Eastland Woolen Mill

Pump and Treat—Steam—Ex Situ Thermal Desorption—In Situ Chemical Oxidation—Biostimulation

Site Name: Eastland Woolen Mill
Site Location: Corinna, Maine
Technology Used:

- Short-Term Pump and Treat
- Thermal (Steam)
- Excavation and Ex Situ Thermal Desorption
- In Situ Chemical Oxidation (ISCO) (Sodium Persulfate)
- Biostimulation, if needed, after ISCO treatments

Regulatory Program: Superfund NPL
Remediation Scale: Full
Project Duration: 1983 to present

Site Information: Eastland Woolen Mill was a textile mill that began operation around 1909. The former mill structure included several connected buildings with a floor space of approximately 250,000 ft^2. The mill ceased operation in 1996, and the majority of the property is now owned by the Town of Corinna.

Contaminants: Hazardous substances were likely used throughout the operating history of the mill. Sampling by the Maine Department of Environmental Protection (MEDEP) and EPA identified chlorobenzenes (mono-, di-, and tri-) in the soil, groundwater (Table 1), surface water, and sediment as the principal contaminants. Elevated soil levels of cadmium, chromium, zinc, dieldrin, and chlorinated solvents such as trichloroethene and 1,1,1-trichloroethane also appear to be related to the site. Chlorobenzenes were reportedly used in large quantities from the 1960s through closure. They were a major component of the dye-aid used in the dye kettles to add color to the wool. Non-aqueous phase liquids (NAPL) were present in the soil and bedrock beneath the building and the East Branch of the Sebasticook River. Groundwater contamination has spread to local water supply wells, including a multi-unit retirement community. A plume with high concentrations of chlorinated benzene compounds exists in bedrock groundwater to depths greater than 300 ft below ground surface (bgs). The bedrock plume extended 1,200 ft laterally along a southwest-northeast axis and approximately 400 ft downgradient from the source area.

Table 1. Initial Groundwater Contaminant Concentrations

Contaminant	Overburden Plume[1]	Bedrock Plume[1]	Water Solubility (µg/L)[2]
Benzene	40	5	1,780,000
Chlorobenzene	19,000	6,300	500,000
1,2-Dichlorobenzene	6,000	3,700	100,000
1,3-Dichlorobenzene	380	180	111,000
1,4-Dichlorobenzene	2,900	2,700	49,000
1,2,4-Trichlorobenzene	7,400	4,800	19,000

[1] Maximum Detected Concentration in µg/L
[2] J. Montgomery and L. Welkom. 1991. Groundwater Chemicals Desk Reference. Lewis Publishers, 640 pp.

Hydrogeology: Starting at the ground surface, soil consists of locally derived fill, underlain by fluvio-glacial deposits including a glacial till, thinly bedded silty fine sand, lower glacial till, and a weathered shaly-siltstone of the Waterville Formation. Soil thickness ranges from 17.7 to 41.5 ft in the immediate area of the mill. Underlying the heavily weathered bedrock is moderately fractured bedrock.

Recharge from infiltrating precipitation within upland areas replenishes upland bedrock groundwater, which then flows downward and laterally toward the river valley, where ultimately it discharges to overburden groundwater and surface water. Very little of this recharge contributes to lateral flow moving out of the local hydrologic system through the overburden and be-

drock aquifers. Bedrock groundwater moves through a network of fractures composed of eastward-trending bedding plane and axial plane fractures and north- to northwesterly trending joints. As bedrock groundwater approaches the river channel and begins to pass underneath, vertical head differentials rapidly turn upwards. The vertical extent of capture appears to be the entire active thickness of the fractured bedrock aquifer

Project Goals: The goals for the cleanup of Eastland Woolen Mills included:

- Connecting residences on well water impacted by the site to the municipal system to prevent exposure to contaminants
- Cleaning up site soil for unrestricted use
- Preventing further migration of contaminants from the site
- Eventually restoring the site groundwater to MCLs, the state maximum exposure guidelines (MEGs), or, in the absence of either, a cancer risk of no greater than 1 x 10^{-6} (whichever was lower)

Cleanup Approach: A time-critical emergency response by the state of Maine removed chemicals and hazardous materials from the site buildings and equipment. The contaminated soil source areas were the result of leaking underground storage tanks, direct discharge to the river, and releases from inside the site buildings. In order to access the DNAPL under the buildings, EPA found it necessary to demolish the structures. Following demolition, the contaminated overburden soil was excavated and staged for future treatment by ex situ thermal desorption.

