1-1-2011

The Impacts Of Lead Contamination On The Community Of Herculaneum, Missouri

Jill McNew-Birren
Washington University in St. Louis

WASHINGTON UNIVERSITY IN ST. LOUIS

Department of Education

Dissertation Examination Committee:
Rowhea Elmesky Co-Chair
William F. Tate Co-Chair
Phyllis Balcerzak
Garrett Albert Duncan
Anne Newman
Joseph Vogel

THE IMPACTS OF LEAD CONTAMINATION ON THE COMMUNITY OF HERCULANEUM, MO

by

Jill McNew-Birren

A dissertation presented to the
Graduate School of Arts and Sciences
of Washington University in
partial fulfillment of the
requirements for the degree
of Doctor of Philosophy

August 2011

Saint Louis, Missouri

Abstract

Lead contamination in Herculaneum, Missouri presents a complex context where the long history of a large lead processing plant has created an environmental health hazard. Local residents have been forced to balance their interest in promoting a clean and healthy local environment against their desire to preserve community identity and honor the history of their city and its most prominent industry. Additionally, contamination and related controversy has substantively impacted this community and its citizens on multiple levels—e. g., education, health, and financial well-being. The study presented in this dissertation explores not only the impact of contamination upon the community, but also the influence of the community upon local lead management. The study crosses disciplinary boundaries and is situated at the intersection of science education literature with environmental policy and public understanding of science research.

The research questions guiding the project focused on (1) the approaches taken in applying regulatory tools to the management of local lead contamination, and (2) the ways that local stakeholders describe the problem of lead contamination in Herculaneum. Accordingly, the findings of this project reflect two primary themes. First, a policy cycle in which the understandings of lead contamination and management is described. The influence of this local policy cycle on the revision of the National Ambient Air Quality Standard for lead in 2008 is discussed as a second policy cycle in which the definition of lead contamination on the national scale was expanded and refined. Second, two activist perspectives that have dominated local lead controversy over the past decade are characterized and changes in their activist strategies are traced. Community Health

Activists advocated for increased regulation and restrictive measures to protect the health of local community members from lead industry activities. Community Preservation Activists fought restrictive regulatory measures and advocated instead for initiatives that would support community prosperity and growth.

The dissertation concludes with a secondary analysis of the findings in terms of environmental policy learning, defined here as the adaptation of stakeholder perspectives and approaches in response to changes in physical or political conditions. The ways that environmental policy learning influenced changes in both policy approaches and stakeholder perspectives with regard to lead management in Herculaneum provide insight into educational dimensions of the context of lead contamination in Herculaneum in terms of changes in the perspectives and approaches of local stakeholders. Implications for research in science studies, interpretive policy research, and science education, as well as for environmental regulatory representatives and citizen activists are explored. The dissertation concludes with a brief outline of two research studies stemming from this dissertation as directions for further work.

Dedication and Acknowledgements

This dissertation is dedicated to the memory of Lottie Pearl McNew, who always delighted in and encouraged her granddaughter's academic pursuits. You are missed.

It is a pleasure to thank the many individuals who made it possible for me to conduct this dissertation. My advisors, Dr. Rowhea Elmesky and Dr. William F. Tate have served as mentors in the truest sense of the word, thank you.

Thank you also to committee members Dr. Phyllis Balcerzak, Dr. Garrett Albert Duncan, Dr. Anne Newman, and Dr. Joe Vogel, who have shared their scholarship, wisdom, and friendship throughout my time at Washington University. I also owe a special thank you to Dr. Carol Camp-Yeakey, who comes up with the best dissertation ideas, your insight continues to be invaluable.

This dissertation could not have been completed without the support of the NSF funded Center for Inquiry in Science Teaching and Learning, or the generous participation of Herculaneum stakeholders. I am grateful.

I am also thankful for the unending patience and support of Marilyn Broughton and Natalia Kolk, who tolerated endless technical questions and sorted through several quirky challenges to help me navigate my own strange path to earning this degree and finding employment.

Dr. Lisa-Anne D. Kelly is an amazing editor and I am so very thankful for the many hours she spent reading and re-reading draft after draft of each of these chapters. It has been a joy to walk this path with you. Thanks also to all of the education graduate students with whom I have shared different parts of this journey, your friendship means a great deal.

Finally, my deepest appreciation goes to my husband, Sean Birren, who always reminds me to focus on what is truly important, and to my family, who keeps me grounded.

Table of Contents

Dedication and Acknowledgements iv
List of Tables and Figures viii
List of Abbreviations xi

CHAPTER ONE: INTRODUCTION 1
Research Context and Rationale 1
The Herculaneum Context 2
Study Focus and Rationale 3
Policy and Scholarly Approaches Informing the Study of Lead Contamination in Herculaneum 5
Science Education 6
Science and Technology Studies 9
Public Understanding of Science 11
Research Questions 12
Research Question One: Policy Approaches 13
Research Question Two: Stakeholder Perspectives 15
Organization of the Dissertation 16

CHAPTER TWO: LITERATURE ON LEAD AND ITS IMPACTS ON INDIVIDUALS AND COMMUNITIES 18
A History of Lead Science and Policy in the U.S. 19
The Early- to Mid-1900s: Early Debates Over the Implications of Widespread Lead Exposure 20
The 1960s: Environmental Regulation in Transition 25
1970s to 1980s: Establishing Health Effects at Low Levels of Exposure 30
1990s to 2000s: Exploring Low Level Exposure Symptoms and Mechanisms 37
Research on Leaded Communities 41
Lead Processing 42
Mine Communities 43
Smelter Communities 44

CHAPTER THREE: THEORY 47
Fischer's Framework for Policy Analysis 47
Interpretive Policy Analysis 47
Research Questions and Fischer's Model for Public Policy Research 64

CHAPTER FOUR: METHODS 69
Research Design 69
Analytical Framework 70
Research Question One – Regulatory Approach 72
Research Question Two- Stakeholder Perspectives 81
Mutual Influence of Regulatory Approaches and Local Perspectives 88
Research Quality 90

CHAPTER FIVE: CASE SUMMARY 95

Introduction and Overview 95
The Process of Environmental Regulation 96
A History of Herculaneum, Missouri 97
Reemergence – A Company Town (1860s -1950s) *98*
Transition Toward Independence (1960s – 1980s) *99*
Severed Alliances – Strike (1990s) *103*
The Modern-Day Herculaneum Context 104
Population, Housing, and Demographics *105*
Local Economy *106*
Company – Community Relations *107*
Regulating Lead in Herculaneum (1999-present) 109
Regulatory Firestorm *112*
The Impact of the Herculaneum Context on National Lead Regulation: The National Ambient Air Quality Standards (NAAQS) Revisited *121*

CHAPTER SIX: THE CYCLE OF ENVIRONMENTAL POLICY DEVELOPMENT 126

INTRODUCTION AND OVERVIEW 126

CHAPTER SEVEN: LOCAL ACTIVISM 198
Introduction and Overview 198
The Emergence of Local Activism *198*
Dichotomous Perspectives in Environmental Controversy 199
Dichotomous Perspectives on Lead Contamination in Missouri *201*
Processes of Divergence in Local Lead Perspectives *204*
Overview of Community Health Activists *207*
Overview of Community Preservation Activists *209*
Moving Toward a More Cooperative Approach to Environmental Controversy 212
Ecological Modernization in Community Health Activism and Community Preservation Activism *214*
Central Themes of Activist Perspectives *216*
'It's Really Not That Black and White' *236*
Summary *240*

CHAPTER EIGHT: CONCLUSIONS, IMPLICATIONS, AND DIRECTIONS FOR FUTURE RESEARCH 242
Discussion of Findings 244
Policy Approaches *245*
Stakeholder Perspectives *250*
Synthesis of the Policy Learning in Regulatory Approaches and Stakeholder Perspectives: 259
A Cycle of Policy Learning 259
Implications 265
Implications for STS and PUS Research *265*
Implications for Interpretive Policy Research *267*
Implications for Environmental Regulatory Representatives *267*
Implications for Citizen Activists *269*
Implications for Science Education Researchers *269*

Directions for Further Research 270
A Study of Activism in Action *270*
Implications of the 2008 Lead NAAQS: Studying A New Crisis *274*
REFERENCES **277**

List of Tables and Figures

Table 4.1. Documents Analyzed in Stage One 76

Table 4.2. Sample Form for Documentary Storyline Analysis 79

Table 4.3. Participant Observation Events 82

Table 4.4. Participants by Pseudonym and Group Affiliation 83

Table 4.5. General Interview Protocols According to Participant Affiliation 84

Table 4.6. Sample Interview Storyline Analysis 86

Figure 5.1. Illustration of Health and Environmental Policy Processes 96

Figure 5.2. Graph of Ambient Air Volume in Herculaneum Between 1982

and 2007 102

Figure 5.3. Conditions of the 2002 Settlement Agreement Between Doe Run Co. and Missouri Department of Natural Resources 113

Figure 5.4. Sign Posted in Herculaneum in 2001 114

Figure 5.5. Children's 2001 Blood Lead Levels According to Distance From Lead Smelter 117

Figure 5.6. Map of Herculaneum Voluntary Property Purchase Plan Area 119

Figure 6.1. Illustrates the Initial State of Balance Between Problem Definition and Management Strategy in the Stasis Phase of the Policy Cycle in Herculaneum 128

Figure 6.2. Illustrates the Unbalanced State Between Problem Definition and Management Strategy in the Crisis Phase of the Policy Cycle in Herculaneum 130

Figure 6.3. Illustrates the Renewed State of Balance Between Problem Definition and Management Strategy in the Renewed Stasis Phase of the Policy Cycle in Herculaneum 131

Figure 6.4. The Bulls-Eye Map Demonstrated Increasing Blood Lead Levels with Proximity to the Doe Run Co.'s Lead Smelting Facility 144

Figure 6.5. A Map of Southeast Missouri Designating Haul Routes Used to Transport Lead Concentrations by Truck Between Doe Run Co. Facilities 153

Table 6.1. Summary of Findings from the 2002 Health Consultation: Public health evaluation of Arsenic and Cadmium levels in air and residential soils - Herculaneum Lead Smelter Site, Herculaneum, Jefferson County, Missouri 160

Table 6.2. Summary of Findings from the 2007 Report Determining baseline prevalence for provider-diagnosed Multiple Sclerosis (MS) and Amyotrophic Lateral Sclerosis (ALS) in Herculaneum and Jefferson County, Missouri 163

Figure 6.6. Maps Representing the Geographic Distribution of a Cluster of ALS Cases Surrounding the Herculaneum Facility between 1998 and 2002 164

Table 6.3. Summary of Considerations for Setting Site Specific Interior Lead Dust Clean Up Level 167

Table 6.4. Summary of Major Contributions of Central Reports Generated in the NAAQS Review Process 170

Figure 6.7. Illustrates substantial Reduction in Air Lead Emissions Between 1982 and 2002 172

Table 6.5. Comparison of Timetables for NAAQS Review Processes Suggested by Missouri Coalition for the Environment and the Environmental Protection Agency, and Court Ordered Deadlines for Finalization 173

Figure 6.8. Conceptual Model for Lead Human Exposure and Health Risk Assessment 180

Figure 6.9. Overview of the Analytical Approach for the 2007 Lead Human Exposure and Health Risk Assessment 183

Figure 6.10. Illustration of Pathways of Lead from Environmental Source to Human Consumption used in the 2006 Air Quality Criteria Document 185

Figure 6.11. Illustration of Pathways of lead from Environmental Source to Human Consumption Used in the 2007 OAQPS Staff Paper 189

Table 7.1. Summary of Community Health Activist and Community Preservation Activist Views with Regard to Industry 222

Table 7.2. Summary of Community Health Activist and Community Preservation Activist Views with Regard to Pollution and Regulation 230

Table 7.3. Summary of Community Health Activist and Community Preservation Activist Views with Regard to Pollution and Regulation 235

Table 7.4. Overview of Community Health Activist and Community Preservation Activist Perspectives 237

Figure 8.1. Under Conditions of Crisis, Problem Definitions and Management Strategies are Considered to be in Balance 260

Figure 8.2. Under Conditions of Stasis, Management Strategies are Inadequate to Address Current Understandings of the Policy Problem 261

Figure 8.3. Additional Management Strategies Balance the Expanded Problem Definition, Contributing to a New Stasis Condition 262

Table 8.1. Summary of the Changes in the Regulatory and Local Activist Approaches to Lead Management 264

List of Abbreviations

Administrative Order of Consent (AOC)

Advocacy Coalition Framework (ACF)

Agency of Toxic Substances Disease Registry (ATSDR)

Amyotrophic Lateral Sclerosis (ALS)

Blood Lead Level (BLL)

Centers for Disease Control (CDC)

Central Nervous System (CNS)

Clean Air Act (CAA)

Clean Air Scientific Advisory Committee (CASAC)

Community Advisory Group (CAG)

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

Dominant Social Paradigm (DSP)

Free Erythrocyte Protoporphrin (FEP)

Environmental Protection Agency (EPA)

Herculaneum Today & Tomorrow (HT&T)

Interdisciplinary Environmental Clinic (IEC)

Lead-Based Paint Poisoning Prevention Act (LBPPPA)

Micrograms per cubic meter ($\mu g/m^3$)

Micrograms per deciliter (µg/dL)

Missouri Coalition for the Environment (MCE)

Missouri Department of Health and Senior Services (MDHSS)

Missouri Department of Natural Resources (MDNR)

Multiple Sclerosis (MS)

National Ambient Air Quality Standards (NAAQS)

National Priorities List (NPL)

National Resources Defense Council (NRDC)

New Ecological Paradigm (NEP)

Office of Air Quality Planning and Standards (OAQPS)

Public Understanding of Science (PUS)

Resource Conservation and Recovery Act (RCRA)

State Implementation Plan (SIP)

Science Technology Studies (STS)

Scientific Advisory Board (SAB)

Tetraethyl Lead (TEL)

Voluntary Property Purchase Plan (VPPP)

Chapter One: Introduction

Research Context and Rationale

> The people of Herculaneum have mounted a Herculean effort to overcome the tragic dichotomy that has befallen this once idyllic community: a benevolent industry that has sustained the community for over one hundred years, whose product has harmed the most innocent—the children. Even though federal and state government agencies are actively involved in the situation, the residents know it is up to them to create the Herculaneum they want for the future – the government cannot do it for them. Regular citizens have had to pull themselves up from the depths of despair to become the defenders and advocates for their children, their homes, their livelihoods and their community. The struggle has been long and difficult, but the people of Herculaneum are up to the challenge and will "stay the course" until their City has overcome its adversities and moved forward to become the regional leader it was meant to be. (City of Herculaneum, 2006, p. 1)

What tragic dichotomy has so impacted the Herculaneum community that overcoming it had to be addressed in its Master Plan? Such a question can only be answered in relation to the closely interdependent relationship between the community and its lead processing plant. Lead contamination in Herculaneum presents a context in which the risk and threat of an environmental health hazard has substantively impacted a community and its citizens on multiple levels—e. g., education, health, and financial well-being. The study presented in this dissertation explores not only the impact of contamination upon the community, but also the influence of the community upon local lead management.

In this chapter I will provide an overview of the Herculaneum context, describe the focus of and rationale for this study, and address the ways in which this study relates and contributes to extant scholarship that addresses public participation in environmental policy processes. I will then articulate the research questions guiding the study and provide an outline of the organization of the dissertation.

The Herculaneum Context

Initially founded in the early 1800s by lead prospectors, Herculaneum was built in conjunction with construction of the local lead plant to accommodate plant workers and their families. Building on its industrial origins, the landscape and economy of the Herculaneum community have been dominated by the lead industry throughout the community's history. The town's industrial history once imparted a great sense of pride and unity to the Herculaneum community; however, findings of widespread lead contamination since the late 1990s have cast a shadow over this identity. A century of lead processing has distributed a particular constellation of contamination challenges throughout the Herculaneum region. Since environmental regulation emerged in the 1970s, sources of contamination and hazardous wastes have come to be managed by a complex collection of regulatory policies. Throughout the processes of identifying and managing local lead contamination, the community has been forced to come to terms with the intricacies of local pollution challenges, their health implications, and efforts to manage them.

The Master Plan writers' choice to open their report with a discussion of the "tragic dichotomy" that has overtaken the community since the late 1990s demonstrates the significance with which residents view local challenges of lead contamination. Their choice of words to describe the community's plight is poignant, as "dichotomy" is an apt description of the contamination-related controversy that has divided the community, and "tragic" emphasizes the emotional sense of loss widely associated with contamination-related community developments since the late 1990s. The statement goes on to acknowledge the involvement of regulatory institutions in local lead controversy, but emphasizes the responsibility of community citizens to fight for the preservation of their community and to defend the health of their families and children.

Study Focus and Rationale

The purpose of this dissertation is to explore environmental policy processes surrounding lead contamination in Herculaneum as an educative setting. Particular attention is paid to the ways that local lead contamination has been addressed by environmental policy institutions and programs, as well as the ways that the community has contributed to defining contamination and shaping its management as they work toward "obtaining and maintaining a healthy environment for Herculaneum" (City of Herculaneum, 2006, Depth of the Lead Issue, p. 5). Thus, the study focuses primarily on (1) policy approaches to regulating lead in Herculaneum, and (2) local understandings of contamination conditions and their management. Moreover, policy approaches and local understandings are not static or uncontested entities; they reflect contemporary interpretations of the implications of lead contamination and exposure, as well as political views on the appropriate roles and responsibilities of industrial corporations and environmental regulatory institutions. Policy approaches and local understandings are continually adapted in response to new information and changing physical and political conditions, a process that policy researchers have discussed in terms of policy learning

(Sabatier & Jenkins-Smith, 1993). The study presented in this dissertation, therefore, aims to establish local environmental policy processes as educative contexts by considering adaptations in the approaches and perspectives of local citizens, regulatory representatives, and policy-makers in terms of policy learning.

This case study of Herculaneum will be a critical addition to the interpretive environmental policy literature for four reasons: (1) a community experiencing industrial lead contamination has yet to be studied from a participatory framework, which incorporates the policy activism of local stakeholders; (2) Herculaneum environmental activists and their representatives have been influential in shaping national lead regulation, and documenting their activities and interactions with neighbors holding different perspectives is essential for understanding community environmental activism; (3) the complexity and multimodality of lead contamination in the area provide a unique opportunity to observe residents engaging with difficult and multi-dimensional scientific challenges; and (4) this study lays the groundwork for future explorations of community activism around historical lead contamination emerging in other areas of the Missouri Lead Belt.

There are two key differences between this project and existing studies about public participation in environmental policy contexts. Such studies fall into three main categories: science education, science and technology studies (STS), and public understanding of science (PUS). First, unlike most science education studies, this research examines stakeholder contributions made as a matter of course in a community confronting an environmental threat, rather than a researcher-led activity or classroom activism project. Second, unlike the STS and PUS research that tends to focus on citizen activism for environmental protection against government and industrial entities defending a status quo management position, this study acknowledges multiple layers of controversy within the community and explores a diversity of perspectives with regard to lead in the area. Highlighting controversy among community members, as well as between community members and regulatory and industry representatives, is an important aspect of this study since disagreement among community members is thought to have impacted the effectiveness of local lead contamination management in Herculaneum. The following sections discuss the science education, STS, and PUS genres as they relate to environmental policy contexts in order to elaborate on the influence of each research tradition on the current study.

Policy and Scholarly Approaches Informing the Study of Lead Contamination in Herculaneum

The Environmental Protection Agency (EPA) has established the active participation of local community members in many decision-making processes as a priority. This commitment is demonstrated in the following excerpt from the EPA's Public Involvement Policy (2003):

> EPA's mission is to protect human health and the environment. To achieve that mission, EPA needs to continue to integrate, in a meaningful way, the knowledge and opinions of others into its decision-making processes. Effective public involvement can both improve the content of the Agency's decisions and enhance the deliberative process. Public involvement also promotes democracy and civic engagement, and builds public trust in government. (U.S. Environmental Protection Agency, 2003, p. 1)

EPA acknowledges, however, that such participation can be difficult since the majority of citizens do not possess sufficiently detailed knowledge of the specifics of environmental problems and programs to be able to effectively participate in regulatory decision making with regard to environmental challenges (U.S. Environmental Protection Agency, 1996).

The current study is situated primarily in environmental policy research, which will be treated extensively in the theory discussion in Chapter Three of this dissertation. Several other scholarly genres have elements devoted to the ways that citizens come to participate in and influence the management of local risk through environmental policy processes: (1) science education, (2) science and technology studies (STS), and (3) public understanding of science (PUS). Because this dissertation study crosses disciplinary boundaries and will make contributions to each of these research genres and be read by individuals that may be unfamiliar with the various disciplines, it is necessary to situate the study within the various approaches to considering participation in environmental policy processes. In the following sections I will briefly describe each of the related genres of research and the ways that each is connected to the current study considering lead contamination in Herculaneum.

Science Education

In a manner complementary to EPA's priority for public participation policy processes, a primary goal articulated in science education standards documents involves the participation of the public in deliberating socio-scientific challenges and solutions. Primary examples of socio-scientific challenges are controversies over the ways that scientific developments potentially impact local health and the local environment. The introduction to the AAAS *Science for All Americans* (1990) document, under the title 'The Need for Science Literacy' states:

> Briefly put, the national council's argument is this:
>
> Science, energetically pursued, can provide humanity with the knowledge of the biophysical environment and of social behavior needed to develop effective solutions to its global and local problem; without that knowledge, progress toward a safe world will be unnecessarily handicapped. (p. *xiv*)

Here, knowledge of science in the hands of public citizens is considered key to solving the world's problems in the interest of global safety. Similarly, the National Science Education Standards placed the goal of preparing students to participate in public socio-scientific discussions as primary among its purposes for science education, stating: Americans are confronted increasingly with questions in their lives that require scientific information and scientific ways of thinking for informed decision making. And the collective judgment of our people will determine how we manage shared resources—such as air, water, and national forests. (National Research Council, 1996, p. 11)
One lofty aim for science education, it is argued, is to prepare students to understand the complexities of the biophysical environment so they can engage in socio-scientific political activism toward a safer world. Controversy over environmental policy concerns is an important example of a setting in which this type of socio-scientific activism is imperative. This goal, however, assumes that socio-scientific decisions are made through processes and methods that would be best understood through learning obtained in the K-12 science classroom. There are at least two major flaws in this assumption: (1) socio-scientific issues, like environmental policy concerns, are deeply embedded in the

particularities of a specific hazard affecting a particular locality; and (2) the majority of classroom science is focused on a standardized and deterministic view of science that doesn't account for the politicized processes inherent in any policy debate (for example see Hurd, 1998, 2001; Rodriguez, 1997). Therefore, it is necessary to turn our attention to socio-scientific learning that occurs outside of the classroom, particularly among adults as they become involved in the management of potential hazards in the local environment.

Select science education scholars have attempted to address the ways that students might participate in socio-scientific discourse in the public arena. These studies frequently attempt to straddle boundaries between classroom science and community activism. They are often centered first in the setting of a K-12 science course in which they facilitate a socio-scientific political activity in the community. Such research generally engages groups of students in either formal or informal educational settings in the exploration of socio-scientific issues. For instance Roth and his colleagues have worked extensively with students in the community of Oceanside to consider and address environmental challenges to the local watershed (National Research Council, 1996, p. 11). Much of this work has been conducted through facilitating the work of student researchers, who then present their findings at community-wide public meetings. Similarly, Barton and colleagues have explored "community-based science" with youth in homeless shelters through after-school science programs. Their work has focused primarily on researcher led socio-scientific community projects, such as the construction of a community garden (Lee & Roth, 2001, 2006; Roth & Barton, 2004).

My research in Herculaneum approaches public engagement with the local management of industrial lead contamination as a site of collective struggle over socio-scientific decision-making. By exploring one such socio-scientific struggle as a context for education the project accomplishes two important goals in the science education genre: (1) it informs science educators about how socio-scientific deliberations are structured and influenced so that they might better prepare students to participate in such debates, and (2) it explores the ways that scientific information is engaged through socio-scientific deliberation.

This dissertation demonstrates that in Herculaneum the socio-scientific challenges of lead contamination are managed through scientific practices and understandings that may seem unfamiliar to anyone not deeply versed in the rhetoric of the environmental regulatory bureaucracy. The study also shows that solutions to Herculaneum's socio-scientific challenges have advanced through complex dynamics that can be seen to be simultaneously scientifically and politically driven. While this study does not focus directly on learners in science classrooms, it demonstrates that a science education that prepared citizens to participate in such socio-scientific decision-making would be hard to recognize in the vision of science education promoted in the AAAS (1990) and National Research Council (1996) standards documents. Citizens do contribute to decisions about lead contamination and regulation in the Herculaneum community, however, and the ways that they participate will be a central focus of this dissertation study.

Science and Technology Studies

Science and technology studies (STS) researchers examine the ways that scientific findings emerge from and interact with local conditions, knowledges, and political processes, including the development and implementation of environmental management policies (Barton, 2003; Roth & Barton, 2004). Much of STS work is constructed around the foundational premise that the management of socio-scientific risk is becoming an increasingly central preoccupation for individuals, families, institutions, and communities (see for example Callon, 1986; Latour, 1993; Law, 1991; Law & Urry, 2004; A. Mol & Law, 1994; A. P. J. Mol, 1996; A. P. J. Mol & Spaargaren, 2000). The prevalence of such contexts is emphasized by Edelstein's (2004) description of the extent of modern industrial contamination as a "toxic plague" (p. 9) characterized by widespread use and dependence upon synthetic chemicals: "My point is that environmental hazards (1) are ubiquitous and (2) are often invisible in the landscape unless we are truly looking for them" (p. 9). Prevalence of toxins in the environment is one consequence of modern industrial society, which produces risks that must be confronted by individuals, institutions, and societies. According to Beck (1992) such socio-technical risks constitute the defining characteristic of life in the present age. He proposed that forces promoting and profiting from socio-technical risks should be challenged through public political engagement:

> The public sphere in co-operation with a kind of 'public science' would be charged as a second center of the 'discursive checking' of scientific laboratory results in the crossfire of opinions. Their particular responsibility would comprise all issues that concern the broad outlines and dangers of scientific civilization and are chronically excluded in standard science. The public would have the role of an 'open upper chamber'. It would be charged to apply the standard, 'How do we wish to live?' to scientific plans, results and hazards. (p. 119)

Beck's 'risk society' theory now dominates STS scholarship and his ideal of public participation shaping the management of socio-scientific hazards has been institutionalized in a variety of fields. In order to examine public participation in scientific controversy, however, it is necessary to consider the potential for public engagement in and understanding of such issues from the perspective of public understanding of science scholars.

Public Understanding of Science

Drawing on conceptions of risk and the political and social contextualization of science from STS, public understanding of science (PUS) scholars have explored the ways that community groups commonly engage in socio-scientific activism, usually focusing on controversies in which community laity are pitted against regulatory experts and powerful industrial lobbyists. Alan Irwin's (1995) *Citizen Science: A Study of People, Expertise, and Sustainable Development*, for example, highlights citizen activism in controversies over pesticide use and the causes of Mad Cow Disease. In addition, Brian Wynne (1989, 1992)(1989, 1992) explored conflicts between scientists' and sheep farmers' perspectives on the effects of radioactive fallout from Chernobyl on sheep farms in Northern England. Each of these cases involved a researcher-led group of community activists or workers (i.e., migrant farm workers, sheep ranchers, or fishermen) confronting a widely accepted scientific stance taken by regulatory representatives. This approach is typical of this genre of research.

STS and PUS research provide grounding for the consideration of (1) the scientific and social processes through which the specifics of local lead contamination in Herculaneum have come to be understood by citizens and other stakeholders, and (2) the influence that these emerging understandings have had on the ways that lead is managed, and (3) the ways management strategies are received in the community. This examination of lead contamination controversy in Herculaneum, however, necessarily departs from common approaches in STS and PUS because the citizen activities and policy learning processes explored here were not initiated by a researcher, but involved more organic interactions among nonprofit environmental activist groups, regulatory representatives, lead industry representatives, and local citizens. In the section below the research questions that framed this exploration of the policies, perspectives, and processes surrounding the management of lead contamination in Herculaneum are discussed.

Research Questions

The primary research questions for this study reflect the stages of policy evaluation described by Frank Fischer (1995), who "conceptualizes policy evaluation as a form of practical deliberation concerned with the full range of empirical and normative issues that bear on policy judgment" (p. 2). Fischer's model will be described in greater depth in Chapter Three; for now it is important to note that it is focused particularly on policy deliberation, or the interpersonal interactions around policy decisions that shape both the policy approach to managing contamination and local understandings of environmental problems. Fischer (1995) suggested a two-dimensional approach to policy analysis that would (1) include a consideration of the policy initiative itself and its appropriateness to the particular context (i.e. locale) under investigation, and (2) explore the underlying ideology behind the policy initiative and the implications of such an ideology for society more generally. Fischer explained:

> The logic of policy deliberation thus works on two fundamental levels, one concretely concerned with a program, its participants, and the specific problem situation to which the program is applied, and the other concerned with the more abstract level of the societal system within which the programmatic action takes place. A policy evaluation, in this sense, must always look in two directions, one micro, the other macro. (p. 19)

Building off of this multi-level model, two primary research questions guided the data collection and analysis for this project: (1) How did relevant environmental regulatory programs approach the problem of lead contamination in Herculaneum? (2) How did local stakeholders describe the problem of lead contamination in Herculaneum? A general discussion of the explorations involved in addressing each of these questions follows. A more specific discussion of the methods used in collecting and analyzing data related to each of these questions is the subject of Chapter Four.

Research Question One: Policy Approaches

The first research question that guided this dissertation study focused on the approaches taken in applying regulatory tools to the management of lead contamination in Herculaneum. In order to explore the local approaches to managing lead contamination, it was necessary to consider two important epochs in the town's regulatory history. The first occurred from 1999 to approximately 2004 when local lead contamination and its impacts on the community first garnered a great deal of public attention and lead regulation in the area was revolutionized. These developments were heavily influenced by the Administrative Order of Consent (AOC) of 2000 and subsequent Abatement and Cease and Desist order, which characterized the lead levels in

Herculaneum as dangerous to local health and ordered Doe Run Co. to take immediate action. Supporting these actions were six public health consultations, which explored the health implications of local lead contamination in great detail. Ultimately the Administrative Order of Consent (2000) and Cease and Desist Order was resolved through a settlement agreement (Missouri Department of Natural Resources v. Doe Run Resources Corporation, 2002). Documents related to the AOC, Cease and Desist Order, Health Consultations, and the settlement agreement discussed briefly here will be analyzed with respect to their contribution to changing regulatory approaches to local lead management during this volatile period in Herculaneum. The late 2000s presented the second important epoch in lead regulation in the Herculaneum area. The development and initial implementation of new National Ambient Air Quality Standards (NAAQS) for lead were a central focus of regulatory agencies and local residents during this period. The new lead NAAQS, released in October 2008, substantially reduced the allowable concentration of lead in the air. It posed significant challenges to existing programs in Herculaneum and forced a major shift in the ways that lead is managed in the area. Extensive documentation supporting the decision to substantially reduce the lead NAAQS will be the focus of analysis for this epoch.

In order to develop an understanding of the perspectives and approaches behind regulatory efforts and decisions made to manage local lead contamination and to reduce the national guideline for air pollution, the analysis of regulatory documents was supplemented through the simultaneous and complementary exploration of the influence of stakeholder perspectives on local policy processes. Thus, the discussion of the results of the exploration of the first research question in Chapter Six will include the ways that policy approaches were shaped by stakeholder perspectives and activities.

Research Question Two: Stakeholder Perspectives

The second research question focused on the ways that local stakeholders describe the problem of lead contamination in Herculaneum. In this investigation I reviewed a variety of perspectives within the community on local issues surrounding lead contamination. In addition, lead management itself has had an undeniable impact on the town and its residents. The landscape of perspectives on lead contamination in the area was explored with particular attention to the viewpoints of residents who have become active in attempting to influence environmental decision-making, as well as the organization of certain community members with similar priorities into activist groups. The histories and priorities of two groups, the Community Advisory Group (CAG) and Herculaneum Today and Tomorrow (HT&T) have been influential in directing community and regulatory activities locally. The ways that local perspectives have been shaped by regulatory developments in the area will also be a prominent feature of the discussion of findings emerging from the second research question. Therefore, the discussion of local perspectives in Chapter Seven will include the ways that these perspectives have been influenced by policy approaches. The specific interactions presented in Chapters Six and Seven will be revisited to conclude the dissertation in Chapter Eight with a review of evolving policy approaches and stakeholder perspectives in terms of policy learning. In the section that follows I will provide an overview of the chapters included in this dissertation.

Organization of the Dissertation

This dissertation is organized according to the following chapters. Chapter One has provided the purpose and importance of this research, outlined the research questions, and will now turn to an overview of the major topics of discussion in each of the following chapters. Chapter Two provides an overview of historical controversy surrounding understandings of lead toxicity and management policy in the United States. This discussion will be followed by an overview of literature investigating the ramifications of living in communities near lead industrial sites. Chapter Three provides theoretical grounding for the study in interpretive policy analysis, particularly Fischer's (1995, 2000, 2003) model. Chapter Four details the interpretive methods utilized in collecting data and conducting the analyses for this dissertation. Chapter Five introduces the findings of the study with a case report of central events in the environmental policy context of Herculaneum that will be analyzed further in Chapters Six and Seven. Chapter Six focuses on answering the first research question regarding policy approaches to managing lead contamination in Herculaneum. This chapter provides a detailed view of lead regulation in Herculaneum. The two epochs in local lead regulation are examined with regard to the ways the policy approach to regulation of lead contamination in Herculaneum have changed. Chapter Seven overviews the various local perspectives on lead contamination and management as explored under the second research question. The chapter provides a trajectory of the development of different perspectives around local lead contamination and how persons holding these perspectives formed groups and accessed resources to work in defense of their viewpoints. The discussion focuses on divergent views within the community on several important points that impact the positions and activities surrounding management of local contamination. Points include: (1) the meaning of community and what makes a community ‘healthy,’ (2) the meaning of activism and what activists should defend, (3) the ways that ‘science’ is used to strengthen and defend different perspectives, and (4) how the concepts of risk, hazard, and threat are viewed and defined for the community and the individual. Each of these points raises fundamental issues of disagreement and differences in priority that illuminate the foundational differences in perspectives and values with regard to lead contamination in the community. Chapter Eight concludes the dissertation by revisiting findings presented in Chapters Six and Seven to interpret the findings through the lens of policy learning. By linking these two discussions together, the ways that the events described in each section can be seen as influencing, or responding, to the other are illuminated. Thus, this chapter illustrates the processes of policy learning in terms of adaptation to local, political, and scientific contexts, with policy approaches making up one important aspect of the setting for local perspectives and vice versa. The chapter also discusses implications of the study and the proposed definition of policy learning for the fields of science education, Public Understanding of Science, Science and Technology Studies, and environmental policy. I then describe two directions that this analysis will take in the future to build toward a body of scholarship around public participation in environmental policy debates tied to the practices and of science education.

Chapter Two: Literature on Lead and its Impacts on Individuals and Communities

In order to situate the current study in the long history of lead science and regulation, as well as in literature examining communities facing industrial lead contamination, this chapter is organized into two sections. The first section describes a history of lead regulation in the United States focusing on important transformations in the ways that lead contamination has been understood and managed. This section provides background on the extended debates over lead in industry, the environment, and public health. Situating the current study in historical lead controversy is necessary to ground the local discussion and its implications within an extended conversation that has been going on for many years in multiple locations, and that will be referenced throughout the rest of this dissertation. The second section overviews the literature on communities facing industrial lead contamination. This segment of the literature is largely limited to work conducted by local health departments throughout the world in efforts to recognize and manage health effects of nearby lead smelting activities. While this literature has been useful in understanding the health implications of living in proximity to lead industrial operations, it generally fails to consider the meanings of lead contamination for impacted individuals and communities, or of efforts at managing it from the perspective of those most affected. a familiarity with the health implications of residing in close proximity to industrial lead activities is necessary both to understand the nature of the particular challenges faced by residents in such areas, and the difficulty of linking particular health outcomes to specific contaminant exposures.[1]

[1] Portions of this chapter were adapted from McNew-Birren, J. (In Press). A 'Tragic Dichotomy': A case study of industrial lead contamination and management in Herculaneum, Missouri. In W. F. Tate (Ed.), *Research on Schools, Neighborhoods, and Communities: Toward Civic Responsibility*. Lanham, MD: Rowman & Littlefield Education.

A History of Lead Science and Policy in the U.S.

Although lead poisoning has been recognized throughout much of human history, it was not until the mid 1900s that any health effects except the most severe cases of lead poisoning were associated with lead exposure. In these cases clinical symptoms of abdominal, head, joint, and muscle pain; poor coordination; affected cognitive and perceptive functions; and changes in behavior to the point of psychosis were evident and linked to high levels of lead exposure, primarily from lead- related occupations. Lead exposures were also implicated in certain kidney diseases, spontaneous abortions, infertility, and early childhood mortality in the 19th and early 20th centuries (Hernberg, 2000). The health effects of severe, often fatal, lead exposures on children were initially recognized in the early 1900s (Needleman, 2004). Throughout the early 20th century concerns over the detrimental effects of lead were limited to these most severe forms of lead poisoning, which have been estimated to occur in children at blood lead levels around 60 µg/dL (micrograms per deciliter).[2]

Lead was primarily used as a paint pigment in the U.S through the early 1900s. Although the White Lead Convention banned interior use of paint containing white lead in several countries due to concerns over potential lead poisoning, the lobbying activities of the politically powerful Lead Industries Association contributed to the successful prevention of similar legislation in the United States, where white lead continued to be

[2] One µg (microgram) is equivalent to 0.000001 grams. It is used to measure extremely small quantities of mass. One dL (deciliter) is one tenth of a liter, which is slightly less than half of a cup. Therefore, µg/dL is used here to measure and describe very small, but medically critical concentrations of lead in blood.

used as an additive in both interior and exterior paints throughout most of the 20th century (Hernberg, 2000).

The Early- to Mid-1900s: Early Debates Over the Implications of Widespread Lead Exposure

In the 1920s, the American automobile industry began to recognize beneficial properties of tetraethyl lead (TEL) as an anti-knock component in gasoline. In 1923, General Motors and DuPont began marketing TEL as a gasoline additive. The effects of high dose lead exposure quickly became evident in factories producing TEL:

Shortly after production began, workers in all three plants began to go crazy and die, often in straightjackets....A moratorium on the use of TEL was called and the Surgeon General [Cummings] convened a meeting of industrialists, public health specialists, and academic physicians to determine if this new product was a serious enough threat to be banned or whether it should be sold to the general public. (Needleman, 1998, p. 79)

Surgeon General Cummings's 1925 conference aimed to bring a scientific perspective to concerns over increasing lead pollution. Although it considered lead poisoning primarily in terms of a hazard for industrial workers, the gathering proved pivotal in shaping criteria for evidence of harm as part of regulatory actions targeted to address environmental and health impacts of industrial activity.

The Surgeon General's conference pitted environmental and labor protection representatives against business leaders promoting industrial advancement in debates over a possible ban on TEL production (Nriagu, 1998). Public health representatives presented a variety of foundational concerns over potential health hazards due to lead enriched automobile emissions. They argued that lead "should be banned, until it is shown safe" (Moore, 2003, p. 17). The lead industry was primarily represented by Robert Kehoe, who over the course of the 20th century reigned as the country's leading authority on lead toxicity. Kehoe required data that would demonstrate the detrimental effects of leaded gasoline on the human population, suggesting that industrial representatives were prepared to discontinue production in the face of such evidence. During this period research linking lead contamination and health effects was extremely limited; as a result public health and environmental scientists were unable to provide the evidence demanded (Nriagu, 1998; Skolnick & Currie, 2007). Although public health scientists were generally in agreement about the potential dangers of large-scale lead exposures, since they were poorly resourced and lacking a unifying voice, they were unable to counter Kehoe's demand for evidence of actual harm.

Following the conference, Surgeon General Cummings appointed a committee "to gather hard evidence for or against leaded gasoline" (Warren, 2000, p. 127). The panel compared samples collected from gasoline station attendants using leaded gasoline against those who relied on gasoline that did not contain TEL. Since both groups had elevated lead levels, the committee concluded that TEL was not absorbed by workers, and therefore reported that a prohibition on the addition of TEL to gasoline was not justified (Warren, 2000). Warren (2000) argued that the conference afforded two opportunities to the lead industry: (1) it was given permission to continue production of TEL, and (2) it was able to effectively monopolize research on the health effects of lead. The importance of this second point can not be overstated:

Although the Surgeon General's panel gave the go-ahead to resume production of tetraethyl lead, it also recommended further study….The outcome of further government investigations was uncertain, especially given the combative atmosphere that prevailed after the Surgeon General's conference. Such considerations probably helped fix in Kettering's mind the importance of establishing a credible, industry-supported, and lead-friendly research body….For the next forty years, industry-owned or -financed centers conducted the most influential studies, usually with pro-lead results. (Warren, 2000, p. 129)[3]

By controlling the definition and quantification of lead's health effects, the lead industry helped to establish and support a system of industrial self- regulation. The industry operated largely under the assumption that lead was safe until it was directly linked to particular negative health outcomes. As a result, lead poisoning from gasoline and paint additives exacted heavy health, environmental, and economic costs in the United States before detrimental effects of environmental lead were sufficiently quantified (Grosse, Matte, Schwartz, & Jackson, 2002; Landrigan, Schechter, Lipton, Fahs, & Schwartz, 2002; Moore, 2003). In addition, since lead industry researchers were primarily responsible for investigating and defining lead toxicity, the health effects of lead exposures continued to be thought of as a disease of lead workers and associated with a threshold of exposure.

According to Warren (2000), it is unclear that controversy surrounding TEL in gasoline influenced the public understanding of lead poisoning. Around the time of Surgeon General Cummings's meeting pediatricians and city health officials gradually became aware of pediatric lead poisoning. Due to different presentations of lead

[3] Charles Kettering was president of General Motors, which had an important stake in TEL as a gasoline additive that resolved a knocking problem associated with General Motors engines.

poisoning in children and adults, pediatric lead poisoning had often gone unrecognized previously. Through the 1920s and 1930s pediatricians gradually accumulated case evidence and characterized symptoms and diagnostic indicators of pediatric lead poisoning, as well as differing effects according to developmental stage. They also identified prominent sources of exposure as the ingestion of paint from cribs and toys coated in lead-based paints. Publicity surrounding these pronouncements sparked public concern over lead-based paints in children's environments. Lead Industries Association representative, Felix Wormser, assured the public that the manufacturers of such items no longer used lead-base paint for such applications (Warren, 2005, p. 120). His assurance initiated a search for other sources of contamination in the late 1930s, which settled on the depression-era practice of the extremely poor to burn salvaged battery casings for heating fuel. This development resulted in the characterization of lead poisoning as "a public health problem only for those whom poverty forced to take drastic measures or those who, through ignorance of the dangers, used lead products in ways for which they were not intended" (Warren, 2000, p. 143). By the late 1930s the definition of lead poisoning had grown to include hazards to impoverished children, children who were poorly supervised and allowed to chew on hazardous items, and the children of lead industry workers. According to Warren (2000) "over the next two decades, improved diagnostics, and treatments developed for the workplace would encourage further research into childhood lead poisoning" (p. 147).

In the early 1940s physicians and researchers began to challenge the assumption that lead exposures short of extreme lead poisoning produced no negative long-term effects. Recognizing potential damages to the developing nervous system, Byers and

Lord (1943) examined the early academic performance of and performed psychological examinations on 20 children with a history of lead poisoning that had been treated and was not considered to be debilitating. They concluded that lead had negatively affected the development of the cerebral cortex of the cohort:

None of them exhibited evidence of severe acute encephalopathy, yet only [one] lived up to the promise of his early development. In some such failure was parallel to a generalized defect in mental development, resulting in a readily recognizable lowering of the intelligence quotient. In others, though the intelligence quotient remained well within normal limits, a specific failure of development in the sensorimotor sphere was the outstanding finding. (Byers & Lord, 1943, p. 483)

Byers and Lord's (1943) report represented a landmark in the way that childhood lead poisoning would be understood subsequently, demanding the consideration of detrimental impacts on the developing nervous system with long-term consequences. Even Robert Kehoe acknowledged the research as convincing, presenting an even greater challenge to the lead industry's efforts to minimize the perceived health implications of widespread lead use (Warren, 2000).

Scientific, political, and ideological shifts in the population following World War II created conditions where industrial domination of disease definition was more effectively challenged. The political climate called for an expanded role of government in protecting the health of the American public. Warren (2000) described the influence of the development of chelation therapies that chemically removed quantities of lead from the bloodstreams of highly exposed individuals on the frequency of diagnosis of lead poisoning. Pediatricians, particularly those in urban settings where exposures were more frequent, began to recognize cases of pediatric lead poisoning more frequently. Additional attention was also paid to sources of exposure in children who received treatment, and efforts were made to find and remove lead sources from their homes. The expanded attention combined with continued increases in the use of lead-based paints and leaded gasoline necessarily identified far larger numbers of lead poisoned children. The Lead Industries Association responded by refuting the legitimacy of these diagnoses as poor understandings of lead poisoning held by pediatricians. Case data gradually accumulated, however, as pediatricians began to recognize and test for lead exposures with increasing frequency, particularly in Baltimore and Cincinnati, where large lead studies were underway. Lead research throughout the 1940s and 1950s was therefore characterized by a cycle of accumulation of evidence of the toxic effects of lead exposure, increased awareness of potential health consequences of widespread industrial activity, and persistent denial by the lead industry that the harms being attributed to lead exposure with increasing frequency were actually lead-related.

The 1960s: Environmental Regulation in Transition

In the 1960s, procedures for measuring lead concentrations in extracted blood used colorimetry. Later, atomic absorption spectrophotometry emerged as the accepted technique to measure the concentration of a metal in a sample (Hernberg, 2000). Despite this more promising technology, procedures were poorly standardized, measurements were unreliable, and blood lead levels (BLLs) from the same blood samples could not be replicated in different laboratories (Hernberg, 2000). Despite their limitations, however, these methodological refinements provided scientists with evidence linking lead exposures to quantities of lead in human tissues. Thus, this upgrade in laboratory technique opened the possibility of examining health effects across a spectrum of exposure levels, allowing the field to move beyond the analysis of only the most extremely symptomatic cases.

New technologies did not eliminate debate related to lead and public health. Robert Kehoe now directed the Kettering Laboratory at the University of Cincinnati. The laboratory was supported by C. F. Kettering, Ethyl Corporation, DuPont, and other lead manufacturers. Despite Kehoe's continued insistence that measurements at his laboratories were uniquely valid, his dominance of lead research and reporting came under serious scrutiny in the late 1950s and 1960s. The challenges were ushered in by widely acknowledged ideological and political shifts in the ways that many Americans viewed the environment and environmental regulation:

Before World War II, environmental attention had focused on conservation of resources in the service of an industrial economy. Living standards improved after the war ended, and people turned to outdoor recreation. Americans began to regard the environment as an asset with intrinsic value apart from utilitarian purposes. (Needleman, The Removal of Lead from Gasoline: Historical and Personal Reflections, 2000, p. 21)

As they became more aware of their environment, Americans also became increasingly concerned about environmental pollution and aware of the possibility of health harms due to exposure to environmental contaminants. The breadth of these concerns was evident in the passing of the first federal legislative actions to begin researching and monitoring air pollution and its effects on human health. The Air Pollution Control Act of 1955 funded research to identify the extent and sources of air pollution problems in the U.S., the original Clean Air Act of 1963 funded a program to research, manage, and minimize air pollution, and the Air Quality Act of 1967 set up a structure for states to establish and begin enforcement of air quality standards (U.S. Environmental Protection Agency, History of the Clean Air Act, 2008a). These legislative actions served to expand support for environmental research that was not exclusively funded by the polluting industries, providing the foundation for the emergence of a more cohesive environmental perspective on lead regulation. Although they focused almost exclusively on information gathering and included virtually no enforcement, this collection of legislative acts initiated federal intervention in environmental management, and provided new research capacity charged to examine the effects of lead exposure on human health.

During this time Clair Patterson surfaced as a figurehead for the emerging environmental movement, which involved researchers concerned about high levels of toxins in the environment and the health implications of this pollution (Nriagu, 1998, p. 76). Patterson, a geochemist, compared lead levels in 1960s samples of air, soil, water, and tissues, which he collected under fastidiously controlled sterile conditions, to levels in pre-industrial mummy tissues, deep sea fish, and ice cores from Greenland. These procedures reflected Patterson's primary critique of past studies that failed to carefully control for widespread lead contamination in the environment at the time of their collection in the 1960s. Specifically, he argued that industrialization introduced such a high baseline lead burden to air and water that previous experimental controls were highly contaminated by exposure to high levels of lead in ambient air and water. According to Needleman (1998), Patterson's research approach and related findings offered three important corrections to Kehoe's claims. First, industrial activity had contributed levels of lead to the human environment sufficient to present a background level of exposure two orders of magnitude higher than would have been common under pre-industrial conditions. Second, urban air lead concentrations had increased 2000-fold due to industrial activity. Finally, historically increasing lead levels in the atmosphere clearly reflected growth in industrial development. Patterson argued that industrial sources contributed unnatural quantities of lead to the environment and that environmental lead caused illnesses, likely affecting the nervous system, in large portions of the population. He emphasized that any amount of lead in the human system was not natural, although due to widespread environmental contamination and exposures the general population had sustained a body burden of lead that could be seen as "typical." Patterson's estimation of the effects of sub-clinical lead exposure differed dramatically from Kehoe's:

When you expose an organism to a toxic substance it responds in a continuum, to continuously changing levels of exposure to this toxic substance. There is no abrupt change between a response and no response. Classical poisoning is just one extreme of a whole continuum of responses of an organism, human organism, to this toxic metal. (quoted in Needleman, 1998, p. 83)

Patterson's research called into question whether the body of accumulated research on the health and environmental effects of industrial lead use met basic scientific standards since the bulk of this research was supported by and in the interest of the lead industry. He argued "that when public health agencies collaborate with polluting industries to decide whether public health is threatened by their products, the results are often absurd" (Needleman, 1998, p. 82).

Kehoe continued to position himself as the preeminent expert on lead contamination. Partnering with other industry-funded researchers, he maintained that lead poisoning was defined only as exposure to the extent that clinical symptoms of severe brain damage or death were observed. This level of exposure occurred primarily in lead workers and children with pica at BLLs now identified as measuring greater than 80-100 ug/dL in adults and 60 ug/dL in children (Hernberg, 2000; Needleman, 1998).[4] These conclusions were based on two main assumptions made by Kehoe: first, that air lead levels in Cincinnati, where his lab was located, had decreased since the inclusion of TEL in gasoline, and second, that a baseline level of lead occurs naturally in the human environment and is measurable in 'normal' body tissues taken from individuals not exposed to TEL in their occupations. These two assumptions were foundational to thirty years of his laboratory's research, which measured lead in air, soil, food, the tissues of factory workers both with and without contact with TEL, and the tissues of residents of rural Mexico.[5] These assumptions were central targets in Patterson's critiques of Kehoe's work, and more generally of industry-supported health research.

---

[4] Pica describes a medical condition whereby individuals eat non-digestible materials. Here the term was likely misapplied to describe natural hand-to-mouth behaviors in young children.

[5] Needleman (1998) retrospectively pointed out that that Kehoe's investigations were 'biased;' for example early air and soil measurements were taken in industrial sites, while fewer industrial sites were sampled in later measurements. He also asserted that in Kehoe's lab "their reagents, instruments, and the very air in their laboratories were freighted with lead. As a result the baseline measurements of all their samples were raised and their results blurred. In addition, the control subjects in Kehoe's studies, the workers in the Dayton plant who did not directly handle TEL, were nevertheless exposed to it. His second 'unexposed' group, the Mexican farmers, ate food that had been cooked in and served from lead-containing ceramic pots and plates" (p. 81). However, at the time the research was presented, these sources of sample contamination were not evident to the majority of scientists.

In 1966 the U.S. Senate held a subcommittee meeting on the Clean Air Act, which offered a platform for a public debate between Kehoe and Patterson with regard to the appropriate characterization of lead toxicity in regulating lead emissions. This hearing proved to be a second watershed moment in the consideration and management of lead contamination in the U.S., and marked an ideological shift in the environmental health approach to judging the health effects of human lead exposure and regulating lead in the environment. Additionally, the meeting introduced the possibility that the relationship between health effects and lead exposures was characterized by a purely dose-response relationship with no threshold of safe exposure.

Following the 1966 hearing, many scientists began to consider the possibility of modeling health effects of lead in terms of dose-response relationships without the assumption of the existence of a threshold below which no negative health effects exist. The possibility of rejecting a threshold of safety for lead represented a major departure from one of the central tenants of toxicology (Pfitzer, 1974). The Kehoe-Patterson controversy was pivotal in the history of lead regulation by (1) establishing a basis on which to question the acceptance of a threshold effect of lead exposure, (2) undermining the lead industry as the primary source for scientific assessment of lead toxicity, and (3) opening the question of health effects of exposure levels below clinically identified poisoning, particularly in children, for further investigation.

1970s to 1980s: Establishing Health Effects at Low Levels of Exposure

In order to expand scientific understanding of the relationship between low level lead exposures and health effects, subsequent to the 1966 hearing researchers began examining the effects of exposure levels below those associated with clinical symptoms of lead poisoning, which involved symptoms of convulsions, coma, and poor coordination associated with BLLs above 80 µg/dL (Goyer, 1993). In 1974 the National Institute of Environmental Health Sciences held a symposium on low level lead toxicity that focused on two main questions: "(1) What are the unwanted effects which occur at low level exposure to lead? (2) What are the biologically significant major sources of these low levels of lead?" (Pfitzer, 1974). In an article summarizing the conference, Pfitzer (1974) described the theoretical debate at the center of the event:

> In toxicology the foundation of our science has been established on the significance of the dose-response relationship and the belief that for most chemicals a threshold level in the body exists at which animal or man can interact with the foreign chemical resulting in no undesirable effects. Traditionally these studies are performed by exposing animals to various dose levels, then determining the dose level which was not significantly different from the control group and referring to this as the "no-effect" level…. Some statisticians, particularly some in federal regulatory agencies, have taken an extremely conservative approach in which the data are not reviewed by actual statistical analysis between individual groups but by the examination of an overall dose-response relationship, with the application of confidence limits to probable slopes for that relationship, then the extrapolation of this statistically possible slope towards the zero dose level of the control group. The acceptable level of exposure is then estimated based upon some very small change which is a presumed "acceptable" fraction of the normal variation within the control group. This

approach is not only a very conservative one, it in fact belies the basic belief in a threshold effect. (p. 250)

Pfitzer provided a thorough summary of a debate in modeling the dose-response relationship between lead exposures and health effects that would ensue for many decades. He also summarized achievements of the conference in terms of the establishment of effective animal models and techniques for extrapolating health effects in humans, epidemiological evidence of lead absorption, and sources of exposure. Pfitzer concluded that convincing evidence had been presented at the 1974 meeting to support associations between lead exposures and behavioral disorders, and identified sources of exposure associated with household sources (i.e. paint, plaster, and dust). In the late 1970s and1980s lead exposures above 30 µg/dL were associated with various impairments of the developing central nervous system (CNS) affecting motor skills, behavioral characteristics, and motor functions in preschool children with effects that continued into school age. Additional evidence was presented that blood lead levels of 10-15 µg/dL produced effects to the CNS function of very young children (Goyer, 1993).

