Lecture 22: Hazardous Wastes, CERCLA, and RCRA

Prof. Austin
Environmental Economics
Econ 4075

Follow up from SDWA Lecture

Drinking water for the DC water system:

- For most large water systems, you can find their Consumer Confidence Reports posted online.

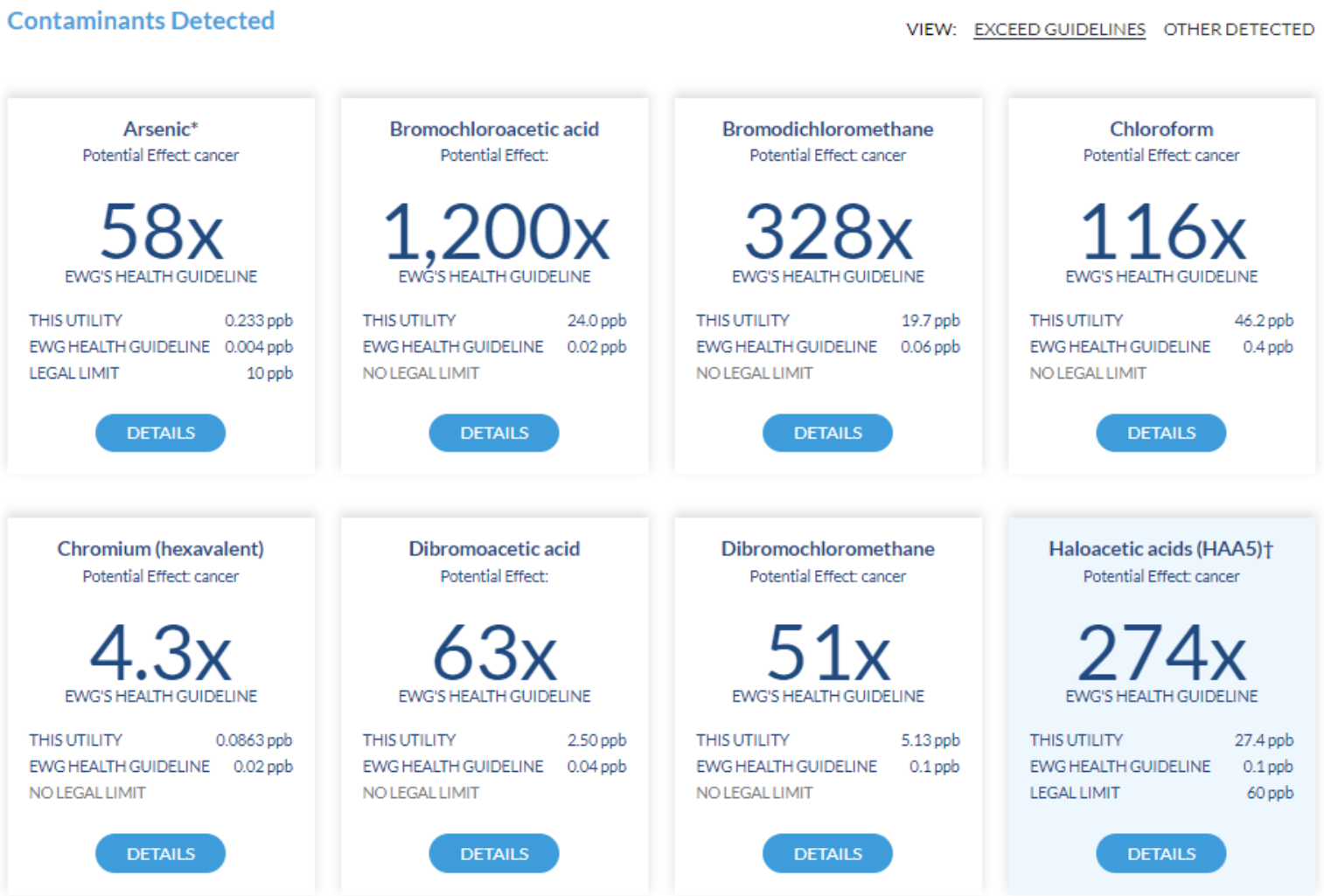
TEST RESULTS OF WASHINGTON AQUEDUCT OCTOBER 2022 TREATED WATER SAMPLES (MEASURED AS PARTS PER TRILLION – PPT)					
Chemical Group	Average	Range	Method Reporting Limit	EPA's Proposed Maximum Contaminant Level	EPA's 2022 Health Advisory Level
Perfluorooctanesulfonic acid (PFOS)	1.9 ppt	Non-detect to 2.9 ppt	2.0 ppt	4.0 ppt[1]	0.02 ppt (interim)
Perfluorooctanoic acid (PFOA)	2.4 ppt	2.2 to 2.5 ppt	2.0 ppt	4.0 ppt[1]	0.004 ppt (interim)
Perfluorobutanesulfonic acid (PFBS)	2.7 ppt	2.4 to 3.0 ppt	2.0 ppt	Hazard Index[2] of 1.0	2,000 ppt (final)
Hexafluoropropylene Oxide (HFPO) Dimer Acid and its Ammonium Salt (GenX)	Non-detect	Non-detect	2.0 ppt		10 ppt (final)

DC Public Water's 2023 CCR showing detections of three PFAS.

Follow up from SDWA Lecture

Drinking water for the DC water system:

- You can find recent (2015-2019) sampling history for many water systems on the Environmental Working Group's Tap Water Database.
  - ➢ Here are DC's results.



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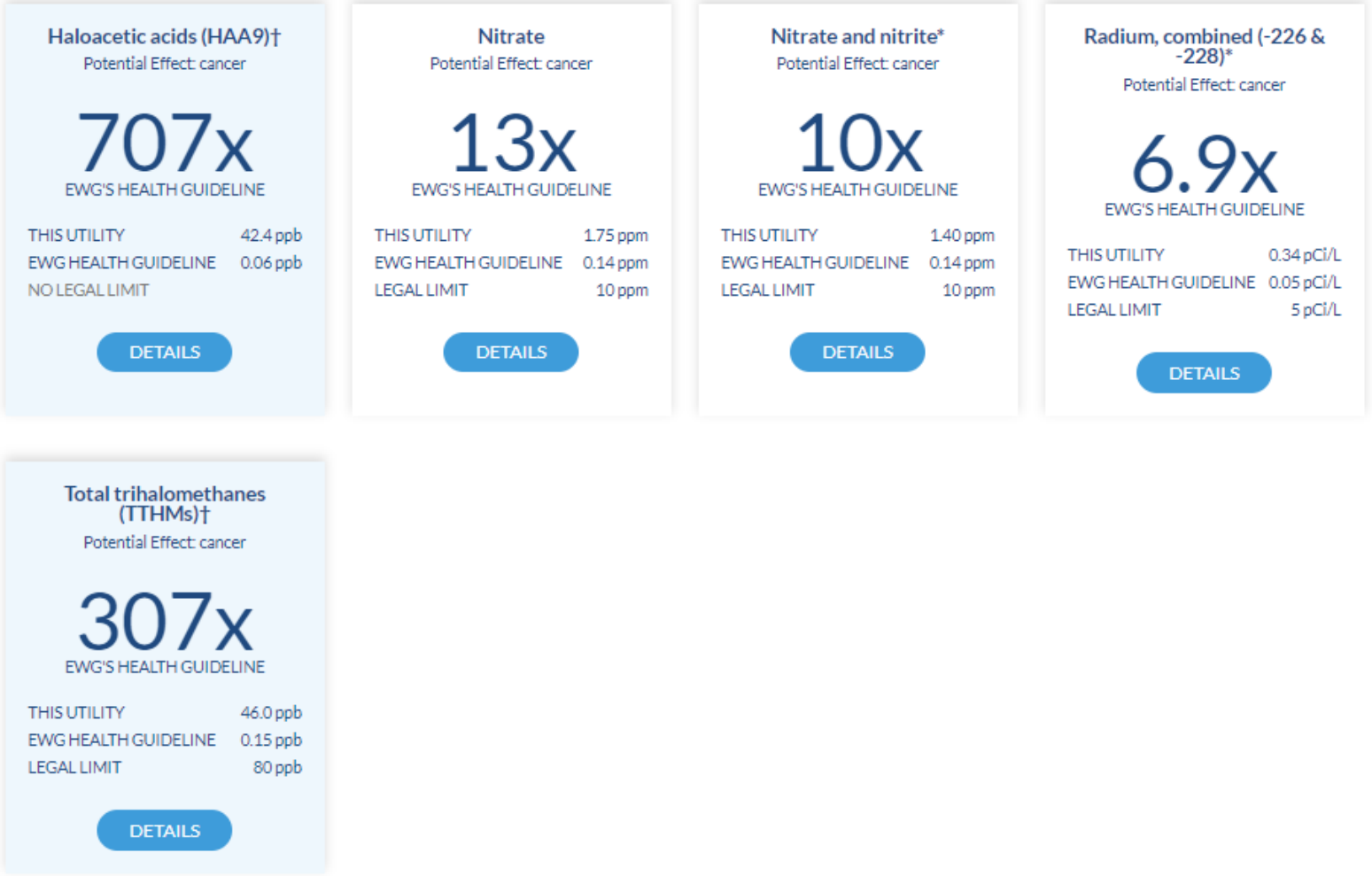


Roadmap

Topics for today:

- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
  - The “Superfund” Program
- Resource Conservation and Recovery Act (RCRA)

Part 1: Comprehensive Environmental Response, Compensation, and Liability Act

ABC News Documentary on Hazardous Waste (1979)

Love Canal, NY

- Original site of a potential canal connecting upper and lower Niagara Rivers.
- Hooker Chemical Company waste dumping site for lindane, chlorobenzenes, acid chlorides, and many other chemicals.
- Miscarriages, half of children had birth defects, one third of residents had chromosomal damage.
- 221 families relocated
- $275m in cleanup costs.

