Superfund Benefits Analysis

EPA Science Advisory Board

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Acknowledgements and Disclaimers

- E^2 Inc.:
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- Support: USEPA Office of Superfund Remediation Technology Innovation

- Work in progress

This presentation is based on a draft study currently undergoing peer review. Do not quote or cite.

Outline

- Scope and Objectives of the study
- Major elements of the report
- Preliminary answers to the study question: *What are the benefits of the Superfund program?*

Guidance

United States Environmental Protection Agency | Office of the Administrator | EPA 240-R-00-003 September 2000

EPA

Guidelines for Preparing Economic Analyses

Federal Register
Vol. 58, No. 190
1993

Presidential Documents

Executive Order 12866 of September 30, 1993

Regulatory Planning and Review

The American people deserve a regulatory system that works for
not against them: a regulatory system that protects and improves their h
safety, environment, and well-being and improves the performance
economy without imposing unacceptable or unreasonable costs on so
regulatory policies that recognize that the private sector and private m
are the best engine for economic growth; regulatory approaches that r
the role of State, local, and tribal governments; and regulations th
effective, consistent, sensible, and understandable. We do not have
a regulatory system today.

United States Environmental Protection Agency | EPA Science Advisory Board (1400A) Washington DC | EPA-SAB-EC-ADV-03-001 December 2002 www.epa.gov/sab

EPA

UNDERGROUND STORAGE TANKS (UST) CLEANUP & RESOURCE CONSERVATION & RECOVERY ACT (RCRA) SUBTITLE C PROGRAM BENEFITS, COSTS, & IMPACTS (BCI) ASSESSMENTS: AN SAB ADVISORY

Circular A-4

September 17, 2003

TO THE HEADS OF EXECUTIVE AGENCIES AND ESTABLISHMENTS

Subject: Regulatory Analysis

This Circular provides the Office of Management and Budget's (OMB's) guidan
Federal agencies on the development of regulatory analysis as required under Section 6(
of Executive Order12866, "Regulatory Planning and Review," the Regulatory Right-to-K
Act, and a variety of related authorities. The Circular also provides guidance to agencie
regulatory accounting statements that are required under the Regulatory Right-to-Know

This Circular refines OMB's "best practices" document of 1996
(http://www.whitehouse.gov/omb/inforeg/riaguide.html), which was issued as a guidanc
2000 (http://www.whitehouse.gov/omb/memoranda/m00-08.pdf), and reaffirmed in 200
(http://www.whitehouse.gov/omb/memoranda/m01-23.html). It replaces both the 1996
practices" and the 2000 guidance.

In developing this Circular, OMB first developed a draft that was subject to publ
comment, interagency review, and peer review. Peer reviewers included Cass Sunstein,
University of Chicago; Lester Lave, Carnegie Mellon University; Milton C. Weinstein a

Scope

- Study Question: *What are the benefits of the Superfund program?*
  - Enumerate
  - Describe
  - Quantify
  - Monetize

- Everything authorized by CERCLA and SARA
  - Baseline: no Superfund and no substitute
  - Includes non-EPA activities

- Study period: 1980-2004

Why Such a Broad Scope?

- Guidance
  - *EPA Guidelines* and *Circular A-4* direct us to focus on all approaches taken to address the problem, and all benefits.
- Completeness
  - CERCLA and SARA are large, complex laws, but only a fraction of their effects have been well studied.
- Ambiguity
  - Many programs authorized by CERCLA and SARA were once responsibilities of EPA but were transferred (e.g., SBRP), or are shared among several agencies (e.g., NCP)
- Data
  - Suitable data are scarce, so every effort was made to use existing sources of information (e.g., NRDAs) per the advice of the RCRA-UST panel.

Common Perceptions

- The public believes toxic wastes are a **major risk, not** experts.
- Superfund addresses the **'worst of the worst'** sites.
- Superfund does **not reduce risk** significantly.
- Superfund is **expensive**.
- Superfund is **inefficient**.
- Superfund is **unfair**.
- Superfund is **slow**.
- There are **many challenges ahead** (e.g., mega-sites).

Approaches and Benefit Categories

- Approaches
  - Response
  - Community Involvement
  - Enforcement
  - Research and Development
  - Training
  - Natural Resource Restoration

Lead to

- Benefits
  - Health
  - Amenities
  - Ecological
  - Materials

Fundamental

Embedded

  - Empowerment
  - Deterrence
  - Emergency Preparedness
  - Information and Innovation
  - International

Why Add the *Embedded* Benefit Categories?

- Some of the outcomes of the Superfund program did not seem to fit adequately into the categories found in the *EPA Guidelines for Preparing Economic Analyses* (e.g., Emergency Preparedness)

- There are potentially significant indirect benefits that could easily be overlooked or forgotten if attention was not drawn specifically to them (e.g., Deterrence)

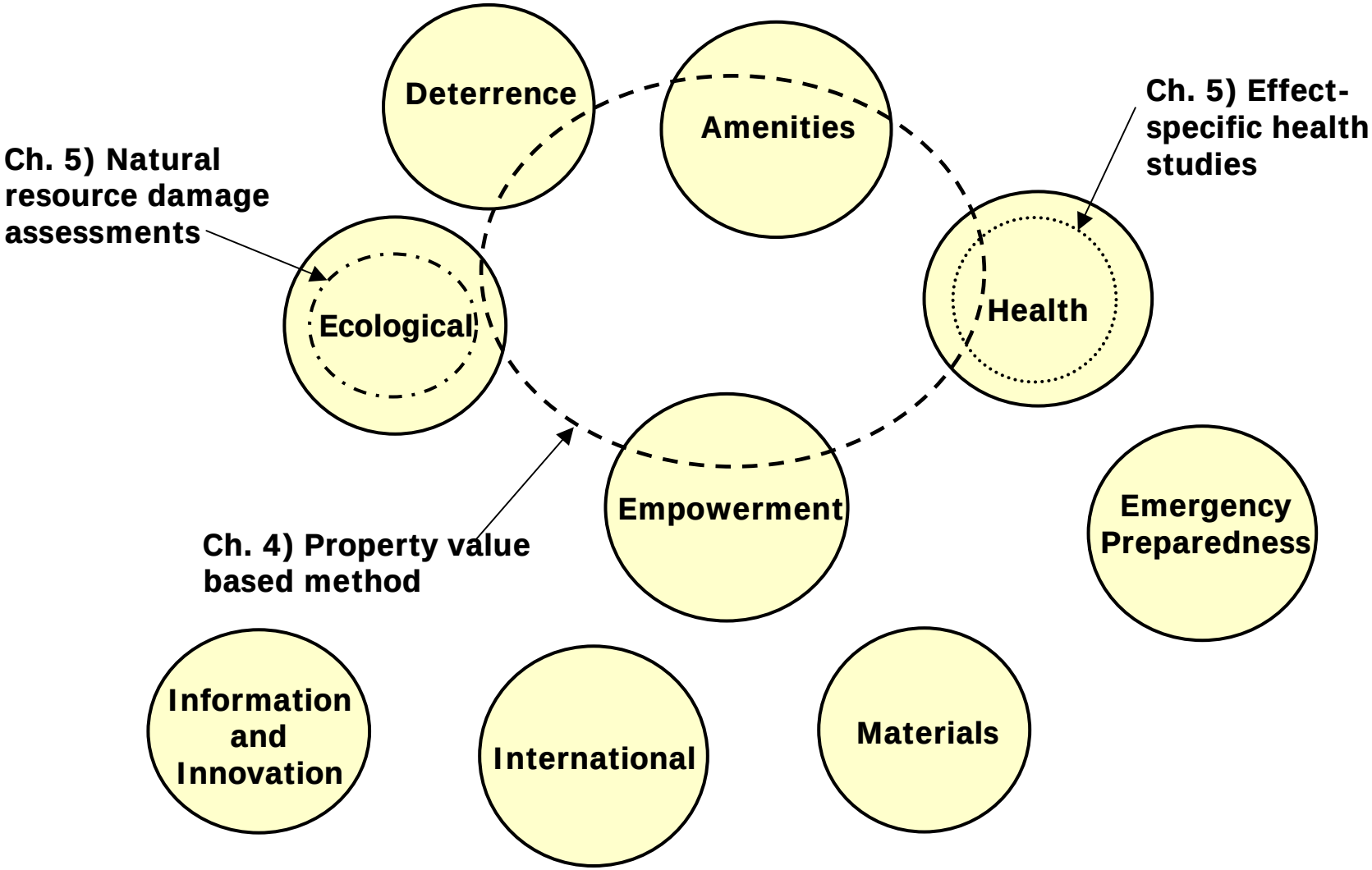
- Note: Some are similar to the benefit categories suggested in the "Suggested Revision of Attributes Matrix" by the RCRA-UST Advisory Panel (e.g., Information and Innovation)

Table of Contents

Ch. 1: Introduction

- Defines approaches, benefits
- Answers some of the key framing questions required by guidance
  - Problem definition
  - Reasons for market failure
  - Need for federal action
  - Description of various approaches
  - Define study question
  - Define baseline
- Introduces analytical methods
- Briefly describes the Superfund program

Ch. 1: Benefits and Quantitative Estimates



Note: Figure is schematic.

Ch. 2: Literature Review

- Covers reviews of the literature since the early 1990s
  - Detailed review of original research in subsequent chapters
- Guidance for analyzing regulatory programs (EPA, OMB)
- Prior analyses of the Superfund program
  - OTA, Probst et al, Hird, GAO, Hamilton and Viscusi, etc.
- Recommendations of the RCRA-UST Advisory Panel (Science Advisory Board)

Ch. 2: Main Themes in the Literature

- Common perceptions
- Risk mitigation from both Removals and Remediation programs
- Significant heterogeneity among Superfund responses
- Lack of adequate data
- RCRA-UST Advisory Panel
  - Use existing data, but avoid inappropriate risk data
  - Property value-based approach
  - Other approaches

Ch. 3, 4, 5: Quantitative Analysis

- Monetization - Benefits Transfer Analysis
  - Apply results from primary research to a new context
  - SBA: from peer-reviewed literature or studies used in court cases to all applicable Superfund-related sites
- Representativeness
  - Does the context of the primary research match the new context?
  - SBA: federal sites, NPL and non-NPL sites
- Scarcity of data is a major limitation
  - EPA data collection is designed for risk management, not benefit estimation
  - Ecological data are virtually non-existent
  - Epidemiological data have no good measure of exposure

