

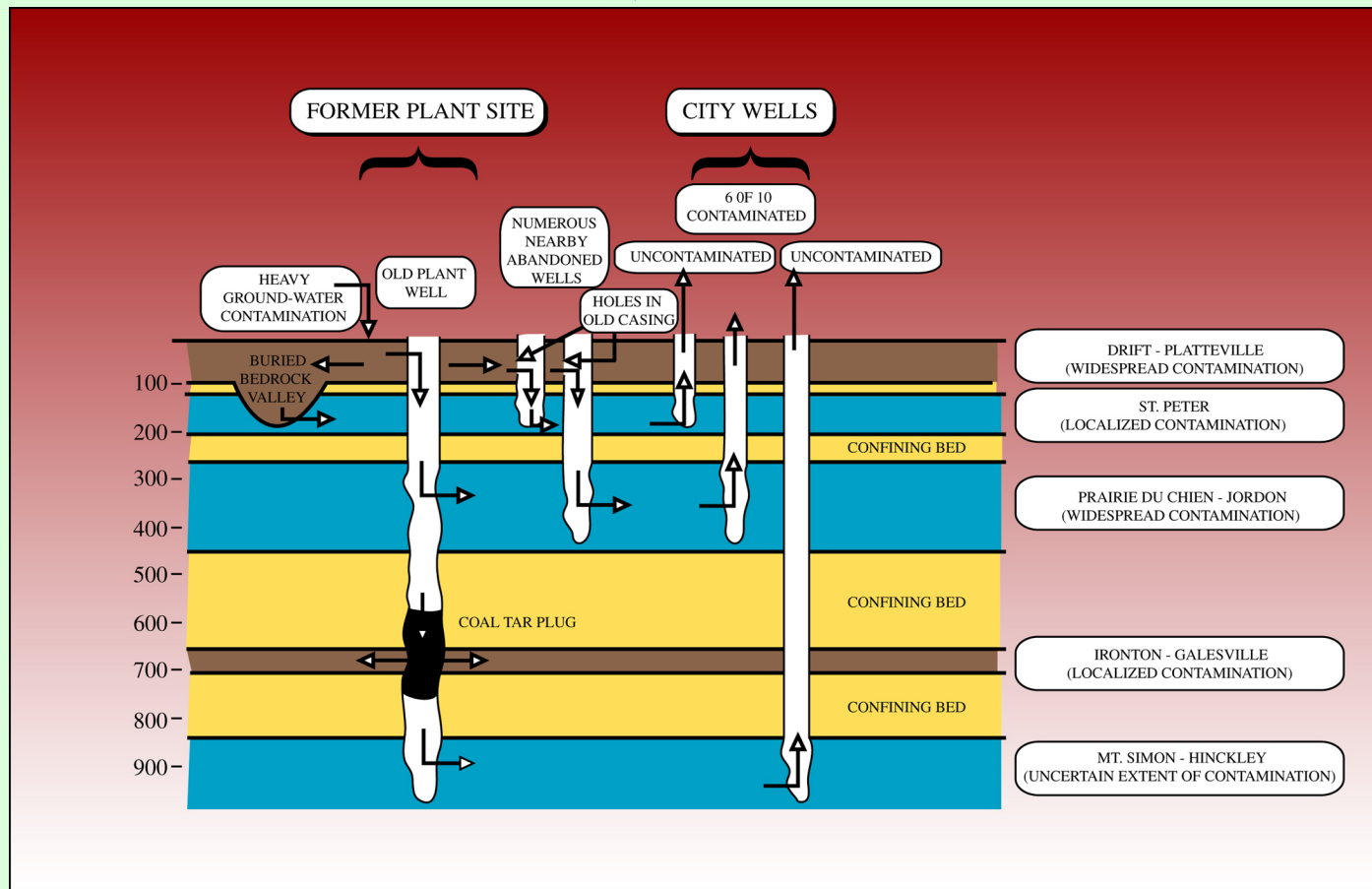
Lecture 1

Introduction to Remediation Technology



U.S. Environmental Protection Agency, September 30, 2002. Emergency Response Program. United States Environmental Protection Agency. Washington, D.C. <http://www.epa.gov/superfund/programs/er/resource/photos1.htm>. Accessed December 20, 2002.

REILLY TAR & CHEMICAL SITE



Between 1917 and 1972, Reilly Tar & Chemical Corp. operated a coal tar distillation and wood preserving plant on 80 acres in St. Louis Park, Minnesota. Wastes from the operation were disposed of on the site and in a network of ditches that discharged to an adjacent wetland. The wastes contained many compounds, including polynuclear aromatic hydrocarbons (PAH), some of which are carcinogenic. Soil and ground water below the wetland and the southern portion of the site are heavily contaminated. Seven wells have been closed. All draw on the Prairie du Chien-Jordan Aquifer, which provides most of the drinking water for local communities. This is the top priority site in Minnesota.

