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Love Canal Tragedy

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Abstract: The purpose of this environmental failure case study paper is to provide educational materials for environmental engineering courses dealing with design and operation of landfills for hazardous waste. In 1978, it was discovered that hazardous waste had contaminated homes and schools in the Love Canal area, a former chemical landfill which became a 15 acre neighborhood of the City of Niagara Falls, New York. On August 7, 1978, the United States President Jimmy Carter declared a federal emergency at the Love Canal. The Love Canal became the first man-made disaster to receive such a designation based on a variety of environmental and health related studies. Background, causes and effects of environmental failure, and remediation actions of the Love Canal superfund site are described in this paper. Lessons learned from this case study show the importance of identification of hazardous waste and the proper disposal of hazardous waste for the protection of the public health and the environment.

CE Database subject headings: Landfills; Failures; Canals; Hazardous wastes; Case reports; New York.

Introduction

This paper is a summary of an environmental failure case study which took place at the Love Canal. The purpose of this environmental failure case study paper is to provide educational materials for environmental engineering courses dealing with design and the operation of landfills for hazardous waste. The Love Canal covers 36 square blocks in the far southeastern corner of the Niagara Falls, in New York, along what is now known as 99th Street. The boundaries of the neighborhood are defined by two water bodies: Bergholtz Creek to the north and the Niagara River one-quarter mile (400 m) to the south. The name Love Canal came from the last name of William T. Love, who in the early 1890s envisioned a canal connecting Lake Ontario and Lake Erie. He believed it would serve the area's burgeoning industries with much needed hydroelectricity. After 1892, Love's plan changed to incorporate a shipping lane that would bypass the Niagara Falls. Due to the economic depression, Love's plan failed. Only one mile (1.6 km) of the canal, stretching northward from the Niagara River, was ever dug (<http://en.wikipedia.org/wiki/Love-Canal>; September 21, 2005).

The project was abandoned when a section of the canal about 1,000 m (3,200 ft) long and 24 m (80 ft) wide had been exca-

vated to a depth of the order of 6 m (20 ft). In 1942, the Hooker Chemical and Plastic Company (Hooker) purchased the abandoned excavation site from the Niagara Power and Development Company and began using the canal excavation as a dump site for industrial wastes that included pesticide residues, process slurries, and waste solvents. In total, approximately 22,000 tons of waste contained in metal drums were placed in the excavation during an 11-year period. Later, studies would show that more than 200 different chemical compounds including at least 12 known carcinogens were present. Once filled, the excavation was capped with a loose soil cover (Brown 1979).

History and Background

The former Love Canal landfill is a rectangular, 16 acre tract of land located in the southeast end of the City of Niagara Falls (estimated population 77,050), in Niagara County (estimated population 242,200), on the western frontier of New York State. Aerial photography from 1938 depicts the canal as being about 3,000 ft long and almost 100 ft wide, extending in a north-south axis, with the southern end approximately 1,500 ft from the Niagara River. Much of the canal bed contained impounded water, and there was no visible evidence of waste disposal in 1938. The excavation was reportedly used as a swimming hole for local residents for several decades into the 20th century.

Manufacturing of chemical and allied products was and is a major industrial enterprise of the Niagara County. According to the 1970 data from the New York State Department of Commerce, there were in the county nine major chemical-producing companies employing a total of 5,267 people. Recent surveys by the State Department of Environmental Conservation point to the presence of approximately 100 chemical dump sites in the county (New York State Department of Health 1978).

