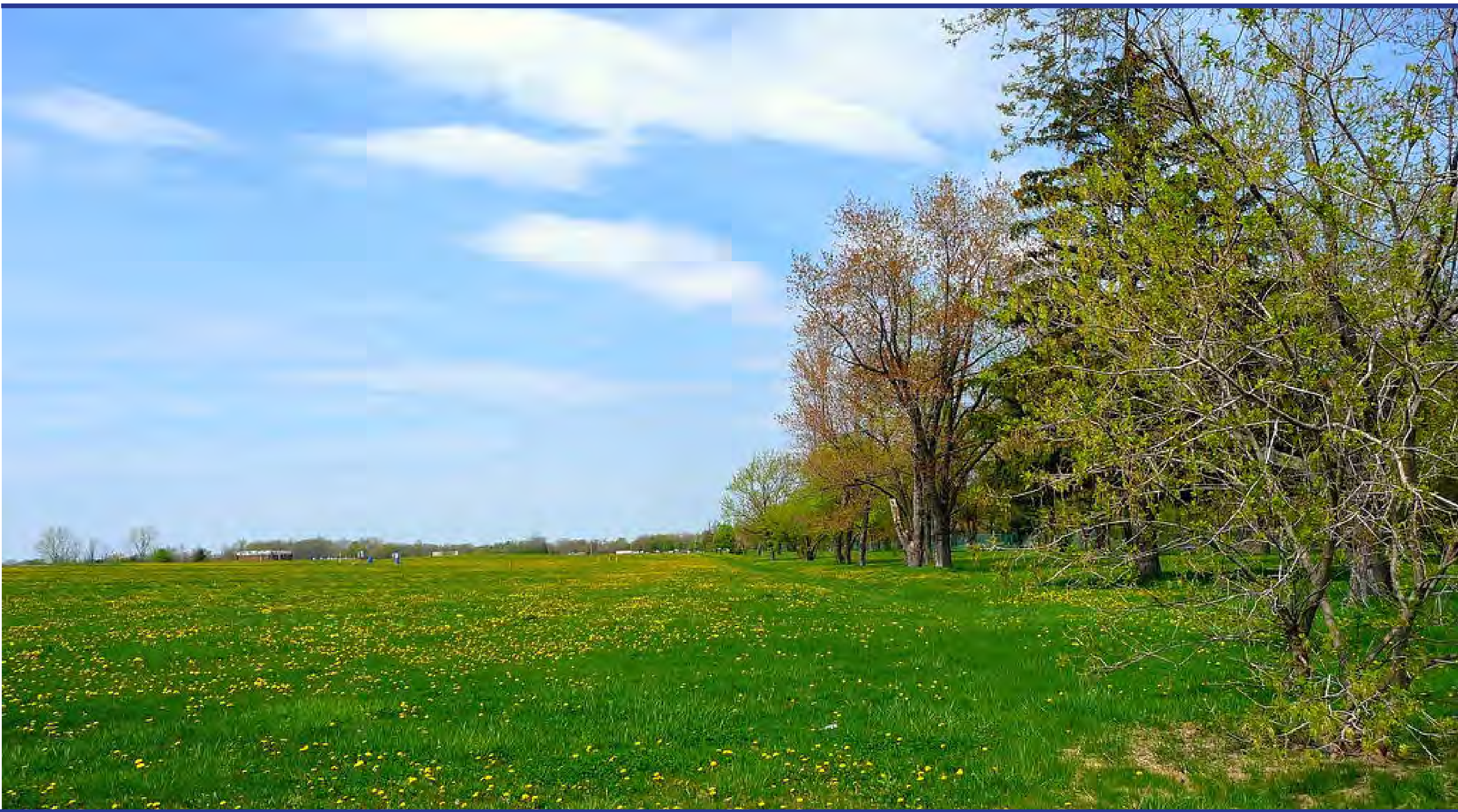
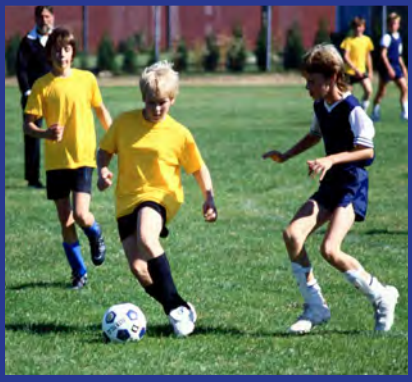
United States Environmental Protection Agency

Beneficial Effects of the Superfund Program





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U.S. Environmental Protection Agency
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Contents

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The debate about whether the costs of the Superfund program are warranted has continued throughout most of the nearly three decades of the program's existence. Following a series of administrative reforms and legislative amendments affecting Superfund over the years, EPA has made considerable progress toward cleaning up hazardous waste sites and responding to emergencies involving hazardous substances. However, much work remains to be done. About one-third of National Priorities List (NPL) sites are not construction complete and new sites continue to be added to the list. In addition, the nature of the work may require a shift in emphasis within the program. Much of the site investigation and cleanup work remaining is at very large, complicated sites likely to cost many millions of dollars per site to clean up. In some cases, the costs may be hundreds of millions of dollars. Many sites that have completed construction of a remedy also require long-term stewardship to ensure that the remedy remains effective in protecting people and the environment.

This paper describes the beneficial effects of the Superfund program on people and the environment since its inception 30 years ago. EPA believes that information on the impacts of its programs will help government officials and the general public make better and more cost-effective policy and business decisions. It discusses Superfund's accomplishments in terms of reduction of threats to human health and ecological systems in the vicinity of Superfund sites; improvement of the economic conditions and quality of life in communities affected by hazardous waste sites; and prevention of future releases of hazardous substances[1] by providing impetus for industry practices that better manage and reduce the generation of hazardous substances. The information in this paper is drawn from government, academic, non-governmental organizations (NGOs), and industry sources.

1. Background

Growing public awareness in the 1970s that areas, such as the Love Canal neighborhood in New York, the "Valley of the Drums" in Kentucky, and the Stringfellow Acid Pits in California, were contaminated with hazardous substances sparked a national controversy. Dramatic events, like the fire at an illegal hazardous waste site in Chester, Pennsylvania that hospitalized over forty firefighters, added to the sense of urgency. By 1980, it had become apparent that hazardous substances released at these sites and in emergency situations have serious acute and chronic health effects on humans, and pose significant risks to plants, animals, and other natural resources. Moreover, many of these contaminated properties in populated areas have remained vacant or underutilized, thereby hampering economic and community development and diminishing the quality of life in surrounding neighborhoods.

1.1 Potential Adverse Effects of Superfund Sites

Hazardous waste contamination can have significant adverse effects on people, communities, local economies, and the environment:

- Hazardous substances found at Superfund sites can cause serious health effects, including fatalities and injuries from fires or explosions; acute poisonings; cancer; congenital abnormalities (birth defects); reduction in cognitive abilities as measured by decreases in IQ scores; and other long-term effects, such as thyroid dysfunction and endometriosis.
- Hazardous substances can contaminate surface water and groundwater. About 66% of people in the United States use surface water and the remainder are supplied from groundwater (EPA 2009d).

[1] For this paper, hazardous substance is defined to also include pollutants and contaminants as defined in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

- Hazardous substances are harmful to plants, animals, and the functioning of ecological systems such as wetlands, lakes, rivers, and grasslands.
- Left unattended, many hazardous waste sites remain vacant or underutilized, contributing to blight in neighborhoods, and representing a forgone opportunity for communities to use potentially valuable resources.
- The presence of Superfund sites may reduce the quality of life and value of other properties in their vicinity.
- In addition to the documented effects of hazardous substance releases, the presence of uncontrolled hazardous substances in the environment presents potential future risks that are not evident today.

1.2 Legislative and Regulatory Response

By 1980, federal laws regulated water quality, oil spills, drinking water, active waste disposal practices, and air pollution, but did not yet address the full consequences of our historic industrial waste disposal practices. The ensuing debate over how best to deal with these problems led to the creation of the Superfund program under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), which was enacted by Congress on December 11, 1980. Under CERCLA and related laws, the Superfund program identifies, investigates, and cleans up America's most contaminated hazardous waste sites.