Ch. 4, 5: Four Estimates of Benefits

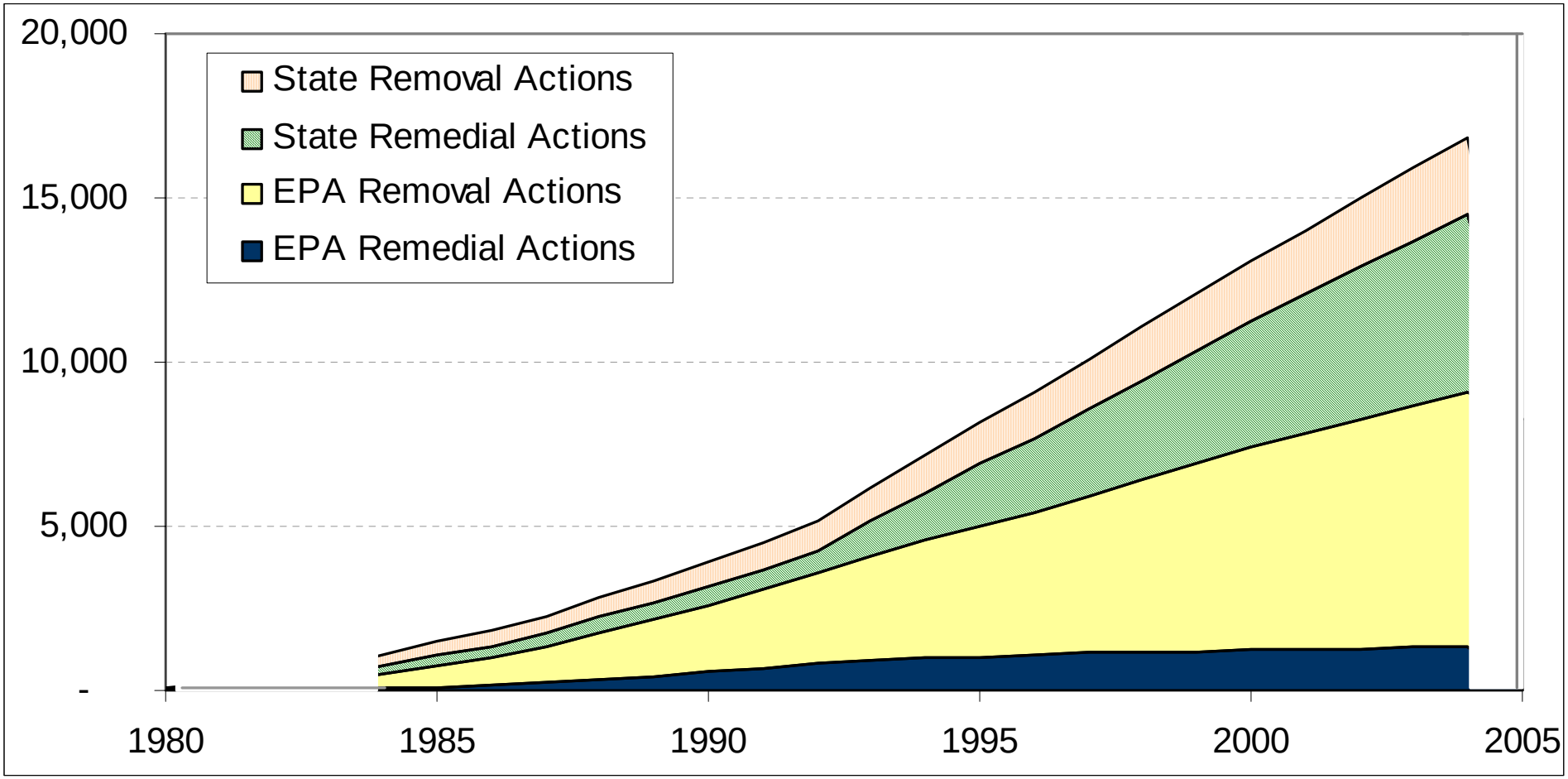
1. Property-value based estimate (NPL, Ch.4)
   (This is the only complete analysis in the current draft)

2. Health effect-based health estimates (NPL, Ch.5)
   (Only proposed in the current draft)

3. Ecological estimate (NRDs, Ch.5)
   (Only proposed in the current draft)

4. Ground water-based estimate (NPL, Ch.5)
   (Only proposed in the current draft)

Ch. 3: Superfund Responses

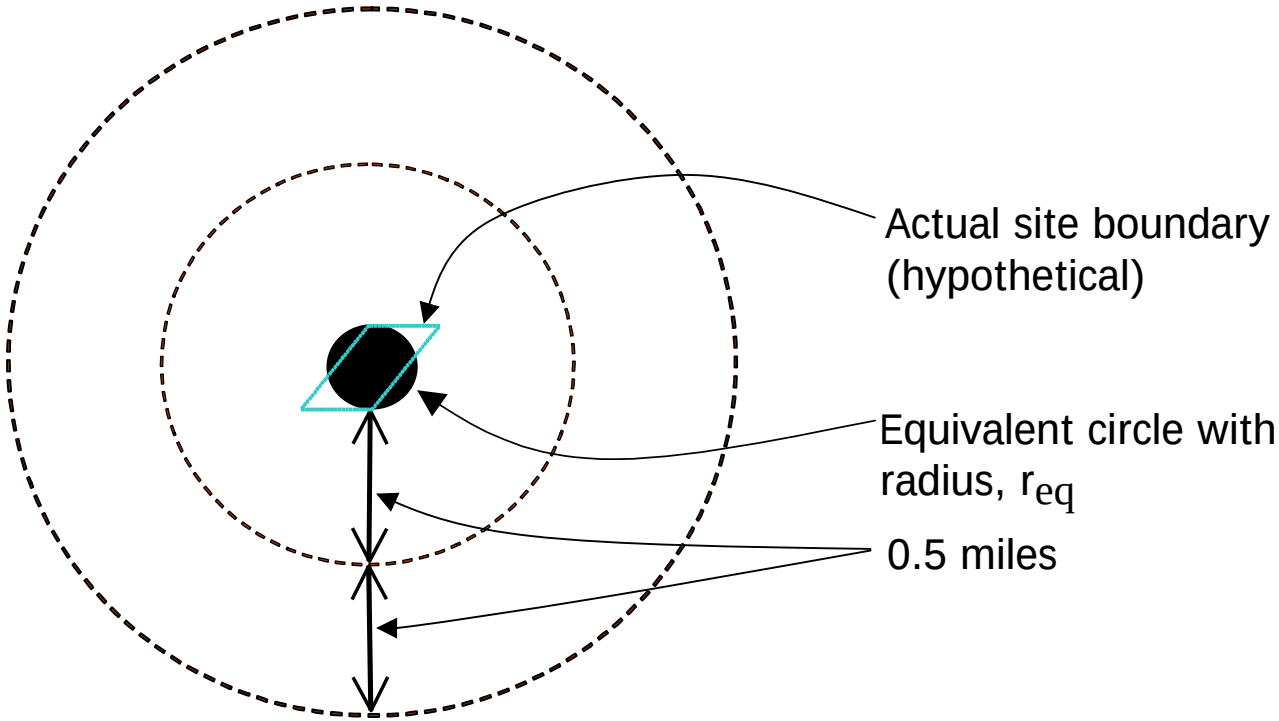


Notes: Approximately 1/4 of removals occur at NPL sites

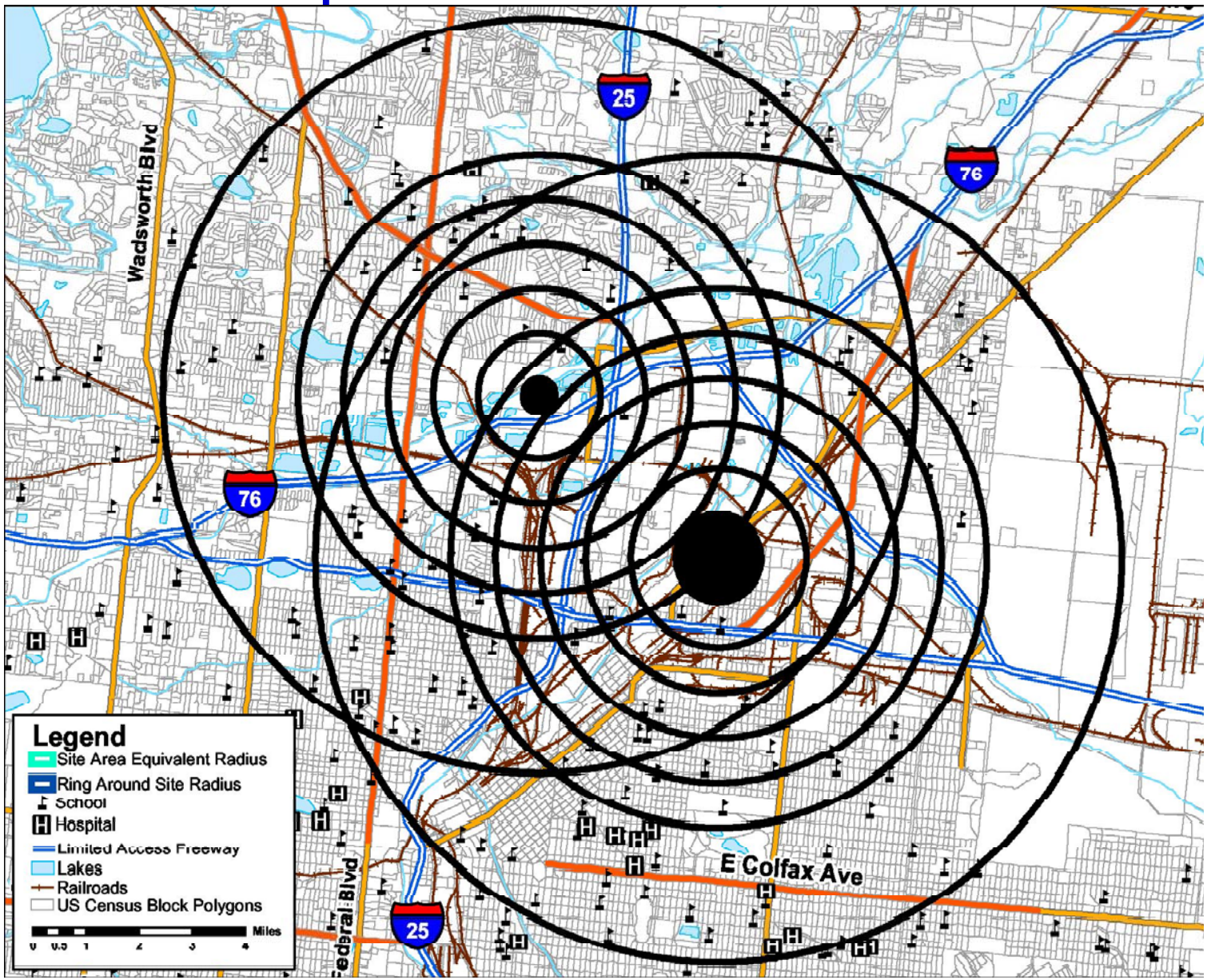
Assumes 25% of state responses are attributable to federal Superfund