The river sediment contained DNAPLs. There is a strong groundwater to surface water recharge in the area, and this allows for the contaminants to dissolve into the water entering the sediments and hence contaminate the surface water. Rather than try to dredge the sediments, it was decided that it would be more environmentally sound to move about 100 yards of the river channel, dewater the contaminated sediment area, and excavate and stage the soil (for ex situ thermal desorption in the future). This was done in 2001.

Soil treatment was initiated during the non-time critical removal action (NTCRA) with the construction of three soil treatment units in 2002. Each unit contained two beds capable of processing between 280 and 500 tons of soil. The units operated by injecting steam into the soil and capturing the off-gas for treatment and offsite disposal. NTCRA treatment of contaminated soil was completed in 2003.

Three areas in saturated zones ranging from six to 40 ft deep were not accessible for excavation. A pilot study was conducted that compared Fenton's Reagent with iron-catalyzed sodium persulfate (ICP). The Fenton's study area was injected with 10,000 gallons of sulfuric acid and ferrous sulfate and 11,534 gallons of hydrogen peroxide while the ICP study area was injected with 5,580 gallons each of persulfate and chelated iron (+2) solution. The study found that the ICP was more effective because it had a longer half life and hence could achieve greater subsurface distribution. ISCO was carried out in two phases under the removal action.

In 2005, 20 injector wells ranging in depth from 15 to 30 ft were used to inject 13,319 gallons of persulfate solution and 13,514 gallons of chelated iron solution into two of the areas. These injections resulted in a 90% reduction of dissolved contaminants and a 71% reduction of residual contaminants. This met the cleanup goals for these areas.

Eleven injection wells were used to treat the third area with 19,256 gallons of persulfate solution and 19,423 gallons of chelated iron solution. This achieved a 63% reduction in dissolved contaminants and a 38% reduction in residual contaminants. This treatment did not meet site remedial goals and further treatment by ISCO was left for the formal ROD.

The 2002 ROD called for ISCO treatment of the contaminated bedrock aquifer. Fifteen bedrock wells were placed to evaluate the aquifer and

gather data for the injection system design. Bedrock fractures were characterized using borehole geophysics, and water samples were collected by packer methods. DNAPL distribution in shallow fractures and rock matrix properties were assessed by methanol extracted rock samples. Evaluation of the methanol extracted rock data indicated that contaminant diffusion into the weathered bedrock matrix and the oxidized bedrock adjacent to fractures has occurred. The mass of contaminants contained in the rock matrix is estimated to be far greater than free DNAPL.

A multi-well aquifer pumping test was initiated utilizing six pumping wells. During the test, individual well flow rates were gradually increased or decreased depending on individual well responses. Following the pumping test a conservative interwell tracer test (CITT) was designed and performed under forced gradient conditions to demonstrate that measurable flow paths exist within the aquifer. Data was used to evaluate dilution factors to verify the scale at which adequate minimum oxidant and surfactant concentrations could be maintained and to demonstrate sufficient aquifer connection at a scale suitable for treatment. A partitioning interwell tracer test was also carried out at the same time as the CITT.

An electrical resistivity tomography and induced polarization (IP) system were completed prior to and in conjunction with the CITT to identify preferential pathways of saline solutions in the fracture system between individual boreholes. Selected IP profile panels were also completed to provide potential evidence for the presence or absence of DNAPL in the weathered bedrock and potentially contaminated fractures.

Results of continued groundwater monitoring and the above studies led the EPA to change its approach. A ROD amendment was issued in September 2006. The amendment dropped long-term pump and treat and surfactant flushing from the remedies, but retained ISCO and biostimulation. The soil and sediment excavation and treatment along with the non-time critical removal ISCO treatments had removed considerable source material. These removals coupled with institutional controls that shut down nearby pumping wells resulted in considerable shrinkage of the contaminant plume.