In the late 1970s, 28 multiaquifer wells were reconstructed to prevent the spread of contamination. In 1982, U.S. Environmental Protection Agency (U.S. EPA) provided funds to the Minnesota Pollution Control Agency (MPCA) to clean out two contaminated wells which had been used for disposal of site wastes. In 1984, a Consent Order was issued requiring Reilly Tar, the potentially responsible party (PRP) as owner and operator of the site, to construct a granular activated carbon treatment plant for two existing contaminated municipal wells, to restore drinking water and to contain the contaminant plume from contaminating other municipal wells. The granular activated carbon treatment plant was completed in 1986. A Consent Decree (CD) was subsequently signed by the PRPs, U.S. EPA and the MPCA in September, 1986. In 1986 and 1987, a number of pumping wells were constructed in the various groundwater aquifers beneath the site to remove the contaminant sources and to contain the spread of the contaminant plume. Another granular activated carbon treatment plant was completed in 1993, to allow a municipal well to be used for containment of the contaminant plume. Two additional pumping wells were also completed in 1991 and 1995. It is estimated that as of 1996, 6.2 billion gallons of groundwater contaminated with PNAs had been pumped and treated. An additional pumping well was constructed in the Summer of 1997. Construction at the site is now complete and a Preliminary Close-Out Report was issued on June 30, 1997.

STRINGFELLOW ACID PITS, CA



Source: U.S. Environmental Protection Agency,
[http://yosemite.epa.gov/r9/sfund/SPHOTOS.NSF/57079f1ed19a0334882565cd006099c5/15d3b6f6f6ad7993882565cd0082879f/\\$FILE/Saerz1nw.jpg](http://yosemite.epa.gov/r9/sfund/SPHOTOS.NSF/57079f1ed19a0334882565cd006099c5/15d3b6f6f6ad7993882565cd0082879f/$FILE/Saerz1nw.jpg). Accessed May 13, 2004.

STRINGFELLOW SITE DESCRIPTION AND HISTORY

Description: From 1956 until 1972, the 17-acre Stringfellow site was operated as a hazardous waste disposal facility. Over 34 million gallons of industrial waste, primarily from metal finishing, electroplating, and pesticide production were deposited in evaporation ponds. Spray evaporation procedures were used to decrease the volume of wastes in the ponds. In 1969, excessive rainfall caused the disposal ponds to overflow and resulted in the contamination of Pyrite Creek and Channel. In 1978, heavy rains caused the California Regional Water Quality Control Board (CRWQCB) to authorize a controlled release of 800,000 gallons of wastewater from the site to prevent further waste pond overflow and massive releases. An additional 500,000 gallons of liquid wastes were removed at that time to a Federally approved facility. In 1979 and 1980, heavy rains again threatened releases from the waste ponds. Between the years 1975 and 1980, approximately 6.3 million gallons of liquid wastes and materials contaminated with pesticides were removed from the site. The neighboring community, Glen Avon, has a population of approximately 10,000 people. A contaminated groundwater plume potentially affected private drinking water wells, however, since 1989 the community has received water from public utilities and no longer relies on groundwater.

Initial Actions: From 1980 to 1984, three groundwater extraction wells, a subsurface barrier structure, and an on-site surface water drainage system with gunite channels were built. All liquid wastes at the surface of the site were removed to a Federally approved hazardous waste disposal facility. With the exception of 1,000 cubic yards of DDT-contaminated soil, which were taken to a Federally approved facility, contaminated soils from the site were used to fill waste ponds. The surface was graded, covered with clean soil, and seeded. In 1984, the State completed initial cleanup measures including fencing the site, maintaining the existing soil cap, controlling erosion, and disposing of the leachate extracted above and below the on-site clay barrier dam. In 1989, residences that had been receiving bottled water from the State were connected to the Jurupa Community Services District. **Pre-Treatment Plant:** In 1984, the EPA selected a remedy for interim treatment of contaminated groundwater. The remedy featured installing a pre-treatment system consisting of lime precipitation for removing heavy metals and granular activated carbon treatment for removing VOCs. The treated groundwater is discharged to an industrial sewer line, which ultimately discharges to a publicly owned treatment works system. Additional interceptor and monitoring wells were installed to extract contaminated groundwater downgradient of the site. The State completed installation of the pre-treatment plant in 1985. As of March 1996, nearly 128 million gallons of groundwater had been extracted and treated. **Source Control:** In 1984, the State completed an investigation to identify and evaluate alternatives to control the source of contamination. At that time, the State determined that continuing the pumping and treating of contaminated groundwater is sufficient to reduce contamination at the site. The treatment system will operate until established cleanup levels have been met. **Lower Canyon:** In 1987, the EPA selected a remedy to: 1) capture and treat groundwater in the lower canyon area of the site with a groundwater barrier system, 2) install a peripheral channel to divert clean surface water runoff from upgradient areas, 3) extend the existing gunite channels southward to discharge surface water into Pyrite Creek, and 4) reconstruct the Pyrite Creek Channel. The potentially responsible parties installed the groundwater barrier system and reconstructed the Pyrite Creek Channel. The State designed the system and completed construction of the northern channels in 1990. **Community Wells and Source Control:** In 1988, the State and the EPA completed an investigation determining the type and extent of contamination in the canyon and community areas. In 1990, the EPA selected a remedy that called for the installation of a groundwater extraction system in the community to treat contaminated groundwater that has migrated downgradient to the area, possibly followed by reinjection of the treated water. The potentially responsible parties have installed an initial community wells extraction system, to attempt to hydraulically control the plume of contaminated groundwater. Further work was begun in September 1997 to install an additional extraction well in order to put the remaining portions of the plume under hydraulic control.