One of these is the Love Canal landfill, in which the Hooker Electrochemical Company, now the Hooker Chemical and Plastics Corporation (Hooker), admits to the deposition, between

1942 and 1953, of 21,800 tons of chemical wastes from its plants in Niagara Falls. It was common at the time; the company did not install a liner to prevent leaching (Colten and Skinner 1996). The wastes included various chlorinated hydrocarbon residues, processed sludge, fly ash, and other materials, including municipal garbage that the City of Niagara Falls had disposed there for a number of years, concluding in 1953 (New York State Task Force on Toxic Substances Files 1981). Approximately 200 chemicals and chemical compounds have been identified there, originally disposed as liquids and solids in metal drums and other types of containers, according to a November 1978 memo from the New York Commissioner of Health (New York State Department of Transportation Files 1989). Occidental later explained that the site had been chosen because it was sparsely populated at the time, even though six homes were already constructed adjacent to the canal (Silverman 1989). Another factor was that the local geology provided some degree of natural containment due to deposits of soft clay underneath the canal that provided low permeability, thus, limiting the potential for groundwater contamination within the layer of glacial till below.

In April 1953, Hooker sold the Love Canal property, to which it then held title, to the City of Niagara Falls Board of Education. Home building directly adjacent to the landfill was accelerated in the mid 1950s, and in 1954, a public elementary school was built on the middle third of the Love Canal property.

Aerial photography from 1956 shows continuing residential development and soil banks, some of them as high as 15 ft, surrounding parts of the canal bed. By 1966, these hills were no longer apparent, and two streets crossed the landfill north and south of the public elementary school. By 1972, virtually all houses with backyards directly abutting the landfill were completed (New York State Task Force on Toxic Substances Files 1981).

History of the Problem

Although the disposal of hazardous waste at the Love Canal dates back to the early 1940s, the contamination of homes located near the site did not become evident until the mid 1960s, when residents complained of fumes and minor explosions. During the construction of the LaSalle Expressway, noxious fumes, corrosive waters, and oily materials were encountered, according to State personnel and local residents. When Read Avenue was installed some 13 years ago, drums were exposed during the excavation work, which allowed the release of noxious fumes and oily liquids, causing several work stoppages. Noxious fumes and hazardous liquid chemicals were detected in various storm sewers, mostly to the west of the site, and at the outfall which collected the flow from both the 97th and 99th Street sewer lines.

In addition to these problems, land subsidence in the grammar school playground occurred regularly, and the holes are periodically filled with soil. School personnel reported to the County Health Department that school children handled waste phosphorous and received burns. In 1976, the New York Department of Environmental Conservation (NYDEC) conducted its first investigations of suspected leaching into nearby sewers and basement sumps. Based on these and subsequent testing the following year, NYDEC hired an environmental consulting firm, Calspan Corporation, to conduct its own studies and later enlisted the help of the New York Department of Health (NYDOH). In February 1978, NYDOH reported finding “quantitatively

significant” levels of chemicals such as toluene and several benzene compounds in sump samples from eight homes located directly adjacent to the site. Still nothing was done to rectify the problems. It was not until the summer of 1978 that a widespread contamination of the entire neighborhood became evident (Fletcher 2001; New York State Task Force on Toxic Substances Files 1981).

The Niagara Falls and nearby Buffalo communities are known for having harsh winter conditions associated with heavy lake-effect snowfall, due to their proximity to Lake Erie. Added to that, the record-breaking blizzard of 1978 and several other storms that season resulted in even more winter and spring precipitation than is usual for the area (DeLaney 2000). In the following summer, there was a widespread leaching of chemicals at the Love Canal, due to what has been called the “bathtub effect,” whereby water percolated through the clay cap, mixed with the chemicals and seeped laterally through sand and silt as the trench overflowed. The chemicals previously contained in the canal, thus, emerged at the ground surface and migrated into the basements of homes. The homes adjacent to the canal were affected most, but the contamination also spread further (Fletcher 2001).

On August 2, 1978, Dr. Robert P. Whalen, M.D., Commissioner, NYDOH, declared a medical state of emergency at the Love Canal and ordered the immediate closure of the 99th Street School. The second health order spoke directly to the health of the children with a recommendation that families with children under the age of 2 years and pregnant women living nearest the canal should relocate temporarily.

