RCRA

RCRA Corrective Action:

Case Studies Report

April 2013

EPA United States Environmental Protection Agency

PREFACE

Over the last 25 years, EPA and its state partners have built an efficient and successful RCRA Corrective Action Program, one that oversees the cleanup of a wide variety of contaminated sites, including many with risks comparable to Superfund sites.

Together, EPA and the states have worked with both industry and communities to identify, prioritize, and characterize nearly 4,000 hazardous waste sites across the country. The program has surpassed ambitious goals to prevent human exposures and protect groundwater resources at these sites. Now, the program is poised and ready to put *permanent* solutions in place.

This report begins with an overview of the RCRA Corrective Action Program, including a discussion of the public health and environmental benefits of hazardous waste cleanups (Section I). Information on the number, location, size, and cleanup progress of corrective action facilities (Section II) is then followed by case studies that profile a series of ongoing cleanups (Section III). Together, their stories illustrate the inherent challenges and real benefits of RCRA Corrective Action. EPA believes this information will help government officials and the general public make better and more cost-effective policy and business decisions.

CONTENTS

I. INTRODUCTION TO RCRA CORRECTIVE ACTION

A. Purpose of the Program

During more than a century of American industrial development, waste disposal—left unchecked—progressively polluted our air, water, and land. Recognizing the need for careful waste management to protect human health and the environment, Congress passed the Resource Conservation and Recovery Act of 1976 (RCRA) to require, among other things, a system to identify and properly manage hazardous waste. Congress amended RCRA in November 1984 to expand cleanup provisions. Under the amended law, owners or operators of facilities where hazardous waste was or is treated, stored, or disposed (i.e., TSDs) must clean up contamination from any past and present releases, including contamination that may have spread beyond site boundaries. Coordinated by EPA and its state partners, the RCRA Corrective Action Program ensures that these cleanups occur.[1]

RCRA Corrective Action facilities include current and former chemical manufacturing plants, oil refineries, lead smelters, wood preservers, steel mills, commercial landfills, and a variety of other types of entities. Sites range in size from hazardous waste treatment facilities of less than one acre to former military bombing ranges covering 2 million acres. Sites of all sizes, however, can threaten human health and the environment. Due to poor practices prior to environmental regulations, Corrective Action facilities have left large stretches of river sediments laden with PCBs; deposited lead in residential yards and parks beyond site boundaries; polluted drinking water wells in rural areas with chlorinated solvents; tainted municipal water supplies used by millions with components of rocket fuel; and introduced mercury into waterways, necessitating fish advisories.

[1] See Appendix A for a history of the program from 1984 to the present.

EPA and state regulators work with facilities and communities to design cleanup remedies based on the contamination, geology, and anticipated use unique to each site. Program goals, however, are the same for all sites: (1) to protect human health and the environment, and (2) to keep or return land to productive use, thereby supporting jobs, a healthy tax base, and other values from the land, as determined by local communities.

B. Human Health Benefits

EPA estimates that more than 35 million people, roughly 12 percent of the U.S. population, live within one mile of a RCRA Corrective Action site.[2] The presence of hazardous constituents in contaminated soil, sediments, groundwater, surface water, and air at, or emanating from, RCRA Corrective Action sites can increase the risk of adverse health effects to exposed populations. This can be especially critical for minority and poor communities—as well as sensitive sub-populations such as children, pregnant women, and the elderly—who can be disproportionately affected. Dangers include acute health effects, such as poisoning and injuries from fire or explosions, and long-term effects, such as cancers, birth defects, and other chronic non-carcinogenic effects (e.g., damage to kidney, liver, nervous and endocrine systems). By reducing exposures to contaminants listed in Table 1, as well as hundreds of others, RCRA Corrective Action cleanups protect the health of local residents, site workers, and others. Corrective Action sites can, and often do, contain more than one contaminant.

[2] Estimate calculated using EPA information on size and location of 3,747 facilities on the RCRA Corrective Action 2020 Universe, as well as 2000 Census population information for blocks and block groups.

Table 1: Health Effects of Contaminants Frequently Found at RCRA Corrective Action Sites

Substance	Potential Health Effects[3,4]
Arsenic	carcinogenic to humans (skin, lung, bladder, liver) • stomach and intestinal irritation, nausea, vomiting • decreased production of red and white blood cells • damage to blood vessels • skin changes • abnormal heart rhythm
Benzene	carcinogenic to humans (leukemia) • harmful to bone marrow, decreased red blood cells, anemia • vomiting, stomach irritation • drowsiness, dizziness, rapid heart rate, headaches, tremors, convulsions, unconsciousness
Cadmium	likely to be carcinogenic to humans • kidney, bone, and lung damage • stomach irritation, vomiting, diarrhea • birth defects in some animal studies
Chloroform	likely to be carcinogenic to humans • liver and kidney damage • skin sores • dizziness, fatigue, headaches • reproductive and birth defects in rats and mice
Lead	likely to be carcinogenic to humans • damage to the brain and nervous system (adults, children, unborn children) • miscarriage, premature births, neonatal mortality due to decreased birth weight, decreased male fertility • diminished learning abilities in children • increased blood pressure • kidney damage
Mercury	brain, kidney, and lung damage • serious harm to neural development of fetuses and young children • chest pains, nausea, vomiting, diarrhea • skin rashes and eye irritation • increased blood pressure and heart rate • irritability, sleep disturbances, tremors, coordination problems, changes in vision and hearing, memory problems
Perchlorate	Inhibition of iodine uptake • hypothyroidism, which may adversely affect the skin, heart, lungs, kidneys, gastrointestinal tract, liver, blood, neuromuscular system, nervous system, skeleton, reproductive system, and numerous endocrine organs
Polychlorinated Biphenyls (PCBs)	likely to be carcinogenic to humans • liver damage • skin rashes and acne • decreased birth weight • short-term behavioral and immune system impacts in children exposed via breast milk
Polycyclic Aromatic Hydrocarbons (PAHs)	likely to be carcinogenic to humans • irritation of skin, lungs, and stomach • reproductive and birth defects in animal studies
Tetrachloroethylene (PCE)	likely to be carcinogenic to humans • dizziness, headaches, sleepiness, confusion, nausea, difficulty speaking and walking, unconsciousness
Trichloroethylene (TCE)	carcinogenic to humans • liver, kidney, and nervous system damage • impaired immune system and heart function • impaired fetal development • skin rashes, lung irritation, headaches, dizziness, nausea, unconsciousness

3 EPA, Integrated Risk Information System (IRIS) database, www.epa.gov/iris.

4 ToxFAQs, Agency for Toxic Substances and Disease Registry (ATSDR). www.atsdr.cdc.gov/toxfaqs/index.asp.

C. Environmental Benefits

Contamination of soil, groundwater, surface water, and other media degrade the functioning of ecosystems by affecting the health of various plant and animal species. The effects vary widely from site to site depending on the species, contaminant, and ecosystem involved, but the overall impact is a change to an ecosystem's species composition and functioning.

In addition to harming plant and animal communities, these changes can lead to a reduction in the benefits—both direct and indirect—that ecosystems provide humans. RCRA Corrective Action cleanups help to protect and restore these benefits, often referred to as ecosystem services. Table 2 lists some of these services, many of which are essential to our society.

D. Community Benefits

While the RCRA Corrective Action Program's primary objective is the protection of human health and the environment, cleaning up and redeveloping contaminated sites also results in positive economic and social benefits for many communities. RCRA Corrective Action cleanups not only eliminate or reduce real and perceived health and environmental risks associated with hazardous waste sites, but they also reduce liabilities associated with reusing these contaminated sites. As a result, the program helps convert vacant and underutilized land into productive resources; reduces blight, uncertainty, and other negative perceptions; improves aesthetics and general well-being; and are likely to boost property values in communities surrounding facilities.

Table 2: Ecosystem Services Protected and Restored by RCRA Corrective Action Cleanups

Benefit Category	Examples
Goods and services for human consumption **(direct benefits)**	• Food (animals, plants) • Water (drinking, irrigation, industrial use) • Materials (fiber, timber, fur, leather) • Fuel (e.g., solar, wind, wood, biofuels) • Pollination of crops • Genetic and medicinal resources (e.g., biotechnology, animal and plant breeding, biochemicals, natural medicines, chemical models and tools)
Regulation and support of ecosystem processes **(indirect benefits)**	• Climate and atmospheric regulation (e.g., greenhouse gas sinks, oxygen production, air pollutant uptake) • Water regulation (e.g., groundwater replenishment, water filtration) • Storm protection (e.g., runoff, flood moderation, energy dissipation) • Control of human diseases, livestock diseases, and crop pests • Soil formation and retention (e.g., erosion control, soil fertilization) • Nutrient cycling • Pollination by wild birds and insects • Provision of habitat and maintenance of biodiversity (e.g., feeding and breeding ground for harvested and other species; maintenance of genetic resources, including protection of threatened, endangered and commercially important species)
Cultural services	• Recreational opportunities (e.g., fishing, hunting, viewing, hiking, swimming, boating) • Aesthetic values (e.g., quality of life) • Cultural, spiritual, and religious values • Preservation of resources for potential future use and for future generations

Redevelopment of RCRA Corrective Action sites can also function as a catalyst for additional development in areas near these sites. Both on-site and off-site development generates jobs, income, and tax revenue for local governments. Since many Corrective Action sites are in built up areas—66% are associated with census-defined urban areas—their redevelopment promotes the efficient use of local and regional infrastructure and contributes to Smart Growth objectives. By diverting development that might have otherwise gone to greenfield sites,[5] redevelopment generally results in reduced energy use, fewer emissions of greenhouse gases and other pollutants, and decreased stormwater runoff.