Scientific developments in understandings of lead toxicity in the early 1970s contributed to the regulatory changes in the management of potential sources of lead exposure. Several legislative acts substantiated this extensive change. First, the Clean Air Act of 1970 provided the first large-scale, enforceable environmental policy to manage air pollution in the U.S. from both mobile and stationary sources. Several regulatory systems were enacted in these amendments, but central to the current discussion of lead, the National Ambient Air Quality Standards (NAAQS) were mandated. The NAAQS required that the federal government identify and establish safety guidelines for air pollutants. Congress mandated that these standards were to be reviewed every five years to ensure that they reflected the most current science related to the health impacts of environmental contaminant exposure. The 1970 amendments established that the primary enforcement of NAAQS would be managed through State Implementation Plans (SIPs), in which each state would develop a plan to meet the individual standards. The scale of enforcement required at the federal level by this new clean air legislation made it evident that a federal environmental agency was needed and the National Environmental Policy Act was passed in 1971, establishing the Environmental Protection Agency (EPA) to implement and enforce clean air policy. The limits on automobile emissions in the 1970 Clean Air Act Amendments preceded the passing of federal laws in 1973 and 1975 that required the use of catalytic converters on new cars.[6] Implementation of this legislation required widespread availability of unleaded gasoline, and permitted the establishment of a timeline for the gradual phase-out of the use of TEL in gasoline, ultimately completed by 1996.

Opponents of the use of lead as a paint pigment also won a legislative victory in 1971 with the passage of the Lead-Based Paint Poisoning Prevention Act (LBPPPA), which provided federal funding for lead abatement in U.S. cities, and prohibited the use of leaded paint in federal housing projects (Warren, 2000). Successive amendments limiting the use of lead in paint were set in 1973, 1975, and 1977, which gradually reduced the allowable level of lead content in indoor paint to 0.06 percent(Markowitz & Rosner, 2002; Silbergeld, 1997; Warren, 2000). Unfortunately, the historically

[6] Small concentrations of lead in gasoline disable catalytic converters. Thus, in order to utilize this technology to limit automobile emissions, the gradual removal of lead from gasoline was required.

widespread use of lead-based paints continues to be the cause of lead exposures in areas where housing stocks predate lead-limiting legislation. Programs to remediate and abate lead-based paint in older housing stocks continue to operate primarily through the Department of Housing and Urban Development (Latour, 1993, 1996, 2005; Law, 1991).

Throughout the history of environmental regulation, court cases have played an important role in the interpretation and implementation of lead regulation legislation. As Melnick (1983) pointed out, "between 1972 and 1981 hardly a day went by when the EPA was not involved in litigation over regulation of airborne lead" (p. 269). EPA did not initially list lead among the criteria pollutants designated to be included as part of the NAAQS under the Clean Air Act Amendments of 1970, choosing instead to manage lead indirectly through limitations on automobile emissions. The National Resources Defense Council (NRDC) brought suit against EPA in 1975 to include lead as a criteria pollutant, an effort that the D.C. Circuit Court supported (Melnick, 1983). In 1976, lead was listed as a NAAQS criteria pollutant, with the level set at 1.5 $\mu g/m^3$ (micrograms per cubic meter)[7] in 1978(Martineau & Novello, 2004).[8] This limitation on air pollution was tied to EPA's development of plans to gradually remove lead from gasoline. In 1976 the lead industry legally objected to the removal of TEL from gasoline, and in 1980 to the level of the lead NAAQS (Melnick, 1983). The courts supported EPA in both of these precedent-setting cases, upholding the removal of TEL from gasoline and EPA's assignment of the

---

[7] Micrograms (µg) are used here in the same manner as in measuring BLLs, to quantify very small amounts of mass. Since air-lead concentrations are mass per volume of a gas, the unit of volume used is cubic meters (m^3).

[8] Controversy between industrial and environmental perspectives on lead regulation was primary in the determination of the appropriate level of the lead NAAQS as well. For a detailed description of this conflict see Needleman (2000) for a scientific perspective, or Melnick (1983) for a legal perspective.

appropriate NAAQS level for lead. Historically, the courts have generally supported EPA in limiting quantities of lead in the environment.

All of this regulatory activity had a profound impact on the way lead exposures were understood to impact human health. Before 1970, clinical symptoms of lead poisoning were considered the primary indicators of harm; today's measurement techniques indicate that these symptoms usually occur at blood lead levels (BLLs) above 60 µg/dL in adults. Thus, the maximum tolerated levels hovered around this figure as long as clinically symptomatic poisoning was considered the threshold effect of lead exposure. Until the early 1970s, BLLs below 40 µg/dL were defined as safe for children, since declining hemoglobin levels (anemia) are observable at this level in youth. Responding to evidence that lead exposures below clinically observable poisoning had serious negative health effects, the Centers for Disease Control (CDC) assigned a maximum allowable BLL of 30 µg/dL in 1975, which acted as an action level for screening children exposed to lead-based paint. By the early 1970s it was known that lead impacts oxygen transport below this threshold:

Research showed that lead begins to effect the production of hemoglobin (the part of the red blood cell that transports oxygen in a number of ways). At 10 micrograms lead inhibits the formation of a catalyst in the production of hemoglobin molecules. Somewhere between 15 and 20 micrograms, levels of free erythrocyte protoporphrin (FEP) in the mitochondria rise, indicating further disruption of hemoglobin production. Far from clarifying the health effects issue, however, these new findings raised two additional questions: first, where precisely does each of these changes begin; and second, which of these various physiological changes are adverse? (Melnick, 1983, p. 273)

However, in setting the lead NAAQS in 1976, it was the CDC's 30 μg/dL blood lead threshold that EPA ultimately used as the target level below which 99.5% of the vulnerable population should fall, with a mean BLL of 15μg/dL, which it considered the onset level for FEP elevation (Melnick, 1983).

EPA reviewed the lead NAAQS between 1981 and 1986, but kept the standard at 1.5μg/m^3 despite a recommendation from its Scientific Advisory Board (SAB) that it be reduced by at least half. The SAB's work in reviewing the lead NAAQS was used, however, to justify reductions in acceptable lead levels in drinking water in 1986, and the complete ban on leaded gasoline in 1995 following the 1990 Clean Air Act Amendments (Silbergeld, 1997). These most recent amendments served primarily to expand EPA's authority with regard to managing a number of additional air pollutants and increased EPA's capacity for enforcing existing NAAQS (U.S. Environmental Protection Agency, History of the Clean Air Act, 2008b). This interaction between the CDC's threshold for identifying lead-exposed children, and the most current scientific data regarding the epidemiology of lead toxicity, when used as an indicator of public health, determined the regulatory threshold for air lead that would be enforced by EPA and state environmental agencies.

In 1989 leading lead toxicity scholar, Herbert Needleman, reflected on the developments in lead toxicity and lead regulation over the previous two decades and described contemporary understandings of lead toxicity. He argued that although lead exposure was now recognized as an environmental hazard for all children, the risks of exposure were considerably higher in inner city communities due to scarcity of quality housing and higher levels of lead in the environment. He summarized contemporary studies that were based on epidemiological and vector evidence that lead exposure impacts neural development, infant growth, learning, language ability, and attention. According to Needleman (1989), "The rate of acquisition of new knowledge in this area is jarring; the newer studies have both lowered the perceived threshold for observed health effects and demonstrated toxic effects in new areas" (p. 643). The collection of extensive evidence and widespread acceptance of the existence of lead effects at relatively low exposure levels set the stage for a great deal of research on the precise nature and mechanisms of childhood lead toxicity at low exposure levels in future decades.

1990s to 2000s: Exploring Low Level Exposure Symptoms and Mechanisms

In the early 1990s researchers began combining standardized assessments conducted across multiple populations by several researchers to expand sample sizes and increase the analytical power of the research (Richardson, 1999, 2002). These studies associated low-level lead exposure in early childhood with increased school failure, reduced reading ability, lowered class standing, increased failure to graduate, reduced fine motor function, and a greater prevalence of behavior problems(Canfield, Kreher, Cornwell, & Henderson, 2003; Needleman, 2004; Richardson, 2002). Additionally, researchers demonstrated that even the lowest levels of lead exposure result in the most rapidly increasing effects on neurological function in a relationship resembling a log-linear curve, leading some to conclude that a safe level of lead exposure does not exist (B. P. Lanphear, Dietrich, Auinger, & Cox, 2000; Needleman & Bellinger, 1991).

Conclusions about the adverse effects of low-level lead exposures have not been universally embraced, as demonstrated in a special issue of the *Archive of Clinical*

Neuropsychology published in 2001, in which Kaufman presented a critical review of three highly respected large-scale meta-analyses tying low-level lead exposures to IQ decrements (Kaufman, 2001). In this volume, Kaufman critiqued the studies in terms of measurement usage, inclusion of confounders and covariates, statistical modeling, and causal inference. Kaufman's review sparked a debate in the remainder of the special issue by leading researchers of lead effects that either supported (Hebben, 2001) or refuted (Brown, 2001; Nation & Gleaves, 2001; Needleman & Bellinger, 2001; Wasserman & Factor-Litvak, 2001) Kaufman's critique. Arguments presented in this special issue closely resemble historical conflicts over the necessary evidence required to characterize the nature and extent of lead toxicity (see Hernberg, 2000; Moore, 2003; Warren, 2000 for historical accounts of lead controversy). While dissention and uncertainty is frequently acknowledged in expert discussions of toxicological evidence, the dominant scientific paradigm accepts linkages between low-level lead exposures and detrimental effects on neural development in children.

Following the removal of lead from paint and gasoline and enforcement of the lead NAAQS, reductions in the nation's exposure to lead became appreciable in epidemiological studies and baseline blood lead levels throughout the U.S. population declined. As the population mean lead exposure declined, the effects of lower lead levels on children became perceptible. Thus, the CDC threshold BLL was adjusted to 25 µg/dL in 1985, and again to 10µg/dL in 1991 to reflect emerging understandings of the persistent hazards at lower levels of exposure:

Each time the screening guideline was revised, new studies were initiated to determine whether the new level used to define *normal* provided children with an adequate margin of safety. Although it is common to see the current screening guideline of 10 μg/dL referred to as a 'safety limit'..., the CDC intended it to be interpreted as a risk management tool rather than a threshold for adverse effect. Research conducted since the last revision of the screening guideline has indeed confirmed the appropriateness of this interpretation, with some results even suggesting that the decline in children's IQ scores per unit increase in blood lead level is greater in the range of 0-10 μg/dL than it is above 10 μg/dL. (Bellinger & Bellinger, 2006, p. 853)

This cycle continued as researchers linked BLLs at or below 10μg/dL in early childhood to reduced IQ scores, increased school failure, reduced reading ability, lowered class standing, increased failure to graduate, and reduced fine motor function(Needleman, 2004; Richardson, 2002; Tong, 1998). Additionally, behavior problems such as increased attention deficit, aggression, and delinquency have been demonstrated to be associated with lead exposure in animal models, epidemiological investigations into human populations, and tied to bone lead levels (a less invasive measure of lead exposure) in school-aged children (Canfield, et al., 2003; Needleman, 2004). Thus, many researchers now conclude that *no safe level of lead exposure exists* and debates over current CDC guidelines for toxic lead exposure continue (Canfield, et al., 2003; Gilbert & Weiss, 2006; B. P. Lanphear, et al., 2000; Needleman & Bellinger, 2001). Scientists now recognize that the relationship between lead exposures and health impacts is far more complicated than the dose response relationship proposed by Clair Patterson in the 1960s. The health effects of lead exposure are impacted by an array of factors including timing of exposure in developmental trajectory, diet and nutrition, exposure to other environmental toxins, other health concerns, genetics, and body chemistry. Reductions in the CDC's threshold BLL have altered the definition of lead poisoning and the understood health effects associated with lead exposures.

Having generally established developmental impacts of low level lead exposures, researchers in the late 2000s turned their focus to studying specific mechanisms and implications of low-level lead exposure on various biological functions involving the neurological, renal, cardiac, and reproductive systems. Additionally lead exposures have been implicated in contributing to incidence of cancer, and genetic factors that impact lead absorption have been identified. In 2009 the National Institutes of Health published a review of the neurotoxic effects of lead exposure. They summarized research on mechanisms of toxicity through which lead acts as:

a systematic toxicant affecting virtually every organ system, [but] primarily affects the central nervous system, particularly in the developing brain….Within the brain, lead-induced damage to the prefrontal cortex, hippocampus, and cerebellum can lead to a variety of neurological disorders, such as brain damage, mental retardation, behavioral problems, nerve damage, and possibly Alzheimer's disease, Parkinson's disease, and schizophrenia. (Sanders, Liu, Buchner, & Tchounwou, 2009)

While many of these outcomes are consistent with those identified by prior research, the gradual mapping of the biochemical mechanisms through which lead disrupts both childhood neural development and adult neurological function allows for extremely convincing, but complex argumentation regarding the health effects of low level lead toxicity. Relationships between lower level lead exposures and cardio-vascular effects (Sanders, et al., 2009) and nephrotoxicity (a form of kidney disease) (Navas-Acien, Guaaller, Silbergeld, & Rothenberg, 2007) have been demonstrated. Additionally, increased consideration has been given to the role of lead as a carcinogen in recent years (Ekong, Jaar, & Weaver, 2006).

The evolving science and regulation of lead demonstrates the complexity involved with environmental policymaking due in part to the intricate epidemiology, exposure pathway, and multimodal character of lead as a toxin. Continuing controversies about the extent of health effects associated with lead exposures and appropriate regulation further complicated the process. Complexity was also introduced by the structure of the organizations that regulate lead at the federal state and local levels. The involvement of the various agencies and programs in lead regulation will be further discussed below as it relates specifically to the case of lead in Herculaneum.

Research on Leaded Communities

The impacts of lead contamination have been examined specifically in terms of contaminated communities, which are home to industrial lead processes including mining, milling, and smelting. These industrial processes emit lead into the air and water, exacerbating many of the problems associated with lead present from historical gasoline emissions and from household paint. The major source of contamination in mining and smelting communities, however, is soil and dust contamination resulting from air emissions settling in the soil and from lead concentrates in various forms being spilled as they are transported from one location to another. Since much of the regulatory focus with regard to lead has been around lead laden paint and gasoline, lead regulations have failed to adequately address challenges in communities with industrial-source lead pollution. There is a federal guideline for soil remediation, but no enforceable standard, and no federal guideline for road or house dust. The majority of mine and smelter community studies focus on the quantities of lead in local soil and house dust, the uptake of these media by children, and the biological absorption of the different forms of lead deposited in these areas. In this arena of public health research, two main controversies permeate the predominantly quantitative case studies of lead contaminated sites: (1) whether or not the forms of lead released into the environment by various mining, milling, and smelting processes are absorbed by residents, termed "bioavailability;" and (2) the long term health effects of lead exposure from living in a 'leaded' communities.

Lead Processing

Before reviewing studies conducted in mining and smelting communities, it is necessary to provide an abbreviated summary of lead mining and processing. Lead is excavated from mines in the form of lead ore, or galena, which is a combination of lead sulfides and other rocks and minerals. A mill is usually in close proximity to the mines for initial processing of the lead ore. Here the ore is crushed or ground, then passed through a chemical bath, which binds lead and copper compounds to air bubbles, causing them to float and allowing them to be separated from the sediment waste (McHenry, 2006). Waste from the milling process is disposed of near the mill and is called mine tailings or chat. Large hills of lead chat dot the landscape throughout the lead belt. Milling products are then dried and shipped as concentrate to a lead smelter for further processing. The first process in lead smelting is termed roasting. Heat is used to drive off sulfur and other remaining minerals from the concentrate producing an impure lead oxide material. After roasting, additional materials are added to the ore to make "sinter," which is then passed through blast furnaces where oxygen and any remaining sulphur are removed through heat-induced reactions with the sinter ingredients to create lead bullion.

Products are further separated and lead bullion is isolated out. The lead bullion is then allowed to cool and a layer of impurities called dross is removed before it is cast into bars for distribution to companies that use lead in manufacturing. The many byproducts of the blast furnace processes are treated to harvest other useful minerals, recycled back into sinter materials, or disposed of as 'slag.' Lead slag is treated much like lead chat and disposed of in large piles near the plant.

In Herculaneum, for instance, a 24 acre slag pile is maintained on the smelter grounds, where waste continues to accumulate on the banks of the Mississippi river. Various processes are used to treat other byproducts isolating valuable minerals before waste is discarded according to the company's government permits; however, throughout the processing of ore into lead bullion, and transportation of concentrates, lead byproducts are released into the environments of surrounding communities.

Mine Communities

Several environmental health studies have argued that mining wastes containing relatively high concentrations of lead present minimal risk to proximal residents due to the low levels of lead absorbed from mineral-lead compounds (Danse, Garb, & Moore, 1995; Steele, Beck, Murphy, & Strauss, 1990). For instance, one argument is that lead in the form of galena is bound in such a way that human systems absorb very little of it even when heavily exposed. This argument has been contested by population studies that compare the blood lead levels of children in mining communities with those in non-contaminated communities. These studies find significant differences in mean blood lead levels in children in mining communities from those located elsewhere, with BLLs in mining communities approximately twice those of children in control communities

(Murgueytio, Evans, & Roberts, 1998; Murgueytio, Evans, Roberts, & Moehr, 1996; Murgueytio et al., 1998). These studies also link lead levels in soil, house dust, and paint to children's BLLs in these communities, finding that soil and house dust make significant and substantive contributions to children's BLLs (Gulson et al., 1994; Malcoe, Lynch, Kegler, & Skaggs, 2002; Murgueytio, Evans, & Roberts, 1998; Murgueytio, Evans, Sterling, et al., 1998). Since mine wastes and lead deposits from transport settle into soil and house dust, this research is used as evidence to argue that mining wastes, which are spread throughout these communities, contribute to elevated lead levels in local children. Thus, the studies indicated that lead in mining waste is absorbed by the human system and impacts human health, although this absorption may be at a lesser degree than other forms of industrial lead waste.

Smelter Communities

Communities surrounding lead smelters have also been studied by environmental science and public health researchers. Research in smelter communities has shown that children living near lead smelters absorb more lead from consumption of contaminated soil and house dust than through breathing lead-laden air, and that lead concentrations in soil, dust, and children's blood are all highly correlated, increasing with proximity to the smelter facility (Albalak et al., 2003; Roels et al., 1980). Another study of the impacts of soil contamination following the deactivation of the historical smelting plant in Trail, British Columbia found a mean decrease in nearby children's BLLs of 18% to 22% per year, far greater than the 5% to 6% per year decreases observed there prior to the closure of the smelter (Hilts, 2003). This finding emphasized the importance of limiting ongoing smelter emissions in managing local health impacts from operating smelters, but also the limitations of lead management technologies versus discontinuation of lead smelting.

A longitudinal study conducted in the smelter city of Port Pirie, South Australia began in 1979 and has documented a variety of health implications for residents of the surrounding community, as well as the implications of regulatory efforts begun in 1989 to manage smelter emissions and clean up existing contamination in an attempt to reduce local lead exposures. This series of studies has identified negative correlations between postnatal blood lead levels in the smelter community and performance on intelligence assessments, as well as emotional and behavioral development throughout childhood and into adolescence (Baghurst et al., 1992; Burns, Baghurst, Sawyer, McMichael, & Tong, 1999; Tong, Baghurst, McMichael, Sawyer, & Mudge, 1996). Many studies on mining and smelting communities by local health departments are ongoing and will continue to explore ways that lead industry facilities more or less negatively impact the public health of nearby communities.

This chapter has provided a background for the study's consideration of lead management in Herculaneum, grounding it in both historical controversy surrounding lead toxicity and the limited body of research exploring the implications of living near lead mining and processing facilities. While the studies discussed above have explored the health implications of living in close proximity to industrial lead activities, they have not looked into the meanings that industrial lead contamination and its management hold for local residents, or the ways that citizens can impact industrial operations and contamination in their area. Exploring the meanings that stakeholders assign to contamination and particular forms of management in this dissertation will afford a more complete and contextual understanding of the challenges of lead in Herculaneum. Additionally, understanding how local perspectives and activities can shape area industrial processing and contamination management can provide insight for communities facing similar contamination conditions in terms of both understanding and reacting to their own conditions. In the chapter that follows I will provide a theoretical grounding for the project in the traditions of interpretive policy research, with an emphasis on Frank Fischer's (1995) model for policy analysis.

Chapter Three: Theory

Fischer's Framework for Policy Analysis

The primary theoretical tool used in this work was Fischer's (1995, 2003) framework for policy analysis, adapted to address environmental policy in *Citizens, Experts and the Environment* (2000). Fischer's framework is grounded in three main theoretical traditions: interpretive policy analysis, Science Technology Studies (STS),[9] and participatory inquiry. This study's focus on the educative context of environmental policy processes required an approach to policy analysis that allowed for understanding policy deliberation in educative terms. For this purpose I have adapted Fischer's approach to policy evaluation to explore how participation in environmental policy processes can be conceptualized in terms of learning on the part of individuals and groups. In this chapter I will first discuss the theoretical grounding of Fischer's approach in terms of interpretive policy analysis, science technology studies (STS), and participatory policy work. I will also include a brief theoretical background for considering learning through policy processes. I will close the chapter with an overview of how Fischer's approach informed the development of research questions for this project, and specific adaptations that I made to consider activism in Herculaneum as an educative context.

Interpretive Policy Analysis

Interpretive policy analysts focus on the multiple understandings and priorities surrounding any policy concern (Silbergeld, 2003). Examining the politics and processes

[9] Science Technology Studies is the term that will be used in this work to refer to the field of work also termed Sociology of Scientific Knowledge, Science Studies, Social Studies of Science, and sometimes is included in the genre of the Philosophy of Science.

surrounding the regulation of industrial lead contamination in Herculaneum required attending to the perspectives of regulatory representatives, industry representatives, city officials, and residents. Interpretive policy analysis permitted the exploration of the interactions and contributions from a variety of stakeholders toward managing lead contamination in Herculaneum. An explanation of the central tenants of Fischer's framework follows.

Multiplicity of perspectives. Interpretive policy analytic approaches are "based on the presupposition that we live in a social world characterized by the possibilities of multiple interpretations" (Yanow, 2000, p. 5). Thus, these approaches emphasize the many perspectives surrounding policy problems and potential solutions. Interpretive approaches to policy analysis consider the perspectives of local stakeholders alongside the views of technical experts or regulatory agencies in pursuit of understanding policy problems from the viewpoint of those most directly impacted. According to Fischer (1995), his approach is a stark contrast to more traditional policy approaches that tend to exclusively privilege expert perspectives and technical knowledge sources in evaluating policy effectiveness. As Yanow (2000) states,

> Interpretive approaches to policy analysis focus on the meanings that policies have for a broad range of policy-relevant publics….Interpretive approaches…explore not only "what" specific policies mean, but also "how" they mean–through what processes policy meanings are communicated and who their intended audiences are as well as what context-specific meanings these and other "readers" make of policy artifacts." (p. 8*)*

By focusing on the meanings and enactment of meanings around policy problems and solutions for impacted communities and individuals, interpretive approaches allow for the consideration of the various sources and forms of knowledge of a policy problem that take shape in affected communities.

Fischer's (1995, 2000, 2003) approach is unique among interpretive approaches since it allows for the combined consideration of the technical thinking and language of environmental discourse alongside the more local and colloquial perspectives emphasized by an interpretive stance. Considering the technical view alongside local perspectives includes dissembling technical rationality into multiple and often divergent viewpoints of individuals, groups, and institutions that make up the regulatory bureaucracy. Thus, it is possible to consider the perspectives of regulatory representatives alongside those of local citizens, acting within complex networks of groups and institutions. Fischer (1995) emphasizes the equal weight afforded to technical perspectives and local perspectives by focusing exclusively on each of these viewpoints in two separate analytical discourses in his model for policy analysis. Balancing local and expert perspectives in this way made Fischer's method optimal for use in the current study, which conceptualizes environmental policy processes in Herculaneum as educative. This approach allows for the examination of the ways that members of the public and regulatory representatives have come to understand, perform, and live with science in an environmental policy context. I will further discuss Fischer's treatment of scientific rationality by drawing upon STS scholarship in the following section.

Science and technology studies. Interpretive policy analysts must make some adjustments when considering policy issues that involve complex scientific and technical definitions of both the policy problem and possible solutions. Fischer's (2000, 2003) perspective on environmental policy requires that scientific and technical knowledge be brought into balanced interaction with the social and normative processes, assumptions, and decisions that shape it: "None of this is to imply that science should not be taken seriously. It means, rather, that the thing we call 'science' has to be understood as a more subtle contextual interaction between physical and social factors" (Fischer, 2000, p. 72). Fischer and interpretive policy analysts in socio-scientific arenas turn to STS to situate scientific facts within the scientific activities and communities that produce them, and to research on the Public Understanding of Science (PUS) to consider the extent and nature of participation in such issues that can be expected of the general citizenry. In the following sections I will discuss important and relevant aspects of these research genres in order to situate the approach to scientific controversy in this study.

Fischer's (1995, 2000, 2003) approach to environmental policy analysis relies heavily on an understanding of science that stems from STS. STS scholars have focused attention on the processes and politics involved in scientific research (Fischer, 1995, 2000, 2003; Hajer, 1995, 2003; Yanow, 1993, 1995, 2003). They have argued that in its approach to studying natural process, scientific research itself proceeds as a human endeavor in which personal priorities and perspectives inform a multitude of choices that ultimately shape scientific findings and conclusions. It is the critical ingredient of nature in the study of science that distinguishes the natural sciences from other contexts since nature must be considered as a central entity, separate from the expectations, ideals, and intentions of researchers. In this way, Latour (1993) and other leading STS scholars differentiate their perspective of science from social constructionists, who argue that nature itself is a social construction (Callon, 1986; Healy, 2003; Jasanoff, 1995; Latour, 1993; Law, 1991). In the view of STS scholars it is our study of nature, not nature itself, which is the product of human processes and decisions.

Ian Hacking (1999) offered an important way of thinking about the social and political nature of scientific findings in his argument that scientific findings are always contingent, nominal, and stabilized by external factors. By contingency, Hacking indicated that multiple interpretations of observed phenomena are feasible. Thus, scientists might interpret the same observations differently. Hacking's concept of nominality emphasizes that particular experiences are not directly reducible to universal structures, but rather reflect the ways that we have named compilations of observational experiences. This is not to say that there is no correspondence between our experience and the objects that we experience, but rather that the correspondence is mediated by the ways we understand and discuss these objects. By arguing that scientific findings are stabilized by social and political factors external to the scientific experiment itself, Hacking suggests social contexts, arguments, and positionalities impact the ways that certain scientific explanations and conclusions come to dominate public understandings. Contingency, nominality and social stabilization are frequently overlooked aspects of scientific research. They reveal that unacknowledged uncertainties are present in scientific and technical knowledge. I have found the clarity with which Hacking philosophically approached situating the scientific endeavor within social and political processes particularly useful in understanding the central distinctions of STS.

STS researchers have examined the processes and conditions through which particular lines of scientific inquiry come to seem necessary and productive, as well as how findings in certain veins come to be socially stabilized through both broad cultural trends and processes of negotiation and practice among communities of scientists(Law & Hassard, 1999). It is these socially embedded aspects of scientific fact that led Latour (1993) to conclude, “Yes, science is indeed politics pursued by other means” (p. 111). Latour described scientific processes in terms of Actor Network Theory (ANT), which has become a dominant perspective framing STS work. For the purposes of this dissertation, ANT provided a structure for examining the ways that scientific arguments are stabilized by factors not accounted for in scientific accounts, as Hacking described. It is this external stability that limits the recognition of the contingency and nominality of scientific findings. Latour (1993) argued that aspects of scientific explanation that are uncertain or open to interpretation become evident through scientific controversy. By exploring the activities of scientists and others in contexts of scientific controversy through tracing networks of activity, ANT researchers identify specific uncertainties associated with scientific facts as well as the social and political events through which particular interpretations become stabilized.[10]

Rather than make oblique references to social and political conditions or realities

---

[10] To illustrate, I discussed in Chapter Two that assumptions that a threshold of lead exposure below which no negative health effects existed dominated understandings of lead toxicity throughout the 19th and 20th centuries. This idea persisted, not because it was sound science or consistent with observations of lead-affected individuals, but rather because it was the dominant and unquestioned assumption ascribed to by virtually everyone in the scientific community. The threshold assumption was also unquestioned because lead industry domination of lead toxicity research meant that no incentive existed for the pursuit of a contradictory line of thinking. As the political and scientific climate surrounding understandings of lead toxicity changed researchers began identifying effects of lead exposures beyond the classical definitions of poisoning. Byers and Lord (1943) introduced serious doubt that negative health effects below the most serious poisonings had more subtle effects on neural development in children. Patterson built on this doubt in the 1960s to develop a case that the assumption of a threshold for lead effects was absurd.

in explaining stabilization of scientific facts, ANT demands that the processes by which scientific understandings are perpetuated and come to influence public policy and perception can be traced to the specific activities of a complex network of individuals and groups as they share experiences and interpretations, and make decisions about the meanings of observations. For the purposes of this research such networks can be understood in terms of the ways that stakeholders interact with physical conditions and one another to develop and defend a particular perspective with regard to local lead contamination. Thus, these networks will reflect the activities, practices, priorities, understandings, and relationships of stakeholders acting within them.

It is not to be construed from this discussion that scientific findings are entirely the product of social or political processes; however, scientific contingency, nominality, and social stabilization present sources of scientific uncertainty[11] in technical knowledge that frequently go unacknowledged in public perspectives on science and policy-making (Irwin, 1995). Scientific uncertainty is particularly influential in discussions of environmental concerns affecting communities where inherent complexity is not easily reduced to the controlled conditions necessitated by traditional scientific research methods (Bell, 2004). Irwin (1995) emphasized that science impacts environmental policy in two key ways: (1) it lends legitimacy to particular perspectives, and (2) it acts to limit the ways that an environmental problem might be framed. Thus, scientific uncertainty, whether or not it is acknowledged, has important consequences for the development of environmental policy.

[11] Scientific uncertainty is differentiated from statistical uncertainty in that scientific uncertainty "is about ignorance – unanticipated and unknown consequences – not known uncertainties" (Wynne, 2005).

A common method for dealing with uncertainty in modern society is through the calculation of risk, defined as an estimation of the relative danger of a particular activity or circumstance. Ulrich Beck (1992) theorized that the perception and management of ‘risk’ created by technological and industrial activities has formed the central preoccupation of modern life. Beck’s ‘risk society’ theory reshaped much of the social and cultural approach to understanding socio-scientific concerns, considering modern consciousness as necessarily focusing on the development of a complex ‘calculus of risk’ (Beck, 1992). Jasanoff (2003) explained that, from this perspective, risk is “a part of the modern human condition, woven into the very fabric of progress. The problem we urgently face is how to live democratically and at peace with the knowledge that our societies are inevitably ‘at risk’” (p. 224). Thus, it is scientific uncertainties associated with the possibility of negative events or outcomes technically quantified that are seen to dominate contemporary decision-making processes, and therefore modern consciousness.

The discussion of historical lead controversy spearheaded by Robert Kehoe and Clair Patterson in the preceding chapter provided a clear demonstration of social and political processes that influence scientific understandings. During the 1920s when Robert Kehoe and his supporters came to dominate debates over lead toxicity, the U.S. population was generally looking to technological and industrial development to promote economic growth and improve living conditions. Therefore, dominant ideologies tended to support industrial growth, despite more precautionary-oriented scientists’ concerns over potential health harms associated with widespread exposure to lead in the environment. When industrialists, led by Kehoe, demanded that regulatory decisions about public health and safety surrounding industrial processes be based on scientific demonstrations of actual harm, precautionary-oriented scientists were unable to produce this level of evidence. Additionally, Kehoe was successful in defining lead-related health harms in terms of 'lead poisoning', which occurs only at very high levels of lead exposure. Dominant ideologies, political strategies, and limitations of scientific and technological advancement came together to allow for the exploitation of scientific uncertainty with regard to the potential hazards of widespread lead contamination and lead was therefore treated as a virtually safe product short of very high level exposure.

Clair Patterson emerged as an opponent to the historically dominant ideology described above, his work becoming well known in the 1960s, a time when medical technology had advanced to a point that lead exposures could be linked to the presence of lead concentrations in human tissue samples at levels well below lead poisoning, and weaknesses in industrial ideologies had emerged due to citizen concerns over a clean and healthy environment (Killingsworth & Palmer, 1992). At this time environmental preservation and the risk of health hazards associated with pollution were raised as potential threats to the American way of life by the emerging environmental movement. Additionally, Patterson's innovative use of carefully collected sources of evidence about historical concentrations of lead in the environment redefined the way that the industry-sponsored control comparison research was understood. In most industry-supported lead studies control samples were associated with high levels of contamination due to a lead-laden contemporary environment, and thus research utilizing these controls largely overestimated background levels of lead and presented faulty conclusions. Patterson's work in discrediting the industrial view of the relative safety of environmental lead exposures fared better than the concerns raised by 1920s precautionary scientists largely due to both scientific advances that provided the types of proof demanded by industry, and emerging aspects of American environmental ideologies that reflected much more widespread sympathy to health and environmental concerns. Patterson was successful in redefining lead as a harmful toxin. Additionally, his contributions led to widespread consideration of lead toxicity in terms of a range of effects across all levels of exposure, in contrast to the threshold of harm model perpetuated by Kehoe. Risks associated with widespread environmental lead contamination were acknowledged by legislators in policies designed to eliminate lead additives in paint and gasoline, as well regulate concentrations of lead in the air through the eventual inclusion of lead as a criteria pollutant in the 1970 Amendments to the Clean Air Act.

Insights from STS and risk society theory provided theoretical tools for exploring the social and political processes surrounding the science of lead management in Herculaneum in more complex terms than simply the success or failure of an appropriate application of policy or technology. Rather, the ways that human actions, practices, priorities, understandings, relationships, and physical conditions shaped local lead management were central to the analysis alongside physical conditions and technical interventions. Technical discourses of agency risk assessments, reports, and policy documents were examined as the products of activities, explorations, and observations of regulatory individuals or groups. Although the policies and perspectives surrounding local lead contamination reflected the natural consequences of human lead exposure, measurements of area lead levels, and understandings of the mechanisms by which lead was incorporated into body tissues, these facts also have meaning as the products of social, economic, and cultural trends, as well as debate and discussion among scientists and other interested parties. Scientific understandings of lead contamination and toxicity were considered as controversial aspects of the Herculaneum context—topics that were central to the policy processes explored in this study.

Power and politics are distributed and local. Focusing on the multiplicity of perspectives surrounding a policy issue is only useful in policy analysis if these perspectives have the potential to shape the outcomes of policy deliberations. The technical complexities associated with modern political issues are often considered the domain of professional experts, and beyond the intellectual grasp of the ordinary citizen. Acceptance of this condition situates experts as powerful decision-makers in modern society, while citizens are rendered relatively powerless. According to Fischer (2000), however, "the increasing unwillingness of citizens to accept uncritically the trained judgments of the experts has become one of the central issues of our time" (p. 9). Public rejection of the conclusions of experts affords the public with a degree of power to resist expert-led policy decisions. Fischer examined the ways that knowledge and power enacted through networks of individuals, institutions, and communities inform the ways policy is developed, implemented, and received. Fischer (2000) drew on Foucault in his discussion of power as distributed:

> Power has now to be seen as multiple and diversely decentralized. Whereas politics in modern political and social theory is largely understood in terms of state power and law… from Foucault's point view, power is dispersed throughout the spectrum of social relations. Manifested in multiple, ubiquitous forms, political power no longer just belongs to the state alone: it is in effect everywhere. (p. 24)

Power and expertise are exercised not only by policy-makers and regulatory representatives but also by local individuals, groups, and institutions. Power and knowledge are accessed and exercised differently according to the differing roles and positionalities of the entities involved. Treating power and knowledge as distributed across individuals and groups within the community was useful for considering lead contamination and management in Herculaneum. Herculaneum was impacted directly by the implementation of lead-management policies enforced by federal, state, and local agencies; however, how this implementation was manifested and what lead contamination and regulation meant in the lives of community members differed across both regulatory representatives and local stakeholders. Additionally, treating power and knowledge as local and distributed allowed for the consideration of the ways that local lead management controversy contributed to shaping lead regulation on a national scale.

Analyzing multiple perspectives. Focus on the multiple perspectives of policy problems and solutions for relevant groups informed understandings of the policy context. First, the data sources that provided insight into diverging viewpoints had to be identified. Second, a framework for identifying and understanding these viewpoints was required. Interpretive methods rely heavily on analysis of discourse as the primary data for consideration. As Fischer (2003) stated, "Political action, like action generally, is shaped and controlled by the discourses that supply it with meaning" (p. 23). An approach to interpreting discourses in terms of both the multiple perspectives themselves, and the ways these perspectives interact was central to the current analysis. Fischer (2003) analyzed policy perspectives in terms of identifying the frames through which stakeholders interpret policy problems and proposed solutions. "Framing is a dynamic process by which producers and receivers of messages transform information into a meaningful whole by interpreting them through other available social, psychological, and cultural concepts, axioms, and principles" (p. 144). Thus, the policy problem itself, as well as related facts, proposed solutions, and possible outcomes are all understood within the particular ideological and experiential frame of a particular perspective. Frames allow stakeholders to make sense of various aspects of a policy problem, and also of other stakeholders who hold consistent or divergent views. Yanow (2000) explained how frames differ within a policy context:

Contending frames entail not just different policy discourses – different language, understandings, and perceptions – and potentially different courses of action, but also different values, and different meanings. The role of the interpretive policy analyst is to map the "architecture" of the debate relative to the policy issue under investigation, by identifying the language and its entailments (understandings, actions, meanings) used by different interpretive communities in their framing of the issue. (pp. 12-13)

Hajer (2003) suggested that frames are largely structured by story lines, which provide analogies and examples that serve as exemplars for particular frames; "The main function of story lines is that these short narratives help people to fit their bit of knowledge, experience or expertise into the larger jigsaw of a policy debate" (p. 104). Hajer argued that collections of story lines serve to unite groups of stakeholders around particular interpretations of events into discourse coalitions, which Yanow (2000) described as interpretive communities.

According to Hajer (1995), shared meanings align groups of stakeholders together at the same time that interactions among these stakeholders allow them to share and interpret story lines, in an iterative process that unites individuals into discourse coalitions holding similar understandings of policy-related events and problems. Discourse coalitions, analogous to interpretive communities, develop among groups that share backgrounds, history, language, ideas, or perspectives. “Instead of being constructed around preconceived beliefs, policy coalitions are held together by narrative storylines that *interpret* events and courses of action in concrete social contexts” (Fischer, 2003, p. 102). The specifics of discursive analysis as it was conducted for this study will be discussed in Chapter Four.

Policy learning. The story lines, or frames that unite discourse coalitions, are not static, but must perpetually adapt to changing conditions, both physical and political. Sabatier and Jenkins-Smith (1993), in a precursor to interpretive policy analysis, described advocacy coalitions in a similar manner to discourse coalitions, but focused exclusively on representatives of government and formal political organizations, rather than members of the general public:

> An advocacy coalition consists of actors from a variety of public and private institutions at all levels of government who share a basic set of beliefs (policy goals plus causal and other perceptions) and who seek to manipulate the rules, budgets, and personnel of governmental institutions in order to achieve these goals over time. (p. 5)

Fischer (2003) largely rejected their Advocacy Coalition Framework (ACF) as unworkable, particularly in their identification of static belief systems as the force unifying advocacy coalitions. He acknowledged the importance of the ACF in directing policy discussions toward “policy debate and argumentation” (p. 100). Fischer promoted instead a framework for understanding shared views among policy stakeholders in terms of discourse coalitions formed around shared story lines (see for example Hajer, 2003). In Fischer's view, it is shared story lines that unite groups engaged in an environmental controversy.

Despite Fischer's (2003) objections to ACF, Sabatier and Jenkins-Smith's (1993) concept of policy-oriented learning, is particularly useful for this study. According to Sabatier and Jenkins-Smith, policy-oriented learning "involves relatively enduring alterations of thought or behavioral intentions that result from experience and which are concerned with the attainment or revision of the precepts of the belief system" (p. 42). Fischer characterized Sabatier and Jenkins-Smith's treatment of policy learning as reflecting "a rather rationalistic, technocratic understanding of learning" (p. 109). He also suggested that policy-oriented learning in environmental controversy is based on outdated understandings of scientific processes and virtually ignores political aspects of argumentation in policy debates:

> The ACF overlooks the fact that the different disciplines that come into play in policy research often work from different and competing premises (or what has been called 'contradictory uncertainties'). There can be – and often are – major problems in reaching a consensus, especially in a complex and multi-faceted problem area such as the environment. (Fischer, 2003, p. 110)

Despite limitations in their concepts of advocacy coalitions and policy beliefs, Sabatier and Jenkins-Smith's (1993) theory that adaptations in understandings of and approaches to dealing with a policy problem in response to changes in physical or political conditions constitute policy learning, is useful for the current discussion of environmental controversy as an educational context. For the purposes of this study I have used Sabatier and Jenkins-Smith's conception of policy learning in combination with Hajer's analytical approach to examining policy perspectives and processes (discussed more thoroughly in Chapter Four) and an STS view of natural science. Together these approaches allow for the integration of policy-oriented learning into Fischer's model, despite his objections to ACF. The policy learning approach is instructive for interpreting adjustments in regulatory approaches and stakeholder perspectives surrounding local lead contamination. Thus, for the purposes of this research responsive adaptations of individual and group perspectives will be considered policy learning. This definition allows for the consideration of public participation in environmental controversy as an educational context.

Public participation and participatory policy analysis. The scientific processes involved in environmental policy-making garner the attention of the affected public whenever individuals and groups become active in policy contexts. This study is grounded in the expectation that the increasingly controversial and technocratic nature of political issues and debates requires that citizens participate in public forums in which they will need to defend their values and viewpoints on socio-scientific issues that impact their lives. Two obvious questions emerge from this expectation: (1) Are citizens willing to become involved in policy controversy? and (2) are they able to defend their interests in such technically complex public issues? A great deal of scholarly debate has surrounded these questions both from the perspectives of policy studies and public understanding of science.

According to Fischer (2000), most scholars and politicians adopt one of several positions with regard to citizen participation in public policy. A first group argues that citizen participation "gives meaning to democracy but also plays an important educational and psychological role in the social development of the individual citizen" (Fischer, 2000, p. x). A second group, who doubts the average citizen's ability to develop and defend an informed perspective on complex technocratic issues, contends that representative experts should be selected and allowed to dominate such decisions. A third group takes the middle ground in the citizen participation controversy; "some portray the situation as a dilemma: citizens don't have enough knowledge to participate meaningfully in technically oriented policy decisions, but it is difficult in a democracy to legitimately deny citizens a place at the decision-making table" (Fischer, 2000, p. x).

Irwin (1995) approached the question of the ability of citizens to participation in environmental controversy from the perspective that risk associated with environmental and health hazards are one of "the more important contexts within which citizens encounter science and technology" (p. 37). Drawing heavily from STS and Beck's risk society theory, Irwin found that publics can participate in socio-technical challenges. This participation generally occurs in particular ways and requires specific assistance from expert facilitators because the institutions that control environmental policy are frequently not open to other, less scientific influences. Irwin explained:

> the challenge is to achieve a flexible and responsive set of institutional structures for the development and scrutiny of expert knowledges of different kinds. As has already been stressed, the point is not to sweep aside one knowledge form and replace it with another. Instead, we need to recognize the contextual and partial nature of all the forms of understanding. (p. 173)

In Irwin's view, public participation in environmental controversy requires more than public groups coming to terms with the technical dimensions of the scientific perspective, but also that institutions and regulatory agents develop understanding of the knowledges that local citizens possess with regard to their particular conditions, as well as the locally understood meanings of contamination problems and potential interventions. This study argues that citizens both can and must participate in policy contexts around environmental controversies, and that through this participation, citizens and regulatory representatives both learn to better understand and address environmental challenges. Therefore, an important focus of this study is on groups that are active in public participation in issues of lead management in the Herculaneum community. In the following sections I will outline the specifics of Fischer's (1995) model for public policy analysis as they influenced the development of the specific research questions that guided the conduct of the current research project.

Research Questions and Fischer's Model for Public Policy Research

Fischer (1995) offered "an alternative methodology capable of integrating the *normative* evaluation of a policy's goals with the kind of *empirical* work already characteristic of policy evaluation" (p. 6). As discussed, this approach is particularly relevant to studying political controversy in the socio-scientific domain since empirical data and expert interpretation is the most influential and authoritative language used in argumentation. As Fischer's approach provides both the theoretical and methodological framework for this study, I will discuss the framework as it informed development of research questions here, and provide a detailed exploration of how the method was carried out in Herculaneum in the chapter that follows.

Fischer (1995) presented a 'logic of policy deliberation,' which considered both the technical and practical, or value-oriented, aspects of political policies or programs. He argued that a complete policy evaluation is made up of "four interrelated discourses" (p. 19): Technical-Analytic, Contextual, Systems, and Ideological, which will be discussed individually in the following sections. These discourses were grouped in pairs, the first two making up first order evaluation focused on the attainment of particular goals, objectives, and activities of a particular policy program and their appropriateness for the given setting; and the second two making up second order evaluation focused on the larger social implications of the policy, its application and implications for society at large. Fischer emphasized:

> this logic of policy deliberation organizes four interrelated *discourses* rather than a single methodological calculus per se. The goal is not to 'plug in' answers to specific questions or to fulfill pre-specified methodological requirements. It is to engage in an open and flexible exploration of the kinds of concerns raised in the various discursive phases. (p. 19)

Since Fischer designed his framework to be flexible in application to a particular policy problem and local situation it was appropriate to adapt Fischer's model to the particular setting and research objective in question. In order to focus on lead contamination and management in Herculaneum as an educative context I relied heavily on Fischer's first two discourses to develop a thorough treatment of the approaches of policy-makers and active citizens to the management of local lead contamination. I then combined the third and fourth discourses in second order evaluation to examine how interactions and influences between the first two discourses could be viewed in terms of local policy learning. Details on my treatment of each discourse and its contributions to the research questions that guided the execution of this study are discussed in the following sections.

First order evaluation. According to Fischer (1995) the first and main task of the interpretive policy researcher is to identify the goals and objectives of a policy program and to evaluate its appropriateness for the given context. In order to explore both the policy goals and their contextual appropriateness, the researcher must become familiar with (1) the policy tools used to manage the issue in question, and (2) the context in which these tools are implemented. The two discourses included in Fischer's first order evaluation are intended to accomplish these tasks.

Technical-analytic discourse (verification). Technical-analytic discourse makes up the first stage of Fischer's (1995) policy analysis. This stage considers the success of the policy program at meeting its particular goals. Environmental policy programs like the network of regulations that apply to lead in Herculaneum are complex and multifaceted. Making sense of the various objectives of multiple large-scale regulatory programs as they apply to a particular setting is no simple task. Additionally, it is important to note that these objectives change over time and their successful implementation often requires a reconsideration of the definition of the policy problem. Keeping these factors in mind, the first research question for the current study was; "How did regulatory agencies approach lead contamination in Herculaneum?" This question encompasses both the program objectives and their outcomes, as well as how these objectives may have changed over time as local lead situation changed.

Contextual discourse (validation). Fischer's (1995) second discourse questions the appropriateness of the program objectives to the particular problem situation in question:

> The validation phase of policy evaluation is concerned with the *relevance* of the policy objectives employed in an evaluative judgment. Whereas verification attempts to show that a program fulfills or fails to fulfill an objective, validation asks whether the policy objectives are appropriate to the specific problem situation under investigation. (p. 69)

In order to determine the appropriateness of the program objectives for the particular context, it is necessary to acquire a depth of understanding of the targeted setting. Thus, the perspectives held by local stakeholders that involve particular, often experiential, knowledge of local circumstances are central to this discourse. Based on the discourse of validation, the second research question for this study was; "How did local stakeholders describe lead contamination and its management?" The focus here was on both local stakeholder views of the problem of lead contamination, and expectations of effective lead management.

Second order evaluation. According to Fischer (1995) the final two discourses that make up the second order of his evaluation (systems discourse and ideological discourse) build on the first two discourses (verification and validation) to examine the larger, societal context. Fischer's intention in the systems and ideological discourses is to examine the societal contribution of the policy goals and the particular values that lie at their heart, but it is unclear exactly how these higher order discussions emerge from further analysis of the first two discourses. He provides examples to demonstrate the various discourses and these illustrate a deeper evaluation the first two discourses (technical-analytical and contextual) as they interact in relation to the policy context. For the purposes of this study I focused particularly on the ways that policy approaches influence local perspectives and vice versa. This strategy allowed me to focus on this study's definition of policy learning involving adaptations in viewpoints or approaches to influencing policy processes.

Exploration of the research questions guiding this study provided a framework for a detailed understanding of the policy situation in Herculaneum in terms of public participation as it was enacted in this setting, and how such a situation can be considered in terms of the processes and outcomes of policy learning. In the following chapter I will discuss the specific processes of data collection and analysis in this project in greater detail.

Chapter Four: Methods

As discussed in Chapter Three, the research questions for this study generally reflect the strategy for policy evaluation described by Frank Fischer (1995) who "conceptualizes policy evaluation as a form of practical deliberation concerned with the full range of empirical and normative issues that bear on policy judgment" (p. 2). As a deliberative approach to exploring policy contexts, Fischer's strategy and, therefore, this study reflects a commitment to an interpretivist epistemology and a constructivist ontology. According to Yanow and Schwartz-Shea (2006):

> An interpretive methodology holds that there is no direct, unmediated access to reality (a basic claim in interpretive epistemology), and this, in turn, means that humans' interactions with their external worlds are always already mediated by the historical, cultural contexts in which they find themselves. But more than this, humans do not *simply* respond to external stimuli but actively make and remake their understandings of those stimuli (a constructivist ontology). (p. 34)

Accordingly, the primary concern in interpretive policy research is the meanings of the policy problem and potential solutions within the relevant context. This chapter will discuss the ways that the problems and programs addressing lead contamination in Herculaneum were systematically explored in this research project.

Research Design

Building off of Fischer's (1995, 2000, 2003) multi-level model, the two primary research questions introduced in Chapter Three guided the data collection and analysis for this project. The research questions were: (1) How do regulatory programs approach lead contamination in Herculaneum and (2) How do local stakeholders describe lead contamination and its management? These questions organized the conduct of this research project into two phases, one associated with each research question. Although the research phases were iterative and informed one another throughout the process each was focused specifically on a particular set of discourses and the collection of associated data.

Analytical Framework

While Fischer developed a robust framework for theoretically grounding and conceptualizing interpretive policy research, he did not specify a detailed analytical framework to guide data analysis, rather he described the approaches of other interpretive policy analysts. Of those suggested by Fischer (2003), the interpretive analytic framework chosen for this study was argumentative analysis as described by Hajer. According to Hajer (2003):

> If we examine controversies in environmental politics from this [argumentative] perspective these conflicts are not to be conceptualized as semi-static plays in which actors have fixed and well memorized roles of environmentalist, policy-maker, scientist, or industrialist. On the contrary, environmental politics becomes an argumentative struggle in which actors not only try to make others see the problems according to their views but also seek to position other actors in a specific way. (p. 53)

The central discourses structuring such environmental controversies are storylines, which are "narratives on social reality through which elements from many different domains are combined and that provide actors with a set of symbolic references that suggest a common understanding" (p. 62). Through identifying and analyzing the storylines promoted by individuals and groups, researchers can develop an understanding of the perspectives that serve to unite groups of individuals sharing perspectives, and shape the practices of these groups as they present arguments and defend their own perspectives against groups united around alternative storylines. Through the analysis of policy documents, field notes, and interview transcripts, central and repeated storylines and arguments were examined to describe the regulatory approaches and local perspectives that were the focus of this research.

Researcher role. Interpretive policy analysis places the researcher as a person with a particular perspective, history, and priorities in relation to the policy problem in question. Yanow (2000) explained two main interpretive suppositions: first, that the "social world [is] characterized by the possibilities of multiple interpretations"; and second, that the analyst cannot "stand outside of the policy issue" (p. 5). In terms of my work in Herculaneum, interpretive analysis placed me, the researcher, as an individual with a background and viewpoint with regard to environmental issues. I came to this research with some general knowledge of lead controversy in Herculaneum from media reports upon entering into fieldwork for this study. I also brought an approach to environmental and health issues from a largely technical perspective, building on my background in biochemistry and science education.

Through interviews and meetings with active residents and regulatory stakeholders I was allowed opportunities to discuss and explore their specific concerns and views on various issues surrounding local lead contamination and its management. An important aspect of my work in Herculaneum was developing empathy with participant viewpoints and balancing the understandings of locals, many of whom 'grew up with lead,' alongside those of regulators, who were tasked with weighing the scientific evidence of health and environmental risk.

In his more recent work Fischer (2000, 2003) envisioned research settings in which the researcher enters a community and facilitates opportunities for public consensus building and mutual understanding of an environmental threat toward becoming politically active in the management of that threat. In this case, however, opportunities for public participation were not initiated or organized by myself as the researcher, but were already well underway when I entered the field. Rather than creating opportunities for participatory democracy this study can be viewed as a case study in a policy arena where more organic public participation was known to have been influential. Thus an important focus in this study was the processes and politics through which Herculaneum residents have been influential in shaping lead management at multiple levels and how these processes and politics themselves represent an educational context. In the following sections I will describe the methods that structured my approach to both collecting and analyzing data in building an understanding of the multiple perspectives surrounding lead contamination in Herculaneum.

Research Question One – Regulatory Approach

The first stage of analysis in this study focused on the question of how regulatory programs approach lead management in Herculaneum, which was developed from Fischer's (1995) treatment of technical/analytic discourse. Fischer expected that either an experimental analysis or a risk/cost-benefit analysis would be required to meet the needs of the technical/analytic discourse. In the study of lead contamination in Herculaneum, however, the data required to conduct such an analysis were privileged to regulatory agencies that have conducted extensive research to evaluate both the local contamination problem and the success of regulatory strategies over the last decade. Such an analysis would also be redundant since reviews of this type have been conducted regularly by regulatory agencies, and their reports are readily available. Therefore, a review of the public reports, documents, and various analyses that have been conducted and released, and that have had notable impact on lead management in Herculaneum between 1999 and 2010 according to local stakeholders was conducted to answer the question of the regulatory approach and the current state of lead regulation in Herculaneum.

Data collection. The first task in considering how regulatory programs address the problem of lead contamination in Herculaneum was to identify the most influential policy programs with regard to addressing lead contamination in Herculaneum. Due to the underlying complexity presented by the programmatic intricacies involved in the environmental regulation of a multi-media, multiple-exposure pathway environmental contaminate, volumes of regulatory reports and programs surround regulation of lead in Herculaneum. In order to identify those policies and programs that carried meaning in the community I familiarized myself with the regulatory activity in lead management in Herculaneum through examining news reports and releases, attending public meetings about lead regulation in both Herculaneum and St. Louis, initiating informal conversations with community members, and collecting documents and publications from the various related regulatory agencies. Documents and programs identified by stakeholders both in interviews and public meetings as important carriers of meaning were considered influential to lead management in Herculaneum and analyzed through argumentative analysis. Thus, the work of identifying meaningful programs and documents occurred in concert with the investigation of local perspectives associated with research question two. Documents identified by participants as significant in the local regulatory framework fell into three main groups: (1) orders and agreements associated with the early 2000s transformation in lead management, (2) health-related studies based on events that occurred in the early 2000s, and (3) reports and studies associated with the 2008 NAAQS revision process.