CERCLA provides broad response authorities for EPA to protect people and the environment from the risks posed by releases of hazardous substances, pollutants, and contaminants. For example, Section 104(a) of CERCLA provides EPA with broad authority to carry out response actions that the Agency "deems necessary to protect the public health or welfare or the environment." In addition, Section 121 of CERCLA includes some "general rules" for selecting cleanup standards and carrying out response actions. These include a number of factors to consider in evaluating alternatives such as the toxicity and mobility of hazardous substances and the short term and long term "potential for adverse health effect from human exposure." In addition, this section of the statute requires that remedial actions selected by EPA are "cost effective." EPA has incorporated CERCLA Section 121 provisions and other statutory requirements into the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), the key regulation addressing Superfund response actions. For example, many of the factors specified in section 121 are captured in the NCP's nine criteria used for evaluating remedial alternatives (see 40 CFR §300.430(e)(9)). In assessing alternative remedies consistent with CERCLA and the NCP, EPA considers the nine criteria, including cost effectiveness, where such action is deemed necessary to protect human health. CERCLA also provides broad authority to take response actions to protect the environment. This authority does not depend on the presence of human health risks.

1.3 Superfund Program Response

The Superfund program has permanently destroyed or isolated many millions of tons of contaminated material; investigated about 40,000 sites to determine the extent of their contamination; developed, promoted, and disseminated site investigation and cleanup technologies; worked to foster compliance with other hazardous waste management laws; and assisted other federal cleanup programs and states in developing and implementing their own cleanup programs. These actions have halted the exposure, or potential exposure, of millions of people to hazardous substances; enabled thousands of acres of previously vacant land to be made available for beneficial use and underutilized properties to be made available for higher value uses; and encouraged industrial practices that prevent future releases of hazardous substances.

The Superfund program has also been responsible for implementing a removal program, which conducts or oversees emergency responses and short-term cleanup actions. The removal program operates an emergency response center to which individuals and communities can turn for help in the case of a hazardous substance emergency. It also provides training and technical assistance to police, firefighters, and other state and local first responders to emergency incidents. For almost three decades, EPA has responded thousands of times under the authority of CERCLA to deal with the problem of hazardous substances in the environment; and the Agency continues to respond to over 300 new (or newly discovered) releases every year.

2. Overview of Superfund Program Benefits and Effects

The Superfund program has three primary components: (1) cleanup of existing waste sites (through removals and remedial actions, including natural resource damage actions where needed); (2) responses to emergencies, including ensuring emergency preparedness (through the removal action program); and (3) deterrence of practices that would lead to future hazardous waste releases (through reporting requirements, CERCLA liability provisions, and EPA compliance efforts). Each of these program components leads to many different types of benefits and impacts, some of which are not the primary objectives of CERCLA.

While the program's primary objective is the protection of human health and welfare and the environment, cleaning up these sites has also resulted in other positive impacts at many sites, such as the reuse of vacant or underutilized properties, the advance of new technologies to characterize and clean up contaminated sites, and improved local and regional economies, aesthetics, and quality of life. For example, a cleanup that reduces the risk of disease also may improve the area's aesthetics and property values.

Beneficial Effects of the Superfund Program

Direct Effects

- Improved health of residents, workers, and others near Superfund sites
- Reduction or reversal of damages to natural resources
- Reduction of harm in emergency situations
- Improved community economies and quality of life

Indirect Effects

- Contributions to other cleanup programs
- Improved environmental practices by industry
- Advances in science and technology
- Reduced unidentified potential future threats

The effects of Superfund response actions can be described in terms of eight basic impact categories (see box). Despite the conceptual distinction between these different impact categories, the various categories are intertwined. The first four categories are considered direct beneficial impacts, because they are directly associated with things of value to society, such as improvements in local ecological resources and the health and welfare of people who live and work in the vicinity of Superfund sites. Some of these impacts are difficult to measure. For example, it is clear that emergency response and emergency preparedness are activities that contribute directly to reduction of health and safety threats and protection of habitats. However, it is less obvious that public knowledge that the government is prepared for emergencies also contributes directly to a feeling of well-being among the protected population. This feeling is itself a direct benefit, though difficult to measure.

The last four categories, labeled "indirect impacts," eventually lead to the direct impacts, but the relationships are more difficult to trace. For example, the direct effects of advances in science and technology include improvements in the efficiency and effectiveness of cleanups. These improvements, in turn, affect the nature and magnitude of the direct effects. CERCLA's liability provisions and EPA's efforts to improve environmental practices throughout the economy contribute to a reduction in future releases of hazardous substances, which in turn, will likely result in reductions in risk to human health and the environment. Improvements to a state cleanup program resulting from the adoption of technologies used at Superfund sites can lead to better, faster, and less costly cleanups. *The indirect effects of the Superfund program are substantial and may be no less important than the direct effects.*

Some elements of these impact categories are “transfer payments,” which do not contribute to the total “national welfare” but are important to specific groups, individuals, or neighborhoods. For example, jobs created at a redeveloped site may displace jobs in another community, or in the site’s host community. Although the site’s redevelopment leads to increased employment in the site’s host community, there may not be a net change in the total number of new jobs in the national economy. Local benefits, however, are important to specific communities and to specific socioeconomic groups near Superfund sites.

Superfund efforts have also contributed substantially to the development and implementation of cleanup programs managed by other federal programs, states, and tribes through partnerships, research and development (R&D), technical assistance, and funding. Moreover, it has been observed that the liability and compliance provisions in CERCLA have provided impetus for many property owners to enroll in state voluntary and other cleanup programs. Sites managed under state programs tend to have roughly the same types of hazardous substances and resulting benefits as those in the federal Superfund program, but are generally, though not always, less complex.

The final category of impacts refers to the reduction of the potential future threats arising from the release of hazardous substances into the environment. Although much progress has been made in understanding how substances move through the subsurface, the science and data available may be insufficient to predict long-term impacts of many types of releases. Once substances are released into the subsurface, there may be considerable uncertainty regarding how they will migrate, what chemical transformations they will undergo, and what the effects will be on ecological systems and human health many years, or centuries, in the future. By preventing, controlling, or cleaning up hazardous substance releases, Superfund actions are leading to the elimination or reduction of these threats.

The environmental issues, cleanup techniques, and benefits vary widely from one site to another. The key benefit of a cleanup action at site A may be avoidance of cancer or improved neighborhood development, whereas at Site B it might be restoration or protection of a wetland habitat. Because of the complicated mix of impacts and response actions, it is difficult to develop a single, comprehensive estimate of the total value of all the impacts, or even for any single impact type. Nevertheless, it is useful to describe these effects to the extent possible. The following sections further describe these eight impact categories.

3. Human Health Benefits

Uncontrolled releases of hazardous substances to the environment can increase the risk of adverse health effects to exposed populations, including minority and poor communities and sensitive sub-populations, such as children, pregnant women, and the elderly, who can be disproportionately affected. The Superfund program is well-positioned to address environmental justice concerns at communities where there are multiple sources of contamination. The principal inherent dangers to people exposed to hazardous substances found at Superfund sites include acute effects, such as acute poisoning and injuries from fires or explosions, and long-term effects, such as cancers and birth defects. More than 250 hazardous substances that have the potential of causing such effects have been found at Superfund sites. Superfund cleanup actions prevent or reduce human health risks by cleaning up or isolating the hazardous

Hundreds of Hazardous Substances Have Been Found at Superfund Sites. Some of the Most Common Are:

- Lead
- Arsenic
- Trichloroethene (TCE)
- Benzene
- Tetrachloroethene (PERC)
- Cadmium
- Chloroform
- Mercury
- Polycyclic aromatic hydrocarbons (PAHs)
- Vinyl chloride

substances, thereby preventing human exposure and further migration of hazardous substances through groundwater, soil, or other media.

> ***Health Benefits in Libby, Montana***
>
> Libby, Montana, is an example of a community benefiting from a Superfund cleanup designed to address long-term exposure to a carcinogen. The small town is set in the northwest corner of Montana, 35 miles east of Idaho and 65 miles south of Canada. Libby has a population of less than 3,000 with 12,000 people living within a ten-mile radius. EPA has been working in Libby since 1999 when an Emergency Response Team was sent to investigate a concern about asbestos-contaminated vermiculite from the local mine. Since that time, EPA has been working closely with the community to remove asbestos and reduce risks to human health. Miners and their families who live in Libby have been diagnosed with asbestosis and mesothelioma associated with exposure to asbestos. Since November 1999, EPA has removed the major sources of asbestos contamination in the town and is now addressing smaller sources found around homes and businesses.

Superfund conducts risk assessments at many sites, which, combined with research into the health effects of various substances, provide insight into the type and extent of the human health impacts. However, because of the wide range of site characteristics and contamination conditions from site to site and community to community, it is difficult to fully articulate the entire range of adverse health effects that would have occurred had a site not been cleaned up. In addition, information available on key variables, such as the nature and extent of contamination; the movement of hazardous substances through soil, groundwater, and other media; and the extent of potential human exposure, vary from site to site. A useful way to envision the potential extent of health effects is to estimate the population potentially exposed and the toxicity of the hazardous substances released into the environment at these sites.