State values for 33 states

Ch. 3: Construction of Equivalent Areas



Ch. 3: Population and Residence Data



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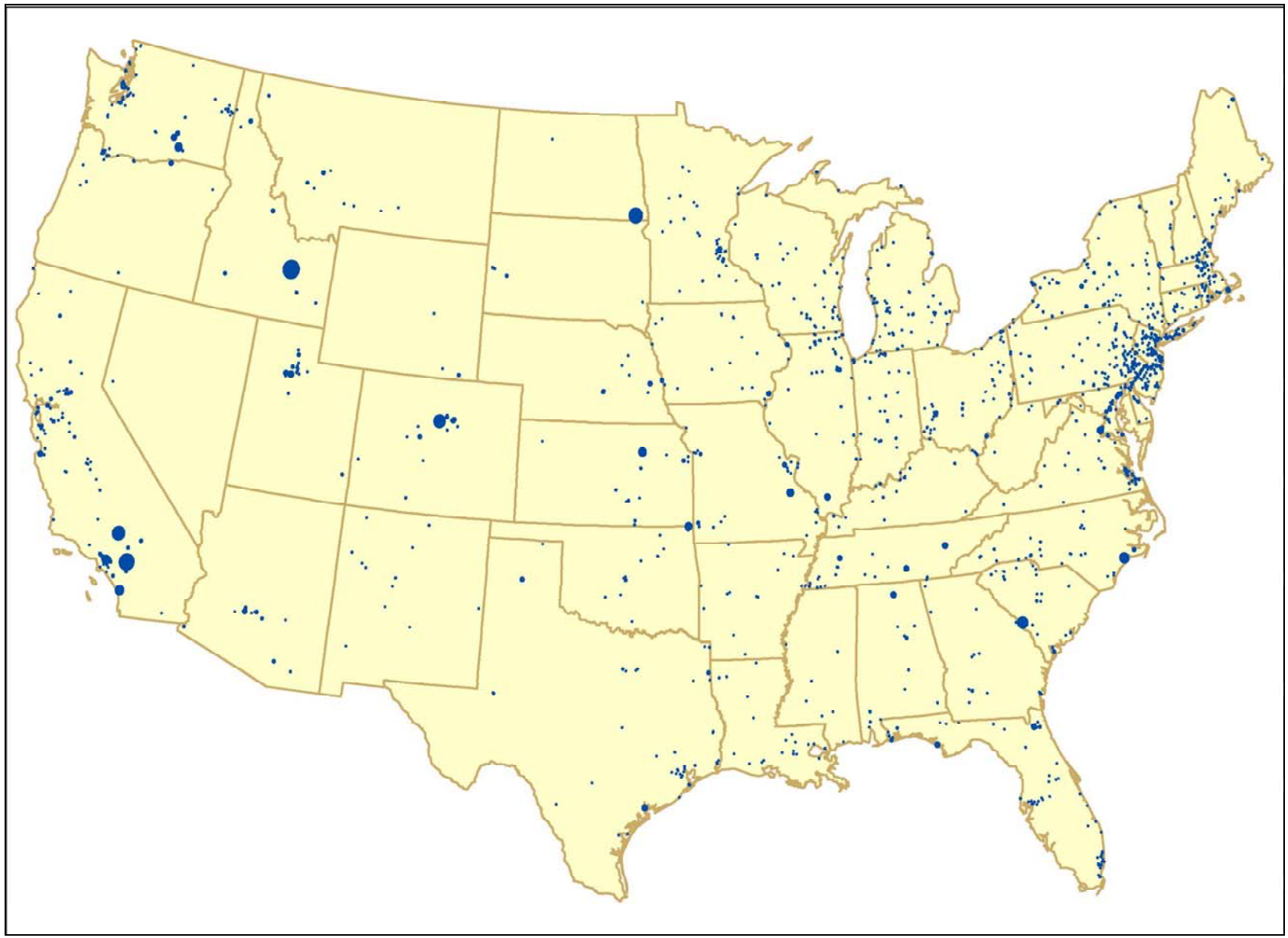
Ch. 3: Places Near NPL sites (site area + 2.5 mile buffer)

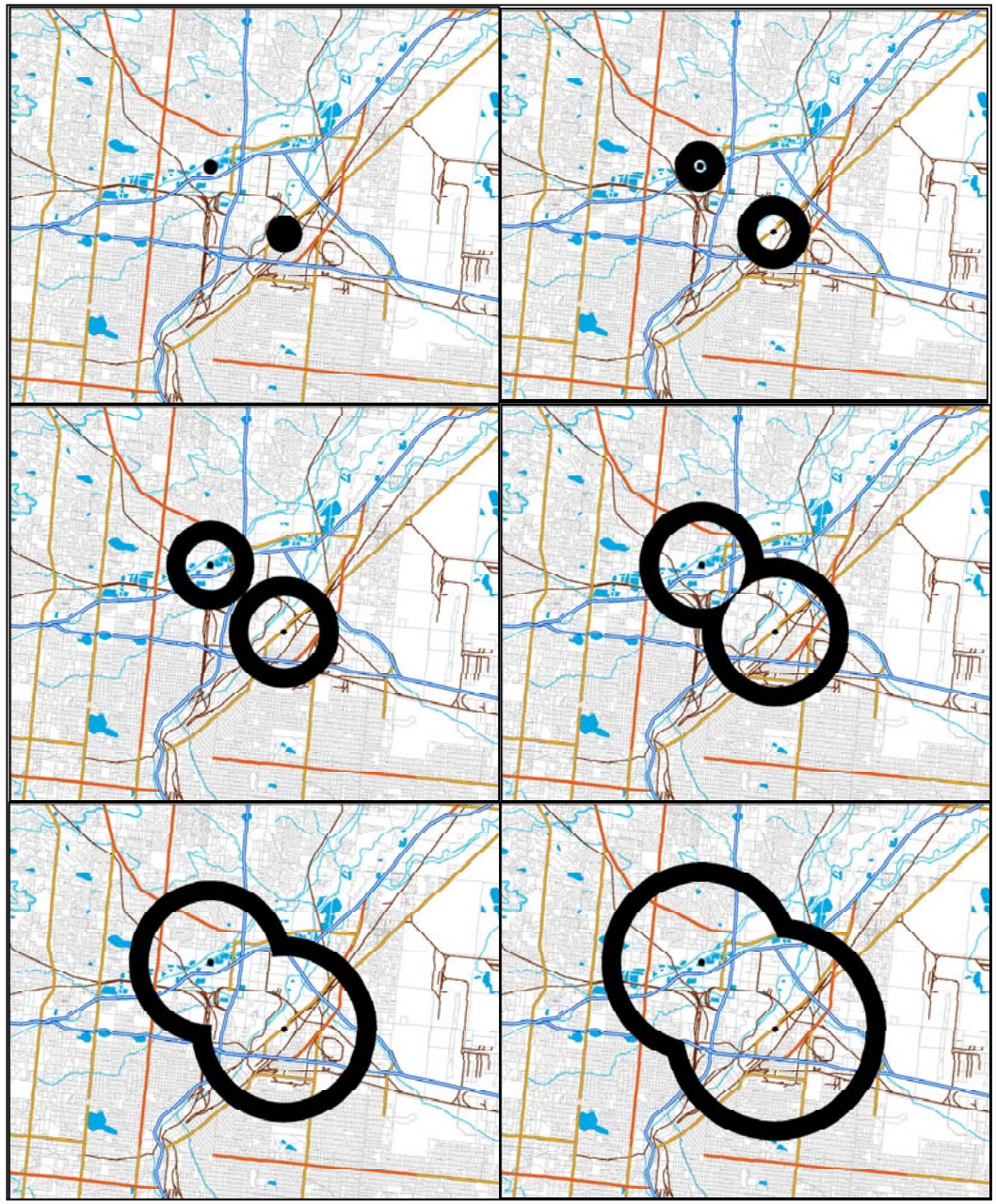


Ch. 3: Counting Population

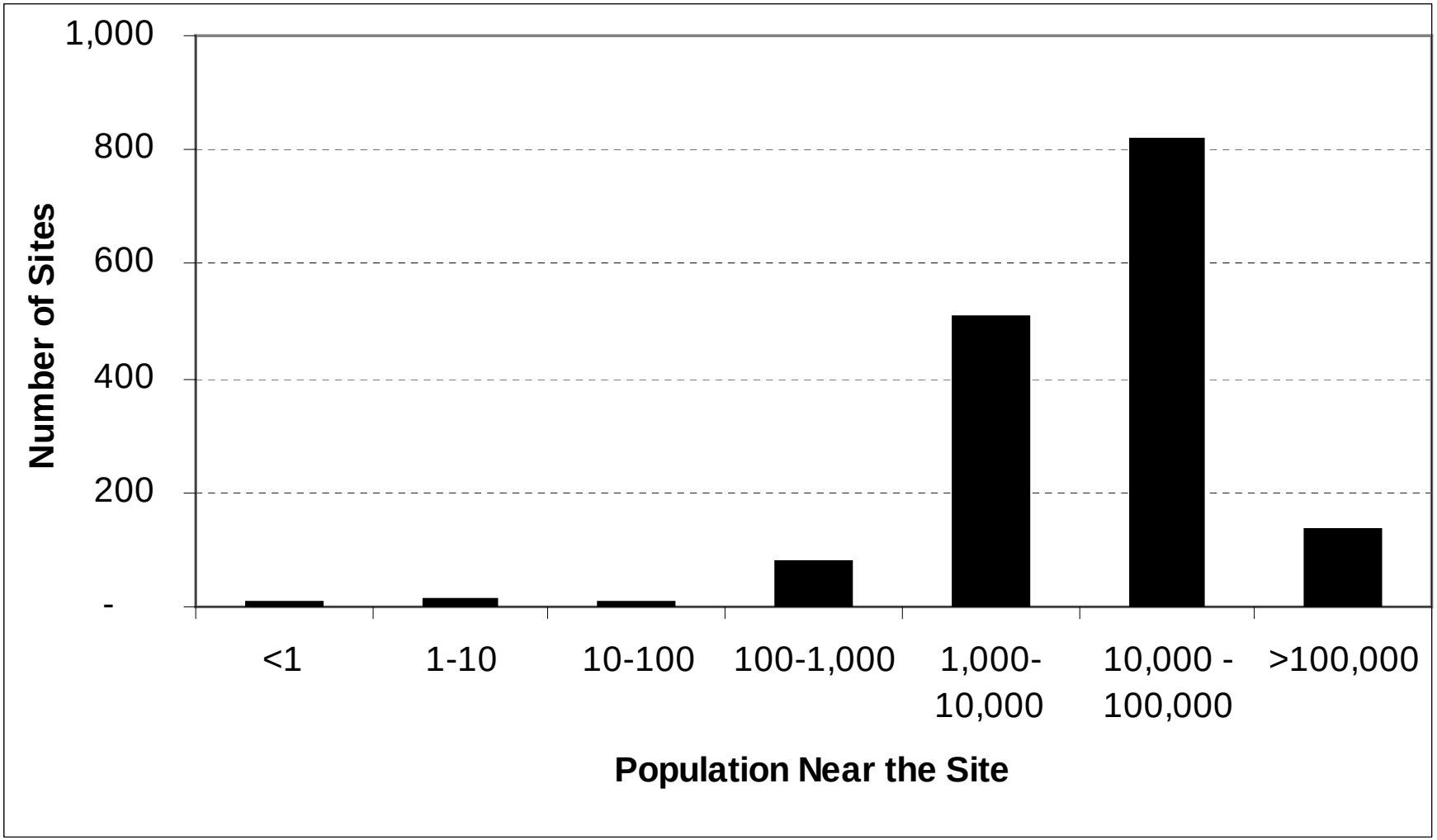
- Multi-count
  - Count population by census block within prescribed distance from equivalent area
  - Preserves site-specific information
  - Total double counts (and more)