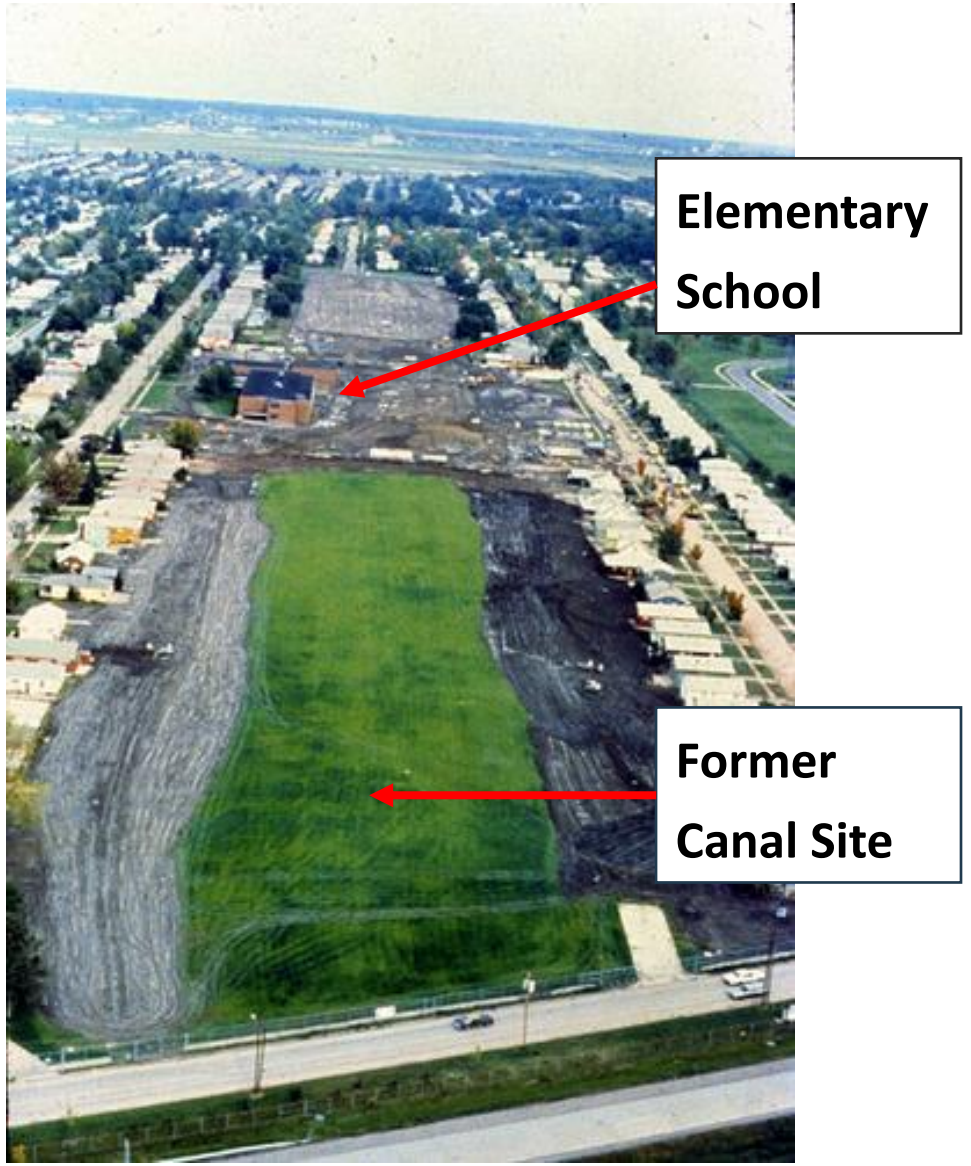
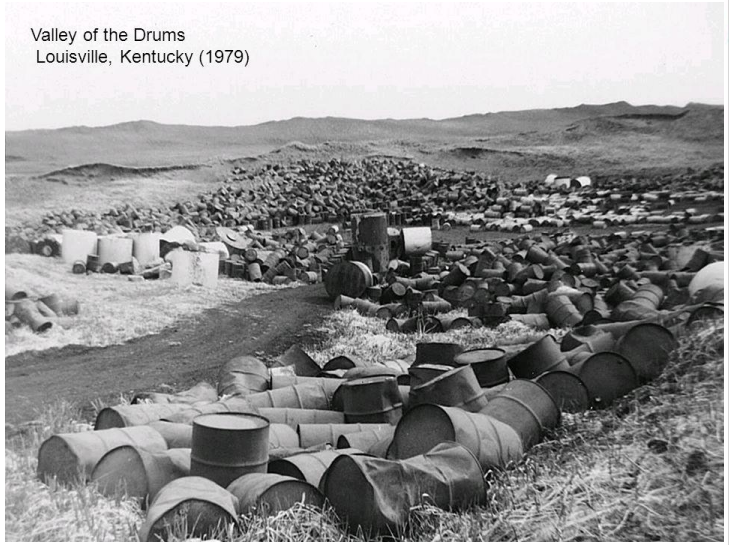


Figure: Aerial image of the Love Canal community (source).

Motivation for CERCLA (1980)

Many other sites:

- The Hudson River (PCBs)
- Times Beach, MO (dioxins) - (image link)
- Valley of the Drums, KY (heavy metals)



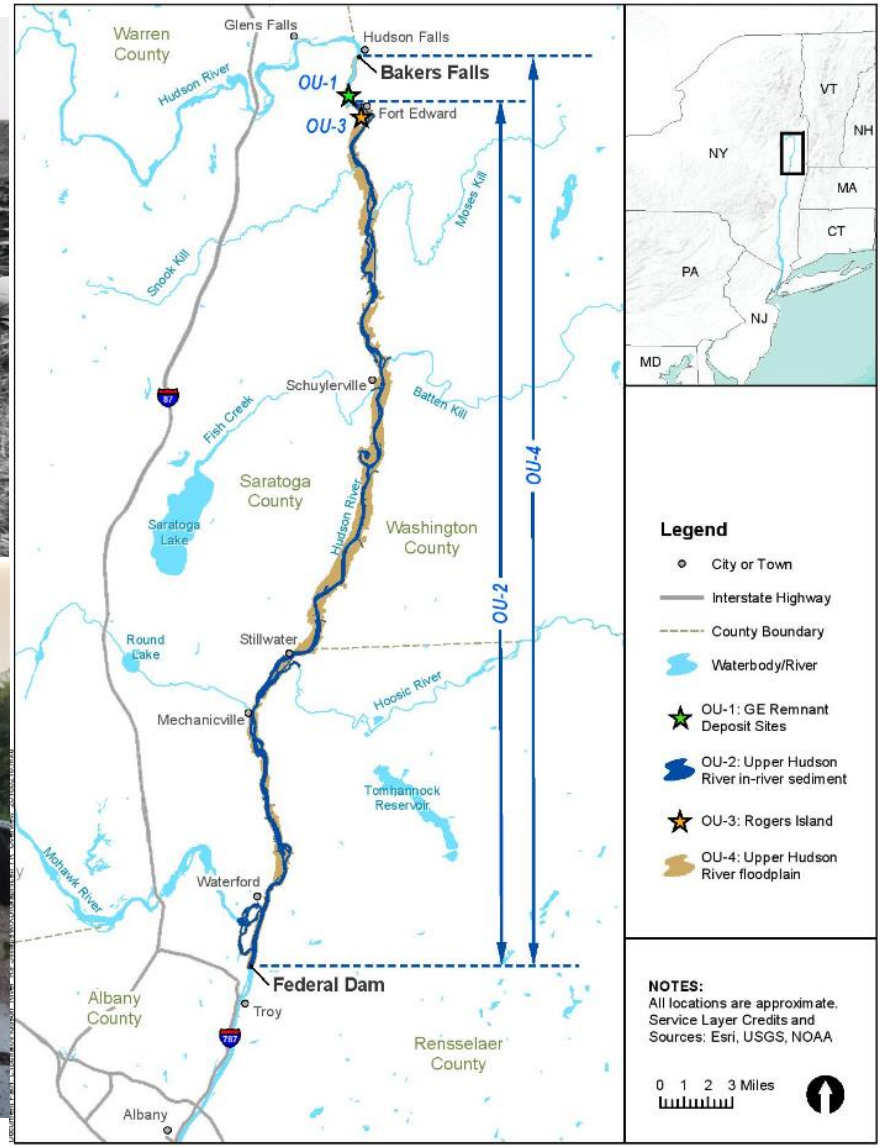


Figure: General Electric (GE) dumped 1.3 million tons of PCBs into the Hudson river over 30 years until 1977.