Group one documents. From 2001 to approximately 2004, local lead contamination and its impacts on the community garnered a great deal of public attention and lead regulation in the area was transformed. These developments were heavily influenced by several regulatory reports: 2001 Administrative Order on Consent (AOC), and subsequent 2001 Public Health Risk Letter, and 2001 Abatement and Cease and Desist Order, which characterized the lead levels in Herculaneum as dangerous to local health and ordered Doe Run Co., the corporation responsible for the operation of the lead smelter in Herculaneum, to take immediate action. Ultimately the AOC and Cease and Desist Order were resolved through a Settlement Agreement and a Voluntary Purchase Plan. Also included in this group of documents was a lawsuit filed by Herculaneum residents and the Missouri Coalition for the Environment, represented by the Washington University Interdisciplinary Environmental Clinic. Together, these orders and actions inspired largely by the 2000 crisis of contamination made up the first group of reports analyzed in this stage of the study.

Group two documents. A series of health reports were generated based on developments emerging in the 2001-2004 period. Local health reports, titled Health Consultations, were conducted cooperatively between the Missouri Department of Health and Human Services and the Association for Toxic Substances Disease Registry. The studies served many functions in shaping local lead regulation. They (1) directly linked local lead exposures to lead plant emissions, (2) reported the results of local blood lead analysis in 2001 and 2002, (3) addressed local concerns over the safety of local schools, or the toxicity of other plant related contaminates, (4) identified appropriate remediation levels for interior dust, and (5) examined a possible link between lead exposure and high rates of Multiple Sclerosis and Amyotrophic Lateral Sclerosis. These health reports made up the second group of documents analyzed in the first stage of this project.

Group three documents. A second period of transformation in local lead regulation began in 2007 and continued through the writing of this dissertation. This period centered on the review and revision of the National Ambient Air Quality Standard (NAAQS) for lead. This standard, released in October 2008, substantially reduced the allowable concentration of lead in the air. It was based on a variety of reports distributed by the Clean Air Scientific Advisory Committee (CASAC), two of which pertain directly to Herculaneum: the Lead Human Exposure and Health Risk Assessment for Selected Case Studies of 2007 report and the Analysis of Socio-Demographic Factors for populations living near Pb TSP Monitors and Larger Pb Point Sources report of 2008. The new lead NAAQS posed significant challenges to existing programs in Herculaneum, and forced a major shift in the ways that lead is managed in the area. At the state level, agencies were required to reassign designations of non-attainment areas according to the new standard. Documents associated with the lead NAAQS review and its local

Table 4.1

Documents Analyzed in Stage One

	Release Date	Title	Lead Agency / Program
Group One	5/29/2001	Administrative Order on Consent	EPA Region Seven and MDNR
	12/1/2001	Administrative Order on Consent, First Modification	EPA Region Seven and MDNR
	8/2001	Administrative Order on Consent, Second Modification	EPA Region Seven and MDNR
	9/24/2001	Public Health Risk Letter	MDHSS
	9/25/2001	Order to abate and cease and desist violations	MDNR: Missouri Hazardous Waste Management Law
	4/25/2002	Settlement Agreement	Doe Run Co. with cooperation of MDNR & EPA Region Seven
	4/26/2002	Voluntary Property Purchase Plan	Doe Run Co. with cooperation of MDNR & EPA Region Seven
	9/14/2005	MO Coalition for the Environment v. EPA	Lawsuit
Group Two	9/2001	Health Consultation: Exposure investigation	ATSDR and MDHSS
	2/26/2002	Health Consultation: Blood lead results for 2001 calendar year	ATSDR Division of Health Assessment and Consultation
	6/2002	Implications from Attending or Working at Herculaneum Schools Health Consultation 2002	Prepared by MDHSS in cooperation with ATSDR Division of Health Assessment and Consultation
	10/22/2002	Health Consultation: Sulfur Dioxide Emissions	MDHSS Section for Environmental Public Health under cooperative agreement with U.S. Dept of Health and Human Services; Public Health Service' ATSDR
	11/2002	Health Consultation Public Health evaluation of Arsenic and Cadmium levels in air and residential soils	ATSDR, Division of Health Assessment and Consultation
	8/14/2003	Health Consultation: Blood lead results for 2002 calendar year	ATSDR Division of Health Assessment and Consultation
	10/6/2003	Health Consultation: Determination if Site Specific Interior Dust Clean-up Levels are Protective of Public Health	MDHSS and ATSDR
	1/15/2004	Health Consultation: Determination if remedial actions are protective of public health	MDHSS: Section for Environmental Public Health under cooperative agreement with U.S. Dept of Health and Human Services; Public Health Service' ATSDR
	3/2007	Determining baseline prevalence for provider-diagnosed Multiple Sclerosis (MS) and Amyotrophic lateral sclerosis (ALS) in Herculaneum and Jefferson County, Missouri	MDHSS office of epidemiology
Group Three	10/2006	Air Quality Criteria for Lead	EPA's National Center for Environmental Assessment in Research Triangle Park (NCEA-RTP) and Academic experts
	12/2006	Lead human exposure and health risk assessments and ecological risk assessments for selected areas – Pilot phase	ICF International for the Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency
	10/2007	Review of the National Ambient Air Quality Standards for Lead: Policy Assessment of Scientific and Technical Information – OAQPS Staff Paper	EPA's Office of Air Quality Planning and Standards
	12/15/2008	Final Rule: National Ambient Air Quality Standard for Lead	Environmental Protection Agency Office of the Administrator
	5/20/2008	Analysis of socio-demographic factors for populations living near Pb TSP monitors and larger Pb point sources	Office of Air Quality Planning and Standards (OAQPS)
	12/3/2009	2009 Lead Boundary Recommendations	Missouri Department of Natural Resources

implementation made up the third group of documents analyzed for the first stage of analysis in this study.

Data analysis. Hajer's (2003) approach to argumentative analysis involves three distinct elements: (1) the "terms of policy discourse," (2) the "formation of particular discourse coalitions," and (3) the "particular institutional practices in which discourses are produced" (p. 103). The most informative aspect of Hajer's approach for this study was the identification of the storylines central to each policy perspective; "The main function of story lines is that these short narratives help people to fit their bit of knowledge, experience or expertise into the larger jigsaw of a policy debate" (p. 104). Storylines can take the form of actual stories, metaphors, or arguments. Where a story will have a plot, a metaphor will substitute an object as representative of something else, and an argument will provide evidence leading to a conclusion. Identification of the stories, metaphors, and arguments at the core of each policy perspective was central to understanding the viewpoints of stakeholders, groups, and policy-making institutions.

In conducting storyline analysis I first read through the document reviewing the entire text (here a policy report) and identified central themes of the text and some basic information about the narrative structure (i.e., speaker, audience, structure, purpose, etc.). Following the initial global reading, I completed a form that I developed to document the analytical process identifying the document's title, report date, audience, and role assignment, as well as summaries of the argumentation warrants, proposed programmatic solutions, and central storylines. From drawing together all of the information listed above a summary of the central arguments put forth in the document was developed based to clarify the way the report discussed current conditions of lead regulation and compliance in Herculaneum. See Table 4-2 for a sample from this analysis. This interpretive analysis was conducted for each of the three groups of documents described above.

As each group of interpretive text analyses accumulated, summary arguments and constituent storylines were considered chronologically in terms of the ways that storylines and arguments overlapped, or related the same events, objects, or actions. Changes in the regulatory approach and the characterization of the local setting were carefully noted, as well as arguments and storylines that were shared by authoring agencies for insight into discourse coalitions and institutional practices. Similar storylines were traced across documents (i.e., storylines that either relate the same events or make similar arguments) and grouped to consider how they indicated discourse coalitions among authoring agencies. Conflicting storylines (i.e., storylines making conflicting or opposing arguments) were compared and considered as identifying either changes in the regulatory approach or differences in approach among agencies. Consistencies and inconsistencies in regulatory approach were then considered in terms of "the institutional practices in which the discoursing takes place and conflicts are played out" (Hajer, 1995, p. 108).[12]

---

[12] It may be useful here to provide a brief example of how documentary data related to the identification of discourse coalitions and institutional arrangements. In the first group of documents analyzed, those authored primarily by MDNR focused particularly on reducing the exposure of the Herculaneum population to lead contamination by relocating the population in closest proximity to the lead smelter. Meanwhile the EPA supported this activity; their programs placed greater weight on reducing local air and soil lead levels in order to reduce local human exposures. These different approaches revealed both different views of the problem of lead contamination in Herculaneum and differing institutional practices that shaped their response to the contamination crisis that emerged in the early 2000s.

Table 4.2

Sample Form for Documentary Storyline Analysis.

Title	Administrative Order on Consent
Date	Effective May 29, 2001
Authoring Agency	EPA Region 7 in cooperation with MODNR
Audience	Doe Run Corporation as a reference on the order and expectations Legal Authorities for enforcement The general public for information
Assignment of Roles	EPA – Administrators of presidential authority under CERCLA MDNR – Administrators of State authority under CERCLA Doe Run – Respondent Public -
Central Themes	Smelter waste and contamination Human effects and exposures Management of waste, contamination and exposure
Summary of Warrants (Body of AOC)	DR Smelter has been in operation under various administrations since the late 1800's. DR disposes of waste in a slag pile, which is in contact with local bodies of water. Slag contains concentrations of lead and other metal toxins. Lead processing (Smelting) releases lead into air. Lead in air is regulated under the lead NAAQS of the CAA. DR vicinity noncompliant with Pb NAAQS since 1/6/1992 despite continual SIP development, implementation, and revision. People can be exposed to Pb through inhalation. Community close to smelter in area with high air lead levels Community has high incidence of elevated Blood Lead Levels. High Pb levels have been found in community soil. Lead present in bodies of water and local wildlife. People and wildlife exposed to water in these bodies. DR is liable and responsible under CERCLA. Conditions in Herculaneum may threaten public health and constitute a hazardous substance emergency.
Summary of Programs (SOW in Appendix A)	I. SOIL Immediate community soil investigation and cleanup: 1) DR will determine extent of surface soil contamination esp. in areas where children would likely be exposed between 0.4 and 1 mile of smelter (if indicated EPA & MODNR will notify DR of excessive contamination beyond 1 mile & DR will determine the extent of contamination between 1 and 1.5 miles of smelter), 2) DR will complete sampling to determine potential areas of contamination, 3) DR will determine contaminated areas and expand characterized areas, 4) DR will conduct a risk assessment and develop an Integrated Exposure Uptake Biokinetic model (IEUBK) on which the cleanup level for lead will be established, 5) DR will replace soil within .4 miles that have not already been replaced and outside of .4 miles where children under 6 have blls above 10ug/dL and all other properties exceeding soil cleanup levels as a result of smelter operations. II. BLL's – DR will submit a community blood lead plan including public meetings, screenings for children, distribution of literature, and community relations activities. III. Air Emissions – 1) plan and conduct reasonably available control technology analysis and control strategy, 2) scheduled implementation of additional control measures listed (plant modifications to reduce air emissions), 3) Implementation strategy must be approved and adjusted according to EPA & MDNR's direction, 4) following implementation DR will test stacks to determine hourly emission rate, 5) additional control measures one additional control measure each quarter beginning 10/1/02, 6) DR will be notified by EPA and MDNR of violations of the lead standard after 6/2/02 following which DR will initiate contingency measures including implementation of all additional control measures

	within 60 days, 7) a second violation following implementation of all additional control measures will result in either limitation on aggregate emissions or limitations on production until EPA and MDNR establish alternative requirements through a modification of this AOC. IV. Slag Pile – 1) DR will create an interim slag pile runoff control plan, a Slag pile/Surface water/Sediment sampling and analysis plan (SAP), a slag pile response options evaluation report, a workplan for conducting an Ecological Risk Assessment (ERA) for the slag pile in cooperation with a Biological Technical Assistance Group (BTAG), a Surface Water and Sediment Response Options Evaluation Report, and a Natural Resource Damage Assessment (NRDA) plan 2) DR will develop and implement a groundwater monitoring plan and if results of implementation are insufficient DR will develop and implement an additional phase II Groundwater monitoring plan. V. OTHER ISSUES – DR shall submit a copy of all sample results and investigations conducted at specified areas, identify all potential receptors for smelter emissions, an Other Areas Evaluation Report, conduct the sampling investigations in the identified 'other areas', address significant risks to human health in the identified 'other areas'. VI. SAMPLING & ANALYSIS PLAN/ QUALITY ASSURANCE PROJECT PLAN – Each sampling activity will be accompanied by a Sampling and analysis plan specifying data quality, sampling procedures, field measurement protocols, analysis procedures.
Central Storylines	Pb and other metals are emitted by DR smelter into the environment Pb and other metals are present in the slag pile Pb and other metals are present in air Pb and other metals are present in soil Pb and other metals are present in water People are impacted by metal exposures People are exposed through inhalation People are exposed to contaminated soil and water in local environment THEREFORE People are exposed to harmful metal contamination from the DR smelter AND Conditions could present a danger to the public's health for which DR is liable under CERCLA & responsible for cleanup and further monitoring (not a legal admission of responsibility for personal harm)
Cross References	CERCLA RCRA
Summary Argument	The Slag Pile is a primary concern of this document. Evidenced by the priority placed on studying and resolving environmental impact of this waste disposal method. The Doe Run Smelter is characterized as responsible for contamination (particularly lead) in Herculaneum, which may present a threat to the public's health and is liable and responsible for cleanup designated by EPA and MODNR.

It is important to emphasize here that the documentary analysis in stage one of this project did not occur in isolation, but rather was conducted iteratively with the collection and analysis of observation and interview data. As mentioned earlier, documentary data were identified as important when they were pointed out by participants as being central to shaping local lead management either during observations of public meetings or interviews. Review of documents then inspired questions and prompts for subsequent interviews, which subsequently indicated additional documents for further analysis. Thus, the findings from this first stage of analysis, primarily reported in Chapter Six, reflect the views of local stakeholders on these environmental policy initiatives and reports as a part of the descriptive account of regulatory perspectives and processes in Herculaneum.

Research Question Two- Stakeholder Perspectives

The second stage of analysis in this study examined the question of how local stakeholders describe lead contamination and its management. The focus of the research shifted here to understanding the community in which this challenge of lead contamination is situated and how lead, as an industry and an environmental contaminant, has shaped the community. In addition, lead management itself has had an undeniable impact on the town. This stage of the analysis was conducted using qualitative, ethnographic data collection techniques in accordance with Fischer's view that a qualitative research orientation "corresponds closely to the question of program relevance, circumstances of the situation, and the interplay of competing objectives based on multiple realities" (p. 77).

Data collection. Evidence of local stakeholder perspectives was collected through observation and interviews. Observations initially centered on bimonthly Herculaneum Community Advisory Group meetings as indicated during the informal pilot phase of this work. Stakeholders active in the controversy surrounding local lead management were initially identified by their participation in these meetings, where contact information was solicited. This information was then used to schedule semi structured individual or group interviews. An iterative process of networking was then used to identify and contact additional interview participants. Additional events and interactions that were relevant to local lead contamination controversy and appropriate for further participation observation were also identified through this iterative networking process. Interview participants and observation events are cataloged in Tables 4.3 and 4.4.

Table 4.3

Participant Observation Events

Date	Event
9/2008	CAG Meeting
11/2008	CAG Meeting
1/2009	CAG Meeting
2/2009	CAG Planning Meeting
3/2009	CAG Meeting
4/2009	MACC Meeting
5/2009	CAG Meeting
5/2009	City Council Meeting
5/2009	HT&T Meeting
6/2009	City Council Meeting
6/2009	HT&T Meeting
9/2009	DNR Public Meeting
11/2009	CAG Meeting
1/2010	CAG Meeting
3/2010	CAG Meeting
11/2010	CAG Meeting

I observed lead management-related events in Herculaneum between September 2008 and November of 2010. Observations consisted of two types of public events: (1) relevant community groups meetings, or (2) meetings scheduled by regulatory agencies to either inform the public as to current regulatory activities or provide a venue for public comment on proposed measures. My participation in these meetings was generally limited to taking fieldnotes, managing recording equipment, and answering questions addressed to me directly. In addition I participated in side discussions with attendees.

These conversations typically focused on the content of the meeting or the purpose of my participation and I refrained from taking sides in discussions in these settings.

I conducted twenty individual interviews and five small group interviews with 32 participants between October 2008 and June 2009. Although interview questions were tailored to the individual or group and their role in the community, they were designed on the basis of particular protocols, which are listed in Table 4.5 below. Questions and prompts were developed to engage interview participants in discussions of their

Table 4.4

Participants by Pseudonym and Group Affiliation

Participant	Interview #	Date	Affiliation	Psuedonym
1	1-1	10/7/2008	HT&T	Jacob Williams
2	1-2	10/7/2008	HT&T	Oliver Brown
3	2-1	10/7/2008	CAG	Isabella Robinson
4	2-2	10/7/2008	CAG	Ethan Lewis
5	3	12/4/2008	CAG	Alex Hill
6	4	12/4/2008	CAG	Sophia Turner
7	5	12/9/2008	MCE	Emily Stewart
8	6	1/21/2009	EPA	Elizabeth Gray
9	7	2/5/2009	DNR	Michael Jones
10	8	2/10/2009	DNR	Matthew Allen
11	9	2/11/2009	EPA	Josh Young
12	10	2/19/2009	DNR	Emma Long
13	11	2/19/2009	DNR	Nick Peterson
14	12	2/27/2009	EPA	Chris Russel
15	13	2/27/2009	EPA	Addison Wallace
16	14	2/27/2009	EPA	Andrew Cole
17	15-1	4/22/2009	Doe Run Co.	Tyler Porter
18	15-2	4/22/2009	Doe Run Co.	Daniel Cooke
19	16	4/22/2009	CAG	Ryan Szimmerman
20	17	4/22/2009	HT&T & CAG	Bill Osborn
21	18-1	4/30/2009	DHSS	Samantha Thomas
22	18-2	4/30/2009	DHSS	Natalie Downs
23	18-3	4/30/2009	DHSS	Grace Travis
24	18-4	4/30/2009	DHSS	Zach Newton
25	19	5/13/2009	EPA Consultant	James Rease
26	20	5/18/2009	ASTDR	Lilly Fischer
27	21	5/20/2009	EPA Consultant	Ashley Hubbard
28	22	6/4/2009	Doe Run Co.	Justin Johnson
29	23-1	6/10/2009	WU IEC	Hannah Glover
30	23-2	6/10/2009	WU IEC	Sarah Buchanan
31	24	4/30/2009	DNR	John Cooley
32		5/20/2009	HT&T Leaders	Ralph and Julie Brown

perspectives on various issues related to lead contamination and its management. Interview participants were encouraged to redirect discussions to include topics

Table 4.5

General Interview Protocols According to Participant Affiliation

	Regulatory Representatives	**Lead Company Employees**	**Environmental Activists**	**Community Residents & Officials**
1	Tell me about your perspective on the challenges of lead in Herculaneum?	How did you get started working in the lead industry?	How did you get involved with Herculaneum?	What is the community like here in Herculaneum?
2	Tell me about the Herculaneum Community from your perspective.	Tell me about the community here in Herculaneum?	Tell me about your perspective on the challenges of lead in Herculaneum?	What does it mean for you to be a part of this community?
3	What kinds of views do you see in the community about lead and contamination?	How does the community interact with the lead company?	Tell me about the Herculaneum Community from your perspective.	How did you become aware that there was a lead concern in Herculaneum?
4	Tell me about the NAAQS standard and how you see it impacting Herculaneum.	Describe the community's perspectives on lead and the lead industry here.	What kinds of views do you see in the community about lead and contamination?	How does the community interact with the regulators?
5	Who do you see as influential in managing lead there?	Tell me about managing health and environmental concerns associated with lead here	Tell me about the NAAQS standard and how you see it impacting Herculaneum.	How do you feel lead pollution has impacted the community?
6	What do you think Herculaneum will be like in the future?	How do you work with the regulatory agencies?	Who do you see as influential in managing lead there?	How do you feel that lead regulation has impacted the community?
7		What do you think about the new NAAQS lead standard?	What do you think Herculaneum will be like in the future?	Who do you see as most influencing lead management here?
8		What do you think Herculaneum will be like in the future?		What do you expect Herculaneum will be like in the future?

that they considered relevant to lead contamination and management that I did not anticipate.

Both interviews and observations were documented with detailed fieldnotes and audio or video recordings when permitted by participants. When recording was not permitted fieldnotes were relied on as the sole record of the interaction. As recordings were collected they were transcribed either by myself or by a confidential transcription

service. I reviewed transcripts to ensure the fidelity of the text representation with the original recording.

Data analysis. Transcripts and fieldnotes were analyzed in a manner similar to the analytical procedures applied to policy documents described in the previous section. I first conducted an initial overview of interview transcripts for stakeholder views of the problems associated with local lead contamination and their views on past and current efforts at area lead management. During this reading I completed a form, similar to the documents described in stage one, that noted basic information about the speaker(s) (i.e., speaker, audience, role, etc.). I also noted sections of discussions that seemed central to the overall argument of the speaker(s).

During a second, more in depth, reading I outlined the central storylines and argumentative structure of each speaker. I then developed summary arguments for each speaker that generalized their perspectives and the ways that they defended or justified their particular views and priorities (Table 4.6). Referring to these storylines and summary arguments I then conducted a review of the transcripts and fieldnotes from my observations to examine the ways that participants' approaches to lead controversy were similar or different across varying settings. Consistencies and inconsistencies in storylines and summary arguments were reviewed across interview participants to examine discourse coalitions and institutional practices.

Several central themes emerged from the examination of grouped storylines and summary arguments: (1) view of the Herculaneum community, (2) view of the presence

Table 4.6

Sample Interview Storyline Analysis

Name(s) / Event:	8-1
Date:	2/10/2009
Speaker role/position	Matthew Allen Title / Agency Affiliation
Storylines	- Herculaneum is an unusual and unfortunate situation in that the population was so close to the lead processing facility. This situation created a lot of problems. - Our primary goal is to protect human health and the environment, with health being by far the most important factor, human health is the driver of almost all of our regulatory activities. We include wildlife and nature protection as secondary issues, but our main focus is health protection. - "It's tough to ask people to disrupt some of their daily lives for our purposes" - The health agencies educate the public on health issues and environmental agencies remove the contamination that's causing health issues from the general population. - Since Herculaneum is a federal-lead site for Superfund EPA is the lead agency and DNR is supportive. - Process: Community Risk Assessment created by DR- hired firm => they submit a draft in which blood data, soil contamination data, air sampling data is compiled and evaluated to DNR and EPA, who each review the Assessment from their perspective and develop a list of comments. EPA and DNR discuss their views on the document along with comments from others including the public. Eventually EPA and DNR put all the comments together and send them back to DR and consultant with instructions to revise the document. - Herculaneum as a community is tight knit, caring, divided – "There's some people I think who support Doe Run and feel very strongly about them. You know, that town probably wouldn't exist without that industry being there. There's others who, while they recognize that Doe Run has done some great things economically and along the lines of infrastructure, stuff like that, they do good things for the community. They also see the other side of that where this industry has substantially polluted that community and something needs to be done about it." - The central question is always how much can be required of industry in terms of clean up without forcing companies out of business and yet requiring responsible operation. - A community that presented a united front would be easier to work with. Herculaneum is unique in that DR continues to operate, which is rare for sites involved with superfund. They are involved in Herculaneum because the contamination is considered uncontrolled. - Community frustration often stems from misunderstandings or incomplete understandings when regulatory reps communicate with stakeholders - "So they talk to a homeowner, they're saying, 'we're going to clean up your yard'. the homeowner thinks that's going to be a one-shot deal, but the agencies didn't have all the data at that time. So they wouldn't be able to inform the community that we may have to do this again in five years." - CAG provides agencies, DR, and the community with a forum in which to discuss issues. It is important because it allows the agencies and the company to understand community concerns. - It is an advantage that DR is operational in remediating contamination, however, the pace and the nature of remediation, as well as the willingness of

(Table 4.6 Continued)	the company to cooperate are not always what the agencies would hope for. - Communities have important influence on agencies through politicians. Agency management is also a factor (i.e. governor and president set policy agenda, appoint leadership, and administer budgets. - Superfund is winding down in the area while RCRA and Air programs are taking over. - Documentary revisions can be exceedingly long, which is sometimes difficult for community members to understand.
Summary Argument	Balancing health protection with economic vitality is a constant challenge in environmental management. Regulatory processes involve long series of writing and revising reports, comments, and further reports, as well as actions and interactions in the community. All of these activities are impacted by political and administrative decisions that set the tone for the various agencies and enforcement strategies in addition to interactions with community members.
Supporting Arguments	1) Herculaneum is a nice, caring community, which unfortunately is located next door to a lead smelter. The community is divided over some issues pertaining to lead management, which slows down the regulatory process. 2) Doe Run contributes a great deal to the community in terms of infrastructure and economy. 3) Doe Run could cooperate more readily in mediating exposures, rather than force agencies to appeal to court authority. However, the fact that they are participating in clean up efforts is an advantage over the majority of lead sites. 4) The agencies are constantly seeking a balance between protecting local health and the interests of business and the local economy. 5) Balancing health protection with economic concerns in the face of historic and ongoing lead contamination presents us with knotty problems throughout Missouri. These challenges are evident in Herculaneum, at St. Joe State Park, and throughout the historic mining towns.
Cross References (documents, individuals, agencies, communities)	2000 AOC Community Risk Assessment RCRA 7003 Order

of the lead industry in Herculaneum, (3) expectations of industry responsibility in processing lead and managing contamination, (4) expectations of government agencies in regulating industry and managing contamination, and (5) position on the science of lead toxicity. Perspectives on these themes were consistently central to participant defenses of their perspective of local lead contamination. In order to gain a better understanding of the interplay of these themes for each participant, I then reviewed the transcripts, summary arguments, and storylines for each interview, developing a summary statement of their view on each theme, which I referred to as a supporting argument. Finally, the supporting arguments and summary arguments of each group were combined to emphasize the common priorities and approaches that were central to each perspective.

The exploration of local perspectives described here occurred iteratively with the investigation of policy approaches described in the previous stage. Therefore, the description of findings from this stage of analysis presented in Chapter Seven also reflects findings in the first stage. This inclusion is necessary and appropriate because local perspectives frequently involved viewpoints on and responses to the changing regulatory framework in Herculaneum. Additionally, the interconnectedness of regulatory approaches described in stage one and the local perspectives described here both reinforces and extends the interpretive policy theory by emphasizing the influence of individual and group viewpoints and interactions on policy processes. An extension of these analyses, described in the following section, served to extend this discussion.

Mutual Influence of Regulatory Approaches and Local Perspectives

To conclude this dissertation I conducted an additional analysis examining how regulatory approaches and stakeholder perspectives interact with one another. The particular focus of this analysis was on how changing viewpoints and approaches can be considered in terms of policy learning. To extend the analysis to interactions between policy approaches and local perspectives I examined the findings from the first two stages as interrelated chronological processes. This strategy represents an adaptation of Hajer's (1995) examination of discourse coalitions as a part of storyline analysis. His method was adapted here specifically to reflect the definition of policy learning presented in this dissertation as adjustments in stakeholder perspectives or regulatory approaches in response to changes in contextual factors. Essentially this analysis involved examining the findings described from stage one regarding policy approaches in the context of contemporaneous stage two findings describing local perspectives then reversing this analysis to consider local perspectives in light of contemporaneous policy approaches. Additional aspects of context were also considered such as changes in the political and physical environment, and how these both shaped and reflected evolving policy approaches and local perspectives. By considering these multiple and overlapping layers of context I was able to identify instances where policy approaches and local perspectives were adapted in response to a variety of contextual factors. Such adaptations in approach and perspective based on argumentative analysis were then interpreted in light of my model of policy learning combining the policy analytical frameworks of both Fischer (1995, 2003) and Sabatier and Jenkins-Smith (1993). Since this stage of the analysis represents a second order of analysis and advances interpretive policy theory, the results are presented as central to the conclusions of the project in Chapter Eight of this dissertation.

Together the stages of analysis described in this chapter shaped the construction of a multifaceted view of the environmental policy context of Herculaneum, Missouri, chronicling the experiences of a community under conditions of environmental threat and survival. In the following chapter, Chapter Five, I will provide an overview of lead contamination in Herculaneum in the form of a case study. Chapters Six and Seven will then report the findings from the first two stages of the research project. The dissertation will conclude in Chapter Eight with a discussion of the third stage of analysis and its implications for interpretive policy work. In the final chapter I will also outline additional research that I intend to conduct based on this dissertation study.

Research Quality

Yanow and Schwartz-Shea (2006) reviewed publications describing criteria for evaluating interpretive work in order to develop a vocabulary in which to ground discussions of research quality across disciplines, or epistemic communities. Criteria for evaluating the work of interpretivist researchers must consider that their primary focus is on meaning-making and the data from which they draw meanings is collected in various forms and settings. She identified seven concepts central to the evaluative criteria literature, four first order terms that were "ubiquitous in the criteria literature and are readily found in text indices" (p. 101) and three second order terms that lacked a central term and compile a set of diverse practices reflecting similar goals. Schwartz-Shea's first order terms include (1) thick description, (2) trustworthiness, (3) reflexivity, and (4) triangulation. Of the terms she identified as second order two, informant feedback and negative case analysis can be viewed as sub-categories of trustworthiness (Guba & Lincoln, 1989), while transparency is related to reflexivity. In the following sections I will describe each of Schwartz-Shea's evaluation criteria terms and discuss the ways in which this research study meets these criteria.

Thick description. According to Schwartz-Shea (2006), the concept of thick description was introduced into the evaluative criteria literature by Geertz (1973), and promotes a detailed description of the setting and topic of the research that allows the reader access to subtleties of the context that support the interpretation of the researcher. The subtext of this wealth of detail is the provision of evidence that the researcher was, in the original case of ethnography, actually present on-site, an eyewitness to the events, setting, and interactions described. The term can be extended to assessing other methods, such as historical or document analysis, because its purpose is not an exhaustive listing of details but a nuanced portrait of the cultural layers that inform the researcher's interpretation of interactions and events (Schwartz-Shea, 2006, p. 101)

I have met this criterion by providing multiple accounts of lead contamination and management from 2000 to the writing of this dissertation, first as a case overview, second in terms of regulatory developments, third in terms of evolving local perspectives, and finally examining the ways that local perspectives have accommodated regulatory developments and vice versa. In each of these accounts I have provided a detailed account of the events discussed particularly through the words and descriptions of participants and policy documents.

Trustworthiness. The criterion of trustworthiness was introduced into the literature by Lincoln and Guba (1989). According to Schwartz-Shea (2006) trustworthiness "offers a way to talk about the many steps that researchers take throughout the research process to ensure that their efforts are self-consciously deliberate, transparent, and ethical" (p. 101). Trustworthiness requires that researchers be transparent about their research practices, that these practices be systematic enough to present a logic connecting data to arguments, and that they be flexible enough to allow for the research to take an unanticipated direction. Several research practices that contribute to the trustworthiness of interpretive research were utilized extensively in conducting this study. First, informant feedback was embedded extensively throughout the research design. As described earlier in this chapter, participants directed me to policy documents that were significant in shaping the regulatory context of Herculaneum, and identified active stakeholders, who could broaden my perspective of the intricacies of local issues.

Additionally, informant feedback was iteratively structured into interviews and informal conversations. For example, one regulatory representative suggested to me that "innovation drives everything" in relation to the impact of emerging lead processing technology on regulatory decisions. In subsequent interviews and informal conversations I then informed various participants that I had heard that the emerging lead processing technology had influenced regulatory decisions, and their reflections on this perspective were included in my analysis. I structured similar conversations around my own impressions and explanations as they emerged throughout the process of this research. Second, negative case analysis was utilized in this study through the careful consideration and description of data that seemed to contradict the direction of my findings. For an example of a finding that utilized negative case analysis see the discussion of the Health Consultation: Determination if Site Specific Interior Dust Clean-up Levels are Protective of Public Health report in Chapter Six. Third, Lincoln and Guba suggested prolonged engagement and persistent observation as criteria for trustworthiness in interpretive research. These criteria were met by the fifteen months I spent attending meetings, conducting interviews, and analyzing the lead contamination situation in Herculaneum.

Triangulation. Triangulation is defined simply as "trying to understand a phenomenon using three different analytical tools" (Schwartz-Shea, 2006, p. 102). Most commonly, as in this study, those tools are multiple data sources including observation, interview, and document analyses. As described above, each of these data sources was important in research conducted for this dissertation.

Reflexivity and transparency. As discussed in the section titled 'Researcher Role' above, interpretive policy analysis situates the researcher as an individual bringing a particular history and perspective into the policy context. According to Schwartz-Shea (2006), reflexivity suggests “a keen awareness of, and theorizing about the role of the self in all phases of the research process” (102). Reflexivity is closely complemented by the concept of transparency in the research process, through which the researcher closely describes the research process so that readers may follow the logic of the analytical processes. Therefore, my personal histories and experiences, particularly as a student and educator in the natural sciences contributed to shaping my impressions as I conducted this study. I initially entered the field with a great deal of sympathy and admiration for resident-activists, who had been influential in reducing exposure to lead in their community. I was initially less sympathetic to the perspectives and activities of residents who appeared to reject scientific evidence of the hazards associated with lead exposure in the interest of personal economic advancement. In order to develop an understanding of perspectives that differed largely from my own, I made a concerted effort to contact and interview participants who were described as leaders in promoting community growth, often with little apparent regard for health concerns. Through the process of this research I came to understand that these residents held a deep sense of place and connection to the Herculaneum community that I could not entirely understand, but could respect. I also came to see that multiple interpretations of scientific evidence, and divergent priorities and ideological commitments all contributed to the diverse perspectives of stakeholders involved in lead contamination and management in Herculaneum. I have also come to see each of these perspectives as nuanced and complex, accounting for the realities of living in Herculaneum and defending particular aspects of a way of life that is held dear there. By keeping detailed fieldnotes, including recording my impressions following every interview and observation event, I was able to incorporate my own sympathies and preferences into my analysis and the accounts of lead contamination in Herculaneum that follow.

Chapter Five: Case Summary

Introduction and Overview

The process of examining the local perspectives and regulatory approaches to lead contamination and management in Herculaneum required that I develop an overall understanding of the central events in lead contamination and management since lead concerns became a dominant aspect of the local community around 2000. In this chapter a background for understanding the contextual nuances of lead contamination in Herculaneum is provided including a history of the local community, an outline of its central institutions, and an overview of the city demographics as of the 2000 census. Together these contextual discussions set the stage for the central feature of this chapter, a review of pivotal events in lead management in Herculaneum from around 2000 to 2011.[13] In the following sections I will first provide some background for understanding the intricacies of environmental policy processes. Second, I will overview Herculaneum's history since its founding in the early 1800s to illustrate the intricate and extensive connections between the community and the lead industry. The historical summary is followed by a description of Herculaneum in its modern-day context, emphasizing central structures and institutions to provide perspective on the modern-day Herculaneum community. In the third section I provide a depiction of lead contamination and its management in Herculaneum since 1999. This section and the one that follows, which discusses events in national lead regulation as they were impacted by processes in

---

[13] Portions of this chapter were adapted from McNew-Birren, J. (In Press). A 'Tragic Dichotomy': A case study of industrial lead contamination and management in Herculaneum, Missouri. In W. F. Tate (Ed.), *Research on Schools, Neighborhoods, and Communities: Toward Civic Responsibility*. Lanham, MD: Rowman & Littlefield Education.

Herculaneum, provide a central storyline in local lead management, which will then be reexamined to focus more intently on particular aspects of the local context of lead contamination and its management according to the study's central research questions. I will refer to the storyline presented in this chapter repeatedly in describing both stakeholder approaches and local perspectives in Chapters Six and Seven, respectively.

The Process of Environmental Regulation

Protection of human health is the driver for the majority of environmental regulatory efforts. Existing processes for protecting the public from exposure to environmental health threats involve a highly complex progression of defining negative health effects, tracing and quantifying the relationship between health effects and sources of exposure in the environment, identifying the origin of pollution in environmental media, setting limits and issuing permits for the amount of pollution allowable in various media, enforcing pollution limitations, and measuring reductions or changes in public health indicative of reduced

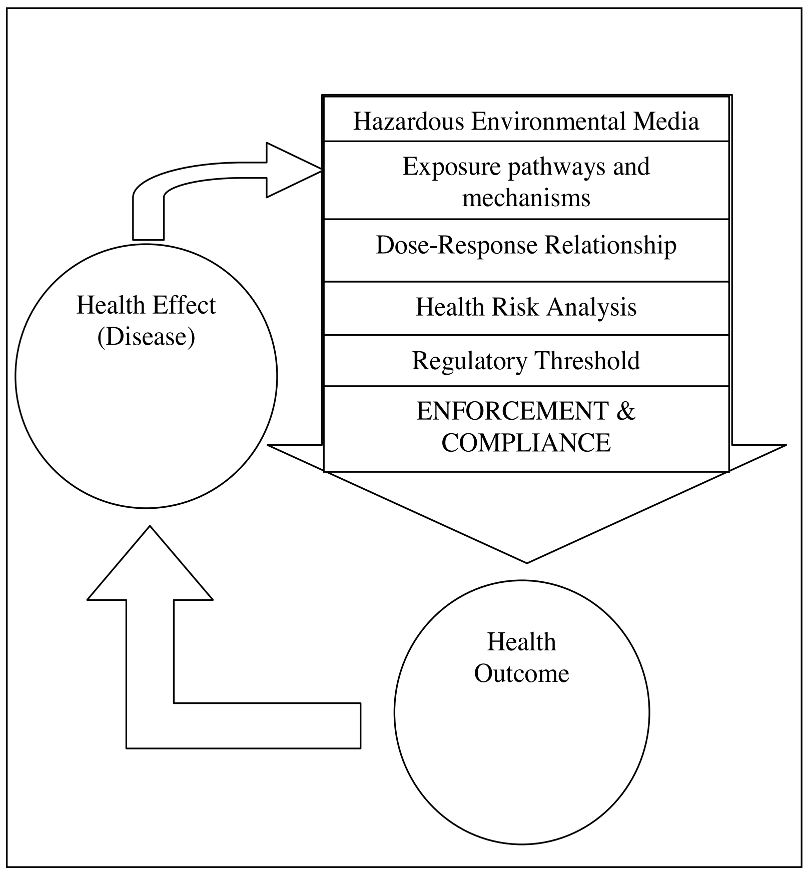


Figure 5.1: Illustrates health and environmental policy processes.

exposure (See Figure 5.1). This process constitutes a complex feedback loop, in which scientific and political developments can act as inputs at any stage in the process, ultimately shaping environmental regulation efforts, health outcomes, and disease definitions. Tracing exposure pathways, calculating dose-response relationships, setting standards for allowable media-levels and guidelines for acceptable exposures involving a multi-source, multi- media contaminant in a complex environment presents a difficult challenge for environmental regulators. Theoretically, the regulatory process should improve with the advancement of environmental science, medical science, and epidemiology, as well as a result of improved technologies for measuring lead in various media and cleaner processing mechanisms. Although, as discussed in Chapter Two, lead is one of the longest recognized and most extensively researched environmental toxins, the complexity of its impacts on human health, particularly neurological development, and its multi- media, multi-pathway characteristics continue to fuel controversy over the ways that it is understood and regulated as an environmental contaminant. The next section presents a historical overview of scientific and regulatory controversies related to lead toxicity and exposure.

A History of Herculaneum, Missouri

The town of Herculaneum emerged rapidly in the early 1800s. The area was first settled in 1799 by homesteader, John Conner. A handful of other settlers and groups of Methodist and Baptist missionaries followed closely behind. In the early 1800s lead prospectors Moses Austin and Samuel Hammond began purchasing land from the early settlers at the intersection of Joachim Creek and the Mississippi River, which they organized into plots for the purpose of establishing a convenient port for processing and shipping products from the nearby lead mines. Austin named the settlement Herculaneum since "the fumes from his own lead smelters reminded him of the smoke that once arose from Vesuvius and because to his imaginative eye the edges of the limestone strata along the Mississippi resembled the seats of the great amphitheatre so recently discovered in Italy (sic)" (Gardner, 1980, p. 107). In the fall of 1815,120 lots in the settlement were sold at auction to formally establish Herculaneum as a town. By 1818 the area served as home to "twenty grist mills and twenty-five distilleries.... It also boasted four stores, a school, the post office, a jail, and from thirty to forty houses" (Gardner, 1980, p. 107). Around this time the area was also home to a hemp rope factory and three lead shot towers.

The local region bordering the Mississippi River was officially designated Jefferson County in 1819 and Herculaneum was named the county seat, a designation it subsequently lost in 1832 when the county seat was relocated to a more central location. Articles for incorporating the town of Herculaneum were filed in the early 1820s, but were never acted upon as the re-designation of the county seat marked the beginning of a period of decline in the area. In 1876 a depiction of the area formerly occupied by Herculaneum in a county atlas showed only one remaining building in the original Herculaneum location (Gardner, 1980, p. 108).

Reemergence – A Company Town (1860s -1950s)

In 1864 New York City-based St. Joseph Lead Company was founded with a mission to tap the rich resources of the lead mines in the Missouri Lead Belt. Recognizing the valuable commodity of Herculaneum's location both on the Mississippi river and proximal to many mines, they procured 540 acres spanning a mile of the river's edge. In 1892 the company, referred to locally as 'St. Joe,' established an advanced lead processing facility on this property that included a refinery, blast furnaces, and facilities for converting energy from coal into both steam and electric power. The establishment of the lead plant in this location has been linked directly to the reemergence of Herculaneum as a thriving company town:

> As the St. Joe Lead Company prospered in the late 1800s and early 1900s, the town of Herculaneum prospered as well. The town truly became a “Company Town”. The paternalistic company basically owned the town and provided every need for the residents free of charge. The towering 350 foot smokestack of the company’s lead smelter was not only a symbol of jobs for the town’s residents, but also meant that homes, lights, streets, sewers and fire protection would be provided free of charge. (City of Herculaneum, 2006, p. 1)

At this time the only civic function left to the town was to support local education, which was done by subscription according to the number of students in attendance. All other infrastructure was owned, controlled, and maintained by the lead company, including homes, local commerce, sewage, water, electrical, and street lighting services.

Transition Toward Independence (1960s – 1980s)

Close ties between St. Joe and the town of Herculaneum extended throughout the late 1800s and early 1900s until the Great Depression, which proved devastating to the local economy. Despite company efforts to keep as many of its employees working as possible, many local workers were laid off as the declining economy forced reduced operations at the lead plant. Ultimately all enterprise in the area was closed down with the exception of reduced operations at the lead smelter and activities of the Works Progress Administration.

As business picked back up in the years following the depression St. Joe gradually sought to reduce its financial obligations to Herculaneum, selling or closing all company stores by 1945 and selling most of the company-owned houses to employees and other residents. A grocery store owner and long-time resident reflected on downtown Herculaneum around the mid-1900s as follows, “In those days, there were all sorts of businesses downtown...we had three groceries, a shoe shop, clothing store, furniture store, hardware store, barber shop, tavern and many others. Now they’re all closed” (City of Herculaneum, 2006, p. 4). Reductions of St. Joe owned and managed business in the town created commercial voids in the city of Herculaneum, forcing residents to frequent retailers and other businesses in nearby towns. Although the company gradually reduced its ownership of commerce in the town, St. Joe did retain responsibility for much of the infrastructure of Herculaneum through the early 1970s when a civic group, Citizens for the Improvement of Herculaneum, moved to act on the Herculaneum incorporation documents from the 1820s. The town was officially incorporated as a fourth class city in 1972, and city government began functioning with the election of “a Board of Aldermen, a City Marshall, a City Clerk and a Municipal Judge” (Selbert, 1998, p. 1). The late 1970s construction of Interstate 55 at the western edge of Herculaneum prompted growth and expansion away from the historic downtown and the lead plant. The city continued to grow increasingly independent from Doe Run Co. throughout the 1970s and 1980s; however, many plant workers continued to reside there, and locals generally treated the company as a valuable contributor to the local economy and community. One writer described Herculaneum’s transition through the 20th century as the town began to openly recognize challenges related to their close association to the lead company:

[Herculaneum was] a gritty town of 2,300 on the Mississippi River about 30 miles south of St. Louis. In such a company town, the plant manager was more important than the mayor. When someone needed a screen door fixed, a company carpenter did it. Before they had a water system, townspeople took baths at the plant's change room. [The Mayor]... said particulate matter from the plant as recently as 25 years ago [1970] was so heavy that it blocked the sun at times – so people couldn't see across the street or what was happening on the field at a high school football game. Residents and employees of the smelter had been unwilling to criticize it openly. (City of Herculaneum, 2006, p. 5)

The mayor's comments demonstrate the growing tensions between the community's close ties to the lead industry and its awareness and concern over the plant's pollution at the end of the 20th century.

As discussed in Chapter Two, in the 1970s environmental regulation became a prominent national policy issue. Soon after the lead NAAQS was first set in 1978, EPA began monitoring air lead levels in the area due to the smelter's designation as a known source of pollution. Several Herculaneum monitoring stations consistently reported noncompliant values throughout the late 1970s and 1980s; however, since the company participated in the development of SIPs for attempting to improve regional air lead pollution, they were generally not cited (Malone, 1995, p. 1C). The lead company reported compliance with the NAAQS for lead in the first quarter of 1989, and for most of 1992 based on the average of the quarterly values of the seven operating air monitors in the area. The EPA interpreted noncompliance in terms of the average of the quarterly (three month) measurements at any area monitoring station producing a value above 1.5ug/dL. In both of these time periods, however, at least one monitor registered average quarterly values above the NAAQS, leading the EPA and the Missouri Department of Natural Resources (MDNR) to counter that the area remained noncompliant (Get the

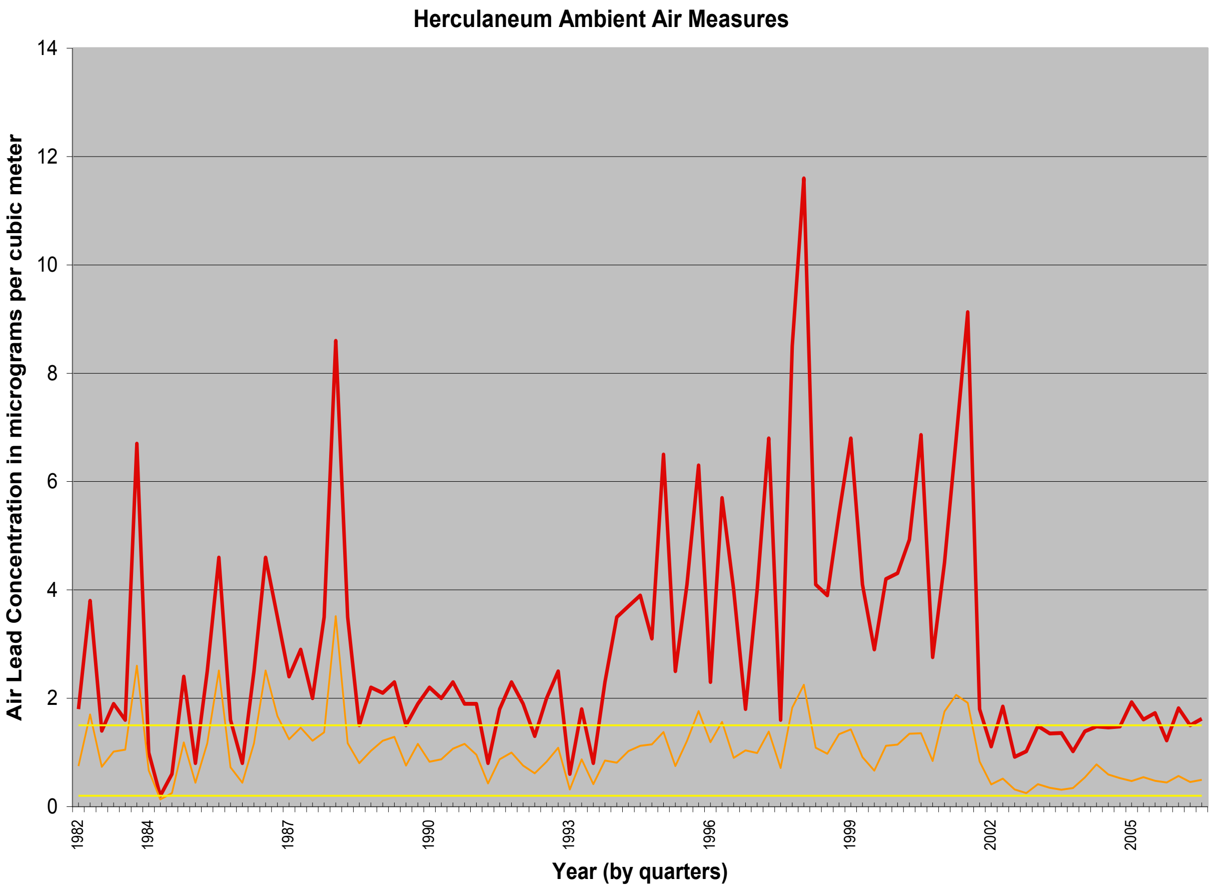


Figure 5.2: Graph of Ambient Air Values in Herculaneum between 1982 and 2007. Data courtesy of Missouri Department of Natural Resources – Air Pollution Control Program, via Herculaneum Community Advisory Group.

Lead Out, 2007). The maximum and average air lead readings in the area since 1982 according to the MDNR are plotted in Figure 5.2, demonstrating the differences between the two readings of the NAAQS lead standard. The orange line represents the average across the eight area lead monitors, the value the lead company reported as compliant. The red line represents the maximum recorded value from those eight monitors, the value that the EPA considers in determining compliance. This chart shows the very important differences in the two interpretations for determining compliance with pre-2008 NAAQS (the top yellow line) in the area. The chart also demonstrates the impact a lowered lead standard had on the company's compliance as the lower yellow line represents the new lead NAAQS established in the fall of 2008.

In 1986 the corporation in charge of the lead smelter in Herculaneum, St. Joseph Lead Co., was purchased by Doe Run Co. Corporation (hereafter Doe Run Co.) based in St. Louis. Doe Run Co. was quickly acquired by partnership between several entities, ownership of which was eventually transferred entirely to Fluor Corp. In 1990 Fluor Corp sold Doe Run Co. to the Renco group Inc., who maintain ownership. The headquarters of the Doe Run Co. subsidiary are still located in St. Louis with approximately 360 employees, of which approximately 70-90 contractors work at the Herculaneum lead plant. Ownership of the local lead plant by a large and increasingly unfamiliar conglomerate further reduced the Herculaneum community's close ties and loyalty to the plant and the lead industry.

Severed Alliances – Strike (1990s)

In July of 1992, over 300 Teamsters walked out over failed contract negotiations with Doe Run officials. A significant point of contention concerned seniority structures and potential wage reductions (Ahmed, 1991). The strike ended two and a half years after it began when Doe Run severed the employment of strikers following the approval of a vote by replacement workers to dissolve the company's labor relationship with the Teamsters Union. Following the strike, less than 20 plant workers resided in Herculaneum and loyalty between residents and the company largely disintegrated. The community entered the twentieth century with an ambivalent attitude toward its largest economic entity. While the company continued to provide the majority of the town's revenue through property taxes and donations, it was perceived by many to have betrayed unionized employees, and in turn a large portion of the local community.

Up until the time of the strike, the attitudes of Herculaneum residents were publicly unified in support of the lead industry and its local operations. The occurrence of the strike and the perceived mistreatment of local Doe Run employees by the large and distant company opened the door for public criticism and opposition to the company and its local activities. Moving forward from the strike, community members took up both sides of the issues. Some residents continued to defend and supported the company and its local activities while others became vocal critics of its record in terms of safety, pollution, and community participation.

The Modern-Day Herculaneum Context

The landscape of modern-day Herculaneum continues to be dominated by the 200-foot stack of the Doe Run Co.'s lead smelter, however, the close associations between the company and the community have become increasingly strained. The following sections describe various institutions in, and aspects of modern-day Herculaneum for the purpose of contextualizing the lead contamination and management events discussed in later sections.

The Doe Run Company

Today Doe Run is "a privately held natural resources company and the largest integrated lead producer in the Western Hemisphere and the third largest total lead producer in the world" (Flannery, 1992). The company is highly profitable, having achieved one billion dollars in sales in 2005 and 1.6 billion in 2006. Doe Run has earned many safety awards throughout its history and spends around sixteen million dollars each year "in keeping with the company's mission to consistently reduce environmental emissions and impact on the natural environment," according to the company website (The Renco Group Inc.:The Doe Run Resources Corporation, 2005).

Doe Run's Herculaneum operations constitute the only remaining functional primary lead smelter in the United States. Doe Run has continually made improvements to the smelter facilities. For instance, in 2007 the company spent $3.5 million to purchase a new furnace, and invested in improving pollution containment, increasing efficiency of lead production, and heightening cleanliness in transportation procedures (The Renco Group Inc.:The Doe Run Resources Corporation, 2005).

Population, Housing, and Demographics

The physical boundaries and total population of Herculaneum have both expanded in recent decades as non-assigned areas near I-55 were incorporated into the city limits (Neighbors: The Doe Run Company's Report to Our Communities, 2007). The total population of the city of Herculaneum declined slightly between 1980 and 1990 from 2,293 to 2,263. The town then grew 24% to a total population of 2,805 in 2000 (U.S. Census Bureau, 2000). Its growth is projected to have progressed at a gradually slowing rate to a peak of 3,183 in 2003 and then declined slightly to 3,172 in 2005. In perspective, Herculaneum's growth rate of 24.0% in the 1990s was more rapid than Jefferson County's growth rate of 15.6%, which was higher than the national average of 13.1% (U.S. Census Bureau, 2000).

In the year 2000 the decennial census provided a snapshot of the demographic makeup of Herculaneum. The town of Herculaneum was predominantly white (96.6%) with a small percentage of black residents (2.6%) and less than 20 members of any other racial group. Of the 2,805 residents, 22.6% were under the age of 18 years, 21.8% were 65 years or older, and 55.6% were between the ages of 18 and 65, with a median age of 40.5 years (Business Information Services LLC., 2007).

Herculaneum has been a town dominated by family households, with 736 (71.6%) of the 1,028 households being occupied by families in 2000, 362 (35.2%) of which were home to children under 18 years. The average household size was 2.52 and the average family size was 2.99. Of the 1,078 total housing units, only 50 were vacant as of the 2000 census, and 77.8% of the housing stock was owner occupied. The housing stock varies greatly in age, with 34.9% built since 1980, 19.7% between 1960 and 1979, 22.7% between 1940 and 1959, and 22.6% before 1939. In 2000, 99.7% of residents were native to the state of Missouri. Between 1995 and 2000 41.4% of the population had moved to a different home; 26.4% exchanged homes in Jefferson County (U.S. Census Bureau, 2000).

Local Economy

Economically, Herculaneum faces several challenges entering the new millennium, as demonstrated by its population’s levels of unemployment, median income, and employment rates, as reported by the U.S. Census Bureau. In 2000, 58.8% of the population aged over 16 participated in the labor force, with 10.9% of the civilian labor force unemployed. The mean home to work travel time was 29.5 minutes, which indicates that most residents do not work in Herculaneum. Herculaneum’s median household income of $40,365 in 2000 was 14.8% percent less than that of Jefferson County ($46, 338). Despite the areas relatively low median family income within Jefferson county only 152 individuals (5.7%) and 18 families (2.4%) were assigned poverty status in 2000. The median household income across Jefferson County was $46,338, and the median family income $51,787, with 6.8% of individuals and 4.9% of families below the poverty level in 2000 (Business Information Services LLC., 2007).