3.1 Populations at Risk and Environmental Justice

Research based on site-specific investigations at NPL sites suggests that the most important pathways of exposure are through groundwater, followed by soil, air, and other media. Generally, ingestion is the most important exposure route, followed by dermal contact and inhalation, although the critical exposure route varies by contaminant. Based on these types of exposures, people living in the vicinity of Superfund sites are the primary population at risk of exposure to the hazardous materials released from the sites.

EPA has estimated that 67 million people live within four miles of the 1,504 sites that had been listed on the NPL by December 31, 2004; and 38 million people live within 2.5 miles.[2] In addition, there have been approximately 9,100 short-term and long-term removal actions under the federal Superfund program, as of May 2009. The large number of actions implies that there is significant potential for human exposure to hazardous substances in the environment, although comprehensive data on the percentage of the population that is potentially exposed are not available.

In February 1994, President Clinton established Executive Order 12898. The order required that "…each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations, and low-income populations…." Researchers have documented environmental injustices across the country, and found minorities and the poor living more frequently near environmental hazards. Many sites on the NPL are located in minority and poor communities. Through the cleanup of these sites, the Superfund program has sought to ensure that residents do not bear a disproportionate share of the negative environmental consequences resulting

[2] By the end of FY 2009, total listings had grown to 1,607; however, similar population estimates for the additional 103 sites are not available. OSWER developed the population estimates by combining U.S. Census 2000 data with Superfund site location data (EPA 2007).

Health Impacts of Lead Exposure at a Superfund Site

The RSR Smelter NPL site is an example of a cleanup addressing a health threat from lead. The smelting facilities cover 6.7 acres amid residential, industrial, and commercial properties in west Dallas County, Texas. Approximately 50,000 people, including 7,000 children under the age of seven, live within 2.5 miles of this site. Almost immediately after discovery of the contamination, but well before the site was placed on the NPL, EPA and the Texas Natural Resource Conservation Commission (TNRCC) began to conduct removal actions under CERCLA. Together the TNRCC and EPA surveyed 6,800 potentially contaminated properties and undertook cleanup at 420 private residences and other high-risk areas where children could be expected to play, including playgrounds, schools, and parks. All soils contaminated with lead greater than 500 parts per million (ppm), arsenic greater than 20 ppm, or cadmium above 30 ppm were removed and replaced with clean soil. The cleanups, in the 1980s and early 1990s, greatly reduced exposure. By 1993, blood lead analyses indicated that only 8% of children in the area exceeded the level of concern of 10 micrograms per deciliter (compared to 90% prior to cleanup), and testing of 305 randomly-selected children showed an average blood lead level of 5.5 micrograms per deciliter (compared to 20.1 prior to cleanup).

from past industrial, governmental, and commercial operations, and that they have meaningful involvement in the decisions on how to clean up the site.

3.2 Threats Posed by Superfund Sites

The major health effects from exposure to contaminants found at Superfund sites include:

- Acute accidents and injuries
- Cancer
- Birth defects
- Other chronic non-carcinogenic effects (e.g., kidney, liver, nervous and endocrine systems).

A given hazardous substance can have many adverse health effects, depending on the route of exposure, concentration levels, and individual exposed. For example, the health impacts of lead at a few Superfund sites are fairly well documented, and there is good evidence of a general relationship between lead-contaminated soil and elevated blood lead levels. Studies have shown associations between adult exposure to low levels of lead and cardiovascular disease, high blood pressure, hypertension, and a decline in cognitive functions. Lead exposure has been associated with reproductive problems in women, including neurobehavioral problems in offspring and neonatal mortality due to low birth weight. Children under age six are most vulnerable to lead exposure because their nervous systems are still developing.
High blood lead levels in children are associated with diminished learning abilities as well as other adverse effects. People residing near NPL sites that are contaminated with lead tend to be exposed to lead through multiple exposure routes and to have higher blood lead levels than those not exposed. At homes near lead-contaminated NPL sites, lead-contaminated soil in yards can be an important exposure pathway. Fortunately, the Superfund program has been very successful in controlling this source of lead exposure by isolating and removing contaminated soil and replacing it with clean soil.

The table on page 7 lists health effects known to be associated with some of the most commonly found hazardous substances at NPL sites.

Health Effects of Contaminants Frequently Found at NPL Sites*

Hazardous Substance	% of NPL Sites**	Potential Health Effect
Arsenic	68%	➢ Irritation of the stomach and intestines, nausea, and vomiting ➢ Decreased production of red and white blood cells ➢ Infertility in women and miscarriages ➢ Known human carcinogen (skin, lung, liver, lymphatic system) ➢ Skin changes and lung irritation ➢ Damage to blood vessels ➢ Abnormal heart rhythm ➢ Damage to DNA
Benzene	59%	➢ Anemia ➢ Leukemia ➢ May be harmful to the reproductive organs and bone marrow ➢ Vomiting, stomach irritation, dizziness, sleepiness, convulsions, rapid heart rate, coma, and death
Cadmium	53%	➢ Lung damage ➢ Fragile bones ➢ Stomach irritation, vomiting, and diarrhea ➢ Probable human carcinogen ➢ Kidney disease ➢ Death
Chloroform	50%	➢ Dizziness, fatigue, headache ➢ Kidney damage ➢ Reproductive and birth effects in rats and mice, but unknown for humans ➢ Reasonably anticipated to be a carcinogen ➢ Liver damage ➢ Skin sores
Lead	75%	➢ High blood pressure and hypertension ➢ Miscarriages and subtle abortions ➢ Neonatal mortality due to low birth weight ➢ Diminished learning abilities of children ➢ Damage to the nervous system and the brains of unborn children ➢ Behavioral problems of children, such as aggression and hyperactivity ➢ Kidney damage ➢ Decreased fertility of men ➢ Brain damage ➢ Probable human carcinogen
Mercury	49%	➢ Permanent kidney damage ➢ Nausea, vomiting, diarrhea ➢ Increases in blood pressure and heart rate ➢ Permanent damage to developing fetus ➢ Effects on brain function, resulting in irritability, shyness, tremors, changes in vision or hearing, and memory problems ➢ Possible human carcinogen (mercury chloride and methylmercury) ➢ Lung damage ➢ Skin rashes and eye irritation
Polycyclic aromatic hydrocarbons (PAHs)	42%	➢ Irritation of the nose, mouth, and eyes ➢ Vomiting, diarrhea, stomach cramps, nausea, and even death ➢ Kidney and liver damage ➢ Probable human carcinogen
Tetrachloro-ethene (PERC)	54%	➢ Dizziness, headaches, sleepiness, confusion, nausea, difficulty in speaking and walking, unconsciousness, and death ➢ Eye, nose, throat, and skin irritation ➢ Possible to probable human carcinogen
Trichloro-ethene (TCE)	60%	➢ Nervous system effects ➢ Abnormal heartbeat ➢ Liver and lung damage ➢ Coma and possibly death

Notes:

* A site may contain more than one contaminant.

** Approximate percent of sites where the contaminant is found.

Source:

Percent of sites where a contaminant is found and health effects data are based on estimates by the Agency for Toxic Substances and Disease Registry (ATSDR), www.atsdr.cdc.gov/toxfaqs/index.asp, June 2008.

4. Ecological Benefits

Healthy ecosystems are important to all aspects of our lives. The status of ecosystems can be linked to the central components of human well-being—health, material inputs, security, freedom of choice, and good social relationships. Contamination of soil, groundwater, surface water, and other media degrade the functioning of ecosystems by affecting the health of various species of plants and animals. The specific effects vary widely among species, contaminants, and ecosystems. The overall impact is a change to the composition of species, and the functioning of the ecosystem. These changes can lead to reductions in the benefits that ecosystems provide humans. Changes in ecosystems also affect life on earth independent of direct human uses of ecosystems.

4.1 Importance of Ecosystems

There are many types and configurations of Superfund sites (e.g., former landfills, industrial facilities, mining properties), and they are located in all kinds of settings, such as rural, suburban, urban, wetlands, grasslands, forests, and riparian areas. Consequently, the effects of a hazardous waste site on ecosystems vary widely from site to site. Evaluation of benefits of the Superfund program requires a broad understanding of the benefits derived from ecosystems.

Ecosystems provide many direct and indirect benefits (often referred to as *services*) to society. These services can be divided into four areas, although there is some overlap:

(1) Provision of goods and other services for human consumption,
(2) Regulation of ecosystem processes,
(3) Supporting ecosystem processes, and
(4) Cultural services.

