inventories, categories) and practices (e.g., sampling, conditional acceptance) locks in the scale at which risks cluster or can be addressed. Table 1 provides an overview of boundary work in each case study.

551. *See, e.g.*, ROBERT AXELROD, THE COMPLEXITY OF COOPERATION: AGENT-BASED MODELS OF COMPETITION AND COLLABORATION 64–65 (1997).

Table 1. Boundary Work Mechanisms by Case Study.

Case Study	Distributional effects of state environmental programs and policies	Air emissions from oil and gas development, production	Radioactive materials disposal in solid waste landfills
Scale of Boundary Work (COP)	Informal technical expertise network (EPA region, ORD benchmarking, control group analytics, case managers in OCR external complaints and compliance)	Professional networks of atmospheric (top-down), environmental health (bottom-up), and occupational health (well pad) scientists	Informal technical expertise network spanning state environmental managers and chemists, well and landfill operators
Ongoing Practices	Title VI complaint intake, jurisdictional review, investigation, and preliminary decision regarding disparate impact	Emissions monitoring, screening-level and human health risk assessment, health impact assessment, baseline health assessment	Waste coding and analysis by generators; monitoring by operators; modeling and conditional acceptance by state agency staff
Institutional Influences	Step-wise analytic tool; benchmarking according to NAAQS and other existing standards	Emissions inventories, fixed monitors targeting CAA compliance lead to temporal averaging, analysis by equipment category, air basin	Yearly balance spreadsheet; federal waste management assumptions borrowed for state guidelines and Form U approval procedures
Outcome	**Constructed Boundaries:** Narrow spatial scope of "impacted community"; limited impacts treated as within scope of existing authority	**Nested Boundaries:** Lack of available data for rulemaking at the scale of human health impact from air emissions (near-field, peak, intermittent)	**Shifting Boundaries:** Waste concentrated at landfills, holding areas; retroactive monitoring to gauge whether hot spots threatened workers or public health

In each community of practice, the ongoing enactment of practices through regular acts, interactions, and institutional influences limits environmental protection. For relatively brief (in Pennsylvania, informal waste management practices were questioned within years of their enactment) or lengthy periods of time (OCR's step-wise approach to Title VI complaints was applied for nearly two decades), the practices endure. Turning from standard units of analysis in federalism to the institutional scale, we can identify and map the extent of regulatory commons and their otherwise stealthy influence over standard policy instruments such as rulemaking and enforcement.

Inherent within this practice-based view of environmental protection are also mechanisms for change. Change can be endogenous, through what organization theorists refer to as performativity: carrying out a practice "play[s] a key role in both reproducing and altering a given practice through variation in its enactment."[552] Endogenous change proceeds through communities of practice, where small innovations respond to local contingencies or the demands of new audiences. Change can also be engineered, through strategic, top-down responses. The key is whether field-level actors, or those who can affect a practice's institutional influences, recognize the local tweaks or rearrangements that occur as a practice is performed.[553] Field-level actors include trade associations, professions, and standard-setting organizations.

Thus, the practice perspective not only offers a unit of analysis for the dynamics that limit protection, but a function for adaptive regulation: auditing, identifying, inventorying, and ultimately encouraging practice innovations that counter boundary work. GAO audits and Inspector General reports,[554] agency inventories,[555] guidance documents,[556] interagency work groups and advisory committees,[557] and multi-stakeholder rulemaking efforts should be attuned to the scale at which practices form and influence boundary work, and are subject to reform through local innovation or adjustment to their institutional influences. Communities of practice are the custodians of ongoing acts and interactions that construct, isolate, and shift risks that are viewed as subject to regulatory control.

552. Lounsbury & Crumley, *supra* note 61, at 996.

553. *Id.* at 1005.

554. *See, e.g.*, INSPECTOR GENERAL REPORT, *supra* note 107.

555. *See, e.g.*, LEGAL TOOLS, *supra* note 90.

556. *See, e.g.*, Draft Revised Guidance, *supra* note 136.