More recently Herculaneum has been described as undergoing a period of transition. In the interest of promoting economic growth the city has proposed programs for (1) distributing grants as incentive for economic development that expand high wage employment opportunities and increase the value of local properties, (2) extending infrastructure to newly developed areas, (3) assisting entrepreneurs in attaining skills and success, and (4) encouraging existing businesses to maintain Herculaneum locations (U.S. Census Bureau, 2000). Doe Run has contributed its support to the town's growth plans; it has contributed large sums of money to various civic and infrastructure projects. In addition, since these programs would be supported by tax revenue, it is important to note that Doe Run contributes a large share of the city's tax revenue in property taxes.

Company – Community Relations

Discordant rumblings began to disturb the mostly congenial atmosphere in industry-community relations in Herculaneum following the strike in the mid 1990s. Two news making events signaled changes in local perceptions of Doe Run. The first occurred in 1988 when the Occupational Safety and Health Administration (OSHA) fined Doe Run $2.78 million for 331 health and safety violations involving regulation and management of lead exposures to plant workers (City of Herculaneum, 2006). The second involved a series of lawsuits filed by Herculaneum residents in the late 1990s against Doe Run. They held the company responsible for reductions in property values, and harms to local residents due to environmental lead contamination. Doe Run's civic and fiscal contributions add complexity in local reactions to the company's persistent pollution problems as evidenced by the following description of public and industry reactions to the release of a SIP to attain NAAQS compliance in the early 1990s:

Doe Run Co. is getting a "third shot" at cutting lead emissions at its smelter in Herculaneum to meet federal clean air rules. But city officials complain that the plan approved by the state is not strict enough. "This thing – to put it in layman's terms – stinks," said... an attorney for the city. "We understand that Doe Run is not an evil thing," [he] said. "But we also understand there are children in the city with lead in their blood." The Department of Natural Resources presented the plan Thursday for the approval of the Missouri Air Conservation Commission. [The] Commissioner... noted the jobs and taxes Doe Run brings to Herculaneum and asked [the attorney]: "Do you know what it's going to cost Doe Run – and your city – if we get too tough on them?" [The] Herculaneum Mayor..., who was seated in the back of the meeting at the Doubletree Hotel Riverport, shouted: "What kind of price can you put on people's health?" [He] said later that Doe Run pays $120,000 in taxes annually to the city, and that only a few more than a dozen of the city's 2,300 residents work at the smelter... (Eardley, 1988)

Regulatory agencies were reluctant to address health and environmental concerns if action exacted too high a financial cost to the company, and ultimately to the community. This type of conflict is typical in discussions related to environmental regulation, as protection of health and the environment are constantly balanced with the need for profitability and commerce. Both concerns are important for local communities. Emerging findings about the extent of lead contamination in Herculaneum would soon shift the priorities in this balancing act in favor of public health, as will be demonstrated in the following sections. In the following sections I will build on both the historical and modern contexts discussed above to outline central events in the story of lead contamination and its management since 1999.

Regulating Lead in Herculaneum (1999-present)

Public meetings were held in Herculaneum beginning around 1999 to keep the community abreast of developments in lead contamination and management. A group of local citizens attended these meetings regularly and voiced concerns, particularly around issues of trucks hauling lead concentrates through local neighborhoods and spilling it onto roads and yards, but felt extremely ineffective in convincing regulators to alter existing enforcement strategies. Rather EPA, MDNR, Agency for Toxic Substances and Disease Registry (ATSDR) and Missouri Department of Health and Senior Services (MDHSS) representatives were focused on reassuring the community of its continued safety and the role of the different regulatory agencies in protecting public health. Behind the scenes in the late 1990s, however, concerns over management of lead contamination in the area were mounting within regulatory agencies, particularly at the state level. One MDNR representative explained several processes that contributed to this shift:

Nick Peterson[14] - [We] had done a lot of residential yard cleanups around the state based on lead mining and smelting, and Herculaneum was, kind of, sticking out as something that we hadn't looked at... and we knew that Doe Run was, kind of, doing things

[14] Names of individuals have been replaced with pseudonyms in order to protect the confidentiality of the research participants.

voluntarily, and I think we just started looking at it more closely. Oh, and there was another thing. We received... some data from US Fish and Wildlife Service that had a lot of bird toxicity data. Some studies done during the floods. A guy... motored right up under the slag pile and took a bunch of samples, and collected birds and fish, and it was pretty hot with lead, and I think that crossed our desk at, kind of, the same time. So we put together several things, decided to start negotiating, talking with the company about it. (Interview, 2/19/2009)

State regulatory agencies cooperating with the EPA began negotiating an Administrative Order on Consent (2001) with Doe Run toward reduction and remediation of lead contamination in the area. Administrative orders of consent are voluntary, but binding and enforceable legal agreements between EPA, sometimes other agencies, and a party responsible for violating one of the laws or executive orders the agencies enforce. This particular Administrative Order of Consent (2001) was entered into under provisions of the Resource Conservation and Recovery Act (RCRA) and of the Comprehensive Environmental Response Conservation and Liability Act (CERCLA, more commonly known as 'Superfund'). It primarily demanded that Doe Run quantify lead pollution and replace contaminated soil throughout the Herculaneum community.

Community reaction to regulatory change. Following negotiation of the terms of the AOC between Doe Run and EPA and MDNR, the order was presented to the Herculaneum community for comment. State regulatory representative, Nick Peterson, also described the community's reaction to this proposal:

From my perspective we were, kind of, proud of it because it was way more comprehensive than anything we'd done before, but the community was not impressed.

(Laughter)..., it was like either we weren't doing enough, or 'what are you doing in our town stirring things up?' (Interview, 2/19/2009)

Community members expressed anger and frustration that they had been uninformed of existing exposure threats, and that their concerns about such possibilities had seemingly gone unheeded. At the same time, others feared and resented the implications of heightened regulatory activity in the area for the local reputation and economy, particularly with regard to the central economic entity, Doe Run. Public comments about lead management in Herculaneum contributed to revisions to the AOC, enhancing clean up, health screening, and agency oversight of the various programs. The particular health concerns being considered as part of the health impact analyses were also adjusted to reflect local comments. Ultimately this AOC was signed and went into effect in May 2001.

A pivotal finding. Public meetings continued to occur regularly in Herculaneum after the AOC went into effect. Regulatory representatives reported progress in implementing the plans in the AOC, while residents contended that the AOC was insufficient to address their concerns. At one of these meetings, a particularly vocal resident approached a state regulatory official, asking that he sample street dust in a particular part of town. The resident, Ethan Lewis, escorted the state regulator to a public street near Doe Run property on August 21, 2001, where he pointed out glittering dust reflecting their truck headlights. The sample was taken and it measured approximately 300,000 parts per million (ppm) lead, or one third lead, 750 times the 400 ppm federal limit (Uhlenbrock, 1993). The influence that this sample had on environmental regulation in Herculaneum can not be overstated. One concerned resident, Isabelle Robinson, described the importance of this discovery:

Until the 300,000 parts per million lead concentration was found on the streets, that changed the ballgame for us because they hadn't addressed it in the AOC. So after that was done then I think the agencies–I don't know if they'd seen an opportunity or we had just shamed them into the fact that they hadn't looked at everything, and they should be looking at everything. (Interview, 10/2008)

Regulatory agents also considered this discovery pivotal because it provided them with justification to initiate a chain of regulatory actions that are considered appropriate only under extremely hazardous circumstances. After conducting additional soil and dust sampling throughout the town, MDNR reported its finding of unprecedented lead levels on Herculaneum streets to the EPA Region Seven office. They then approached the Missouri Department of Health and Senior Services (MDHSS), requesting a statement of the potential health impacts of such high lead levels. The director of the MDHSS complied, sending the MDNR director a letter stating, "Due to the recent discovery of extremely elevated levels of lead contamination on some streets, yards, and play areas in Herculaneum, I believe risks to the public's health, especially women and children through age six, are clear and present and are an *imminent and substantial endangerment* [emphasis added]." (Rowden, 2001)

Regulatory Firestorm

By describing the situation in Herculaneum as an "imminent and substantial endangerment," the MDHSS dictated further action on the part of the MDNR; "We actually have the authority to declare an imminent and substantial health risk, and once we do that, DNR has to act. There is no choice other than act" (Natalie Downs, MDHSS, Interview 4/2009).

Legal action. The MDNR proceeded to issue an Abatement Cease and Desist Order under Missouri's Hazardous Waste Management Law, Missouri's Air Conservation Law, and Missouri's Clean Water Law, demanding that Doe Run meet the requirements outlined in Figure 5.3. Failure to meet these conditions would result in severe fines. Doe Run appealed this order to the Governor's office and to the Missouri - Hazardous Waste, Clean Water, and Air Conservation – Commissions. In relatively short order, the punitive financial provisions of the order were removed. However, pending appeals pressured the company to cooperate with the MDNR in clean

The 2002 settlement agreement between Doe Run and MDNR ordered Doe Run to:

- immediately cease all activities that cause fugitive dust to leave the facility;
- immediately upgrade their truck washing facility to include all vehicles leaving contaminated areas of the plant;
- complete all road and facility cleaning within seven days;
- ensure that all water from street and vehicle washing is contained and treated;
- repave any remaining contaminated roads within 60 days of the MoDNR's notice to proceed;
- submit a detailed plan for discontinuing the use of open-backed trucks, either tarped or untarped, for hauling lead concentrate within 10 days;
- cease and desist the use of open-backed trucks for hauling lead concentrate within 45 days'
- complete all residential yard characterization and remediation outlined by EPA;
- fund MoDNR or EPA to characterize and cleanup indoor residential dust;
- cease and desist transport of lead concentrate along the streets of Herculaneum if any of the deadlines required in the order are not met.

Figure 5.3: Conditions of 2002 settlement agreement between Doe Run Co. and Missouri Department of Natural Resources. Adapted from Missouri Department of Natural Resources, 2009. *Herculaneum lead contamination: Overview of actions*. Retrieved August 6, 2009 from http://www.dnr.mo.gov/env/herc/herc.htm.

up and management of lead in soil and dust locally, as well as participate in purchasing homes in the most effected areas.

Clean up. The excessive lead levels discovered in 2001 brought about unprecedented remediation efforts in the Herculaneum area. In cooperation with the MDNR, Doe Run first moved families out of the neighborhood and attempted to professionally remove indoor lead dust and replace yard soil. Treated yards were showing signs of recontamination within several months. Regular use of vacuum street sweepers, warning signs, and the distribution of HEPA-filtered vacuum cleaners throughout the effected neighborhoods constituted further attempts to reduce public exposure to indoor and outdoor lead dust in the area ("The Herculaneum Master Plan," 2006, Depth of the lead issue). Emergency measures were taken to reduce children's exposure to extreme levels of lead in soil, including the posting of signs warning "Caution! High-Lead Levels on Streets: Do not allow children to play in the street or on curbs, have children play on solid grass cover or play at Crystal City park, remove shoes before entering your home, wash hands and face before eating drinking and sleeping" (See Figure 5.4).

Figure 5.4: Sign Posted in Herculaneum in 2001. Sign states Caution! High-Lead Levels on Streets. Do not allow children to play in the streets or on curbs. Have children play on solid grass cover or play at Crystal City park. Remove shoes before entering your home. Wash hands and face before eating, drinking and sleeping. Produced by Missouri Department of Health and Senior Services. *Pilot Project – Herculaneum: Environmental Public Health Tracking*. Retrieved June 29, 2010 from www.dhss.mo.gov/EPHT/Herc.html.

A series of studies were conducted in Herculaneum under the leadership of the EPA and MDNR following the declaration of "imminent and substantial endangerment." EPA performed the necessary analyses to quantify Herculaneum's contamination status under the Superfund program, finding that the area would have ranked at the top of the National Priorities List (NPL) due to evidence of health impacts to local residents (Interview, MDHSS, 4/4/09). Superfund legislation is written to apply to abandoned properties, however, so the area was never assigned NPL status. If at any time Doe Run had failed to cooperate in clean up efforts the package of materials to list the area would have been filed and Herculaneum would have officially become a Superfund site. This knowledge allowed EPA to bring some of the resources from Superfund programs to bear on the environmental challenges in Herculaneum, even though Herculaneum was never formally listed as a Superfund site. In addition to cleaning up existing pollution, a Community Advisory Group (CAG) was created under the auspices of a program supporting community involvement in resolving environmental threats in Superfund sites:

A Superfund Community Advisory Group (CAG) is made up of members of the community and is designed to serve as the focal point for the exchange of information among the local community and EPA, the State regulatory agency, and other pertinent Federal agencies involved in cleanup of the Superfund site. (Dempsey, 2001)

CAG participants worried about the health and environmental effects of lead approached environmental activist groups including the Missouri Coalition for the Environment (MCE), the Sierra Club, and the Washington University Interdisciplinary Environmental Clinic (IEC) for technical and legal support in understanding and defending their health interests. The involvement of environmental activists provided for more sophisticated argumentation in CAG meetings. The CAG was chaired by community members, who were closely allied with the environmental activist groups, and meetings became forums for these residents to confront regulatory representatives.

Risk assessment. The MDHSS and ASTDR cooperated with EPA and MDNR to initiate several health consultations. The first consultation, completed in February 2002 found that 28% of children in Herculaneum had BLLs over the 10µg/dL threshold. Further examination of this data showed that BLLs increased with residential proximity to the smelter, with 56% of children within 1⁄4 mile of the smelter having elevated BLLs (U.S. Environmental Protection Agency, Superfund community envolvement: Community Advisory Group, 2007). Figure 5.5 provides the map that MDHSS released in association with this report demonstrating increasing BLLs in children with increasing proximity to the lead smelter. In April 2002 DHSS released its second health consultation, reporting that the lead clean up and contamination management plans should reduce lead exposures in the community; however, the report expressed concern over management of lead in indoor dust (Missouri Department of Health and Senior Services & Agency for Toxic Substances and Disease Registry, 2001). The Dunklin R-5 Schools Health Consultation released in June was a direct response to community-members' concerns over the potential exposure from attending or working in area schools and established cleaning protocols for protecting the health of the school population

(Missouri Department of Health and Senior Services & Agency for Toxic Substances and Disease Registry, *Health Consultation: Determination if remedial actions are protective of public health - Herculaneum lead smelter site Herculaneum, Jefferson County,*

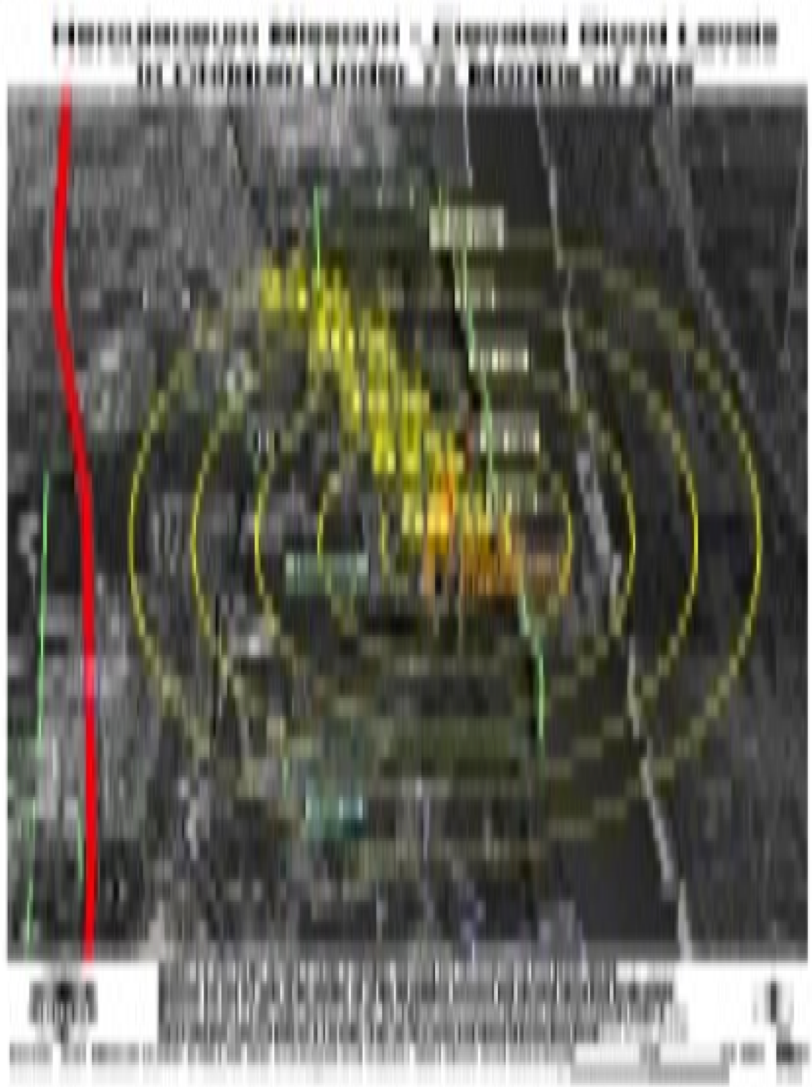


Figure 5.5: Children's 2001 Blood Lead Levels according to distance from lead smelter. Produced by Missouri Department of Health and Senior Services (2001). *Herculaneum Missouri – Elevated Blood Lead Levels in Children under 72 Months of Age.* Retrieved August 6, 2009 from http://www.dhss.mo.gov/hazsubstancesites/herc2001map.pdf

Missouri, 2002). A public health review of interior sampling methods was released in August 2002, which made specific recommendations for lead abatement in the interiors of residences, and for further testing of these locations for recontamination (MDHSS & Agency for Toxic Substances and Disease Registry (ATSDR), 2002c). Based on resident complaints two additional analyses were conducted during this period examining the possible health impacts from smelter emissions of Sulfur Dioxide, and of Arsenic and Cadmium (Missouri Department of Health and Senior Services & Agency for Toxic Substances and Disease Registry, *Health Consutation: Public health implications from attending or working at Herculaneum schools - Herculaneum Lead Smelter Site Herculaneum, Jefferson County, Missouri*, 2002). A final exposure investigation tracked the specific sources of exposure of two local families with children measuring BLLs at or above 15 µg/dL. The study identified lead smelter emissions as a significant contributor to lead in house dust and the likely source of exposure for children in at least one of the households (Missouri Department of Health and Senior Services & Agency for Toxic Substances and Disease Registry, *Health Consultation: Public health evaluation of Arsenic and Cadmium levels in air and residential soils - Herculaneum Lead Smelter Site, Herculaneum, Jefferson County, Missouri*, 2002, *Health consultation: Sulfer Dioxide monitors in Herculaneum - Herculaneum Lead Smelter Site, Jefferson County, Missouri*, 2002). The MDNR also conducted data collection in the area as it continued to monitor air lead concentrations in accordance with the lead NAAQS, and investigated pollution releases into the Mississippi River.

Settlement Agreement and Voluntary Purchase Plan. In April, 2002 Doe Run and MDNR reached a settlement on the Abatement, Cease, and Desist order. This agreement included specifications for materials handling and transportation, continued compliance with the 2001 AOC, a plan for rerouting concentrate hauling outside of residential areas, and, most dramatically, a large scale Voluntary Purchase Plan in which Doe Run agreed to purchase 160 homes surrounding the lead smelter (see Figure 5.6).

Homes not purchased in the buy-out, but continuing to produce high scores on lead monitoring tests were provided repeated soil replacement and indoor cleaning and abatement services. In 2008 Doe Run constructed a fence to isolate the 'contamination zone' and reduce its accountability for air lead levels in the areas surrounding the plant (Agency for Toxic Substances and Disease Registry, 2005).[15]

Figure 5.6: Map of Herculaneum Voluntary Property Purchase Plan Area courtesy of Missouri Department of Natural Resources – Air Quality Program (2002). *Doe Run Herculaneum Smelter Buy Out Zone*. Retrieved August 6, 2009 from http://www.dnr.mo.gov/enf/herc/herc_buyoutmap.pdf.

The Voluntary Purchase Plan largely changed the landscape of

---

[15] The NAAQS regulate ambient air, or air in the public domain. By extending their fence line, Doe Run Co. eliminated public access to the area near the smelter, thereby reducing their accountability for air levels in close proximity to the operating facility.

Herculaneum, effectively emptying the historical core of the town. As this plan moved forward, some residents became concerned about the long-term implications of lead remediation and management for their community. The EPA responded by hiring a consultant to work with this subgroup of the Community Advisory Group (CAG). In conjunction with the EPA, CAG worked on plans for the future use of the buy-out zone. This group of citizens became very focused on community preservation and future growth. Eventually, a new civic organization emerged - Herculaneum Today & Tomorrow (HT&T) - out of community preservationist commitments. The efforts of this group in planning for the future use of the buy-out zone evolved and eventually led to the production of the Herculaneum Master Plan. This relatively new group tends to view the CAG group as alarmist and obsessive about lead concerns, which they view as largely in the past. Remaining CAG members, on the other hand, view HT&T as more concerned about property values and community reputation than about the real and eminent threats that they believe are perpetually present in Herculaneum as long as the lead smelter continues to function.

The CAG and HT&T have continued to function separately, and generally in opposition. CAG works closely with regulatory representatives and concerns itself with the protection of public health in light of the lead situation as well as informing the community of important developments and concerns. The HT&T organization, with its focus on community sustainability, works with city government to attract residents and businesses to the area. Although their purposes are not in direct opposition, HT&T prefers to consider lead contamination problems resolved, and any further issues to be the purview of regulatory agencies. The CAG considers the lead concerns to be ongoing, and expects the community to play a vital 'watchdog' role in continuing regulatory enforcement and fastidiously defending public health protection. One issue that further divided these two groups was the efforts of some CAG members to influence EPA to tighten lead regulation throughout the country. These two groups remain central in local lead activism, and will be discussed in greater detail in Chapter Seven. In the following section I will focus on the ways that lessons learned through the local lead controversy were extended and influential in shaping national air lead policy.

The Impact of the Herculaneum Context on National Lead Regulation: The National Ambient Air Quality Standards (NAAQS) Revisited

In 2002 Herculaneum met the lead NAAQS for the first time, and continued to meet it in most quarters for the next several years. The CAG leadership remained unsatisfied that the company's borderline compliance with this standard was sufficient to prevent further consequential lead exposures in the area. In May 2004, Herculaneum residents and the Missouri Coalition for the Environment, represented by the Washington University Interdisciplinary Environmental Clinic, filed a lawsuit demanding that the EPA review the NAAQS for lead according to the legislative requirement that such standards be regularly reexamined (*Missouri Coalition for the Environment et al, v. United States EPA,* 2005*).* In September 2005, the U.S. District Court in eastern Missouri ruled that the EPA had not met requirements for regular review of this standard and set a timeline for a thorough review of NAAQS to be completed by September 2008. As part of the review process the EPA voiced consideration of a plan initiated by the lead industry in 2006 to revoke all standards for regulating lead in air due to prominent overall reductions in air lead levels following removal of lead from paint and gasoline (Doe Run builds fence around smelter, 2008). The final rule released in November 2008 surprised almost everyone by detailing a 90% reduction in the lead NAAQS. The new standard of $0.15 \mu g/m^3$ is not to be exceeded by any monitor reading averaged over a rolling three month period (Lost in the fine print, 2008). This standard requires a large-scale expansion of the air lead monitoring network throughout the United States. The EPA required that states have monitoring plans in place by January 2011. In addition, designated non-compliant areas with established monitoring are charged to develop SIPs to bring them into compliance by July 2010. These areas are then expected to attain the standard by January 2016, with newly monitored areas to follow around January 2017.

The implications of the new lead NAAQS are extensive both throughout the country and for Herculaneum specifically. EPA expects over 200 monitoring sites to be created or relocated nationwide due to the monitoring requirements of the new standard. It is expect that additional monitoring will reveal many areas that are out of compliance with the new lead NAAQS and efforts to reduce lead emissions in these areas would have to be drastic to meet the 2017 deadline. In Herculaneum, the existing monitoring network is currently being reconsidered. Doe Run is examining its process to isolate sources of emissions where it can make adjustments, but it is not confident that lead can continue to be smelted at the Herculaneum facility when the new standard goes into effect. A Doe Run spokesman described the difficulty of managing the ever-smaller concentrations of emissions from the plant:

As I mentioned, we didn't have any more big bites of the apple to take, we were just nibbling around the core to get this last SIP [Air Pollution Control Program (2007)].... You know 1.5 is the limit. 1.2 is what we got at Broad Street and .2 is what we got at

Sherman.... So I went [to] our lab. I said,"I want you to give me 1 milligram of lead concentrate; I want to see what it looks like." They said, "We can't do it but we can give you 2 milligrams for you." And it came back and I'm going to put this pencil on here and turn it and this dot right there that's about 2 milligrams. The air lead standard is in micrograms, which you have to divide a milligram by 1000. So this dot right here you have to divide by 1000 to get 2 micrograms right there and our limit is 1.5 micrograms to just kind of put it in perspective of what we're trying to capture on the monitors and what levels we're trying to meet in the air. And then coming soon to the area will be a new lead standard... so we'll do as we've done before; We'll strive to meet whatever standard we have. (statement at public meeting, 9/2008)

Part of the company's striving to reduce air lead emissions included a heightened investment in research and development on an alternative procedure for processing lead ore into bullion. The company is optimistic that this process will "revolutionize the industry globally, because this will be the new standard that everybody will need to hold themselves up to" (Interview, 5/09). Whether or not this process will occur in Herculaneum, and how the shift will affect the local economy remains to be seen.

In the case of the lead NAAQS environmental activists and Herculaneum residents were successful in using contemporary science to reframe the definition of health effects of lead exposure by using the community as an example of health harms occurring at existing levels. Between the 2004 lawsuit and the 2008 release of the final ruling, the EPA went through an extensive process of reconsidering health effects, dangerous media, exposure pathways, dose- response relationships, and risk analysis (U.S. Environmental Protection Agency, 2007a, 2008a, 2008b, 2008c). Based on their analyses the regulatory threshold was lowered substantially and enforcement agencies and lead producers are adjusting their practices to accommodate the new limit. As a part of the research substantiating the revised lead NAAQS, the EPA considered the potential impacts of reduced lead exposure on child development in terms of lifetime earnings. EPA calculated the benefits of avoiding IQ loss for children under age seven that would result from a revised lead NAAQS:

Because expected lifetime earnings are related to IQ, we describe benefits as an expected increase in lifetime earnings at full implementation of the NAAQS in 2016. The estimate also includes co-benefits associated with other health improvements expected to occur as a result of fine particulate matter reductions resulting from controls applied to reduce lead levels. EPA estimates the revised standards will yield benefits between \$3.8 billion to \$6.9 billion. (U.S. Environmental Protection Agency, *National Ambient Air Quality Standards for Lead: Final Rule*, 2008)

This is compared to an estimated cost of implementation of the new standard of \$150 million to \$2.8 billion. These aggregate costs and benefits fail to represent the improved quality of life for children in communities like Herculaneum, where lead exposures have been a daily reality. It also fails to represent the costs to this community where the lead industry is the central economic entity. The costs and benefits to children, families, and the community will accrue over the generations of children who grow up in an environment that is exponentially less leaded than that experienced by residents past and present.

In the chapters that follow I will revisit events overviewed here to present arguments about the meanings of regulatory approaches, and community perspectives shaping lead contamination in Herculaneum. Subsequent findings chapters will approach the basic story provided in this overview from a different angle, and focus in on different aspects of the situation. Chapter Six reviews the events described here within a careful analysis of the ways the political and physical contexts that shaped the evolving regulatory approach to local lead management were impacted. Chapter Seven then revisits these events in terms of the ways that they have shaped and been shaped by local lead perspectives.

Chapter Six: The Cycle of Environmental Policy Development

Introduction and Overview

This chapter addresses the research question, "how did regulatory programs approach lead contamination in Herculaneum?" The analysis conducted in response to this question produced a descriptive account of a cycle of policy change in Herculaneum lead management that developed after the initial release of the 2001 Administrative Order of Consent. This cycle was then extended to the late 2000s review and revision of the National Ambient Air Quality Standard (NAAQS) for lead. While this stage of analysis focused primarily on documentary data sources identified as influential in local lead regulation, the discussion also includes the influence of stakeholder perspectives due to the iterative nature of the analysis conducted in the two stages of this study. In the following sections I will first briefly situate the discussion of policy changes in Herculaneum in the interpretive policy analytical approaches of Fischer (2003) and Hajer (1995). Next I will provide a brief overview of the policy cycle identified in the first phase of this study. Then I will discuss in detail two important periods of transition in the regulatory approach to managing lead in Herculaneum: (1) from pursuing compliance with EPA's 1978 lead NAAQS to developing a more holistic perspective of lead contamination and complementary management strategy, (2) from managing local contamination according to the expanded definition to demanding a review of the 1978 NAAQS.

Examining Policy Change.

A central argument of this chapter is that the perspectives on lead contamination developed by both local citizens and regulatory representatives influenced the changes in the regulatory framework managing local lead contamination, which in turn informed the revision of the 2008 lead NAAQS. The processes through which environmental policy frameworks are adapted have been an important focus of interpretive policy work in the environmental arena. Hajer (1995) emphasized the centrality of defining a policy problem, characterizing environmental policy processes as activities of problem creation and problem resolution. Thus, circumstances that come to be seen as environmental threats often existed unexplored until the issues were framed in such a way that it became possible and necessary to examine and address them through established policy processes:

Policy-making is in fact to be analysed as the creation of problems, that is to say, policy-making can be analysed as a set of practices that are meant to process fragmented and contradictory statements to be able to create the sort of problems that institutions can handle and for which solutions can be found. Hence policies are not only devised to solve problems, problems also have to be devised to be able to create policies. (Hajer, 1995, p. 15)

Similarly, Fischer (2003) contended "policymaking is a constant discursive struggle over the definitions of problems, the boundaries of categories used to describe them, the criteria for their classification and assessment, and the meanings of ideals that guide particular actions" (p. 60). Thus, in order to initiate changes in the regulatory framework a problem like lead contamination must not only be recognized as an unaddressed environmental and health hazard, but the problem must also be understood in such a way that it is seen as both necessary and possible to address the specific issues involved using available policy tools. Accordingly, I examined changes in the lead contamination management framework in Herculaneum in terms of activities of defining local lead contamination problems and developing appropriate solutions. In this way I was able to consider the adaptations to local lead management in the context of local events and stakeholder understandings. The centrality of problem definition to environmental policy processes is directly linked to the policy cycle that emerged from the analysis conducted for this study. As long as the dominant problem definition of local lead contamination remained static and was reflected in lead management efforts, a stable condition in which little policy change occurred was maintained. When the problem of lead contamination was changed in response to either evidence that the problem definition did not appropriately reflect physical conditions or to a larger scale policy change that redefined levels of lead considered hazardous, a crisis ensued in which changes in the regulatory framework were quickly implemented to manage newly defined contamination problems. In the following section I will provide an overview of the policy cycle in Herculaneum lead management that occurred between

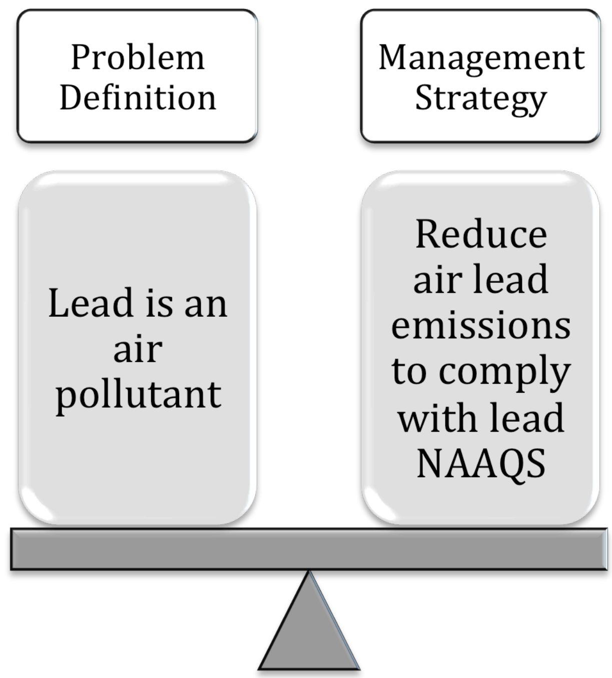


Figure 6.1. Illustrates the initial state of balance between problem definition and management strategy in the Stasis phase of the policy cycle in Herculaneum.

2000 and 2010. Following this description, I will provide a detailed discussion characterizing transitions between each phase of the policy cycle.

Overview of the Policy Cycle in Herculaneum.

In Herculaneum prior to 2001, lead emissions from the Doe Run Co. smelter were considered an air pollution issue and managed under EPA's 1978 NAAQS for lead, which was established under the authority of the 1970 Clean Air Act. I have characterized this phase of the policy cycle as "stasis" (illustrated in Figure 6.1) because the dominant problem definition was balanced by relevant management strategies, creating a stable condition in which little policy change occurred. Lead management involved regulatory negotiation and support of Doe Run Co's efforts toward compliance with the 1978 lead NAAQS. The compliance efforts were considered sufficiently effective until the late 1990s when Missouri Department of Natural Resources [MDNR] representatives began to question whether other forms of contamination might be present.

High levels of lead in street dust and yard soil discovered in 2000 provided evidence that forms of lead contamination other than air lead were present in Herculaneum. The existence of multi-media contamination forced stakeholders to reconsider their definitions and understandings of local lead problems. When concentrations of 300,000 ppm lead were identified in local street dust extensive exploration of lead contamination was initiated in the area. Eventually local lead contamination came to be understood as a multi-media environmental problem with potentially serious implications for human health. With this definition a "crisis" phase (illustrated in Figure 6.2) emerged due to widespread recognition that existing lead management strategies were inadequate to address lead contamination from multiple media sources. In response to evidence of the inadequacy of the dominant problem definition, questions were raised about various aspects of lead contamination that were as yet unaddressed by the existing regulatory framework. Management strategies were adapted to address newly acknowledged aspects of local contamination.

Figure 6.2: **Crisis**

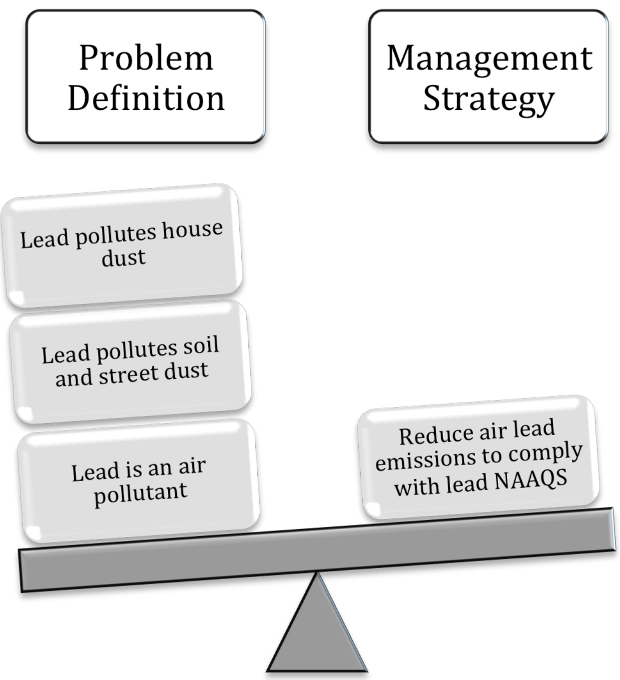


Figure 6.2. Illustrates the unbalanced state between problem definition and management strategy in the Crisis phase of the policy cycle in Herculaneum.

As strategies for managing contamination in local soil, street dust, and house dust were implemented, regulatory agency representatives began to consider the extent to which these strategies were effective in managing multi-media contamination. As regulatory representatives became satisfied that they had sufficiently explored and addressed additional aspects of local lead problems, a new stasis phase emerged (Illustrated in Figure 6.3). In the newly established stasis phase, the expanded definition of lead contamination was balanced by additional strategies for managing lead contamination. This new stasis was short-lived, however, as the new regulatory framework in Herculaneum was used to develop a case for a significant reduction of the NAAQS for lead. This reduction constituted a redefinition of problems associated with concentrations of lead in the air, and thus initiated a lead management crisis at the national level. This time the crisis in local lead management in Herculaneum was accompanied by a larger-scale crisis that required the characterization of air lead problem areas and the development of appropriate management strategies throughout the country.

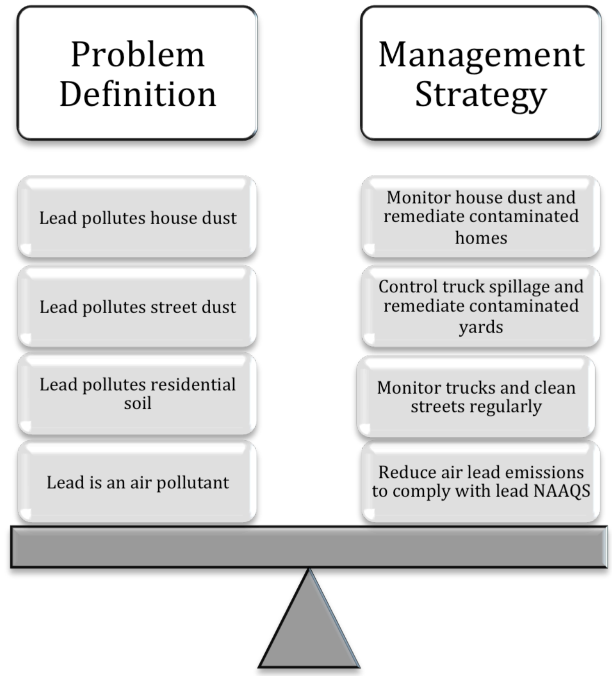


Figure 6.3. Illustrates the renewed state of balance between problem definition and management strategy in the renewed Stasis phase of the policy cycle in Herculaneum.

The Stasis-Crisis-Stasis Policy Cycle in Herculaneum: Redefining Lead Contamination

In the sections that follow I will provide a more detailed discussion of each phase of the policy cycle that produced a multi-media definition for local lead contamination in Herculaneum.

A Period of Stasis: Enforcing Compliance with the 1978 lead NAAQS

In the late 1990s community conflicts around the breaking of the Doe Run Co. strike had generally settled down, and although some residents harbored continued resentment against the company, the community as a whole was peaceably coexisting with its main economic driver. MDNR was operating air monitors in compliance with the Clean Air Act of 1976 under EPA oversight. Although air lead levels were consistently above the 1.5 $\mu g/m^3$ NAAQS for lead established in 1978, Doe Run Co.'s continued participation in the negotiation of new State Implementation Plans (SIPs) toward attaining this level resulted in their technical compliance with the EPA's air standards. The Jefferson County Health Department in cooperation with MDHSS and Doe Run Co. reported that fifteen percent of children under the age of six residing within one mile of the lead smelter had elevated blood lead levels (BLL)[16] (Missouri Department of Natural Resources, n.d.). Although this percentage was much higher than the national rate of 4.4 percent of children with elevated BLLs in 2000, it was not overly alarming as it was much closer to the Missouri average of ten percent of children with elevated BLLs, and was far below the rate in St. Louis of 29 percent of children with elevated BLLs (Ellis & Kane, 2000; Missouri Department of Health and Senior Services, 2003).

The apparent stability of this period masked two important developments that eventually undermined the dominant definition of local lead contamination. First, between 1992 and 1998 the U.S. Fish and Wildlife Service collected samples that indicated high lead levels in Mississippi River fish and birds near the smelter (U.S. Environmental Protection Agency Region VII, n.d.). Second, a few Herculaneum residents developed concerns about the potential health consequences of conditions they observed in their community and associated with lead processing activities. Information from the U.S. Fish and Wildlife Service was combined with a conjecture by MDNR

[16] Although research has demonstrated detrimental effects of very low levels of lead exposure, the CDC guideline continues to define eBLLs as children displaying blood lead concentrations at or above 10 ug/dL.

personnel that soil problems being addressed in the more southern regions of the lead belt would likely be present in Herculaneum as well, motivated the MDNR to initiate negotiations with EPA and Doe Run Co. for a more comprehensive approach to managing lead in the area (MDNR Representative, Interview, 2/2009).

The 2001 Administrative Order of Consent. Based on data from the U.S. Fish and Wildlife Service and their suspicions of more extensive contamination in Herculaneum, MDNR and EPA entered into negotiations with Doe Run Co. over plans to expand lead management in the Herculaneum area. In May 2001 they jointly released an Administrative Order of Consent, reporting agreements with Doe Run Co. to develop programs to more extensively monitor local lead contamination and remediate problem areas as they were identified (U.S. Environmental Protection Agency Region VII, n.d.). The major provisions of the 2001 Administrative Order of Consent included orders for Doe Run Co. to (1) explore contamination in local soil and remediation of contaminated areas, (2) establish a plan for regular blood lead screening and inform the public about the potential health hazards associated with lead exposure, (3) investigate and implement additional controls to limit air emissions, and (4) examine options for containing the slag pile and develop a plan to limit run-off into local waterways. Thus, the approach to regulating local lead contamination presented in the 2001 Administrative Order of Consent primarily focused on quantifying contamination in non-air media and subsequently managing any locations that proved problematic.

Before the 2001 Administrative Order of Consent was signed, however, a public comment period was required, through which the proposal was exposed to public scrutiny and suggestions for adaptation were considered. Public comment meetings on the 2001

Administrative Order of Consent revealed that Herculaneum community members held concerns over both the impacts of industrial activities on local health and the environment, and the potential economic and social challenges faced by the community due to heightened attention and regulation of local lead issues[17]. The depth, intensity, and divergence of community concerns with regard to the lead industry became a prominent aspect of these discussions:

The community definitely didn't speak with one voice. It was really pretty divided because it was a company town for most of its history and they busted the union and then there's kind of pro-Doe Run and anti-Doe Run factions. But I think both sides were angry at somebody, and often [angry at] the agencies. Some people thought we were making too big a deal out of things and a lot of folks thought we really weren't doing enough. There was a lot of things the community pointed out that were, kind of weaknesses in our regulatory framework or things that we really hadn't looked at (Interview, Nick Peterson, 2/19/09).

Despite differences in perspective held by community members, Mr. Peterson and other regulatory personnel described how the community expressed particular concern over the constant flow of large trucks hauling lead products to and from the smelter over neighborhood streets. These trucks were considered by community members to be a nuisance since they were loud and extremely dirty (interviews and conversations with Herculaneum stakeholders, 2008-2010). Truck traffic represented one important example among a long list of complaints expressed by community members regarding the existing regulatory framework surrounding local lead contamination.

---

[17] Characterization of the perspectives of these two groups of community members is a central topic of Chapter Seven.

A Period of Crisis: Developing a Multi-media Definition of Lead Contamination

The 2001 Administrative Order of Consent represented an initial effort to expand the definition of local lead problems and to explore multi-media sources of contamination. A crisis over local lead contamination emerged as prominent definitions of the contamination were challenged by evidence of contamination sources not addressed by enforcement of the lead NAAQS or by the 2001 Administrative Order of Consent. Thus, although the introduction of the 2001 Administrative Order of Consent and resulting controversy over defining and managing local lead problems did not substantially alter the treatment of local contamination, these developments provided a forum through which health-concerned community members were able to campaign for the collection and analysis of evidence that challenged the existing definition of the local lead problem.

Initiating crisis. According to research participants in this study, complaints about truck traffic went largely unaddressed for some time because trucks were not thought to present a serious contamination problem and no established programs or procedures had been established to address truck-related concerns. Certain community members remained persistent in their insistence that conditions surrounding Doe Run Co.'s transportation of lead to and from their plant was causing local contamination. MDNR representative, Nick Peterson, was eventually convinced to collect a sample under the guidance of Ethan Lewis, who described the process; "Finally we got down there and we got to where I wanted him [Nick] to get the sample from… headlights pointing at it. It's like… 'do you see the glitter in there? What the hell do you think that is?' 'Oh my gosh' he says. 'I don't even have to test it to know what it is'" (Interview, Ethan Lewis, 10/7/2008). As mentioned, this sample was then analyzed and found to contain 300,000 ppm lead, which means that approximately one third of the collected dust was lead. The agency perspective leading up to taking this sample and the significance of the high lead levels the sample exhibited was discussed by MDNR representative, Nick Peterson in our interview:

We were dealing with other things and it was also a little unclear who had the lead… From my perspective, [agencies weren't] dealing with this truck and road dust issue. I wasn't necessarily dealing with it either, but I finally did go out after a meeting at about 11:00 at night and looked, went out with a guy [Ethan Lewis] who showed me this road dust and I collected samples, and it was screaming high, it was all over the place. So in that, just by going out and listening to this guy… he was right, you know, and it just changed the whole approach. (2/19/2009)

Both the levels of lead identified in this sample and the circumstances of its collection became an important symbol exemplifying the challenge of local lead contamination and initiated a turning point in local lead management. In response to the 300,000 ppm road dust finding, EPA and DNR issued an order that the timetable of activities outlined in the 2001 Administrative Order of Consent be drastically accelerated. Specifically, Doe Run Co. was given 60 days to evaluate soil contamination in the area and ordered to begin remediation of contaminated areas as they were identified (Missouri Department of Natural Resources, n.d.). Also in response to the 300,000 ppm finding MDNR sought the advise of MDHSS and ATSDR to evaluate potential health hazards based on data quickly collected to characterize lead levels in local street dust and yard soil. MDHSS representative, Zack Newton, described the interaction between his group and representatives from MDNR:

This concentrate on the roads caused a huge explosion of concern because instead of having this invisible stuff coming out, now you've got stuff that was literally measured at 333,000 ppm. One third of it was actual lead and it was on the road in small enough quantities it was dust and there were kids riding through it. DNR contacted us and said, 'oh my god, what's the risk?' And that's when we said, 'it's a big risk, shut off the roads.' So there was actually signage put up that said don't let your kids play in the roads (Interview, Zack Newton, 4/30/2009).

This cooperation between MDNR and MDHSS was a departure from previous practice in lead management in Herculaneum. Previously, Doe Run Co. cooperated with the Jefferson County Health Department in conducting area health screenings, monitoring area blood lead levels, and fielding community health concerns and questions (Interviews, regulatory representatives, 2008-2009). MDHSS replied to MDNR's query that conditions in Herculaneum presented a clear and substantial endangerment to the health of the local public. This declaration was issued in the form of a 2001 letter, which was addressed to the Director of MDNR from the Director of MDHSS, and stated:

Due to the recent discovery of extremely elevated levels of lead contamination on some streets, yards, and play areas in Herculaneum, I believe risks to the public's health, especially pregnant woman and children through age six, are clear and present and are an imminent and substantial endangerment. Because of this public health risk, I am requesting that your agency take all necessary and appropriate actions to eliminate this source of exposure. We are aware that the U.S. Environmental Protection Agency has sent a letter to the Doe Run Companies, directing them to assess this risk in a manner more expeditious than that originally agreed to in The Administrative Order on Consent for Doe Run' s Herculaneum Lead Smelter. We agree with and support that effort. Those planned assessment activities alone, however, will not reduce this health risk unless swift and appropriate follow-up activities are taken based on the results of that assessment. (Dempsey, 2001)

Street dust and yard soil lead levels were central in the argument made by MDHSS representatives that local lead contamination presented an urgent threat to local health. Additionally the letter indicated a divergence in the approaches of MDHS, ATSDR, and MDNR with that of EPA. The letter expressed concern that EPA's order to accelerate assessments detailed in the 2001 Administrative Order of Consent was not sufficient to reduce public health threats. Thus, instead of accelerating already agreed upon plans to explore the extent of multi-media contamination, MDHSS advised MDNR that more extensive regulatory interventions were required.

In response to the "clear and substantial endangerment" declaration by MDHSS, MDNR initiated additional actions to protect public health. More specifically, they posted signs along city streets instructing residents to exercise care in protecting themselves and their children from toxic dust and soil (see Figure 5.4). Also, MDNR issued an Order to Abate Cease and Desist Violations (2001) demanding that Doe Run Co. stop all operations in Herculaneum that might result in the release of leaded dust, especially the transport of lead over city streets (Missouri Department of Natural Resources, 2001).

Constructing a case for a crisis. My examination of reports developed by MDHSS and ATSDR from the period immediately following the 300,000 ppm finding indicated that MDHSS and ATSDR's research into human exposures lent itself to supporting and justifying major interventions by MDNR and EPA. Additionally, efforts were made by ATSDR and MDHSS to provide both scientific evidence and convincing tools with which to refute company claims that plant related contamination was not a source of health concern. Three documents most directly illustrated this effort: the declaration of clear and substantial endangerment in a letter from the director of MDHSS to the director of MDNR (Dempsey, 2001), the Health Consultation: Blood Lead Results for the 2001 Calendar Year (Missouri Department of Health and Senior Services & Agency for Toxic Substances and Disease Registry, 2001), and Health Consultation: Exposure Investigation – Herculaneum Lead Smelter Site, Jefferson County, Missouri (Agency for Toxic Substances and Disease Registry, 2005).

Declaration of Clear and Substantial Endangerment. Despite the influence the clear and substantial endangerment declaration had on shaping the MDNR's initial response to the 300,000 ppm street dust finding, according to MDHSS personnel, this characterization of the lead levels in street dust masked complexity in the relationship between local lead conditions and heath hazards. My interviews with MDHSS health representatives indicated that while the alarming lead levels in soil and street dust presented evidence of extensive area contamination, the declaration of clear and substantial endangerment was thought to be overstated in terms of bioavailability[18]. The particular form of lead present in street dust samples was not easily absorbed by humans; however, the MDHSS letter presented the lead levels in dust and soil as an imminent threat to local health. The declaration of clear and substantial endangerment provided

[18] Bioavailability describes the relative amount of the contaminate that can be absorbed by humans in terms of the particular biological processes through which humans are exposed to a toxin, which depends on the chemical form of the contaminant in the environment.

MDHSS and ATSDR with a rationale for the expansion of their exploration of lead exposure in Herculaneum. Following the declaration, extensive data collection commenced in order to characterize multi-media conditions of lead contamination surrounding the smelter. This data was eventually used to produce the 'bulls eye' map (Figure 5.5) that then justified the endangerment declaration and ultimately led to the buy-out, (This report and map will be the topic of discussion in the next section). The following discussion between health officials demonstrated how the declaration of clear and substantial endangerment was used as a storyline[19] that capitalized on public concern over dramatic lead levels and justified expanded examination of local conditions:

Zach Newton - That's actually related to the whole business about the eminent and substantial health risk. We're talking about stuff that although it's [particle size is] very small, it's definitely not very bioavailable in comparison to like an emission from the stack. *But* it gave us those high numbers, gave us the legal ability to say it was eminent and substantial. If someone had said, 'OK, but how bioavailable is it in comparison?' Then we would have had to go, 'well'.

Natalie Downs - But once we had the bulls eye map it was OK...

Zach Newton - I think citizens, if anything, would dislike the whole issue that you've got 300,000 ppm lead here. I don't care if it's one chunk, that's bad as opposed to saying you've got 800 pounds coming out of the stack and every bit of it's bioavailable. Every smidgen of it you can just absorb into your blood like that if you breathed it. They don't care that much about that" (Focus Group Interview, MDHSS representatives, 4/30/2009).

[19] As discussed in Chapter Three, storylines are narrative interpretations of events that hold symbolic meaning for groups of individuals and serve to align individual perspectives into discourse coalitions.

According to this conversation, a data point that initially inspired a great deal of community alarm was used to justify extensive regulatory intervention. The lead identified on streets and in soil was in a form that presented less of a threat to public health than other known sources of lead contamination in the area; however, the dust level presented such dramatic evidence of the extent of area contamination that it provided a definitive “emblem” around which the public perception of a much more complex environmental reality of local lead contamination could be focused in order to garner support for extending the local regulatory framework. Hajer (1995) explained how events such as the 300,000 ppm soil lead finding in Herculaneum become emblems that define an environmental crisis:

> Calamities only become a political issue if they are constituted as such in environmental discourse, if story-lines are created around them that indicate the significance of the physical events .… They depend on agency and discursive strategies… Furthermore, the dominant role of emblems in environmental discourse indicates that single issues determine the public perception of a much more complex reality” (Hajer, 1995, p. 21).

The collection of the 300,000 ppm lead sample became emblematic in the management of lead in Herculaneum, particularly among the most environmentally concerned community members and regulatory agency representatives. The conversation between Mr. Newton and Ms. Downs revealed an instance in which strategic management of the story lines surrounding local lead contamination shaped the regulatory response to the 300,000 ppm finding. Mr. Newton explained how MDHSS developed a case for the substantive reduction of area lead emissions and clean up of historical contamination based on public concern over the 300,000 ppm street dust finding. This case was developed despite the limited health hazard that the sample actually presented. By building on public alarm over such a dramatically high contamination level, MDHSS was able to support MDNR in reducing the community's exposure to other, more bioavailable forms of lead. Ultimately, the data collection that followed the 300,000 ppm finding permitted MDHSS to conduct health screenings and to generate reports to provide further evidence linking lead plant emissions to human health exposures in Herculaneum.

Health agency representatives' treatment of the 300,000 ppm soil lead finding in Herculaneum reflected Hajer's (1995) argument that problem definition constitutes an important aspect of environmental policy-making. MDHSS personnel capitalized on public concern over high levels of lead in Herculaneum's road dust and soil to define conditions in Herculaneum as a substantial health threat, despite their knowledge that the particular form of lead in soil and dust samples would likely have limited impacts on health. The data collection that followed MDHSS's characterization of the 300,000 ppm finding as a "clear and substantial endangerment" then enabled MDHSS to generate further evidence linking plant emissions to human health exposures in Herculaneum thereby justifying the endangerment claim.

Health Consultation: Blood Lead Results for the 2001 Calendar Year. The Health Consultation: Blood Lead Results for the 2001 Calendar Year (2001) asserted:

> Based on the blood lead data provided to DHSS, significant blood lead elevations have been documented in this community.… Children may be exposed to lead inside their homes, outside in their yards, playgrounds, parks, and while attending school. This community is faced with widespread environmental contamination.