E. Relationship of RCRA Corrective Action to Other EPA Cleanup Programs

Since 1980, Congress has mandated that several programs be established to clean up contaminated land. Four main programs are listed below, together with: year of establishment, features that distinguish one program from another, and the current number of acres addressed by each program.

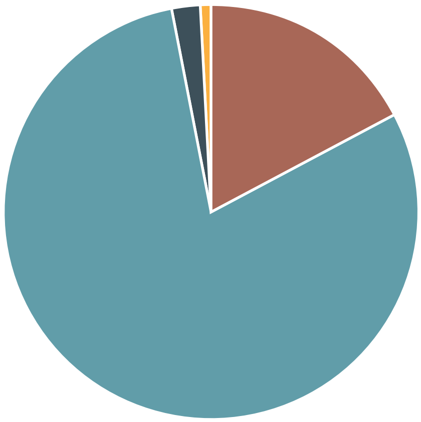
- **Superfund (1980):** sites that are abandoned, bankrupt, or have multiple responsible parties and uncontrolled releases of hazardous substances (3.9 million acres)
- **RCRA Corrective Action (1984):** sites with viable owners or operators that have treated, stored, or disposed of hazardous waste since 1980 and released hazardous constituents to the environment (18 million acres)
- **Underground Storage Tanks (1984):** leaking underground storage tanks (507,000 acres)
- **Brownfields (1998):** contaminated sites (Superfund, RCRA or other) restored to usable property with assistance from a Brownfields grant (164,000 acres)

The same hazardous constituents contaminate RCRA Corrective Action and Superfund sites, and cleanups result in similar benefits. Each program has a significant number of large, complex cleanups that will require many years to complete, and sites occasionally move between the two programs. While similarities exist, important distinctions also exist and are discussed below.

The **RCRA Corrective Action Program** addresses facilities with *viable owners or operators*, many of whom are still engaged in manufacturing or other

[5] In 2001, an EPA-sponsored study by the George Washington University titled "Public Policies and Private Decisions Affecting the Redevelopment of Brownfields: An Analysis of Critical Factors, Relative Weights, and Area Differentials," found that the redevelopment of one acre of contaminated land saves, on average, 4.5 acres of greenfields.

Figure 1: Acres Addressed per Cleanup Program



Typical Cleanup Process Steps

- √ Initial Facility Review
- √ Assessment, Investigation, Sampling
- √ Interim Actions to Eliminate Exposures
- √ Develop Remedy Options
- √ Public Engagement
- √ Remedy Decision and Construction
- √ Operation and Maintenance of Remedy Systems
- √ Sampling to Verify Cleanup Complete
- ○ Long-Term Stewardship—*Maintenance of Institutional and Engineering Controls Where Appropriate*

business operations at the site (e.g., 105 operating petroleum refineries that, together, process 90 percent of all oil refined in the U.S.). In all cases, even if the specific facility has closed, site *owners or operators are required to fund the cleanup* work and provide financial assurance to cover cleanup costs in case of bankruptcy. Regulators provide oversight and take enforcement actions where appropriate.

Operating facilities provide advantages in that they generally employ members of the local community, produce tax revenue for local governments, and have a vested interest in maintaining a safe and healthy work environment. They also have revenues which may be used to pay for cleanup work. Operating facilities provide challenges as well; committing money to cleanup may be difficult for financially-struggling facilities, and operations themselves can make areas of contamination difficult to access. Regulators play a vital role in ensuring the timely achievement of cleanup goals, but the financial capacity of site owners can also control the pace of cleanup work.

EPA *authorizes states* to implement the RCRA Corrective Action Program. To date, 42 authorized states and one territory lead implementation at their Corrective Action facilities, with assistance from EPA grants. EPA regional offices have work-sharing agreements with both authorized and unauthorized states, with whom they meet regularly to discuss sites and topic areas where states need regional help. See **Figure 3** for a list of authorized and unauthorized states.

The **Superfund Program** typically addresses *abandoned* hazardous waste sites (including sites of spills or illegal dumping) and sites where uncontrolled releases demand an immediate response. Superfund provides funding to clean up dangerous sites when no viable responsible party can be found, or when action is necessary before disputes over liability can be resolved. In such cases, the Superfund program seeks to recover costs after the fact from one or more responsible parties, if they can be identified. Generally, recovered funds do not cover the full cost, and cleanup actions are *partially taxpayer-funded*. Although states play a critical role, federal Superfund programs are *not delegated* to the states, and EPA regional offices oversee individual Superfund cleanups.

In creating the RCRA Corrective Action program, Congress provided a powerful tool to prevent current hazardous waste management facilities (i.e., RCRA facilities) from becoming future Superfund sites. RCRA compels facility owners and operators to take responsibility for hazardous waste contamination arising from their operations before costs can be externalized onto the public.

II. CORRECTIVE ACTION FACILITIES

A. Number of Sites

More than 6,000 facilities in the United States are potentially subject to RCRA Corrective Action. To more accurately reflect the program workload, EPA and the states established a list of 3,747 RCRA facilities—referred to as the **2020 Universe**—to include those that have been cleaned up; those that are being cleaned up; and those that were deemed, at the time, most likely to need a cleanup under the Corrective Action Program. The number of facilities may grow in the future as the program reassesses its workload and additional sites are investigated and, if necessary, cleaned up.

B. Facility Location and Size

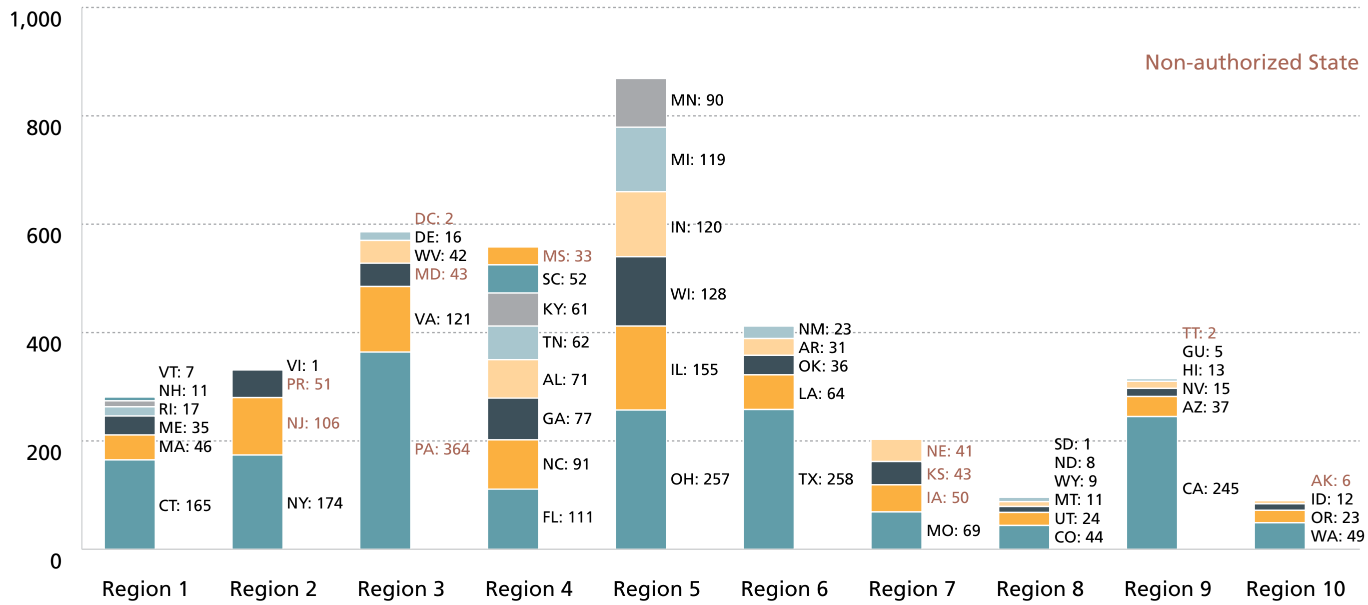
All 50 states, as well as Puerto Rico, the U.S. Virgin Islands, the District of Columbia, Guam, and the Pacific Trust Territories have at least one Corrective Action site. Pennsylvania, Texas, Ohio, and California have the largest numbers of sites, together accounting for 30% of the national total.

All together, facilities on the 2020 Universe cover 18 million acres, a landmass larger than the entire state of West Virginia. The median site covers 32 acres, but the average size (4,800 acres) is much larger due to 90 sites of 10,000 acres or more. Many of the largest sites are Department of Defense or Department of Energy facilities.

Figure 2: Location of RCRA Corrective Action 2020 Universe Sites

Although not shown, the 2020 Universe also includes 6 sites in Alaska, 13 in Hawaii, 51 in Puerto Rico, 1 in the U.S. Virgin Islands, 5 in Guam, and 2 in the Pacific Trust Territories.

Figure 3: RCRA Corrective Action 2020 Universe Sites by State and EPA Region



EPA has ten regional offices that work with authorized state governments to implement the RCRA Corrective Action Program. EPA Regions play a more prominent role in 8 states (NJ, MD, PA, MS, NE, KS, IA and AK) not authorized for RCRA Corrective Action, as well as the District of Columbia, Puerto Rico, and the Pacific Trust Territories.

C. Cleanup Progress

EPA has established three metrics, two of which are referred to as environmental indicators (EIs), to track cleanup progress at RCRA Corrective Action sites. See **Appendix B** for a more detailed analysis of progress toward cleanup goals.