557. *See, e.g.*, NAT'L ENVTL. JUSTICE ADVISORY COUNCIL, NATIONALLY CONSISTENT ENVIRONMENTAL JUSTICE SCREENING APPROACHES (2010), http://www.epa.gov/compliance/environmentaljustice/resources/publications/nejac/ej-screening-approaches-rpt-2010.pdf.

They span agencies and enact policy in the gaps and at the intersection of existing statutes. Given the pace at which environmental statutes are amended or their scope of authority refined,[558] communities of practice open up a more active arena in which updates to practices can yield tangible improvements in risk management.

One area of focus for future research should be the role of communities of practice in speeding or slowing the flow of new knowledge in a regulatory field. Brown and Duguid, whose work helped bring the study of communities of practice to organization theory,[559] recognized them as sites where much of the knowledge in an organization is created or shared.[560] Knowledge is not simply held by individuals. It resides in communities of practice, "within the relationship between people participating in specific practices."[561] This is the "where" of knowledge—its location within a unique set of historical, material, and practical circumstances.[562] Because knowledge emerges and is embodied in practice, it is not easily shared, controlled, or amenable to management through the simple introduction of new rules or best practices.[563] The case studies above demonstrate that communities of practice not only generate, but also involuntarily spread or trap knowledge in ways that constrain environmental protection and increase risk.

Much of the variance in the boundary work that we considered—whether environmental protection was limited according to constructed, nested, or shifting boundaries—was the product of two variables. The first was the location of the professional and expertise networks that we identified. The second variable is the makeup of the networks themselves—whether they included one or more distinct communities of practice. Considered together, the networks were located, for example, across different practices within a single agency (e.g., analytics and Title VI case management within EPA), or along similar practices that extended beyond an organization (e.g., atmospheric scientists who study air quality in oil and gas regions). These two-factor combinations begin to explain how knowledge can either "stick,"

558. Lynn E. Blais & Wendy E. Wagner, *Emerging Science, Adaptive Regulation, and the Problem of Rulemaking Ruts*, 86 TEX. L. REV. 1701, 1720 (2008).

559. *See, e.g.,* John Seely Brown & Paul Duguid, *Organizational Learning and Communities of Practice: Toward a Unified View of Working, Learning, and Innovation*, 2 ORG. SCI. 40 (1991).

560. *See* Brown & Duguid, *supra* note 54.

561. Davide Nicolini, *Practice as the Site of Knowing: Insights from the Field of Telemedicine*, 22 ORG. SCI. 602, 603 (2011).

562. *Id.* at 612.

563. Marco Marabelli & Sue Newell, *Knowledge Risks in Organizational Networks: The Practice Perspective*, 21 J. STRATEGIC INFO. SYS. 18, 26 (2012).

or prove resistant to transfer when a core of common practices is not shared, or "leak," where involuntary transfer occurs along practices that span organizational boundaries.[564] New knowledge applied to a regulatory problem, such as how to define disparate impact, measure air quality at a given scale, or determine acceptable storage parameters for waste materials, is less likely to be adopted by, for example, an isolated network of heterogeneous practices such as an intra-agency program, and more likely to spread across a network of shared practices such as regional air quality monitoring. Two forms of path dependence emerge. Isolated, heterogeneous networks of practices limit the sharing of new knowledge or use it to reinforce existing preferences. At the same time, strong communities of practice that span agency boundaries spread knowledge to new, potentially incompatible policy settings. Solving the two-factor problem of the location and makeup of practices can inform the broader project of agency coordination. It points to where suboptimal practices are more likely to diffuse or become locked in, and where boundary objects and other tools to encourage or direct knowledge transfer across practices should be located.