> Because children depend on adults for risk identification and management decisions, it is prudent that further lead exposure be prevented. (Missouri Department of Health and Senior Services & Agency for Toxic Substances and Disease Registry, 2001)

The actual blood lead data provided evidence only that lead exposures were greater in the area surrounding the lead plant than in the rest of Jefferson County. MDHSS drew on research being conducted in the area by EPA and MDNR combined with knowledge of common sources of lead exposure in children to elaborate on potential sources of exposure and suggest protective actions. In order to further support their case that high lead levels in the area were associated with lead plant emissions, the MDHSS geocoded the blood lead data and superimposed it on a map of Herculaneum. The graphic they produced, frequently referred to as the 'bulls-eye map' (Figure 6.4) presented a convincing visual argument that the lead plant was responsible for contributing to elevated blood lead levels in area children. The bulls-eye map presents concentric circles over a map of Herculaneum with the lead smelter at the center. It indicates the percentages of children residing between one and one and a quarter miles of the smelter having elevated BLLs. The bulls-eye map was used by regulatory representatives to convincingly link the prevalence of elevated blood lead levels to lead plant activities for a variety of audiences including the Herculaneum public and decision-making groups within MDNR and EPA (Interviews, MDHSS and ATSDR representatives, 4/30/2009 and 5/18, 2009). The bioavailability of the source in question became less of a barrier to the successful argument that lead plant activities were impacting the health of Herculaneum residents in the face of visual evidence that the plant was the geographic

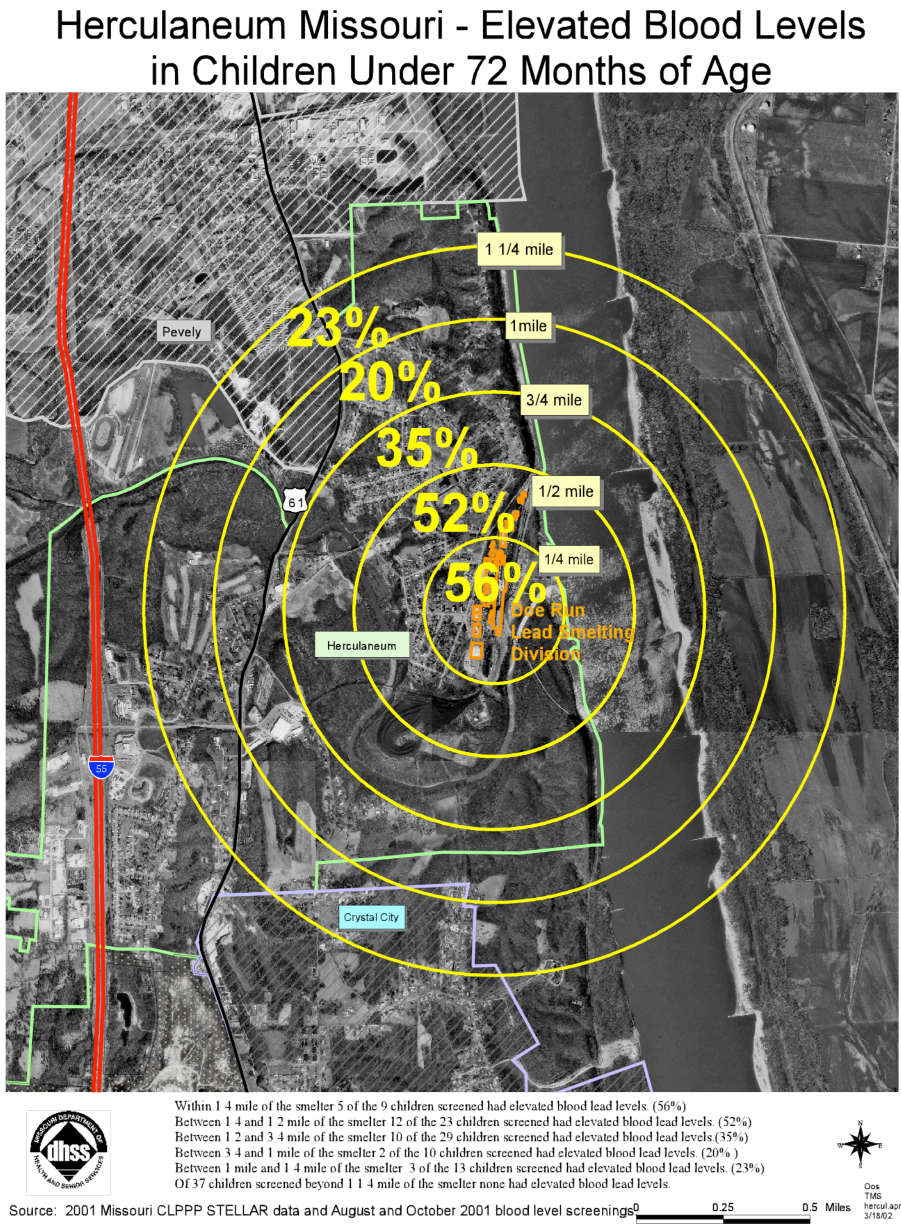


Figure 6.4. The bulls-eye map demonstrated increasing BLL's with proximity to the Doe Run Co.'s lead smelting facility. Within one quarter mile of the facility 56% of children tested above 10ug/dL. The concentration declines with increased distance from the facility such that only 23 percent of children living between one and one and one quarter miles away from the facility tested above 10 ug/dL. From Missouri Department of Health and Senior Services (2001). *Herculaneum Missouri – Elevated Blood Lead Levels in Children under 72 Months of Age.* Retrieved August 6, 2009 from http://www.dhss.mo.gov/hazsubstancesites/herc2001map.pdf

center of documented and increasing lead exposures and, therefore, likely responsible for lead exposures in local children. Thus, the position held by ATSDR and MDHSS that further research would convincingly link health exposures to plant activity proved accurate.

Health Consultation: Exposure Investigation – Herculaneum Lead Smelter Site, Jefferson County, Missouri. Doe Run Co. responded to the Health Consultation: Blood Lead Results for the 2001 Calendar Year that produced the bulls-eye map by suggesting that the elevated blood lead levels in children residing near the smelter could be a result of the aging housing stock in close proximity to the smelter. Based on the age of these homes the company proposed that they would be more likely to contain lead-based paint than newer homes located further from the smelter. Doe Run Co.'s vice president of community relations explained to the St. Louis Post-Dispatch that:

Some of the lead poisoning found near the smelter – where houses are generally older than in other parts of the city – may partly be traced to lead paint. "I don't want to diminish that we want our facility to be in compliance, but we want to make sure the residents are considering all the sources (of lead)". (Carroll, 2002)

In response to the suggestion that lead exposures near the plant might be attributable to residential lead-based paint, ATSDR conducted the Health Consultation: Exposure Investigation – Herculaneum Lead Smelter Site, Jefferson County, Missouri (2005). Families were selected for the study on the basis of two factors: (1) at least one child had a BLL above 15ug/dL, and (2) having resided in the area for the child with the elevated BLL's entire lifetime. The study linked contaminated dust samples taken from houses and yards, as well as biological samples (blood and urine) from the family to Doe Run

Co. operated lead mines. This was accomplished by studying isotopic ratios characteristic of each of the two types of samples. Doe Run Co.'s mines in Missouri display a uniquely high ratio of lead isotope 206 to lead isotope 204. The identification of isotopic ratios can be used in a manner somewhat analogous to a chemical fingerprint to identify the origins of samples. The isotopic ratios of samples taken from the families' biological samples and non-paint samples from their home environments approximated the isotopic ratio of samples from Doe Run Co. mines. Accordingly, ATSDR representatives concluded that the families' lead exposures were related to lead mining and processing in Missouri, and not to lead-based paint. Summaries of this investigation also provided scientific evidence, which was convincing to the public, that the Doe Run Co. lead plant was an important source of lead exposure for children living in close proximity to the smelter.

In this section I discussed the influence of the perspectives on local lead contamination held by MDHSS, MDNR, and ATSDR representatives on initial efforts to expand the definition of lead contamination in Herculaneum following the 300,000 ppm lead finding in road dust near the Herculaneum smelter. I described initial responses by EPA and MDNR as emergency responses to the extreme lead levels identified in the environment. I used documents issued as early reactions to the 300,000 ppm street dust finding to argue that the redefinition of this finding as a health crisis by MDHSS and ATSDR served to support extensive efforts by MDNR toward remediation and expansion of lead management in the area. In the next section I will discuss the ways that MDNR made use of the clear and substantial endangerment designation and the bulls-eye map to justify measures to protect community members from smelter-related lead exposures.

Redefining contamination to fit regulatory programs. MDNR representatives viewed the 300,000 ppm road dust finding and the MDHSS declaration of clear and substantial endangerment as a considerable environmental challenge and as an opportunity to initiate solutions to a variety of concerns associated with the lead facility in Herculaneum:

And to me that [the proximity of the community to the smelter] was a concern not only from an environmental perspective and a lead perspective, but just from a safety perspective. I mean, suppose there was an explosion at the plant or something, and with people in that close proximity, you just wouldn't see that today. And so we viewed it as a dual strategy of both having the company install controls to reduce their emissions and to create this buffer zone around the plant to where people weren't right on top of it (Interview, Emma Long, MDNR Representative, 2/19/2009).

In order to address these concerns regulators defined local lead contamination problems in terms of existing regulations. At the time of the 300,000 ppm road dust finding, dust had not been considered a concern in terms of environmental protection, and only a guideline existed for the remediation of yard soil. Additionally, industrial clean up efforts were administered under the superfund program, which was exclusively designed to address abandoned properties containing extensive environmental hazards. Thus, regulatory representatives from both MDNR and EPA confronted a situation demanding that in order to protect local health interests they must (1) manage a contamination medium previously unaddressed by environmental regulation, (2) enforce a guideline with the stringency of a standard, and (3) apply procedures to resolve problems associated with abandoned industrial sites to the ongoing operations of an active industrial facility. One agency representative described this effort as follows: “the Herculaneum smelter was a square peg that you’re trying to put in round holes all the time. We had lots of round holes and lots of misshapen pegs, and it was tough” (Interview, Nick Peterson, 2/19/2009). In terms of Hajer’s (1995) and Fischer’s (2003) emphasis on problem definition and problem resolution, defining lead contamination in the form of multi media hazards related to industrial activity required regulatory representatives to force existing regulatory programs (square pegs) to fit the emerging challenges in Herculaneum (round holes).

On the national level lead regulation has focused on limiting and remediating lead associated with paint and gasoline contamination as discussed in Chapter Two. Hazardous contamination from lead paint is currently managed under the Residential Lead Paint Hazard Reduction Act of 1992. Thus, the majority of regulatory efforts to address lead pollution have largely addressed these historical contamination sources, and not targeted the management of ongoing emissions. Thus, in Herculaneum regulatory representatives were faced with a mismatch between available policy tools for managing and remediating lead contamination and the actual ongoing contamination challenges faced by the Herculaneum community. Regulatory representatives’ attempts to characterize local lead problems in terms that allowed for their management through existing regulatory programs were evident in my analysis of the documentation summarizing two regulatory efforts: (1) the MDNR’s 2001 Order to Abate Cease and Desist Violations (Missouri Department of Natural Resources, 2001), and (2) the subsequent agreement that provided for the settlement of Doe Run Co.’s appeal of this order (Missouri Department of Natural Resources v. Doe Run Resources Corporation, 2002). The 2002 Settlement Agreement included two central provisions, the Voluntary Property Purchase Plan and the Transportation and Materials Handling Plan. In the following three sections I will discuss the 2001 Order to Abate Cease and Desist Violations and each of the plans central to its settlement in 2002 in greater detail.

***Order to Abate Cease and Desist Violations* (2001).** The clearest example of the creative application of existing regulatory strategies to unique lead problems was in the application of the Missouri Hazardous Waste Management Law to the transportation of lead concentrates. To address the eminent threat of lead exposure associated with the lead levels reported in community soil and dust samples in September, 2001 MDNR instructed Doe Run Co. to:

abate releases of hazardous substances and hazardous wastes under the Missouri Hazardous Waste Management Law…. The MDNR has issued this Order to prevent exposure of residents of the City of Herculaneum to hazardous substances transported by trucks under contract with the facility and hazardous waste released during transport. (Missouri Department of Natural Resources, 2001).

This approach represented a departure from that taken in the 2001 Administrative Order Of Consent, which had attempted to expand regulatory efforts in the area by investigating the possibility and extent of potentially harmful exposures. In contrast the Order to Abate Cease and Desist Violations (2001) treated such impacts as established facts, and focused instead on adapting existing standards to regulate lead in the environment and ultimately eliminate sources of exposure (Missouri Department of Natural Resources, 2001; Missouri Department of Natural Resources v. Doe Run Resources Corporation, 2002). The Order to Abate Cease and Desist Violations (2001) invoked state laws governing clean air, clean water, and disposal of hazardous wastes, arguing that in spilling lead-contaminated product Doe Run Co. had allowed a hazardous contaminate to be placed where it was likely to contaminate local air or water and ultimately impact human health. Lead concentrate had not formerly been classified as waste because it was an intended intermediate product of smelting activities. In order to apply Hazardous Waste regulation to street dust, MDNR representatives were required to redefine lead concentrate, a valuable intermediate product of lead processing, as waste when it was unintentionally released into the environment. The order described MDNR representatives' observations of lead dust being carried by the wind off of highly contaminated areas of the facility, and of lead concentrate being spilled off of trucks traveling through local neighborhoods. Accordingly, MDNR representatives characterized misplaced lead concentrates, either blown off plant property or spilled out of trucks, as "fugitive dust" (Missouri Department of Natural Resources, 2001). The Order informed Doe Run Co. that it must "immediately cease all activities that cause fugitive dust to leave the property boundaries of the facility" (Missouri Department of Natural Resources, 2001, p. 7).This dust, having been attributed to sloppy handling and transportation of lead concentrates was redefined as fugitive dust, a waste product. Fugitive dust could then be managed through Missouri Hazardous Waste Management Policy, the Resource Conservation and Recovery Act of 1976 (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA or Superfund) and other laws protecting air, water, and soil from illegal dumping of hazardous wastes. The large-scale programs associated with each of these acts are directed by EPA with a complementary structure in state agencies. Superfund is primarily devoted to cleaning up defunct properties with extensive and hazardous contamination problems. RCRA focuses on oversight and enforcement of the rules governing the handling, transportation, and disposal of hazardous wastes.

Restrictions in the Order to Abate Cease and Desist Violations (2001) demanded immediate elimination of activities contributing to the release of fugitive dust, cleaning dust off of roads and shoulders, and abating yards where dust had contaminated the topsoil. TheOrder to Abate Cease and Desist Violations (2001) was immediately appealed by Doe Run Co. and under court order they set about negotiating a settlement to the dispute with MDNR, eventually producing a settlement agreement released in 2002 (Missouri Department of Natural Resources v. Doe Run Resources Corporation, 2002). The Settlement Agreement consisted of a Voluntary Property Purchase Plan, a Transportation and Materials Handling Plan, concessions regarding the payment of associated regulatory costs, and distinctions in the relevant regulatory authority held by EPA and MDNR.

Voluntary Property Purchase Plan. The major provisions of the Voluntary Property Purchase Plan (Missouri Department of Natural Resources v. Doe Run Resources Corporation, 2002) demanded that Doe Run Co. purchase 160 residences within approximately one quarter-mile of the smelter (Figure 5.6). An independent consultant retained by Doe Run Co. was responsible for establishing an order of priority for properties, with preference given to families with very young children, and with acquiring appraisals to determine the fair market value for each property (Missouri Department of Natural Resources v. Doe Run Resources Corporation, 2002). The plan also included provisions for relocation assistance for displaced families, and for a process by which property owners might appeal Doe Run Co.'s offer for the purchase of their property. Rather than focusing exclusively on emission reductions or contamination remediation, this intervention removed residents away from the area of highest exposure concern. MDNR representative, Emma Long credited this strategy with significant reductions in childhood exposure to lead in the area; "Frankly, we went from a situation of having about 50 percent of the children with elevated blood levels within a quarter mile of the smelter to zero mostly because the kids had moved out" (Interview, 2/19/2009). The buy-out was considered by MDNR representatives to be necessary to expediently eliminate the most harmful human exposures, which were linked to living in very close proximity to the lead smelter.

Transportation and Materials Handling Plan. In addition to the Voluntary Property Purchase Plan, the settlement of the Order to Abate Cease and Desist Violations (2001) also established a framework for the regulation of lead concentrates spilled onto roads through the Transportation and Materials Handling Plan. This plan had far reaching implications for lead management throughout the lead mining and refining regions of Missouri. Its guidelines for transportation of lead concentrates applied throughout the state. The major provisions of the transportation and materials handling plan included (1) extensive truck washing procedures to be implemented at every Doe Run Co. facility, (2) regular treatment of streets by specially equipped HEPA[20] filtration street sweeping units, and ongoing soil and road dust monitoring. Ultimately programs were established with EPA as the lead agency to first abate road side and soil contamination under CERLA (Superfund), and then to manage ongoing road dust and soil contamination as hazardous waste under RCRA (Interview, Chris Russel, 2/27/2009). The implementation of

[20] HEPA stands for High Efficiency Particulate Air and designates a type of filter that traps and retains very small particles.

strategies for managing the transportation of concentrates set a precedent for which Doe Run Co. has subsequently been held accountable in all concentrate transportation throughout the Missouri lead belt. Lead concentrate haul routes to which this plan is applicable are mapped in Figure 6.4.

The implementation of the Voluntary Property Purchase Plan (2002) and the Transportation and Materials Handling Plan (2002) represent only a portion of a larger scale regulatory response to the discovery of unaddressed lead contamination in

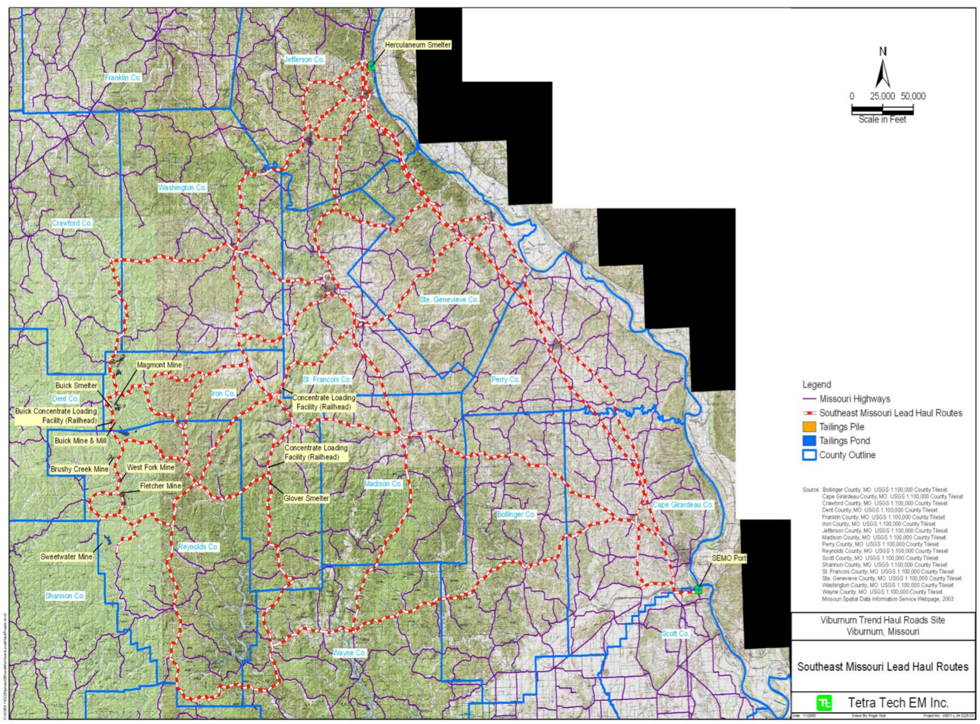


Figure 6.4: A map of southeast Missouri designating hauling routes used to transport lead concentrates by truck between Doe Run Co. facilities. Provided as a hand out at Herculaneum Community Advisory Group Meeting, 11/2010.

Herculaneum. Additional clean up and remediation of local lead contamination was conducted through a variety of projects including: (1) clean up of contaminated soils by EPA under CERCLA, (2) procedures for regular testing and replacing contaminated soil in residential yards by EPA under RCRA, (3) new strategies for managing fugitive dust by EPA under CERCLA and RCRA, and (4) heightened enforcement of the lead NAAQS implemented by MDNR with EPA oversight. Additionally, ongoing health assessments conducted by MDHSS and ATSDR in cooperation with the Jefferson County Health Department were initiated to assess the health implications of the newly recognized levels of lead contamination for Herculaneum residents. By extending existing regulatory tools to address the newly recognized multi-media contamination problems in Herculaneum, MDNR and EPA representatives expanded the regulatory framework for local lead contamination.

Establishing a Successful Strategy for Managing Lead Contamination

As the Voluntary Property Purchase Plan was implemented and families moved away from the historical core of Herculaneum, air standards were more strictly enforced, and measures were taken to clean and regulate street dust, the focus of regulatory efforts transitioned again. Regulators turned from interrogating the extent of community contamination to assessing the effectiveness of programs and interventions in managing contamination. In light of the extensive concern surrounding the local lead crisis, it was urgent that regulators provide evidence that the identified problems were being effectively addressed. The scientific practices with which they approached their work did not change, rather, the formulation of research questions and the design of studies moved from exploring the extent and source of local lead contamination, to examining the extent to which that contamination had been reduced by newly implemented programs. In order to transition from addressing a crisis of lead contamination to establishing effective management of local pollution, agencies had to once again redefine the problem of local lead contamination. In establishing the crisis, emphasis had been placed on the need to eliminate all sources of lead exposure in the Herculaneum community; however, in attempting to establish conditions for ongoing management of an operating lead smelter, practical limits to exposure became the focus of regulatory efforts.

Defining a manageable problem. Evidence of a shift in regulatory focus began to appear in the 2002 Settlement Agreement (Missouri Department of Natural Resources v. Doe Run Resources Corporation, 2002). Although the agreement prescribed all of the rather extreme actions described in the Voluntary Property Purchase Plan and transportation and materials handling plan, the approach was substantially softened compared to the staunch stance taken in the Order to Abate Cease and Desist Violations (2001). The charge in the Order to Abate Cease and Desist Violations (2001) to *eliminate* sources of human exposure to lead contamination morphed into the less ambitious aim of managing human exposures to lead to a level that would be *reasonable* for industry. That this shift was already beginning as early as the Settlement Agreement is evident in provisions for plans to minimize contamination from transportation of lead concentrates: "include all actions necessary to *minimize to the extent practicable* [emphasis added] exposure of the citizens of Herculaneum, Missouri, resulting from the transportation and handling of materials containing lead" (Missouri Department of Natural Resources v. Doe Run Resources Corporation, 2002). Thus, the exacting language of MDNR's 2001 Order to Abate Cease and Desist Violations was tempered in the settlement to Doe Run Co.'s appeal of this order, Missouri Department of Natural Resources v. Doe Run Resources Corporation (2002), to prescribe a more practical level of lead management from the perspective of the lead industry. The use of the term "practicable" refers to procedures for establishing environmental policies and programs in the Herculaneum area in accordance with reports from regulatory representatives. For instance, EPA representative Andrew Cole described the approach usually taken by the agencies in setting goals for reducing and remediating contamination:

We're trying to go middle of the road most of the time. I mean, it's not realistic to clean everything up to zero, there's a diminishing return there, so we take a look at what's the most improved health effects that you can get and what are the most necessary health effects – health risk reductions that you need to get and go from there… There's a lot of information out there about lead. People don't understand that lead standards 30 years ago aren't the lead standards today. (Interview, 2/27/2009)

Industrial representatives made a complimentary argument when asked about how they balance business interests related to industrial profitability with interests in protecting the environment. For example, Tyler Porter explained that through the process of limiting the release of lead waste in the form of fugitive dust from the plant, the efficiency of the smelting process had been improved. Restated, an unexpected result of the implementation of environmental protection strategies was improved efficiency in the industrial process. In this way he viewed environmental protection as largely complementary to industrial profitability. Both Mr. Cole and Mr. Porter's comments were reflective of Christoff's (1996) description of changing approaches to environmental regulation:

> Prescriptive regulatory approaches and 'technological forcing' – applied in the 1970s as the sole or predominant strategy for achieving ongoing improvements in environmental conditions – are more often accompanied or displaced by co-operative and voluntary arrangements between government and industry:

> increasingly environment protection agencies seek to use industry's existing investment patterns and its capacity and need for technological innovation to facilitate improvement in environmental outcomes. (p. 477)

Where once environmental regulation was seen publically as a process that restricted the activities of polluting industries, it is now much more focused on cooperation and negotiation between government agencies and polluting companies in the interest of minimizing waste, and maximizing efficiency. MDNR's initial approach of eliminating exposure sources reflected the more prescriptive, forceful methods Christoff associated with environmental regulation in earlier periods. This strategy served to advance MDNR's efforts to extend the contamination crisis, however, the approach was short lived under contemporary regulatory conditions. The department was forced by court order into negotiation with Doe Run Co., which demanded a more cooperative approach to seeking a level of lead management that would be both protective of residents' health and practical for industry.

Researching effectiveness. In a similar manner, the focus of health reports were modified after the initial reactions to the 300,000 ppm lead dust finding from providing evidence linking plant activity with lead exposures (Agency for Toxic Substances and Disease Registry, 2005; Missouri Department of Health and Senior Services, 2001; Missouri Department of Health and Senior Services & Agency for Toxic Substances and Disease Registry, 2001) to determining the effectiveness of recently established lead management efforts (Missouri Department of Health and Senior Services & Agency for Toxic Substances and Disease Registry, *Health Consultation: Determination if remedial actions are protective of public health - Herculaneum lead smelter site Herculaneum,* *Jefferson County, Missouri*, 2002, *Health Consultation: Public health evaluation of Arsenic and Cadmium levels in air and residential soils - Herculaneum Lead Smelter Site, Herculaneum, Jefferson County, Missouri*, 2002, *Health consultation: Sulfer Dioxide monitors in Herculaneum - Herculaneum Lead Smelter Site, Jefferson County, Missouri*, 2002, *Health Consutation: Public health implications from attending or working at Herculaneum schools - Herculaneum Lead Smelter Site Herculaneum, Jefferson County, Missouri*, 2002, 2003; Missouri Department of Health and Senior Services Office of Epidemiology, 2007). These later health studies focused on supporting and defending existing regulatory actions and providing assurance of safety in the face of lead-related health fears . The action plans included in each report moved from calling for stringent reductions in emissions and waste to promising to examine additional data and information as it became available. However, health-concerned residents continued to demand research targeted at extending the boundaries of the contamination crisis. For example community requests inspired the following reports: Health Consultation: Public Health Evaluation of Arsenic and Cadmium levels in air and residential soils (2002), and Health Consultation: Sulfur Dioxide monitors in Herculaneum (2002).

The changing focus of health research related to Herculaneum was most clearly demonstrated through the examination of two studies conducted by MDHSS in response to specific community health concerns: (1) Health Consultation: Public Health Evaluation of Arsenic and Cadmium Levels in Air and Residential Soils (2002), and (2) Health Consultation: Determination of Baseline Prevalence for Provider Diagnosed Multiple Sclerosis (MS) and Amyotrophic Lateral Sclerosis (ALS) in Herculaneum and Jefferson County, Missouri (2007). Both reports constitute responses to specific health concerns associated with exposure to lead and other potentially toxic byproducts of lead smelting. An exception to the trend from research to expand understandings and management of local contamination to assessment of effectiveness of management strategies was the identification of local dust levels released in 2003. I will discuss each of these reports in the following sections.

Health Consultation: Public health evaluation of arsenic and cadmium levels in air and residential soils – Herculaneum lead smelter site, Herculaneum, Jefferson County, Missouri (2002). The Arsenic, Cadmium, and Lead study completed in 2002 documented known science about each of these byproducts of lead smelting. The study responded to an explicit concern voiced by Herculaneum residents:

Specifically, the community is concerned about past and current arsenic and cadmium emissions from the smelter and if combined (past and continuing) exposures could result in adverse health effects. In particular, concerns have been raised about adverse effects on the kidney (As, Cd, Pb[21]) .

The findings of the study are summarized in Table 6.1. For both arsenic and cadmium air and soil levels were above the appropriate guidelines for cancerous and non-cancerous health effects for at least some portion of the population. Accordingly further analysis was conducted for each form of each contaminant for both cancerous and non-cancerous health effects.

[21] As, Cd, and Pb are the chemical symbols for arsenic, cadmium, and lead respectively.

Table 6.1

Summary of Findings from Health Consultation: Public Health Evaluation of Arsenic and Cadmium Levels in Air and Residential Soils – Herculaneum Lead Smelter Site, Herculaneum, Jefferson County, Missouri (2002).

	Arsenic (As)		Cadmium (Cd)	
	Local Levels	Guideline	Local Levels	Guideline
Soil	≤82 ppm	EMEG* = 200 ppm for adults, 20 ppm for children	≤240 ppm	EMEG = 100 ppm for adults, 20 ppm for children
Street Dust	138 ppm	No Guideline	598 ppm	No Guideline
Air	≤0.64 $\mu g/m^3$	CREG** = 0.0002 $\mu g/m^3$	≤0.66 $\mu g/m^3$	CREG = 0.0006 $\mu g/m^3$
Post-remediation Interior Dust	≤39 ppm	No Guideline	≤24.2 ppm	No Guideline
Maximum Estimated dose from Soil	Adults – 0.00006 mg/kg/day Children – 0.0005 mg/kg/day	Chronic MRL*** = 0.0003 mg/kg/day	Theoretical risk indicated at 2001 maximum levels	
Maximum estimated dose from air	Adults – 0.00009 mg/kg/day Children – 0.00075 mg/kg/day	MRL = 0.0002 mg/kg/day	Theoretical risk indicated at 2001 maximum levels	

MDHSS concluded that non-cancer effects were unlikely to occur in Herculaneum. Estimates of the likelihood of a person developing cancer based on soil arsenic concentrations indicated no significant risk over 70 years of exposure to arsenic at the maximum levels identified in Herculaneum. Levels of cadmium in local air represented a very small fraction of the amount required to pose a non-cancerous risk to human health. MDHSS representatives' review of literature regarding human exposure from cadmium in soil identified one study in which children in a smelter community were shown to have elevated cadmium levels associated with soil levels comparable to those in Herculaneum, suggesting a possible, but uncorroborated risk of exposure from area soil. Calculation of the maximum predicted local exposure to cadmium indicated an increased risk of cancer, however, since this level was not typical for the area, MDHSS representatives did not predict an increased risk of cancer. Accordingly, MDHSS representatives concluded that no known risk was posed to the health of the Herculaneum community based on arsenic and cadmium levels in the area.

The report *Public Health Evaluation of Arsenic and Cadmium Levels in Air and Residential Soils in* Herculaneum (2002) acknowledged that the lack of information about both arsenic and cadmium levels in air and soil in the past made it impossible to determine the risk associated with cumulative exposure. The report also concluded that insufficient information existed to determine if increased health risks might be related to consumption of vegetables grown in the area. MDHSS representatives acknowledged that arsenic has been linked to kidney and bladder cancer, but at levels much higher than those measured in Herculaneum; however, since arsenic, cadmium, and lead all have impacts associated with the kidney it is thought that combined exposure to these metals may present a greater risk to the kidney. The study concluded: "Because some arsenic and cadmium exposure… is still possible, although at levels not expected to be harmful, this site is classified as a no apparent public health hazard for current exposure to arsenic and cadmium" (Missouri Department of Health and Senior Services & Agency for Toxic Substances and Disease Registry, *Health Consultation: Public health evaluation of Arsenic and Cadmium levels in air and residential soils - Herculaneum Lead Smelter*

Site, Herculaneum, Jefferson County, Missouri, 2002). Recommendations from the *Public Health Evaluation of Arsenic and Cadmium Levels in Air and Residential Soils* (2002) included the suggestion that an additional exposure investigation be conducted to explore past exposures and to determine the risk associated with locally grown vegetables.

Determining Baseline Prevalence for Provider-diagnosed Multiple Sclerosis (MS) and Amyotrophic Lateral Sclerosis (ALS) in Herculaneum and Jefferson County, Missouri (2002). A report titled *Determining baseline prevalence for provider-diagnosed multiple sclerosis (MS) and amyotrophic lateral sclerosis (ALS) in Herculaneum and Jefferson County, Missouri* (hereafter referred to as the MS and ALS prevalence study), completed in 2007 by the MDHSS Office of Epidemiology, was generated in response to local concerns that anecdotally high numbers of these diseases in the area might be linked to long-term lead exposures (Findings summarized in Table 6.2). ATSDR representative, Lilly Fischer, explained the complexity of conducting this epidemiological study:

When you're looking at prevalence, there were some people who came forward that said we had it but they weren't diagnosed in the period that we were looking at, cause there's always a lag time between onset of symptoms, when you're diagnosed, and when it gets reported. Plus there are different codes used as you look at medical charts so sometimes it's hard to pull out of it. So we could have missed some. We always hoped to get more money to look more closely at MS and ALS. (Interview, 5/18/2009)

According to Ms. Fischer, researchers remained uncertain that all cases of MS and ALS relevant to the study had been identified, and that more research on ALS and MS in the

Table 6.2: Summary of Findings from Health Consultation: Public health evaluation of arsenic and cadmium levels in air and residential soils – Herculaneum lead smelter site, Herculaneum, Jefferson County, Missouri (2002).

		MS	ALS
Overall		105 cases / 100,000 residents	3.9 cases / 100,000 residents
Gender	Female	169 cases / 100,000 residents	
	Male	41 cases / 100,000 residents	Majority of Cases were Male
Race		The majority of cases were white, non-Hispanic	Majority of cases were white, non-Hispanic
Age		The highest occurrence was between the ages of 50 and 59 years	The highest occurrence was over the age of 75, with a mean age of 65
Comparison to General Population		Prevalence not unusual when compared to other areas.	Prevalence not unusual when compared to other areas.
Additional Information			An accumulation of three cases was identified around the lead smelter.

area would have been useful. The following excerpt summarizes the research findings with regard to the identification of an ALS cluster around the Herculaneum lead smelter as reported in the *Journal of Neurological Sciences*:

A number of recent studies have suggested that impaired detoxification mechanisms play a role in the development of ALS; therefore environmental toxicity in a susceptible individual may precipitate ALS…. Our study has lent some support for the findings of those studies…. In summary, in Jefferson County, Missouri, the prevalence of ALS appears to be comparable to that seen in Western European countries in recent years. A small cluster of ALS cases was found in the proximity of a lead smelter…. Well-designed etiologic studies are needed to assess whether living in close proximity to a lead smelter may be associated with the development of ALS. (Turabelidze et al., p. 85 - 86.)

Thus, the conclusion in the main report indicated that a small but significant cluster of ALS cases identified near a heavy metals processing plant (Figure 6.5) was consistent with and supportive of the findings of similar studies conducted in Europe. The report called for extensive research to further investigate the relationship between residing near a lead smelter and developing ALS; however, the study was not limited to the

Herculaneum area, but considered Jefferson County as a whole since the county's population size allowed for appropriate sampling.

Residents' awareness and interpretation of the results of this study further demonstrate the misalignment between the regulatory objectives and concerned resident interest in associations between living near the lead smelter and development of MS and/or ALS. In our interview Herculaneum resident, Sophia Turner, discussed this study as an example of the ways that the environmental and health regulatory science was often not applicable to informing local residents about the specific challenges of living in a lead contaminated community.

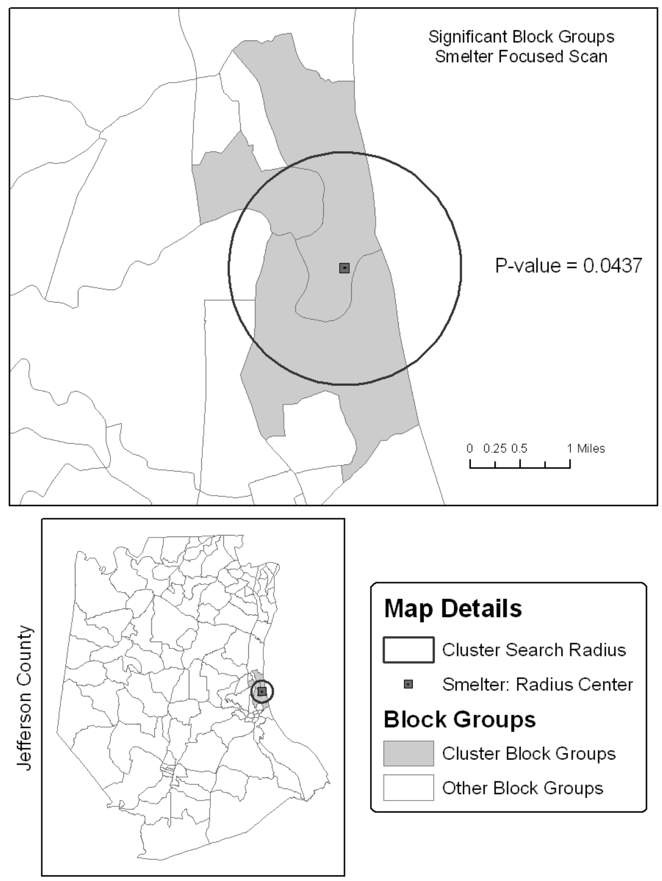


Figure 6.6: Maps Representing the Geographic Distribution of a Cluster of ALS Cases Surrounding the Herculaneum Facility Between 1998 and 2002.

There's a high incidence of MS and ALS in this town. They won't come out and say – well and of course they did the study. When they did the study, instead of just doing Herculaneum, they did all of Jefferson County. So that kind of messed the numbers up, but yet they could not deny that there was a cluster of ALS here in town, and I know several people who have MS in town but were not included in the study. (12/4/2008)

Ms. Turner displayed a great deal of knowledge and insight with regard to the scientific developments informing consideration of area health risks, as well as the environmental policy infrastructure shaping area lead management. Her statement illustrates that she weighed the procedures through which the study was conducted and her own experience of the Herculaneum community alongside the reported findings of the study. In so doing she questioned whether the actual risk of developing a neurodegenerative disorder based on living in close proximity to the smelter was reflected in the reported findings. The ALS and MS Study and the arsenic, cadmium and lead study are characteristic of other studies conducted at this time. Based on resident concerns, research was also conducted to determine health hazards associated with sulfur dioxide emissions, and the potential risks of living or working in Herculaneum schools, with each report concluding that although exposures were possible and community concern justified, no adverse effects were expected.

Health Consultation: Determination if Site-Specific Interior Dust Clean-Up Levels are Protective of Public Health – Herculaneum Lead Smelter Site, Jefferson County, Missouri (2003). One health and regulatory document did not fit the trend of shifting focus of health studies. The evaluation of interior dust clean up levels was conducted by a cooperative working group that included both regulatory representatives from MDHSS and MDNR and concerned community members. Interior lead dust became a concern in Herculaneum almost immediately following the 300,000 ppm finding and a focus group was quickly convened to determine the appropriate level of lead in dust that would trigger clean up specifically for this site, as well as appropriate screening procedures for interior dust. From 2001 to 2003 the group developed an extensive scientific background and carefully crafted model for the exposure pathway for interior dust with a particular emphasis on the source and contents of this dust in the local environment. Despite efforts to manage local contamination, the evaluation team's concern over ongoing lead emissions in Herculaneum were steadfast:

In developing a recommendation for site-specific interior dust lead clean-up level for Herculaneum, scientific evidence was evaluated which indicates that the current EPA lead dust standard, 40μg/ft^2 for floors, may not be protective of public health at this site…. For over 100 years, the smelter has released lead in their stack emissions as well as in fugitive dust from activities throughout the smelter, which has built-up in soil and other media over time. Although lead emissions from the smelter are declining, the smelter is still allowed to release up to 858.8 pounds of lead per day into the atmosphere. This continuing deposition and the historical environmental burden that has accumulated must be taken into account in the development of any interior lead dust clean-up level. (Missouri Department of Health and Senior Services Office of Epidemiology, 2007, p. 41-42)

Ultimately, the interior dust clean-up level was set at 20 μg/ft^2, half of the EPA's national clean up level (study findings summarized in Table 6.3). This recommendation reflected consideration of both historic and ongoing contamination, as well as a finding that local lead in interior dust was more highly bioavailable than the more common source of lead-based paint.

Table 6.3

Summary of Considerations for Setting Site Specific Interior Dust Clean-Up Level. From Health Consultation: Determination if Site-Specific Interior Dust Clean-Up Levels are Protective of Public Health – Herculaneum Lead Smelter Site, Jefferson County, Missouri (2003).

	Current EPA Lead Dust Standard	Standard in a Community with Similar Conditions	Relative Bioavailability	Proposed Standard for Herculaneum
Factors Considered	40 μg/ft^2	24 μg/ft^2	General U.S. value = 30% Herculaneum value = 36%	20 μg/ft^2

This discussion of the policy cycle that redefined lead contamination in Herculaneum in the early 2000s described transitions in regulatory activity following the crisis associated with the 300,00 ppm lead dust finding. Initially research was conducted and presented in a way that it contributed to the development of a convincing case for extending local lead management. The better known health concerns surrounding childhood lead exposures were central to framing the contamination crisis, and agencies worked to quantify and examine the local situation with regard to these health effects. Additional concerns voiced by residents and holding potential warrant in scientific research, as well as local anecdotal observations, did not provide the groundwork for a convincing case that lead management should be expanded. Rather the MDHSS reports described in this section emphasized uncertainties and inadequacies in scientific understandings of the potential risks they explored. At the same time MDHSS attempted to assure community-members that additional health harms associated with industrial activity were unlikely.

To be transparent, I am not arguing that this change in approach to regulation in Herculaneum was indicative of some sort of regulatory oversight or conspiracy. Rather I am pointing out that the emblematic 300,000 ppm finding and related circumstances served to align the interests of health concerned residents and regulatory representatives in Herculaneum toward expanding the definition of local lead contamination. In light of the crisis surrounding that finding, regulatory representatives constructed a convincing case for the expansion of existing definitions of local lead contamination, thereby extending local lead management by drawing upon existing programs in a novel manner. At the same time, concerned residents campaigned for and supported the buy-out and other clean up measures, often calling for even more stringent controls. As the crisis waned, residents that were most concerned about local health hazards maintained expectations that regulatory agencies would continue with the types of crisis-extending practices that characterized their activities early in the process. At the same time, stakeholders more interested in protecting community economic interests began to oppose further expansion of lead regulation. Additionally, no clear crisis emerged around community risks of development of ALS or MS or exposure to arsenic or cadmium that would justify additional regulatory measures. Thus, regulatory interests shifted from redefining the contamination problem and extending regulatory efforts to establishing that the solutions provided had been effective at managing the newly defined problems and were being maintained. In focusing on the maintenance of the conditions defined in the Voluntary Property Purchase Plan, and 2001 Administrative Order Of Consent modifications as well as adjusted RCRA orders and increased adherence to NAAQS standards regulatory agencies ushered in a new period of stasis. This period was short-lived, however, because health concerned residents cooperating with environmental activist groups were able to leverage events in Herculaneum to impact national lead policy.

The NAAQS Policy Cycle: Building a Case for Changing National Lead Policy

Developments in lead management in Herculaneum had important impacts on the regulation of lead contamination nationwide. Of particular consequence is the role that Herculaneum played in the 2008 revision of the NAAQS for lead. In the following sections I will discuss central components of the NAAQS review process: (1) the lawsuit that initiated and established a timeline for NAAQS review, (2) the Lead: Human Exposure and Health Risk Assessment for Selected Case Studies (2007), (3) the Air Quality Criteria Document (2006), (4) the Review of the National Ambient Air Quality Standards for Lead: Policy Assessment of Scientific and Technical Information – OAQPS Staff Paper, (2007) and (5) the National Ambient Air Quality Standards for Lead: Proposed and Final Rules (2008d, 2008e). A summary of the contributions from each report central to this analysis is provided in Table 6.4. I will conclude the chapter with a brief summary of connections between the policy cycles redefining local lead contamination in Herculaneum, and the one surrounding the NAAQS revision.

Table 6.4: Summary of major contributions of central reports generated in NAAQS review process.

2007 Lead: Human Exposure and Health Risk Assessment for Selected Case Studies	***2006 Air Quality Criteria for Lead, Final Report.***	***2007 Review of the National Ambient Air Quality Standards for Lead: Policy assessment of scientific and technical information - OAQPS Staff Paper.***	***2008 National Ambient Air Quality Standards for Lead: Proposed Rule***	***2008 National Ambient Air Quality Standards for Lead: Final Rule***
Pathways for consideration include inhalation & ingestions	Examine health effects associated with current air lead levels	Emphasized CAA requirement that NAAQS be set to protect the public from toxic exposures with an 'adequate margin of safety'	Requested comments on a proposed standard between 0.10 and 0.30 ug/dL	Lead NAAQS set at 0.15 ug/dL
Metrics for primary consideration will emphasize Blood Lead Levels	Although considerations must include childhood hematological and immune and adult renal, cardiac, and hematologic effects, IQ loss will remain central to risk calculations	Set review of goal as establishing an acceptable health effect, meaning an acceptable IQ loss	Requested additional comments on levels below 0.10 and up to 0.50.	NAAQS of 0.15 ug/dL associated with a mean IQ loss of less than two points
Endpoints central to consideration will be neurological deficit in terms of IQ decrement	Responses to lead exposure are individuated by genetic and environmental factors	Mean IQ loss of 1-2 points associated with a standard between 0.1 and 0.2 ug/dL and reflective of existing scientific evidence.	Additional comments were solicited on when it might be appropriate to consider a lead NAAQS of zero	NAAQS of 0.15 ug/dL considered protective within the "adequate margin of safety" guideline of the CAA
Strategy will involve connecting specific air lead levels with a range of blood lead levels and associated IQ decrement	Consider effects in terms of population shifts rather than individual impacts	Mean IQ loss of less than one point associated with a standard between 0.02 and 0.05 and express precaution in the face of current scientific evidence	EPA also requested comments on changes in the indicator, averaging time, and form of the lead NAAQS	NAAQS of 0.15 ug/dL expected to contribute to substantial improvement in environmental conditions for the most highly exposed populations

Missouri Coalition for the Environment et al vs. United States Environmental Protection Agency.

Health concerned community members in cooperation with environmental advocacy groups emerged from the policy events of the early 2000s that transformed local lead regulation in Herculaneum with a desire to continue improving environmental conditions in the area. They described three observations pivotal in shaping this effort: (1) local environmental conditions were improving and a new level of 'clean' was being enforced in Herculaneum, (2) despite improvements ongoing smelter emissions would continue to expose local residents to lead and recontamination of remediated areas would likely occur, and (3) air emissions from the plant stack were a substantial source of ongoing health threats. Local resident and health activist, Isabella Robinson, reflected on that period:

There was a point where right after the AOC [2001 Administrative Order of Consent] went into effect they were meeting the 1.5 NAAQS. They were cleaning up the yards, they were doing remediation, everything like that… .We have these people we're still concerned about. Where do we go from here? Well, we're still dealing with them barely meeting an outdated NAAQS standard, so there has to be children still exposed in that town. Let's see what we can do to at least get the standard and update it…. Let's sue the EPA to review. (Interview,10/7/2008)

Accordingly, in May of 2004 the Washington University Interdisciplinary Environmental Clinic (WUIEC), on behalf of the Missouri Coalition for the Environment (MCE), and a group of Herculaneum residents, sued the EPA to review the lead NAAQS. The lawsuit argued that EPA had failed to meet the mandated schedule for NAAQS review. The 1970 Clean Air Act required that each NAAQS be reviewed every five years to ensure that standards reflect the most current scientific understandings of contamination and toxicity. The lead NAAQS had last been considered in 1990 in a partial review and a full review was last conducted in 1986. Neither of these reviews produced revisions to the lead NAAQS, however, so the original standard of 1.5 ug/dL set in 1978 remained in effect. Air lead levels nationwide have fallen well below the standard since the 1980s due to the removal of lead from gasoline and industrial emissions controls (Figure 6.7). In response to the lawsuit, EPA argued that "it chose not to revise the criteria based on the most current CD and staff paper relating to lead [1990]" (Missouri Coalition for the Environment v. U.S. Environmental Protection Agency, 2005, p. 3). The MCE responded that EPA had not "definitively stated that it considered the review complete and that it was inappropriate to revise the standards" (Missouri Coalition for the Environment v. U.S. Environmental Protection Agency, 2005, p. 3). Eventually EPA agreed to MCE's claim that a review of

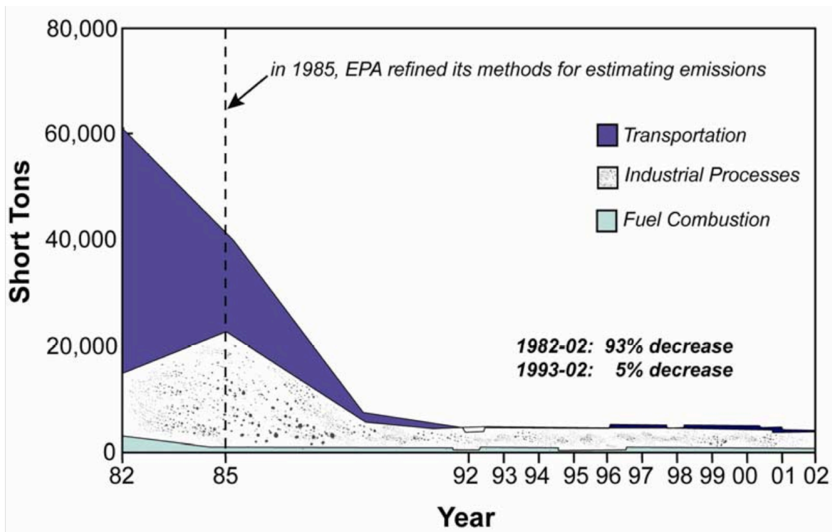


Figure 6.7. Illustrates a substantial reduction in air lead emissions between 1982 and 2002. From U.S. Environmental Protection Agency. (2006). *Air Quality Criteria for Lead, Final Report*. (EPA/600/R-05/144aF-bF). Washington, DC. p. 8-6.

the lead NAAQS was warranted, however, the parties continued to debate the time required for EPA to conduct such a review. In the final judgment, the District Court of Missouri, Eastern Division ruled that EPA was required to perform the scientific assessment, regulatory development, and implementation phases of the review of the lead NAAQS according to a prescribed timeline, outlined in Table 6.5.

Table 6.5

Comparison of timetables for NAAQS review processes suggested by MCE and EPA and court ordered deadlines for finalization.

Mandated Document	MCE Suggested Date for Finalization	EPA Suggested Date for Finalization	Court Ordered Deadline for Finalization
Air Quality Criteria Document	December 30, 2005	Feb. 28, 2007	October 1, 2006
OAQPS Staff Paper	December 30, 2005	Not listed	January 1, 2007
Proposed Rule	January 20, 2006	September 26, 2007	May 1, 2008
Final Rule	May 30, 2006	June 26, 2009	September 1, 2008

Missouri Coalition for the Environment v. U.S. Environmental Protection Agency, No. 4:04CV00660 ERW (Eastern District Court of Missouri 2005).

The Influence of the Herculaneum Context on The NAAQS Review Process

Through their work in documenting lead contamination in Herculaneum, representatives of the EPA, MDNR, ATSDR, MDHSS, and Jefferson County Health Department working in the area presented decision-makers in the national EPA Air Program with the evidence of health effects from ongoing exposures to industrial sourced, multiple media contamination from Herculaneum. This evidence provided a unique perspective about the long-term impacts of ambient air concentrations approximating the 1.5ug/m^3 NAAQS standard for lead (Interviews with EPA representatives Elizabeth Gray, 1/21/2009 and Andrew Cole 2/27/2009). The Herculaneum context was central to lead NAAQS discussions since it was one of only two areas in the nation areas considered noncompliant with the existing lead standard, and the only noncompliant area with an active lead processing facility:

Only two areas, the East Helena, Montana Area..., and part of Jefferson County in Herculaneum, Mo. are designated nonattainment for the current National Ambient Air Quality Standards for lead. The industrial facility contributing to the lead problem in the East Helena area closed in 2001 (Fact Sheet for the Risk Assessment, 2008. p. 2)

Accordingly, conditions in Herculaneum served as proof of the potential impacts of lead levels both above and approximating the standard in a context of ongoing contamination. Measurements of dust and soil contamination in Herculaneum along with evidence linking human lead exposures to air-related dust and soil contamination were especially convincing . The lead industry's suggestion that regulation of lead through its air program should be eliminated because the existing NAAQS was easily met across the country (with the exception of two areas) was poorly received in light of evidence linking contamination approximating the 1978 NAAQS to human health impacts produced in Herculaneum in the early 2000s. EPA Air Program representative, Elizabeth Gray, explained the role that Herculaneum's situation played as an emblematic setting for reconsidering the lead NAAQS:

Herculaneum played a very big, large role… .I think that they played a very important role in suing us, and then moving the action forward, and Herculaneum was one of the case studies…. To be able to say, "'Sure, we haven't addressed this for a long time because it hasn't been as much of an issue across the country, but this is an area where people are being affected directly by this." And so it is important that we look at this again and review it, and it's not something that we can just dismiss and say, "Oh that problem is solved." (Interview, 1/21/2009)

Another EPA representative, primarily involved in Herculaneum through Superfund (CERCLA), explained how the regulatory work conducted in Herculaneum was instrumental in demonstrating the multiple pathways through which humans can be exposed to lead originating from air pollution:

I don't know if you've been following the air emission standard for lead, but that's been a real interesting saga, and Herculaneum is very, very instrumental in that happening. Not just the fact that the Missouri Coalition sued the agency to follow their own regs and do their job, but the fact that we [EPA representatives working in Herculaneum] had developed a lot of important data that went into influencing that new number. I think that's a positive; I think that's a success. That's what we're supposed to be doing is looking at new data and evaluating it. (Interview, Andrew Cole, 2/27/2009)

Thus, in addition to being the focus of the lawsuit that initiated the lead NAAQS review, regulatory agents considered their efforts to redefine lead contamination in Herculaneum to be central to shaping foundational aspects of the revision process. MDNR representative Nick Peterson emphasized one of the central contributions of evidence from Herculaneum to shaping the NAAQS review:

I think some of the work we did in Herculaneum was instrumental in making that [the new lead NAAQS] happen. It seemed like a lot of folks weren't adequately making the link between air emissions and soil concentration, secondary exposure that people have to soil. That's something we did in Herculaneum (Interview, 2/19/2009).

According to the interpretive theoretical lens utilized in this dissertation, evidence from the redefinition of local contamination in Herculaneum was used to undermine dominant understandings of air lead contamination early in the NAAQS review process. In the following sections I will demonstrate that characterizing the links between air emissions, soil and dust concentrations, and human exposures became a primary focus of the NAAQS review process, and that data gathered through the early 2000s lead cycle in Herculaneum was influential throughout the NAAQS review.