Faced with thousands of sites, the program's priority has been to first eliminate or control exposures. At the majority of sites achieving the following interim milestones, additional work is necessary to permanently protect human health and the environment:

1. The **Human Exposures Under Control EI** ensures that people near a particular site are not being exposed to unacceptable levels of contaminants.
2. The **Groundwater Under Control EI** ensures that contaminated groundwater is not spreading and further contaminating groundwater or surface water resources.
3. **Final Remedy Construction** is achieved when the facility has completed construction of a final remedy, and that remedy is fully functional as designed. The remedy may need to operate for a period of time before cleanup goals are achieved.

By the end of **FY 2012**, out of 3,747 sites in the 2020 Universe, the program had:

- Met the Human Exposures EI at 3,041 sites (more than 81%), covering 13.6 million acres
- Met the Groundwater EI at 2,691 sites (more than 71%), covering 7.2 million acres
- Reached Final Remedy Construction at 1,762 sites (more than 47%), covering 2.1 million acres

D. The Long Road Ahead

The ambitious 2020 goals—to meet all three milestones at 95 percent of RCRA Corrective Action facilities by 2020—have accelerated the pace of cleanups. EPA and the states now work with a greater sense of purpose. Facilities with cleanup obligations now have a specific target. As we close in on 2020, however, the reality is that significant challenges will likely prevent the program from reaching some of its goals. The remaining facilities include the most complex and difficult sites, and resources are more limited. At the same time, we continue to find new sites that require cleanup.

Looking further into the future, the 2020 milestones themselves fulfill only part of the program's mission—a significant part of each site's journey toward final cleanup, but certainly not the "end of the road." Congress and the public expect that, ultimately, all past spills and contamination will be cleaned up, and all RCRA Corrective Action facilities will be safe.

To meet this expectation, facilities need to fully address—not just temporarily contain—threats. Once remedies are installed, they need to be operated and maintained to meet cleanup levels, which must then be verified. While the program has made significant progress to date, it has a long way to go to meet these collective expectations.

As we continue to push toward the 2020 goals, the program will look to set new aspirational goals in the future for completing cleanups and ensuring properties are safe for reuse. The specifics for these future goals have not yet been set, but future resource levels will largely determine what rate is possible, as confirmed by a 2011 GAO study.[6] On its mission to achieve *final* cleanup of *all* facilities, the RCRA Corrective Action Program still has a long road ahead.

[6] GAO, Early Goals Have Been Met in EPA's Corrective Action Program, but Resource and Technical Challenges Will Constrain Future Progress. July 2011. GAO-11-514.

III. CASE STUDIES

Congress created the RCRA Corrective Action Program to oversee cleanup of the following highlighted facilities and many others like them. With the authority to address past releases and require remediation beyond property boundaries—both evident in these case studies—the program can effectively address the wide array of contaminated sites resulting from our country's industrial legacy. The program specifically addresses sites with viable owners and operators, like U.S. Steel and others included here, who fund the cleanup work themselves. Because companies must balance cleanup obligations with business operations, RCRA Corrective Action cleanups often proceed along schedules similar to those presented here, with critical areas addressed first.

U.S. STEEL – GARY, INDIANA

100+ Years Industrial Use | 260,000 Pounds Contaminants Removed | 500 Jobs Created
$220 Million Reinvestment in Manufacturing | 300 Site Areas Still Need Remediation

At its 4,000-acre facility on the shores of Lake Michigan, U.S. Steel has produced steel and other metal products for more than 100 years, supporting industries as diverse as car manufacturing, building construction, and food and beverage packaging. The largest integrated steel mill in North America, and once the largest steel mill in the world, the Gary Works is also an active RCRA Corrective Action site. Bordered by shoreline to the north, the Indiana Dunes National Lakeshore to the east, and the Grand Calumet River to the south—with the community of Gary, Indiana, just beyond—the Gary Works ranks among the larger and more complex Corrective Action sites. Its story, however, resembles that of more than 3,000 ongoing Corrective Action cleanups.

A long history of industrial operations, much of which occurred prior to modern environmental practices, left a legacy of contamination; PCBs, heavy metals (e.g., lead), and organic contaminants (e.g., benzene) from site operations contaminated soils, groundwater, and sediments, both on and offsite.

View of the U.S. Steel facility.

Prior to investigation and remediation, contamination degraded the environment and spoiled the beneficial use of natural resources. Contaminated sediments, up to 20 feet deep, were largely responsible for degrading fish and wildlife populations, limiting the use of natural resources, and lowering property values along the river. Out of 43 Great Lakes Areas of Concern, the Grand Calumet River Area—this includes the Gary Works—is the only one considered "impaired" for all 14 potential beneficial uses, necessitating restrictions on drinking water consumption, fish and wildlife consumption, dredging activities, and use of beaches. Furthermore, the impacted area includes the rare oak savannah ecosystem and habitat for the federally endangered Karner Blue Butterfly.

Recent work has, however, characterized the site, blocked human exposure pathways, and installed remedial measures to check the spread of contaminants offsite. Corrective Action work started at the Gary Works with a 1998 Consent Order signed by U.S. Steel and EPA. Since that time, dredging operations along five miles of the Grand Calumet River have removed 228,000 pounds of contaminants, including more than 1,550 pounds of PCBs, and could raise the value of adjacent residences by an average of 27 percent; air sparging, stripping, and vapor extraction systems have removed an estimated 33,000 pounds of benzene from groundwater migrating toward the lake; EPA has teamed up with University of Waterloo researchers to rapidly characterize contaminant plumes at the shoreline via thermal imaging; slag piles have been pulled back along 1,350 feet of shoreline; more than 200 waste drums have been removed from lagoons at the Grand Calumet's headwaters; and a barrier wall now blocks seepage of additional contaminants into the lake.

Despite work completed thus far, much remains to be done to permanently address site contamination. Many of the 300 solid waste management units identified within the site still need remediation or containment. Even after systems are built, monitoring will be necessary to ensure they work, and long-term stewardship of certain areas will be necessary to ensure future land uses are appropriate.

Regulators have worked with both responsible parties and local communities to find cleanup solutions acceptable to stakeholders. Parties agreed to include a specific parcel among the high-priority areas targeted first, a decision that facilitated construction of a new carbon alloy production facility important to both U.S. steel and the local community. As a result, contaminated soil in the area was excavated and safely disposed of, and construction of the new, cleaner-running facility proceeded on schedule, creating 500 construction jobs and supporting a $220 million investment in the plant's continued operation. Meetings open to all members of the community serve as a forum to discuss major decisions like this. At the Gary Works, meetings have been held quarterly since 2001 and remain an important part of the community involvement strategy forged by U.S. Steel and site regulators.

Slag piles previously bordered the shoreline at Gary Works.

TRONOX – HENDERSON, NEVADA

Drinking Water Protected for 15 Million People | Perchlorate Science Advanced
$80 Million in Superfund Costs Prevented | Model for EPA-State Collaboration

Thirteen miles southeast of Las Vegas lies the Tronox Henderson facility, source of the nation's largest ever perchlorate release. Several owners have produced and handled perchlorate—an important component of rocket fuel and explosives—and other chemicals since site operations began in 1942 with the outbreak of World War II. Through 1988, all perchlorate used in the U.S. came from either the 450-acre Tronox site or a second facility also located in the Henderson area. In 1997, site investigations required by the RCRA Corrective Action Program discovered that perchlorate-contaminated groundwater was travelling three miles off-site, entering the Las Vegas Wash, and reaching Lake Mead and the Colorado River, affecting drinking water for 15 million people in Nevada, Arizona, and California.

A long history of industrial operations and unregulated waste disposal prior to RCRA left a legacy of contamination. The disposal of perchlorate-containing wastes in unlined ponds from the early 1940s to 1976 contaminated groundwater and, decades later, began to impact surface drinking water supplies. Groundwater at the site also contains chromium, and soils were left with perchlorate, chromium and other metals, dioxins, hexachlorobenzene and other SVOCs, PCBs, asbestos, and organochlorine pesticides above screening levels.

Measures were taken quickly to address the potential for major human health impacts, but significant cleanup work continues. Upon discovery of the perchlorate release in 1997, Tronox worked with both the Nevada Division of Environmental Protection (NDEP) and EPA to quickly set up a temporary water collection and ion exchange treatment system to intercept and treat perchlorate-impacted groundwater before it reached surface water supplies. After considerable research and development, a more advanced bioremediation treatment plant was installed in 2001; as of November 2012, nearly 3,600 tons of perchlorate had been removed from the environment. Concentrations entering the Las Vegas Wash have been reduced by 90 percent since 1997, and perchlorate levels are too low to measure in most samples of the plant's discharge water. More recently, cleanup efforts have shifted to safe management of contaminated soils on site, with 930,000 tons excavated to date, including 800,000 tons of dioxin-contaminated soil removed for proper disposal in 2011.

Tronox wastewater treatment system.

EPA partnered with a local university to promote research facilitating the cleanup of this and other perchlorate-contaminated sites across the country. An EPA STAR grant awarded to the University of Nevada, Las Vegas funded research from 1999 to 2003 that provided significant information to regulatory agencies, private firms, and decision makers interested in the remediation of perchlorate-contaminated sites. Researchers used the Tronox site as a laboratory to model the fate and transport of perchlorate in the environment and investigate the role of biological degradation and sorption processes. Results informed the advanced treatment system now in place at the Tronox site and are applicable to a number of RCRA Corrective Action and Superfund sites with perchlorate contamination.

Nearby waters of Lake Mead.