The designated area included homes adjacent to the canal and those across the street, later regarded as Rings 1 and 2. Table 1 describes the chemical compound concentration present in the air of the basements of the homes in Rings 1 and 2 (New York State Department of Health 1978). These compounds include chloroform, trichloroethene, tetrachloroethene, chlorobenzene, and chlorotoluene. Table 2 describes the concentration of ten chemical compounds in the air taken from the basements of homes located at the peripheral of the Love Canal site (New York State Department of Health 1978). People living within this boundary were also urged to avoid using their basements and to stop consuming food from their gardens. The order stated that there was “growing evidence that there is a higher risk of subacute and chronic health hazards, as well as spontaneous abortions and congenital malformations,” presumably limited geographically to the area affected by the health order (Fletcher 2001).

The health effects of the chemicals identified in the Love Canal are listed in Table 3 (New York State Department of Health 1978). Almost all human’s physiologic systems can be adversely affected by exposure to these chemicals identified at the Love Canal site.

The parameters of the health orders continued to expand over the following days and weeks. Five days after the second health order was issued, President Jimmy Carter declared a federal state of emergency in the area, the first ever for a technological hazard (Silverman 1989).

Toxicological Investigation

Since March 1978, the State Health Department’s Division of Laboratories and Research has carried out more than 6,000 analyses of environmental and biological samples associated with the Love Canal. The United States Environmental Protection Agency

Table 1. Organic Compounds in Air Samples of Love Canal, June–August, 1978 ($\mu\text{g}/\text{m}^3$) (New York State Department of Health 1978, Used with Permission)

Location	Number of houses	Lowest value	Highest value	Median	Mean	Percent with measurable level
Ring 1						
North 97th	25	0	393	17	67	92
Ring 1						
North 99th	28	0	142	9.5	29	89
Ring 1						
North Total	53		393	0.12	47	91
Ring 1						
South 97th	22	0	3,816	53.5	427	95
Ring 1						
South 99th	24	0	6,944	24	356	96
Ring 1						
South Total	46	0	6,944	28	390	96
Ring 2						
North 97th	22	0	43	0	6	41
Ring 2						
North 99th	25	0	149	0	12	48
Ring 2						
North Total	47	0	149	0	9	45
Ring 2						
Central 97th	15	0	69	3	10	67
Ring 2						
Central 99th	13	0	170	0	13	15
Ring 2						
Central Total	28	0	170	0	12	43
Ring 2						
South 97th	21	0	63	8	13	62
Ring 2						
South 99th	28	0	37	0	4	43
Ring 2						
South Total	49	0	63	2	8	51
Ring 1						
Total	99	0	6,944	17	207	93
Ring 2						
Total	124	0	170	0	9	47

Note: Chemical compounds monitored are total of 5 chemicals: Chloroform, trichloroethene, tetrachloroethene, chlorobenzene, and chlorotoluene.

(USEPA) also conducted extensive air, water, and soil samplings in homes and yards throughout the Love Canal neighborhood, following a federal emergency declaration in May 1980.

The primary goals for the environmental and toxicological studies were to:

- Identify the chemical compounds present in the Love Canal environment;
- To establish whether the kind or degree of chemical exposure bears a relationship to observed health effects;
- To determine the extent and means of the chemical migration outward from the landfill;
- To validate the efficacy of remedial construction work undertaken at the site; and
- To develop improved methodologies for analyzing toxics in environmental samples and biological specimens.

At the request of the State Interagency Task Force on Hazardous Wastes, the Hooker Chemical Corp. submitted a declaration estimating that 21,800 tons of chemical wastes had been buried

in the Love Canal over a 10-year period, including significant quantities of trichlorophenols (TCP). Laboratory analysis of soil and sediment samples from the Love Canal indicates the presence of more than 200 distinct organic chemical compounds; approximately 100 of these have been identified to date.

Dioxin [2,3,7, and 8 tetrachlorodibenzoparadiioxin (TCDD)], considered one of the most toxic man-made compounds based on animal experimental studies, is one of the chemicals found in the landfill. Since dioxin (TCDD) is a contaminant byproduct formed during the manufacture of trichlorophenols (TCPs), its presence in the Love Canal was suspected when 200 tons of TCPs appeared on the list of chemicals buried at the site; its presence was confirmed in April 1979 using sophisticated analytical equipment at the University of Nebraska's Midwest Center for Mass Spectrometry. The Department of Health has since acquired the same type of mass spectrometry and formed its own dioxin analysis capability.