Beltsville Agricultural Research Center (BARC), Maryland

Source: 5-Year Review Report

The center is also referenced in local folklore as the creation place of the Goatman, claiming that Goatman was once a scientist who worked at the center before an experiment on goats backfired and mutated the scientist into a half man, half goat creature who aggressively attacks cars in the vicinity of Beltsville.[8]

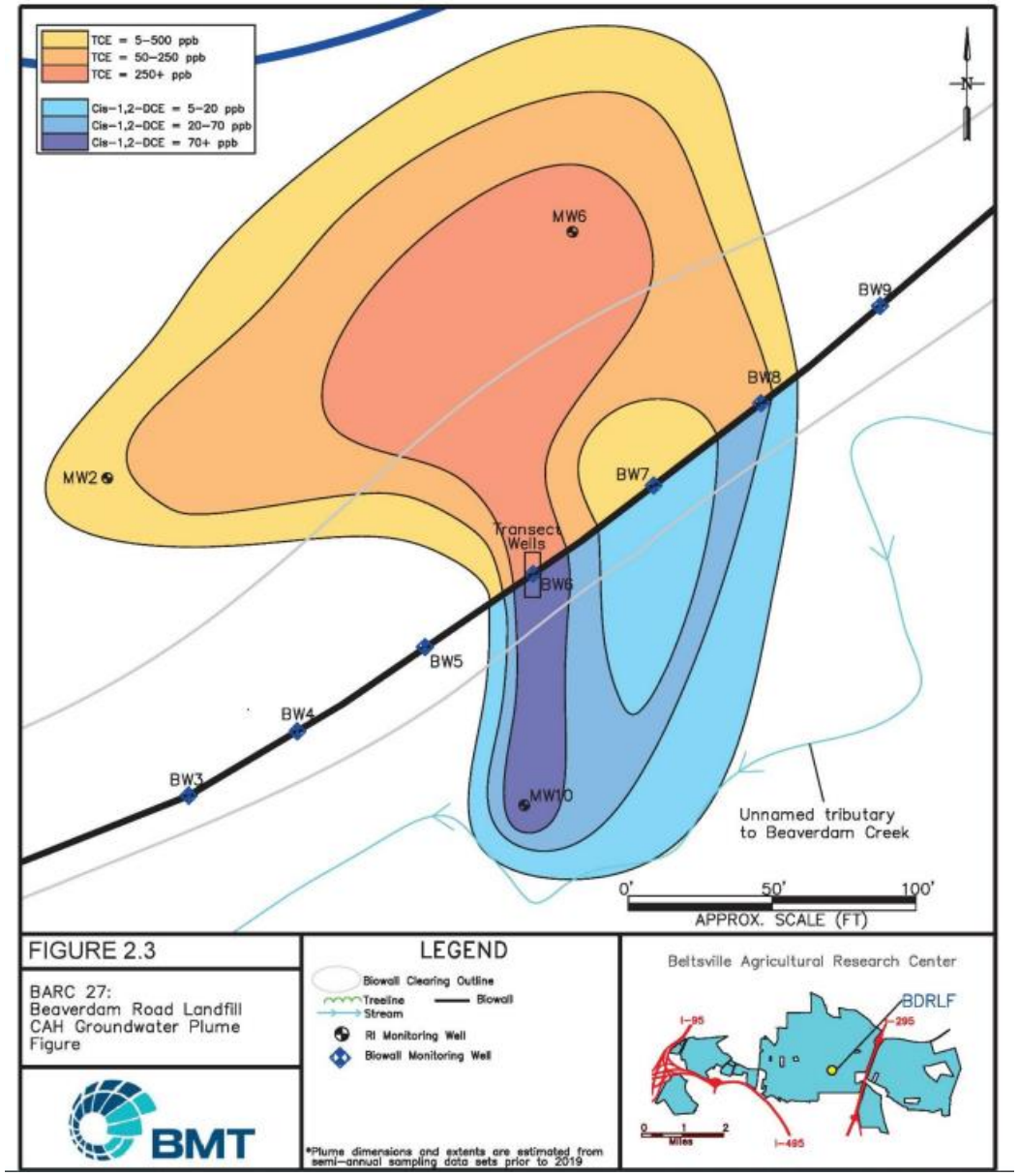


Figure: A TCE Groundwater Plume near Beaverdam Road.

CERCLA and the Superfund Program

Three key pieces to CERCLA:

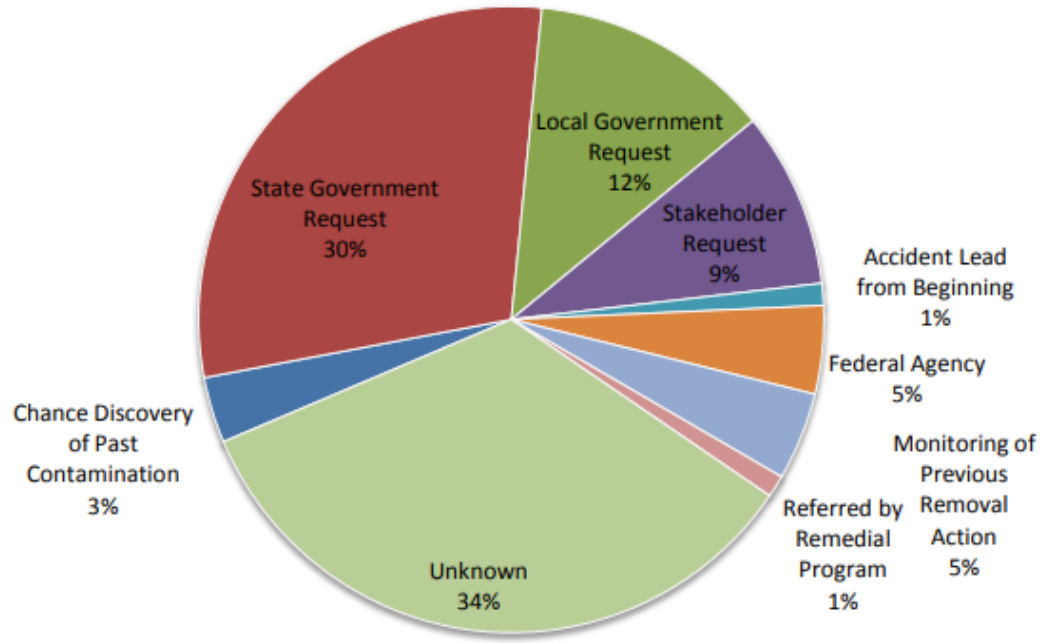
1) Identify hazardous waste sites, characterize their toxicity, and place some on a **National Priorities List (NPL)**.
2) Establishment of a fund (i.e., the "**Superfund**") to clean up these sites in a timely manner.
   - Originally, fund was created with a tax on oil refineries and chemicals producers, which was dropped and then re-instated in 2021.
3) Allows the government, states, or private entities to recover cleanup costs from the release or potential release of hazardous substances from **Potentially Responsible Parties**.