Overview of the NAAQS review process. The Clean Air Act of 1970 governs the establishment and enforcement of standards for the regulation of six criteria pollutants, one of which is lead. The details of the NAAQS review and revision process are well established in both the 1970 Clean Air Act and procedural practices within EPA. The purpose of NAAQS and, therefore, the goal of the NAAQS revision process is foregounded throughout all NAAQS review documents and discussions:

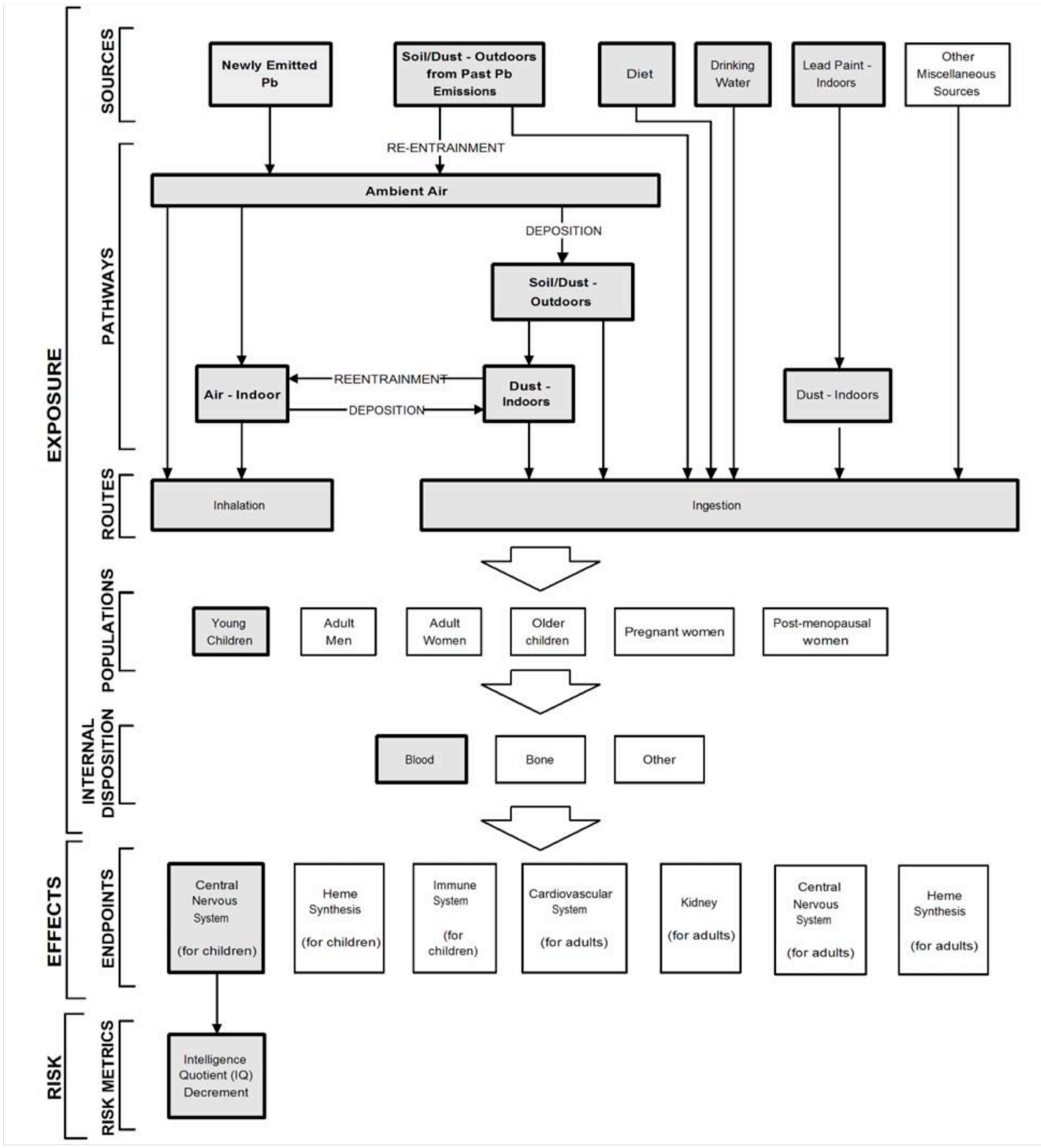
Sections 108 and 019 of the Clean Air Act (CAA) govern the establishment and periodic review of the National Ambient Air Quality Standards (NAAQS) by the U.S. Environmental Protection Agency (EPA). These standards are established for pollutants that may reasonably be anticipated to endanger public health and welfare, and whose presence in the ambient air results from numerous or diverse mobile or stationary sources. The NAAQS are to be based on air quality criteria, which are to accurately reflect the latest scientific knowledge useful in indicating the type and extent of identifiable effects on public health or welfare that may be expected from the presence of the pollutant in ambient air. (U.S. Environmental Protection Agency & Office of Air Quality Planning and Standards, 2007, p. 1-1)

The review process for the 2008 lead NAAQS followed an established pattern involving various groups within EPA and an independent scientific advisory board mandated by the Clean Air Act (Missouri Coalition for the Environment v. U.S. Environmental Protection Agency, 2005, p. 3). The Clean Air Scientific Advisory Committee (CASAC) served in the role of advisory board and provided EPA with important feedback throughout the review process (U.S. Environmental Protection Agency, *National Ambient Air Quality Standards for Lead: Final Rule*, 2008). The public is also given opportunities to give feedback on EPA's progress and direction at critical junctures in the review process following the development of key documents. The scientific assessment phase of the NAAQS review process depended on the generation of two central documents, the Lead: Human Exposure and Health Risk Assessment for Selected Case Studies (2007) and the Air Quality Criteria Document (2006). Together these documents served to expand the problem definition associated with lead in air to better reflect updated scientific findings about lead contamination and toxicity. A Review of the National Ambient Air Quality Standards for Lead: Policy assessment of scientific and technical information – OAQPS Staff Paper (2007) was developed by EPA's Office of Air Quality Planning and Standards. This report outlined the policy options available to the administrator and was central to the regulatory development phase of the NAAQS review process. In the Air Quality Criteria for Lead: Proposed Rule (2008) the EPA Administrator interpreted evidence from the scientific assessment phase of the review process in light of the policy options provided and suggested a range of appropriate revisions to the lead NAAQS. After a comment period on the proposed rule passed, the Air Quality Criteria for Lead: Final Rule (2008) was released, which detailed and defended the EPA Administrator's final decision. His discussion pulled from each of the documents considered in this section to build a case for (1) an expanded definition of the problem of lead contamination in the air and (2) the adequacy of the revised standard to address the updated policy problem. A brief discussion of each of these central documents and their contributions to building a case for a significantly reduced lead NAAQS are included in the following sections.

Lead: Human Exposure and Health Risk Assessment for Selected Case Studies. The Lead: Human Exposure and Health Risk Assessments and Ecological Risk Assessment for Selected Areas (2007) (hereafter referred to as the 2007 Risk Assessment) was developed by the EPA's Office of Air Quality Planning and Standards to quantify the risks associated with exposure at current, compliant, and proposed levels of contamination. The 2007 Risk Assessment focused particularly on harmful effects of lead exposures approximating current conditions throughout the nation. Thus, the focus of the analysis was on levels of human lead exposure that were far lower than those considered in prior lead NAAQS reviews. The 2007 Risk Assessment traced human exposure to lead from initial sources, pathways into the human environment, routes of exposure, exposed populations, internal dispositions (tissues that reflect exposures), endpoint systems where health effects are observed, and exposed populations (See Figure 6.10).

My analysis of NAAQS review documents indicated that decisions made in the 2007 Risk Assessment were foundational to establishing the indicators of interest for two central dimensions of NAAQS consideration. First, inhalation and ingestion of media contamination from lead in ambient air were reported as the most significant exposure pathways relevant to the lead NAAQS review. Second, the risk analysis identified the estimation of neurological deficit in terms of IQ decrement in young children as the health effect to be quantified in the risk analysis. This decision was based on past research, which established a relationship between IQ loss and lead exposure levels approximating modern exposures.

The 2007 Risk Assessment's emphasis of ingestion as an important exposure pathway related to lead in the air is reflective of the influence of regulatory efforts in Herculaneum to understand lead in terms of multimedia contamination. Contributions of various exposure pathways to blood lead and IQ loss as they were modeled in the 2007 Risk Assessment are outlined in bold in Figure 6.8. Consideration of the ingestion of soil and dust as an important pathway of human lead exposure was a notable departure from prior NAAQS reviews. This was particularly true of the initial lead NAAQS established in 1978 when the primary focus was on the direct inhalation of airborn lead. The 1986 lead NAAQS review acknowledged important contributions to human exposure from non-air sources, but did not consider these sources relevant to the regulation of lead in air. In the 2007 Risk Assessment the OAQPS incorporated additional complexity into the analysis by including multimedia contamination considered to originate with air sources:



Note: Boxes outlined in bold are included in the quantitative risk assessment. Sources and pathways for which ambient air has played a role are in bold text.

Figure 6.8. Conceptual Model for Lead Human Exposure and Health Risk Assessments. Demonstrates inclusion of Soil and Dust ingestion pathways in consideration of contamination sources and pathways in risk analysis. From U.S. Environmental Protection Agency, & Office of Air Quality Planning and Standards. (2007). *Lead: Human Exposure and Health Risk Assessment for Selected Case Studies*. (EPA-452/R-07-014a). Research Triangle Park, NC: Retrieved from http://www.epa.gov/ttnnaaqs/standards/pb/data/20071101_pb_ra_body.pdf.

The focus for this Pb NAAQS risk assessment is on Pb derived from those sources emitting Pb to ambient air. In designing and implementing this assessment, we have been faced with significant limitations and complexity that go far beyond the situation for similar assessments typically performed for other criteria pollutants. In addition to the constraints of the timeframe allowed for this review, we are also constrained by significant limitations with regard to data and tools needed for the assessment. The multimedia and persistent nature of lead and the role of multiple exposure pathways contribute significant additional complexity to the assessment as compared to other assessments that focus only on the inhalation pathway. (U.S. Environmental Protection Agency & Office of Air Quality Planning and Standards, 2007, p. 1-5).

Since the estimation of neurological deficit was identified as the central health effect in the 2007 Risk Assessment, it became necessary to link this effect with specific levels of exposure. A spectrum of BLL's were modeled such that air lead levels represented the independent variable and IQ scores represented the dependent variable. The primary difference between the risk assessment approach used in the current pilot analysis and the assessment completed in 1990 involves the risk metric employed, which reflects the quantitative and qualitative health effects evidence available today that was not available in 1990 (CD). Rather than estimating the percentage of study populations with exposures above blood Pb levels of interest as was done in the last review (i.e., 10, 12 and 15 μg/dL), the current pilot analysis estimates the degree of health decrement in study populations exposed to Pb. Specifically, the pilot analysis estimates the distribution of IQ loss associated with Pb exposure for child populations at each of the case study locations with that IQ loss further differentiated between background Pb exposure and policy-relevant exposures. (U.S. Environmental Protection Agency & Office of Air Quality Planning and Standards, 2007, p. 1-5)

Since IQ decrements in young children have been repeatedly demonstrated and quantified at lead levels approximating levels relevant to environmental exposures of today, this health effect was the primary harm considered in limiting the levels of lead permissible in air. The conceptual model linking ingestion and inhalation to BLL and IQ decrement used in the risk assessment is illustrated in Figure 6.9. The projected quantitative relationship between environmental lead levels, consequent blood lead levels, and projected IQ deficits was carried through the entire NAAQS revision process, and was a topic of lengthy discussion in the National Ambient Air Quality Standard for Lead: Final Rule (2008). The emphases on both IQ decrement and multi-path, multi-source exposure were maintained throughout the entire policy-making process; and although many health effects were identified as important, it was limiting IQ decrement that dominated the policy goal addressed in the National Ambient Air Quality Standard for Lead: Final Rule of 2008.

It is important to note that Herculaneum played a particularly significant role in the 2007 Risk Analysis. Herculaneum was included in the 2007 Risk Assessment as the only extant case with current compliance problems, as the secondary smelter case in Troy, Alabama involved far less severe contamination. Findings associating exposures at various projected lead NAAQS levels with corresponding IQ loss for the median and 95th percentile of the Herculaneum area population are presented in Table 6.5. Although both the current conditions and a model reflecting attainment were considered, negligible

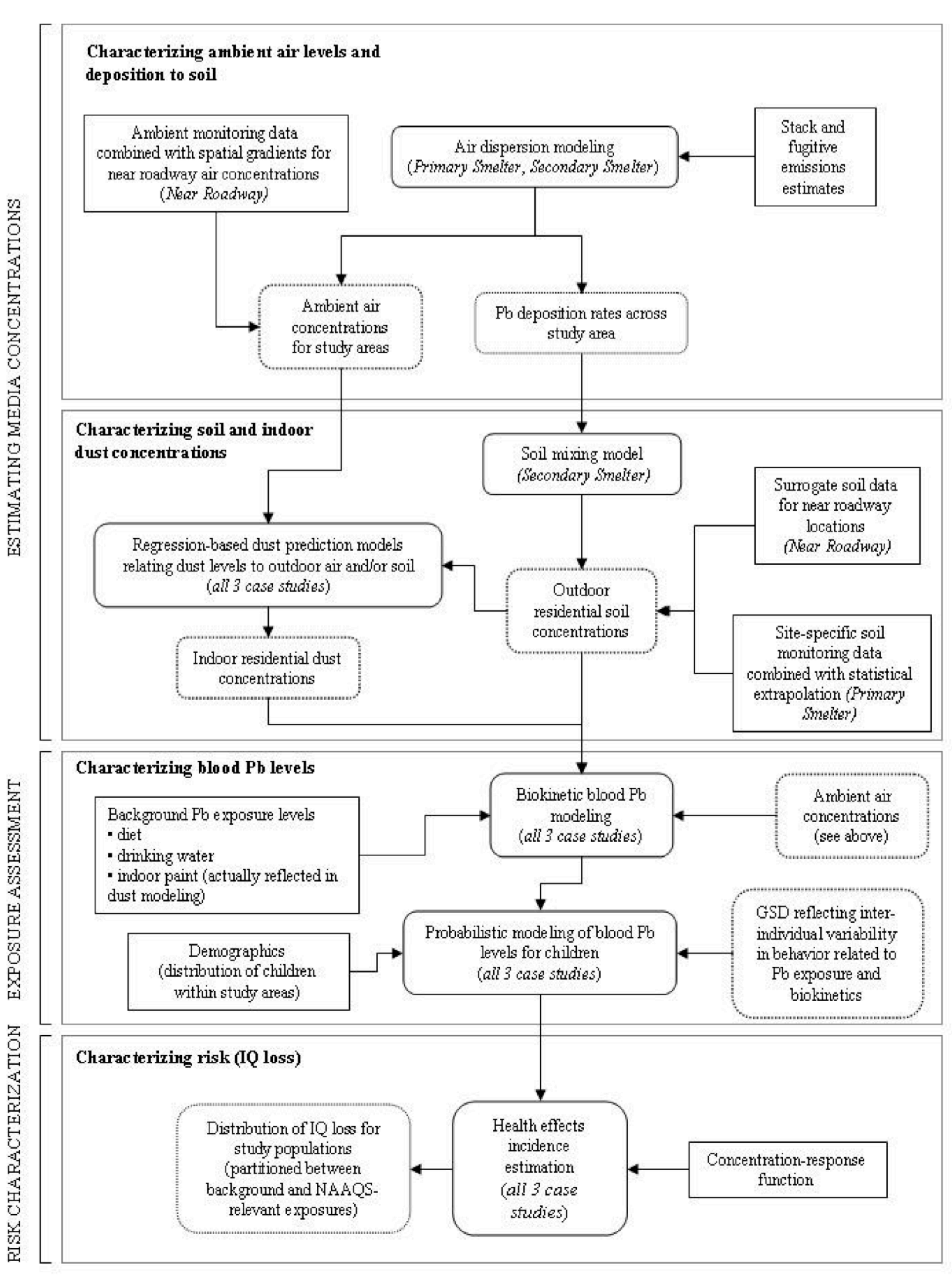


Figure 6.9. Overview of Analytical Approach for the 2007 Risk Analysis. Demonstrates the process of characterizing risk in terms of tracing sources of exposure to quantification of IQ loss. From U.S. Environmental Protection Agency, & Office of Air Quality Planning and Standards. (2007). *Lead: Human Exposure and Health Risk Assessment for Selected Case Studies*. (EPA-452/R-07-014a). Research Triangle Park, NC: Retrieved from http://www.epa.gov/ttnnaaqs/standards/pb/data/20071101_pb_ra_body.pdf. p. 2-36.

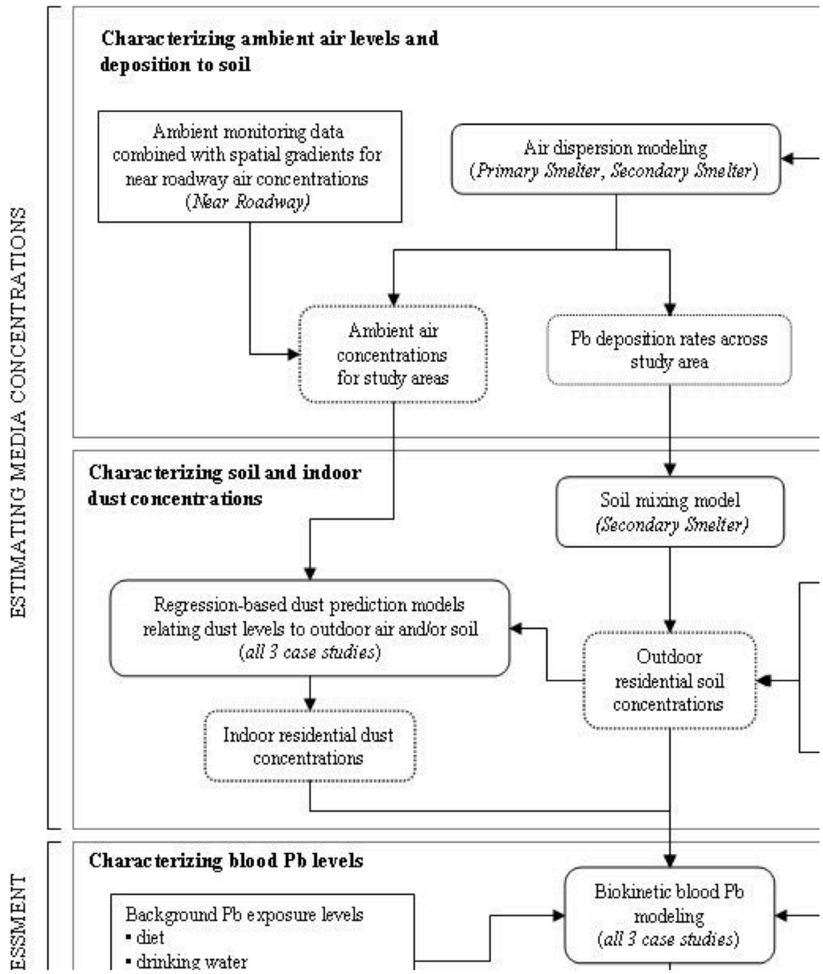
differences were shown to exist for the entire study area providing further justification for a reduction to the existing lead NAAQS. Building on the quantification of health effects for various levels of exposure to sources of lead considered relevant to air policy in the 2007 Risk Assessment, the Air Quality Criteria Document (2007) "provide[d] a critical assessment of the latest available scientific information upon which the NAAQS is to be based" (U.S. Environmental Protection Agency, 2006, p. 1-1).

Air Quality Criteria Document (2006). In developing the 2006 Air Quality Criteria Document, EPA described relevant research having emerged since the 1990 lead NAAQS review (U.S. Environmental Protection Agency, *National Ambient Air Quality Standards for Lead: Final Rule*, 2008).[22] The 2006 Air Quality Criteria Document synthesized the current state of knowledge related to health effects of various concentrations of lead in ambient air. Results from the 2007 Risk Assessment were reflected in the 2006 Air Quality Criteria Document in two primary ways: (1) the consideration of multiple routes of exposure, and (2) the focus on the neurological effects on children as the primary health outcome.

In developing the 2006 Air Quality Criteria Document, the EPA's National Center for Environmental Assessment in Research considered multiple exposure routes (Figure 6.12*)*. The graphic in Figure 6.12 traces the various sources of lead in the environment through processes of dispersion to identify specific routes of exposure. The heavy arrows toward the left side of the graphic indicate a link between ambient air to soil and dust.

[22] Throughout NAAQS review processes EPA exchanges drafts of the most central documents, however, none of these are finalized until all parties come to agreement on the final report. Thus, although the 2007 Lead: Human Exposures and Health Risk Assessment for Selected Case Studies has a later publication date than other documents, the draft report was the first step in the review process and other drafts were developed utilizing information obtained through the risk assessment process.

These pathways were considered to be relevant to air regulation. The discussion in the Criteria Document considered the identification of the most pressing effects of low level lead exposure according to recent scientific findings. While childhood neurological effects were part of the detailed analyses of lead exposure and toxicity in the 2006 Air Quality Criteria Document, childhood hema tological (related to the blood) and immune and adult renal (related to the kidney), cardiovascular,



and hematological effects were also considered to be of concern. Because of the extensive research surrounding childhood neural effects at levels of exposure more reflective of those commonly found in the modern day U.S., however, childhood neural effects were retained as the main health indicator for the lead NAAQS review. Furthermore, it was noted that the neurological impacts on children can substantially alter life-course, partially due to the potential to harm development and impair early learning processes, which were acknowledged as foundations for future life outcomes.

Three important contributions were made by the 2006 Air Quality Criteria Document to the NAAQS review process. First, the review would focus on levels of exposure that reflect current environmental conditions. Second, the review accounted for the attenuation of individual response to lead exposure by specific characteristics of individuals (i.e., genetic factors, health history, nutrition). Finally, the review recommended that IQ loss be evaluated in terms of both individual risk and population effects.

Due to the stark decline in air lead levels and population mean blood lead levels since prior reviews conducted by EPA in 1978,1986, and 1990. The 2006 Air Quality Criteria Document emphasized that a preponderance of current scientific information about the health effects of lead exposure indicate impacts at levels below what was considered hazardous in prior reviews:

Newly available scientific information… further expands our understanding of a wide array of Pb-induced health effects, underlying mechanisms, and factors that enhance or lessen susceptibility to Pb effects. Very importantly, the newly available toxicologic and epidemiologic information, as integrated below, includes assessment of new evidence substantiating risks of deleterious effects on certain health endpoints being induced by distinctly lower than previously demonstrated Pb exposures indexed by blood-Pb levels extending well below 10 µg/dL in children and/or adults. (U.S. Environmental Protection Agency, 2006, p. 8-25)

To protect against these lower-level effects, further reductions of environmental sources of lead exposure was considered an important public health goal. Thus, a convincing argument for the reduction of the lead NAAQS began to emerge in the 2006 Air Quality Criteria Document.

In past reviews EPA primarily handled IQ loss by considering the impact of the mean IQ loss across the population. The review for the 2008 NAAQS instead considered the range of potential BLLs expected at a particular air lead concentration, which were shown to deviate based on individual factors such as nutrition and genetic inheritance. This range in exposure levels was then used to predict IQ losses the population, providing for a range of effects so that specific consideration could be made for groups residing at the extreme ends of the distribution.

The 2006 Air Quality Criteria Document took both individual risk and population effects into consideration when measuring the impacts of air lead contamination. The 2006 Air Quality Criteria Document argued that lead absorption and biological response are individually attenuated: “Individuals for whom the Pb [lead] biomarker measured has the same value can have markedly different values on the health indicator measured…. A major challenge is therefore to decompose this variability, to distinguish components of it that reflect error from components that reflect biological processes that determine an individual’s response to Pb” (p. 8-70). Two of the most influential factors involve genetic markers and dietary nutrition. Balancing individual and population effects was further discussed in the following excerpt:

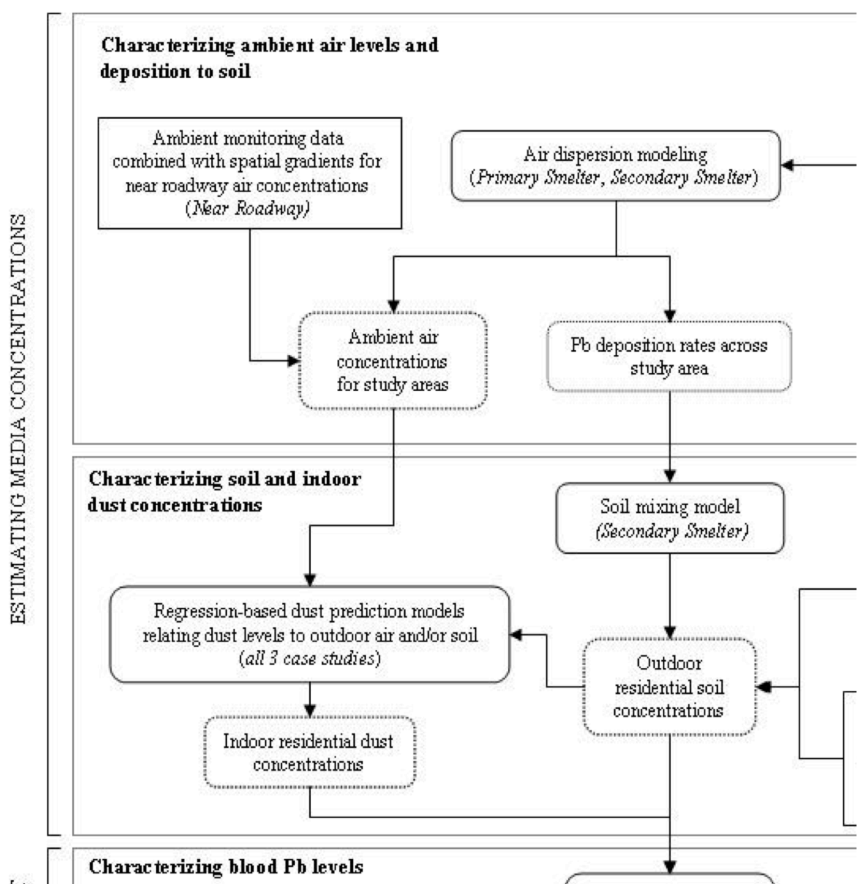
The critical distinction between population and individual risk, an issue pertinent to many questions in chronic disease epidemiology, has often been blurred in discussions of the public health implications of Pb-associated decrements in health. In regard to neurodevelopment, although a two- or three- point decline in IQ might not be consequential for an individual, it is important to note that this figure represents the central tendency of the distribution of declines among individuals. Thus, some individuals might manifest declines that are much greater in magnitude, while others manifest no decline at all, reflecting interindividual differences in vulnerability… Moreover, interventions that shift the population mean, in a beneficial direction, by an amount that is without clinical consequence for an individual have been shown to produce substantial decreases in the percentage of individuals with values that are clinically significant. (U.S. Environmental Protection Agency, 2006, p. 8-77)

Thus, the effects of lead exposure vary by individual, but must be considered in terms of how a shift in the population mean IQ represents important health consequences for groups that are more vulnerable to the health effects of lead exposures.

Review of the National Ambient Air Quality Standards for Lead: Policy Assessment of Scientific and Technical Information - OAQPS Staff Paper. The 2007 Review of the National Ambient Air Quality Standards for Lead: Policy Assessment of Scientific and Technical Information - OAQPS Staff Paper (hereafter referred to as the 2007 OAQPS Staff Paper) developed by EPA's Office of Air Quality Planning and Standards (OAQPS) informed the regulatory development phase of the NAAQS review process and connected the scientific analyses in the 2006 Air Quality Criteria Document and the 2007 Risk Assessment to the intricacies of policy decision-making. The 2007 OAQPS Staff Paper provided a detailed discussion of the various policy options to be considered by the EPA Administrator in choosing whether or not to revise the standard.

The 2007 OAQPS Staff Paper also summarized the scientific assessment in terms of warranted levels for a revised standard (OAQPS, 2007).

The 2007 OAQPS Staff Paper retained and built on the important developments identified in the 2007 Risk Assessment and the 2006 Air Quality Criteria Document. Important advances from 2007 OAQPS Staff Paper included developing a new model for assessing lead levels in ambient air that might be considered acceptable, and projecting levels for the revised standard reflecting particular policy goals.



The model for establishing an appropriate level for the lead NAAQS used in the 2007 OAQPS Staff Paper traced sources of exposure to human routes of exposure in terms of policy-relevant sources (directly related to air-lead concentrations and policy-relevant background sources (contribute to lead exposure in the population but are not directly related to concentrations of lead in the air) (Figure 6.13). For the lead NAAQS review OAQPS staff emphasized empirical evidence as less uncertain than risk assessment and therefore relied more heavily on the conclusions of the review of research in the 2006 Air Quality Criteria Document than the models and projections of the 2007 Risk Assessment. The review of the lead NAAQS conducted in the late 2000s initially followed a precedent identified with previous NAAQS reviews, which established a policy goal of the identification of a safe exposure level associated with an appropriate mean BLL and prescribed air lead level:

At the time of the last review, Pb was recognized to produce multiple effects in a variety of tissues and organ systems across a range of exposure levels, with blood Pb levels of 10-15 µg/dL being recognized as levels of concern for impaired neurobehavioral development in infants and children… The current CD [refers to the 2006 Air Quality Criteria Document] recognizes the existence of a wide array of Pb[lead]-induced deleterious effects, including several in children and/or adults that are induced by blood Pb [lead] levels extending well below 10 µg/dL, to below 5 µg/dL and possibly lower. (U.S. Environmental Protection Agency, *Review of the National Ambient Air Quality Standards for Lead: Policy assessment of scientific and technical information - OAQPS Staff Paper*, 2007, p. 3-1)

In 1978 the standard was set such that a high percentage of the population would have a blood level approximating an established level deemed to be safe. This level placed most areas of the country at air lead concentrations well below the standard where mean BLLs were far below those in more highly exposed areas. In light of evidence that has emerged since 1990 indicating no safe level of lead exposure, the goal in this staff paper became to identify the lowest BLL that has been shown to display adverse health effects and set the NAAQS such that the mean BLL of the exposed population (i.e. children living in communities where air levels approximate the standard) would lie below that level. By considering the exposed population, rather than the national population mean as the targeted indicator, the OAQPS staff calculated the standard in such a way to account specifically for populations in areas like Herculaneum where exposure levels are highest. Accordingly, for the 2007 OAQPS Staff Paper an *acceptable* health effect, in this case mean IQ loss, was established then an associated mean BLL and maximum allowable air lead level were determined according to calculations from the 2006 Air Quality Criteria Document and 2007 Risk Assessment.

The view that a NAAQS standard would reflect an *acceptable* detrimental health effect represents an ideological shift in managing toxic exposure. As described in Chapter Two, all previous lead regulations relied on a threshold of 'safe' exposure. In fact toxic contaminant management has generally depended on the identification of a level of exposure that was considered safe (U.S. Environmental Protection Agency, 2006, *Review of the National Ambient Air Quality Standards for Lead: Policy assessment of scientific and technical information - OAQPS Staff Paper*, 2007). The shift to considering acceptable health effects resulted from scientific developments that indicated that toxic exposures at all levels produce negative physiological consequences for at least the most vulnerable groups:.

In the Staff Paper application of an adapted 1978 framework, the focus shifted away from identifying a safe blood Pb level for an individual child (and then determining an ambient air level that would keep a very high percentage of children at or below that safe level), because information was no longer available to identify such a level. Rather, the Staff Paper approach focused on identifying an appropriate population mean blood Pb level, and then identifying an ambient air level that would keep the mean blood Pb levels of children exposed at that air level below the target population mean blood Pb level. Based on the review of the evidence, the Staff Paper approach substituted a level of 2 μg/dL for the target population geometric mean blood Pb of 15 μg/dL used in 1978. In the absence of a demonstrated safe level, at either an individual or a population level, the Staff Paper used 2 μg/dL as representative of the lowest population mean level for which there is evidence of a statistically significant association between blood lead levels and health effects… The approach takes as the public health goal the identification of an ambient air lead level that can be expected to keep the mean blood lead level of an exposed population of children at or below the lowest level at which a statistically significant association has been demonstrated between blood lead level and neurocognitive effects. (U.S. Environmental Protection Agency, *Review of the National Ambient Air Quality Standards for Lead: Policy assessment of scientific and technical information - OAQPS Staff Paper*, 2007, p. 29238)

The OAQPS staff concluded that establishing a lead NAAQS with reference to a precise policy goal was necessary and identified a standard between 0.1 and 0.2 μg/m^3 to be associated with a mean IQ loss of one to two points. OAQPS staff argued that this range reflected current scientific evidence of actual effects of exposures at this level. Alternatively, the OAQPS staff recommended that the standard should be set between 0.02 μg/m^3 and 0.05 μg/m^3 if the policy goal was a mean IQ loss of less than one point.

Staff argued that this range would reflect precaution in the face of uncertainty regarding the health effects of lead at these very low levels

National Ambient Air Quality Standards for Lead: Proposed and Final Rules (2008). In the National Ambient Air Quality Standards for Lead: Proposed Rule (2008) and National Ambient Air Quality Standards for Lead: Final Rule (2008) the EPA Administrator judged the preponderance of current scientific research focused on lead's human health impacts. In particular he focused on, epidemiological and vector (extrapolation from animal research) evidence summarized in the 2006 Air Quality Criteria Document, the discussion of various risks associated with exposures at the level of the existing standard, and an evidence-based IQ to air lead model developed to complement the 2007 Risk Assessment. Since the administrator must set standards to protect public health with an adequate margin of safety while not necessarily eliminating all risk, he identified an acceptable IQ loss of approximately two to five points in the subpopulation of impacted children.

In the proposed rule the administrator requested comments on proposed changes in the "indicator" (tools and units used for measurement), "averaging time" and "form" (the time unit and method for averaging collect data for comparison to the standard), and "level" of the new lead NAAQS. The new level of the lead NAAQS will be the primary focus of this discussion as it is the most notable revision, and most pertinent to forthcoming occurrences related to implementation of the new NAAQS in Herculaneum. Based on the scientific assessments from the 2007 Risk Assessment and 2006 Air Quality Criteria Document and the policy recommendations from the 2007 OAQPS Staff Paper, the administrator requested that comments be made on a potential standard in the range of

0.10 μg/m^3 to 0.30 μg/m^3, although comments would also be accepted on levels below 0.10 μg/m^3 and up to 0.50 μg/m^3. An additional request was included for comments on whether and at what time the consideration of a standard of zero would be appropriate. The administrator suggested his inclination to follow the OAQPS staff's recommendations for setting a standard that was protective of public health in accordance with existing scientific evidence. By offering to accept additional comments on levels both higher and lower than the proposed range, he left the conversation open to both advocates for more precautionary approaches, and a more permissive recommendations related to the lead NAAQS. The EPA Administrator followed the lead of OAQPS staff in his identification of the population of interest in lead NAAQS considerations:

Further, in considering the risk estimates in light of IQ loss estimates… of the air-related IQ loss evidence-based framework, we focus here on risk estimates for the general urban and primary Pb smelter subarea case studies as these cases studies generally represent population exposures for more highly air-pathway exposed children residing in small neighborhoods or localized residential areas with air concentrations nearer the standard level being evaluated than do the location-specific case studies in which populations have a broader range of air-related exposures including many well below the standard level being evaluated. (Jasanoff, 1990)

The exposure experienced by areas with levels approaching the NAAQS was central in the EPA administrator's calculation of a range of appropriate lead NAAQS levels.

After consideration of comments from CASAC and the public the EPA administrator set the lead NAAQS at 0.15 μg/dL, a reduction of the 1978 lead NAAQS by a factor of ten :

Thus, after carefully taking the above comments and considerations into account, and fully considering the scientific and policy views of the CASAC, the Administrator has decided to revise the level of the primary Pb standard to 0.15 µg/m3… The Administrator judges that such a standard would protect, with an adequate margin of safety, the health of children and other at-risk populations against an array of adverse health effects, most notably including neurological effects, particularly neurobehavioral and neurocognitive effects, in children. A standard set at this level provides a very significant increase in protection compared to the current standard. The Administrator believes that a standard set at 0.15 µg/ m^3 would be sufficient to protect public health with an adequate margin of safety, and believes that a lower standard would be more than what is necessary to provide this degree of protection. (Final Rule, 2008, p. 67007)

The EPA Administrator argued that based on his summative evaluation of the evidence, comments, and advice included in the NAAQS review, that in his judgment public health would be protected within an adequate margin of safety upon implementation of this standard and substantially more protected than under the prior standard. It was noted that the “adequate margin of safety” guideline was intended to provide for protection against uncertainties in scientific analysis as well as against hazards as yet unknown. This standard was considered to be reflective of existing evidence of the associations of lead exposures with IQ loss estimates, however, the new standard does not qualify as precautionary according to the OAQPS staff recommendations.

The ways that this new standard has been viewed is varied among Herculaneum stakeholders, although surprise is the reaction most consistently reported (Interviews with Herculaneum residents and regulatory representatives, 2008-2009). Health concerned citizens were generally pleased with the new standard. These residents felt vindicated that their concerns had been heard and that lead in the environment and health exposures would be significantly reduced. Many expressed skepticism about whether Doe Run Co. could effectively achieve compliance using existing smelting technology. While the prospect of the new standard forcing the closure of the local smelter pleased some, others expressed concern about the implications for the local economy. Residents on the other side of the lead issue, those more concerned with preserving the Herculaneum community, suggested that the significant reduction reflected in the new standard was unnecessary and punitive to Doe Run Co. This group of residents voiced concerns that Doe Run Co. would be forced to offshore its smelting operations, a move that was expected to drastically impact the Herculaneum economy (these perspectives are discussed in greater detail in Chapter 7).

Summary

In this chapter I discussed the process of policy development in the initial crisis over lead management in Herculaneum, the establishment of a new stasis phase, the extension of the Herculaneum crisis to the revision of the NAAQS for lead, and a new regulatory crisis in Herculaneum initiated by the new lead NAAQS. I have described how the definition of an environmental problem has important implications for the ways that environmental policy tools can be applied to solve problems. Moreover, I have documented how these definitions are influenced by scientific, social, and political contexts. I have also shown how local involvement in lead contamination management in Herculaneum influenced lead regulation on both the local and national level. The findings reported in this chapter both reflect and extend Fischer’s (2003) proposition that public policies are "as much a competition over social meanings as they are empirical outcomes" (p. 69). These findings also provide a background for the consideration of the ways that the practices and perspectives of scientists become institutionalized as they are used to support particular environmental policy practices and influence local environmental controversies. In the next chapter I will turn to the perspectives of local residents and the ways that the policy processes have shaped their local lead controversy. This discussion will focus on the two forms of activism that dominated local controversy over lead regulation.

Chapter Seven: Local Activism

Introduction and Overview

You've got victim, villain, hero, and basically that's been how the environmental arena's been performed for the last 35, 40 years; it's victim, villain, hero. We alternate[d] with the agencies between villain and hero depending on what they were doing….What we really need to do is get beyond the victim, villain, hero template and look at collaboration. (Justin Johnson, Interview, 6/4/09)

In the statement above Mr. Johnson, a high profile Doe Run employee, insightfully categorized the stances taken by stakeholders in the local lead controversy in terms of "villain," "victim," and "hero." Through these combative terms, Mr. Johnson has captured the historical controversies around stakeholder perspectives on lead issues in Herculaneum and more recent desires to moving beyond difference in environmental perspectives and priorities and toward "collaboration." The primary purpose of this chapter is to provide a detailed exploration of stakeholder perspectives on lead contamination in Herculaneum in terms of the local activism that historically began as very divergent as well as to trace the shifts and evolution of this activism over time. Since this activism was largely based on and in response to changes in the regulatory framework discussed in the previous chapter, this discussion also reflects intersections of local perspectives with policy approaches.

The Emergence of Local Activism

An analysis of perspectives in Herculaneum captured over a decade revealed that local activism initially took two forms – activism that reflected concerns over potential health implications of local contamination and activism that defended community interests within the context of lead contamination. These two activist stances taken in Herculaneum have been altered in response to changing local conditions and shifted as environmental challenges have been understood in ever-changing ways throughout the country. At the time of their formation, activist stances taken by the two main groups largely reflected the 'developmentalist' – 'environmentalist' dichotomies that have dominated media reporting and public understanding of environmental controversies (Killingsworth and Palmer, 1992). Such activist groups, described here as discourse coalitions, however, must constantly adjust their arguments and compromise their views in order to remain relevant to continually changing physical, social, and regulatory contexts (Hajer, 1995). For example, over time and in response to changes in local environmental and regulatory circumstances, activist orientations in Herculaneum have adapted their approaches for participating in local environmental controversy. That is, residents that remain active in local lead management and community preservation now defend perspectives that are *much less* divergent than they were in the past. In the following sections I will describe dichotomous perspectives as they emerged in Herculaneum in the context of the current research project, while also tracing their evolving process toward less divergent positions.

Dichotomous Perspectives in Environmental Controversy

Various characterizations of perspectives on environmental contamination have abounded as scholars have attempted to describe the diversity of such positions taken in environmental controversies (Killingsworth and Palmer, 1992; Shafer, 2006). For example, within discussions of socioeconomic controversy related to the environment, much of the literature from the fields of sociology, economics, and business contrasts a

Dominant Social Paradigm (DSP) to a New Ecological Paradigm (NEP) (Shafer, 2006). The DSP reflects the historically dominant capitalist ideology, which primarily defends corporate autonomy and free enterprise, while NEP demands that governments authoritatively limit the impacts that individuals and corporations are allowed to have on the environment. According to Shafer (2006), commitments ascribed to by DSP proponents include: 1) a limited role for government regulation, 2) an emphasis on private rights to own and manage property, 3) a commitment to free enterprise, 4) a trust that economic growth is potentially unlimited, and 5) a confidence that any problems that arise due to growth and development will be resolved by scientific and technologic innovation. In its defense of largely unregulated free enterprise and pursuit of unlimited economic growth, the DSP is diametrically opposed to the NEP perspective. Shafer (2006) further summarized the priorities of NEP as follows: 1) a finite ecological system demands limits to growth, 2) human societies are pushing limits of ecological sustainability, setting the stage for an environmental crisis, 3) people must learn to live in "greater harmony" with the natural environment, 4) stress moral limitations to human activities that alter or impact the environment, and 5) reject the proposition that science and technology are capable of developing appropriate solutions to all potential environmental problems. Hence, the NEP forefronts ecological limitations to economic growth and emphasizes proponents' central concern that society should function in a way that protects the environment.

Killingsworth and Palmer (1992) described the dichotomous characterizations of environmental debates in terms of conflicts between industrialists and environmentalists:

> On one side are environmentalists, who seek long-term protection of endangered environments regardless of short-term economic costs. On the other side are the developmentalists, who seek short-term economic gain regardless of the long-term environmental costs. This analysis oversimplifies the dilemma by projecting the psychological dilemma – the realization that our system produces both economic prosperity and environmental pollution – onto a social background, dividing two stages of liberal consciousness against one another in a kin of allegory of good guys and bad guys, demanding of the observer a value judgment about the goodness or badness of each side. (p. 9)

The illustration of "good guys and bad guys," is similar to Justin Johnson's description of the performance of "victim, villain, hero" and demonstrates a common tendency to distill complex controversy into relatively simplistic dichotomies. Killingsworth and Palmer (1992) argued that such prescriptive divisions have rarely resulted from actual alignment of the views of many actors, but rather from the efforts of each side to negatively characterize the opposing viewpoint. Although other terms are also used, environmental controversies have frequently been understood through the lens of an industrialist-environmentalist or DSP-NEP type dichotomy.

Dichotomous Perspectives on Lead Contamination in Missouri

The positions taken by industry representatives and environmental activist groups in lead debates in Missouri have largely reflected the unified dichotomous perspectives that characterized the early environmental movement. Such divisions were evident in an early 2000s controversy in the state of Missouri over exploratory drilling for lead in the

Mark Twain National Forest[23] documented in the editorial section of the St. Louis Post Dispatch. Doe Run spokesperson, Barbara Shepard (2002), defended the company's request for permission to expand exploratory drilling in the National Forest as practical and necessary:

> The Doe Run Co. is seeking permission from the U.S. Forest Service to explore for additional lead deposits in Missouri's Mark Twain National Forest for one very simple yet vitally important reason: America needs lead! Often overlooked in the debate over lead mining in Missouri is the fact that we Americans rely on lead heavily in our everyday lives. Lead is the vital component in automobile and truck batteries (transportation; television and computer screens for radiation protection (entertainment, commerce); and protection from X-ray radiation (health care)…. There is no known or economically viable substitute for lead as it is used in our daily lives. Those opposed to mining by Doe Run should try living their lives without the use of automobiles, televisions, computers or X-rays. (p. D7)

Ms. Shepard went on to argue that proposed drilling would not harm the environment or preclude recreational activities and preservation efforts in the forest, and that drilling would be carefully monitored to ensure environmental protection. In her view, expanding drilling on federal property was appropriate and consistent with the United States' growing consumption of lead. Therefore, Shepard's position was consistent with the DSP and developmentalist paradigms (Killingsworth & Palmer, 1992; Shafer, 2006). Although Shepard dismissed environmentalist concerns over harm from exploratory drilling as

[23] The Mark Twain National Forest is located approximately 100 miles southwest of Herculaneum in south central Missouri.

unfounded, she did acknowledge that supervision of all activities by regulatory agencies would insure the conservation of the natural environment.

On the other hand, Sierra Club[24] activist, Tom Kruzen (2002), dismissed Shepard's main premise that "America needs lead." In alignment with the NEP and environmentalist paradigms, he argued that alternative technologies were available and required only minimal investment to become viable, a worthy effort considering the significant costs of lead contamination:

Lead is toxic. The lead industry spread it around the planet for 70 years in paint and gasoline. It's a major environmental health problem for children, and is hurting adults as well. We only have to look as far as Herculaneum to find examples. Our environments are rife with lead…. [There are] very viable alternatives to ripping up more ground and polluting more air and water by mining and processing lead from our public lands. It just means we have to stop the addiction to lead for a few moments and consider these innovations and more. It would also be cheaper than having to clean up more superfund sites. (p B6)

For Mr. Kruzen, extending the mining of lead in the National Forest was a dangerous mistake, as all lead brought to the surface eventually contributes to environmental contamination and risk of human exposure. He suggested, therefore, that investment in alternative technologies is a very worthy expense that would be expedient in consideration of the long-term costs of lead remediation.

---

[24] The Sierra Club was founded in 1892. According to its website, the Sierra Club is "America's largest and most influential grassroots environmental organization. Inspired by nature, we are 1.4 million of your friends and neighbors, working together to protect our communities and the planet" (http://www.sierraclub.org/). The Missouri Chapter has been active in debates over lead regulation throughout the state's lead belt.

In Shepard's and Kruzen's arguments, aspects of both the DSP-NEP and developmentalist-environmentalist dichotomies were evident. Shepard's justification of lead mining expansion based on U.S. consumer trends and minimization of environmental impacts reflects DSP emphasis on free enterprise, a lack of willingness to consider ecological limits, and a developmentalist focus on short-term economic gain. Kruzen's denial that lead consumption was justified in light of the attendant costs of introducing additional lead to the earth surface over the long term, reflects NEP prioritization of ecological limitations and environmentalist eagerness to make short term investments in favor of long term environmental protection.

Mr. Johnson's (Doe Run Co. employee) characterization of environmental debates in terms of assigning roles of "victim," "villain," and "hero" is relevant to this discussion as well. In Shepard's editorial, environmental protection activist groups, like the Sierra Club, are characterized as the "villain" due to their opposition to the focus upon material necessities for maintaining current standards of living. Conversely, Kruzen characterizes Doe Run Co. as the villain in its haste to perpetuate a damaging and hazardous technology rather than pursue potentially less harmful alternatives. These opposing views reflect both the priorities and beliefs of the individuals within the community, and the lengthy history of opposition between the two groups over the operations of the lead industry in the state of Missouri.

Processes of Divergence in Local Lead Perspectives

When lead controversy erupted in Herculaneum following the 300,000 ppm street dust finding, the local stakeholders largely adopted the dichotomous perspectives already dominating controversy over lead management throughout Missouri. According to stakeholders, the conflicting activist positions divided the community into two opposing groups. For the purposes of this research, I have characterized the two groups as Community Health Activists and Community Preservation Activists, whose views initially reflected environmentalist and industrialist priorities respectively. Accordingly, Community Health Activists tended to view Doe Run as the source of community pollution and the villain in the story of local lead regulation, while Community Preservation Activists considered restrictive enforcement of environmental regulation to be the local villain. In order to consider current activist orientations, and to trace adjustments and accommodations in their approaches to lead management over the last decade, it is first necessary to describe the processes through which these groups emerged and coalesced.

The Emergence of the CAG. Following the finding of 300,000 ppm lead dust on city streets and high levels of contamination in yard soil, community members generally shared alarm over what these levels might mean and how they would be addressed. Soon after this finding, meetings over the Administrative Order on Consent (AOC) were redefined into Community Advocacy Group (CAG) meetings under an EPA Superfund–supported program intended to facilitate community involvement in the resolution of hazards at contaminated sites. As meetings proceeded and solutions were considered, differences in concern amongst residents became a roadblock to moving lead management forward and can be eventually recognized in the formation of two opposing activist positions (Interview, Health Regulatory Agents, 4/30/2009). The extreme levels of lead identified and the urgency with which regulatory representatives approached this finding lent support and leverage to those residents within the CAG that were most focused on resolving local health threats at any cost. A vocal core of health-concerned residents sought the support of environmental activist groups such as the Missouri Coalition for the Environment (MCE) and the Missouri branch of the Sierra Club. These groups provided health-concerned residents with education on the health and environmental implications of lead contamination and strategies for community organizing and confronting regulatory representatives toward furthering restrictive management of lead contamination. Isabelle Robinson described this time period in our focus group interview with Ethan Lewis:

I started reading it [Health Department Report] and highlighting it and then asking questions. Like [Ethan] said though it was a forced education and they would set up more meetings and sub meetings of meetings and it just–there for about five years we'd see ourselves coming and going, but what we did early on because we were so outgunned, so overpowered, is that's when we called the Missouri Coalition for the Environment and they sent down a lady, [who] was just I think floored…. [And a Sierra Club representative] came up with a lot of history information and handouts and kind of how this bureaucracy works and what all he had done, 'cause he'd worked a lot with lead and lead mining…. And it was like they taught us kind of how to organize the community or the concerned part of the community because there was a whole other beast there too. (10/7/08)

Health concerned citizens initially had to request information in the form of lengthy reports from regulatory agencies. An important turning point in these citizens' efforts to understand the environmental and health impacts of the local lead industry came when they recruited the help of environmental activist organizations. These formal activist groups, adhered largely to a strict NEP/environmentalist paradigm in approaching environmental controversies, and were eager to assist health-concerned Herculaneum residents in gathering information and confronting regulatory agencies and Doe Run Co. with their concerns. As they drew on environmental activist resources and gathered information about the health threats associated with local lead contamination, the Community Health Activist group coalesced at the center of the CAG. This group began drawing on resources provided by MCE and the Sierra Club to confront regulatory agency representatives and push them to force Doe Run to remediate local contamination and reduce plant emissions. During this time community health activists were also deeply invested in negotiating the sale of many of their homes through the Voluntary Property Purchase Plan.

Overview of Community Health Activists

Community Health Activists were characterized by most of the regulatory agents with whom I spoke as those that lived in the neighborhood most impacted by contamination. This was the working class area where most of the houses were once company-owned employee residences but had long since been sold to local families. Ashley Hubbard, an EPA contractor hired to help the community move beyond the environmental crisis described community divisions in terms of those most concerned about and impacted by the contamination crisis:

There was something that was very insidious about it because it kind of fell into the popular and the unpopular crowd. The popular crowd were [*sic*] more kind of connected or networked with the company, Doe Run, they might have had more standing in the community…. And then there were sort of the people that were struggling and they did have kids with health problems, and they had a lack of resources to just move out, you know so they felt stuck. So there was kind of an economic and a status division I think. (Interview, 5/20/09)

Thus, residents with fewer resources to escape the contamination crisis were considered those who were most impacted by lead exposure. The highest levels of environmental concern were concentrated in the areas with the oldest and least valued housing stock, and the highest concentration of individuals likely to have lost jobs in the strike.

As lead management was implemented, the Community Health Activists in the CAG continued to work to hold Doe Run and regulatory agencies accountable for effective management of lead contamination in the community. As the buy-out proceeded and other regulatory initiatives took effect, the atmosphere of crisis in lead contamination settled down and the regulatory focus became the day-to-day intricacies of lead management as I described in Chapter Six. CAG members had to adapt their focus to the current activities of regulatory representatives, requiring that they develop a familiarity with the ongoing regulatory programs being enforced in the area. These programs included mainly Superfund (CERCLA), RCRA, and Air Pollution Control. During this time CAG membership slowly deteriorated. Regulatory representatives and Herculaneum residents whom I interviewed attributed this downward trend in membership to several factors: (1) the removal of most of its core members through the buy-out, (2) the reduced urgency involved in maintaining and scrutinizing ongoing lead management, (3) the community perception of CAG meetings as exceedingly contentious and stressful activities, and (4) the complexity of the ongoing regulatory discussions that began to dominate CAG meetings. Some of these explanations were discussed in the following statement by CAG leader, Alex Hill:

There are not very many people who are coming. I'm not really sure about why. I think a lot of them felt that it was not very productive, cause of the past activities. I think when you get down to a small number of people, there's kind of an inertia that goes on to say 'oh that activity that group is not very effective and so I'm not gonna waste my time.' Plus, I think Doe Run has gotten better, that their performance, as reflected in the readings and the monitoring systems, suggest that they don't have the huge violations they had before… As the CAG moved forward – and this probably is one of the things that contributed to the smaller members of the CAG now – it had the evolution I just described… We had these different subgroups that were not antithetical to each other, but simply trying to break this out and have some focus. We would report on anything new developing. Well, one of the groups… that evolved within that was like, "Okay, given the fact we do have a lead smelter here now, how do we move forward?" … So out of that came the development of this committee or this group called Herculaneum Today and Tomorrow, which then split off from the CAG at one point (Interview, 12/4/2008)

In reaction to the confrontational tone associated with CAG meetings, some members decided to form a second activist group in Herculaneum that would focus on the growth and preservation of the local community.

Overview of Community Preservation Activists

CAG attendees who didn't share the personal stake in lead management that many Community Health Activists held began to resent the contentious tone of CAG meetings. Considering the 300,000 ppm finding to be an anomalous oversight soon to be rectified by Doe Run, they desired that the crisis be quickly and thoroughly addressed so that the community and the company could return to their former coexistence. These residents considered regulatory agency representatives to be qualified and capable of managing the contamination crisis, and resented the reactions that the regulators received by community health activists:

They [regulatory representatives] would bring in these reports and this data that they were so diligent to collect, and we had people saying, "You're lying. You're wrong." People that weren't scientists [refers to Community Health Activists]. Some didn't even have college degrees, not that that's the end all of education but telling these people that have Masters that, "You guys don't know what you're talking about". And there was a few of us standing up and saying, "No, wait a minute… can we look at it from this angle and this angle?" That's how we approached it and gave those scientists a little bit of comfort zone that there are some people in the city that just don't think you guys are a bunch of nimrods. Although we didn't like the policy [likely a reference to the VPPP] but we did appreciate their work. (Interview, Oliver Brown, 1/7/08)

Additionally, these residents felt that the publicity being generated by the contamination crisis and confrontational meetings was having a devastating impact on the city of Herculaneum's reputation in the region and potential for future growth. While the Community Health Activist group was occupied with negotiating the terms of buy-outs and pressing regulatory agency representatives for further protection, the group of citizens more concerned with how Herculaneum as a community would survive the contamination crisis (the Community Preservation Activists) began to focus on possible future uses for the buy-out area and other community-building activities. Appreciating that this was a productive direction for community focus, EPA provided resources from its Superfund program to support the community in planning for its future. An EPA representative, who worked with communities to support future planning in the face of widespread contamination was assigned to facilitate these discussions and described her initial involvement with this group, as follows:

We found out that there was another fledgling group that really hadn't done a lot of work but had come together because they were unhappy with what the CAG's agenda was. They wanted a positive focus on the community as opposed to the very negative one that the CAG operated from…. [We] tried to help them figure out how to focus beyond the immediate to look at the future of the community and what they might need to do. (Interview, Addison Wallace, 2/27/2009)

With support from EPA's community development programs, the Community Preservation Activist group within the CAG began to coalesce around finding a positive way to move past the contamination crisis and to resist the Community Health Activists' approach to engaging local lead management and media. Eventually, this group split completely from the CAG due to the animosity and lack of productivity generated by repetitive arguments and confrontations in CAG meetings. The group began to call themselves "Herculaneum Today and Tomorrow (HT&T)" and set about laying the groundwork for a bright future for Herculaneum first by developing a Future Use Plan for the buy-out area. Subsequently, this group, which became the primary outlet for Community Preservation Activism, developed the Herculaneum Master Plan, successfully campaigned for an office of City Administrator to be added to the Herculaneum City Government and filled by one of its leaders, and organized a variety of community activities and events aimed at promoting a strong, unified community in Herculaneum. Changes in the ways local activists have come to approach environmental controversy in Herculaneum more recently will be discussed in depth in the following sections.