The *goods and services* that ecosystems provide for human use, such as food, fuel, materials, and water, are primarily direct benefits. Most of these services are readily identified as benefits to individuals, and many are necessary for daily activities.

Many regulating and supporting services are indirect benefits, because their contributions to our daily lives and intrinsic values are not always obvious. Nevertheless, these services are no less important than direct benefits, because they support or contribute to the basic biological and biochemical processes

Superfund Actions Protect and Restore Ecosystems that Provide Services Essential to Society

Benefit Category	Examples
Provision of Goods and Other Services (direct benefit of ecosystems)	➢ Water (drinking, irrigation, industrial use) ➢ Food (animal, plant); materials (fiber, timber, fur, leather) ➢ Fuel (e.g., wood, solar, wind) ➢ Genetic and medicinal resources (e.g., biotechnology, animal and plant breeding, biochemicals, natural medicines, chemical models and tools); pollination of crops
Regulating Services (largely indirect benefit)	➢ Climate and atmospheric regulation (e.g., greenhouse gas sinks, oxygen production, air pollutant uptake) ➢ Water regulation (runoff, flood moderation, groundwater replenishment, water filtration) ➢ Storm protection ➢ Control of human diseases, and crop and livestock diseases and pests
Supporting Services (mostly indirect benefit)	➢ Soil formation and retention (e.g., prevention of damage from erosion and siltation; maintenance of productive soils, including soil fertilization and sediment trapping, maintenance of arable land) ➢ Nutrient cycling ➢ Water 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 biodiversity and genetic resources, including protection of threatened, endangered and commercially important species)
Cultural Services (includes non-use benefits)	➢ Spiritual and religious values; cultural heritage values; aesthetic values; other nonuse benefits (e.g., passive-use, which includes option, existence, and bequest values) ➢ Recreational opportunities (e.g., fishing, hunting, viewing, hiking, swimming)

needed to support life. *Regulating services* maintain ecosystem health by regulating the essential ecological processes that occur through biochemical and biospheric processes. Examples of these services include climate regulation (including carbon sequestration), disease and pest regulation, water regulation (e. g, flood moderation), water purification, and pollination. *Supporting services* are processes, such as soil formation, nutrient cycling, and provision of habitat and maintenance of biodiversity, that are necessary for the production of all other ecosystem services.

Ecosystems also provide *cultural services*, which are non-material benefits that people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences. Although recreational opportunities, such as fishing, hunting, scenic vistas, wildlife viewing, hiking, and boating, may be considered as a component of cultural services, many individuals also consider them to be a good or service that provide benefits directly to individuals.

Cultural services may also include non-use benefits, which refer to the value that people place on a resource, even though they may or may not use it. These "passive uses" include the value people place on the ability to use a resource although they may not currently use it (o*ption value*); knowledge that the resource exists in an undisturbed state (*existence value*); and knowledge that future generations will be able to use the resource (*bequest value*). In addition, ecosystems support threatened, endangered, and commercially important species.

4.2 Threats Posed by Superfund Sites

Threats to ecosystems presented by Superfund sites can be grouped into two broad areas: exposure of plants, animals, soil, and water resources to contaminants, and the physical impacts of specific Superfund sites. Exposure to contaminants at some sites has resulted in the immediate or short-term death of some plants and animals. At other sites, contaminants (such as toxic metals, including copper, cadmium, zinc, and lead; organochlorine pesticides; and a variety of chlorinated organic compounds) accumulate in the tissues of organisms at abnormally high concentrations. These substances can reduce organism survival and growth rates. The contaminants may also accumulate at increasingly greater concentrations in the tissues of organisms higher up in the food chain. The amount of bioaccumulation of a contaminant can vary widely among species. This process can alter the composition of species in an area, both on and off the Superfund site; seriously damage or destroy the functioning of an ecosystem; and render fish, game, and plants inedible.

Industrial activities at some Superfund sites have resulted in the removal or destruction of all vegetation and topsoil, leaving little or no viable ecosystem. There are no permanent plant communities on these sites that can provide erosion control and wildlife habitat, or reduce flooding and stormwater runoff. Because wildlife species require a minimum habitat area necessary to thrive, and a minimum viable population, the biodiversity in the area surrounding Superfund sites can be very low.

Biodiversity is required for the recycling of essential elements, such as carbon, oxygen, and nitrogen. It is responsible for mitigating pollution, protecting watersheds, and combating soil erosion. Biodiversity is intrinsic to the ecosystem qualities we value, such as physical beauty and harmony. Plants and animals provide food, medicine, energy, and building materials. In recent years, entire species and natural areas have been lost at unprecedented rates, primarily due to human activity.

4.3 Ecological Impacts of Superfund Actions: Some Examples

While the available data are insufficient to fully quantify all the ecological benefits for the Superfund program, it is evident that many cleanups have included important features to ensure the creation, restoration, or protection of ecosystems, both on site and off site. Some examples of projects that have provided ecosystem benefits include:

- At Loring Air Force Base in northeastern Maine, site project managers removed soil and sediment from wetlands and stream channels. Following a detailed plan using maps, records, and photographs, they were able to reconstruct wetland topography, restore stream channels and in-stream structures, and restore plant communities.
- At the Bunker Hill Mining and Metallurgical Site, Kellogg, Idaho, three different types of ecosystems were restored at this second largest Superfund site in the country. A grassy riparian floodway, which was created on about 200 acres along a 1½- mile stretch of a river, is now home to frogs, deer, birds, and other wildlife. A 1,000-acre hillside area, denuded of vegetation from former smelter operations, was revegetated using innovative soil amendment techniques. This approach has reduced the amount of sediment entering surface waters. The project has provided a healthy habitat for elk and other native species, which are returning to the area. Native grasses were also planted in a 27-acre wetland, and waterfowl and otters are coming back.
- At Silver Bow Creek/Warm Spring Ponds, Butte, Montana, wetland and riparian areas were remediated and restored to provide a habitat for more than 230 types of resident or migratory waterfowl, birds of prey, brown and rainbow trout, and terrestrial wildlife. The site is also used for low-impact recreational activities, such as catch and release fishing and hiking.
- At Bowers Landfill, Pickaway County, Ohio, a seven-acre wetland was developed in a pit created when clay was dug up for the landfill cap. The wetland functions as a buffer to protect the landfill from flooding and prevent damage to the cap. The wetlands and a meadow also support waterfowl and other species.
- At the Cherokee County Galena Subsite, Cherokee County, Kansas, native prairie grasses were used to stabilize the clean soil that was placed over mine tailings. The tall, wavy grass stands have encouraged the return of wildlife and now harbor birds and small mammals.
- At Army Creek Landfill, New Castle County, Delaware, grains, wildflowers, and other carefully selected vegetation were planted to attract migratory birds for resting, nesting, and feeding. In addition, high-quality wetlands that had become contaminated from hazardous substances in groundwater were restored by the National Oceanic and Atmospheric Administration, the U.S. Fish and Wildlife Service, and the State of Delaware, which are trustees for these resources.
- The tidal marsh adjacent to the LCP Chemicals site in Brunswick, Georgia, became contaminated with mercury-contaminated sludge, lead, PCBs, and semi-volatile organic compounds. Several terrestrial wildlife species, including the endangered wood stork, were found to be at risk from mercury and lead contamination. A removal action, which involved excavating 13 acres of contaminated sediment, on-site soil, and waste piles, led to reduced environmental risks at the site, including lower levels of PCBs and mercury in the site's aquatic species. A Georgia Department of Natural Resources advisory against eating locally caught red drum was removed (although other species remained unsafe for consumption). In addition, 13 acres of marsh were restored. Further ecological benefits are anticipated.
- At the former Bailey Waste Disposal site in Bridge City, Texas, contaminants of concern included metals and organic compounds present in soil, surface water, and groundwater on and surrounding the site. An environmental assessment revealed a variety of marine fish and organisms that live on or near the bottom of the estuary and 15 endangered or threatened species. Furthermore, contamination from the site was found to affect 10 acres of estuarine marsh, freshwater marsh, and terrestrial habitats. In addition to restoring the site to baseline conditions, the National Oceanic and Atmospheric Administration, Texas Natural Resource Conservation Commission and other agencies responsible for natural resources in the area constructed 28 acres of estuarine wetlands at a nearby location in the lower Neches Wildlife Management Area as compensation for natural resource injuries.

In addition to the impacts of Superfund sites on surrounding ecosystems, valuable habitats have been created on some sites, after cleanup.