The Superfund Timeline to Full Cleanup

Steps leading up to clean-up:

- A site is reported to the National Response Center (24/7 call line) and then proposed as a site ("proposal")
- Preliminary investigation and site assessment
- National Priorities Listing ("listing")
- Remedial investigation and cleanup feasibility study
- Design of remediation action and Record of Decision (ROD) for the plan
- Remedial cleanup construction ("construction")
- Eventually, de-listing ("deletion")

Figure 5: How EPA was Informed of the Contamination at Region 3 Sites, 2001-2006



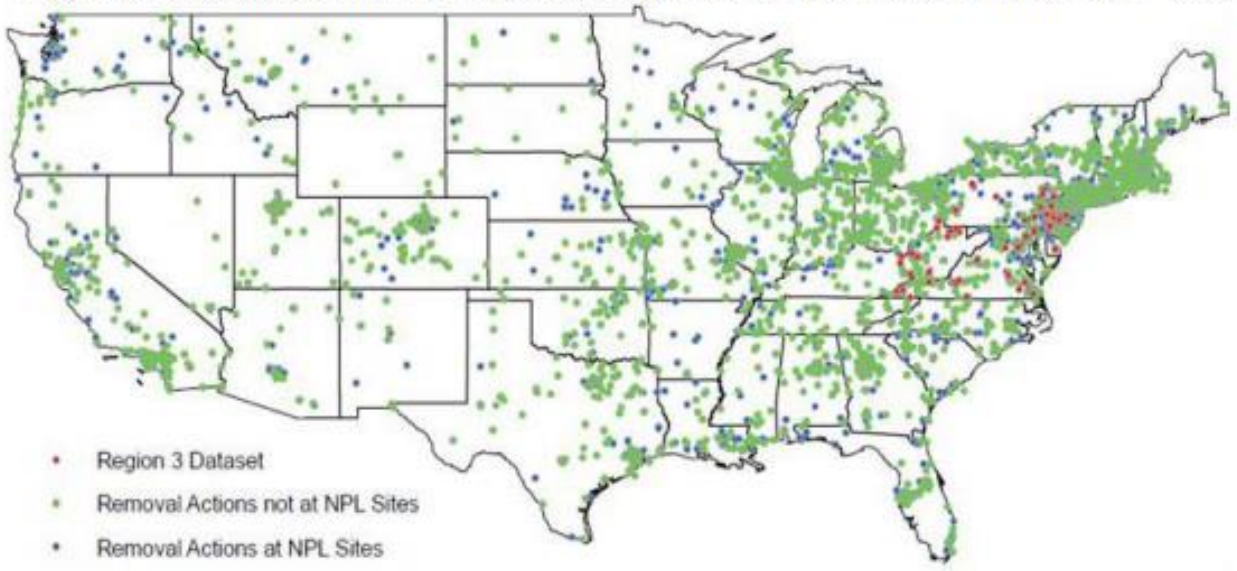
Source: Jenkins et al. (2011).

Two Types of Actions

Depending on the nature of the site, there are two types of action that may be taken:

- **Removal actions:** Immediate short-term responses to an emergency spill or ongoing urgent threat to public health. Much more common but less well-known incidents.
- **Remedial actions:** Longer-term response to complex sites with multi-year investigation, detailed planning, public comment periods, and eventual clean-ups.

Figure 2: Locations of EPA Emergency Response and Removal Actions, 1981 – 2010*

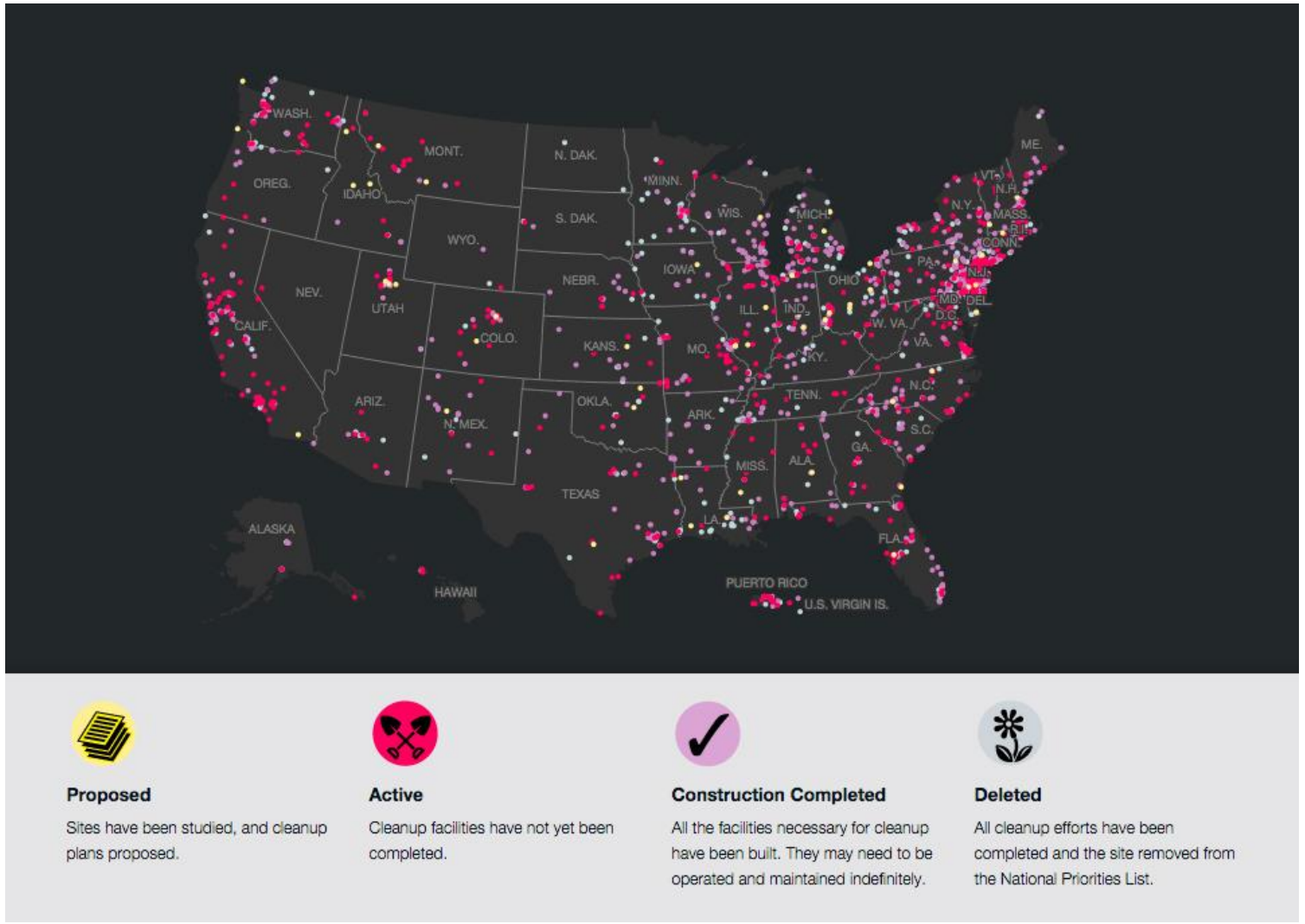


Source: Jenkins et al. (2011).

National Priorities Listing (NPL)

During site assessment:

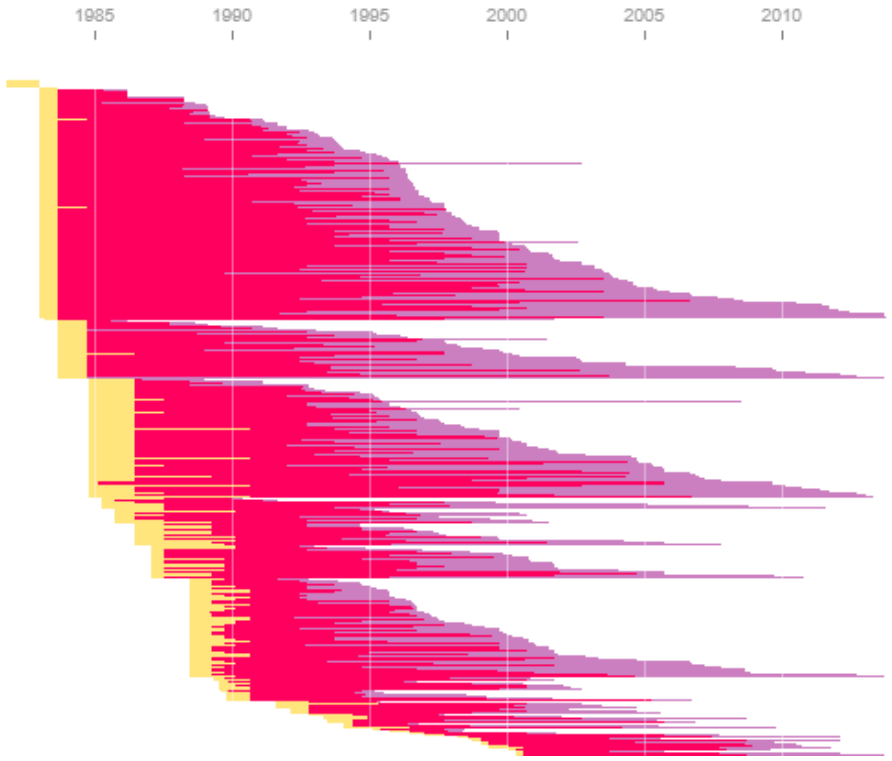
- Locations receive a Hazard Ranking Score (HRS).
- Sites with a HRS above 28 are placed on the NPL.
- 1,700 NPL sites created from 47,000 investigations.
- Currently there are 1337 NPL sites, and 392 have been de-listed.