- Full Count
  - Count population nation-wide by distance to nearest NPL site
  - Site-specificity is lost
  - No double counting

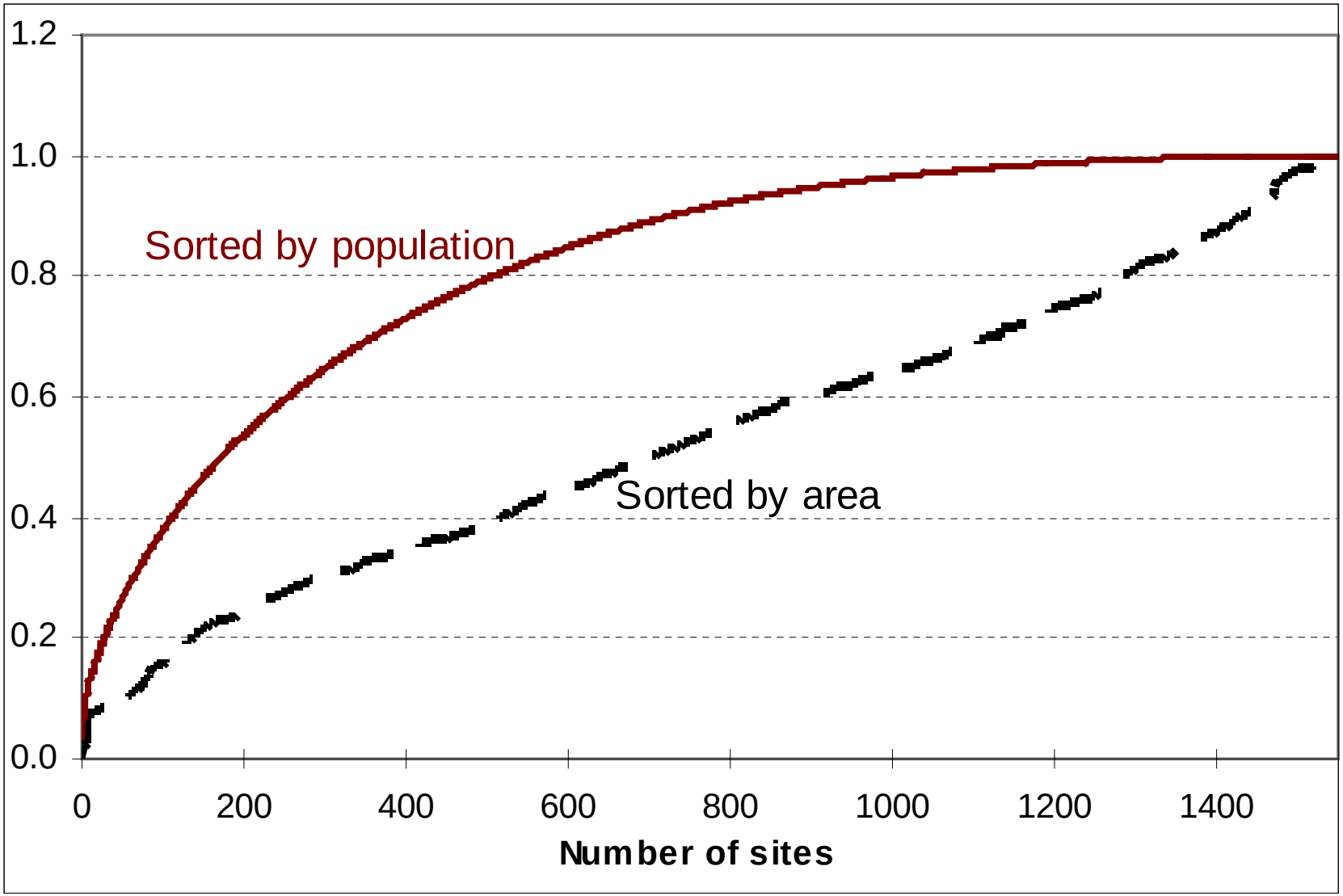
Ch. 3: Full Count Procedure



Ch. 3: Distribution of Population Near NPL Sites



Ch. 3: Cumulative Population Distribution



Ch. 4: Property Value-Based Benefit Estimate

- Only monetary estimate in the current draft

- Uses actual real estate data and a widely-accepted methodology

Ch. 4: Methodology

- Hedonic price theory: Products are bundles of attributes, each of which contributes to the entire value of the product.
- Example: $P_i = \beta_0 + \beta_1 SqFt_i + \beta_2 AvgInc_i + \beta_3 Distance_i + u_i$
- Benefits transfer method:
  a) Determine effect of NPL sites on residential property
  b) Determine number of affected properties
  c) Calculate the value of remediating all NPL sites
  d) Distribute over time and calculate present value
- Data: EPA databases, U.S. Census, ~24 peer-reviewed papers

Ch. 4: Key Assumptions

- Discovery produces negative price effect
- ROD causes 100% rebound of property prices
- Effect is the same for all varieties of homes
  - Single-family, owner-occupied, detached homes are about half of all homes
- Excluded
  - Benefits home buyers don't know or care about
  - Benefits associated with commercial property
  - Benefits that accrue to non-neighbors
  - Benefits other than those at NPL sites (e.g., removals, deterrence)

Ch. 4: Rebound – Why Does This Happen?

- Buyers are willing to pay more
  - Sellers believe that buyers are willing to pay more

- Risk mitigation and less uncertainty
  - Negative price effect occurs because of *discovery*
  - This leads to uncertainty about the magnitude of the risk and what, if anything, will be done about it
  - Release of information changes the negative price effect
  - Release of the *Record of Decision* reverses negative price effect
  - Immediate risks are mitigated (possibly by removals) and now there is little uncertainty that the long-term risks will be mitigated

- May not hold for sites with long or complicated histories

Ch. 4: Events and Data Collection

Study	Site Name	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04
	Year																														
1, 9	Operating Indust.					**D**					P		L	ERS															E		
2	Industri-Plex					**D**			P	L			ER		E				S											
	Nyanza Chem.						**D**		P	L		R		SE	E	E			E											
	Salem Acres						**D**				P		L		E		E			R	S					C		X		
	W.R. Grace					**D**			P	L						R				S										
	Wells G&H					**D**			P	L			E	E	E	R			S											
3	Brio Refining								D		P	E			R	LS														C
	Crystal Chem.						**D**		P	LE					E		R	E				S							C	
	Geneva Indust.							**D**		PE	LE		R	S						C										
	Harris (Farley)								**D**P	L		R	S		CX															
	N. Cavalcade St.										**D**P		L		R			S												
	Sol Lynn										**D**P				R	LE		S		C								E		
	S. Cavalcade St.									**D**	P		L		R							S				C				
4	New Bedford	(Data from 1969)				**D**			P E	L	E	E					R	S												
5	Indust. Excess						**D**				P		L	R	E	S				E										
6	RSR Smelter							**D**												P		LER					S		E	
7	Industriplex					**D**			P	L			ER		E				S											
	Wells G&H					**D**			P	L			E	E	E	R			S											
8	Butterworth #2					**D**			P	L						E	E		R						S		C			
	Chem Central				**D**				P	L								R			S	C								
	Folkertsma Refuse							**D**					P			L		R		S	C		X							
	H. Brown Co.						**D**					P	L						ER							S	C				
	Kentwood	(Data from 1971						P	L								R			S	C									
	Organic Chemicals					**D**			P	L								R			S								C	
	Spartan Chemical					**D**			P	L										R					S					

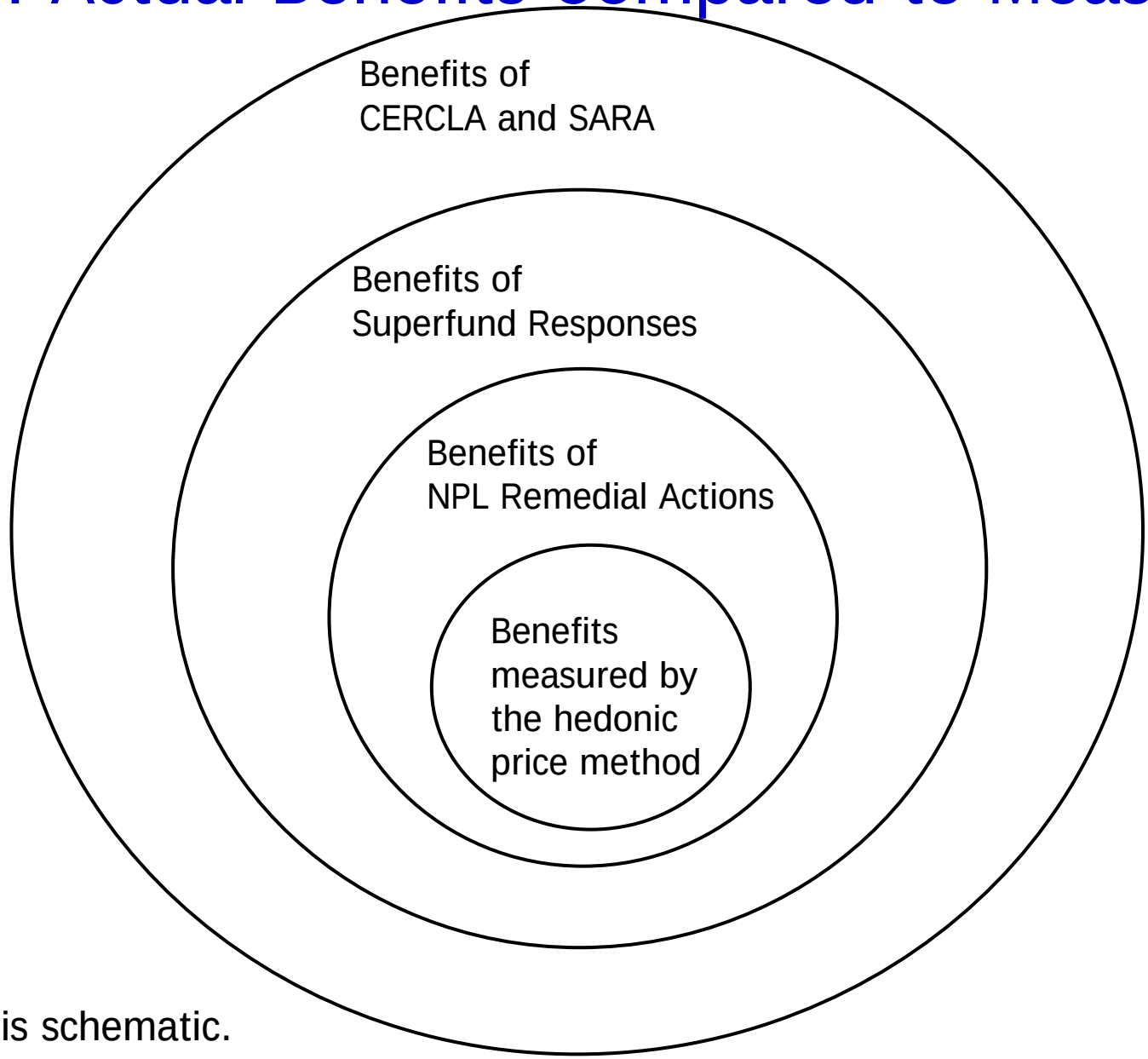
Legend:

Site: 1-McClelland 1990; 2-Michaels 1990; 3-Kohlhase 1991; 4-Mendelsohn 1992; 5-Reichert 1997; 6-Dale 1999; 7-Kiel 2001; 8-Gayer 2002; 9-Hurd 2002.