Former landfills, abandoned dumps, mining areas, and other contaminated sites throughout the United States, once thought to be of limited or no value, are being transformed into viable habitats where terrestrial or aquatic plants and animals can flourish. As of January 2009, at least 10% of the approximately 500 Superfund sites that have planned, continued, or actual new use are being used for ecological purposes (EPA 2009a). Many of the sites in ecological reuse also support additional use types. Likewise, sites being used in recreational, green space, commercial, or other capacities may also have an ecological component.

Cleaned up Superfund sites are being used for wetlands, meadows, streams, and ponds, where they provide habitat for terrestrial and aquatic plants and animals, and for low-impact or passive recreation, such as hiking and bird watching. In developed areas, the Superfund program has conducted or overseen the cleanup of waterfront industrial properties and their conversion to scenic trails and parks. It has also remediated properties that connect smaller ecosystems or recreational areas, effectively enlarging the habitat size and enhancing biodiversity in the region.

5. Community Impacts and Property Values

While the Superfund program's primary objective is the protection of human health and the environment, cleaning up and redeveloping contaminated sites has resulted in positive economic and social impacts in many communities. By eliminating or reducing real and perceived health and environmental risks associated with hazardous waste sites, Superfund cleanups help convert vacant and underutilized land into productive resources; reduce blight, uncertainty, and other negative perceptions; and improve the aesthetics and general well-being in the communities surrounding the sites.

Community Impact Highlights

- As of January 2009, more than 500 Superfund sites are in various types of planned, continued, or actual reuse. These sites support thousands of jobs with a payroll of billions of dollars (EPA 2009a, 2006).
- Cleanup and development of these properties often improve the local economy and government by making available land for economic development; providing a catalyst for other development in the area; and increasing efficiency in the use of public and private infrastructure, which reduces per capita cost.
- These properties have improved the quality of life in many communities by eliminating blight and uncertainty, and providing valuable amenities, such as commercial and industrial sites, residences, sports fields, parks, green space, and public facilities.
- EPA has documented cases where the values of properties that contain Superfund sites have grown substantially after cleanup (EPA 2009c and 2010e). There are also cases where the values have not improved.

The nature and extent of the impacts vary widely from site to site and community to community. In some communities, a cleaned up Superfund site may represent an opportunity for adding parks or recreational facilities. Other communities may need the site to support expanding or new businesses that bring jobs to the area or balance to the local economy. On the other hand, some communities do not have an immediate demand for the property, because the local economy is stagnant, or because lingering concerns or uncertainty discourages reuse. Because of this wide range of circumstances, it is difficult to quantify, or even fully articulate the range of impacts. A useful way to envision community impacts is to examine what happens to Superfund sites as a result of the cleanup process, and how the activities at the sites affect communities. For this discussion, Superfund sites can be divided into four groups:

1. Over 500 NPL sites at which EPA is tracking actual or planned use;
2. Hundreds of NPL sites where cleanup construction has been completed, but the sites are not yet ready for reuse;
3. Thousands of properties that have been made available for reuse, or continued use, following investigations that resolved uncertainty regarding potential risk which, in many situations, had been an obstacle to reuse; and
4. Thousands of properties that have been made available for reuse, or continued use, following removal actions.

The community impacts and property values associated with NPL sites are described in the following sections, and removal actions are discussed in Section 6.

5.1 Superfund Sites in Use

Former landfills, abandoned dumps, and other contaminated sites throughout the United States, once thought to be of little or no value, are being transformed into viable commercial, industrial, and residential developments, parks and other recreational areas, and wildlife habitats. A large number of other Superfund sites, including removal sites, have potential for similar uses after they are cleaned up.

The Superfund program is tracking information on over 500 sites that are in actual or planned use. In some cases the entire site is in use, while in others only a portion of the site is being utilized. The Superfund Program developed the Sitewide Ready for Anticipated Use (SWRAU) measure that identifies sites where the *entire* site is ready for reuse. At the end of Fiscal Year 2009, 409 sites had been designated as SWRAU (EPA 2010d).[3]

> Many communities are benefiting from the revitalization of over 500 Superfund sites, which are being used or prepared for use for commercial, industrial, residential, ecological, public service, military, and agricultural purposes.

The Superfund site tracking information provides valuable insight into the range of community impacts. Superfund sites are being used for commercial, industrial, recreational, residential, and other purposes. Many sites have mixed uses. For example, a business park development may also include parkland or other greenspace. Cleaned up Superfund sites are being used for high-rise office buildings, retail centers, intermodal transportation facilities, port facilities, airports, restaurants, residences, and indoor and outdoor recreational facilities, including golf courses and soccer fields. Thus, in addition to eliminating or reducing the disamenities associated with Superfund sites, many communities have benefited from economic and other uses of the land.

5.2 Superfund Sites Not Yet Being Used

There are hundreds of NPL sites where cleanup construction has been completed, but the site is not currently being used. Some sites are simply not ready for reuse. For others, there may be lingering concerns that discourage reuse; the local economy may be too stagnant to warrant use at this time; the local civic leaders, planners, and developers may not yet have come to agreement on local land use plans; or institutional controls restrict the use too severely for many types of development and a specialized project has not yet been proposed. While some of these sites may never be redeveloped, experience with previous Superfund site redevelopments indicates that many of them can ultimately overcome these obstacles and be put, partially or completely, into beneficial use. As with previous redevelopments, reuse activities at these sites will also depend on community and market needs. Although little reuse and community impact information is available for these sites, there is no reason to expect that redevelopment of these sites would not be similar to the reuse that has occurred at other sites.

[3] These estimates do not include redevelopment that might have occurred on the approximately 40,000 sites that have been investigated, many of which were found to require little or no federal cleanup activities.

Thousands of sites have been investigated and made available for reuse. There are no data on how many are in productive reuse.

Meanwhile, the site investigations and cleanups at these sites have reduced or eliminated the actual, perceived, and potential health and environmental risks associated with these sites and, in many cases, improved site aesthetics. The elimination of blight and uncertainty is a first step toward improved quality of life in the affected communities.

5.3 Investigated Sites with Reuse Potential

Since the early 1980s, more than 40,000 sites with potential contamination have been reported to EPA. Because these sites were suspected of being contaminated, property owners and developers were reluctant to market or develop them and prospective buyers looked elsewhere. Through the Superfund program, these sites were assessed and the extent of the risk determined. By defining the risk or lack of risk, Superfund has removed a major obstacle to their reuse. There is little information on the reuse of these properties because they were never included on the Superfund National Priorities List (EPA 2010f).

5.4 Off-Site Effects

The cleanup and reuse of a Superfund site also affects the surrounding community. Abandoned dumps, contaminated industrial facilities, and landfills can hamper both on-site and off-site development, are unsightly, emit odors, and may be associated with both real and perceived health and environmental risks. As a result of this negative perception, businesses are reluctant to locate or expand in the area, and the general quality of life and property values are diminished. By removing the sources of this negativism and uncertainty, cleanup and redevelopment of these sites have led to the following positive impacts for many communities:

- Reduced disamenities and uncertainty associated with contaminated sites can lead to reductions in actual and perceived health risks, and improvements in the area's aesthetics and general quality of life.
- A redeveloped Superfund site, in combination with improved neighborhood quality of life, can function as a catalyst for additional development in the area.
- Both on-site and off-site development generates jobs, income, and tax revenue for local communities.
- Superfund sites have been revitalized to provide sports fields, green space, and other amenities.
- Increased off-site, as well as on-site, development can increase the efficiency in the use of local and regional infrastructure. Increased efficiency results in better services and lower cost per capita when infrastructure is spread over a greater number of individuals and businesses.
- Since most Superfund sites are in built up areas, their redevelopment contributes to Smart Growth objectives, by diverting development that might have gone to greenfield sites in less accessible locations with lower housing and employment densities. This type of tradeoff generally results in reduced energy use, emissions of greenhouse gasses and other substances, and stormwater runoff.
- Studies have indicated that real estate values are often diminished by the presence of Superfund sites in an area and that, after cleanup, values may eventually recover, in whole or in part, at many sites. Thus, property values are, to some extent, an indicator of value of cleanup and redevelopment. However, the interpretation of this indicator, which does not necessarily measure all of the value of a cleanup, is not straightforward. This indicator is discussed in greater detail in Section 5.5.

Why Are There So Many Different Estimates of Superfund's Impact on Property Value?

The following factors confound estimates of Superfund's property value impacts, contributing to the difficulties encountered in collecting and analyzing data to evaluate impacts, and to the disparity of results. Many previous studies did not address one or more of these factors.