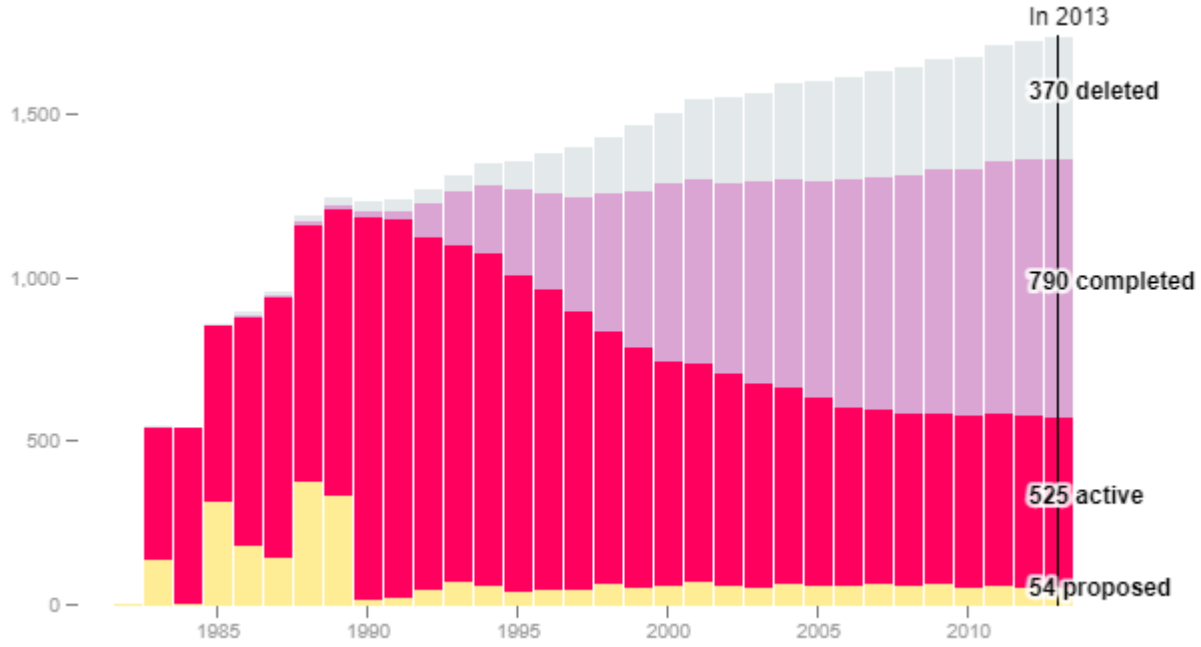


Source: National Geographic (2014)

Timeline for NPL De-listing

It can take a long time to complete clean-up…





Source: National Geographic (2014)

Potentially Responsible Parties (PRPs)

CERCLA allows compelling that cleanup payments be recovered from or made by **potentially responsible parties**.

- Liability is joint across all polluting parties although costs are not divided equally
  - Firms or operators of facilities that generated the hazardous substance
  - Firms that transported the pollution to or from the site
  - Firms that stored the pollution
- Cleanup liability is strict (i.e., fault-based vs. no-fault liability)
- Liability is fully retroactive

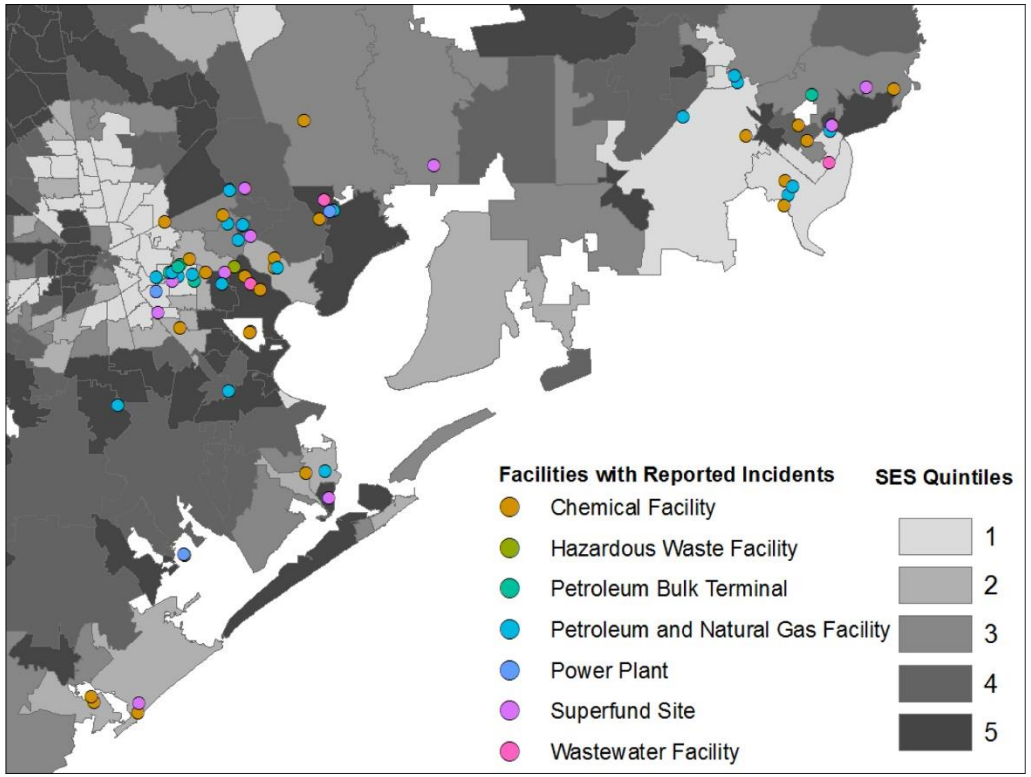
Cannot escape liability by paying another firm to get rid of the waste or subsidiarizing the pollution.

Some Limits to CERCLA Liability

Strict liability except in a few cases:

- Nearby landowners
- Acts of a third-party
- Extreme acts of nature
- Acts of war

Figure: Hurricane Harvey Accidents Near Houston



Source: Lieberman-Cribbin et al. (2021).

Liability as a Regulatory Instrument

Advantages:

1) Low cost if minimal risk and infrequent accidents.
2) More decentralized than direct regulation, hence lower information requirements for the regulator.

Disadvantages:

1) More costly than direct regulation for common and/or significant hazards.
2) Legal process is not always initiated and can be capricious, hence lowering incentive for polluters to take precautions.
3) Polluter bankruptcy → cleanup costs may fall on taxpayers.

Gamper-Rambindran and Timmins (2013)

Research question: Does cleanup of superfund sites raise housing values?

Methods:

- Compare housing values within 3 miles of 321 NPL sites that are cleaned (i.e., delisted from the NPL) to those that are not cleaned using tract-level data from the 1990 and 2000 census.
- Run a basic hedonic model -- the effect of de-listing on home values.

$$\ln(Housing)_{kt} = \beta_1 P_{kt} + \beta_2 L_{kt} + \beta_3 C_{kt} + \beta_4 D_{kt} + \beta_5 X_{kt} + \epsilon_{kt}$$

Gamper-Rambindran and Timmins (2013)

Tract-level first-differences hedonic model:

- Tract k, years t ∈ {1990, 2000}.
- Main variable of interest is D_{kt}, the share of the tract in a 3-mile buffer around the NPL site.
- Point estimate of interest is β_4.

$$\ln(Housing_{2000} - Housing_{1990})_k = \beta_1(P_{k,2000} - P_{k,1990}) + \beta_2(L_{k,2000} - L_{k,1990}) + \beta_3(C_{k,2000} - C_{k,1990}) + \beta_4(D_{k,2000} - D_{k,1990}) + \beta_5(X_{k,2000} - X_{k,1990}) + \epsilon_{kt}$$

Variables for steps in the superfund process (proposal, listing, construction, de-listing).

Housing stock, socioeconomic, and demographic characteristics of the tract.

Gamper-Rambindran and Timmins (2013)

Another twist:

- G&T run these regressions nine times, once for each percentile θ of the housing value distribution in a given tract where:

$$\theta \in \{10, 20, \ldots, 90\}.$$

- Why not just use the median?

Table 1: Summary statistics for 3 mile tracts around 321 sites (No. obs.=3,584)

	1990 Mean	1990 Std Dev	2000 Mean	2000 Std Dev
Variable				
Housing value distribution				
10th percentile	$46,918	$37,940	$48,222	$38,483
20th percentile	$56,291	$43,197	$57,212	$45,645
30th percentile	$63,344	$47,136	$64,178	$50,251
40th percentile	$69,790	$50,731	$70,664	$54,495
50th percentile	$76,225	$54,448	$77,358	$59,180
60th percentile	$83,310	$58,729	$84,651	$64,370
70th percentile	$91,520	$63,249	$93,386	$70,419
80th percentile	$102,410	$69,174	$105,424	$78,586
90th percentile	$120,717	$78,996	$127,079	$94,576
Share of tract exposed to a Superfund milestone				
Proposal	0.007	0.080	0.006	0.068
Listing	0.316	0.414	0.168	0.343
Construction Complete	0.024	0.145	0.111	0.283
Deletion	0.018	0.122	0.097	0.275

Gamper-Rambindran and Timmins (2013)

Findings:

1) Proposing a site for the NPL list is associated with significant decreases in home values for the lowest-valued homes.