Events: D-Discovery; P-Proposed to NPL; L-Final on NPL; E-Removal Action; R-ROD; S-Start of Remedial Action; C-Construction complete; X-Deleted

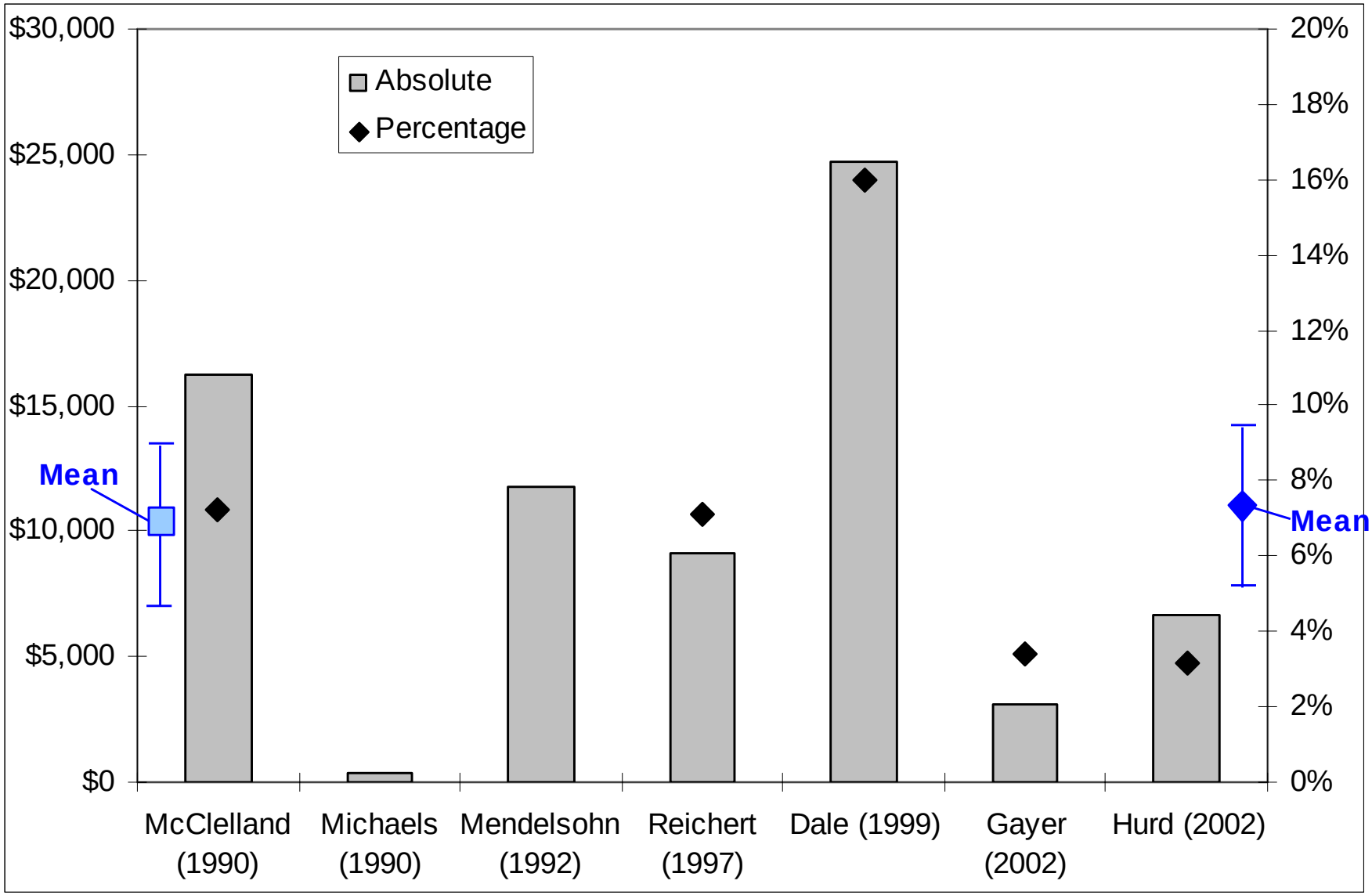
Colors: Different shades indicate how panel data were divided longitudinally.

Ch. 4: Actual Benefits Compared to Measured

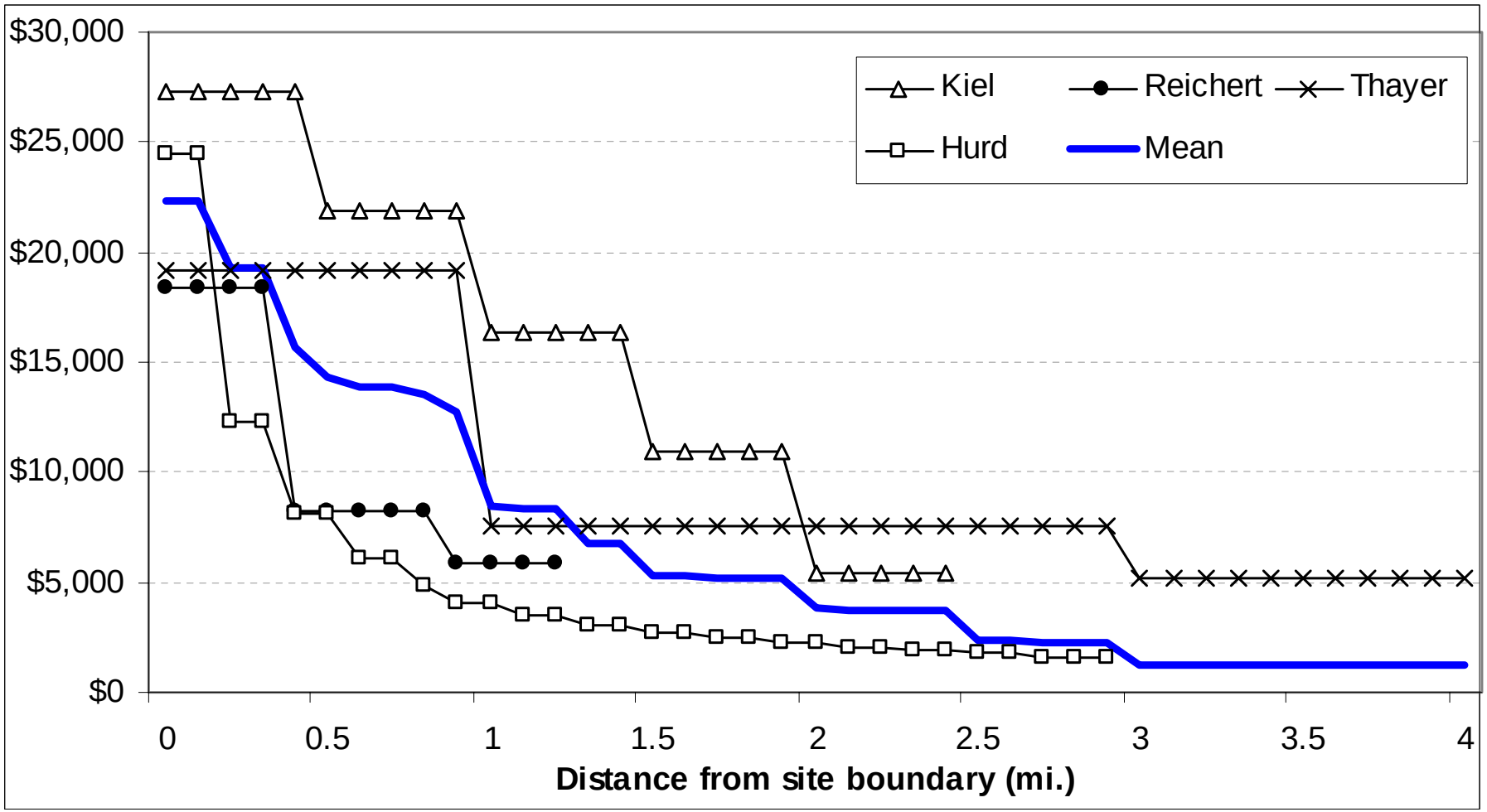


Note: Figure is schematic.