The site would likely have become a Superfund site without the involvement of the RCRA Corrective Action Program. Tronox LLC filed for bankruptcy in February 2009. Without NDEP oversight in the mid-1990s, the perchlorate contamination may have gone undetected longer than was the case, and the environmental response it set in motion would not have been as far along by 2009. Without the site characterization and cleanup work already completed under RCRA Corrective Action authorities, the state of Nevada and EPA may not have been able to secure the $81 million and other assets it received as part of the bankruptcy settlement. Those assets are now managed under the Nevada Environmental Response Trust (NERT) established in 2011 to oversee the continued operation and maintenance of the perchlorate treatment system and remaining cleanup work at the site.

Through effective collaboration, EPA and the state of Nevada have maintained productive use of the property as cleanup has occurred. Under the bankruptcy settlement, Tronox no longer owns the site. The company leases back a portion from the NERT, however, for the production of manganese dioxide (used for advanced battery materials) and specialty boron products (used in the pharmaceutical, semiconductor, high-performance fiber, ceramic, defense, pyrotechnic, and automotive airbag industries). In 2010, the Tronox Henderson facility reported more than $7 million in payroll and benefits, $327,000 paid in state use and property taxes, and $49 million spent on goods and services.

LOS ALAMOS NATIONAL LABORATORY – LOS ALAMOS, NEW MEXICO

28,000 Acres & 2,100 Potential Release Sites I Organic, Heavy Metal & Radioactive Wastes
Fractured Geology I Restricted Access I $1.7 Billion Cleanup I 1 of 200 Federal Facilities

The Pajarito Plateau in north central New Mexico consists of a series of flat, finger-like mesas separated by deep canyons with perennial and intermittent streams. On 28,000 acres of this landscape, 25 miles northwest of Santa Fe, the U.S. Department of Energy (DOE) operates a national security research lab with intertwined legacies of scientific achievement and environmental contamination.

The Los Alamos National Laboratory (LANL) was established in 1943 as part of the Manhattan Project for the purpose of designing and fabricating the first atomic bombs. The Lab continued to serve as a key center for nuclear weapons research throughout the Cold War but has since branched out to apply multiple disciplines to threats as diverse as nuclear proliferation, the spread of deadly diseases, inadequate energy supplies, and the effects of climate change.

Aerial view of the site. *Photo courtesy of Los Alamos National Laboratory.*

Current operations involving hazardous substances are stringently controlled, but decades of unregulated waste disposal caused extensive contamination. Prior to RCRA, excess chemicals, contaminated materials and equipment from nuclear research activities were routinely buried in unlined pits and landfills or dumped into deep shafts. Liquids containing plutonium, uranium, and other radioactive isotopes; lead, mercury, barium, and other metals; RDX, TNT, perchlorate and other explosive compounds; as well as PCBs, asbestos, and organic contaminants were discharged into trenches, unlined lagoons, and outfalls to streams in nearby canyons. Together, these activities created what is now an enormously complex RCRA Corrective Action site. The region's volcanic strata, full of faults and fractures, further complicate the task of assessing and protecting groundwater resources.

Significant progress has been made in characterizing, prioritizing, and beginning cleanup activities, but work is far from finished. Restoration efforts began in earnest in 1989, and 2,100 independent areas were identified where potential releases required, at a minimum, further investigation. Areas included former chemical storage locations, wastewater outfalls, septic tanks and lines, spill sites, firing ranges, transformers, and 26 Material Disposal Areas spread over 43 square miles. An extensive groundwater monitoring network has been installed and continues to be expanded. Data from monitoring wells guide cleanup decisions and ensure that groundwater contamination—present in the shallow alluvial, perched intermediate and deep regional aquifers—does not reach water supply wells and surface drinking water resources for Los Alamos County, Santa Fe County, and San Ildefonso Pueblo. An ecological risk framework has been established to ensure cleanup decisions adequately protect plants and animals, including the endangered Mexican Spotted Owl, from specific pollutants of concern. To date, more than 40 percent of the original 2,100 potential release sites have been cleaned up, investigated and determined not to need additional work, or consolidated with similar sites.

Several decades ago, the facility moved operations across Los Alamos Canyon, and the town of Los Alamos developed and grew from the original location. A significant amount of work to date has focused on the investigation, and any necessary cleanup, of "township" potential release areas now located on private property, as well as the 26 large Material Disposal Areas within the facility boundary. After forest fires threatened Los Alamos in 2011, the State realigned cleanup priorities to safely remove above-ground transuranic waste as rapidly as possible.

Equipment operates on steep canyon. *Photo courtesy of Los Alamos National Laboratory.*

Challenges presented by this site are indicative of those posed by a number of large federal facilities being cleaned up under the RCRA Corrective Action Program. LANL is one of 200 federal facilities undergoing RCRA Corrective Action, most of which are owned and operated by either the Department of Defense or DOE. These 200 facilities represent 5.3 percent of all facilities on the program's baseline, but they account for 75 percent of the total acreage, with many closely resembling Superfund megasites. The sheer size and complexity of these facilities present unique challenges, as does arranging for access to national security sites, and dedicated teams are often necessary to provide effective oversight of site assessment and cleanup operations that can span several decades. At LANL, a New Mexico Environment Department (NMED) team leads the oversight, DOE performs the cleanup work, and EPA provides staff and contractor support to both. DOE estimates that the total life cycle cost for soil and water remediation at LANL will exceed $1.7 billion.

The high degree of public interest in this complex cleanup means that a significant amount of time and resources are necessary to ensure the opportunity for adequate public participation. Multiple active, knowledgeable, and vocal citizen groups are engaged in the LANL cleanup process. The large number of New Mexico residents with a stake in the cleanup, combined with the site's complex nature, means that NMED spends a significant amount of time and resources to fully understand and address their concerns. During the facility's last RCRA permit renewal in 2010, the state allowed 240 days for public comments on the proposed permit; held 35 meetings with DOE and interested parties, in addition to 17 days for a public hearing, to resolve issues; and held seven two-hour listening sessions in different cities to better understand residents' perceptions and concerns.

DUPONT – POMPTON LAKES, NEW JERSEY

540 Homes Potentially Affected | More than 200,000 Tons Contaminated Soil & Sediments Removed More than 285 Vapor Mitigation Systems Installed | Vapor Intrusion Science Advanced

From 1886 to 1994, DuPont and previous owners of the Pompton Lakes Works manufactured explosives on a 578-acre site in northern New Jersey. Owned by DuPont since 1902, the facility produced large quantities of gunpowder, grenades, detonators, and blasting caps used in both World Wars. These operations generated hazardous wastes, and poor waste management typical of the times released toxic chemicals into site soils and local streams.

A century of manufacturing, and related waste management activities, contaminated both the site and surrounding community. Explosives production at Pompton Lakes relied heavily on mercury and lead powders, as well as solvents to degrease metal parts and equipment. As a result, the plant generated significant amounts of wastes containing mercury, lead, copper, and the chlorinated solvents trichloroethylene (TCE) and tetrachloroethylene (PCE). A 1988 New Jersey Department of Environmental Protection (NJDEP) Corrective Action order compelled DuPont to investigate releases of these wastes, and the company identified more than 200 areas of concern. Investigations revealed that, over time, mercury- and lead-contaminated sediment travelled off-site via a perennial stream called Acid Brook. The stream passed homeowners' backyards on its way to Pompton Lake. Ultimately, the brook, 140 homes, and the lake would need cleanup. During this same time period, groundwater contaminated with TCE and PCE migrated off-site underneath a different set of more than 400 homes. TCE and PCE present a risk to human health when they vaporize from groundwater and seep into homes through cracks in foundations, contaminating indoor air. Known as "vapor intrusion," this pathway is most pronounced during wintertime, when buildings are tightly sealed and heating systems are on.

Cleanup activities addressing soil, sediment, and groundwater contamination have reduced the potential for human exposures. To protect residents from mercury and lead, soil and sediment was removed from 1991 through 1997—both in Acid Brook and at and around homes in the floodplain. In total, more than 200,000 tons of contaminated soil and sediment were removed (including a smaller, ongoing cleanup along the nearby Wanaque River) and 10 acres of wetlands replanted. In addition to reducing human health risks, these early actions eliminated the source of contaminants flowing into the Acid Brook Delta and Pompton Lake. Excavation, protective caps and other interim measures, meanwhile, prevent site soils from re-contaminating the brook. A pump-and-treat system installed near the southern site boundary in 1998 removes contaminants from groundwater and prevents further spread of TCE and PCE off-site. Since discovery of the vapor intrusion problem, DuPont has also mapped the entire groundwater plume, and more than 285 homes have had vapor mitigation systems installed. These minimally intrusive, low-cost systems vent the air beneath homes over the groundwater plume, keeping contaminants out of indoor air in the process.


View of Acid Brook after remediation.

The story of vapor intrusion at Pompton Lakes highlights the unpredictable nature of hazardous waste sites and the challenges this presents for affected communities. As site regulators focused on preventing exposures to contaminated soils and sediments during the early 1990s, the science of vapor intrusion was evolving and not fully understood. Early actions ensured that homes over contaminated groundwater gained, or already had, access to municipal water supplies instead of relying on potentially contaminated private wells. More than fifteen years would pass, however, before it was better understood that certain characteristics, all present at Pompton Lakes, allowed for the transfer of contaminants from groundwater to indoor air. Specifically, the presence of volatile contaminants, shallow groundwater, older homes, and cold winters that lead residents to tightly seal houses all contribute to potential threats from vapor intrusion. Although a 2009 study by the New Jersey

Department of Health and the Agency for Toxic Substances and Disease Registry (ATSDR) could not make conclusions about past exposures, local residents and officials have expressed concerns about a perceived excess of unexplained illness in the community, and the Agencies did conclude that current and future exposures due to vapor intrusion may harm the health of Pompton Lakes residents without vapor mitigation systems.