Full-scale ISCO treatment was carried out between 2007 and 2010. Following the ISCO treatment a multi year rebound study was begun to determine if additional injections are necessary to achieve the cleanup objectives. Application of biostimulants may also be implemented after completion of the ISCO program.

Project Results: The project constructed four ex situ steam treatment units that processed 100,000 tons of contaminated soil (Table 2). The system captured about 10,000 pounds of contaminants which were sent off site for disposal. Less than 10% of the processed soil failed the treatment criteria. Twenty-two of 25 acres have been cleaned up and made ready for reuse, to date. A 20-unit seniors housing facility, a recreational park, and veteran's memorial have been constructed on part of the land. In 2012 EPA deleted a large portion of the land from the NPL site (Figure 1)

The groundwater contaminant plume has shrunk by about 40% (Figures 2 and 3).

Re-routing the East Branch of the Sebasticook River has reduced chlorobenzene contamination in its sediment and surface water. As the groundwater is cleaned up, its discharge into the river should meet surface water standards.

Table 2. Summary Statistics of Soil Treatment

Contaminant	Initial Average Concentration[1]	Average Post Treatment Concentration[1]	Percent Contaminant Reduction
1,2,4-Trichlorobenzene	72.2	5.6	92
1,2,3-Trichlorobenzene	20.2	1.7	91
1,2-Dichlorobenzene	12.9	.74	94
1,3-Dichlorobenzene	1.1	.28	76
1,4-Dichlorobenzene	9.6	.66	93
Chlorobenzene	2.8	.18	93

[1] Concentrations are in mg/kg

Sources:

Personal contact with Ed Hathaway, August 2007, 2011, 2012.

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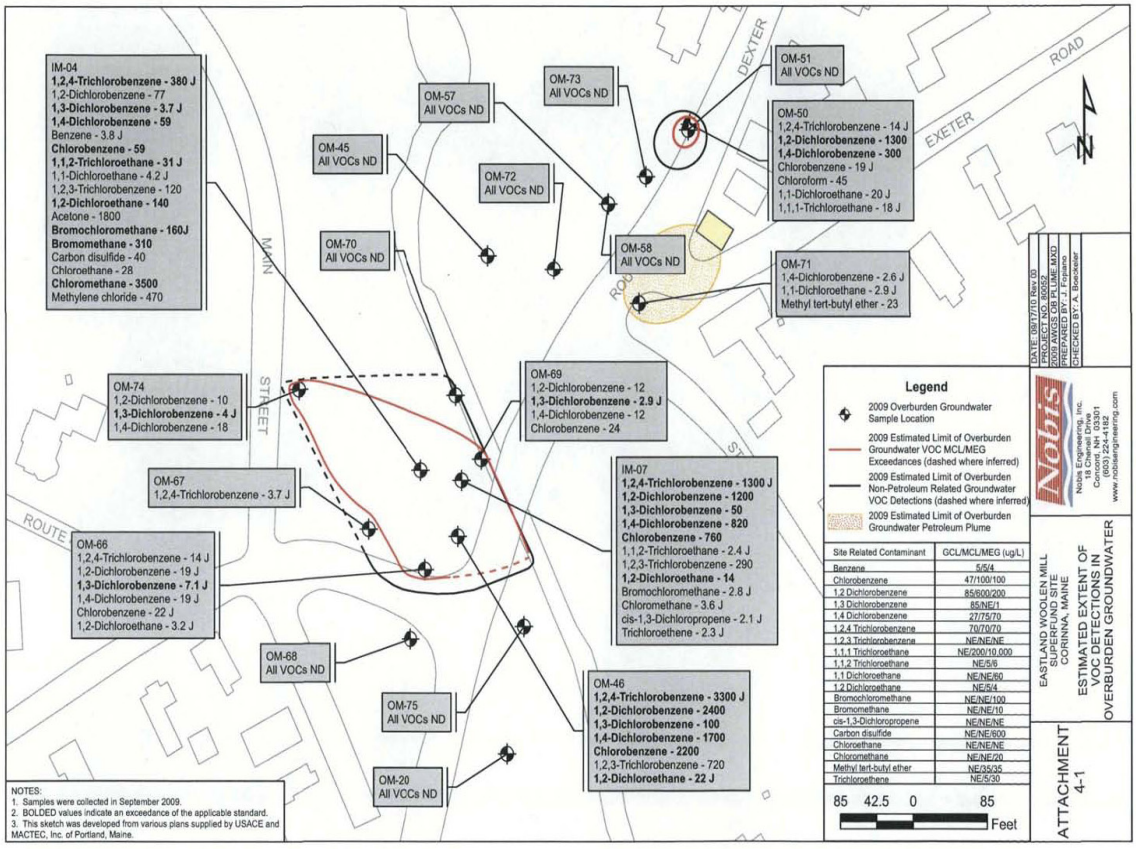