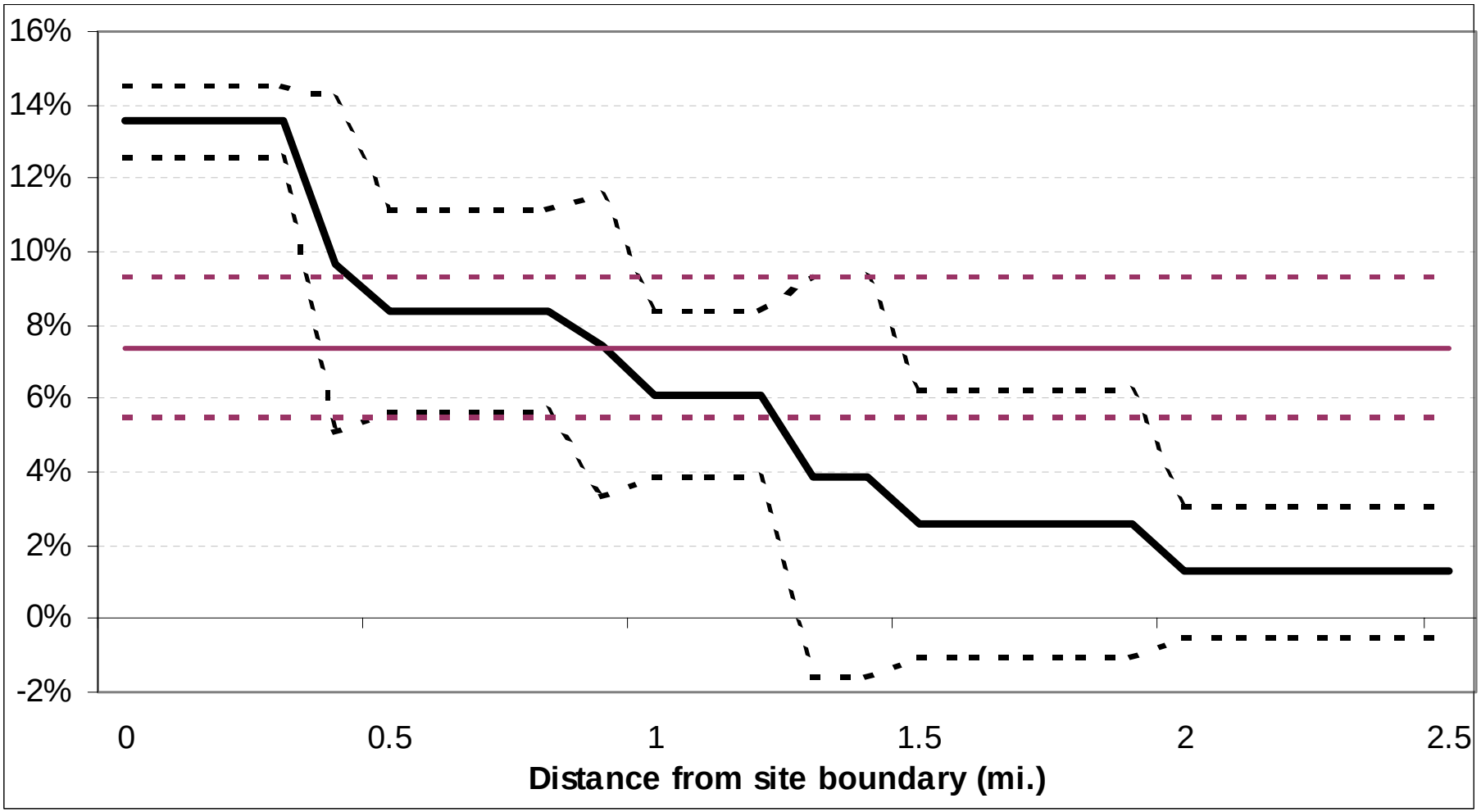
Ch. 4: Linear Effect Data



Ch. 4: Non-linear Effect Data



Ch. 4: Percentage Effect Estimates (mean, 95% CI)



Ch. 4: Four Models to Estimate Total Benefits

$$B_r^{LA} = LE \times R_r$$ Linear Absolute (LA) model (Equation 4.2)

$$B_r^{LP} = LPE \times P_r \times R_r$$ Linear Percentage (LP) model (Equation 4.2)

$$B_r^{NLA} = \sum_i \left(NE_i \times R_{i,r} \right)$$ Non-Linear Absolute (NLA) model (Equation 4.4)

$$B_r^{NLP} = \sum_i \left(NPE_i \times P_r \times R_{i,r} \right)$$ Non-Linear Percentage (NLP) model (Equation 4.5)

Ch. 4: Calculations

- Distribute total benefits over time
- Account for inflation
- Account for population growth
- Discount
- Calculate present value in 1980 and annualized values
- Uncertainty analyses
- Sensitivity analyses

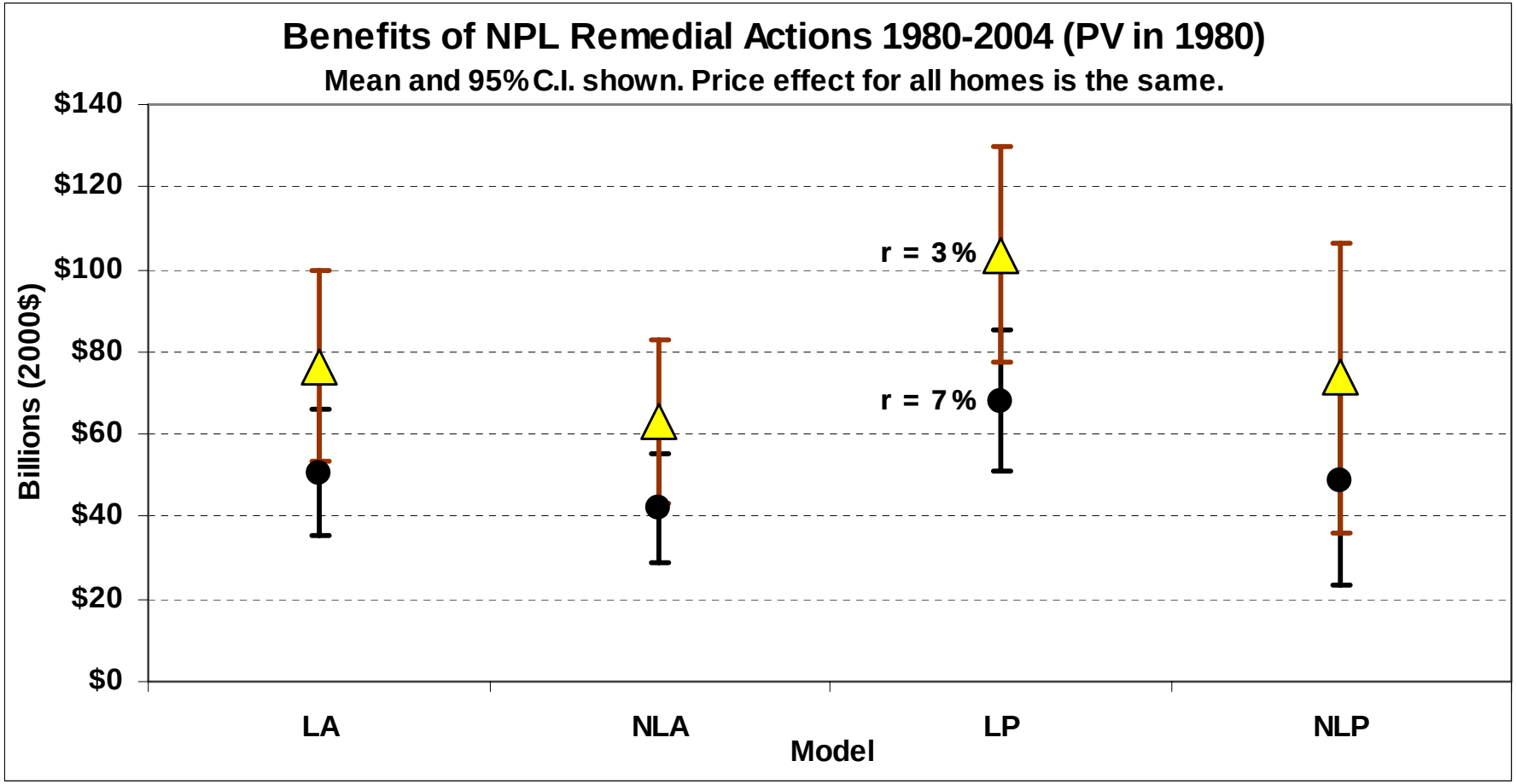
Ch. 4 Present Value Estimates

(Billion 2000$, base year 1980)

Discount rate = 7%	Value	Model			
All residence types equivalent		LA	NLA	LP	NLP
Max distance 2.5 mi.	Mean	50	42	68	49
	95% CI	35-66	29-55	51-85	27-74
50% effect for Non SOD homes	Mean	38	31	51	36
Max distance 1 mi.	Mean	14	-	-	-
Max distance 4 mi.	Mean	94	-	-	-

Discount rate = 3%	Value	Model			
All residence types equivalent		LA	NLA	LP	NLP
Max distance 2.5 mi.	Mean	77	63	100	74
	95% CI	53-100	43-83	77-130	41-110
50% effect for Non SOD homes	Mean	57	47	77	55
Max distance 1 mi.	Mean	22	-	-	-
Max distance 4 mi.	Mean	140	-	-	-

Ch. 4: Present Value Estimates



Excludes: – Benefits home buyers don't know or care about
– Commercial property
– Benefits that accrue to NPL non-neighbors
– Benefits other than those at NPL sites (e.g., removals, deterrence)

Ch. 4: Annualized Values

(Billion 2000$, base year 1980)

r = 7%	Value	Model			
All residence types equivalent		LA	NLA	LP	NLP
Max distance 2.5 mi.	Mean	4.3	3.6	5.8	4.2
	95% CI	3.0-5.6	2.5-4.7	4.3-7.3	2.3-6.3
r = 3%	Value	Model			
All residence types equivalent		LA	NLA	LP	NLP
Max distance 2.5 mi.	Mean	4.4	3.6	5.9	4.2
	95% CI	3.1-5.7	2.5-4.8	4.4-7.4	2.4-6.4

Ch. 4: Summary

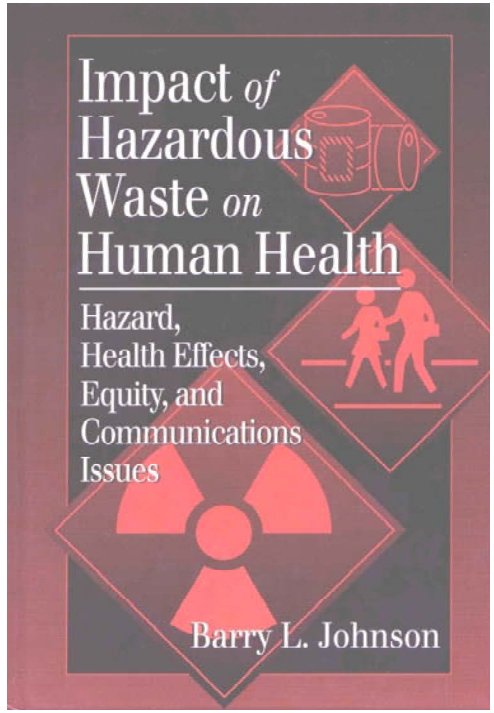
- Based on hedonic price method, widely used in real estate
- Negative price effect is due to the *discovery of contamination*
- Rebound complete by the time the ROD is issued
  - Comes about due to willingness to pay in real estate markets
  - Certainty associated with mitigation of current and future risks
- Only a partial measure of benefits
- 1980 present value (2004$, mean estimates, various assumptions)
  - Total: $40-$100 Billion
  - Annualized: $4-$6 Billion per year

Ch. 5: Health Effect-Based Health Benefit

- Proposed in the current draft

- Different methods for different health effects
  - Cancer: Extrapolate a modified risk-assessment approach
  - Lead: Modeling and cost-of-illness data
  - Birth defects: Application of epidemiological results to Census data, then apply cost-of-illness data
  - Other: various

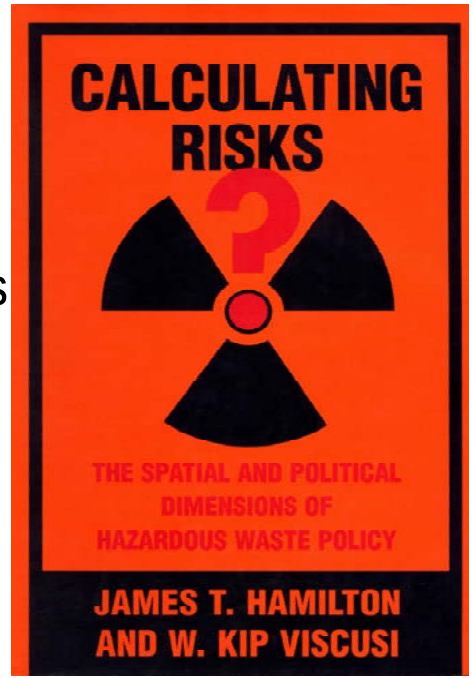
Ch. 5: Health Effects Literature



- Sites with hazardous substances, not just NPL
- Epidemiological studies
  - Lack of exposure data is a significant limitation
  - Birth defect studies (11 papers)
  - Cancer and other studies (5 papers)
- Lead studies (16 papers)
  - Loss of IQ is well documented, as is cleanup
- Acute accidents and injuries (~12 papers)
  - ~18,000/yr. among first responders and first providers (ER staff)
- Lybarger (1998) estimates value of avoiding some birth defects
  - Identify sites with completed exposure pathway for VOCs
  - Epidemiological study results are applied to population within ½ mi.
  - Apply cost-of-illness values
  - Results: ~$300/yr. (Million 2000$)