In addition, the EPA's 1990 remedy selected dewatering of the on-site groundwater, a more aggressive effort to remove water from the groundwater table, as an interim source control measure. The potentially responsible parties have installed an initial system but more work may still be needed. The potentially responsible parties also conducted field studies of soil vapor extraction in the on-site area, and paper studies of reinjection. During 1997, the State carried out additional investigation of the source area and began a well drilling program to enhance the capability of the dewatering facilities at the site.

STRINGFELLOW GROUND-WATER PLUME

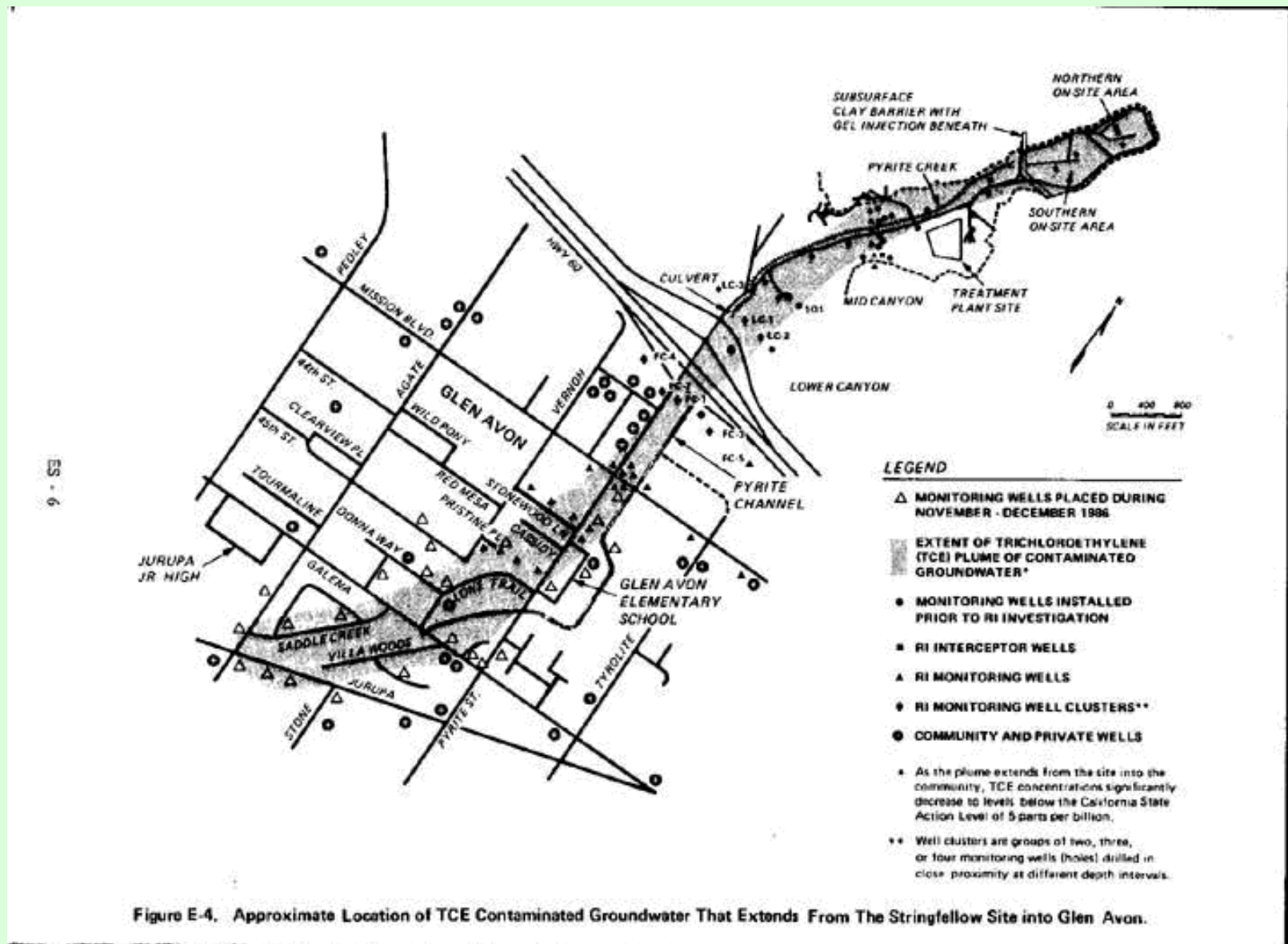
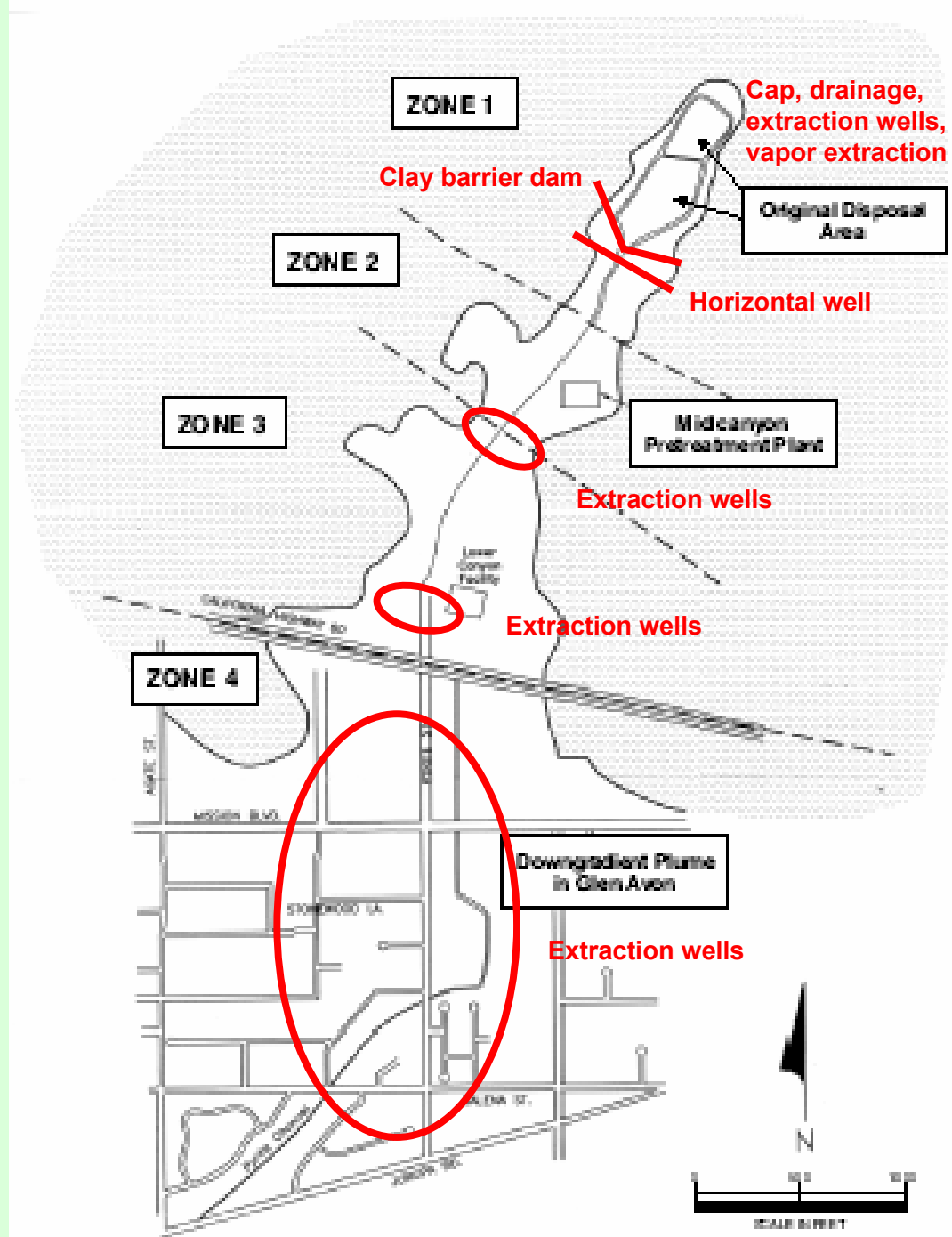