Figure 2. Estimated Overburden Groundwater Plume at Eastland Woolen Mill August 2010

Source: U.S. EPA 2010

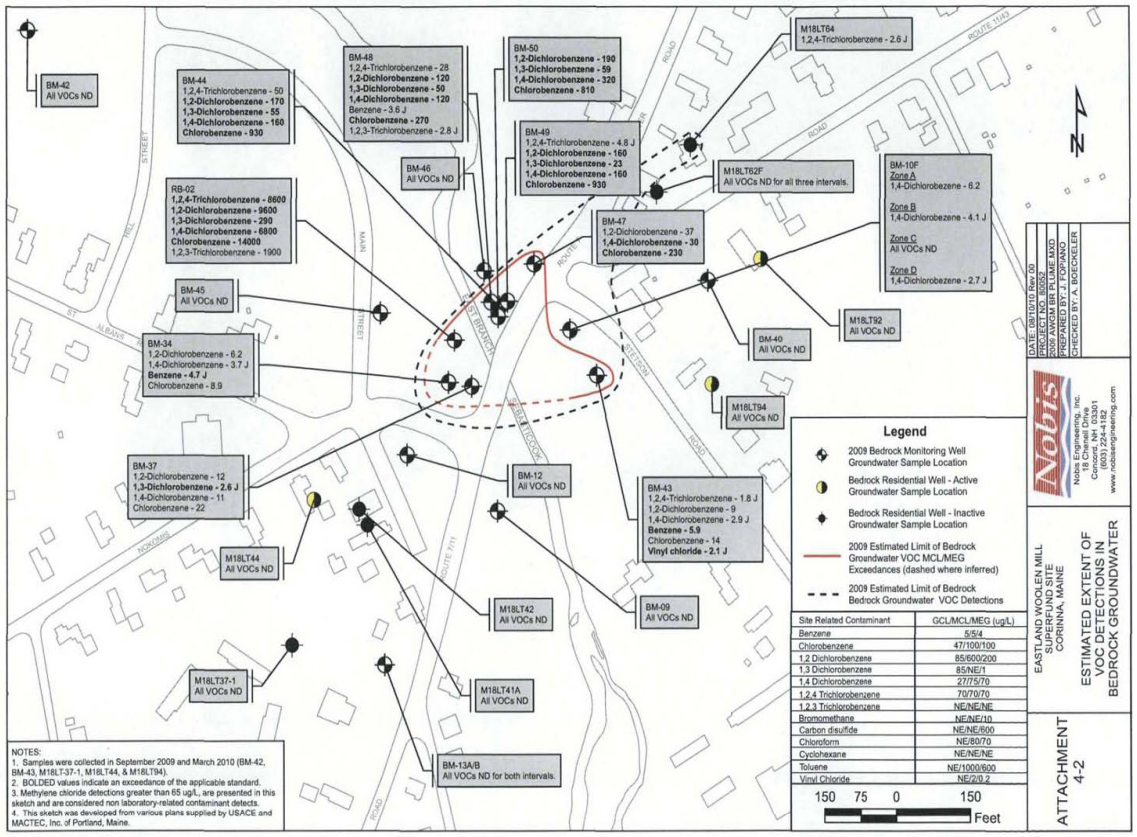

Figure 3. Estimated Bedrock Groundwater Plume at Eastland Woolen Mill August 2010

Source: U.S. EPA 2010