Cost and Performance Summary Report
In Situ Chemical Reduction at the Morses Pond Culvert, Wellesley, Massachusetts

Summary Information [1, 2, 4, 5, 9]

The Morses Pond Culvert Site is located in Wellesley, Massachusetts. As shown in Figure 1, the site includes a residential property and portions of properties owned by the Town of Wellesley and the Massachusetts Bay Transportation Authority. Morses Pond drains into a 200-ft long culvert which discharges under the railroad tracks into a pond (Paintshop Pond) downstream of the site. The southern portion of the site includes a steeply sloped, 35-foot high, earthen embankment that is divided by the culvert into eastern and western embankments. The northern portion of the site includes a 0.2 acre cove area. The site is adjacent to a town beach and additional residential properties.

In 1994, in response to the presence of stained soils around the culvert at the site, the Massachusetts Department of Environmental Protection (MADEP) collected one surface water and six surface soil samples. Results from the analyses of these samples showed soils containing chromium at levels as high as 10,000 mg/kg, and surface water containing hexavalent chromium at a concentration of 210 ug/L and zinc at concentrations above ambient water quality criteria. A 1998 Phase 1 investigation identified elevated levels of total chromium, hexavalent chromium, and lead in the soil at the site. In December 1998, MADEP covered the portions of the site nearest the culvert with geotextile fabric and polyethylene tarps and installed fencing to minimize erosion and human exposure to the soil, in response to evidence that portions of the site were being used by the public for recreation. Results of additional site investigations conducted in 1999 identified levels of total chromium as high as 129,000 mg/kg and hexavalent chromium as high as 31,000 mg/kg in surface soils located on the residential property, the embankment, and areas adjacent to the pond, and levels of total chromium as high as 10,800 mg/kg in soils and sediments in the culvert and cove areas.

The suspected source of the contamination at the Morses Pond site was a former paint factory that was operated by the former Henry Woods Paint Company until approximately 1900, when it burned down. Chromium-laden pigment wastes were thought to have been taken from the former paint factory, located to the south of the Morses Pond site, and used as fill material for improving the railroad embankment around the culvert.

In September 2000, EPA signed a removal action memorandum for the site based on the threats posed by the site to the local population and the environment. The removal action was started on October 12, 2000. The engineering design plans and specifications for the removal action were prepared by the U.S. Army Corps of Engineers (USACE).

The removal action included excavation and off-site disposal of contaminated soil and sediment from the site. Excavated soil and sediment were stockpiled and tested, then shipped off-site for disposal in an approved landfill. For the embankment area, excavation and off-site disposal was conducted for contaminated soil to a maximum depth of 4 ft. However, because of slope stability and structural concerns with the steep embankment area, excavation of contaminated soils deeper than 4 ft was determined to not be practical or safe.

Although not required for the removal action, EPA opted to use in situ treatment in an attempt to reduce the long-term mobility of residual contamination at depth. In situ chemical reduction using calcium polysulfide was performed from September to October 2001 to reduce hexavalent chromium to less mobile and less toxic trivalent chromium. This in situ treatment application is the focus of this report.

Following in situ treatment and excavation activities at the site, low permeability caps were installed in the eastern and western portions of the embankment area. Site closure and demobilization activities were conducted from July to August 2002. The removal action was completed on August 7, 2002. MADEP will oversee maintenance of the caps and future groundwater studies at the site, as well as the cleanup of the former paint factory site.

EPA ID No.	MAN000103085
Type of Action	Removal
Lead	Fund-lead

Timeline [1, 4 ,5]

Date(s)	Activity
1994 - 1999	Site investigations performed
September 26, 2000	Removal action memorandum signed
October 2000 - December 2001	Excavation of contaminated soil and sediment
September to October 2001	In situ treatment conducted in embankment area
August 2002	Removal action completed

Factors That Affected Technology Cost or Performance [1, 2, 7, 10]

Listed below are the key matrix characteristics for this technology and the values measured for each during site characterization.

Matrix Characteristics

Parameter	Value
Soil Classification:	Coarse to fine sand, with silt and gravel (interlaced with veins of solid paint pigment waste)
Clay Content and/or Particle Size Distribution:	Limited clay content
Moisture Content:	28-30%
Organic Content:	Information not provided
pH:	10.3-10.6
Bulk Density:	94.5 lb/cubic ft (average)

Treatment Technology Description [1, 2, 9]