Figure E-4. Approximate Location of TCE Contaminated Groundwater That Extends From The Stringfellow Site into Glen Avon.

REMEDIAL ACTIONS

Estimated eventual cleanup cost:
\$400 million to
\$700 million

Source: U.S. Environmental Protection Agency.



UNION CHEMICAL, MAINE

See Union Chemical site images at the Web site of the U.S. Environmental Protection Agency:

<http://www.epa.gov/region01/superfund/sites/union/35789.pdf>

(Accessed May 13, 2004.)

The 12-acre Union Chemical Company, Inc. site began operations in 1967 as a formulator of paint and coating strippers. In 1969, the company expanded its operations and began handling and recovering petrochemical-based solvents. In 1979, as part of the recovery process, the company added a fluidized bed incinerator to burn contaminated sludges, still bottoms, and other undetermined hazardous wastes. Some of these types of waste were burned in an on-site boiler that provided heat and operating power to the facility. Between 1979 and 1984, the plant was cited by the State for deficiencies or violations of several operating licenses. The State closed the waste treatment operations in 1984, at which time approximately 2,000 drums and 30 liquid storage tanks containing hazardous waste were stored on the site. The on-site soil and groundwater contamination resulted from improper handling and operating practices such as leaking stored drums, spills, use of a septic tank and a leachfield for disposal of process wastewater, and could also be attributed to past disposal methods.

In 1984, the State and EPA collectively removed all surface drums, over 100,000 gallons of liquid wastes and sludges from aboveground storage tanks, and some contaminated soil from the site. In 1994, EPA with the Maine Department of Environmental Protection and community concurrence, adjusted the treatment to soil vapor extraction of the contaminated soils. In addition, the groundwater extraction system was significantly expanded to clean up groundwater more quickly at the site. In late 1994 and early 1995, EPA began limited source control actions in preparation for the soil vapor extraction and groundwater extraction systems. The soil vapor extraction and groundwater extraction systems began operating in early 1996. Compliance sampling of the site soils in September 1998 demonstrated that the soil performance standards had been achieved.