- The characteristics of the site, which often can influence market reaction (sites that are more visible, have noxious odors or a history of fires, explosions, or other events, or contain especially fearsome environmental contaminants such as radioactive materials, may be more likely to have negative property value effects)
- Site size, which was not always explicitly considered in some previous property value studies
- Perceptions of buyers and sellers regarding the extent of the real and perceived health and environmental effects
- Media attention and interest of local and national public interest groups
- Knowledge and perceptions of the local population regarding hazardous waste sites, remediation approaches, and future prospects for cleaned up sites
- Socioeconomic characteristics of the neighborhood
- Economic conditions in the area
- Population density and other measures of neighborhood characteristics
- Cleanup approach and timeliness
- Nature and extent of redevelopment
- Stage of cleanup (Property value effects can operate differently depending on the stage of the cleanup. For some sites, a significant impact occurs prior to discovery; for others, the news of the discovery triggers a negative market reaction. The release of site investigation and feasibility studies, or the publication of the ROD can trigger a partial or complete price rebound, because these events are signs that the "problem" will be resolved. Completion of construction or delisting can also lead to rebound, although sometimes price rebound could take years.)

5.5 Property Values as Indicators of Impacts and Potential Benefits

The disamenities associated with Superfund sites often result in a general decline in the quality of life and property values for both residential and non-residential properties in the area. Thus, property values are a powerful indicator of the extent of the real and perceived negative impacts of Superfund sites on communities. Estimating the extent of this effect is complex and subject to extensive qualifications and explanation. Nevertheless, the available information provides useful insight regarding property values.

The information indicates that the impact of a Superfund site on property values varies widely from site to site and area to area. Generally, the presence of a site tends to reduce property values in the vicinity of a site, and various response actions may eventually lead to a recovery of these values, in whole or in part, at many sites. These results are not universal, the recovery is not always complete, and, for revitalized sites, it is uncertain how much of the recovery is due to the cleanup versus the redevelopment. For some insight into the nature of the uncertainty of the property value impact, see the text box (EPA 2009c)

6. Reduction of Harm in Emergency Situations

While remedial efforts at large sites with long-term cleanup projects (mostly NPL sites) is the most visible part of the Superfund program, the removal program has also been active in protecting millions of people from releases or threats of releases of hazardous substances. This program is at the center of the nation's efforts to respond to emergencies involving hazardous substances. It is responsible for short-term cleanup actions and emergency responses involving hazardous substances. Because of the variety of activities under this program, this section provides a primarily qualitative discussion of the program.

The Superfund Program Plays a Central Role in Emergency Response and Emergency Response Planning in the United States:

- Superfund staff responds to hundreds of spills and accidents involving hazardous substances each year.
- EPA maintains teams of emergency response personnel who provide on-scene technical advice and assistance in all 50 states and territories.
- Superfund plays a leading role in contingency planning for all types of emergencies with other federal, state, and local organizations.
- EPA provides training to police, fire, and other first-responders.

Most removal and emergency actions are conducted at sites that are not on the NPL. EPA classifies removal actions into three categories: emergency responses, time-critical actions, and non-time critical actions. Non-time critical actions generally follow procedures and practices similar to that of NPL sites. Emergency and time-critical removal actions involve a system of partnerships and coordination with a network of federal, state, and local agencies and EPA staff in all 10 regions. Some of the key components of this system are:

- **On-Scene Coordinators (OSCs).** EPA staff includes 250 OSCs in its 10 regional offices. The OSC is the federal official responsible for monitoring or directing responses to all oil spills and hazardous substance releases reported to the federal government. The OSC coordinates all federal efforts with, and provides support and information to, local, state, and regional response communities. These individuals assist and support police, fire, public health, medical emergency management, public works, and other first-responders and related organizations. EPA OSCs have primary responsibility for spills and releases to inland areas and waters, while U.S. Coast Guard OSCs have responsibility for coastal waters and the Great Lakes.
- **EPA's Environmental Response Team (ERT).** The ERT is a group of EPA technical experts that provide around-the-clock advice and assistance at the scene of hazardous substance releases, offering expertise in such areas as waste treatment, biology, chemistry, hydrology, geology, and engineering. The ERT can provide support to the full range of emergency response actions, including unusual or complex emergency incidents. For example, they maintain a diving team that is capable of performing underwater hazardous substance recovery. The ERT has been active in all 50 states, all U.S. territories and Commonwealths, and 28 foreign countries.
- **Contingency Planning.** Through the National Response Framework and National Contingency Plan, EPA plays a leading role in coordinating with federal, state, and local agencies in developing and maintaining contingency plans with different levels of geographic scope. These plans form the backbone of the country's efforts to prepare for and coordinate responses to emergency incidents.
- **Training First Responders.** EPA has provided first-responder training for thousands of state and local personnel.

Superfund Technical Assistance for National Emergencies

- **Anthrax Contamination in a Senate Office Building.** Shortly after the discovery of anthrax contamination in the Hart Senate Office Building in 2001, EPA-led efforts to determine the extent of the problem in all Congressional office buildings and to decontaminate the Hart Building. This type of monitoring and decontamination of anthrax in public buildings had never been attempted previously.
- **World Trade Center Response.** EPA had an important role in responding to terrorism after the World Trade Center and Pentagon attacks on September 11, 2001. Within hours, the On Scene Coordinators (OSCs) and Emergency Response Team (ERT) staff were monitoring air and water quality to determine whether they posed residual threats to human health and the environment. EPA staff provided worker health and safety support, made respirators available to all on-scene personnel, and worked to remove residual hazardous substances, such as fuel in tanks, in the collapsed buildings.
- **Hurricane Katrina Response.** In the aftermath of this massive hurricane that devastated the Gulf Coast in August 2005, EPA emergency response personnel and contractors worked closely with the Federal Emergency Management Agency (FEMA) and state and local agencies to assess the damage, test health and environmental conditions, and coordinate cleanup activities.

6.1 Typical Emergency Response Actions

Because each release incident is different, EPA's emergency response activities vary widely in terms of the method of response and site-specific situations, such as weather conditions, accessibility, and proximity to nearby communities. Some typical emergency response actions may include the following:

- Removing hazardous substances in soil or containers;
- Burning or otherwise treating and destroying hazardous substances;
- Draining waste ponds or repairing leaky waste disposal pits so that hazardous substances do not seep into the ground;
- Using chemicals to neutralize, absorb, or otherwise stop the spread of the hazardous substances;
- Encasing hazardous substances in place or otherwise ensuring that winds or rain do not move them;
- Providing a safe supply of drinking water to people affected by hazardous substance contamination;
- Temporarily relocating residents affected by hazardous substance contamination while cleanup activities take place; and
- Installing fences to prevent direct contact with hazardous substances.

6.2 Removal Program Accomplishments

Since 1980, the Superfund Removal Program has responded to numerous and diverse threats:

- EPA has conducted over 9,400 removal actions, most of which were time-critical or emergency actions.
- EPA has responded to a variety of incidents involving hazardous substances, including:
  - Fire and explosions at operating or abandoned facilities, such as tire fires;
  - Truck accidents and train derailments;
  - Cleanup and monitoring of mercury contamination at schools and private residences;
  - Removal and disposal of chemicals abandoned on roadsides in vehicles or in abandoned or bankrupt facilities or warehouses; and
  - Cleanup and monitoring of hazardous substance releases due to natural disasters, such as floods (e.g., Hurricane Katrina in 2005).

- Since 1980, EPA has participated in the development and management of a system of federal, state, and local responders who field thousands of reports of hazardous substances releases each year from all over the country.
- Over two million people have been provided with a safe supply of drinking water (either bottled water or hook-up to safe local water systems) when their drinking water became contaminated.
- Thousands of people have been moved from the vicinity of dangerous sites and given temporary housing. Most of these people were able to return home as soon as the EPA made the site safe. When necessary, the emergency response program permanently relocated people.
- Superfund actions have resulted in the containment or treatment of hazardous wastes to make sites safe, including: millions of cubic yards of contaminated soil and debris, billions of gallons of contaminated liquids, and hundreds of million gallons of polluted water (EPA 2008).

In addition to the direct benefits of protecting the public health and safety and the environment, the emergency response program contributes to the general psychological health of the public. By ensuring the public and businesses that the government has systems and procedures in place in case of an emergency, the Superfund program improves the general sense of security, which is needed for peace of mind and a healthy business climate.