Table 2. Air Samples Taken from Basements of Houses near Love Canal in July 1978 ($\mu\text{g}/\text{m}^3$) (New York State Department of Health 1978, Used with Permission)

Compounds	No. of times found in houses	Percent of total houses sampled	Highest value observed
Chloroform	23	26	24
Benzene	20	23	270
Trichloroethene	74	84	73
Toluene	54	61	570
Tetrachloroethene	82	93	1,140
Chlorobenzene	6	7	240
Chlorotoluene	32	36	6,700
m + p xylene	35	40	140
o-xylene	17	19	73
Trichlorobenzene	11	13	74

The highest level of dioxin quantified to date at the Love Canal is approximately 300 parts per billion (ppb) in a storm sewer adjoining the canal. Lesser concentrations also have been found in leachate collected from remedial holding tanks, soil samples from the canal and backyards of nearby homes, and sediment and marine life of two creeks bordering the Love Canal neighborhood. The Departments of Health and Environmental Conservation launched an intensive air, soil, and groundwater sampling program in spring 1978, following qualitative identification of a number of organic compounds in the basements of 11 homes adjacent to the Love Canal.

To determine the extent of the chemical migration into the private residences, 800 basement air samples from 400 homes within a four block radius of the landfill were analyzed for seven chemical compounds: Chloroform, benzene, trichloroethene, toluene, tetrachloroethene, chlorobenzene, and chlorotoluene. The mapping of benzene air concentrations revealed no clear patterns of contamination. On the other hand, compounds not present in common household products, such as chlorobenzene and chlorotoluene showed definite clusters of contamination in homes immediately adjacent to the canal, with significantly less evidence of contamination further out (New York State Department of Health 1978).

Evacuation

Evacuation from the Love Canal was a disputed issue that evolved over the course of the crisis. For most residents, the obvious preference was for permanent relocation and the purchase of their homes at fair market value. For those living beyond the boundary of Ring 2, the ultimate goal of most residents was to force the government to purchase their homes as well. Though they would eventually achieve success in that regard, there was no way of knowing it when remedial construction work began in October 1978. Remediation began just 1 month after the decision to purchase the homes in Rings 1 and 2, yet even those residents had not yet been moved.

The residents were apprehensive that the digging would increase their exposure to the chemicals underneath the surface if

Table 3. Health Effects of Compounds Identified at Love Canal (New York State Department of Public Health 1978, Used with Permission)

Compound	Acute effects	Chronic effects
Benzene	Narcosis Skin irritant	Acute leukemia Aplastic anemia Pancytopenia Chronic lymphatic leukemia Lymphomas (probable)
Toluene	Narcosis (more powerful than benzene)	Anemia (possible) Leukopenia (possible)
Benzoic acid	Skin irritant	
Lindane	Convulsions High white cell counts	
Trichloroethylene	Central nervous depression Skin irritant Liver damage	Paralysis of fingers Respiratory and cardiac arrest Visual defects Deafness
Dibromoethane	Skin irritant	
Benzaldehydes	Allergen	
Methylene chloride	Anesthesia (increased carboxy hemoglobin)	Respiratory distress Death
Carbon tetrachloride	Narcosis Hepatitis Renal damage	Liver tumors (possible)
Chloroform	Central nervous narcosis Skin irritant Respiratory irritant Gastrointestinal symptoms	

fumes and contaminated dust were picked up by the wind and blown through the neighborhood, and particularly, if an explosion of fire occurred. In response to these concerns, the Love Canal Task Force run by the New York Department of Transportation agreed to evacuate people in school buses in the event of an explosion or similar problem. On October 10, 1978, the plan also failed its first test of credibility when the buses did not arrive for a trial run emergency evacuation (Gibbs 1981, 1998). Nonetheless, the state offered nothing more until February 1979, when the third public health order, issued by Commissioner Axelrod, offered financial assistance for temporary relocation. Even then, however, the benefit was only for families with pregnant women and children under the age of 2 years living in Rings 1–3 (Fletcher 2001).