INDUSTRIPLEX 128, WOBURN, MA



Source: US EPA

From 1853 to 1969, a succession of manufacturers at the site produced chemicals, insecticides, munitions, and glue products made from raw and chrome-tanned animal hides. As a result of these activities, large waste piles of animal hides remain. Soil at the site is contaminated with lead, arsenic, and chromium, and the groundwater beneath portions of the site is contaminated with benzene, toluene, arsenic, and chromium. Since 1969, a variety of industrial and commercial establishments have occupied portions of the site. Approximately 60 acres are currently used for warehousing and distribution.

The cleanup plan included controlling the sources of contamination by demolishing buildings on the site and constructing several protective covers (e.g., soil, clay, and synthetic layers, concrete foundations, asphalt parking lots) over portions of the approximately 110 acres of contaminated soil. The plan called for a system to collect and treat gases that may form under the covers. The cleanup plan also identified an area of highly contaminated groundwater requiring treatment to reduce contaminants and limit migration away from the site.

INDUSTRIPLEX 128 TODAY



Source: U.S. EPA

A 135,000 square foot Target discount store is one of the several redevelopment projects planned for the site.

WOODLANDS SUPERFUND SITE, NJ

The Woodland Route 72 Dump site is a 12 acre industrial dump located along Route 72, just two miles away from an almost identical site on Route 532. Both are on the National Priorities List. From the early 1950s to the mid-1960s, various wastes were brought to this uncontrolled disposal site in 55-gallon drums and in bulk transport. Records indicated that the wastes were dumped into open pits and trenches, and then burned. However, investigations revealed that substantial amounts of these wastes were just buried.

EDC (ethylene dichloride or 1,2-DCE) tar was major waste.

Also, BCEE = bis(2-chloroethyl) ether

One generator hauled 50,000 drums from one plant alone starting in 1951. Ground-water contamination plume is over 1 mile long.

By January 1991, a combined amount of approximately 100,000 cubic yards (160,000 tons) of contaminated waste materials were removed from both the Route 532 and Route 72 sites and disposed of by the potentially responsible parties at an EPA-approved facility.

The New Jersey Department of Environmental Protection (NJDEP) completed a study of soil and ground water pollution at the site in 1989. In 1990, EPA and NJDEP selected the cleanup remedy, which included excavating all contaminated surface materials and disposing them at an approved offsite facility, and installing a ground water extraction and treatment system, with reinjection of the treated water back into the aquifer. By January 1991, waste materials were removed and disposed of by potentially responsible parties at an EPA approved facility. In 1993, a subsurface soils study was completed, which indicated that there was no contamination in the subsurface soils that poses a risk to human health and the environment. In September 1993, NJDEP documented that no further action was necessary regarding the subsurface soils; EPA concurred. In 1997, the potentially responsible parties conducted a study that analyzed and compared the groundwater remedy selected in the Record of Decision (ROD) with an alternative combination of air sparging-soil vapor extraction with natural attenuation. In April 1999, NJDEP amended the groundwater remedy from the extraction and treatment system selected in the 1990 ROD to a combination of air sparging-soil vapor extraction with natural attenuation; EPA concurred.

MASSACHUSETTS MILITARY RESERVATION

See image at the Web site of the
Massachusetts Military Reservation
Installation Restoration Program:
http://www.mmr.org/Cleanup/about_fs.htm
(Accessed May 13, 2004.)

FIRE TRAINING AT MMR



Source: Massachusetts Military Reservation Installation Restoration Program, <http://www.mmr.org/irp/genprog/images/EFfta1-B.gif>. Accessed May 13, 2004.

FIRE TRAINING AT MMR



Source: Massachusetts Military Reservation Installation Restoration Program, <http://www.mmr.org/irp/genprog/images/EFFTA1.gif>. Accessed May 13, 2004.

GRACE CHEMICAL, ACTON, MA



Source: Peter Shanahan.

The W. R. Grace and Company site covers approximately 200 acres. The site was the former location of the American Cyanamid Company and the Dewey & Almy Chemical Company. These companies produced sealant products for rubber containers, latex products, plasticizers, resins, and other products. Operations at the W. R. Grace facility included the production of materials used to make concrete, container sealing compounds, latex products, and paper and plastic battery separators. Effluent wastes from these operations flowed into several unlined lagoons (the Primary Lagoon, Secondary Lagoon, North Lagoon, and Emergency Lagoon), and solid and hazardous wastes were buried in or placed onto an on-site industrial landfill and several other disposal areas. These other waste sites include the Battery Separator Lagoons, the Battery Separator Chip Pile, the Boiler Lagoon, and the Tank Car Area. In addition, the by-products of some chemical processes were disposed of in the Blowdown Pit. Since 1973, residents in South **Acton** have filed complaints about periodic odors and irritants in the air around the W. R. Grace plant. Investigations in 1978 indicated that two municipal wells, Assabet #1 and #2, were contaminated. As a result of these findings, the Town took precautionary action and closed the two wells. Discharge to all lagoons and the Battery Separator Area ceased in 1980. The site is bounded in part by Fort Pond Brook and by the Assabet River.

Groundwater is contaminated with volatile organic compounds (VOCs) and heavy metals including lead, arsenic, chromium, and nickel. Sediments are contaminated with cadmium. The soil and sludge in the disposal areas are contaminated primarily with arsenic and VOCS, including vinyl chloride, ethyl benzene, benzene, 1,1-dichlorethylene, and bis(2-ethylhexyl)phthalate.