B. Precaution as Boundary Work

Boundary work can also inform the distributional effects of environmental law, analyzed at increasingly finer scales, from the level of communities and households to personal exposure as citizens carry out their daily routines.[565] As embodied health, environmental justice, and other movements learn more about how risks cluster, the prevailing response is to call for wider use of the strong precautionary principle.[566] "Weak" versions of the principle pervade environmental law, giving regulators the means to address risks before they are fully understood.[567] John Applegate identified several kinds of provisions that adopt a weak precautionary principle, such as transitions from tort to risk-based rules and the use of margins of safety in risk assessment.[568] A strong version of the principle begins with precaution as the

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564. Brown & Duguid, *supra* note 54, at 206–09; *see also* Roberts, *supra* note 53, at 629–30.

565. Gregg P. Macey, *The Architecture of Ignorance*, 2013 UTAH L. REV. 1627, 1657–58.

566. *See, e.g.*, Phil Brown et al., *Embodied Health Movements: New Approaches to Social Movements in Health*, 26 SOC. HEALTH & ILLNESS 50, 70–71 (2004).

567. Noah Sachs, *Rescuing the Strong Precautionary Principle from its Critics*, 2011 U. ILL. L. REV. 1285, 1293.

568. John Applegate, *The Precautionary Preference: An American Perspective on the Precautionary Principle*, 6 HUM. & ECOLOGICAL RISK ASSESSMENT 413, 420–24 (2000).

default response, and shifts the burden to private entities to "overcome the default by proving that risks are acceptable . . . ."[569] For example, a firm seeking to introduce a new chemical compound might be required to prove that it poses "no substantial risk" to human health.[570] Even stronger applications of the precautionary principle are found in the practice of environmental law in the European Union.[571]

A recent attempt to adopt the strong precautionary principle in the U.S. can be found in the Safe Chemicals Act, versions of which were introduced to amend the Toxic Substances Control Act (TSCA)[572] in 2005, 2008, 2010, 2011, and 2013.[573] TSCA gives EPA the authority to gather data on risks posed by tens of thousands of chemicals in commerce, and control risks by preventing or limiting their use.[574] On paper, EPA's authority seems vast, as five key sections of the statute span the entire life cycle of chemical production.[575] But TSCA places the burden on EPA to prove "unreasonable risk" before it can pursue certain restrictions.[576] For example, Section 4 requires EPA to demonstrate public health or environmental risks before it can require manufacturers to test new chemicals.[577] In rare instances where EPA requires chemical testing, it takes several years to promulgate a rule and two or more additional years to receive data that are often insufficient to conduct a risk assessment. The statute places the burden to prove unreasonable risk on a regulatory body more than thirty-five times. The result is a stark absence of information: more than 84,000 chemicals appear on the TSCA inventory, but EPA holds detailed toxicological data for several hundred.[578] The Safe

569. Sachs, *supra* note 567, at 1295.

570. *Id.* at 1297.

571. *See, e.g.*, John S. Applegate, *Synthesizing TSCA and REACH: Practical Principles for Chemical Regulation Reform*, 35 ECOLOGY L.Q. 721, 741 (2008).

572. *See* 15 U.S.C. §§ 2601–2692 (2012).

573. Safe Chemicals Act of 2013, S. 696, 113th Cong.; Safe Chemicals Act of 2011, S. 847, 112th Cong.; Safe Chemicals Act of 2010, S. 3209, 111th Cong.; Kid-Safe Chemicals Act of 2008, S. 3040, 110th Cong. (2008); Kid Safe Chemicals Act, S. 1391, 109th Cong. (2005).

574. *Observations on the Toxic Substances Control Act and EPA Implementation: Testimony Before the Subcomm. on Env't and the Econ. of the H. Comm. on Energy and Commerce*, 113 Cong. 4 (2013), http://democrats.energycommerce.house.gov/sites/default/files/documents/Testimony-Gomez-EE-Toxic-Substances-Control-Act-2013-6-13.pdf (statement of Alfredo Gomez, Dir., Nat. Res. & Env't, Gov't Accountability Office).