Table 3: Panel analysis of tracts within 3 mile buffers of 321 sites whose 1982 HRS scores are in (16.5, 40.5)

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
Percentiles	10	20	30	40	50	60	70	80	90
Panel A: Dependent variable: Δ Log price of owner occupied housing units at the θth percentile									
Δ Proposal	-0.127*	-0.124*	-0.118	-0.110	-0.104	-0.095	-0.076	-0.063	-0.034
	(0.077)	(0.074)	(0.072)	(0.071)	(0.071)	(0.073)	(0.074)	(0.071)	(0.066)
Δ Listing	0.090**	0.073**	0.060*	0.056*	0.053	0.048	0.053	0.043	0.031
	(0.036)	(0.035)	(0.033)	(0.033)	(0.032)	(0.032)	(0.032)	(0.031)	(0.032)
Δ Construction	0.138***	0.136***	0.127***	0.120***	0.113***	0.110***	0.113***	0.098***	0.069**
Complete	(0.036)	(0.035)	(0.035)	(0.035)	(0.034)	(0.033)	(0.033)	(0.031)	(0.031)
Δ Deletion	0.245***	0.217***	0.213***	0.206***	0.203***	0.200***	0.195***	0.185***	0.186***
	(0.041)	(0.040)	(0.038)	(0.038)	(0.037)	(0.037)	(0.037)	(0.036)	(0.036)
R-sqr	0.238	0.278	0.276	0.261	0.258	0.276	0.285	0.285	0.267
Panel B: Dependent variable: Δ Price of owner occupied housing units at the θth percentile									
Δ Proposal	-2,523	-2,259	-2,541	-3,545	-3,991	-3,910	-3,348	-2,705	-1,169
	(3,190)	(3,528)	(3,749)	(4,021)	(4,423)	(4,798)	(5,375)	(5,581)	(5,790)
Δ Listing	3,517**	2,695	1,922	1,277	1,260	810	1,486	909	-2,468
	(1,572)	(1,792)	(1,973)	(2,204)	(2,351)	(2,504.162)	(2,795)	(2,900)	(3,386)
Δ Construction	5,101***	4,828**	4,623**	3,972	3,936	3,611	4,554	3,820	-985
Complete	(1,607)	(1,874)	(2,095)	(2,436)	(2,602)	(2,729)	(2,879)	(2,992)	(3,471)
Δ Deletion	9,240***	10,226***	11,417***	11,581***	12,292***	12,581***	12,129***	12,824***	17,553***
	(1,764)	(2,049)	(2,235)	(2,581)	(2,759)	(2,916)	(3,728)	(3,764)	(4,447)
R-sqr	0.129	0.170	0.179	0.170	0.171	0.188	0.209	0.226	0.234

Gamper-Rambindran and Timmins (2013)

Findings:

2) Listing a site on the NPL is associated with significant increases in home values, with increases being more evenly spread across homes in the bottom half of the value distribution.

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Gamper-Rambindran and Timmins (2013)

Findings:

3) Finishing construction of the remediation plan on an NPL site is also associated with significant increases in home values across the value distribution.

- Increases are largest in magnitude for homes with the lowest baseline values.

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Gamper-Rambindran and Timmins (2013)

Findings:

4) Deletion from the NPL list dramatically increases home values, by 19-25% depending on the starting values.

- Increases are largest in magnitude for homes with the largest baseline values, but proportionally are largest for lowest-valued homes.

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Δ Deletion	0.245***	0.217***	0.213***	0.206***	0.203***	0.200***	0.195***	0.185***	0.186***
	(0.041)	(0.040)	(0.038)	(0.038)	(0.037)	(0.037)	(0.037)	(0.036)	(0.036)
R-sqr	0.238	0.278	0.276	0.261	0.258	0.276	0.285	0.285	0.267
Panel B: Dependent variable: Δ Price of owner occupied housing units at the θth percentile									
Δ Proposal	-2,523	-2,259	-2,541	-3,545	-3,991	-3,910	-3,348	-2,705	-1,169
	(3,190)	(3,528)	(3,749)	(4,021)	(4,423)	(4,798)	(5,375)	(5,581)	(5,790)
Δ Listing	3,517**	2,695	1,922	1,277	1,260	810	1,486	909	-2,468
	(1,572)	(1,792)	(1,973)	(2,204)	(2,351)	(2,504.162)	(2,795)	(2,900)	(3,386)
Δ Construction	5,101***	4,828**	4,623**	3,972	3,936	3,611	4,554	3,820	-985
Complete	(1,607)	(1,874)	(2,095)	(2,436)	(2,602)	(2,729)	(2,879)	(2,992)	(3,471)
Δ Deletion	9,240***	10,226***	11,417***	11,581***	12,292***	12,581***	12,129***	12,824***	17,553***
	(1,764)	(2,049)	(2,235)	(2,581)	(2,759)	(2,916)	(3,728)	(3,764)	(4,447)
R-sqr	0.129	0.170	0.179	0.170	0.171	0.188	0.209	0.226	0.234

Gamper-Rambindran and Timmins (2013)

Summary of findings and take-away:

- Large impacts of completing construction of remediation on home values, larger impacts from deletion from the NPL.
- Benefits are the sum of the housing value changes for each decile times the tract-level number of houses divided by ten.
- Average benefits per site are $72 million, average costs are $9 million.
- Benefits > Costs for 35 out of 55 sites…

Other Benefits of Cleanup: Persico, Figlio, and Roth (2020)

Research goal: Examine the long-term effects of prenatal exposure to environmental toxics from Superfund sites on observable outcomes in restricted-use education data. Research setting:

- 8% of Florida students born from 1994-2002 live within 2 miles of a Superfund site.
- These students also have K-12 education records.

Methods: Compare siblings living within 2 miles of an NPL site who faced different toxic exposures during gestation because of Superfund site cleanup.

Persico, Figlio, and Roth (2020)

Empirical Model: Sibling comparison before and after cleanup of a superfund site.

$$Y_{ijt} = \beta_1 Before_{ijt} + \beta_2 During_{ijt} + \gamma' X_{ijt} + \theta_j + \epsilon_{kt}$$

Family fixed effect

Controls for gender, birth year, birth month, birth spacing, and birth order

- Child i, family j, year t
- Y_{ijt} is the school-related behavioral problems, Florida Comprehensive Assessment Test (FCAT) scores, grade repetition, and diagnosis with a cognitive disability
- Before is an indicator for being born before cleanup, during is an indicator for being born during cleanup.

Persico, Figlio, and Roth (2020)

Children born before cleanup, in comparison to siblings born after cleanup, are significantly more likely to:

- Repeat a grade
  - ➢ 8.3 percentage points more likely
- Score lower on standardized tests
  - ➢ Effect is one half the impact of being in a small class in Kindergarten.
- Have more behavioral incidents
- Be diagnosed with a cognitive disability

Table 3
School Outcomes with Family Fixed Effects for Children Born within Two Miles of a Superfund Site

	Likelihood of Repeating a Grade (1)	Average FCAT Score (2)	Likelihood of Behavioral Incident (3)	Likelihood of Cognitive Disability (4)	Likelihood of Autism (5)
	B. Estimates for Nonmoving Families				
Conceived before cleanup versus after	.083***	−.068*	.061***	.033*	−.001
	(.018)	(.035)	(.023)	(.018)	(.003)
Conceived during cleanup versus after	.051***	−.065**	.032***	.015	−.001
	(.010)	(.016)	(.012)	(.013)	(.002)
Observations	29,245	27,683	29,549	29,667	29,667

Descriptive Characteristics of Children Living Near Superfund Site

	All Children Born in Florida, 1994–2002 (1)	All Children Born within Two Miles of a Superfund Site (2)	Families with ≥2 Siblings Born within Two Miles of a Superfund Site (3)	Nonmoving Siblings Born within Two Miles of a Superfund Site (4)
Behavioral incidents in school	.226	.244	.27	.265
Average test score	.06	−.074	−.150	−.145
Ever repeats a grade	.22	.249	.277	.281

Persico, Figlio, and Roth (2020)