It was not until June 1979 that the evacuation policy was expanded further. The New York Supreme Court ordered temporary relocation for any residents in the area who furnished certificates from physicians attesting that illness or breathing difficulties were associated with the remediation work at the Love Canal (Levine 1982; Silverman 1989). They were particularly frustrated that many doctors were reluctant to write certificates that might be interpreted as an assignment to blame to Hooker. This controversy became especially thorny on August 25, 1979, when chemical fumes from the site combined with the summer heat and humidity made several residents violently ill. In early September, the New York Supreme Court ruled that the Task Force should relocate any Love Canal resident who complained of poor health effects without medical certification. The number of families living in hotels grew to 120, a total of 425 individuals (New York State Department of Health 1978; Silverman 1989). The state government paid \$7,500 per day for these expenses (New York State Department of Health 1978).

The residents of the Love Canal were allowed to stay in their motel rooms until November 5, 1979, when the deep excavation work was completed (New York State Department of Health 1978). The residents of Ring 3 returned to their homes, but it would take another 6 months before they were assured of permanent relocation. On May 21, 1980, Governor Carey made a formal request to President Carter to declare a second state of emergency in the area and to provide aid for the relocation of over 700 families in Rings 1, 2, and 3. This request was prompted by a long series of events, the most recent of which had occurred the day before when angry Love Canal residents held two USEPA representatives hostage for 5 h, before releasing them unharmed (Silverman 1989). On May 22, during his unsuccessful bid for re-election, President Carter made a series of announcements about the Love Canal, one of which was to grant Carey's request for the state of emergency and the extension of permanent relocation to Ring 3. The action provided for the purchase of all privately owned properties, including businesses and rental housing (Fletcher 2001).

Remedial Actions

This site has been addressed in seven stages: Initial actions and six major long-term remedial action phases, focusing on:

- Landfill containment with leachate collection, treatment, and disposal;
- Excavation and interim storage of the sewer and creek sediments;
- Final treatment and disposal of the sewer and creek sediments;
- Remediation of the 93rd Street School soils;

- Emergency declaration area (EDA) home maintenance and technical assistance by the Love Canal Area Revitalization Agency (LCARA), the agency implementing the love canal land use master plan; and
 - Buyout of homes and other properties in the EDA by LCARA. Three other short-term remedial actions:
 - Frontier Avenue sewer remediation;
 - EDA soil removal; and
 - Repair of a portion of the Love Canal cap, were completed in 1993 and are discussed below.
1. **Initial Actions:** In 1978, New York State Department of Environmental Conservation (NYSDEC) installed a system to collect leachate from the site. The landfill area was covered and fenced and a leachate treatment plant was constructed. In 1981, Environmental Protection Agency (EPA) erected a fence around Black Creek and conducted environmental studies.
 2. **Landfill Contaminant:** In 1982, EPA selected a remedy to contain the landfill by constructing a barrier drain and a leachate collection system; covering the temporary clay cap with a synthetic material to prevent rain from coming into contact with the buried wastes; Demolishing the contaminated houses adjacent to the landfill and nearby school; conducting studies to determine the best way to proceed with further site cleanup; and monitoring to ensure the cleanup activities are effective. In 1985, NYDEC installed the 40 acre cap and improved the leachate collection and treatment system, including the construction of a new leachate treatment facility.
 3. **Sewers, Creeks, and Berms:** In May 1985, as identified in a record of decision (ROD), EPA implemented a remedy to remediate the sewers and the creeks which included:
 - Hydraulically cleaning the sewers;
 - Removal and disposal of the contaminated sediments;
 - Inspecting the sewers for defects that could allow contaminants to migrate;
 - Limiting access, dredging, and hydraulically cleaning the Black Creek culverts; and
 - Removing and storing Black and Bergholtz Creeks' contaminated sediments.