OU I and OU II activities at the site have been completed. Activities included the removal, solidification/stabilization, and placement/capping of contaminated soils and sludges into an on-site landfill. A Thermal Oxidation Unit is currently treating landfill gases from the recovery vents in the landfill. A Five Year Review was completed for the site in September, 1999. A groundwater recovery and air stripping tower is also currently operated at the site and its effectiveness will be evaluated in the RI/FS for OU# 3. Currently the potentially responsible parties are performing the OU#3 RI/FS for on-site and off-site groundwater contamination. Field activities for the RI/FS began in early 2000 and are scheduled to be completed by Spring 2001.

Photo by P. Shanahan

MW MANUFACTURING, PENN.



Source: Peter Shanahan.

The 15-acre MW Manufacturing site in Valley Township, Pennsylvania, was a recovery operation for scrap wire. The main building was being used as a storage facility, and a smaller building was occupied by a metal fabrication operation by a caretaker resident who was evicted by the land owner in 1993. Since 1993, no commercial activities have occurred at the site. The recovery process, which changed the polyvinyl chloride (PVC) insulation around the wire into granular black carbon sludge, also helped dissolve heavy metals like lead, zinc, and copper into the waste materials. Workers then treated the copper wire with chlorinated solvents. The spent solvent apparently was dumped on the site. Metal Wire (MW) Manufacturing, the first owner, used both mechanical and chemical processes and went bankrupt in the early 1970s. The current owner, Warehouse 81, Inc., used a mechanical process. Waste accumulation on the site consists of an 86,000-gallon surface impoundment, 32,000 cubic yards of finely divided scrap wire called "fluff," a buried underground tank, and 13,000 cubic yards of contaminated soil. While the mechanical process generated the most fluff, the chemical processes were responsible for the biggest environmental impact.

Approximately 800 drums of Polychlorinated By phenol (PCB) contaminated waste were transported off site for incineration in 1992. In 1990, the EPA selected a remedy for the cleanup of the fluff pile, which entailed excavation of the fluff pile wastes and underlying soils, on-site burning of the wastes and soils, and disposing of the incinerator ash in an EPA-approved hazardous waste landfill. Engineering designs began in 1990. The treatability study for burning of fluff and soil was completed and the results indicated that burning of fluff could cause a potential threat to the public due to emissions of dioxin which is a byproduct of burning of fluff. Therefore, EPA made a decision not to implement the selected remedy. Additional PRP searches in 1992 identified records that led to Lucent Technology (formerly AT&T) and Pennsylvania Power & Lights (PP&L) as Potential Responsible Parties (PRPs).

One of the PRPs, Lucent Technology, proposed alternate remedies and conducted a focus feasibility and treatability study to demonstrate the viability of other remedies. EPA reviewed this work and issued a Record of Decision (ROD), December 22, 1997, revising the 1990 decision document. This new ROD called for the ex-situ (outside of the immediate area) stabilization of the fluff, lagoon sediment and surface soils and the backfilling the excavated areas with the stabilized material. These areas will then be covered with two feet of clean topsoil, regraded and vegetated to prevent ponding and to control erosion. Soils contaminated with Non-Aqueous-Phase Liquids (NAPLs) will be treated with low temperature thermal desorption. Tank and drum contents and other debris remaining at the site will be transported off site to an appropriate facility. Institutional controls such as deed restrictions and fencing will insure security and protectiveness as will a continuing monitoring and Operation and Maintenance program.

In 1992, the EPA selected a remedy for the groundwater contamination - providing public water to the affected residences and businesses, and pumping and treating the groundwater, and discharge of treated water to a nearby creek. Under a Unilateral Administrative Order, the public water line installation was completed by Lucent Technology in the summer of 1996. Pre-design study for the groundwater pump and treat portion is ongoing.

Both the groundwater pump and treat and the soil stabilization constructions should be complete in the year 2000. Groundwater pumping and treating will continue for 30 years or until cleanup standards are achieved.

Photo by P. Shanahan

BLACKFOOT RIVER: MINE TAILINGS



Source: Montana Department of Environmental Quality, Remediation Division Activities and Accomplishments: Upper Blackfoot Mining Complex.
<http://www.deq.state.mt.us/rem/Accomplishments/cecrubmc.asp>.
Accessed December 1, 2002.

Tailings and waste rock dumps have contaminated the surface water, sediments, groundwater, and soil in this region (approximately 15 miles from Lincoln, MT). The area was known as the Upper Blackfoot Mining Complex, which included the following: Mike Horse, Anaconda, Carbonate, Edith, Mary P, and Paymaster mines. The mines have been inactive for about 50 years now, but heavy rains caused the impoundment to fail in 1975 and metal-laden water flooded into the Blackfoot River. The mines are located at the headwaters of the Blackfoot River, which provides drinking water for the town of Lincoln (15 miles downstream).

Montana Department of Environmental Quality, February 2, 2002. Remediation Division Activities and Accomplishments: Upper Blackfoot Mining Complex.
<http://www.deq.state.mt.us/rem/Accomplishments/cecrubmc.asp>. Accessed December 1, 2002.