Home vapor mitigation system inspection.

In response to community concerns, EPA has expanded its role in recent years to accelerate final cleanup. As off-site vapor intrusion problems became apparent, and the focus in Pompton Lakes shifted back to immediate human health risks, EPA joined NJDEP as a co-lead for the site. Jointly managing efforts to remediate groundwater and reduce vapor intrusion exposures, EPA and NJDEP officials held public meetings and went door-to-door to encourage residents to install vapor mitigation systems. The Agencies worked with DuPont to let residents hire independent contractors—at DuPont's expense—for installation and/or additional vapor intrusion sampling. Taking the lead for off-site soil and sediment investigations, EPA recently proposed a permit modification to require DuPont to remove 68,000 cubic yards of sediment from the Acid Brook Delta in Pompton Lake and 7,800 cubic yards of soil from the uplands of the Acid Brook Delta. The cleanup will reduce the potential for mercury in sediments to methylate and enter the food chain. EPA conducted an unannounced inspection of the Pompton Lakes Works in May 2011 to verify the integrity of on-site remedial measures, and NJDEP has conducted periodic split-sampling at groundwater monitoring events with DuPont. EPA has also made technical support available to the community through the Technical Assistance Services for Communities (TASC) program, allowing for an independent, third-party review of groundwater monitoring data.

OPERATING PETROLEUM REFINERIES – 105 SITES IN 33 STATES

90 Percent of Domestic Refining Occurs at RCRA Corrective Action Sites | 16.5 Million Barrels per Day

The RCRA Corrective Action Program protects human health and the environment at active industrial facilities where, in many instances, current operations will continue indefinitely. As demonstrated by the following look at our nation's oil refineries, Corrective Action cleanups can stop human exposures and environmental degradation from past releases without interrupting current operations:


View of an active oil refinery.

The U.S. Energy Information Administration (EIA) tracks oil refineries across the United States, and as of July 2012, EIA reported that 142 refineries in 33 states and the U.S. Virgin Islands provide a domestic operating capacity of 18.2 million barrels of oil per day. These sites represent an integral part of the nation's economy and employ many thousands of Americans. Historical waste management practices, however, combined with spills and leaks from underground pipes and tank bottoms, have in many cases led crude oil, gasoline, and other petroleum hydrocarbons such as benzene and xylenes to accumulate in soils and groundwater beneath refineries. Left unchecked, contaminant plumes can migrate toward drinking water wells, into rivers and lakes, or beneath residences, in which case contaminants may volatilize and enter indoor air (a pathway known as vapor intrusion).

Through its direct involvement at 105 of the 142 active refineries—representing more than 90 percent of our domestic refining capacity—the Corrective Action Program works to protect the health of site workers and nearby residents, as well as groundwater resources. As of January 2013, human exposures had been controlled at more than 92 percent, and the migration of contaminated groundwater had been controlled at more than 83 percent, of all operating refineries in the program's 2020 Universe. Only 29 percent of these facilities have final remedies in place, however, and much work remains.

Refineries not involved with the Corrective Action Program are predominantly newer facilities built with more effective controls, but the broader RCRA program regulates these facilities, often as hazardous waste generators. EPA and its state partners can require corrective action cleanups if necessary, as they have done at the operating Frontier Refinery in El Dorado, Kansas. The facility never had a permit to treat, store, or dispose of hazardous waste (the most common reason facilities are subject to Corrective Action), but EPA Region 7 specifically added the facility to its 2020 Universe in 2009 amid growing state and community concerns about soil and groundwater contamination.

The Corrective Action Program also oversees cleanups at a number of closed oil refineries, including the former Texaco refinery in Casper, Wyoming, where Chevron now operates a 16.5 megawatt wind farm as cleanup of underlying groundwater nears completion.

Sources: (1) U.S. Energy Information Administration, Ranking of U.S. Refineries, accessed January 2013. http://www.eia.gov/neic/rankings/refineries.htm
(2) RCRAInfo Database, accessed January 2013.

BP EXPLORATION ALASKA – PRUDHOE BAY, ALASKA

3 Month Work Season | 1,854 Areas of Suspected Contamination | 240,000 Acres of Tundra

Two hundred and fifty miles north of the Arctic Circle, on 240,000 acres of tundra, the BP Exploration Alaska (BPXA) Prudhoe Bay facility ranks as the largest oil field in North America. During 35 years of extensive oil and gas production—amidst grizzly bears, caribou, and 80 species of migratory birds—this facility and its rotating crew of up to 5000 employees have produced more than 10 billion barrels of oil for refineries in Alaska, Washington, California, and Hawaii. In a land where temperatures sit below freezing from September to June, where all roads must be five feet thick and building pads must be carefully constructed to avoid melting the permafrost (and causing sinkholes), BPXA represents one of the most geographically distinct and uniquely challenging RCRA Corrective Action sites.

Grizzly bear takes stroll near monitoring well.

Similar to petroleum refineries undergoing corrective action, releases and spills of various oil field products have occurred due to historic and ongoing operations. Sampling has detected benzene, toluene, trichloroethylene (TCE), methylene chloride, chromium, lead, mercury and other contaminants at levels that threaten human health and this fragile ecosystem. Crude oil, diesel fuel, natural gas liquids, methanol, spent acids, biocides, and hydraulic fluids continue to leak into surface soils and gravels. Blocked by frozen soil at shallow depths, contaminants move into surface waters used by both site workers and local fauna, including two salmon species (pink and chum) important to commercial and subsistence fisheries. Both species spawn in the Sagavanirktok River, which cuts across the facility.

Cleanup efforts to date have focused on areas of known contamination and include the excavation, treatment, capping, or reconstruction of close to 100 pits, impoundments, and landfills built in past decades to contain or bury drilling muds, excess well fluids, incinerator ash, and oily wastes. BP has also installed a runoff collection and water treatment system, and piloted the use of nano-scale zero valent iron, to remediate an area contaminated with chlorinated solvents; workers had routinely used one building with a bare-ground floor to degrease equipment with solvents through the early 1980s.

Despite challenges posed by the remote location, short working season, and large facility size, EPA continues to work closely with BP and the State of Alaska to make cleanup progress at Prudhoe Bay, mindful of both continuing oil and gas operations and the fragile arctic ecosystem. Including the specific areas discussed above, BP is proceeding under the terms of a sitewide EPA order issued in 2007 to investigate and, as necessary, remediate 1,854 areas with known or suspected contamination.

ROMIC – EAST PALO ALTO, CALIFORNIA

12.6-Acres | 7 Million Gallons of Waste Processed per Year at Peak | $2.5 Million Minimum Cleanup Cost

From the mid-1950s through 2007, Romic Environmental Technologies and its predecessors operated a hazardous waste treatment and storage facility in the multi-ethnic, environmental justice community of East Palo Alto, California. A half century of handling hazardous wastes from the chemical, paint, semiconductor, electronics, pharmaceutical, and other industries left the site heavily contaminated with volatile organic compounds (VOCs) such as trichloroethylene (TCE) and tetrachloroethylene (PCE), most notably in the form of a groundwater plume extending 80 feet underground. The plume flows directly toward an adjacent wildlife marsh and San Francisco Bay.

Though small for a RCRA Corrective Action site, this 12.6-acre facility has considerable contamination. For decades, the facility continually moved hazardous substances in and around various operation areas, processing seven million gallons of waste materials per year at its peak. Spills, tank overflows, pipe breaks, and flooding events—including a March 1973 levee break that sent 20,000 gallons of liquid wastes per day into the bay—left their mark. Risks due to the large waste volumes handled at Romic are magnified by the facility's proximity to a dense population center and vital estuary habitat.

View of intertidal marsh along San Francisco Bay.

EPA officials have worked closely with state agencies, the City of East Palo Alto, and active community groups to guide the cleanup and foster future redevelopment of the site. After successful pilot projects showed up to 99 percent reductions in VOC concentrations using enhanced biological treatment (EBT), EPA selected the technology in 2008 as the cornerstone of a remedy addressing soil and groundwater contamination at the site. By injecting a fine-tuned mixture of cheese whey, molasses, and fresh water into contaminated soil and groundwater, EBT enhances the natural breakdown of chlorinated solvents. Compared to the continued pumping and treatment of contaminated groundwater, EBT will meet cleanup goals 90 percent faster and require substantially less energy, preventing an estimated 8,500 tons of carbon dioxide emissions over the life of the project. The remedy also requires a sitewide subsurface investigation after removal of all concrete structures, as well as a requirement for emission mitigation of all diesel powered equipment used during the cleanup.

All aboveground structures have now been demolished and removed, and the site-wide subsurface investigation was completed in 2012. Full remedy implementation will begin in 2014. The successful pilot project has been expanded to include a system of injection wells along the facility boundary that intercepts and treats contaminated groundwater, limiting the migration of contaminants toward San Francisco Bay. EPA oversees quarterly injections of new cheese whey and molasses and evaluates the effectiveness of treatment regularly. Should Romic default on its cleanup obligation, EPA would complete the cleanup using $2.5 million the Agency previously required Romic to set aside as financial assurance. EPA has already received several inquiries about redeveloping the property.