7. Contributions to Other Cleanup Programs

While the Superfund program is primarily focused on remedial and emergency responses, it has directly and indirectly made substantial contributions to the development and operations of other cleanup programs. Other hazardous waste cleanup programs in the U.S. can be grouped into six major categories—RCRA corrective action, Underground Storage Tanks (UST), Department of Defense (DOD), Department of Energy (DOE), other federal agencies, and state and brownfield cleanups. Over the past 2-1/2 decades, approximately 500,000 sites have been remediated under these pro-grams.[4] The cleanup and, in many cases, redevelopment of these sites have had substantial impacts that parallel those described earlier for Superfund on human health, community revitalization, the environment, and emergency response and preparedness.

Other Cleanup Programs Influenced by Superfund are Substantial

- Other hazardous waste cleanup programs (RCRA corrective action, UST, DOD, DOE, other federal agencies, and state and brown-field cleanups) collectively have addressed hundreds of thousands of contaminated sites in the past and, over the next 30 years, will address an estimated nearly 300,000 sites.
- The impacts of these programs on human health, the environment, and the vitality of communities, are enormous, though diffi-cult to quantify in terms of social welfare benefits measures.

It would be difficult to formally quantify the impacts of the cleanups addressed under all the cleanup programs, and to quantify the role of Superfund's influence on them. The sites in these programs represent a heterogeneous mix of thousands of different situations around the country. Nevertheless, it is of interest to qualitatively discuss Superfund's impacts on these programs:

- The regulations and technical guidance developed under the Superfund program have helped shape those used by other federal cleanup programs and state Superfund and other hazardous waste programs. Some states, such as Illinois, New Jersey, and Washington, have adopted or adapted a

[4] Approximate number of sites already cleaned up = 1,080 Superfund sites (EPA 2010a) + 22,000 DOD sites (DOD 2009) + 6,000 DOE sites (DOE 2010 and EPA 2004a), + 96,000 state and private party sites as of 2001 (ELI, 2002) + 388,000 UST sites (EPA 2010b) = 513,000. This estimate does not include state sites cleaned up after 2001, civilian (non-DOD and non-DOE) federal agency sites, and RCRA corrective action sites.

number of EPA technical and management guidance materials for their cleanup programs, such as EPA's risk assessment guidance and soil screening guidance.

Examples of Superfund Regulations and Guidance Adopted by Illinois

- "Regulated Substance" *means any hazardous waste as defined under Section 101(14) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (P.L. 96-510) and petroleum products including crude oil or any fraction thereof, natural gas liquids, liquefied natural gas, or synthetic gas usable for fuel (or mixtures of natural gas and such synthetic gas)*. [14 ILCS 5/58.2]
- "SSL" means soil screening levels as defined in EPA's *Soil Screening Guidance: User's Guide* and *Soil Screening Guidance: Technical Background Document*, as incorporated by reference in Illinois regulations governing cleanup.
- *Risk Assessment guidance for Superfund, Vol. I: Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors,"* OSWER Directive 9285.6-03 (March 1991).
- *Risk Assessment guidance for Superfund, Vol. I: Human Health Evaluation Manual, Supplemental Guidance, Dermal Risk Assessment Interim Guidance*, Draft (August 18, 1992).
- *Soil Screening Guidance: Technical Background Document,* EPA Publication No. EPA/540/R-95/128, PB 96-963502 (May 1996).
- *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites,* OSWER Directive 9355.4-24 (December 2002).

- Superfund's cleanup levels have driven research and development efforts by government and the private sector. For example, R&D to develop less expensive, faster site characterization and cleanup technologies has been driven by the Program's requirement to meet maximum contaminant levels (MCLs) in all actual or potential drinking water aquifers, except when it is technically impractical as well as by Superfund's nine remedy-selection criteria. Many of these technologies have been adopted by state, brownfield, UST, and RCRA programs.

The Departments of Defense and Energy have large environmental research programs supporting their CERCLA cleanups. These programs, plus EPA-funded research, development, and demonstration efforts, have led to improved site characterizations, cleanup practices, and risk assessments that have helped make cleanups more effective, cheaper, and faster. These efforts have led to implementation of useful technologies, such as in situ chemical oxidation (ISCO), bioremediation, and advanced site characterization approaches.

During the 1990s, the approach to site characterization involved a phased series of site mobilizations. Each subsequent mobilization depended upon the results of the previous samples taken, with the results not becoming available until two to three months after collection. Now the approach is to use new equipment which provides results immediately. Tasks that used to take years can now be done in months, increasing the speed and accuracy of the site investigation.

To meet the MCL cleanup goals for aquifers, groundwater pump and treat (P&T) systems were the technology of choice in the 1980s and 1990s. There were no good alternatives. Pump and treat systems are expensive to build and operate, require considerable amounts of fuel or electricity, and can

Superfund, DOD, and DOE Sponsored Research Has Led to a More Efficient Program and Better Cleanups

- In-situ chemical oxidation can replace or reduce the need to pump and treat groundwater in many applications, resulting in less expensive, quicker cleanups with a lower carbon and energy footprint.
- Today's approach to site characterization enables more accurate delineation of subsurface conditions at lower cost and at a fraction of the time it previously took.
- Bioremediation of chlorinated solvents, which was thought to be impossible in the 1990s, is now the remedy of choice at many sites, allowing the reduction or elimination of long-term pump and treat remedies.

take long periods of time for aquifer cleanup. Today, there are a number of alternatives. For example, bioreme-diation of chlorinated solvents, which was not thought possible in the 1990s, is now the remedy of choice at many sites. In-situ chemical oxidation is now being used to accelerate treatment of contaminants at source zones. This technology is becoming common at UST and dry cleaner sites.

Superfund's routine collaboration with other federal agencies and state programs, combined with its technical, management, and community involvement activities have contributed to the success of all waste cleanup programs currently operating in the U.S.

- The Superfund program's technology transfer and assistance efforts have helped other cleanup programs become aware of and adopt the latest and most effective techniques. Superfund operates one of the world's most extensive collections of site characterization and cleanup information on its CLU-IN web portal (www.cluin.org). The program also sponsors conferences, training, and publication of numerous informational documents. Superfund training programs address all aspects of environmental response, site characterization and management, cleanup approaches, and community involvement. Thousands of people have attended Superfund training events. In addition to Superfund staff, participants have included other federal, state and local government personnel, consulting and engineering firms, technology vendors, and others.
- Most cleanup programs follow site management practices that parallel those of Superfund, including requirements for initial assessments, emergency response, site investigations to determine cleanup needs, evaluation of alternative cleanup approaches, efforts to ensure public participation in decision making regarding site cleanup and reuse, and remedy decision criteria. For example, the RCRA Facility Investigation (RFI) and Corrective Measures Study (CMS) process is modeled on the Superfund Remedial Investigation/Feasibility Study (RI/FS) (EPA 1989). Although state Superfund programs vary from state to state, many have authorities similar to the federal program (ELI 2002).
- EPA has shared the lessons it has learned in developing effective methods for involving communities and collaborating among stakeholders at Superfund cleanup projects with other federal and state cleanup officials. EPA has developed comprehensive procedures and guidance for community involvement activities, and these procedures have become a model for other federal and state cleanup programs. For example, one of EPA's goals in funding state and tribal response programs is to have states and tribes include in their response program *mechanisms and resources to provide meaningful opportunities for public participation, at the local level*…(EPA 2010c). The funding guidance for this program references Superfund's community involvement policies.

In addition to the sites where cleanup has been completed, a significant amount of cleanup work remains to be done. A December 2004 report estimated that under current regulations and practices, nearly 300,000 hazardous waste sites will need to be cleaned up over the next three decades (see table). This estimate does not include sites where cleanup is completed or ongoing, nor does it include estimates for removal actions or oil spills. It is anticipated that the lessons learned in Superfund cleanups will significantly benefit the cleanups at these sites.

Estimated Number of Sites to be Remediated: 2005–2034

NPL (non-federal)	736
RCRA corrective action	3,800
UST	125,000
DOD	6,400
DOE	5,000
Other federal agencies	> 3,000
States and brownfields	150,000
Total	**294,000**

Source: U.S. EPA, *Cleaning up the Nation's Waste Sites: Markets and Technology Trends*, EPA 542-R-04-015, December 2004. Clu-in.org/marketstudy

8. Improved Environmental Practices by Industry

It has been argued that prevention of pollution is the most cost-effective way to protect the public and the environment from exposure to hazardous substances. Prevention generally involves improving waste management practices and modifying industrial and commercial processes to (a) use less hazardous substances, (b) use less materials in general, and (c) reuse and recycle materials to the extent practicable. Thus, a significant benefit occurs when industry improves its industrial practices to produce less waste, better manage its waste, and use fewer hazardous substances. Such practices will avert hazardous waste releases in the future. The reporting requirements and liability provisions of CERCLA, serve as powerful incentives to deter risky industrial and commercial practices that can result in releases: Some factors that deter risky practices include:

- EPA has often used its authority to identify parties responsible for creating or contributing to the pollution at a site.
- EPA has often used its authority to either compel responsible parties to conduct necessary hazardous waste cleanups, or to recover the cost of such actions.
- Citizens may bring suits to enforce CERCLA provisions.
- Federal agencies, states, and tribes may bring actions for damages to natural resources.
- Liability can extend to site owners, facility operators, waste transporters, or anyone who generates hazardous substances.
- The liability is strict, joint, and several. There is no requirement for the responsible party's hazardous substance to be the sole cause of the need for a cleanup. Legal proof of negligence is not required, and conducting activities in accordance with standard industry practices is not considered an adequate defense.