COAL-FIRED POWER PLANT BARRY, ALABAMA

- 5-unit 1525 MW power plant (coal, oil, and natural gas fired units)
- Unlined ash pond for fly and bottom ash
- Operated since 1954
- Ash pond is 624 acres (for comparison MIT campus is 153 acres)
- Ash is known to contain arsenic, mercury, chromium, selenium, boron at elevated concentrations

COAL-FIRED POWER PLANT REMEDIATION

- Remediation will require:
 - Dredging and consolidating 7.5 million cubic yards (\$58 million) following by capping
- Total remediation = approx. \$100 million
- Switchyard has PCBs from transformers
- Southern Company has 31 plants

MANUFACTURED GAS PLANTS



Source: Peter Shanahan.

Preserved manufactured gas plant in Concord, New Hampshire. Manufactured gas plants produced fuel gas from coal and were common in most cities prior to the mid-1900s. Residuals include coal tar, cyanide, and other wastes. Coal tars typically are found in the subsurface as dense non-aqueous phase liquids (DNAPLs).

Photo by P. Shanahan

SEAWAY BOATS SITE, MAINE



Source: Peter Shanahan.

Used solvents in manufacture of fiberglass boats. Complaints of odors led to investigation and discovery of contaminants in nearby private water wells. Subsequent EPA removal action to remove drums of hazardous materials from site.

Photo by P. Shanahan

SEAWAY BOATS SITE, MAINE



Source: Peter Shanahan.

LEAKING UNDERGROUND STORAGE TANKS



Source: Peter Shanahan.

The U.S. Environmental Protection Agency (EPA) estimates that there are about 716,000 federally regulated USTs buried at over 269,000 sites nationwide (as of March 2001). Nearly all USTs at these sites contain petroleum. These sites include marketers who sell gasoline to the public (such as service stations and convenience stores) and nonmarketers who use tanks solely for their own needs (such as fleet service operators and local governments). EPA estimates about 25,000 tanks hold hazardous substances covered by the UST regulations.

LEAKING UNDERGROUND STORAGE TANKS



As of Dec 1998 when UST rules became fully effective:
1,236,000 tanks closed
892,000 tanks still active
371,000 confirmed releases

Photo by P. Shanahan in West Acton, MA

Source: Peter Shanahan.

LEAKING UNDERGROUND STORAGE TANKS

See image at the Web site of the Kansas Department Health and Environment, Superfund Unit: KDHE Bureau of Environmental Remediation, Assessment and Restoration Section. www.kdhe.state.ks.us/ber/ars/superfund_unit.html.

(Accessed May 13, 2004.)

This is a "tank yank"

Cleanup costs depend on a variety of factors, including the extent of contamination and state cleanup standards. The average cleanup is estimated to cost \$125,000. If only a small amount of soil needs to be removed or treated, cleanup costs can run as low as \$10,000. However, costs to clean more extensive soil contamination can reach \$125,000. Corrective action for leaks that affect groundwater can cost from \$100,000 to over \$1 million, depending on the extent of contamination. The presence of methyl tertiary-butyl ether (MTBE) can lead to a substantial increase in cleanup and drinking water treatment costs.

What cleanup activities have taken place?

As of March 31, 2001, states have used Trust Fund and state money to:

Confirm over 417,000 releases,

Oversee or conduct more than 12,800 emergency responses,

Oversee or initiate more than 375,000 cleanups,

Oversee or complete more than 258,000 cleanups, and

Oversee or conduct more than 1,468,000 closures.