575. *Id.*

576. *Id.*

577. *Id.*

578. *Id.*; *see* Steve Owens, Assistant Adm'r, Office of Chem. Safety & Pollution Prevention, EPA, The Future of Chemical Toxicity Testing in the US: Creating a Roadmap to Implement the NRC's Vision and Strategy (June 21, 2010) ("TSCA puts such significant limitations on EPA's ability to gather data on chemicals that, over the last 34 years, EPA

Chemicals Act is a rare statutory attempt to address the distribution of environmental hazards. The bill called for review of all existing and new chemicals and the creation of a priority list.[579] It shifted the burden to manufacturers within five years of a chemical's placement on the list to demonstrate "reasonable certainty that no harm will result."[580] The bill also embraced the environmental justice movement's focus on cumulative exposure, vulnerable subpopulations, biomonitoring, and other indicators of risk at finer scales that EPA could include in required testing.[581] As a rare expression of the strong precautionary principle in American law, the bill failed to make it out of committee.[582]

Legal scholars offer helpful distinctions between the level of uncertainty that should trigger the strong precautionary principle, and the regulatory tools by which it should be expressed.[583] Others criticize the principle for being "unhelpful," a "plea for a kind of regulatory insurance" that would "paralyz[e]" activity if adopted indiscriminately and that "offers no guidance" for when it should be applied.[584] Cass Sunstein argues that the principle results in high cost per life saved, imposes impossible burdens of proof, and invites risk-risk tradeoffs, from relatively low-risk activity to those that cause preventable harm. For example, EPA argued that more stringent control of arsenic in drinking water might encourage people to switch from local water systems to private wells with higher contamination.[585]

Sunstein's response to the principle and its encouragement of risky tradeoffs is to "acknowledge that a wide variety of adverse effects may come from inaction" or regulation, "consider all of those adverse effects and not simply a subset," and adopt "simplifying devices" to suggest a suitable action when we are unable to do so.[586] In response, scholars argue that Sunstein is attacking a straw-man version of the principle, essentially

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has been able to require testing on only around 200 of the 84,000 chemicals on the TSCA inventory.").

579. Safe Chemicals Act of 2013, S. 696, 113th Cong. § 3 (proposing amendments to section 2(c) of the Toxic Substances Control Act).

580. *Id.* § 7 (proposing amendments to section 6(d) of the Toxic Substances Control Act).

581. *See id.* § 4 (describing kinds of environmental data and standards for the development of test information).

582. *S.696 — Safe Chemicals Act of 2013*, CONGRESS.GOV, https://www.congress.gov/bill/113th-congress/senate-bill/696/all-actions (last visited Sept. 16, 2015).

583. *See, e.g.*, Richard B. Stewart, *Environmental Regulatory Decision Making Under Uncertainty, in* 20 RESEARCH IN LAW AND ECONOMICS 71, 71 (Timothy Swanson ed., 2002).

584. *See, e.g.*, Cass R. Sunstein, *Beyond the Precautionary Principle*, 151 U. PA. L. REV. 1003, 1007–08, 1020 (2003).

585. *Id.* at 1025.

586. *Id.* at 1056.

"regulation is required whenever there is a possible risk . . . ."[587] Moreover, the principle can help lawmakers identify a wider range of risk–risk tradeoffs than revealed in traditional cost–benefit analysis.[588] In fact, cost–benefit analysis remains a key element of the strong precautionary principle. It merely shifts the analytic burden to private firms to prove that benefits of risky activities outweigh costs. Rather than require regulators or residents to "prove" impacts after the fact, the focus is on premarket review of safety. The principle may even correct for some of the cognitive biases that Sunstein claims account for its popularity in theory, if not in practice.[589]

Boundary work offers a path through this debate. Two key concerns that motivate the debate are where to place burdens of proof, and the benefits and burdens of risk–risk tradeoffs. Boundary work shows that risk tradeoffs are not limited to discrete choice, such as a decision to lower the permissible concentration of arsenic in tap water. They are constantly in play. Governable risk is narrowed as the interplay of institutions and practices proceeds on a daily basis within communities of practice. Standards, categories, data management tools, and other institutions limit identifiable risk and available response. A strong precautionary principle should address boundary work that creates the circumstances for uncertainty in the first place, when it limits the context and scale at which risk management can be practiced. Its implications should include burdens to prove safety as well as a heightened burden on regulators to police overlapping responses to risk, the extent to which they increase uncertainty, institutional influences over those practices, and local innovations that could be leveraged to counter boundary work. To conceive of precaution as boundary work, we apply the principle to a wider range of reforms that can be tried before the kinds of drastic, quantitative, and inevitably incomplete risk tradeoffs envisioned by Sunstein are made as part of the legislative process.