Ch. 5: Summary of Health Effects Literature

- Lead and acute effects literature documents negative effects and effectiveness of intervention in some cases.
- Epidemiological studies provide various insights
  - Lack of exposure data is a significant limitation
  - Considerable evidence of increases in birth defects
  - Some evidence of other effects (e.g., endometriosis, low birth weight)
  - Essentially *no* evidence of increases in adult cancers
- Only one rigorous benefits study
  - Risk assessment approach
  - *Most* sites have very small benefits, far less than costs (major basis for common perceptions)
  - NPL only
  - Adult cancer risk only



Ch. 5: Proposed Health Effects Benefit Estimate

- Cancer:
  - Extrapolate Hamilton and Viscusi (1999)
- Lead:
  - Apply IEUBK model to sites with completed lead exposure pathways
  - Apply cost-of-illness data
- Birth defects:
  - Identify NPL sites with completed exposure pathways for substances for which epidemiological data are available
  - Apply epidemiological results to Census data for those sites
  - Apply cost-of-illness data (i.e., Lybarger's method)

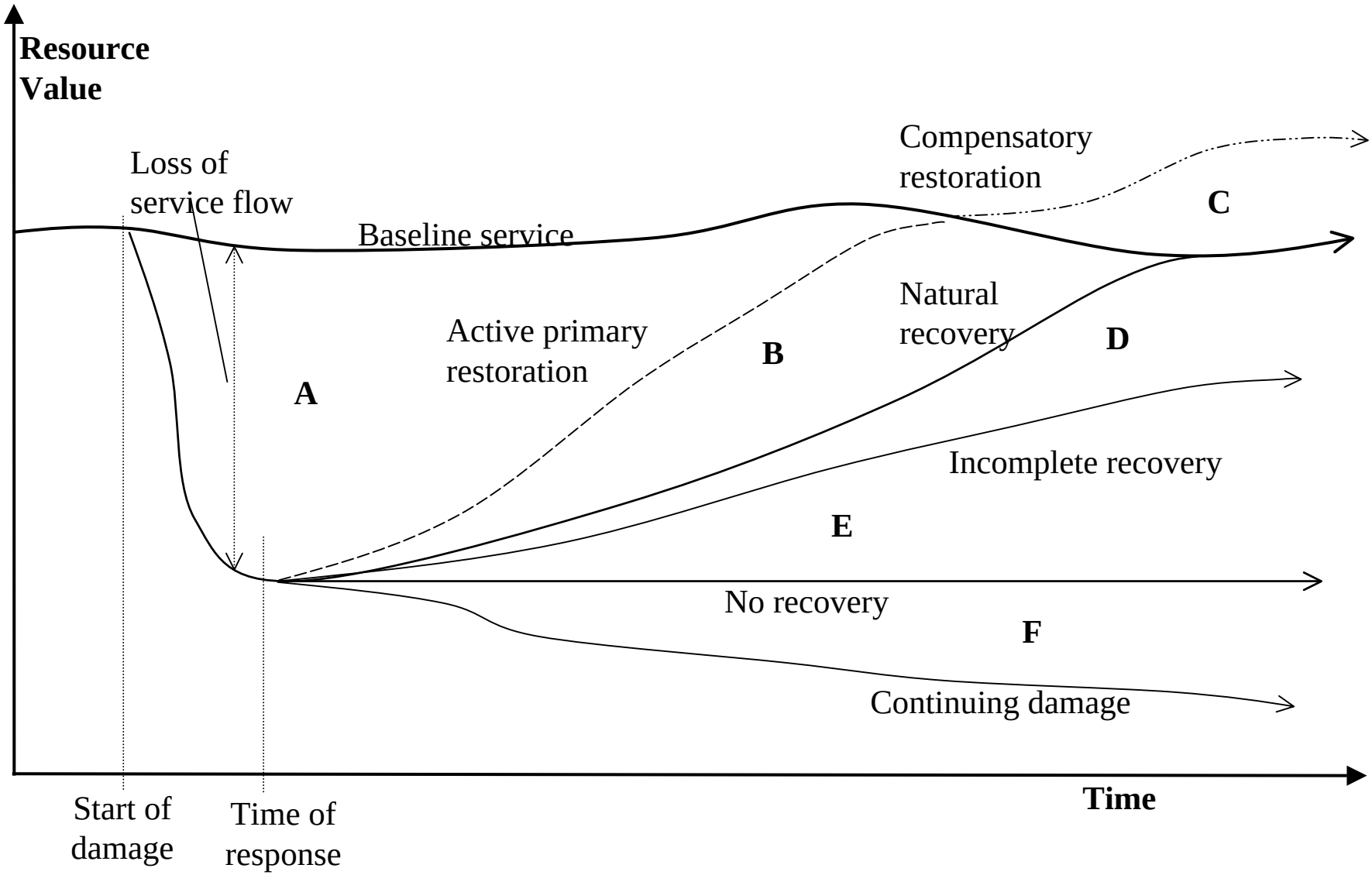
Ch. 5: Natural Resource Benefits

Subsidence

Acid mine drainage

Slickens

Ch. 5: Resource Harm, Recovery, Restoration

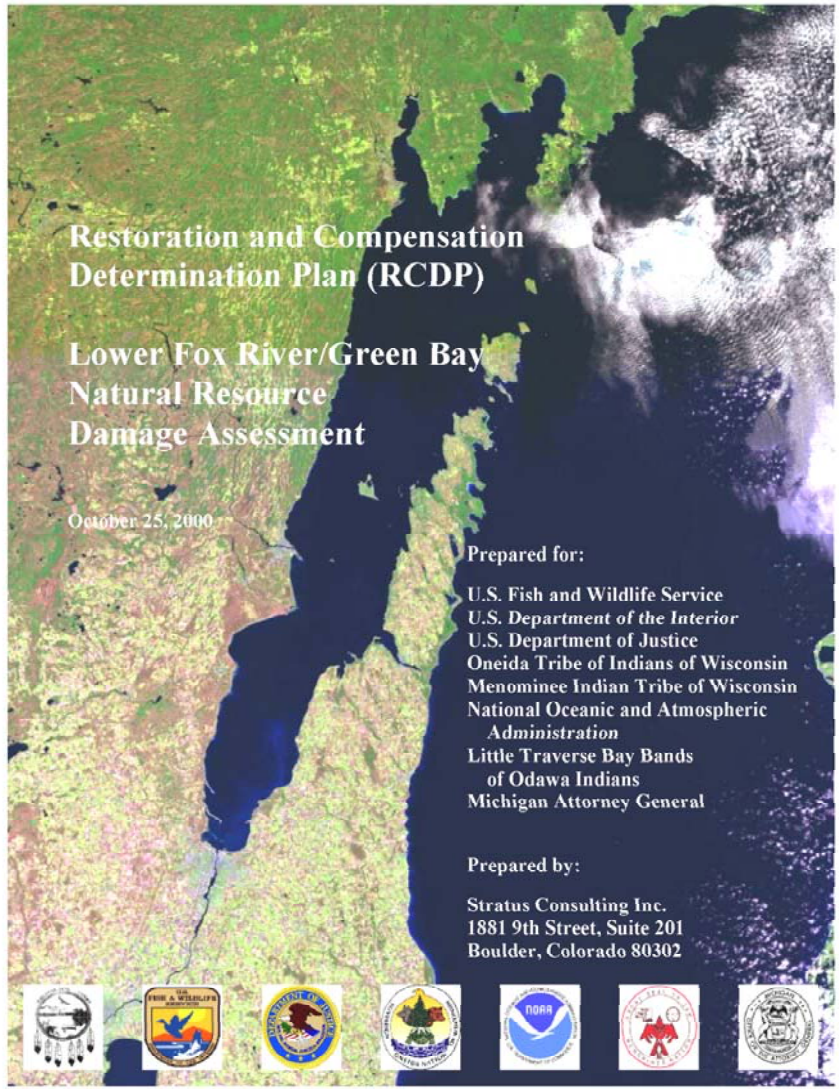


Ch. 5: Natural Resource Damage Assessments

- Authorized under CERCLA §§104(b), 107(f), and 122(j)

- Trustees sue responsible parties
  - US Dept. of Interior (FWS, etc.)
  - US Dept. of Commerce (NOAA)
  - US Dept. of Justice
  - States
  - Tribes

- Damages may include
  - Cost of restoration
  - Interim losses
  - Cost of assessment



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Ch. 5: Why Use NRDAs?