EXIDE TECHNOLOGIES – READING, PENNSYLVANIA

Extensive Lead Contamination | 200 Residential Yards Excavated | Cleanup Undeterred by Bankruptcy

The Exide Technologies site occupies 50 acres of land northeast of Reading, Pennsylvania, but decades of lead smelting—which began with previous owners manufacturing batteries in the mid-1930s—have contaminated soils over a much broader area. Exide took over in 1987 with its purchase of General Battery Corp. Off-site sampling in the 1990s revealed what 35 years of smelting prior to the Clean Air Act, and the resulting installation of air pollution controls, had left behind. Sampling detected soil lead levels as high as 10,000 parts per million (ppm) in residential yards adjacent to the facility, and communities within a mile radius were adversely impacted, prompting a quick RCRA Corrective Action Order from EPA.

Heavy equipment removes lead tainted dirt from nearby park. *Photo courtesy of Reading Eagle.*

For more than a decade, EPA, the State of Pennsylvania, and the Agency for Toxic Substances and Disease Registry (ATSDR) have worked with Exide and local residents on this $20 million cleanup. Under EPA supervision, Exide collected over 12,000 soil samples to map the deposition zone and tested for lead and other metals at 600 properties. Yards at more than 200 homes, all those with lead concentrations above the 650 ppm cleanup level, have been dug up and replaced with clean soil. At EPA's direction, properties with soil lead levels above 1,200 ppm, and those with children age six and under—the population group most sensitive to lead's toxic effects—were cleaned up first. A nearby 40-acre park, closed since 1996 due to lead concerns, will re-open in 2013 now that soil cleanup and other park improvements, negotiated with Exide and the city, are complete.

The potential for unacceptable human health risks, particularly to young children, guides all cleanup decisions at the Exide site. Given the presence of lead in drinking water, ambient air, and lead paint in addition to soil—which can be ingested directly or tracked into homes and inhaled as dust particles—the agencies applied EPA's Integrated Exposure Uptake Biokinetic (IEUBK) Model to predict the risk of elevated blood lead (PbB) levels in children under the age of seven. By measuring environmental lead sources such as lead in soil, tap water, and paint at local homes, and accounting for ambient air concentrations, the model assured EPA that a cleanup level of 650 ppm lead in soils would ensure the long-term protection of children and other residents in the Reading area, in light of accumulated exposures from other environmental lead sources. Throughout the process, Exide has paid for independent blood lead testing for local residents.

Financial struggles, both before and after Exide filed for bankruptcy in 2002, threatened to slow the pace of cleanup work at this site. The Corrective Action Program's focus on cleanup goals, however, and its attention to community concerns ensured that progress continued amidst difficult circumstances. EPA chaired a series of public meetings to explain the ongoing investigation and cleanup work, and the Agency worked through the bankruptcy court to ensure residential cleanups continued during the two-year bankruptcy. Exide has continued to fund the cleanup throughout the last decade, and as work nears completion, the facility continues to operate—in compliance with state air permits—and employ more than 140 people.

WALTER COKE – BIRMINGHAM, ALABAMA

Up to 1,000 Homes Affected | Environmental Justice Concerns | Cross-Program EPA Response

In historically industrialized North Birmingham, Alabama, the 400-acre Walter Coke plant ranks as one of the oldest remaining facilities, with industrial activity dating to the 1880s. Formerly known as Sloss Industries, Walter Coke operates three coke oven batteries here, where coal is baked at more than 1000 degrees Celsius—four to five times hotter than a household oven—to produce pure carbon (coke) for use in iron and steel manufacturing.

Soil sampling outside a Birmingham home.

In addition to contaminating the facility grounds, 125 years of coke production have potentially contaminated off-site areas in three environmental justice communities surrounding the site. Elevated levels of both arsenic and polycyclic aromatic hydrocarbons (PAHs), known constituents of coke oven emissions, are present in soils and surface waters. The RCRA Corrective Action investigation at Walter Coke uncovered a larger off-site contamination problem now addressed by EPA's North Birmingham Environmental Collaboration Project involving the RCRA, Superfund, Air, Water, and Enforcement programs.

A Corrective Action order, issued by EPA in 1989, compelled the company to investigate its site and assess the extent of contamination resulting from its operations. Investigations have since identified more than 50 areas where hazardous waste activities occurred in the past, or contamination is otherwise known to exist. On-site work continues today, but interim measures addressed the most critical areas early on, and growing concerns about potential off-site risks led the Agency to shift its focus beyond the facility boundaries. After a series of negotiations, EPA-directed sampling in 2005 detected elevated levels of both arsenic and PAHs, including benzo(a)pyrene, in soils from the Harriman Park, Collegeville, and Fairmont neighborhoods. The site received significant attention from local media, elected officials, and community groups, all of whom expressed concerns and hopes for a swift solution.

From 2009 to 2011, EPA, in partnership with Walter Coke and the Alabama Department of Environmental Management, supervised soil cleanups at more than 20 properties (including 16 homes and 2 schools) and expanded the off-site Corrective Action investigation. The results, when paired with air modeling data, led EPA to suspect an additional 850 to 1,000 homes might also be impacted. EPA is now using its Superfund authorities to assess nearby communities. The agency began this assessment by seeking access to residential properties in October 2012, and sampling started in November 2012. Corrective Action now focuses primarily on the site itself, and progress will continue for years under both programs.

EPA meets with the local community.

To match the high degree of public interest, EPA officials have dedicated significant time and resources toward informing and engaging the North Birmingham community. The Agency holds one-on-one information sessions with homeowners, leads community-wide events to discuss sampling results and explain decisions, and maintains a webpage exclusively for community outreach related to the cleanup.

PFIZER – NORTH HAVEN, CONNECTICUT

Innovative DNAPL Remediation | 60 Acres of Wetlands & Meadows to be Restored

When Pfizer acquired the Pharmacia Corporation in 2003, it also took over the ongoing investigation and cleanup of 78 acres on the banks of the Quinnipiac River in central Connecticut. Pfizer has never operated here, but from the mid-1800s through 1993, four prior owners produced dyes and pigments, photographic chemicals, additives for perfumes and cosmetics, herbicides, and pharmaceuticals. Over many years, several hundred thousand cubic yards of wastewater treatment residuals accumulated in unlined lagoons and waste piles. Including these materials, historic spills and disposal practices contaminated 1.3 million cubic yards of soil with lead, PCBs, and multiple chlorinated VOCs and SVOCs. The same hazardous chemicals polluted both groundwater and sediments in nearby tidal flats.

North Haven residents tour different parts of the property. *Photo courtesy of http://www.upjohnnorthhaven.com.*

The remediation of dense non-aqueous phase liquids (DNAPL) represents one of the most challenging tasks at Pfizer, and at many other RCRA Corrective Action sites. Often found as mixtures of chlorinated organic compounds—1,2 Dichlorobenzene is the predominant compound at Pfizer—DNAPLs are more dense than water and sink to the bottom of aquifers. Difficult to locate and extract, DNAPL pools can slowly re-dissolve and re-contaminate aquifers even after the treatment of overlying groundwater.

Close coordination between EPA, the State, and Pfizer prevented the ownership change from jeopardizing ongoing measures that control human and ecological exposures. Pfizer continued to provide site security, maintain covers over contaminated soils, and operate a state-of-the-art groundwater extraction and treatment system, all while working to complete the sitewide investigation, ecological risk assessment, and evaluation of remedy options. All parties agreed on a final remedy in the fall of 2010 and signed a negotiated consent order in March 2011. The $140-150 million final cleanup will include hydraulic containment walls, in-situ thermal remediation for DNAPL, continued groundwater extraction and treatment, the removal and safe disposal of impacted soils and sediments, and extensive wetland restoration activities. Construction began in 2012, and final remedy construction is expected in 2019. When complete, 17 acres on the west side of the property will be available for commercial or light industrial use, and more than 60 acres of tidal marsh, wetland, and upland meadow will be restored on the east side as an ecological preserve.

EPA and Pfizer co-lead a highly effective stakeholder engagement process with community representatives and environmental groups. Joint efforts with the Quinnipiac River Watershed Association, North Haven Land Trust, Regional Growth Partnership, North Haven Trail Association, and multiple town boards and commissions established key objectives for the cleanup and reuse of the property. Pfizer continues to hold open houses at the site, providing the public an opportunity to see cleanup progress and better understand the property's characteristics and layout.

BOEING PLANT 2 – SEATTLE, WASHINGTON

PCB Contamination of Tribal Fishing & Gathering Areas I Green Remediation Pilot Project

Historic Boeing aircraft.

Often referred to as the "Building that won World War II," Boeing Plant 2 produced the majority of B-17, C-47, B-29, and B-52 airplanes manufactured prior to the 1960s. Related manufacturing continued through the early 1990s, with more recent operations shifting to research and administration. Located on 107 acres in Seattle and Tukwila, Washington, the facility lies in close proximity to two environmental justice communities and sits on the Lower Duwamish Waterway, the customary fishing and gathering area for several American Indian Tribes.

Widespread contamination has been associated with the site, including PCBs, PAHs, phthalates, and other SVOCs in site soils and nearby waterways, as well as trichloroethylene (TCE) in groundwater. The sediments near Plant 2 represent the largest volume of high-concentration PCBs in the Lower Duwamish Watershed, and the site has received significant media attention. The 2009 PBS Frontline Special "Poisoned Waters" highlighted the site while addressing PCB contamination in Puget Sound.

Working with EPA to address high risk areas in advance of final cleanup, Boeing has removed nearly a mile of PCB-contaminated caulk from aircraft runways and other pavement, cleaned storm drains to reduce metal and PCB levels, and embraced green remediation technologies to treat contaminated groundwater. Five highly successful pilot projects have reduced groundwater contaminant concentrations by 98% through the injection of a natural sugar substrate; experience with this emerging and energy-saving remediation technique (known as Enhanced Reductive Dechlorination) may also be applicable to other sites struggling with chlorinated solvents in groundwater. EPA and Boeing recently agreed on a final cleanup remedy that, beginning in late 2012, will remove and safely dispose of approximately 200,000 cubic yards of contaminated sediments over three working seasons. In total, the action will replace 15 acres of river bottom with clean fill at a projected cost of more than $50 million.