Consider an issue of longstanding interest to the environmental justice community. The Clean Air Act requires periodic review of emissions standards.[590] For example, Section 112 includes a process to control hazardous air emissions from stationary sources.[591] EPA identifies major sources and sets

587. CASS R. SUNSTEIN, LAWS OF FEAR: BEYOND THE PRECAUTIONARY PRINCIPLE 24 (2005).

588. Sachs, *supra* note 567, at 1290–91.

589. *Id.* at 1316.

590. 42 U.S.C. § 7412(b)(2) (2012).

591. *Id.* § 7412(4).

technology-based NESHAPs for emissions from those sources.[592] The standards are known as maximum achievable control technology (MACT), because they balance cost, energy efficiency, and other considerations. Once they are adopted, EPA reduces remaining risk to an acceptable level (often in the one-in-ten thousand to one-in-one million range).[593] EPA must review and revise MACT standards "as necessary (taking into account developments in practices, processes, and control technologies)."[594] In Spring 2014, EPA proposed new NESHAPs for the nation's 142 petroleum refineries.[595] The proposal was not the result of an active analysis of advances in emissions control practices. Rather, it was drafted as part of a consent decree resolving a claim that EPA failed to meet its duty to review.[596]

To ensure that new emissions standards are met, the proposed rule requires each refinery to monitor benzene concentrations at the fenceline.[597] The purpose of fenceline monitoring is to "identify a significant increase in emissions," which would allow refinery managers to fix leaks or tears in storage vessel seals "in a timely manner."[598] Environmental justice communities share this concern. In fact, the first attempt by a community to gather its own fenceline air samples took place during a Unocal refinery release that sent several thousand people to the hospital.[599] The release continued unabated for two weeks. A rich tradition of community monitoring near refineries followed.[600] Given this history, and the scale of emissions at stake in the proposed rule (potential reductions equal thousands of tons

592. *Id.* § 7412(d)(2), (3).

593. *Id.* § 7412(f)(2)(A).

594. *Id.* § 7412(d)(6).

595. Petroleum Refinery Sector Risk and Technology Review and New Source Performance Standards, 79 Fed. Reg. 36,880 (proposed June 30, 2014); *Number and Capacity of Petroleum Refineries*, U.S. ENERGY INFO. ADMIN., http://www.eia.gov/dnav/pet/pet_pnp_cap1_dcu_nus_a.htm (last visited Sept. 16, 2015).

596. Petroleum Refinery Sector Risk and Technology Review and New Source Performance Standards, 79 Fed. Reg. at 36,886.

597. *Id.* at 36,923.

598. *Id.* at 36,920.

599. Karyn Hunt, *Residents Say Chemical Leak Made Them Sick*, SEATTLE TIMES, Dec. 13, 1994 ("Jane Strike went blind. Vickie Wood is about to give birth to a stillborn child and does not know whether its twin will be healthy. Leanna Devy has had fainting spells for two months. All three are convinced their problems began with a chemical leak at a nearby Unocal refinery that went unabated for 16 days this summer . . . ."). A 1996 study suggested that residents of Crockett suffered an increased rate of eye problems, memory loss, and anxiety compared to the control community. Rosemarie M. Bowler et al., *Epidemiological Health Study of a Town Exposed to Chemicals* 72 ENVTL. RES. 93, 93–94, 100–91 (1997).