LEAKING UNDERGROUND STORAGE TANKS

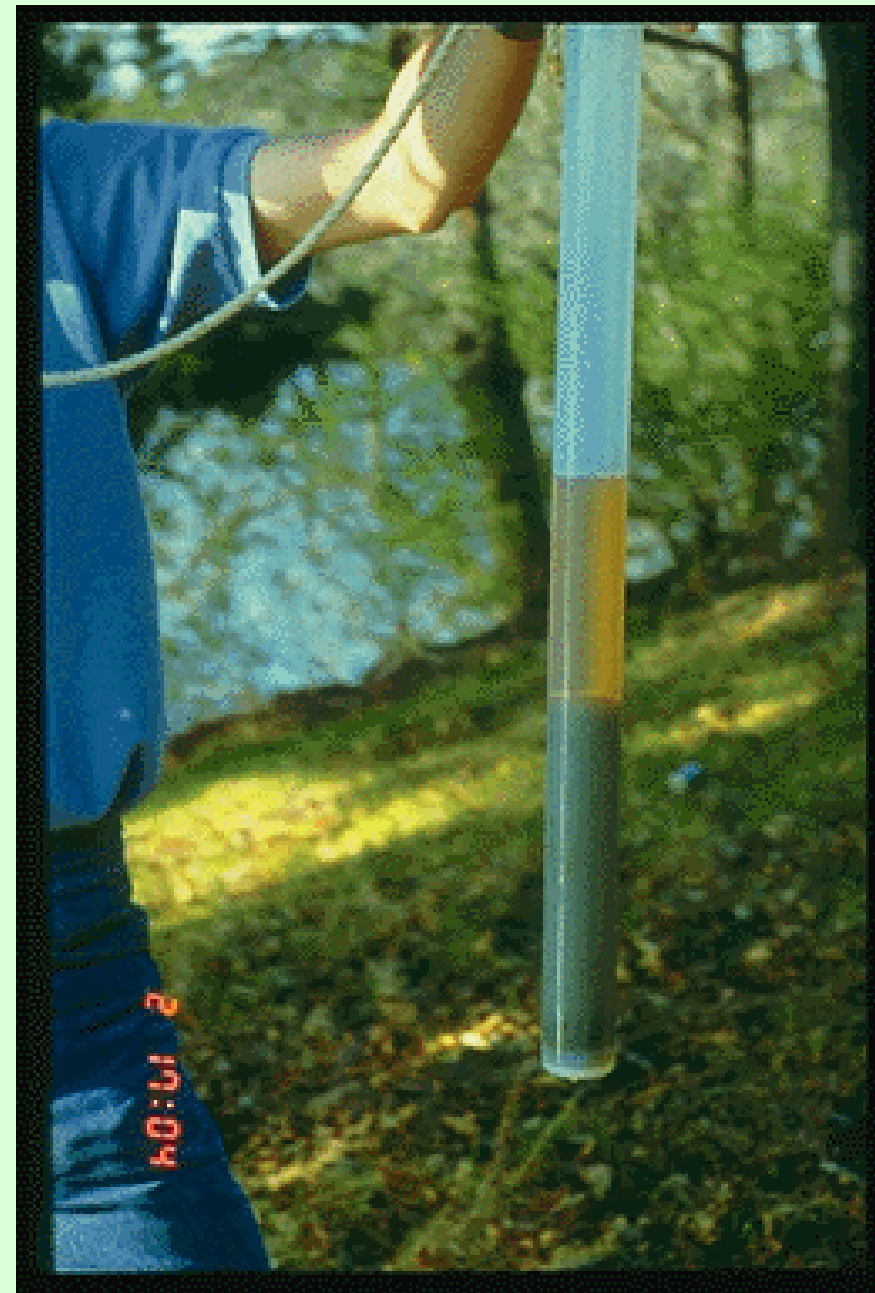


Source: U.S. Environmental Protection Agency, August 7, 2002. Office of Underground Storage Tanks (OUST). U.S. Environmental Protection Agency. Washington D.C. www.epa.gov/swrust1/graphics/miscpix1.htm. Accessed January 28, 2003.

Until mid-1980s, most tanks were bare steel – subject to corrosion and leakage.

LEAKING UNDERGROUND STORAGE TANKS

Source: U.S. Environmental Protection Agency, August 7, 2002. Office of Underground Storage Tanks (OUST). U.S. Environmental Protection Agency. Washington D.C. www.epa.gov/swrust1/graphics/miscpix1.htm. Accessed January 28, 2003.



Petroleum products are lighter than water and hence float as LNAPL (light non-aqueous phase liquid) on top of the ground water. Picture shows water and LNAPL in a transparent bailer used to sample a monitoring well.

LANDFILL

See image at the Web site of Zero Waste America,
Landfills: Hazardous to the Environment,
<http://www.zerowasteamerica.org/Landfills.htm>.

(Accessed May 13, 2004.)

LANDFILL LEACHATE COLLECTION



Source: The D.O.E. Consortium for Research on Enhancing Carbon Sequestration in Terrestrial Ecosystems.
<http://csite.esd.ornl.gov/research.html>. Accessed May 13, 2004.

LANDFILL GAS COLLECTION



Source: NASA Goddard Space Flight Center, "NASA Warms Up to Maryland's Trash," <http://www.gsfc.nasa.gov/topstory/2003/0508landfill.html>. Accessed May 13, 2004.

LINER SYSTEMS

See images at the following Web sites:

Engineering Design in Geotechnics and the Environment UK Ltd., Geosynthetics.

http://www.edgeconsultants.co.uk/liner_for_landfill.html.

Pennsylvania Department of Environmental Protection, How New Pads are Built.

http://www.dep.state.pa.us/dep/deputate/enved/go_with_inspector/landfill/constructing_pads.htm.

(Accessed May 13, 2004.)

Summary: What each site illustrates

Reilly Tar & Chemical

- Importance of hydrogeology
- Interdisciplinary nature of work
- DNAPL
- Subtleties of risk

Stringfellow Acid Pits

- Superfund not necessarily just
- Costs may be very high
- Ground-water impacts significant

Union Chemical

- Typical solvent site and remediation approach

Industriplex

- Site reuse: “Brownfields” site

Olympia Avenue

- Surprising contaminant sources

D’Imperio Site

- Innocent landowner provision

Woodland Site

- Historical knowledge
- Cleanups can be difficult

MMR

- Military sites are sources
- Large plumes, but variable dispersion

Summary: What each site illustrates

Kansas City Airport

Contamination from routine industrial practices

Innovative remedy (dual-phase vapor extraction)

W.R. Grace, Acton

Threat to public water supplies

Point-of-use treatment

\$70 million cleanup

Platt-Saco-Lowell site

Metals (chromium) contamination

Value of historical photos

MW Manufacturing

Joint and several liability

Anaconda Site

Super(?) Fund

Plant Barry Ash Pond

Large scale of sites (624 acres vs. 153 acre MIT campus)

Manufactured Gas Plant Sites

Common type of site

Importance of historical research

Seaway Boats

Hazwaste sites are everywhere!

Summary: What each site illustrates

LUST (leaking
underground storage
tank) sites

Hazwaste sites are
everywhere!

Very common type of site

LNAPL

Landfill

Major topic of this course