Moving Toward a More Cooperative Approach to Environmental Controversy

In the following excerpt from the CAG meeting held September 16, 2008, CAG leaders tried to defend their efforts to employ a more cooperative atmosphere, against arguments from visiting Community Preservation Activists, who maintained the perspective that CAG invariably supported punitive and highly restrictive regulation of the lead industry:

Sophia Turner - It seems to me like uh some of you may think that uh the CAG is out to get Doe Run, or that we're here to stir up trouble for Herculaneum. That's not the case at all. We've been working on this for six, six-seven plus years….We're not out to shut Doe Run down. I have children that I'm trying to raise in a healthy environment, and I can't do that if I have extremely high levels of lead in my yard. I can't let my children go out and play in their own yard.…That [targeting Doe Run] is not what the CAG is here to do and it never has been.

Ralph Brown - Miss, well I cannot say what I'd like to say. [crowd laughter] But what you've said is contrary to what has happened in this city over the last several years….The facts indicate different from what you're saying. And we have to look at the facts… that's the situation, the facts are the facts.

Alex Hill - I think there's a point of disagreement and that's been there for a long time. And I guess -

John Cameron – Alex, I'd just like to know who the CAG is.

Alex Hill - There's just a couple of us now [inaudible]

John Cameron - But you have the majority of the community here. So you can't have a couple that are creating problems for the entire community.

In this meeting, the central focus was a plan for the construction of a bridge. Both Community Health Activist leaders and Community Preservationist Activists supported a plan for the construction of a bridge that would allow Doe Run traffic more direct access to the plant from the highway, alleviating many of the problems associated with transporting lead concentrate over city streets. Community Preservation Activists specifically attended this CAG meeting to display support for the bridge plan in the presence of regulatory representatives were also in attendance. Evident through the combative tone of interactions in this meeting, CAG's efforts to work more cooperatively with Doe Run, regulatory agencies, and city government in pursuing a clean local environment had largely gone unheeded by some Preservation Activists. Health Activists' efforts to support preservation initiatives had therefore done little to reduce divisiveness between the two activist positions on lead in Herculaneum. Moreover, despite genuine, collaboratively-oriented adaptations in the approach to public participation in lead management within the CAG and the success in community planning in HT&T, the two groups continued to *perceive* themselves to be in opposition over issues surrounding local lead management.

Ecological Modernization in Community Health Activism and Community Preservation Activism

Environmental policy scholars have argued that a compromise position has taken over the dichotomous structure that had historically dominated environmental controversy. Hajer (1995) argued that "the environmental conflict has changed. It has become discursive. It no longer focuses on the question of whether there is an environmental crisis, it is essentially about its interpretation….Talking Green no longer connotes a radical social critique" (p. 13-14). Ecological modernization is a theoretical approach to environmental preservation that seeks to revolutionize industrial societies by developing and incorporating environmentally sensitive and sustainable practices into a capitalistic economic model. Under this theoretical approach, industries would seek cleaner technologies that would be environmentally sustainable, minimally polluting, and highly efficient. Efficiency and sustainability would maximize profitability and competitiveness for implementing industries, while ensuring that environmental pollution and degradation are minimized. Ecological modernization incorporates several important approaches to resource management including sustainable development and industrial ecology, which have come to dominate popular consciousness and policy approaches since the 1990s. Peter Christoff (1996) asserted that ecological modernization's "growing popularity derives in part from the suggestive power of its combined appeal to notions of development and modernity, and to ecological critique" (p. 476). By appealing to both sides of the theoretical dichotomies between DSP and NEP or the environmentalist and developmentalist orientations described early in this chapter, ecological modernization makes room for the actual perspectives of individuals that are often complex and contradictory. That is, ecological modernization demands compromise on fundamental tenants from both DSP and NEP hardliners, demanding that developmentalists acknowledge and address ecological limitations and radical environmentalists adapt to the institutional arrangements of capitalist democracy.

Christoff (1996) suggested that ecological modernization presents both an important compromise, and a sophisticated discursive strategy through which both developmentalist and environmentalist priorities can be accommodated:

> These developments reflect an evolving international discourse in response to commonly perceived environmental problems. However, they also reflect an increasingly sophisticated political response by governments and industry to popular mobilization around issues such as nuclear power, acid rain, biodiversity preservation, ozone depletion, and induced climate change. In other words, the new policy culture and its trends are not always simply or primarily intended to resolve environmental problems. They are also shaped by contest over political control of the environmental agenda and, separately, over the legitimacy of state regulation. (p. 477)

Ecological modernization offers environmentalists with interest in economic growth, and developmentalists with concern over environmental preservation a popular discourse in which to situate their views. In the remainder of the chapter, I dissect various aspects of activist perspectives in the controversy over lead management in Herculaneum and discuss the ways that both sides reflect properties of ecological modernization in their views.

Central Themes of Activist Perspectives

In an effort to more fully characterize the activism around lead contamination in Herculaneum, I have identified four central themes that distinguish the views of residents involved in each of the two activist orientations identified in this research: Community Health Activism and Community Preservation Activism. These themes are: (1) industry, (2) pollution, (3) regulation, and (4) science. It is important to emphasize here that individual *perspectives* continue to be nuanced and varied despite the two main *activist positions* that dominate the groups active in lead management and community preservation. These positions have emerged from the variety of perspectives, and I developed these characterizations based on areas where the views of each group align to inform their engagement in activism.

Detailed Characterization of Community Health Activists. Throughout the 2000s, health concerned citizens prioritized threats that lead contamination presented to the health of local citizens, particularly children. Since Community Health Activist perspectives were initially associated with those residents most impacted by the 300,000 ppm finding and subsequent events, this group was characterized by Preservationist stakeholders as angry, bitter, anti-Doe Run, and extremely critical of regulatory agencies. With health and environmental regulators expressing concern over the effects that living in their homes and neighborhoods might have on the health of their children, media coverage of health hazards in the area negatively influencing their property values (Interview, Sophia Turner, 12/4/2008), signs posted on their streets warning that normal neighborhood activities were unsafe, and entities within the community suggesting that any health impacts to their children resulted from some deficiency in their hygiene or housekeeping, residents became alarmed, defensive, and angry at the company responsible for the contamination and at the agencies they viewed as having failed to protect them. Meetings and interactions closely following the contamination crisis were often heated and emotional, and at times regulatory personnel were the targets of critical attacks. Regulatory representatives described these interactions as difficult, but many seem to have largely understood the extreme pressures being experienced by residents.

Over the course of the buy-out, remediation, and clean up, many of the Health Activists' most pressing concerns were addressed, and the most vocal citizens moved away from the community. As the predominant health threats were attended to and the urgency of the situation died down, the combativeness of the Community Health Advocacy perspective necessarily eased. The few residents who continued to be involved in local lead management activities began to focus on establishing and maintaining a community that was as informed and safe as possible in light of its proximity to the active lead smelter. These residents (1) accepted the presence of the lead industry, but not of community contamination (industry); (2) considered industry to be professionally and morally obligated to reduce pollution such that public health and the environment was protected, while not trusting it to do so (pollution); (3) expected government to actively enforce health and environmental protection with community oversight (regulation); and (4) took emerging science on lead hazards seriously and considered lead exposure to approximate harm to human health (science).

Detailed Characterization of Community Preservationist Activists. Community–concerned citizen activism emerged in response to the threat to the community that citizens perceived to have emerged from the lead management crisis of the early 2000s. Additionally, the EPA's provision of community planning resources to preserve community interests in the face of a Superfund threat was seen to have contributed to the formation and solidification HT&T as the center of this coalition as discussed earlier in this chapter. As health activism has declined in the years following the buy-out, community activists have garnered prominent leadership positions in city organizations and government, and are pursuing many of the goals laid out in the plans they established in the midst of the crisis.

The residents of Herculaneum who were more concerned with defending the community against the threats to its reputation and ultimate survival posed by the lead contamination crisis agreed that no harm should be done to health of anyone in their community. Their specific concerns focused less on health and the environment, and more on the local economy, community institutions, and community growth. They believed that environmental regulation should be balanced with preservation of the economic prosperity and community longevity, and that professional regulators should be solely responsible for protecting local health and the environment according to existing national standards for public health and safety. In addition, they tended to view emerging scientific findings that linked low-level lead exposures to health harms with skepticism.

This community activist group considered fighting for the continued success of the lead industry in their community to be not only in their own best interests, but their global responsibility. Four characteristics of the community activist perspective follow: (1) they embraced presence of plant as a historical reality, and an important aspect of community identity (industry); (2) they expected that the company would make every effort to function as cleanly as possible while maintaining appropriate levels of profitability (pollution), (3) they considered health and environmental protection the domain of government, regulatory agencies, and the lead company (regulation); (4) they skeptically viewed reports of health threats associating harm with low lead exposures as inconsistent with personal experience, while voicing concern for any child *actually* harmed by lead (science). Table 7-4 displays the characteristics of Community Health Activists and Community Sustainability Activists for comparison. These characteristics generally parallel those of the Health Activists; however, the Preservationists' views were nuanced differently by their prioritization of ensuring the future viability of the Herculaneum community. I juxtapose each characteristic of the Community Preservationist Activist and the Community Health Activist positions in the following paragraphs.

Industry: Community Health Activists. Community Health Activists as a whole accepted the lead plant as a central and important entity in their community. Sophia Turner explained; "Like I said, there are people who truly think that our agenda is to shut Doe Run down, and I know that would be detrimental to the city, because they are really the only business we really have that produces a good tax base." However, this group of residents argued fervently that the plant's operations should have no negative impact on the health of community residents. Later in our conversation Sophia stated, "We want to get the town clean. We want to see it thrive, but we want a healthy place to live, we don't want to live in fear." Community Health Activists argued that while the company played an important economic and political role in the community, it was responsible to do and spend whatever was necessary to ensure that industrial activities pose no threat to the health of residents. Residents considered this industrial responsibility to extend far beyond the geographical boundaries of their community. One Community Health Activist even traveled to the site of another Doe Run facility in Peru to speak to the community there about her experiences advocating against lead contamination in Herculaneum. Community Health Activists, like Sophia also expressed a great deal of interest in what were at that time rumors that Doe Run had developed a promising technology for purifying lead without the use of pyro-technology. This process would be a much cleaner avenue for processing lead and would resolve many of the environmental and health related concerns surrounding the local industry.

Industry: Community Preservation Activists. Community Preservation Activists considered the lead plant to be a valuable asset to the community economy and a central feature of community identity. Many advocates in this group identified strongly with the town's history as a lead company town, having relatives and friends who had long and successful careers in the plant. Additionally, these residents remembered a variety of ways that the company has supported the town, from funding the construction of a new fire department to participating in flood clean up and town beautification projects.

Part of the issue is Doe Run. It is what it is and I'm not defending it and I will not defend them. Everybody knows what they've done. All the results are there. You can talk to the regulatory agencies and see the steps they've taken to improve, but on the other hand recent history requires some fairness. They're not Satan. This plant manager is a very caring individual, not a phony. He means it. I've watched him participate in city activities. I've watched him demonstrate support for city groups and civic projects, and

so they've turned a new page as
well. (Jacob Williams, interview, 1/7/2008)

Doe Run's efforts to be a part of the community and a "good neighbor" were considered further evidence of their commitment to supporting and improving Herculaneum, which was expected to extend to operating the lead plant in as clean a manner as was practical.

Similarities and differences. Both Health Activists and Preservationists accepted the presence of the lead industry in the Herculaneum community and its valuable economic contributions. Both groups also expected that the company would work to prevent harms to local health and the environment. Combining concerns over local health and the environment with local economic interests is reflective of the ecological modernist paradigm; it encompasses a range of compromises between health and environmental protection and economic growth while promoting sustainable development as a viable middle road between environmental exploitation and handicapping production. Differences between the groups arise from their prioritization of economic interests and environmental responsibility. While Health Activists might argue that Doe Run Co.'s operation in the area should depend on its effective reduction or elimination of potential environmental and health hazards, Preservationists expect that the company will make every reasonable effort to operate with minimal hazardous impacts, and the community will understand and adjust to any unmanaged sources of risk.

Table 7.1

Summary of health and preservation activist views with regard to industry.

	Community Health Activists	Community Preservation Activists	Similarities	Differences
Industry	Accept the presence of the lead industry, but not of contamination	Embrace presence of plant as a historical reality, and an important aspect of community identity.	- Accept the presence of industry - Expect prevention of harm	Prioritization of economic interests versus environmental responsibility

Pollution and Regulation: Community Health Activists. Health Activists expected that any harm attributed to lead processing activities in the area should result minimally in compensation or resolution of that harm and maximally in severe punitive fines and restrictions assessed to Doe Run. Although some residents who took this stand were resentful of Doe Run for past activities, most activist residents generally appreciated what the company had accomplished in reducing lead emissions and cleaning up contamination over the last decade. As Ms. Turner stated:

I do think that the cleanup and everything has tremendously helped and I think that the regulations that they've [refers to EPA and MDNR] put on Doe Run have helped. The problem was that the plant has been here 100 years, so those new regulations didn't really apply…it was very frustrating in the beginning because everything was a negotiation, and it's like it should not be a negotiation. Doe Run basically called the shots. "We'll do this if you give us this." That's not right and so that was very frustrating, but I do think that they are working together now, and I think Doe Run has even been going above and beyond to do things that are better for the community, so I see it as improving, definitely.

Most Health Activists understood that the company has existed in the town much longer than widespread knowledge of the toxic effects of lead, or the standards that now regulate it. They also pointed out that the company has made a great deal of money mining and selling lead in Missouri and should be able to prevent further exposures and compensate residents for any harm that its products or wastes have caused.

Community Health Activists also expected that government health and environmental agencies were responsible for ensuring that harmful exposures from industrial contamination were prevented. If exposures did occur, these residents expected that government health and environmental agencies must force responsible parties to mitigate and manage exposure sources, as well as make restitution with harmed parties. In order to ensure that Doe Run fulfilled its obligations to protect the community's health, Community Health Activists have relied on the government agencies charged with protecting the public's health. Residents primarily viewed EPA and MDNR as the entities responsible for ensuring that local health is protected, although the Missouri Department of Health and Senior Services (MDHSS) and other agencies were believed to hold particular responsibilities. They regarded the scientific knowledge held by agency representatives as limited when it came to the specifics of managing lead contamination in Herculaneum. Ms. Turner explained:

Well, to give them [regulatory representatives] credit, I guess, they have never been involved with a clean up that still has an operating smelter, so it's a whole new ballgame, and I think they've done their best to try to, but I don't think they foresee things…. [Now] I just more or less just request more information. It's like the lead results or the street results. We want to know what those are, but they have gotten very good about sending us information….I think for a long time in my mind the CAG provided oversight of the agencies to keep them on their toes, so now–and the one frustrating part is that it switches. You never know. There's always a new member coming in from the government. First it was Josh Young with the EPA and now it's RCRA, and so you have to relearn. Everybody has to relearn all of this stuff, and these people have to become accustomed to what we expect and what we want….Josh would always say, "This is the most important project that I work on." I'm like, "Yeah, but you get to go home. You can forget about it for a month. You don't have to live it every day. We live it every day," and it's a fear, and so just getting them in that mindset I think was a challenge, but we did it, and we all learned how to work together.

Ms. Turner's remarks indicated that Health Activists considered the community to have a vital role as a "watchdog" ensuring that Doe Run was accountable around the clock for implementing protective programs. Additionally, Turner emphasized the challenges associated with the ever-changing regulatory framework and turn-over in regulatory personnel. When such changes occur, activists have to adjust to the new programs and their application to local contamination, and new representatives have to learn to accommodate the practices and expectations of Herculaneum activists. Health Activists' role also involved drawing regulatory attention to aspects of lead issues in Herculaneum that regulatory agencies may have missed in implementing established programs and policies. Another CAG leader, Alex Hill, described the community's watchdog role as follows:

There is a mindset that takes some energy day in and day out, of vigilance - a vigilance about the conditions here…. It takes different forms. I would drive down the street going out here and I'll see some yard being replaced and think, "Oh, okay, that's getting close." Or I'll see, not so much now, but, before, these lead concentrate trucks, eighteen-wheelers, coming up and down the street and close to my house…. I'm thinking, "I wonder what the lead levels on the street are right now." So that's just kind of a day-to-day experience.

For Health Activists, living in Herculaneum requires a constant "vigilance" in terms of living with lead. Throughout their daily activities Health Activists maintain a certain awareness of the activities of Doe Run Co., a concern over current levels of pollution in various media, and a constant apprehension over the impacts that exposure might be having on their personal health or that of their loved ones.

Pollution and Regulation: *Community Preservation Activists*. Community Preservationist Activists expected Doe Run to conduct lead processing activities in a way that minimized emissions and fugitive dust that could potentially pose a threat to resident health while maintaining appropriate levels of profit. The following statement from Jacob Williams illustrates his perspective on appropriate relationships between Doe Run, regulatory agencies, and the Herculaneum community:

I sincerely believe that they will not let money keep them from making significant strides to improve the smelting.…If you were building a lead smelter today you would not build it in the middle of the city. How idiotic, but compliance regulations could likely force Doe Run out of the country, and I for one don't want to see them go to Peru or China or someplace where the regulations are lax and where they'll actually be allowed to pollute it more. I want them here where we can watch them and where we can make sure that they are making improvements.[25] They're a major employer in my community and the economic impact [if they left] would be devastating. But we don't want them on their terms, and we don't want them on our terms. We want them to be regulated and have government work. I've seen vast improvements in the three years I've been here. They were out of compliance on this monitor right here. But they're tearing down 50 homes and so you've got the dust and debris and lead paint and other things from–. Remember there've been people living here before the Louisiana Purchase in 1803. Actually Moses Austin came here in 1808 but there almost assuredly were people around Joachim Creek according to historians. These first 25 or 30 homes, and then in 1892 when the smelter came Doe Run built most of the homes. They built most of the roads. They built it on slag, on the mine tailing. So obviously there's lead throughout the community that has to be remediated and we understand that, but um we're trying we're just trying for people to tell the true story. Don't paint doom and gloom. Children today in Herculaneum are not dying. (10/7/2008).

Unlike Community Health Activists, who expected toxic releases to initiate severe and punitive consequences, Community Preservationist Activists expected Doe Run to balance corporate and community interests. This balance was thought to best be achieved through negotiations between Doe Run Co. and regulatory agencies, a system which would ensure that protection of local health. When contamination was identified, preservationists considered it an oversight on the part of Doe Run and expected the

[25] For clarification, according to later conversations with Jacob Williams and other Community Preservationist Activists, when he used 'we' to discuss enforcement of environmental regulation, he intended to indicate American institutions like city government in which he was involved, not the local citizens.

company to cooperate with agencies in rectifying the situation and bringing the area into compliance with existing lead regulations.

From a Community Preservationist perspective, health and environmental protection were considered the exclusive domain of experts employed by government agencies. These agencies were thought to function best when allowed to implement established and proven programs without community interference. Residents sharing this perspective made a nuanced and somewhat contradictory argument that the regulatory agency representatives hold expertise in lead management and that ordinary community members with less technical knowledge should not attempt to influence their actions. Preservation activists indicated that, in their opinion, much local regulatory activity constituted an overreaction on the part of regulators to lead exposures which preservationists thought presented less danger to locals than scientific and regulatory activities would indicate. Jacob explained his reasoning for depending on the regulatory agencies to manage the lead hazards:

I trust the agencies to do the job that they're supposed to do, not 100% because I know government and government makes mistakes…but I have to trust them because I don't have the wherewithal or the background to deal with the lead issue, and so I'm not going to try to judge that part of the issue. I'm going to assume that those people that are supposed to be the watchdogs in the regulatory agency are going to do what they can do to control the environment here in Herculaneum and make it a healthy environment (10/7/08).

Jacob described his expectation that regulatory representatives would be more effective at managing lead due to their expertise, while he and city leaders should focus on projects that the city could effectively accomplish. While his statement generally expressed a trust that the regulatory agencies would protect the community to the best of their ability, this view is somewhat contradictory to the discussion of Community Preservation Activists' views on lead science, later in the chapter.

Similarities and differences - Pollution and regulation. Both Community Health Activist and Community Preservation Activist positions expected Doe Run Co. to reduce pollution to the extent possible. Differences in views of pollution management resided in the trust afforded to lead industry decision makers and government regulatory agencies. Preservationists trusted that the company would do whatever it could to function cleanly since maintaining a positive relationship with the community was in Doe Run Co.'s best interest. Although Preservationists sometimes resented the interference of regulatory agencies, they expected ongoing negotiations between agencies and the lead industry would further insure the community's protection from harms associated with lead pollution. Additionally, Preservationists considered non-expert local influence (i.e. Community Health Activism) on the management of lead contamination to be largely inappropriate. In contrast, Health Activists held no faith that Doe Run Co. would make any effort to minimize pollution without strict and stringent regulation by government agencies. Health Activists tended to regard the company as having tendencies to be abusive or negligent toward the community in wastefully and carelessly dumping hazardous materials in the environment. In the view of Health Activists, community members themselves had an important role in both informing agencies of company practices that were out of compliance with existing regulations, and in shaping regulatory understanding of local lead problems so that effective strategies of lead management could be implemented. Therefore, in terms of pollution and regulation, Health Activists' perspectives continued to reflect the NEP/environmentalist paradigm, while Preservationists' perspectives retained characteristics of the DSP/developmentalist paradigm. Furthermore, ecological modernization, which argued that sustainable practices serve both environmental and economic interests by minimizing waste and maximizing productivity, was largely absent in the residents' (i.e., the Health and Preservation Activists) comments about pollution and regulation. The ecological modernist paradigm, however, was pervasive in my conversations with Doe Run Co. representatives, and regulatory representatives, as argued in both the previous chapter and Justin Johnson's statement at the opening of this chapter: "What we really need to do is get beyond the victim, villain, hero template and look at collaboration" (Justin Johnson, Interview, 6/4/09). In fact, present-day regulatory relationships tend to be much more cooperative and dependent on negotiation than earlier, more punitive regulatory strategies. That this change in the environmental regulatory landscape was generally not appreciated by the Herculaneum public is an important finding of this study and may have contributed to some of the community's divisiveness and difficulty in impacting local lead management. The mismatch between local activists' understandings of current regulatory relationships and the more cooperative relationships described by regulatory representatives and industry employees, is important for two main reasons. First, it indicates that the public continues to adhere to a more punitive model of pollution management that tends to characterize industry and regulatory agencies in terms of villain and hero, despite the widespread embrace of ecological modernization in environmental policy circles. Second, such characterizations of the industry-regulatory relationship denote that these activists largely continue to characterize their own role in environmental

Table 7.2

Summary of health and preservation activist views with regard to pollution and regulation

	Community Health Activists	Community Preservation Activists	Similarities	Differences
Pollution	Considered industry to be professionally and morally obligated to reduce pollution such that public health and the environment was protected, while not trusting it to do so.	Expected that the company would make every effort to function as cleanly as possible while maintaining appropriate levels of profitability.	Appreciate historical and economic contributions from Doe Run Co. to the community and expect Doe Run to reduce pollution.	Hold different views of how harms to the community should be handled and the role of residents in informing lead management
Regulation	Expected government to actively enforce health and environmental protection with community oversight.	Considered health and environmental protection the domain of government, regulatory agencies, and the lead company.	Expect agencies to ensure that residents are protected	Different levels of trust of Doe Run to maintain clean practices and expectation of agency responsibility for enforcement

policy debates in terms of the victim role in the "victim, villain, hero viewpoint considered at the opening of this chapter. This is surprising given the effectiveness that activists in Herculaneum have experienced in influencing local regulatory debates, and has implications for the ways that the public should be allowed to participate in policy debates, as well as the types of scaffolding required for them to do so effectively.

Science: Community Health Activists. Community Health Activists regarded scientific findings that lead exposures in early childhood impact neurological development as trustworthy and very alarming. This group was very informed with regard to current lead science and emerging findings regarding the neurological effects of very low-level lead exposures, referring to prominent lead epidemiological studies by scientists like Herbert Needleman and Bruce Lanphear.[26] Sophia discussed her experiences with getting her daughter's blood lead levels tested and her perspective on the results:

They wouldn't give you a definite number. They would say, "Oh, it's less than five, or more than five." It wasn't a 1.3, or something like that, and I wanted definite numbers, and for a long time, the health department didn't do that either, and they did start getting more accurate numbers, and as far as she [my youngest daughter] goes, she has a level of a three, which according to the CDC, that is not leaded, and it just infuriates me every time that they would call the nurse in the doctor's office will call and, "She's fine. It's below a ten," and I'm like, "I want the number. Tell me the number, because I need to know if it's gone up or gone down"…. And she's pretty much stayed at a three the whole time, and studies have shown that even at that level, it can cause problems, long-term exposure, so it still worries me, but I just try to do the best that I can do. (Interview, Sophia Turner, 12/4/2009)

[26] For examples see (Dixon, 2010)

Community Health Activists also suspected that lead exposures likely have potential negative health consequences beyond the most common concerns surrounding the neurological development of young children, despite the scientific community's claim that lack of sufficient evidence to support these conclusions. As discussed in the previous chapter, the health consultation conducted by ATSDR and MDHSS between 1998 and 2002 found no significant elevation in amyotrophic lateral sclerosis (ALS) incidence in Jefferson County. The study did identify a very small cluster of ALS surrounding the Herculaneum smelter (Markowitz & Rosner, 2002; Warren, 2000). Sophia cited this study as evidence that the possibility of further adverse effects of lead exist beyond what is currently known, and that the scientific studies conducted to find such effects are insufficient to rule out the possibility of further harms. Concern over unidentified health effects took varied forms among Health Activists. For instance elderly resident, Ryan Zimmerman, identified his observation of a strange, metallic taste in his mouth and beginning to feel unwell with evidence of recontamination in his neighborhood reported the previous year; "there is recontamination of the soil out there…. The thing is, too, that I began to acquire some strange taste in my mouth, you know, which kinda tells me that there might be some sort of contamination" (Interview, 4/22/2009). Mr. Zimmerman, who lives very close to the smelter, also mourned his hobby of gardening, which he stopped in the late 1990s due to concerns that his vegetables would harm the health of his family and neighbors. Community Health Activists worried that, as yet, unidentified effects of lead combined with other contaminates associated with the smelter would contribute to health problems in their families and friends. These activists assumed lead exposures were harmful and emphasized scientific uncertainty with regard to the possibility of effects that are currently unrecognized as being associated with lead exposures.

Science: Community Preservation Activists. Community Preservation Activists' views regarding the science surrounding lead management and the health effects of lead exposure was consistent with the Community Preservationist perspective that generally viewed emerging science with regard to the hazards of low level lead exposure with a level of suspicion. Many of these residents had lived in close association with the lead plant throughout their lives. Drawing on personal and community experience they argued that little or no harm had come to them, their friends, or neighbors by residing near the plant or having direct contact with lead byproducts throughout their lives. Therefore they considered regulatory activity such as posting signs warning of the dangers of lead in the streets, forcing the purchase of homes, restricting access to large areas in the historical core of the town, and placing a heavy burden of restrictions and bureaucracy on Doe Run operations to be extreme, unfounded, and threatening to the survival of the community itself. Jacob Williams stated:

According to the definition of elevated blood lead, yes, you can find children. I can show you children on Main Street where one parent has [a child with] a blood lead level of three. Where will science determine what is safe and what is not safe? We don't know. It changes all the time. In recent history it's been going down and we understand that. We care about the children in Herculaneum tremendously… We care strongly about children, but we also care about fairness. If you go to East St. Louis, if you go to St. Louis proper, you walk into an average neighborhood and take an average blood lead level of kids that are miles away from the lead smelter, guess what? They're gonna have threes, they're gonna have fours, they're gonna have fives. We know they're out there. If you look at ambient air quality in the U.S., Doe Run is not even in it with a small town in Indiana, with Los Angeles, with others, Jefferson County, Missouri isn't in it. So it's a complex problem that requires a complex solution. Unfortunately the city keeps getting a black eye when the city had nothing to do with any of it. We've now taken steps to be part of the solution instead of sitting by and reacting to what the agencies and what Doe Run do we now are proactive.

Some Community Preservationist residents, however, are not as trusting that the experts will come to an accurate conclusion as evidenced in the following excerpt from a contentious CAG meeting:

Julie Brown - I'd like just to say one comment. What about all of these people that are sitting here tonight that were born and raised in this city, and none of them are leaded?

Alex Hill - What about them?

Julie Brown - Why is it all of the sudden we have this big...problem with Doe Run, who has been the supplier of homes for many many families for many many years?

Alex Hill - I acknowledge Doe Run for being the supplier of resources and so on for the community. I don't take that away from them. I at the same time don't feel like if there is a danger to human health here that we shouldn't acknowledge it, and say, "Look there's something going on here that we need to address."

Julie Brown - I don't think its as much a danger as a lot of people think it is.

Evident in their exchange, this group also did not expect that the health effects of lead exposure might be more diverse than currently identified by scientific research. Instead they frequently suggested that the effects of lead exposure were less serious than lead management policies would indicate. In defense of their point of view some members of this group cited scientists like Theresa Bowers and Alan Kauffman[27], who have questioned the validity of adverse effects at low levels of lead exposure. Community

Table 7.3

Summary of health and preservation activist views with regard to science.

	Community Health Activists	Community Preservation Activists	Similarities	Differences
Science	Took emerging science on lead hazards seriously and considered lead exposure to approximate harm to human health.	Skeptically viewed reports of health threats associating harm with low lead exposures as inconsistent with personal experience, while voicing concern for any child *actually* harmed by lead.	Both groups incorporate scientific findings to support and extend their views and priorities	Both groups maintain skepticism about scientific uncertainty in areas where current scientific understandings appear to challenge or limit their priority concerns.

Preservationist Activists emphasize scientific uncertainty in demonstrating that low level lead exposures are harmful to human health.

Similarities and differences. As discussed above, Community Health Activists tended to trust emerging findings of negative health effects at very low levels of lead exposure, and even to expect that toxic releases from the lead smelter may harm human health in ways that are currently unrecognized. Thus, it is a priority for Health Activists

[27] For example see (Landrigan, et al., 2002; B. P. Lanphear, et al., 2000; B. P. Lanphear et al., 2005; Bruce P. Lanphear et al., 1998; Needleman, *Human Lead Exposure*, 2000, 2004; Needleman & Bellinger, 1991, 2001; Needleman, Schell, Bellinger, Leviton, & Allred, 1991)

that human exposures to lead contamination be eliminated. Community Preservation Activists maintain skepticism with regard to actual health harms associated with low levels of lead exposure based on their experiences and observations of living in close proximity to the lead smelter for many years, but agree that minimizing human exposure to lead contamination is in the best interests of the community. Ecological modernization has mostly been applied to global environmental problems like climate change or ozone depletion, and not to local pollutants like lead contamination, so it is unclear how the paradigm would treat this particular scientific issue. However, I argue that since ecological modernists generally respect scientific characterizations of environmental realities in terms of crises, they would also respect epidemiological evidence of harm at very low levels of lead exposure. Thus, like both groups of Herculaneum activists, I expect that ecological modernists would pragmatically emphasize the reduction of lead in the environment as an important and desirable aspect of lead management.

'It's Really Not That Black and White'

Together, the four characteristics of the Community Health Activist perspective described here present an ecologically modernistic view that emphasizes local health concerns in the context of an industry that functions in a way that respects the local environment and protects the health of the surrounding community. Health Activists expected that lead exposures were generally harmful to human health and the community and that the community along with regulatory representatives have a role in holding the lead industry responsible for preventing and rectifying any harmful effects from the exposure of the Herculaneum community to lead contamination. Moreover, the belief that the lead industry should balance profitability while eliminating harms to the environment

Table 7.4

Overview of Community Health Activist and Community Preservation Activist Perspectives

	Community Health Activists	Community Preservation Activists	Similarities	
Industry	Accepted the presence of the lead industry, but not of community.	Embraced presence of plant as a historical reality, and an important aspect of community identity	- Accept the presence of industry - Expect prevention of harm	Prioritization of economic interests versus environmental responsibility
Pollution	Considered industry to be professionally and morally obligated to reduce pollution such that public health and the environment was protected, while not trusting it to do so	Expected that the company would make every effort to function as cleanly as possible while maintaining appropriate levels of profitability	Appreciate historical and economic contributions from Doe Run Co. to the community and expect Doe Run to reduce pollution	Hold different views of how harms to the community should be handled and the role of residents in informing lead management
Regulation	Expected government to actively enforce health and environmental protection with community oversight	Considered health and environmental protection the domain of government, regulatory agencies, and the lead company	Expect agencies to ensure that residents are protected	Different levels of trust of Doe Run to maintain clean practices and expectation of agency responsibility for enforcement
Science	Took emerging science on lead hazards seriously and considered lead exposure to approximate harm to human health	Skeptically viewed reports of health threats associating harm with low lead exposures as inconsistent with personal experience, while voicing concern for any child *actually* harmed by lead	Both groups incorporate scientific findings to support and extend their views and priorities	Both groups maintain skepticism about scientific uncertainty in areas where current scientific understandings appear to challenge or limit their priority concerns

and local health hazards reflects the sustainable development side of ecological modernization. On the other hand, the four characteristics of the Community Preservation perspective describe a group that considered lead to be a manageable yet toxic chemical that, if handled well, poses little threat to the health of their community. The preservationists trust the lead industry, in cooperation with government agencies, to mitigate any potential hazards. Balancing corporate profitability with environmental concerns is an industrial ecological way of applying ecological modernization. Further, ecological modernists would look for a way that the efficiency and productivity of lead refining processes could be enhanced while limiting waste and pollution through the development of innovative new technologies. Hence, despite their origination as opposing viewpoints, close analysis of the four characteristics of activism (industry, pollution, regulation and science) exemplifies how divergent activist perspectives on local lead management in Herculaneum have adapted to changes in the physical and regulatory environment and now are in agreement on many points. One regulatory representative, who was deeply sympathetic of and involved in community activities argued,

It's really not that black and white, and people aren't as far apart as maybe they think they are. And we certainly have some community leaders in town…who certainly have very strong concerns about lead contamination, but they also love the community and that is their home. (Interview, Emma Long, 2/19/09)

My research in Herculaneum also reflected areas of agreement within apparently conflicting perspectives on lead management. Despite their obvious resentment of the other group's activities, conversations with leaders from each group revealed similarities in their views of Herculaneum and its lead-related challenges. In fact, the depth of both groups' affection and concern for the community of Herculaneum was evident throughout my discussions with long-time residents. All community members I spoke with shared a desire to live in a town that is both healthy and thriving. They shared a sense that Herculaneum was their true home and therefore a central part of their identity. Resident participants also discussed a sense of loss with regard to the community that Herculaneum was before the contamination crisis and buy-out.

Today, both groups defend the presence of Doe Run Co. in Herculaneum, while expecting it to operate cleanly. Both groups also value minimizing sources of human exposure to lead in the environment. Health Activists retain many of the assumptions of NEP/environmentalist paradigms and Preservationists views likewise reflect many of the priorities of DSP/developmentalist paradigms; however, in response to changing environmental and political conditions, both groups have had to adapt their views and incorporate priorities of the opposition. In many ways the two lines of activism now function in parallel and complementary ways, with Preservationists promoting community involvement and growth, and Health Activists advocating ongoing regulatory management of lead contamination and clean industrial processes.

The four aspects of Community Health Activism and Community Preservation Activism described above illustrate both differences and similarities in activist orientations in Herculaneum. They also reflect aspects of DSP/developmentist, NEP/environmentalist, and ecological modernist paradigms. Understanding local activist positions in a nuanced way offers insight into different ways that public participation in environmental controversy can manifest, and how aspects of broader social trends and ideological contexts shape local interactions. It is evident that while both local perspectives reflect compromises associated with ecological modernization, Community Health Activists' views retain aspects of the NEP/environmentalist paradigm, while Community Preservation Activists' views retain aspects of the DSP/developmentalist paradigm.

Summary

In this chapter I described the formation of two activist groups in Herculaneum that reflected attributes of the developmentalist/DSP – environmentalist/NEP dichotomy. I argued that while these perspectives once echoed that well-known dichotomy, they now incorporate aspects of the compromise position of ecological modernization that has emerged as the dominant paradigm in environmental research and regulation since the 1990s. Through the close examination of these perspectives, I have shown how two discourse coalitions adapted their activist positions in light of changes in the physical environment and regulatory context. In adapting their perspectives to accommodate regulatory practices, the perspectives of both groups have begun to reflect the compromise position of ecological modernization. Close examination of points of agreement between these groups reveals how the apparently antagonistic activist positions have resulted in complementary activities that promote both community growth and a clean and safe environment. In the following chapter, I will conclude this dissertation by building on the arguments from this chapter and the previous one to discuss how local policy processes and local activism have shaped one another in terms of environmental policy learning. This discussion will center on very recent developments in Herculaneum that will help illustrate the ways that community, regulation, and industry have interacted in pushing both the science of lead production and regulation forward.

Chapter Eight: Conclusions, Implications, and Directions for Future Research

Broad public participation, in this respect, makes an instrumental as well as normative contribution to democratic policymaking. By decreasing conflict and increasing acceptance of or trust in decisions by government agencies, it can provide citizens with an *opportunity to learn about policy problems* [emphasis added]. Such learning can improve the chances they will support the resulting decisions. But even when it does not increase such support, it offers the possibility of clearing up misunderstandings about the nature of a controversy and the views of various participants. (Fischer, 2003, p. 206)

According to Fischer, learning that occurs during policy controversies serves a variety of political ends. Moreover, he contends that it is important to prioritize learning contexts that promote *public participation* in policy processes. However, Fischer did not offer any insight into how learning on the part of public individuals and communities in the context of political controversy might be understood or explored. This omission is unfortunate since learning that occurs through political controversy may hold important insights for educational research, particularly for preparing students to participate in complex democratic debates. Accordingly, in this concluding chapter I will further explore my findings with regard to regulatory approaches and local perspectives surrounding lead contamination in Herculaneum in terms of potential insights into policy learning.

The aim of this dissertation was to explore both the impact of lead contamination on the community of Herculaneum, Missouri, and the influence of the Herculaneum community on lead management. The interpretive exploration of policy processes and changing local perspectives conducted for this dissertation focused on two central research questions: (1) How do relevant environmental regulatory programs approach the problem of lead contamination in Herculaneum? and (2) How do local stakeholders describe the problem of lead contamination in Herculaneum? In the conclusion to this dissertation, I synthesize my findings about policy learning in order to draw conclusions about its occurrence in the context of lead management in Herculaneum. More specifically, I will: (1) offer a revised definition of policy learning that takes into consideration both local perspectives and the regulatory approaches that were made in response to the changing physical and political conditions, and (2) explore policy learning in the Herculaneum context where an evolving environmental controversy has produced changing political and physical conditions that required accommodation from both citizens and policy-makers. To begin, I interpret central aspects of my findings from the first research question (presented in Chapter Six), which considered changes in regulatory approaches to managing local lead contamination through the lens of policy learning. Specifically, I examine changes in the policy approach to local lead management in terms of policy learning. Additionally, I discuss adjustments to the local regulatory approach in light of the identified regulatory process cycle of stasis, crisis, and renewed stasis. Conclusions from this discussion identify three factors that were involved in policy learning in Herculaneum. These factors involve changes in: (1) available evidence demonstrating the physical conditions of local lead contamination, (2) the ways that the relationship between lead exposure and health effects were understood, and (3) local attitudes about lead contamination. Next, I interpret central aspects of my findings from the second research question (presented in Chapter Seven), which considered changes in local stakeholders' perspectives, through the lens of policy learning. Conclusions from this discussion indicate that three activities were central to policy learning for local stakeholders: (1) identifying and implementing effective strategies for influencing regulatory activity, (2) responding to changes in the approaches of regulatory representatives, and (3) adapting views and identifying goals that incorporate the values and priorities of the opposing side of the local lead controversy. Finally, I provide a synthesized description of the local policy cycle in relation to changes in both the regulatory approaches and local perspectives regarding local lead contamination. From this synthesis, I draw conclusions about the mutual influence of local perspectives and regulatory approaches on changes in lead management policy as it impacted the Herculaneum community. These conclusions lay the foundation for a discussion of the theoretical and practical implications of this research, and specific directions for future research, which appear at the end of this chapter.

Discussion of Findings

In this section, I interpret the central findings about adaptations in policy approaches and stakeholder perspectives presented in Chapters Six and Seven through the lens of the policy learning definition that was first presented in Chapter Three: adaptations and accommodations in response to changing physical and political contexts. I draw conclusions about three aspects of policy learning in regulatory approach and in stakeholder perspectives. First, I identify actions that constitute policy learning across groups and which proved pivotal in shaping the policy context surrounding local lead contamination. Second, I draw conclusions about the specific ways that these instances of policy learning influenced the local lead context. Finally, I draw conclusions across changing policy approaches and stakeholder perspectives to consider factors central to each type of policy learning.

Policy Approaches

My exploration of policy approaches to lead management in Herculaneum focused on two periods—when initial recognition of potential implications associated with the area's long history with a multi-media contaminant emerged around 1999 and when implementation of the new lead NAAQS was established in 2008. Two main findings emerged from the exploration of policy approaches for managing local lead contamination during these periods and the influence of local perspectives on these approaches. The first finding identified three iterative stages in changing the policy approach to local lead management: (1) a period of stasis where the widely accepted definition of local contamination lined up with regulatory efforts to manage it, (2) a period of crisis in which redefinition of local contamination showed regulatory efforts to be substantially inadequate, and (3) a renewed stasis, where a new definition of local contamination was considered effectively managed by newly applied regulatory programs. I contend that movement between these stages was influenced by the combined activities of regulatory representatives and local stakeholders in challenging the definitions of local contamination that were being reflected in existing lead management policies. More specifically, three policy transitions were central to policy learning from the discussions in Chapters Five and Six: (1) extension of the exploration of local lead contamination in the 2001 Administrative Order of Consent, (2) revision of the definition of local lead contamination following the 300,000 ppm sample, and (3) application of developments in Herculaneum lead contamination management involved in the reconsideration of national air lead policy.

The role of policy learning in the 2001 Administrative Order of Consent (AOC). In Herculaneum, locally involved regulatory representatives came to suspect that local lead contamination conditions were more complex and extensive than was implied by the definition of lead as an ambient air contaminant. Prior to the 2001 Administrative Order of Consent, local lead contamination was managed exclusively through the Clean Air Act amendments designating 1.5 $\mu g/m^3$ as the limit for lead in ambient air. The area was considered in compliance with this standard since the lone pollution source, the Doe Run Co. lead smelter, was cooperating with regulatory agencies to make improvements toward reducing lead emissions to a level that would meet the standard. In light of information that indicated a more complex definition of local lead contamination than previously suggested, local regulatory representatives negotiated for the collection of data that would specify lead levels in local soil and river water; hence campaigning for adjustment to the regulatory framework. This initial adjustment in the regulatory approach to local lead management in Herculaneum constituted policy learning on the part of regulatory representatives. Here, policy learning informing the revision of the 2001 AOC and influenced the creation of a forum where local concerns over both the limitations of regulatory initiatives in addressing local environmental concerns and the implications of expanded regulation for the local economy could be voiced. My findings suggest that policy learning by regulatory representatives in this case involved several factors. First, the definition of local lead contamination was expanded by the application of knowledge about contamination sources present in other areas of the lead belt. Second, concern over non-air sources of exposure was important in light of recent scientific developments linking lower level lead exposures to health outcomes for children. Third, local stakeholders were voicing some concern over potential exposures from local environmental contamination. A second example of policy learning as a change in the regulatory approach occurred after the 300,000 ppm road dust finding, as discussed below.

The role of policy learning in reacting to the 300,000 ppm lead sample. When local stakeholders' activism demanded the collection of data that provided evidence of local and dire contamination problems, regulatory representatives sought additional information in order to properly redefine local lead contamination and establish management programs appropriate to the new definition. Thus, the regulatory approach was further adapted toward examining the extent of local lead contamination problems, particularly in terms of DHSS research designed to identify public health implications of local lead processing activities. My findings indicate that the process of establishing a more appropriate definition of lead contamination and the complementary strategy for management initiated an ongoing process of policy learning in area regulatory approaches. In this case, policy learning involved the reexamination of local conditions as well as the application of more current understandings of the potential health effects of exposure to such conditions. Regulatory representatives studied additional potential sources of health risk and attempted to address public concerns. In this way, they expanded the problem definition regarding lead contamination in Herculaneum.

Opportunities to raise questions and explore existing conditions continued until regulators were satisfied that their emergent understanding and the treatment of local lead contamination was adequate to address actual conditions in Herculaneum. Accordingly, regulatory representatives came to consider that lead contamination—according to their new definition—was managed to the extent possible under existing policies addressing lead contamination, emissions, and waste. Thus, I conclude that the urgent examination of lead contamination to identify possible sources of exposure constituted policy learning in this instance. Policy learning on the part of regulatory representatives was instrumental to the process of redefining local contamination and establishing new strategies for local lead management following the 300,000 ppm lead dust finding. This process contributed to the development of a variety of programs to reduce local exposures including: reducing plant emissions to meet the 1.5 $\mu g/m^3$ air lead standard, monitoring and managing lead in road dust, monitoring and remediating lead in residential yards, monitoring and remediating lead in house dust, monitoring lead on truck tires and parts leaving the smelter facility that could contribute to contamination in the community, and extending the property line surrounding the plant thereby limiting public exposures more proximal to the facility. Each of these programs was a product of policy learning as changes in the regulatory approach resulted, including an expanded definition of the local contamination problem. This expanded definition of local contamination problems became an important consideration in the reconsideration of lead regulation of air lead in the national context.

The role of policy learning in the lead 2008 NAAQS revision. As discussed, early in the NAAQS review process, the case study conducted for the risk analysis in Herculaneum forced the EPA to include (for the first time) the multimedia impacts of lead released into ambient air and the implications of multimedia contamination on human health in their definition of the problem of lead in the air. The use of this model in revising the NAAQS for lead was based in part on lessons from redefinition work conducted by local regulatory representatives in Herculaneum. I conclude that the entire NAAQS review process, which considered expanded implications of air contamination including multi-media exposure routes, was a process of policy learning initiated by the activity conducted in Herculaneum. The NAAQS revision process involved: (1) a revision of the problem definition of lead contamination in air to include indirect sources of exposure to lead, (2) reconsideration of the health implications of lead exposure based on current science, and (3) a response to reduced public tolerance for toxic contamination in the environment. The implications of reducing the lead NAAQS are not entirely known at the time of this dissertation, but are expected to be very far reaching.

Policy learning as changing regulatory approaches. Three factors were involved in the examples of policy learning described in this section: (1) the development of the 2001 Administrative Order of Consent, (2) the campaign for the collection of the 300,000 ppm lead dust sample, and (3) the 2008 lead NAAQS revision. First, each of the described policy learning instances reflected adaptations of the definition of lead contamination problems due to the incorporation of additional evidence. Second, policy learning in each instance reflected developments in the scientific community's understanding of the relationship between lead exposures and health outcomes. Third, in every case examined here, changes in the regulatory approach reflected changes in the political climate with regard to the ways that local contamination was understood and tolerated.

Above, I discussed conclusions about the role of policy learning in adapting regulatory approaches to local lead management. Regulatory approaches work in tandem with stakeholder perspectives; therefore, in the following section, I draw conclusions about the findings regarding stakeholder perspectives, which were presented in Chapter Seven. I will then synthesize the conclusions from both sections before turning to the implications of this work.

Stakeholder Perspectives

The exploration of stakeholder perspectives conducted in this dissertation study produced (1) a description of the way that two central perspectives on local lead issues emerged and coalesced into activist groups following the discovery of high lead levels in local road dust, (2) a description of the ways that the perspectives and approaches of these activist groups have been altered over the years to maximize their effectiveness in promoting their viewpoint under evolving political and physical conditions, and (3) a detailed characterization of the two local activist perspectives at the time of this study in the late 2000s. I conclude that changes in local activist perspectives and in the approaches to accommodate changes in the policy and physical contexts of local lead contamination constitute policy learning in a manner similar to how adaptations in policy approach constitute policy learning. More specifically, three instances of policy learning by stakeholders in adapting their approaches to effecting lead management were particularly influential in shaping the storylines of lead contamination and management presented in this dissertation. First, community health activists' efforts to promote an extended definition of lead contamination, which included additional media and health implications, eventually provided grounds for the extensive redefinition of local lead contamination. Second, community preservation activists' efforts to plan and prepare for future growth, prosperity, and the ongoing survival of the Herculaneum community laid the groundwork for community events and campaigns that are expected to shape the future of the region. Third, both groups have adapted their perspectives to reflect the emerging dominant ideology of ecological modernization in promoting and supporting initiatives that balance the interests of a productive industry with the needs of a clean and healthy community. I will discuss each of these changes and draw conclusions about policy learning in terms of adapting perspectives.

The role of policy learning in influencing the definition of the local lead problem. Strong reactions on the part of the community emerged after the release of the proposed AOC in 1999. The proposal mandated additional data collection toward quantifying the extent of non-air media contamination in Herculaneum and inspired strong reactions on the part of community members. Some came out in defense of Doe Run Co. while others contended that protections needed to be immediately extended rather than spend time collecting additional data. These debates continued after the AOC was finalized in 2001, with neither side entirely dominating the discussion. The local lead controversy accelerated after health activist residents successfully demanded that additional data in the form of soil and dust samples be taken in areas they suspected to be contaminated since soil and dust contamination were not addressed by existing management strategies. By doing this they demonstrated the inadequacy of the definition of the local lead policy problem on which the existing management strategy rested. As discussed earlier in this chapter, during the crisis that ensued, a great deal of data was collected and analyzed to provide agencies and the community with a more complete conception of current local lead challenges.

Community health activists experienced success in utilizing information and confrontational approaches encouraged by environmental activist organizations. The following excerpt from my interview with Isabella Robinson further demonstrated the approaches health activists, with the support of environmental activist organizations, adopted in meetings:

We kept hammering that and hammering that and with the help of the Coalition and… the Wash U. [IEC] once they got involved to help us. They [formal activist organizations] gave us the answers so we could ask the questions just to catch 'em [regulatory representatives] not knowing their own job or else lying….We would ask them [regulatory representatives] questions that we already knew the answers to, to see what the response would be and to get them to publicly admit that in front of – the media – hundreds of other people. Once they did that then the meetings really started taking off. (Interview, 10/7/2008)

In successfully demanding the collection and analysis of local lead levels, I contend that health activists identified an effective strategy for forcing the extension of contamination problem definitions and establishing a need for additional regulation. Therefore, I conclude that the adoption of confrontational strategies to force the consideration of additional media in the problem definition of local lead contamination fits the definition of policy learning as adaptation of local perspectives. In the face of widespread acknowledgement of considerable contamination, health oriented activists continued to demand the collection and analysis of additional data, as well as contend that existing agency knowledge was inadequate to accurately characterize the extent of local lead industry-related hazards. I conclude that health oriented activists' adoption of confrontational strategies in cooperation with environmental activist organizations constitutes policy learning, which was influential in promoting an expanded definition of local lead contamination.

Policy learning in this vein continued since confrontational approaches were successful as long as regulatory representatives were reconsidering the problem definition of local lead contamination. However, confrontational strategies proved less successful after regulatory representatives had taken actions to manage the contamination crisis, as discussed by Natalie Downs:

You know there's different behaviors work at different stages in a process and there are times when that—"I'm gonna get you, you're killing my kid, you're poisoning my kid"—there are times when that kind of thing works. And once you get to a certain point, that doesn't work anymore. When people are really, you know OK, the agencies are out there, they're trying to work, you see things getting done, and to have somebody still hollering 'baby killer' all the time turns a certain group of people, well probably the majority of the people off…. In the beginning that level of drama helped to get a few things moving. That level of drama got that street sample taken…, which was the starting block for a lot of action. So yeah, at that point that was an appropriate action. Three years down the line after you've been bought out… that's wholly inappropriate. (Focus Group, 4/30/2009)

Thus, community health activists learned that the same confrontational approaches that proved effective in the face of the contamination crisis became largely ineffective under conditions of ongoing lead management. Community health activists then had to adjust their approaches in light of changes in the regulatory approach that began to focus more on enforcing and maintaining newly established programs rather than extending the regulatory framework. Moreover, as community health activists' efforts to extend the definition of lead contamination became less effective, community preservation activists found unexpected allies in regulatory agents and were able to gather resources in pursuing measures to ensure the ongoing success of the town of Herculaneum. Policy learning in terms of such planning for community longevity is discussed in the next section.

The role of policy learning in promoting community longevity. Natalie Downs suggested that the confrontational strategies utilized by community health activists early in the controversy over local lead contamination began to offend residents holding different views. According to findings from participant interviews, those most offended by this behavior were not in agreement with much of the confrontational activity of community health activists throughout the contamination crisis. At the point that regulatory agencies considered lead contamination in Herculaneum to have been accurately characterized and effectively managed to the extent possible under current policy conditions, regulatory representatives began to resent the constant demands from local activists for extending local lead regulation. Regulatory representatives then offered residents who were interested in promoting and shaping positive directions for the future of the Herculaneum community the opportunity to participate in the development of a plan for the future utilization of the property purchased through the Voluntary Property Purchase Plan (VPPP). This group, which I have called community preservation activists, was extremely concerned with the reputation, survival, and prosperity of the Herculaneum community. Agency representatives involved community preservation activists and community health activists in planning for the community's future in the face of ongoing lead management by inviting leaders of both groups to participate in constructing a plan for moving the community forward in a productive and sustainable way. EPA in particular provided resources and facilitators for planning meetings in which community members developed a vision for what the community and its buy-out area could become. James Rease, a consultant who facilitated a great deal of the planning process for future use of the buy-out area described cooperation among group members in the following way:

The important thing about the process that we were running is that it wasn't really about the contamination….We were thinking about the factors that influence future land use other than contamination and often times when you think about the revitalization opportunities, the contamination is just one of the factors that gets taken into consideration and then there's a lot of other pieces on the table. Like what's happening with Herculaneum in general? Where is this town headed? So I think that the group didn't have—there weren't so many opportunities for conflict around the lead issue itself because the sort of driving force behind the process was thinking about future use. (Interview, 5/13/2009)

Through this facilitated visioning process, community preservation activists gained experience and resources in considering the future of the town, and avenues to pursue in supporting growth and development. Thus, I conclude that policy learning occurred through the visioning process, such that preservationists learned to strategize for community growth and longevity, while accommodating the activities and priorities of regulatory agencies to limit lead contamination and human exposures. Policy learning surrounding this balance of local economic and environmental interests is further discussed in the section below.

The role of policy learning in balancing local interests. Ecological modernists argue that objectives of economic growth can be complemented and supported by environmental objectives of sustainability and health protection. Hajer (1995) asserted that "ecological modernization has become the most credible way of 'talking Green' in spheres of environmental policy-making and increasingly functions as the organizing principle for the innovation of institutional procedures" (p. 30). Accordingly, ecological modernist views require that policy-making and industrial institutions both be willing to compromise toward a more prosperous and environmentally friendly future.