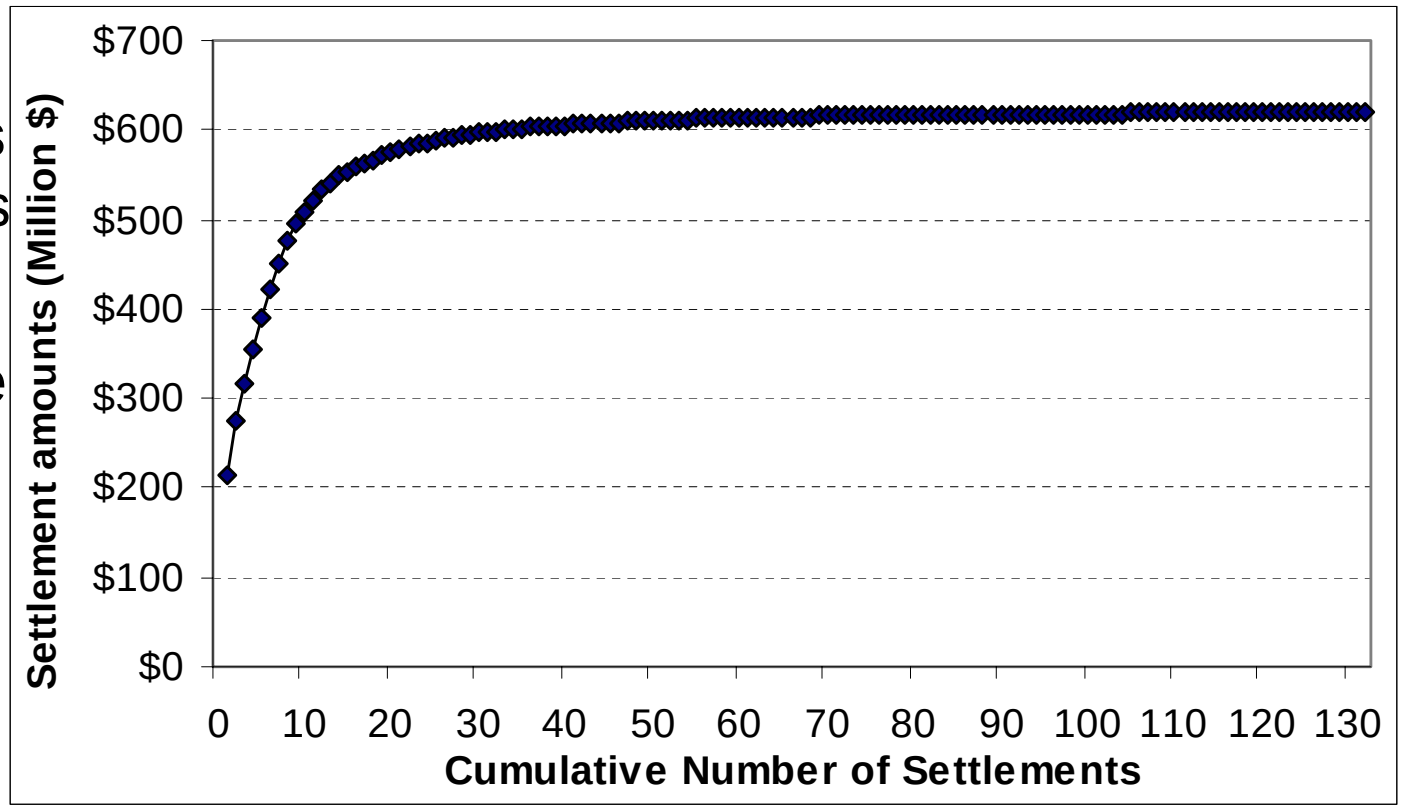
- Natural resource restorations are authorized by CERCLA (42 U.S.C. 9601(16)), and thus are part of this analysis.

- Some natural resource restorations may have effects like some Superfund response actions, and so studying the former may inform us about the latter.

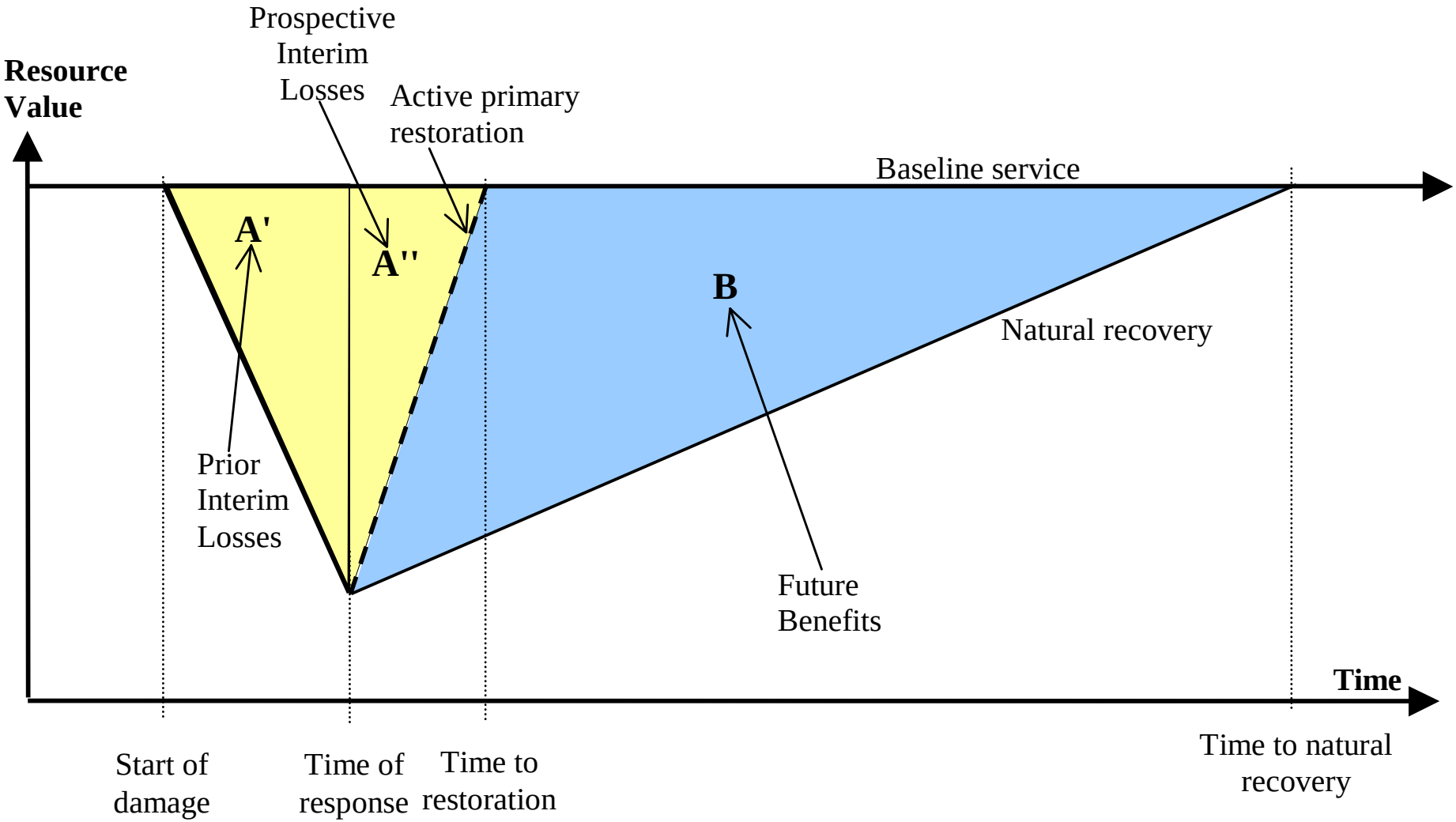
- Data about the ecological effects of mitigating the risks of hazardous substances, and the monetary value of mitigation, are very difficult to obtain, and may not be available except in NRDAs.

Ch. 5: Inventory of NRDAs

- ~130 settlements
- $620 Million
- More coming (no federal settlements yet)
- Largest tend to be mines or rivers
- Well accepted by economists and the courts
- Systematic underestimate of benefits



Ch. 5: Temporal Structure of Benefits
(natural recovery)



Ch. 5: From NRDAs to Benefits

- Locate complete NRDAs (n=7)

- From the NRDA:
  - Determine magnitude of annual losses
  - Determine equilibrium annual service flow after restoration
  - Determine temporal structure of benefits

- Calculate benefits
  - Determine annual benefits for t=0 to 100
  - Present annual values (if intergenerational)
  - Calculate present value (if intra-generational)

- Proposal: Apply to sites with data and perhaps extend

Ch. 5: Ground Water-Based Benefit Estimate

- A large fraction of water used in the U.S. is ground water
  - Over 40% of drinking water
- CERCLIS contains data on NPL sites with actual/potential ground water contamination
- The literature on the economic value of ground water has grown
- Proposal: Use GIS technology to quantitatively estimate:
  - the amount of ground water contamination that Superfund has prevented/cleaned up/protected
  - the economic value (rough estimate)

Ch. 6: Non-quantified Benefits

- 28 pages (~10% of document)
- Description
- Comparison to the baseline of no Superfund
- Relationship to quantified benefits
- Two examples

Ch. 6: Emergency Preparedness

On Scene Coordinators

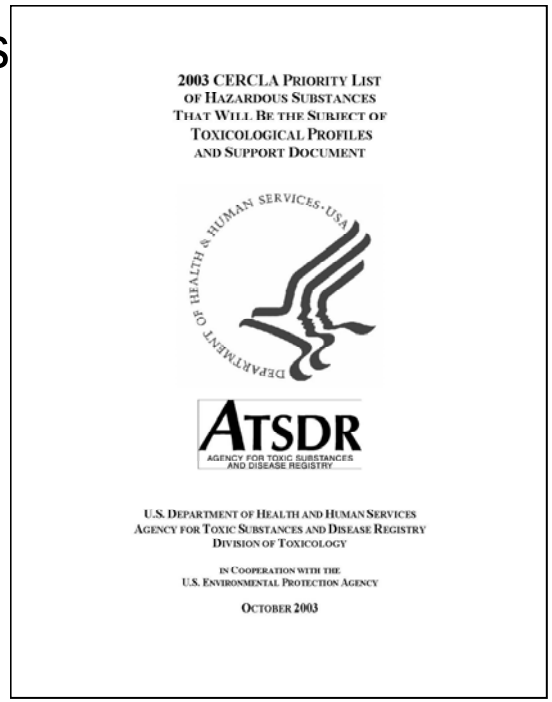
Field training

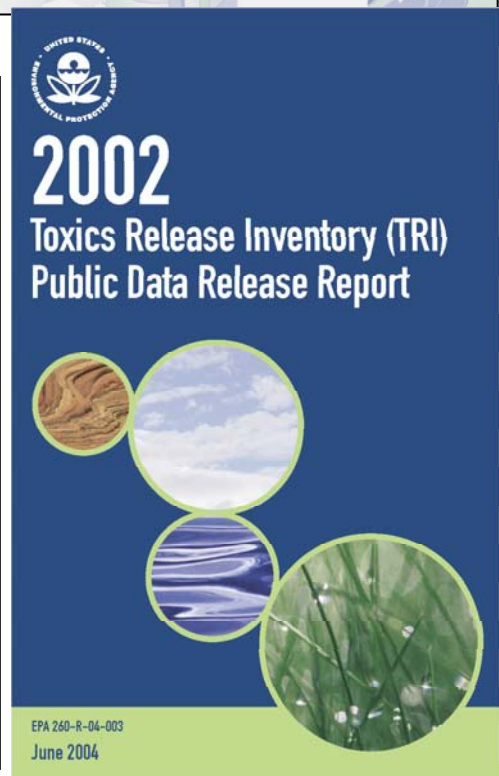
- Chair, Federal Response Team
  - Addresses emergencies that overwhelm the capabilities of state and local governments (including training).
- Special Forces
  - Environmental Response Team (ERT)
  - Radiological Envr. Response Team
  - Scientific Support Coordinator (SSC)

Anthrax cleanup 2001

Ch. 6: Information and Innovation

- Superfund Basic Research Program
- Remediation Technologies Development Forum
- Environmental Response Team
- Agency for Toxic Substances and Disease Registry
- Toxics Release Inventory
- Etc.





Conclusions: What are the Benefits of Superfund?

- Data availability strongly limits the ability to answer this question.
- The benefits of Superfund are varied.
- The benefits of Superfund are intergenerational.
- The benefits that have been monetized in this study are substantial.
  - Total: $40-$100 Billion (2000$ discounted to 1980)
  - Annualized values: $4-$6 Billion per year (2000$)
  - Actual value depends on various assumptions
  - This is a partial estimate: only a fraction of the benefits of NPL remedial actions are counted, ignoring Removals as well as other benefits.