The remediation of the 102nd Street outfall area, as originally proposed in the 1985 ROD, has been addressed under the completed remedial action for the 102nd Street Landfill Superfund Site. The State cleaned 62,000 linear ft of storm and sanitary sewers in 1986. An additional 6,000 ft were cleaned in 1987. In 1989, Black and Bergholtz Creeks were dredged of approximately 14,000 cubic yards of sediments. Clean riprap was placed in the creek beds, and the banks were replanted with grass. Prior to final disposal, the sewer and creek sediments and other wastes (33,500 cubic yards) were stored at Occidental Chemical Corporation's Niagara Falls RCRA-permitted facilities.
 4. **Thermal Treatment of Sewers and Creeks Sediments:** In October 1987, as identified in a second ROD, EPA selected a remedy to address the destruction and disposal of the dioxin-contaminated sediments from the sewers and creeks:
 - Construction of an on-site facility to dewater and contain the sediments;
 - Construction of a separate facility to treat the dewatered contaminants through high temperature thermal destruction;

- Thermal treatment of the residuals stored at the Site from the leachate treatment facility and other associated Love Canal waste materials; and
- On-site disposal of any nonhazardous residuals from the thermal treatment or incineration process. In 1989, OCC, the United States, and the State of New York, entered into a partial consent decree to address some of the required remedial actions.

Also, in 1989, EPA published an explanation of significant differences (ESD), which provided for these sediments and other remedial waste to be thermally treated at OCC's facilities rather than at the site. In November 1996, a second ESD was issued to address a further modification of the 1987 ROD to include off-site EOA approved thermal treatment and/or land disposal of the stored Love Canal waste materials. In December 1998, a third ESD was issued to announce a 10 ppb treatability variance for dioxin for the stored Love Canal waste materials. The sewer and creek sediments and other waste materials were subsequently shipped offsite for final disposal; this remedial action was deemed complete in March 2000.

5. **93rd Street School:** The 1998 ROD selected remedy for the 93rd Street School property included the excavation of approximately 7,500 cubic yards of contaminated soil adjacent to the school followed by on-site solidification and stabilization. This remedy was re-evaluated as a result of concerns raised by the Niagara Falls Board of Education (NFBE), regarding the future reuse of the property. An amendment to the original 1988 ROD was issued in May 1991; the subsequent selected remedy was excavation and off-site disposal of the contaminated soils. This remedial action was completed in September 1992. Subsequently, LCARA purchased the 93rd Street School property from the NFBE and demolished the building in order to return the resulting vacant land to its best use.
6. **Home Maintenance:** As a result of the contamination at the site, the Federal government and the State of New York purchased the affected properties in the EDA. LCARA is the coordinating New York State agency in charge of maintaining, rehabilitating, and selling the affected properties. Pursuant to Sec. 312 of CERCLA, as amended, EPA has been providing funds to LCARA for the maintenance of those properties in the EDA and for the technical assistance during the rehabilitation of the EDA. EPA awarded these funds to LCARA directly through the EPA cooperative agreement for home maintenance and technical assistance. The rehabilitation and sale of these homes have been completed.
7. **Property Acquisition:** Sec. 312 of CERCLA, as amended, also provided \$2.5M in EPA funds for the purchase of properties (businesses, rental properties, vacant lots, etc.) which were not eligible to be purchased under the earlier Federal Emergency Management Agency loan/grant. EPA awarded these funds to LCARA through a second EPA cooperative agreement.
8. **Short-Term Remedial Actions:**
 - The Frontier Avenue sewer project required excavation and disposal of contaminated pipe bedding and replacement with new pipe and bedding;
 - The EDA 4 project required the excavation and disposal of a hot spot of pesticide contaminated soils in the EDA and backfill with clean soils; excavated materials were disposed of off-site; and

- The Love Canal cap repair required the liner replacement and regrading of a portion of the cap. These short-term remedial actions were completed in September 1993 (<http://www.epa.gov/region2/superfund/npl/0201290c.pdf>; September 21, 2005).