In EPA's Region 10, many cleanup sites are located either within tribal reservation lands or within the "usual and accustomed fishing areas" established by treaties between the U.S. government and tribes. Contaminants in sediments and surface water may contaminate fish and shellfish—both directly and through their food chain—in these areas, and it is important for the Agency to conduct risk assessments that are respectful of tribal sovereignty and culture in terms of both the amount and types of seafood consumed, as well as where the seafood is obtained. EPA and Boeing have worked to engage affected tribes throughout the cleanup process, and the contaminant cleanup levels set for the site reflect this commitment; all included consideration of tribal fish and shellfish consumption habits. As the cleanup moves forward, quarterly Duwamish-wide community involvement meetings continue to be held between project managers and local stakeholders.

Local shellfish warning sign.

DENVER FEDERAL CENTER – LAKEWOOD, COLORADO

Phased Cleanup & Redevelopment | 2,000 Jobs Created | New Light-Rail Station | 8 MW Solar Park

Aerial view of solar power arrays. *Photo courtesy of GSA.*

Since 1941, government agencies have used the Denver Federal Center (DFC) for purposes as diverse as ammunition manufacturing, pesticide testing, wastewater treatment, and the disposal of construction, demolition, and laboratory wastes. The 623-acre campus now houses more than 25 federal agencies within 55 permanent buildings. Three groundwater contaminant plumes lie beneath the site, however, and all three affect off-site properties. Surrounded by the close in suburb of Lakewood, Colorado, just minutes from downtown Denver, the site's location creates both high potential for human exposures and excellent redevelopment opportunities. Together, these two factors determine the approach taken by site regulators, which has served as a model for EPA coordination with federal and state agencies, contractors, and other private parties interested in cleanup and redevelopment.

The size, complicated historical use, and underlying geology at DFC have made investigation and remediation of potential hazardous waste areas very complex. Trichloroethylene (TCE) and other recalcitrant chlorinated compounds present in groundwater migrate through fractured bedrock at DFC, making it more difficult to map plumes, predict movement, and identify contaminant sources than would otherwise be the case. Since the State negotiated a RCRA Corrective Action order with the General Services Administration (the facility landlord) in 1997, however, $30.8 million has been spent on investigation, and approximately $30.9 million on remediation. An underground permeable reactive barrier, which treats contaminated groundwater as it moves off-site, and other interim measures now block all human exposure pathways and contain the migration of contaminated groundwater.

With exposure pathways blocked and groundwater stabilized, redevelopment interest has guided decisions about where to implement final remedies first. Through an effective federal-state partnership with the Colorado Department of Public Health and Environment, required cleanup activities have been completed in a timely manner, facilitating the safe redevelopment of specific properties on the site. The new St. Anthony Hospital and Medical Campus, built on 50 acres near the site's western boundary, opened in June 2011. Bringing more than 2,000 jobs, the medical campus is now the third largest employer in Lakewood. Just north of the hospital, a new light-rail station and park-and-ride facility are under construction, with associated commercial and residential properties. Part of the larger West Rail Line project that will connect Denver to its western suburbs, the "Federal Center Station" is set to open with ten other stations opening in April 2013. Additional redevelopment projects include the construction of a new Department of State building, the clearance of land for a city park, and the construction of an 8 megawatt solar park whose photovoltaic arrays now produce electricity for DFC operations.

Looking forward, the next portion of the site to be addressed includes several large landfills. Final corrective measures have been selected, and implementation of these multimillion dollar remedies will occur over the next five years.

VOLUNTEER ARMY AMMUNITION PLANT – CHATTANOOGA, TENNESSEE

Vacant for 20 Years Prior to Corrective Action I Remedy Constructed 2010 I 13,000+ Jobs Created

Built by the U.S. Army Corps of Engineers to support the World War II effort, the Volunteer Army Ammunition Plant (VOAAP) in Chattanooga, Tennessee, produced and stored 2.8 billion pounds of trinitrotoluene (TNT) between 1941 and 1977. Although the Army leased a portion of the site through 1986 for commercial production of ammonium nitrate fertilizer and related products, most of the site sat idle for three decades despite its location nine miles from Chattanooga's central business district. Spurred by a RCRA Corrective Action order in 2001, however, cleanup led to redevelopment that has transformed the vacant, overgrown complex into a thriving economic and recreational resource.

Aerial view of new Volkswagen Plant. *Photo courtesy of Volkswagen Chattanooga*.

The site's size, its mixed use, complex hydrogeology, and years of inactivity made remediating VOAAP a challenge when the site first came to the Corrective Action Program's attention in the 1990s. Contamination centered in the 800-acre TNT Manufacturing Valley, with its 16 TNT batch lines and associated nitric acid and sulfuric acid production areas, but the site also included asbestos landfills, a two-mile long toluene pipeline connecting the facility to the Tennessee River, and other areas with soil, groundwater, and sediments contaminated by TNT, arsenic, PCBs, PAHs, and nitrates/nitrites. Extensive over-growth, due to decades of inactivity, had made large swaths of the 7,350-acre site virtually inaccessible by 2001, and the highly-faulted karst bedrock—topped by impermeable clays ranging from 10 to 105 feet thick—complicated efforts to characterize groundwater contamination.

Through effective collaboration, however, the EPA, Army, and Tennessee Department of Conservation, with the help of local government and partners in private industry, overcame these challenges to successfully remediate the site. By 2005, more than two thirds of the plant was ready to be transferred or made available for redevelopment. When the entire site reached final remedy construction in 2010, the Army transferred 3,000 acres to the City of Chattanooga and Hamilton County for commercial reuse, and another 2,800 acres were set aside as a Nature Park for hiking, biking, wildlife management, and historic preservation. The Tennessee Department of Transportation, Army Reserve, and Hamilton County Department of Education have also built new facilities at the site.

VOAAP represents a dramatic success for the RCRA Corrective Action Program in terms of cleanup resulting in revitalization, commercial reuse, and economic development. In 2009, Volkswagen USA constructed a $1 billion, LEED Platinum auto assembly plant on 500 acres, creating 2,000 direct jobs and, after $700 million in local and state contracts awarded thus far, 9,500 supplier-related jobs in the area. The first Volkswagen Passat rolled off the assembly line in May 2011, and the company's investment at the former VOAAP has translated into $12 billion in income growth and $1.4 billion in new tax revenues. In 2010, Gestamp Corporation built a $90 million stamping plant on the property, creating 230 jobs, and Amazon followed with a $90 million order fulfillment center in 2011 that the City of Chattanooga reports will support 1,250 full-time jobs and 750 seasonal jobs.

NAVAL WEAPONS INDUSTRIAL RESERVE PLANT – MCGREGOR, TEXAS

Drinking Water Protected for 500,000 People I 1,000 Jobs Created I 1,000 Acres for Agricultural Reuse

Sampling team collecting samples.

Owned by the Army, the Air Force, and finally the Navy, U.S. military organizations used the former Naval Weapons Industrial Reserve Plant (NWIRP) near Waco, Texas, to research, test, and manufacture weapons and rocket propulsion systems from 1942 through 1995. A half century of these activities contaminated soil and groundwater at large portions of the 9,700-acre site with trichloroethylene (TCE) and other industrial solvents; chromium, cadmium, lead and other metals; benzene and other petroleum products; PCBs; and perchlorate, a major component of rocket fuel and missile propellants. Beginning in 1992, RCRA investigations targeting soil, groundwater, and surface water discovered—in addition to contaminated soils onsite—three major plumes of contaminated groundwater migrating off-site. With soils exposed and plume contaminants exceeding state drinking water standards, the investigation raised concerns that site runoff and groundwater plumes could reach nearby lakes providing drinking water for 500,000 people. Contamination never made it to Lakes Belton and Waco, however, thanks to the installation and optimization of a sophisticated biological treatment system (above ground) and what was then, at three miles long, the world's largest permeable reactive barrier or biowall (below ground). By 2011, NWIRP had not only controlled human exposures and the migration of contaminated groundwater, but the facility completed final remedy construction.

Trenching machine used in biowall construction.

Returning properties to productive use is a high priority for the RCRA Corrective Action Program, and the collaboration between EPA, the Navy, the Texas Commission on Environmental Quality, and local officials makes NWIRP a model for other sites. After consulting with the community on future site uses, meeting cleanup levels safe for these uses (a mixture of commercial, light industrial and agricultural in this case), and ensuring that appropriate land use restrictions were in place, NWIRP became the first Navy facility to receive the "Ready for Reuse" designation pioneered by EPA Region 6. Soon after, parties agreed to a deal transferring all 9,700 acres to the City of McGregor, 1,000 of which were sold for agriculture, with the remainder now making up the city-owned McGregor Industrial Park.

NWIRP employed 625 people when the Base Closure and Realignment Commission (BRAC) closed the facility in 1995, dealing a major economic blow to surrounding communities. Redevelopment spurred by the RCRA Corrective Action cleanup, however, has helped create nearly 1000 jobs at companies leasing space in the new industrial park. Tenants include a Space X rocket development facility; C3 and Convergys call centers for the Humana health insurance company and AT&T, respectively; a Ferguson Enterprises distribution center for plumbing and building supplies, and several smaller operations.