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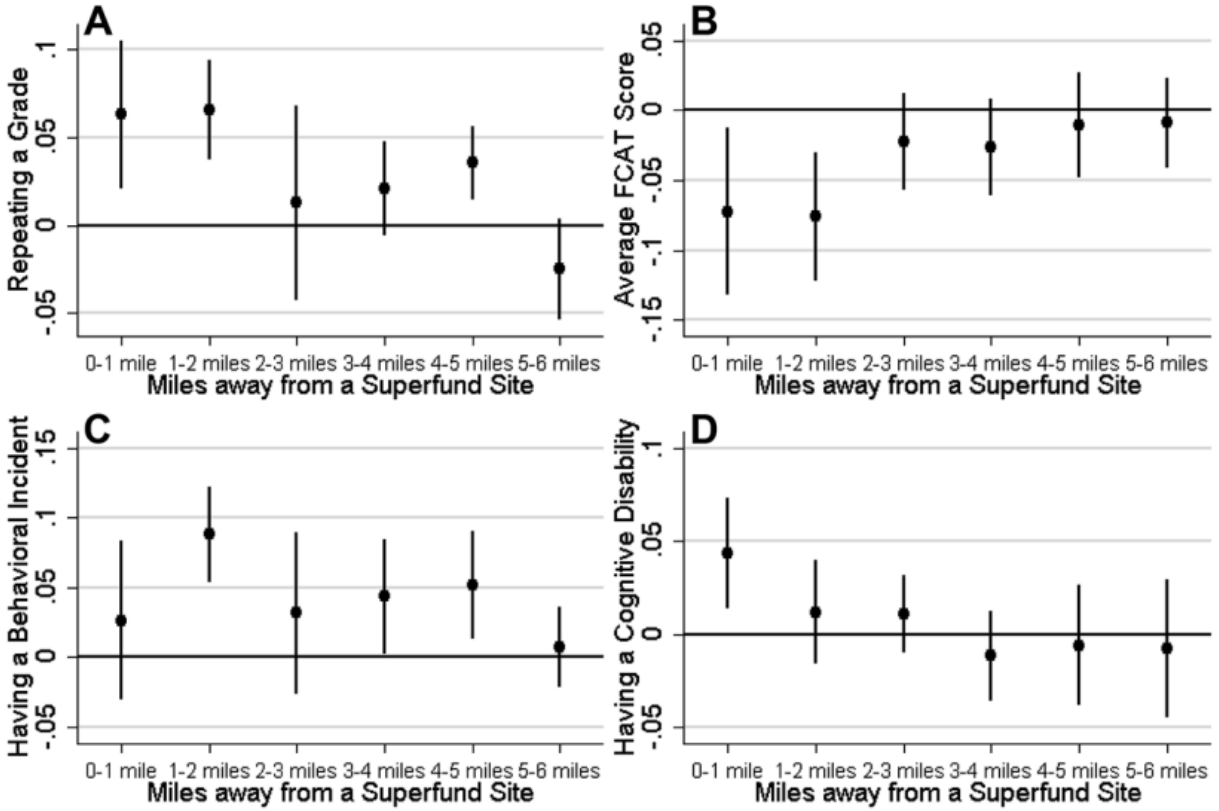
Persico, Figlio, and Roth (2020)

Other notable findings:

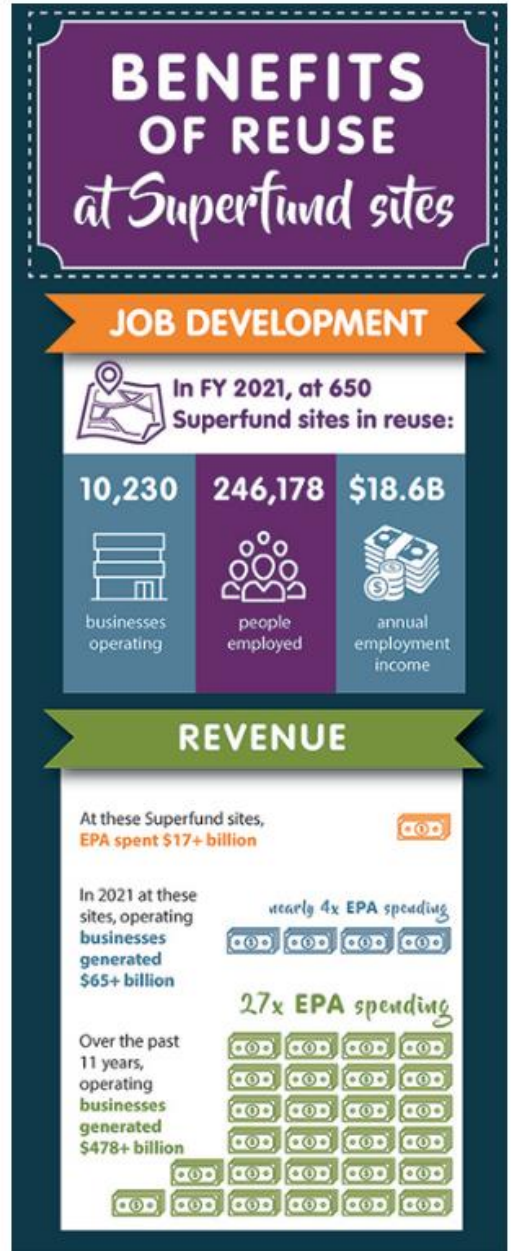
- Results are not necessarily limited to within two miles of a Superfund site.
- 80 million Americans live within 3 miles of a Superfund site, and 11 million live within one mile.



Other Impacts of Cleanup

EPA has spent nearly $17 billion to clean up roughly 650 Superfund sites since the start of the program. Now, these sites:

- Support over 10,000 businesses with total annual sales of more than $63 billion.
- These businesses employed over 245,000 employees taking home $18 billion in income annually.



Source: EPA, 2022.

CERCLA in the News: Designation of PFAS as a Hazardous Substance

EPA recently proposed to to designate PFOA and PFOS as hazardous substances.

- You can see the regulatory record here.

A hazardous substance designation would mean that sites contaminated with these chemicals could become Superfund sites, with resulting cleanup and liability.

- As many as 44,000 new sites would be investigated.

Some notable opposition from industry (see Chamber of Commerce report).

Part 2: Resource Conservation and Recovery Act

RCRA Overview

The Resource Conservation and Recovery Act (RCRA) of 1976, which existed before the Superfund program, provides minimum standards for land storage of waste.

It was the "... last remaining loophole in environmental law, that of unregulated land disposal of discarded materials and hazardous wastes" (Jenkins et al. 2008).

- Subtitle D, Hazardous Waste: "cradle-to-grave" requirements on hazardous waste management.
- Subtitle C, Nonhazardous Waste: Minimum standards for landfills and recycling programs.

RCRA: Subtitle D

Largely based on the first hazardous waste control act written by California, RCRA:D establishes many requirements for hazardous waste management:

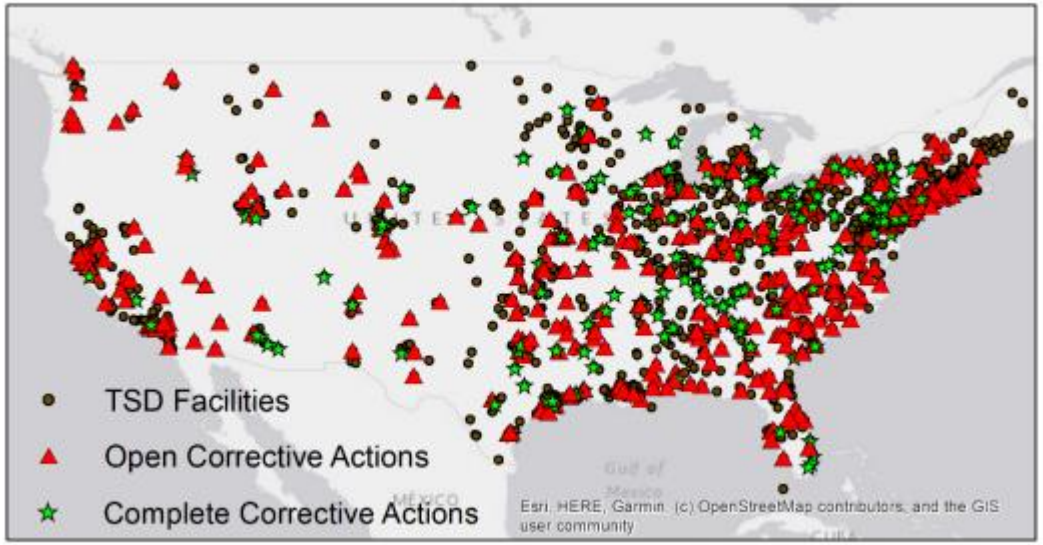
- Defines hazardous waste.
  - Specific listed chemicals *OR* any substance that exhibits toxicity, ignitability, corrosivity, or reactivity.
- Tracking and reporting of all wastes from cradle to grave.
- Transport, storage, and disposal procedure requirements.
- New waste management industry: Treatment, Storage, and Disposal facilities (TSDFs)
- EPA is allowed to issue **corrective actions**, or mandatory investigation and cleanup of contamination events.

Guignet and Nolte (2023)

Research goal: Estimate how RCRA corrective actions impacted nearby home values.

- 12% of the US population, or 35 million people, live within one mile of a corrective action site.
- Investigate only TSDFs, the riskiest RCRA sites, and ask how real estate values changed after 689 corrective actions were completed across 2,400 potential sites in a D&D framework.
- 9.7 million home transactions from 2000-2018.