Through the process of planning for future use of the VPPP property, community preservationists' perspectives turned from focusing on resisting additional regulation to promoting initiatives that would simultaneously (1) benefit the community and (2) local lead industry, and (3) limit local lead exposures. For example, Jacob Williams, a community leader, described his approach to promoting community development and reducing the lead contamination burden simultaneously by citing examples of community plans to construct a bridge and develop a port on or near the smelter property:

And then if you look at secondary issues like the establishment of a port as opposed to trucks on the highway carrying concentrate, as opposed to trucks on the highway carrying scrap iron, by establishing a port we can take 500 trucks off of the road, save 50,000 gallons of diesel fuel on an average tow of 250 miles, and the corresponding air pollution is caused by diesel fuel. If we're really concerned about air pollution then they need to make a list of plusses, make a list of minuses, and see if we can't find a way to make this happen. I will leave here a happy man knowing that the bridge happens because I am so convinced that it's gonna be to everybody's benefit. (Interview, 10/7/2008)

Jacob's statement provides evidence of community preservation activists' policy learning such that it reflects the ways that community preservation activists have come to focus on agendas that simultaneously promote community growth and prosperity while reducing the lead contamination and exposure burden on the local population. The establishment of the northernmost port on the Mississippi River in Herculaneum would launch the town as a transportation hub for the northern Midwest. Port activities would bring with them a great deal of business opportunities, thereby multiplying Herculaneum's currently minimal commercial sector. The bridge plan is a necessary precursor to the port, as it would provide efficient access between the port and the interstate highway. The bridge also provides Doe Run Co. with a route to transport lead concentrate that bypasses local neighborhoods, thereby reducing the community's lead contamination burden, a goal highly valued by regulatory representatives. In addition, Doe Run Co. has enthusiastically supported plans for both the port and the bridge because they would improve the efficiency by which Doe Run Co. could transport products to and from its Herculaneum facility. The port and bridge plans emerged in the process of community planning for the future use of the buy-out zone. Through this policy learning process, community preservationist residents were able to develop plans that would be supported by institutions with a broad spectrum of interests.

Community health activists were less enthusiastic about shifting the focus of local lead management from extending regulation and limiting exposures to planning for community growth. Through participating in future-use planning activities, however, community health activists' perspectives began to accommodate concerns over the future and sustainability of the Herculaneum community. Responding to changes in the context of local lead contamination, community health activists learned to support initiatives that promoted reducing contamination and human exposure while also supporting economic vitality. During this transition, the CAG reassigned leadership roles to reflect the new, more cooperative approach necessary for continuing to advocate for the defense of community health. The two leaders at the core of the CAG today maintain that Doe Run Co. has an important role to play in the economic future of Herculaneum as well as a vital responsibility to consider the community's health as they make decisions with regard to lead management. For instance, community health activist, Alex Hill, described his central concerns in local lead management in ways that value *both* local health and community growth:

Recontamination. Adherence of Doe Run to consistent maintenance [and] compliance with the standards—the air standards [both] the old and the new. Just the general health of this area. Part of that is making sure that we don't get bogged down in focusing on just health, that we do grow this [community]. I'm really excited about the possible growth of Herculaneum. (Interview, 12/4/08)

In Alex's view, focusing on community growth is an important component in addition to the health interests of the Herculaneum community that CAG works to defend. In fact, today, the CAG leadership considers the CAG's role in lead management to be more of a partnership with regulatory agencies in information sharing and holding Doe Run Co. accountable for compliance, rather than the confrontational role adopted by CAG in the past. In so doing they defend a clean environment so that citizens and businesses looking to relocate would consider Herculaneum an attractive destination.

Policy learning as changing stakeholder perspectives. Based on the above discussions, I conclude that policy learning occurred through adjusting the perspectives of both community health activists and community preservation activists. Policy learning by local stakeholders was instrumental in both contributing to an expanded definition of local lead contamination problems, and in laying a foundation for the future of Herculaneum. This form of policy learning incorporated three central adaptations. First, both groups actively identified and capitalized on the most effective strategies to promote their priorities in the management of lead contamination in Herculaneum. Second, both groups adapted these strategies in response to changes in the approach to local lead management taken by regulatory representatives. Finally, avenues through which both groups sought to meet their goals of ensuring health protection and supporting community longevity were gradually adjusted to accommodate the priorities of both sides and to reflect the ecological modernist compromise position that has come to dominate environmental debates.

Synthesis of the Policy Learning in Regulatory Approaches and Stakeholder Perspectives:

A Cycle of Policy Learning

Building on the above discussions of adaptations in policy approaches and stakeholder perspectives in terms of policy learning, I contend that the policy learning of one group impacts the policy learning of others, and both set the stage for changes in the regulatory framework. Thus, a cycle of policy learning in response to the cycle of lead management discussed in Chapter Six was evident in Herculaneum. Examining the policy cycle of stasis, crisis, and renewed stasis as it aligned temporally with policy learning in terms of regulatory approaches and stakeholder perspectives provided insight into the ways that policy learning can be viewed as promoting, or responding to, a regulatory crisis. Here a regulatory crisis is understood to be a condition where the problem definition reflected in the current regulatory framework is known to inadequately reflect actual conditions. Additionally, policy learning as changes in stakeholder perspectives in Herculaneum set the stage for policy learning as changes in regulatory approaches. I will synthesize both types of policy learning in the policy cycle in Herculaneum in the following sections.

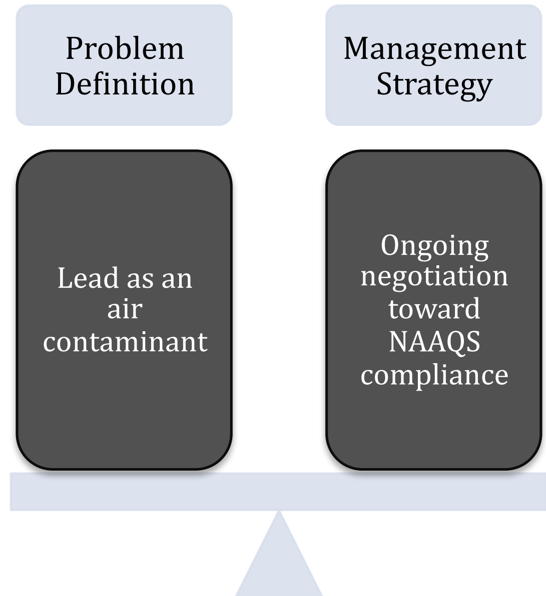


***Figure 8.1*: Under conditions of stasis, problem definitions and management strategies are considered to be in balance.**

Moving from initial stasis to crisis. Before the crisis in local lead management in 2001, local lead regulation involved ongoing negotiations between regulatory agencies and Doe Run Co. over improving lead emissions toward meeting the lead NAAQS of 1.5 $\mu g/m^3$. Policy learning on the part of regulatory representatives initiated a relatively minor adaptation of the regulatory approach to examine additional media contamination in Herculaneum. Regulatory representatives defended this action in meetings to comply with a mandated public comment period. These public meetings provided a forum for health-concerned citizens to point out additional concerns, particularly in relation to problems created by the transportation of lead products to and from the processing facility. Through this activity, health activists demanded the collection of the street dust sample that provided evidence that the definition of lead contamination addressed by existing regulatory programs did not adequately reflect physical conditions in Herculaneum. Through their success in demanding the collection of the street dust sample that produced the 300,000 ppm finding and accessing resources from environmental activist organizations, health activists learned that the examination of additional media could reveal previously unconsidered aspects of local lead contamination. During the crisis that followed the road dust finding, residents continued to press for extensions in the problem definition of local lead contamination. Regulatory representatives also worked to develop a more accurate definition of local lead contamination. This process of raising and examining additional sources of contamination and potential exposure in the local environment constituted an iterative cycle of policy learning in which the learning of health activists promoted learning by regulatory representatives and vice versa. I conclude that throughout the processes described here, policy

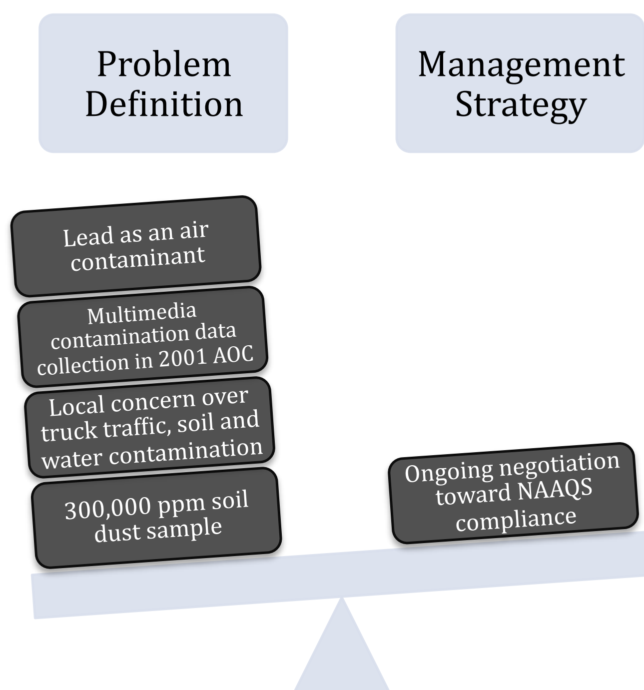


Figure 8.2: **Under conditions of crisis management strategies are inadequate to address current understandings of the policy problem.**

learning on the part of regulatory representatives contributed to circumstances that encouraged policy learning on the part of local stakeholders, which then promoted additional policy learning on the part of regulatory representatives.

Moving from crisis to renewed stasis. The lead contamination crisis in Herculaneum waned as regulatory agents implemented a variety of programs to manage the expanded conception of local lead problems. I contend that in response to the establishment of an expanded regulatory framework for managing local lead contamination, preservationist stakeholders engaged in policy learning to support community growth in a context of extensive lead regulation. Additionally, when regulatory approaches shifted from focusing on expanding definitions of local lead contamination to establishing effective management conditions, health activists moved from a confrontational approach of fighting for the expansion of local lead management to a conciliatory approach of cooperating in the local enforcement of existing regulatory programs. Both groups have made accommodations of alternate perspectives and moved toward a more ecological modernist approach, which

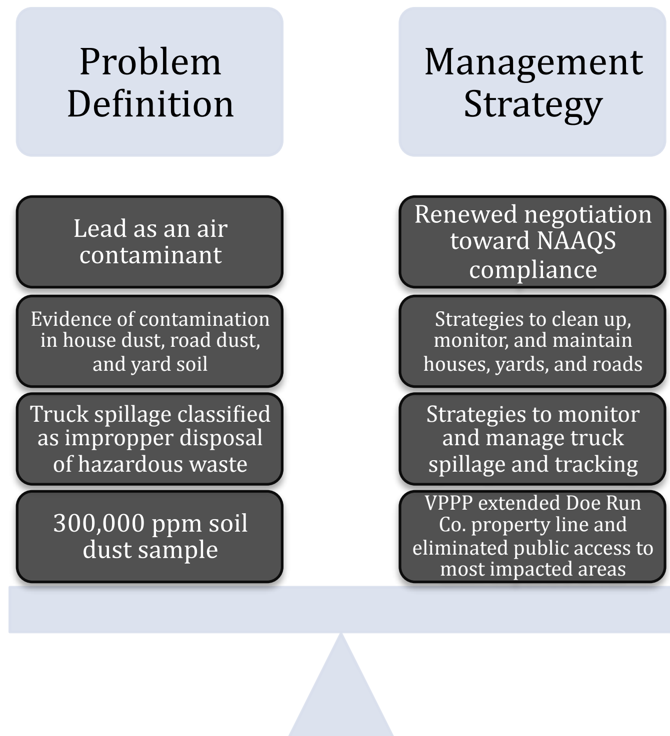


Figure 8.3: **Additional management strategies balance the expanded problem definition, contributing to a renewed stasis.**

simultaneously values economic development and environmental protection and reflects policy learning.

Setting the stage for another crisis. The activities of health activist Herculaneum residents in filing suit against EPA to demand the review of the NAAQS for lead extended lessons that they had learned through participating in local controversy over lead contamination. An overview of the different changes in the approaches of regulatory representatives and local activists is provided in Table 8.1. Their action provided a context in which regulatory representatives were able to provide evidence that air lead contamination could be linked to contamination in other media. By including discoveries about the extent and health implications of persistent air lead levels around the levels of the former lead NAAQS, EPA decision-makers reconsidered the former problem definition of air lead contamination. In conducting additional research to establish a more extensive problem definition for air lead contamination, additional learning occurred with regard to the health implications of lead exposures once thought innocuous. Thus, a new crisis emerged from their work in which the emerging definition of health hazards associated with lead contamination was not reflected in the existing lead NAAQS.

In both lead contamination crises discussed in this dissertation, policy learning on the part of either stakeholders or regulatory representatives set the stage for policy learning on the part of another group. Additionally, policy learning conceptualized as changes in both stakeholder perspectives and in regulatory approaches set the stage for changes in the regulatory framework for managing local lead contamination. Meanwhile

Table 8.1

Summary of the changes in the regulatory and local activist approaches to lead management.

Stage	Lead Management Strategy	Regulatory Representative Approach	Local Activism
Initial Stasis	Working toward compliance with 1.5 μg/m^3 lead NAAQS through SIPs largely focused on limiting plant emissions		
Transition		Begin to question the appropriateness of current problem definition	Press for recognition of contamination in terms of non-air media
Crisis	Lead problems are recognized as extending beyond existing management strategy.		
Transition		Conduct research toward identifying dimensions of expanded lead problems and devise relevant management strategies	Local stakeholders debate appropriate problem definition, management, and implications of lead contamination for Herculaneum
Renewed Stasis	• Compliance with 1.5 μg/m^3 lead NAAQS • Pollution controls • Road dust monitoring • Interior dust monitoring • Truck monitoring • Extended plant property line • Fence limiting access to area		
Transition		Conditions in Herculaneum presented as case evidence in review of lead NAAQS	Herculaneum residents bring suit against EPA for reconsideration of lead NAAQS
Second Crisis	New lead NAAQS defined air lead levels exceeding 1.5μg/m^3 to be noncompliant	Develop plans to bring Herculaneum area into compliance with new NAAQS according to established timeline	• Health activists campaign for accelerated timeline for moving toward attainment of new NAAQS for areas already known to be out of compliance. • Preservationists campaign for continued presence of Doe Run Co. in area.

policy learning through developing skills to contribute to community preservation promoted projects that supported both environmental protection and economic growth. In the next section I will discuss implications of these conclusions for relevant research arenas and for stakeholders in environmental controversies.

Implications

The findings of this study hold implications for the research arenas of science and technology studies (STS), public understanding of science (PUS), interpretive policy research, and educational research, as well as for regulatory representatives and citizens engaged in controversy over environmental policy. In this section I discuss ways that the findings of this study potentially inform research and activities in each of these contexts.

Implications for STS and PUS Research

The closely aligned genres of STS and PUS examine the social processes by which scientific discoveries are made and become widely accepted, and the ways that citizens participate in socio-scientific controversies respectively. The descriptions of local processes of policy learning, problem definition, and refined management strategy inform the ways that STS researchers consider differences between scientific processes that are focused on establishing and defending environmental policy frameworks designed to manage contamination in specific contexts and traditional models of scientific research focused on laboratory processes of hypothesis testing. The argument that policy learning understood as changing regulatory approaches influenced policy learning understood as changing stakeholder perspectives and vice versa informs PUS work by promoting not only the consideration of whether stakeholders are capable of participating in socio-scientific policy debates, but also of the ways that their perspectives shape the context within which shifts in policy approach develop. The study also provides potential insight for both STS and PUS research, encouraging a move from focusing on researcher-facilitated policy participation to recognizing policy learning on the part of regulatory representatives and local stakeholders in contexts where changes in a policy framework have inspired local controversy. Finally, additional work in both STS and PUS to flesh out the processes through which perspectives that dominate policy-making contexts gradually become pervasive in public discourses over local environmental controversy would be particularly informative for understanding the widespread adoption of ecological modernist positions.

Ecological modernization is a central topic of the PUS and STS literatures. Evidence of policy learning as local perspectives that initially appeared to reflect the environmentalist/industrialist dichotomy characteristic of early phases of the environmental movement transitioned to resemble contemporary ecological modernist perspectives constitute policy learning in this case study of Herculaneum. As discussed in Chapter Six, community health activists’ emerging accommodation of economic interests and concern for community longevity, and community preservation activists’ pursuit of agendas that promote both reduced contamination and community growth both fit well within an ecological modernist agenda. The contribution of this research to the discussion of ecological modernization is that through processes of policy learning and interactions between citizens and environmental regulatory representatives, the ecological modernist compromise has reached beyond policy-makers and been incorporated into the viewpoints of citizen activists.

Implications for Interpretive Policy Research

This dissertation study suggests that a constellation of local processes and interactions shaped lead management in Herculaneum and ultimately influenced national lead regulation. Tracing the mutual influences between policy approaches and stakeholder perspectives provided insights into the influence of controversy over different understandings of an environmental problem. The controversy was particularly evident in attempts to define the local contamination problem and to devise or adapt strategies for managing newly defined problems. Additionally, conceptualizing adjustments and accommodations made by regulatory representatives and local stakeholders in terms of policy learning provides a framework for tracing processes whereby policy approaches and local perspectives gradually evolve in response to changes in political and physical context. Based on the findings presented in this dissertation, interpretive policy researchers may wish to consider the ways that local activism can influence regulatory representatives to reconsider existing problem definitions and management programs. Furthermore, the research presented here suggests that policy learning in local contexts can have important implications for shaping policy agendas on a much larger scale. This contention builds on theory from STS that large scale scientific and policy processes can be traced to the culmination of multiple and diverse activities of a complex network of actors addressing local problems in particular contexts.

Implications for Environmental Regulatory Representatives

Regulatory representatives may draw several insights from this work. First, my findings in Herculaneum further stress the potential contributions of locally held knowledge. That is, local knowledge assists in the enforcement of existing contamination management programs and in pointing out additional aspects of contamination problems that should be considered. Second, this research recognizes the potential for policy learning on the part of both regulatory representatives and local stakeholders, and these findings might inspire policy representatives to (1) make efforts to become familiar with the diverse perspectives and main concerns of stakeholders, and (2) create opportunities for citizens to become familiar with aspects of local contamination in terms of scientific understandings and regulatory practices. In so doing, regulatory representatives could create productive and cooperative settings in which both the exploration of local policy problems and the implementation of effective management strategies are combined in a reflexive relationship between regulatory agencies and local stakeholders. Hajer (1995) explained the reflexive dimension of the ecological modernist agenda:

> Reflexive ecological modernization focuses the discussion on the social order in terms of which we define what constitutes pollution. In this model ecological modernization automatically ceases to be a primarily techno-administrative affair in which the objective reality of expert discourse determines what is out of place and where solutions are selected that respect the implicit social order of expert discourse. (p. 281)

A relationship in which local policy problems are defined and management strategies are developed through ongoing cooperation between regulatory agencies and local stakeholders would begin to fulfill the reflexive ecological modernist vision. More practically, it would end the regulatory cycle described here in terms of stasis, crisis, and secondary stasis. This cycle would be replaced with an ongoing process of exploration of existing conditions, application of current science, and consideration of local concerns in defining and managing local policy problems.

Implications for Citizen Activists

The results of this study suggest that, during environmental regulatory processes, particular activities of citizens are more influential at different times. That is, attention to the *stage* of the environmental controversy that a community is experiencing and adjusting activist efforts accordingly may help local stakeholders maximize their effectiveness at promoting both health protection in and the ongoing success of the community. Under conditions where citizens view the established regulatory framework as ineffective or irrelevant, they may advocate for the collection of evidence of more extensive contamination or other sources of pollution and then support an expanded treatment of contamination management. Alternatively, when measures have been taken to manage existing contamination, efforts to minimize ongoing exposures while maximizing economic benefits to local institutions may be expected to attract widespread support.

Implications for Science Education Researchers

Americans are confronted increasingly with questions in their lives that require scientific information and scientific ways of thinking for informed decision making. And the collective judgment of our people will determine how we manage shared resources—such as air, water, and national forests. (National Research Council, 1996, p. 11)

This dissertation study demonstrates one context in which an American community has been confronted with a controversy that held implications for their health, their community, and the management of local resources. It also demonstrates that "informed decision making" in Herculaneum was not an event for which residents were prepared in science classrooms, but an ongoing learning process through which their perspectives and approaches to local lead contamination and its management were shaped and adapted to accommodate an evolving physical and political context. Building on this work, important considerations for pursuit by educational researchers include: (1) how classroom instructional experiences might contribute to the preparation of students in socio-scientific controversy, and (2) how policy learning as it is described here constitutes a frequently unrecognized educational context.

Directions for Further Research

In this section I describe two potential studies that I envision will build off of the research presented in this dissertation and further characterize issues of lead contamination in the Herculaneum area: 'Activism in Action' and 'Implications of the 2008 Lead NAAQS.'

A Study of Activism in Action

During data collection for this study, two efforts of community health activists and community preservation activists were central concerns of the two groups. First, following their success at influencing the reduction of the national standard regulating lead in the air, community health activists became preoccupied with promoting the establishment of a standard for regulating road dust, which would allow them to determine whether extant levels of lead in dust on their roads is safe. Second, community preservation activists have pursued the planning, funding, and construction of a bridge that would more directly connect the lead processing facility to the highway, effectively rerouting traffic away from neighborhood streets. These two activist projects have been met with very different reactions and have produced very different results. I plan to conduct a comparative study of the efforts of the two groups in pursuit of these goals. Below I provide a brief description of processes surrounding the lead dust standard and bridge construction efforts that will be the central focus of this future analysis.

A standard for lead dust. Following the 300,000 ppm finding, community health activists have called repeatedly for the development of a standard for lead dust in order to properly regulate the kind of contamination that created the initial local crisis. Despite perceived victories in forcing the buy-out and suing for the reconsideration of the lead NAAQS, many of their requests for reconsideration or calls for increased attention have apparently fallen on deaf ears. Herculaneum resident, Alex Hill, explained his perspective on the need for a standard regulating street dust:

One of the things that just blows my mind, Jill, is that when we ask, "What is the standard for clean roads?"… But there is no standard. Now, I just can't get my mind around that. How do you determine whether this is healthy or not if there's no standard? Well, a couple of years ago…we really ticked off the other camp by forcing DNR to erect signs saying, "These streets are unhealthy." If there's no standard, how do you deal with that? Well, how do you determine they're unhealthy if there's no standards for health? (Interview, 12/4/2008)

Health activists' expectation that lead regulations should be in place to control any source from which they might be exposed to lead has come into conflict with regulatory practices establishing appropriate standards in different media. Standards are used to determine whether a given concentration of lead in a particular media can be considered safe or hazardous; however, procedures used to establish these standards were developed to manage concentrations of contaminants in water and air. In such media, processes of diffusion allow for the assumption that the concentration of contaminant in a small sample will reflect the concentration over a large volume. This is not the case for a media such as road dust, which will be present in various concentrations in specific locations on streets throughout an area of concern.

When asked about the possibility of setting a standard to regulate lead concentrations in road dust, Nick Peterson (a representative of MDNR) explained:

No, I mean, we've pretty much struggled with that ever since the advent of finding that road dust problem, and one of the issues is Missouri is one of the last places they're mining lead, you know? Most places in the country or in North America are not dealing with this issue, and the science is difficult. What is the exposure scenario for road dust, you know? It's easy to think of if it's in a residential setting or an ecological setting, but in a road – I don't know. There would have to be – it's not undoable [impossible]. There's probably something feasibly that can be done, but I don't see the feds doing it because it's not a widespread problem, and the state isn't gonna have the resources. (Interview, 2/19/2009)

While regulatory representatives recognized the potential usefulness of setting a standard for lead in road dust, it is not seen as practical or feasible in terms of the intricate details of exposure pathway and standardized methods for sample collection. To clarify, regulatory strategies for establishing standards for limiting contamination in particular media are not directly applicable to a media such as dust. Dust samples can not be collected and quantified in the same manner as air or water samples and, therefore, do not align with existing regulatory practices associated with setting and enforcing such standards. Additionally, it remains unclear what agency and program would be responsible for regulating contaminated road dust. Thus, activism toward the development of a road dust standard has been difficult to organize and has not been successful in encouraging regulatory change.

The bridge plan. An example of local activism, which will also impact local road dust contamination, and that has been far more successful, is a plan for the construction of a bridge providing a more direct route from the Interstate 55 to the lead facility. Plans for the construction of a bridge to provide direct truck access between I-55 and the Doe Run lead processing facility originated in the property buy-out reuse plan released in conjunction with the 2002 AOC amendments. This plan was the product of planning meetings facilitated by EPA-contracted consultants, and were widely supported in the community. Jacob Williams defended this plan at a widely attended CAG meeting in September 2008:

There are obvious advantages to Doe Run to have this bridge up out of the floodplain, but the city sees it as advantageous. And I shouldn't speak for the city myself but I think it's a consensus. This will give us a new bridge that's 14 feet above the 93 flood level.… We can save taxpayers money, we can build something we can all be proud of, we can make sure that our emergency vehicles can access both sides of town—the emerging side of town and the old historic part of town—quickly.… So police and fire [services] will be half a mile away instead of during periods of high water when we have to ride that circuitous route through Pevely because 61/67 is flooded and our bridge is flooded.… I don't have to tell you about that, all of you have lived through that for three years when this bridge was down and in '93 when both bridges were down. It's not just inconvenient;

it's not cost effective. It costs the school a bunch of money; it makes it less safe for children we're transporting on busses. It certainly makes it less safe for a two year old that is on the wrong side of town from the new fire station. (Observation, 9/16/2008)

Despite controversy over specific aspects of bridge construction, the bridge plan has experienced widespread support from local stakeholders and regulatory agencies, as well as Doe Run Co. and the bridge is currently under construction. Thus, I assert that exploration of differences in the activities and outcomes of citizen activist efforts between the bridge plan and the development of a standard to regulate road dust will provide insights into arenas in which citizen activists might expect to find success and arenas that may prove more difficult, which is related to the effective activist strategies described earlier. This study could extend the implications for stakeholders involved in environmental controversy by clarifying the contexts and strategies that have been most effective in achieving stakeholder goals in the local lead controversy in Herculaneum.

Implications of the 2008 Lead NAAQS: Studying A New Crisis

Changes in the national policy regulating air lead have created another crisis point for lead management locally, and the lower than expected lead NAAQS is having far reaching impacts for the Herculaneum community, local lead regulation, and Doe Run Co. The new NAAQS have forced a change in the landscape of local lead monitoring. The monitoring network in Herculaneum has maintained compliance with the old NAAQS for several years. In anticipation of the implementation of the new standard, however, Doe Run and regulatory agencies are facing a huge challenge in coming into compliance with the new standard. I intend to follow their efforts at complying with the new lead NAAQS, both in relation to regulatory efforts and technological developments. These regulatory efforts and technological developments are described below.

Regulatory efforts. In response to a requirement of the new NAAQS, DNR proposed boundary recommendations and a revised lead monitoring network in the state of Missouri that extend the possible zone of non compliance through Pevely and Crystal City. According to 2006-2008 data, none of the existing samplers meet the 2008 lead standard. The primary consideration is the fact that the ambient air monitoring in the city shows violations of the 2008 lead NAAQS. Since none of the data collected by existing monitors have attained compliance with the new standard, it is difficult to determine the boundaries of the area where ambient air is not compliant with the new standard. Therefore, a new monitoring network must be established in the Herculaneum region: There is insufficient current monitoring data at a distance from the smelter and a great deal of uncertainty associated with EPA-recommended monitoring data interpolation and dispersion modeling techniques. This leads to the Department's recommendation of nonattainment to be limited to the city limits of Herculaneum, which is identical to the 1978 nonattainment boundary. (Missouri Department of Natural Resources, 2009) Areas of Pevely, Crystal City, and Festus are to be considered unclassifiable until the monitors at new locations have collected sufficient data in 2010 to make this judgment. The NAAQS recommended classifying entire counties with noncompliant areas as noncompliant, but MDNR has argued that this approach is not relevant to such a heavy pollutant as lead, which falls out of the air relatively close to the source. They suggest more specific boundary designations when a particular source is targeted. It appears that they have been successful in making this argument, as the proposed monitoring network is currently being reviewed by EPA.

Technological developments. Doe Run is shifting its primary lead processing operations to an as yet undisclosed location where they will be building a cutting edge facility that it is to be developed over the next several years, as described in their March 22, 2010 Press Release, excerpted below.

The Doe Run Company today is unveiling a revolutionary new technology for producing lead that company officials estimate will reduce all air, land and water releases by nearly 99 percent. The new process replaces traditional, high-temperature lead smelting with a wet chemical process that is safer, cleaner and more efficient. Its application is expected to transform the global lead industry. (Dixon, 2010)

This facility will either be located at Herculaneum or a location closer to the Doe Run's operating mines. The Herculaneum lead smelter will become inactive and will be the focus of an ongoing clean up effort. It is unclear what impact this development will have on Herculaneum, particularly if Doe Run chooses an alternate location for the new facility. At the time this dissertation is being written, Herculaneum is cooperating with Doe Run to campaign for opening a port facility on the former smelter site. If successful, this initiative is expected to bring a great deal of commerce to the area. Whatever the outcome of these negotiations, the storyline of lead contamination in Herculaneum will provide insight into community interaction with environmental policy and processes of policy learning well into the future.

References

AAAS. (1990). *Science for All Americans*. New York: Oxford University Press.

Agency for Toxic Substances and Disease Registry. (2005). *Health consultation: Exposure investigation - Herculaneum lead smelter site, Jefferson County, Missouri*. Retrieved from http://www.atsdr.cdc.gov/hac/PHA/HCPHA.asp?State=MO.

Ahmed, S. (1991, January 30). Official challenges significance of company's air-quality data, *St. Louis Post-Dispatch,* p. 4C.

Albalak, R., McElroy, R. H., Noonan, G., Buchanan, S., Jones, R. L., Flanders, W. D., Gotway-Crawford, C., Kim, D., Dignam, T., Daley, W., Jarrett, J., Eduardo, E., McHeehin, M. A. (2003). Blood lead levels and risk factors for lead poisoning among children in a Mexican smelting community. *Archives of Environmental Health, 58*(3), 172-183.

Baghurst, P., Tong, S., McMichael, A. J., Robertson, E. F., Wigg, N. R., & Vimpani, G. (1992). Determinants of blood lead concentrations to age 5 years in a birth cohort study of children living in the lead smelting city of Port Pirie and surrounding aeas. *Archives of Environmental Health, 47*(3), 203-210.

Barton, A. C. (2003). *Teaching science for social justice*. New York: Teachers College Press.

Beck, U. (1992). From industrial society to the Risk Society: Questions of survival, social structure and ecological enlightenment. *Theory , Culture & Society, 9*, 97-123.

Bell, M. (2004). *An invitation to environmental sociology* (2nd Ed. ed.). Thousand Oaks: Pine Forge Press.

Bellinger, D. C., & Bellinger, A. M. (2006). Childhood lead poisoning: The torturous path from science to policy. *The Journal of Clinical Investigation, 116*, 853-857.

Brown, R. T. (2001). Behavioral teratology/toxicology: How do we know what we know? *Archives of Clinical Neuropsychology, 16*, 389-402.

Burns, J. M., Baghurst, P. A., Sawyer, M. G., McMichael, A. J., & Tong, S.-l. (1999). Lifetime low-level exposure to environmental lead and children's emotional and behavioral development at ages 11-13 years: The Port Pirie Cohort Study. *American Journal of Epidemiology, 149*(8), 740-749.

Business Information Services LLC. (2007). Dunklin R-V School District: Demographics Study Retrieved January 28, 2008, from http://www.dunklin.k12.mo.us/images/District/Facilities%20Assessment%20Documents/Dunklin_Demographic_Report_071507.pdf

Byers, R. K., & Lord, E. E. (1943). Late effects of lead poisoning on mental development. *American Journal of Disabilities in Children, 66*, 471-483.

Callon, M. (1986). Some elements of a sociology of translation: domestication of the scallops and the fishermen of St. Brieuc Bay. In J. Law (Ed.), *Power, action and belief: A new sociology of knowledge?* (pp. 196-223). London: Routledge.

Canfield, R. L., Kreher, D. A., Cornwell, C., & Henderson, C. R. (2003). Low-level lead exposure, executive functioning, and learning in early childhood. *Child Neuropsychology, 9*(1), 35-53.

Carroll, C. (2002, February 27, 2002). Tests show heavy lead poisoning in Herculaneum; Incidence is highest in state, official says, *St. Louis Post-Dispatch*.

City of Herculaneum. (2006). The Herculaneum Master Plan Retrieved May 9, 2008, 2008, from http://www.cityofherculaneum.com/services/masterplan.html

Danse, I. J. R., Garb, L. G., & Moore, R. H. (1995). Blood lead surveys of communities in proximity to lead-containing mill tailings. *American Industrial Hygiene Association, 56*(4), 384.

Dempsey, M. E. (2001). Missouri Department of Health and Senior Services Sept. 24, 2001 Letter - Herculanum Missouri Lead Contamination Public Health Risk Retrieved August 6, 2009, from http://www.dnr.mo.gov/env/herc/docs/dempsey-letter-dhss9-24-01.pdf

Dixon, C. (2010). Doe Run Announces revolutionary new lead processing technology that would be world's first application: Breakthrough virtually eliminates environmental impacts; shows promise for global industry Retrieved March 15, 2011, 2011, from http://www.doerun.com/NewLeadProcessingTechnologyAnnouncement/tabid/168/language/en-US/Default.aspx

Doe Run builds fence around smelter. (2008, March 6). *The Associated Press State & Local Wire*.

Eardley, L. (1988, February 13). Smelting firm to protest $2.78 million fine, *St. Louis Post-Dispatch,* p. 1B.

Edelstein, M. R. (2004). *Contaminated communities : Coping with residential toxic exposure* (2nd ed.). Boulder, CO. ; Oxford: Westview Press.

Ekong, E., Jaar, B., & Weaver, V. (2006). Lead-related nephrotoxicity: A review of the epidemiologic evidence. *Kidney International, 70*, 2074-2084.

Ellis, M. R., & Kane, K. Y. (2000). Lightening the lead load in children. *American Family Physician, 62*(3), 545-564.

Fischer, F. (1995). *Evaluating public policy*. Chicago: Nelson-Hall Publishers.

Fischer, F. (2000). *Citizens, experts, and the environment : the politics of local knowledge*. Durham NC: Duke University Press.

Fischer, F. (2003). *Reframing Public Policy: Discursive politics and deliberative practices*. Oxford: Oxford University Press.

Flannery, W. (1992, July 31, 1992). 300 workers strike at Doe Run: Company imposed contract proposal, *St. Louis Post-Dispatch,* p. 10D.

Gardner, J. A. (1980). *Lead King: Moses Austin*. St. Louis, MO: Sunrise Publishing Co. Inc.

Geertz, C. (1973). Thick description: Toward an interpretive theory of culture *The Interpretation of Cultures: Selected Essays* (pp. 3-30). New York: Basic Books.

Get the lead out. (2007, March 5). *St. Louis Post -Dispatch,* p. B8.

Gilbert, S. G., & Weiss, B. (2006). A rationale for lowering the blood lead action level from 10 to 2 ug/dL. *NeuroToxicology, 27*(2006), 693-701.

Goyer, R. A. (1993). Lead toxicity current concerns. *Environmental Health Perspectives, 100*, 177-187.

Grosse, S. D., Matte, T. D., Schwartz, J., & Jackson, R. J. (2002). Economic gains resulting from the reduction in children's exposure to lead in the United States. *110, 6*(563-569).

Guba, E. G., & Lincoln, Y. S. (1989). *Fourth generation evaluation*. Newbury Park, California: Sage Publications.

Gulson, B. L., Davis, J. J., Mizon, K. J., Korsch, M. J., Law, A. J., & Howarth, D. (1994). Lead bioavailability in the environment of children: Blood lead levels in children can be elevated in a mining community. *Archives of Environmental Health, 49*(5), 326-331.

Hacking, I. (1999). *The social construction of what?* Cambridge, Mass. ; London: Harvard University Press.

Hajer, M. (1995). *The politics of environmental discourse: Ecological modernization and the policy process*. New York: Oxford University Press.

Hajer, M. (2003). A frame in the fields: Policymaking and the reinvention of politics. In M. A. Hajer, Wagenaar, Hendrik (Ed.), *Deliberative policy analysis: Understanding governance in the network society*. Cambridge: Cambridge University Press.

Healy, S. (2003). Public Participation as the Performance of Nature. In B. Szerszynski, W. Heim & C. Waterton (Eds.), *Nature performed: Environment, culture and performance* (pp. 94-108): Blackwell.

Hebben, N. (2001). Low lead levels and neuropsychological assessment: Let us not be mislead. *Archives of Clinical Neuropsychology, 16*, 353-357.

Hernberg, S. (2000). Lead poisoning in a historical perspective. *American Journal of Industrial Medicine, 38*, 244-254.

Hilts, S. R. (2003). Effect of smelter emission reductions on childen's blood lead levels. *The Science of the Total Environment, 303*, 51-58.

Hurd, P. D. (1998). Scientific literacy: New minds for a changing world. *Science Education, 81*(4), 407-416.

Hurd, P. D. (2001). Modernizing science educaton. *Journal of Research in Science Teaching, 39*(1), 3-9.

Irwin, A. (1995). *Citizen Science: A study of people, expertise, and sustainable development*. London: Routledge.

Jasanoff, S. (1990). *The fifth branch: Science advisers as policymakers*. Cambridge, MA: Harvard University Press.

Jasanoff, S. (2003). Technologies of humility: Citizen participation in governing science. *Minerva, 41*(3), 223-244.

Jasanoff, S. (Ed.). (1995). *Handbook of science and technology studies*. Thousand Oaks, CA: Sage Publications.

Kaufman, A. S. (2001). How dangerous are low (not moderate or high) doses of lead for children's intellectual development? *Archives of Clinical Neuropsychology, 16*, 403-431.

Killingsworth, J. M., & Palmer, J. S. (1992). *Ecospeak: Rhetoric and environmental politics in America*. Carbondale and Edwardsville: Southern Illinois University Press.

Kruzen, T. (2002, January 11, 2002). Alternatives to lead, Editorial, *St. Louis Post-Dispatch,* p. B6.

Landrigan, P. J., Schechter, C. B., Lipton, J. M., Fahs, M. C., & Schwartz, J. (2002). Environmental pollutants and disease in American children: Estimates of morbidity, mortality, and costs for lead poisoning, asthma, cancer, and developmental disabilities. *Environmental Health Perspectives, 110*(7), 721-728.

Lanphear, B. P., Dietrich, K., Auinger, P., & Cox, C. (2000). Cognitive deficits associated with blood lead concentrations < 10 microg/dL in US children and adolescents. *Public Health Report, 115*(6), 521-529.

Lanphear, B. P., Hornung, R., Khoury, J., Yolton, K., Baghurst, P., Bellinger, D. C., . . . Roberts, R. (2005). Low-level environmental lead exposure and children's intellectional function: An international pooled analysis. *Environmental Health Perspectives, 113*(7), 894-899.

Lanphear, B. P., Matte, T. D., Rogers, J., Clickner, R. P., Dietz, B., Bornschein, R. L., . . . Jacobs, D. E. (1998). The contribution of lead-contaminated house dust and residential soil to children's blood lead levels: A pooled analysis of 12 epidemiologic studies. *Environmental Research, 79*(Section A), 51-68.

Latour, B. (1993). *We have never been modern*. Cambridge, Mass.: Harvard University Press.

Latour, B. (1996). On interobjectivity. *Mind, Culture and Activity, 3*(4), 228-245.

Latour, B. (2005). *Reassembling the Social*. Oxford: Oxford University Press.

Law, J. (Ed.). (1991). *A sociology of monsters: Essays on power, technology and domination*. London: Routledge.

Law, J., & Hassard, J. (Eds.). (1999). *Actor network theory and after*. Oxford: Blackwell Publishers.

Law, J., & Urry, J. (2004). Enacting the social. *Economy and Society, 33*(3), 390-410.

Lee, S., & Roth, W.-M. (2001). How ditch and drain become a healthy creek: Re-presentations, translations and agency during the re/design of a watershed. *Social Studies of Science, 31*(3), 315-356.

Lee, S., & Roth, W.-M. (2006). Community-level controversy over a natural resource: Toward a more democratic science in society. *Society and Natural Resources, 19*, 429-445.

Lost in the fine print. (2008, May 9). *St. Louis Post-Dispatch,* p. C10.

Malcoe, L. H., Lynch, R. A., Kegler, M. C., & Skaggs, V. J. (2002). Lead sources, behaviors, and socioconomic factors in relation to blood lead of Native American and White children: A community-based asessment of a former mining area. *Environmental Health Perspectives, 110*(Supplement 2), 221-231.

Malone, R. (1995, October 8). Mood swing: Herculaneum shifts loyalty over plant's lead emissions, *St. Louis Post-Dispatch,* p. 1C.

Markowitz, G., & Rosner, D. (2002). *Deceit and denial: The deadly politics of industrial pollution*. Berkeley: University of California Press.

Martineau, R. J., & Novello, D. P. (2004). *The Clean Air Act handbook* (2nd ed.). Chicago, Ill.: American Bar Association.

McHenry, R. E. (Ed.). (2006). *Chat dumps of the Missouri lead belt, St. Francois County*. Park Hills, MO: Distributed by Missouri Mines State Historic Site and Museum.

Melnick, R. S. (1983). *Regulation and the courts : the case of the Clean Air Act*. Washington, D.C.: Brookings Institution.

Missouri Coalition for the Environment v. U.S. Environmental Protection Agency, No. 4:04CV00660 ERW (Eastern District Court of Missouri 2005).

Missouri Department of Health and Senior Services. (2001). *Herculaneum Missouri - Elevated blood lead levels in children under 72 months of age*. Retrieved from http://www.dhss.mo.gov/hazsubstancesites/herc2001map.pdf.

Missouri Department of Health and Senior Services. (2003). Childhood blood lead screening and risk data 1997-2001 Retrieved May 5, 2011, 2011, from http://health.mo.gov/living/environment/lead/pdf/Cal97-01.pdf

Missouri Department of Health and Senior Services, & Agency for Toxic Substances and Disease Registry. (2001). *Health consultation: Blood lead results for 2001 calendar year - Herculaneum Lead Smelter Site Herculaneum, Jefferson County, Missouri*. Retrieved from http://www.atsdr.cdc.gov/hac/PHA/herculaneum/hls_p1.html.

Missouri Department of Health and Senior Services, & Agency for Toxic Substances and Disease Registry. (2002). *Health consultation: Determination if remedial actions are protective of public health - Herculaneum lead smelter site Herculaneum, Jefferson*

County, Missouri. Retrieved from http://www.dhss.mo.gov/PreventionAndWellness/Hercprotectiveaction.pdf.

Missouri Department of Health and Senior Services, & Agency for Toxic Substances and Disease Registry. (2002). *Health consultation: Public health evaluation of arsenic and cadmium levels in air and residential soils - Herculaneum Lead Smelter Site, Herculaneum, Jefferson County, Missouri*. Retrieved from http://www.dhss.mo.gov/PreventionAndWellness/HercCAS-CDfnlbe.pdf.

Missouri Department of Health and Senior Services, & Agency for Toxic Substances and Disease Registry. (2002). *Health consultation: Sulfer Dioxide monitors in Herculaneum - Herculaneum Lead Smelter Site, Jefferson County, Missouri*. Retrieved from http://www.dhss.mo.gov/PreventionAndWellness/HercS02.pdf.

Missouri Department of Health and Senior Services, & Agency for Toxic Substances and Disease Registry. (2002). *Health consutation: Public health implications from attending or working at Herculaneum schools - Herculaneum Lead Smelter Site Herculaneum, Jefferson County, Missouri*. Retrieved from http://www.dhss.mo.gov/PreventionAndWellness/Hercschools.pdf.

Missouri Department of Health and Senior Services, & Agency for Toxic Substances and Disease Registry. (2003). *Health consultation: Determination if site specific interior dust clean-up levels are protective of public health - Herculaneum Lead Smelter Site, Jefferson County, Missouri*. Retrieved from http://www.dhss.mo.gov/PreventionAndWellness/Hercindoorsampling.pdf.

Missouri Department of Health and Senior Services Office of Epidemiology. (2007). *Determining baseline prevalence for provider-diagnosed Multiple Sclerosis (MS) and*

Amyotrophic Lateral Sclerosis (ALS) in Herculaneum and Jefferson County, Missouri. Retrieved from http://www.dhss.mo.gov/hazsubstancesites/FinalReport_Herculaneum.pdf.

Missouri Department of Natural Resources. (2001). *Order to abate cease and desist violations*. Retrieved from http://www.dnr.mo.gov/env/herc/hercabateorder.pdf.

Missouri Department of Natural Resources. (n.d.). Herculaneum Lead Contamination Retrieved May 5, 2011, 2011, from http://www.dnr.mo.gov/env/herc/index.html - doerun100302

Missouri Department of Natural Resources v. Doe Run Resources Corporation, No. SF-0 1-1A (Hazardous Waste Management Commission State of Missouri, Clean Water Commission State of Missouri, Air Conservation Commission State of Missouri 2002).

Mol, A., & Law, J. (1994). Regions, networks and fluids: Anaemia and social topology. *Social Studies of Science, 24*(4), 641-671.

Mol, A. P. J. (1996). Ecological modernisation and institutional reflexivity: Environmental reform in the late modern age. *Environmental Politics, 5*(2), 302-323.

Mol, A. P. J., & Spaargaren, G. (2000). Ecological modernization theory in debate: A review. *Environmental Politics, 9*(1), 17-49.

Moore, C. F. (2003). *Silent scourge: Children, pollution, and why scientists disagree*. New York: Oxford University Press.

Murgueytio, A. M., Evans, R. G., & Roberts, D. (1998). Relationship between soil and dust lead in a lead mining area and blood lead levels. *Journal of Exposure Analysis and Environmental Epidemiology, 8*(2), 173-186.

Murgueytio, A. M., Evans, R. G., Roberts, D., & Moehr, T. (1996). Prevalence of childhood lead poisoning in a lead mining area. *Journal of Environmental Health, 58*(10), 12-17.

Murgueytio, A. M., Evans, R. G., Sterling, D. A., Clardy, S. A., Shadel, B. N., & Clements, B. W. (1998). Relationship between lead mining and blood lead levels in children. *Archives of Environmental Health, 53*(6), 414-423.

Nation, J. R., & Gleaves, D. H. (2001). Low-level lead exposure and intelligence in children. *Archives of Clinical Neuropsychology, 16*, 375-388.

National Research Council. (1996). *National Science Education Standards*. Washington, DC: National Academy Press.

Navas-Acien, A., Guaaller, E., Silbergeld, E. K., & Rothenberg, S. J. (2007). Lead exposure and cardiovascular disease - A systematic review. *Environmental Health Perspectives, 115*(3), 472-482.

Needleman, H. L. (1989). The persistent threat of lead: A singular opportunity. *American Journal of Public Health, 79*(5), 643-645.

Needleman, H. L. (1998). Clair Patterson and Robert Kehoe: Two views of lead toxicity. *Environmental Research, 78*, 79-85.

Needleman, H. L. (2000). *Human lead exposure*. Boca Raton, FL: CRC Press Inc.

Needleman, H. L. (2000). The removal of lead from gasoline: Historical and personal reflections. *Environmental Research, 84*, Section A 20-35.

Needleman, H. L. (2004). Lead Poisoning. *Annual Review of Medicine, 55*, 209-222.

Needleman, H. L., & Bellinger, D. C. (1991). The health effects of low level lead exposure. *Annual Reviews of Public Health, 12*, 111-140.

Needleman, H. L., & Bellinger, D. C. (2001). Studies of lead exposure and the developing central nervous system: A reply to Kaufman. *Archives of Clinical Neuropsychology, 16*, 359-374.

Needleman, H. L., Schell, A., Bellinger, D. C., Leviton, A., & Allred, E. (1991). The long-term effects of exposure to low doses of lead in childhood. *The New England Journal of Medicine, 322*(2), 83-88.

Neighbors: The Doe Run Company's Report to Our Communities. (2007) Retrieved March 30, 2008, from http://www.doerun.com/Portals/0/CommunityReports/DoeRun_Neighbors_2007.pdf

Nriagu, J. O. (1998). Clair Patterson and Robert Kehoe's paradigm of ''Show me the data''on environmental lead poisoning. *Environmental Research, 78*, 71-78.

Pfitzer, E. A. (1974). An overview of the conference on low level lead toxicity. *Environmental Health Perspectives, 7*, 247-252.

The Renco Group Inc.:The Doe Run Resources Corporation. (2005) Retrieved May 12, 2008, from http://www.rencogroup.net/companies/doerun.html

Richardson, J. W. (1999). *The social consequences of lead poisoning in low-income children: Lessons learned from the implementation of Public Law 102-550 in Richmond, Virginia.* Dissertation, University of Virginia.

Richardson, J. W. (2002). Poor, powerless and poisoned: The social injustice of childhood lead poisoning. *Journal of Children & Poverty 8*(2), 141-157.

Rodriguez, A. J. (1997). The dangerous discourse of invisibility: A critique of the National Research Council's National Science Education Standards. *Journal of Research in Science Teaching, 34*(1), 19-37.

Roels, H. A., Buchet, J.-P., Lauwerys, R. R., Bruaux, P., Claeys-Thoreau, F., LaFontaine, A., & Verduyn, G. (1980). Exposure to lead by the oral and the pulmonary routes of children living in the vicinity of a primary lead smelter. *Environmental Research, 22*, 81-94.

Roth, W.-M., & Barton, A. C. (2004). *Rethinking scientific literacy*. New York: Taylor and Francis Books Inc.

Rowden, T. (2001, September 1). Herculaneum residents are warned of contamination, *St. Louis Post-Dispatch,* p. 7.

Sabatier, P. A., & Jenkins-Smith, H. C. (1993). *Policy change and learning : An advocacy coalition approach*. Boulder, Colo.: Westview Press.

Sanders, T., Liu, Y., Buchner, V., & Tchounwou, P. B. (2009). Neurotoic effects and biomarkers of lead exposure: A review. *Review of Environmental Health, 24*(1), 15-45.

Selbert, P. (1998, September 3). Lead led to good and bad times for 190 years, *St. Louis Post-Dispatch,* p. 1.

Shepard, B. (2002, January 8, 2002). Americans need lead. Missouri has lead. Doe Run should explore., *St. Louis Post-Dispatch,* p. D7.

Silbergeld, E. K. (1997). Preventing lead poisoning in chidren. *Annual Review of Public Health, 18*, 187-210.

Silbergeld, E. K. (2003). Facilitative mechanisms of lead as a carcinogen. *Mutation Research, 533*, 121-133.

Skolnick, J. H., & Currie, E. (Eds.). (2007). *Crisis in American Institutions* (13th Edition ed.): Pearson Education Inc.

Steele, M. J., Beck, B. D., Murphy, B. L., & Strauss, H. S. (1990). Assessing the contribution from lead in mining wastes to blood lead. *Regulatory Toxicology and Pharmacology, 11*, 158-190.

Tong, S. (1998). Lead exposure and cognitive development: Persistence and a dynamic pattern. *Journal of Pediatric Child Health, 1998*(34), 114-118.

Tong, S., Baghurst, P., McMichael, A., Sawyer, M., & Mudge, J. (1996). Lifetime exposure to environmental lead and children's intelligence at 11-13 years: The Port Pirie cohort study. *British Medical Journal, 1996*(312), 1569-1575.

Turabelidze, G., Shootman, M., Zhu, B.-P., Malone, J. L., Horowitz, S., Weidinger, J., Williamson, D., Simoes, E. (2008). Multiple sclerosis prevalence and possible lead exposure. *Journal of the Neurological Sciences, 269*, 158-162.

U.S. Census Bureau. (2000). American Fact Finder: General Demographic Characteristics 2000 Retrieved January 28, 2008, from http://factfinder.census.gov

U.S. Environmental Protection Agency. (1996). *Community advisory groups: Partners in decisions at hazardous waste sites case studies*. (EPA 540-R-96-043). Washington, DC: Retrieved from http://www.epa.gov/superfund/community/cag/resource/CAG Case Studies-Winter 1996.pdf.

U.S. Environmental Protection Agency. (2003). *Public involvement policy*. (OA-2003-0005:FRL-7508-7). Retrieved from http://www.epa.gov/publicinvolvement/policy2003/frnlead.pdf.

U.S. Environmental Protection Agency. (2006). *Air Quality Criteria for Lead, Final Report*. (EPA/600/R-05/144aF-bF). Washington, DC: Retrieved from http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=158823.

U.S. Environmental Protection Agency. (2007a). *Review of the National Ambient Air Quality Standards for Lead: Policy assessment of scientific and technical information - OAQPS Staff Paper*. Research Triangle Park, North Carolina: Retrieved from http://www.epa.gov/ttnnaaqs/standards/pb/data/20071101_pb_staff.pdf.

U.S. Environmental Protection Agency. (2007b). Superfund community envolvement: Community advisory group Retrieved July 16, 2008, from http://www.epa.gov/superfund/community/cag/index.htm

U.S. Environmental Protection Agency. (2008a). *Analysis of socio-demographic factors for populations living near Pb TSP monitors and larger Pb point sources*. (EPA-HQ-OAR-2006-0735). Retrieved from http://www.epa.gov/air/ej/pdfs/20080520_pbnaaqsej.pdf.

U.S. Environmental Protection Agency. (2008b, November 16, 2010). History of the Clean Air Act Retrieved July 8, 2011, from http://www.epa.gov/air/caa/caa_history.html - intro

U.S. Environmental Protection Agency. (2008c). History of the Clean Air Act Retrieved August 6, 2009, from http://www.epa.gov/air/caa/caa_history.html

U.S. Environmental Protection Agency. (2008d). *National Ambient Air Quality Standards for Lead: Final Rule*. Federal Register Retrieved from http://www.epa.gov/fedrgstr/EPA-AIR/2008/November/Day-12/a25654.pdf.

U.S. Environmental Protection Agency. (2008e). *National Ambient Air Quality Standards for Lead: Proposed Rule*. (EPA-HQ-OAR-2006-0735). Retrieved from http://www.epa.gov/oaqps001/lead/fr/20080520.pdf.

U.S. Environmental Protection Agency, & Office of Air Quality Planning and Standards. (2007). *Lead: Human Exposure and Health Risk Assessment for Selected Case Studies*. (EPA-452/R-07-014a). Research Triangle Park, NC: Retrieved from http://www.epa.gov/ttnnaaqs/standards/pb/data/20071101_pb_ra_body.pdf.

U.S. Environmental Protection Agency Region VII. (n.d.). *Administrative Order of Consent*. Author Retrieved from http://www.epa.gov/region7/cleanup/superfund/pdf/final_doe_run_aoc_sow.pdf.

Uhlenbrock, T. (1993, June 25). Herculaneum fights plan on Doe Run emissions, *St. Louis Post-Dispatch,* p. 9A.

Warren, C. (2000). *Brush with death: A social history of lead poisoning*. Baltimore: The Johns Hopkins University Press.

Warren, C. (2005). Little pamphlets and big lies: Federal authorities respond to childhood lead poisoning, 1935-2003. *Public Health Report, 120*(May-June), 322-329.

Wasserman, G., & Factor-Litvak, P. (2001). Methodology, inference and causation: Environmental lead exposure and chldhood intelligence. *Archives of Clinical Neuropsychology, 16*, 343-352.

Wynne, B. (1989). Sheepfarming after Chernobyl: A case study in communicating scientific information. *Environment, 31*(2), 10-39.

Wynne, B. (1992). Misunderstood misunderstanding: Social identities and public uptake of science. *Public Understanding of Science, 1*, 281-304.

Yanow, D. (1993). The communication of policy meanings: Implementation as interpretation and text. *Policy Sciences, 26*, 41-61.

Yanow, D. (1995). Practices of policy interpretation. *Policy Sciences, 28*, 111-126.

Yanow, D. (2000). *Conducting interpretive policy analysis*. Thousand Oaks, Calif.: Sage Publications.

Yanow, D. (2003). Interpretive empirical political science: what makes this not a subfield of qualitative methods. *Qualitative Methods, Fall 2003*, 9-13.

Yanow, D., & Schwartz-Shea, P. (2006). *Interpretation and method: Empirical research and the interpretive turn*. Armonk, New York: M.E. Sharpe, Inc.