Cleanup Progress

In 1988, EPA issued the Love Canal EDA Habitability Study (LCHS), a comprehensive sampling study of the EDA to evaluate the risk posed by the site. Subsequent to the issuance of the final LCHS, NYSDOH issued a Decision of Habitability, based on the LCHS's finding. This Habitability Decision concluded that:

- Areas 1–3 of the EDA are not suitable for habitation without remediation but may be used for commercial and/or industrial purposes; and
- Areas 4–7 of the EDA may be used for residential purposes.

In 1998, the wastewater discharge permit issued to OCC was modified to include the treatment of the leachate water from the 102nd Street Landfill site. In March 1999, the Love Canal leachate collection and treatment facility (LCTF) began receiving the 102nd Street leachate water for treatment. The following represent the makeup of the various Love Canal waste materials:

- Sewer and Creek Sediment Wastes: 38,000 yard³ @ 1.6 tons/yard³=62,240 tons;
- Collected LCTF DNAP (2003): 6,000 pounds;
- Collected 102nd Street DNAPL: 14,400 pounds;
- Spent Carbon Filter Wastes (2003): 40,380 pounds;
- Treated LCTF Leachate: 4.35 MG (million gallons); and
- Treated 102nd Street Landfill Treated Leachate (2003): 0.58 MG (million gallons).

OCC is responsible for the continued operation and maintenance of the LCTF and groundwater monitoring. The site is monitored on a continual basis through the numerous monitoring wells which are installed throughout the area. The yearly monitoring results show that the site containment and the LCTF are operating as designed.

As shown above, numerous cleanup activities, including landfill containment, leachate collection and treatment, and the removal and ultimate disposition of the containment sewer and creek sediments and other wastes, have been completed at the site. These completed actions have eliminated the significant contamination exposure pathways at the site, making the site safe for nearby residents and the environment. The site was deemed construction complete on September 29, 1999. In September 2003, EPA issued a Five-Year Review Report that showed that the remedies implemented at the site adequately control exposures of site contaminants to human and environmental receptors to the extent necessary for the protection of human health and the environment. The next five-year review is scheduled for September 2008 (<http://www.epa.gov/region2/superfund/npl/0201290c.pdf>; September 21, 2005).

Conclusions

- Politics, public pressure, and economic considerations all take precedence over scientific evidence in determining the outcome;
- Characteristic of such events is that the victims, although hostile to Hooker Chemical, directed most of their rage at an indecisive, aloof, often secretive, and inconsistent public health establishment;

- Lawsuits against Occidental Petroleum Corporation, which bought Hooker chemical in 1968, were initiated by both the State of New York and the U.S. Justice Department to cover costs of the cleanup and the relocation programs and by over 2,000 people who claimed to have been personally injured by the buried chemicals. In 1994, Occidental agreed to pay \$94 million to New York in an out-of-court settlement, and the following year, the federal case was settled for \$129 million. Individual victims have, thus far won in excess of \$20 million from the corporation; and
- In early 1994, it was announced that the cleanup of the condemned homes in the Love Canal had been completed, and it was safe to move back to the area. The real estate company offering the inexpensive refurbished homes for sale had chosen to rename the area "Sunrise City" (<http://onlineethics.org/edu/precol/classroom/cs6.html>; September 21, 2005).

Lessons Learned

- Proper disposal of hazardous waste is important in protecting the public health;
- Site selection and site preparation are important factors to be considered for hazardous waste disposal. Proper leachate collection and treatment systems and adequate lining and cover systems shall be provided for the hazardous landfill sites;
- Citizens, environmental practitioners, and environmental engineering and science students need to be educated in environmental protection and health effects of hazardous waste; and
- Industrial plants need to observe environmental and professional ethics when dealing with disposal of hazardous waste in areas adjacent to residential area.

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