Figure 1. Treatment, Storage, and Disposal Facilities (TSDF) and Corrective Actions.

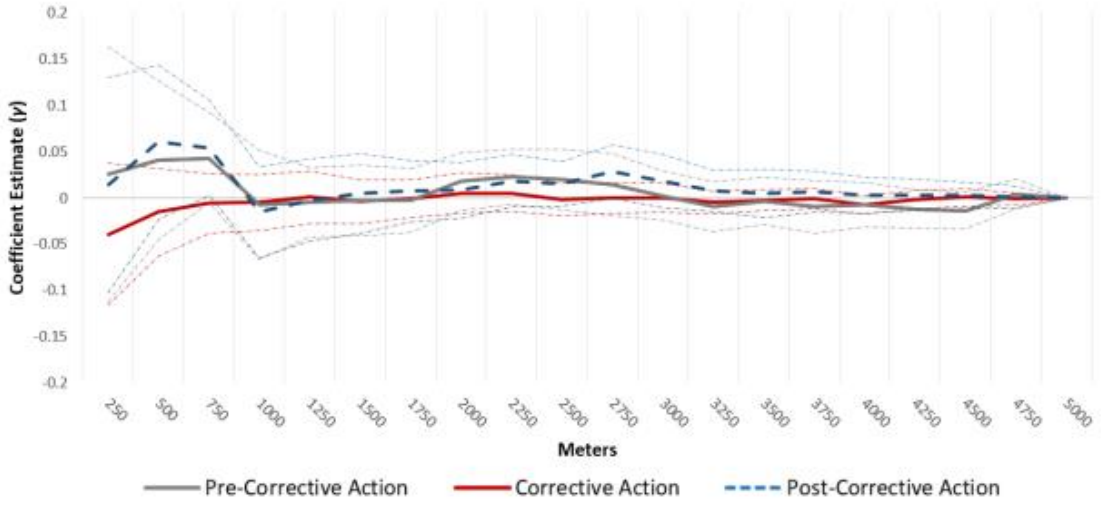


Guignet and Nolte (2023)

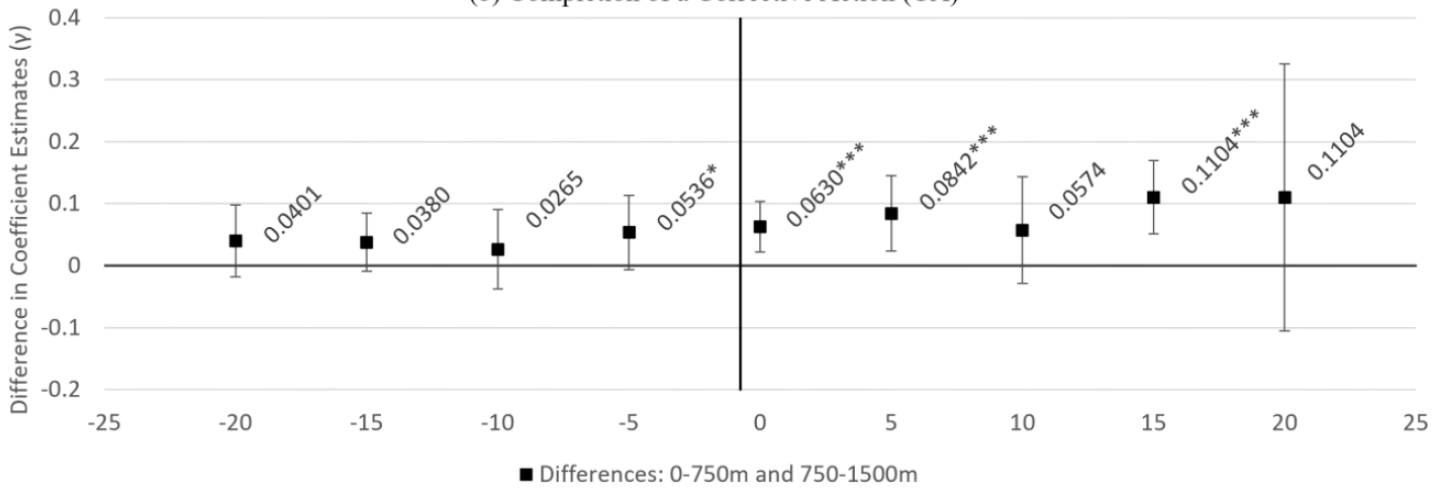
Findings: Completion of CAs dramatically increase nearby home values.

- Starting a CA has unclear and often insignificant impacts on housing values.
- Average increase in value post-cleanup of $12,000.
- Increase in housing stock value of $295 million, or an average of $430,000 per cleanup.

Figure 3. Conditional Price Gradients with respect to Distance from the Corrective Action Site.



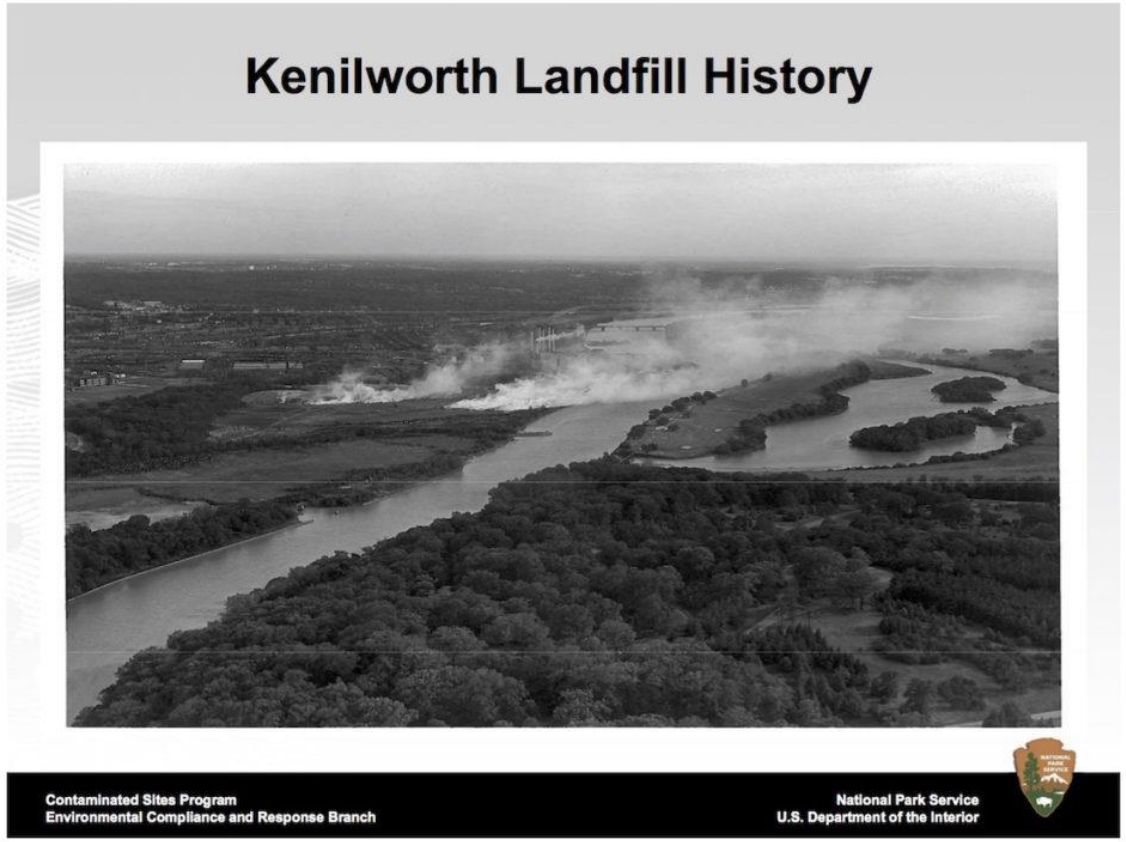
(b) Completion of a Corrective Action (CA)



RCRA: Subtitle C

Increased landfill requirements:

- Eliminated open dumping and open burning of waste.
- Closed nearly 900 landfills and led to increasing concentration in the waste management industry.
- Recycling and trash programs delegated to states, resulting in a wide variety of program types.



The Kenilworth Dump in DC allowed open burning for decades. Source.

Experimentation in Waste Management

Some market-based examples:

1) Front-end disposal charges
   - Examples: Plastic bag fees, car batteries.
2) Deposit refund schemes
   - Examples: Soda cans, car batteries.
3) Cash for trash programs
   - Examples: Seattle, Austin TX, Portland ME, all have “pay as you throw” strategies
   - Increased composting, recycling, and trash compacting. Might have increased illegal dumping by 28-43% (Fullerton, 1996).

Mandatory three-stream waste collection in San Francisco diverts 80% of waste (EPA, 2021).

Next class

- Next class will cover the topic of international economics.

- A reading and optional podcast for Monday:
  - Levinson (2023) and
  - (*optional*) Bellelli et al. (2023)