600. *See* Dara O'Rourke & Gregg P. Macey, *Community Environmental Policing*, 22 J. POL'Y ANALYSIS & MGMT. 383, 383 (2003).

per year),[601] EPA's evaluation of fenceline monitoring practices was surprising. EPA identified a "least burdensome" alternative and a set of acceptable alternatives.[602] Based on a single pilot study near the Flint Hills West Refinery in Corpus Christi, Texas, EPA called for refineries to use passive samplers at the fenceline.[603] Passive samplers are small devices that are scattered along the edge of a facility, where they absorb chemicals over time.[604] They are collected and analyzed once every two weeks. Because passive samples of benzene and other HAPs accumulate over two weeks (they are "time-integrated"),[605] they do not provide information on emissions spikes or short-term changes in operating conditions. They cannot be analyzed on-site, and must be shipped great distances to an accredited laboratory.[606]

Aware of these limitations, several refineries have adopted monitoring systems that generate data in real time and publish them on a web site to assist in emergency response.[607] The goal is to find and fix fugitive releases. During the Unocal incident, a fugitive release sent over one hundred tons of toxic material into neighboring communities, within the time it takes to collect and process a single passive sample.[608] There is no discussion in the proposed rule of how passive sampling practices would limit the ability to detect accidents and upsets that can dramatically increase HAP emissions. The benefits of improved emergency response to community health, or reduced product loss through faster leak detection, are not considered in EPA's cost comparison and dismissal of real-time options.[609] The basic organizing principle for community monitoring, which is to prevent dramatic increases in risk due to facility upsets, is cast aside over several paragraphs in an 800-page document. Boundary work offers guidance on how reviews of existing standards should be

601. Petroleum Refinery Sector Risk and Technology Review and New Source Performance Standards, 79 Fed. Reg. at 36,952.

602. *Id.* at 36,922.

603. *Id.* at 36,921, 36,923; *see also* Eben D. Thoma, *Facility Fence-Line Monitoring Using Passive Sampling*, 61 J. AIR & WASTE MGMT. ASSOC. 834, 835 (2011).

604. Petroleum Refinery Sector Risk and Technology Review and New Source Performance Standards, 79 Fed. Reg. at 37,047.

605. *Id.* at 36,921.

606. *See id.*

607. *See, e.g.*, Real-Time Data, Atchison Village Area, North Richmond Area, Point Richmond Area, RICHMOND CMTY. AIR MONITORING PROGRAM, http://www.fenceline.org/richmond/data.php (last visited Sept. 16, 2015).

608. *See Major Accidents at Chemical/Refinery Plants in Conta Costa County*, CONTRA COSTA HEALTH SERVS., http://cchealth.org/hazmat/accident-history.php (describing the incident at the Unocal facility) (last visited Sept. 16, 2015).

609. Petroleum Refinery Sector Risk and Technology Review and New Source Performance Standards, 79 Fed. Reg. at 36,922–36,923.

conducted. Proposed practices (fenceline data collection) and institutions (passive devices) and their potential for boundary work (inability to address upsets with a duration of less than fourteen days) would be folded into cost comparisons. More importantly, an ongoing inventory of potential boundary effects would encourage a more robust, less passive approach to setting and updating standards.

CONCLUSION

Boundary work provides a more complete approach to the limits of environmental protection than standard accounts such as comparative competence, statutory limits, and equity–efficiency tradeoffs. It applies the recent practice turn in organization theory to model the limits of knowledge availability and management in regulation. Specifically, communities of practice organize around durable institutions such as analytic frameworks, inventories, and data management tools, span multiple agencies and jurisdictions, and drive the extent to which issues such as pollution control can be pursued. Their work limits the use of existing authority to respond to disparate harms, stalls its extension to impacts including intensive oil and gas development, and alters identifiable risks over time. The result is to construct, shift, and move boundaries beyond the reach of existing legal authority. At the heart of boundary work are the mechanisms through which regulatory commons limit protection. At the same time, they hold the potential for reform. When we identify communities of practice, the institutional focal points of their efforts, and the variety and pace of their boundary work, we open up new avenues for improvement in environmental health and quality of life.