APPENDIX A: HISTORY OF THE RCRA CORRECTIVE ACTION PROGRAM

Milestones/Timeline

1984	RCRA amended by Congress, creating the RCRA Corrective Action Program
1985–1992	Universe assessed; sites prioritized; states authorized; investigations begun; regulations (Subpart S) proposed
1994	Environmental Indicators established
1996	Subpart S regulations not finalized but issued as guidance; RCRA/CERCLA parity policy; public participation manual
1998	Post-closure regulations; risk-based clean closure guidance; remediation waste guidance
1999-2001	RCRA Cleanup Reforms implemented; GPRA goals established; Land Revitalization Initiative begun; Groundwater Handbook released
2002	RCRA 2020 Vision announced; first National Corrective Action Conference
2003	Corrective Action Completion guidance
2005	1st set of GPRA goals exceeded for 1,714 highest-priority Corrective Action facilities (2005 Baseline)
2008	2nd set of GPRA goals exceeded for 1,968 highest-priority Corrective Action facilities (2008 Baseline)
2009	"Strategies for Meeting the 2020 Vision" training delivered in all 10 regions
2011	GAO report praises program success but warns about resource constraints & challenges; NESCA issued
By 2020	**EPA will strive to achieve environmental indicators and construct remedies at 95% of the 3,747 facilities on the 2020 Universe**

Setting up the Program

The program spent its early years gathering information about hazardous waste facilities, prioritizing potential sites, considering regulations, beginning critical site investigations, and authorizing states wanting to run their own Corrective Action programs—42 states and one territory now lead implementation at their sites, with assistance from EPA grants.

Improving the Program

Site remediation was a relatively new field during the program's first decade, and EPA and the states relied on numerous reviews and rigorous processes to assess contamination and choose remedies. As both regulators and facilities learned from experience, the program instituted a series of "RCRA Cleanup Reforms" to focus on results instead of process. Reforms removed obstacles to efficient cleanups and maximized program flexibility to meet the first set of GPRA cleanup goals established in 1999.

Achieving Results

With the program framework established, program resources have been more clearly directed toward achieving cleanup results during the last decade.

- Focusing on immediate threats at the 1,714 highest-priority sites, the program exceeded "Environmental Indicators" goals to control human exposures at 95% and the migration of contaminated groundwater at 70% of these facilities by 2005.
- Expanding the list of priority facilities to 1,968 and introducing a third cleanup measure, the program exceeded goals to control human exposures at 95%, control migration of contaminated groundwater at 81%, and construct final remedies at 27% of these facilities by 2008.
- Adopting a more comprehensive list of 3,747 facilities (the 2020 Universe) in need of RCRA Corrective Action, the program is working to construct final remedies at 95% of these facilities by 2020.

APPENDIX B: FACILITY PROGRESS TOWARD CLEANUP GOALS

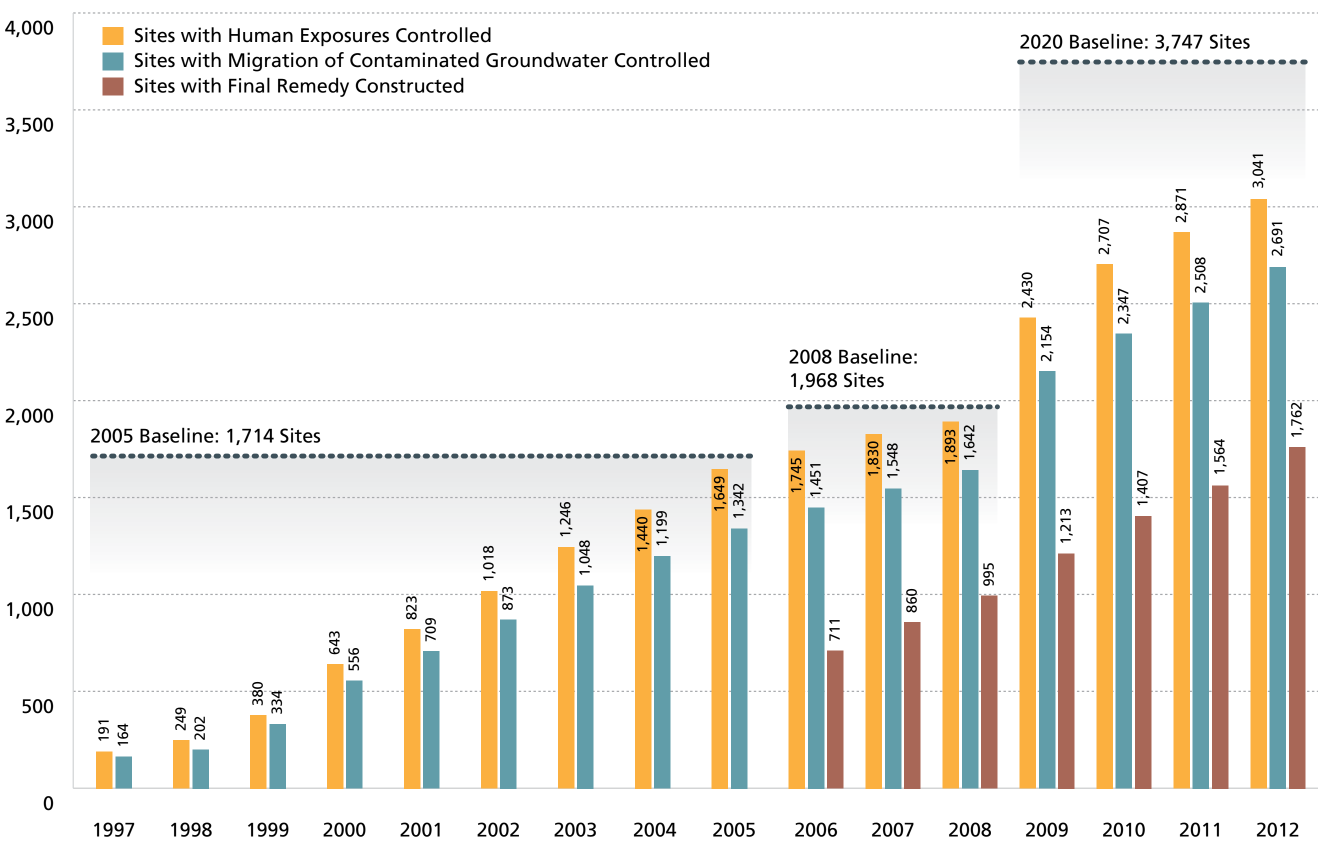
EPA has established three metrics, two of which are referred to as environmental indicators (EIs), to track cleanup progress at RCRA Corrective Action sites.

Faced with thousands of sites, the program's priority has been to first eliminate or control exposures. At the majority of sites achieving the following interim milestones, additional work is necessary to permanently protect human health and the environment:

1. The **Human Exposures Under Control EI** ensures that people near a particular site are not being exposed to unacceptable levels of contaminants.
2. The **Groundwater Under Control EI** ensures that contaminated groundwater is not spreading and further contaminating groundwater or surface water resources.
3. **Final Remedy Construction** is achieved when the facility has completed construction of a final remedy, and that remedy is fully functional as designed. The remedy may need to operate for a period of time before cleanup goals are achieved.

By the end of **FY 2012**, out of 3,747 sites in the 2020 Universe, the program had:

- Met the Human Exposures EI at 3,041 sites (more than 81%), covering 13.6 million acres
- Met the Groundwater EI at 2,691 sites (more than 71%), covering 7.2 million acres
- Reached Final Remedy Construction at 1,762 sites (more than 47%), covering 2.1 million acres



Numbers shown represent accomplishments at of the end of the indicated fiscal year. Full tracking of Final Remedies Constructed began in 2006.

APPENDIX C: ABBREVIATIONS AND ACRONYMS

ATSDR	Agency for Toxic Substances and Disease Registry
BPXA	BP Exploration Alaska
BRAC	Base Closure and Realignment Commission
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (Superfund)
DFC	Denver Federal Center
DNAPL	Dense Non-Aqueous Phase Liquid
DOE	U.S. Department of Energy
EBT	Enhanced Biological Treatment
EI	Environmental Indicator
EIA	U.S. Energy Information Administration
EPA	U.S. Environmental Protection Agency
FY	Fiscal Year
GAO	U.S. Government Accountability Office
GPRA	Government Performance and Results Act
IEUBK	Integrated Exposure Uptake Biokinetic Model
LANL	Los Alamos National Laboratory
LEED	Leadership in Energy and Environmental Design
LLC	Limited Liability Corporation
LNAPL	Light Non-Aqueous Phase Liquid
NAPL	Non-Aqueous Phase Liquid
NDEP	Nevada Division of Environmental Protection
NERT	Nevada Environmental Response Trust
NESCA	National Enforcement Strategy for Corrective Action
NJDEP	New Jersey Department of Environmental Protection
NMED	New Mexico Environment Department
NWIRP	Naval Weapons Industrial Reserve Plant
PAH	Polycyclic Aromatic Hydrocarbon
PbB	Blood Lead Level
PBS	Public Broadcasting Service
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethylene
PPM	Parts Per Million
RCRA	Resource Conservation and Recovery Act
RDX	Cyclotrimethylenetrinitramine
STAR	Science to Achieve Results
SVOC	Semi-Volatile Organic Compound
TASC	Technical Assistance Services for Communities
TCE	Trichloroethylene
TNT	Trinitrotoluene
TSD	Treatment, Storage, and Disposal
VOAAP	Volunteer Army Ammunition Plant
VOC	Volatile Organic Compound

RCRA Corrective Action:

Case Studies Report

RCRA

EPA 530-R-13-002
April 2013

United States
Environmental Protection
Agency