The potentially costly litigation and liabilities that may result from these provisions serve as a powerful deterrent to poor environmental practices. This deterrence has contributed to the substantial improvement in industrial processes and waste management practices over the past 30 years. However, it is difficult, if not impossible, to determine how much of this improvement is also attributable to other factors that have been important over the past three decades. Some other factors that have contributed to deterrence include:

- RCRA and state regulations that directly specify requirements for the management of hazardous substances, as well as penalties for non-compliance.
- Under Title III of the Superfund Amendments and Reauthorization Act (SARA), EPA has established an inventory of routine toxic chemical emissions from certain facilities (Toxic Release Inventory, or TRI). This source makes information on a company's environmental performance readily available to the general public, regulatory authorities, and the investment community.
- In recent years, there has been a general trend of more complete public environmental reporting by corporations, which impacts the investment evaluations and advice in the financial community, and highlights a moral responsibility to protect the environment adopted by many corporate managers.

Although it is impossible to determine the amount of the improvement in industry's environmental performance that is attributed solely to the Superfund liability provisions, anecdotal evidence indicates that it is substantial.

9. Advances in Science and Technology

The Superfund program conducts and sponsors research, development, and demonstration efforts to (a) advance site investigation and cleanup technologies, (b) expand the understanding of toxicology and environmental processes associated with hazardous substances in the environment, and (c) examine the epidemiology and health impacts associated with contaminated sites. These efforts have led to substantial improvements in the efficiency and accuracy of site investigations and more effective, faster, and less costly cleanups. A number of innovative treatment technologies allow cleanups to be conducted with minimal physical disturbance to a site, thereby reducing potential disruptions to nearby communities and ecosystems. Examples of successes of these efforts include:

- Advances in site investigation and cleanup technologies have improved our ability to respond to emergency situations. For example, based upon results of EPA's research program, the Exxon Corporation used bioremediation applications on many miles of shoreline in Prince William Sound, Alaska to help remediate the materials spilled during the March 1989 Exxon Valdez oil spill. The bioremediation technique applied involves adding nutrients to enhance the growth of bacteria naturally present in the environment. These bacteria degrade certain toxic hydrocarbons in oil.
- Using information developed in EPA's research program and extensive experience gained from cleanups of chemical spills and hazardous waste sites, EPA was able to develop and implement a timely response to anthrax contamination in the Hart Senate office building in Washington, DC, and other buildings in 2001. EPA selected, tested, and applied fumigants to successfully decontaminate these buildings, the first cleanup of office buildings contaminated by a lethal form of anthrax.
- EPA has been instrumental in advancing the use of direct push rigs to replace rotary drilling in many applications for the collection of subsurface soil and groundwater samples during site investigations. Compared to conventional rotary drilling, direct push techniques employ more time-saving tools, avoid use of drilling fluids, generate less investigation-derived waste and no drill cuttings, require less field mobilization efforts and site disturbance, and generally require less than half the drilling time. Employment of these technologies has resulted in faster, more appropriate, and less costly cleanups.
- EPA has advanced methods for treating waste in place and for using natural processes, such as bioremediation and phytoremediation, which have enabled the remediation of contaminated materials to be conducted with a minimum of on-site and off-site physical disruption.

The Superfund program encourages the use of these and other advanced approaches through the operation of cleanup technology databases, participating in public/private partnerships, sponsoring forums, and supporting research and development projects conducted by EPA's Office of Research and Development, the National Institute of Environmental Health Sciences, and universities. For example, the Hazardous Waste Clean-up Information (CLU-IN) web site is a tool frequently used by hazardous substance remediation professionals and other parties for information about innovative site characterization and treatment technologies.

10. Reduced Unidentified Potential Future Threats

The final category of impacts refers to reduction of the potential future threats that are not yet fully defined, but may result from the release of hazardous substances into the environment. Although much progress has been made in understanding how substances move through the subsurface, the science and data available may be insufficient to predict long-term impacts of many types of releases. For example, releases into very heterogeneous soil strata or fractured bedrock are difficult to delineate and may pose a serious threat. One class of substances, known as dense non-aqueous phase liquids (DNAPLs), can have unpredictable effects many years into the future if not cleaned up. Once released into the soil or groundwater, DNAPLs are difficult to detect. They are only marginally soluble in water (parts per million) but are toxic at even lower levels (parts per billion).

Once substances are released into the subsurface, there may be considerable uncertainty regarding where they will migrate, the chemical transformations they will undergo, and the effects they will have on ecological systems and human health many years, or centuries, in the future. By preventing, controlling, or cleaning up hazardous substance releases, Superfund actions are leading to the elimination or reduction of these threats.

11. Summary: Beneficial Effects of the Superfund Program

Under the Superfund program, vast amounts of hazardous substances have been cleaned up or isolated from the environment, and incentives have been created to encourage good environmental practices. The effects of these actions are summarized below:

Direct Effects

1. **Improved Human Health**. The reduction of potential hazardous substance exposure of people in the vicinity of Superfund sites is likely to translate into diminished rates of a number of known and unknown acute and chronic adverse health conditions. Many of these conditions are quite onerous, including cancer, congenital abnormalities, reduced cognitive abilities in children, and cardiovascular disease.
2. **Reduction or Reversal of Damages to Natural Resources.** Damage to valuable natural resources in the vicinity of Superfund sites has been mitigated and reversed. Many of these natural resources provide valuable services necessary to sustain humans, including food and water, recreational opportunities, groundwater replenishment, water filtration, and nutrient recycling. Superfund cleanups have also contributed to the maintenance of habitats and ecological diversity.
3. **Improved National Security.** In thousands of emergency response efforts Superfund has reduced the risk of harm when emergencies strike. EPA is using the experience in this work to improve emergency response capabilities at all levels of government. These efforts have helped to (a) minimize or reverse harm to exposed or injured persons, (b) prevent exposure of others, (c) enhance the capabilities of state and local first responders through training, R&D, and technical assistance, and (d) improve emergency preparedness, especially for emergencies that involve hazardous substances and biological contagions.
4. **Improved Community Economics and Quality of Life.** The evaluation, cleanup, and revitalization of Superfund remedial and removal sites have increased the usability of land and led to substantial improvements in the economy, aesthetics, and quality of life in many communities.
   - Superfund actions have made hundreds of vacant or underutilized NPL sites and thousands of non-NPL properties available for productive reuses of all kind, which has contributed to economic and community development, improved quality of life, and reduced energy use in many communities.
   - Through the Superfund program, the status of about 40,000 sites suspected of containing hazardous substances has been determined, resolving uncertainty regarding potential risks, and removing a major obstacle to the reuse of these sites.

Indirect Effects

5. **Contributions to Other Cleanup Programs.** Superfund has contributed substantially to the development and operation of cleanup programs managed by states, tribes, and other federal programs, through funding, R&D, technical assistance, and partnerships.
6. **Improved Environmental Practices by Industry.** The liability provisions in CERCLA, combined with EPA compliance, outreach, and enforcement efforts have provided impetus for industry to (a) participate in state voluntary and other cleanup programs, and (b) modify industrial processes and waste management practices to reduce the risk of future hazardous substance releases into the environment.
7. **Contributions to Environmental and Health Sciences and Technology Innovation.** Through research, development, demonstration, and technology transfer efforts, the Superfund program has advanced site investigation and cleanup methods, knowledge of toxicology and environmental processes associated with hazardous substances in the environment, and knowledge of the health impacts of hazardous substances.
8. **Reduced Unidentified Potential Future Threats.** Superfund actions reduce or eliminate threats that are not fully defined at this time, primarily because we do not have the capability to fully predict the movement of hazardous substances through groundwater, soil, and other media, the chemical transformation they undergo in these media, and the ultimate environmental and human health impacts. In addition to providing a safer environment, avoiding these threats results in a positive sense of well-being.

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