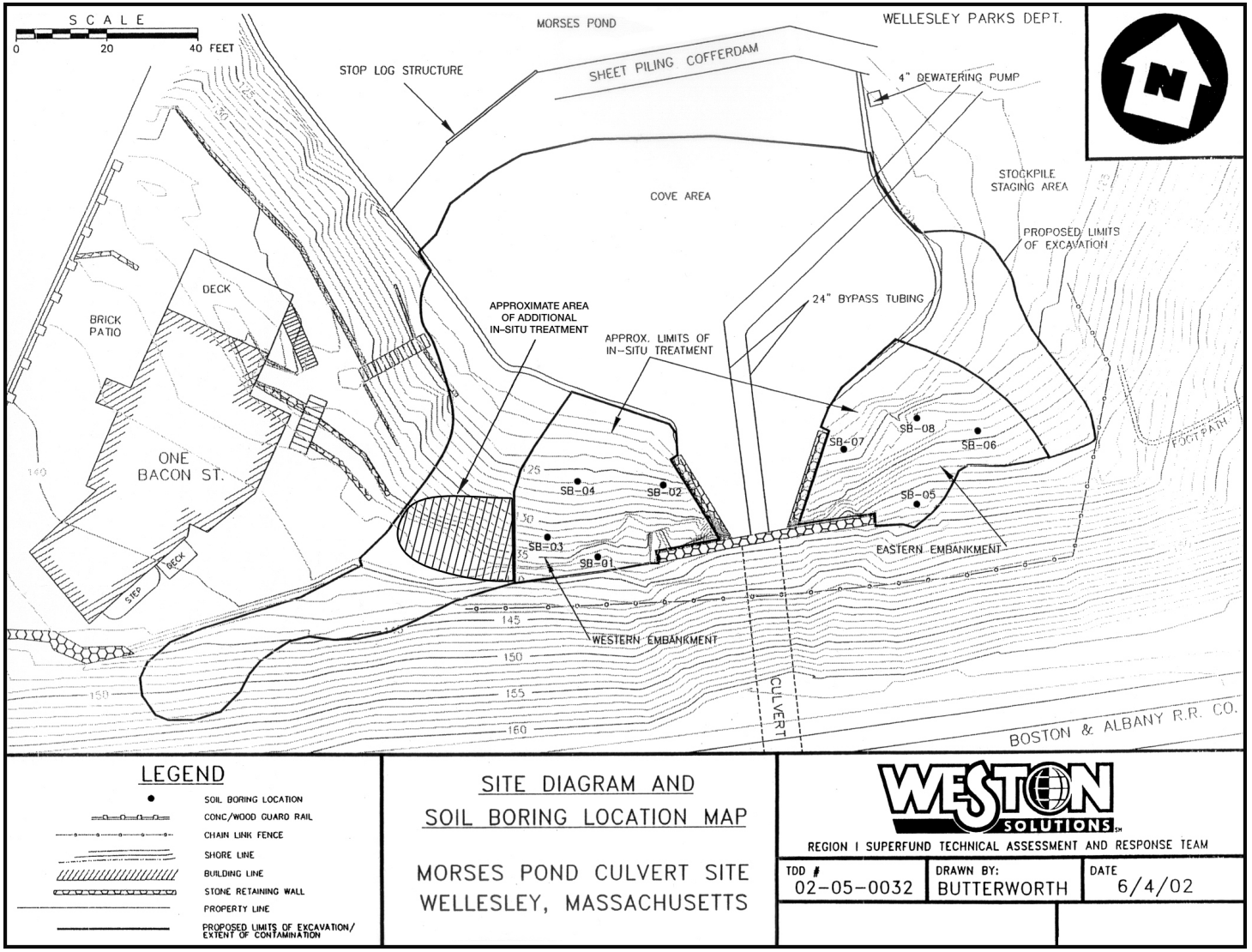
In situ chemical reduction was used in the embankment areas of the site to treat the chromium-contaminated soil deeper than 4-ft bgs. As discussed in the summary section, in situ treatment was selected for the deeper soil because of slope stability and structural concerns with the embankment. Prior to treatment, eight soil borings (depths ranging from 8 to 20 ft) were collected from the eastern and western portions of the embankment, as shown in Figure 1, and analyzed for total chromium and lead (off-site laboratory) and hexavalent chromium (field screening using HACH test kits).

As part of the work plan, the volume of soil to be treated, the number of wells by treatment area, and volume of reagent required was estimated for the embankment area using results of soils samples collected during the site investigations. As shown in Table 1, in situ treatment of 925 cubic yards of soil was estimated for the embankment area. Calcium polysufide and ferrous sulfate were considered for use during treatment. Calcium polysulfide was selected for this application based on the quantity of reagent required.and that this reagent would not require pH adjustment to off-set the basic soil conditions at the site. The polysulfide had a lower density (1.83 lb/gal) than the ferrous sulfate considered (6.07 lb/gal). The total estimated volume of calcium polysulfide solution was 46,704 gallons (17% solution) based on injecting one pore volume uniformly over the treatment areas (see Reference 2 for the detailed calculations).

Table 1: Estimated Area for In Situ Treatment - Initial [2]

Treatment Area	Area (ft^2)	Average Depth (ft)	Volume (cubic yard)
Western Portion of Embankment	1,200	10	444
Eastern Portion of Embankment	1,300	10	481
Total	2,500		925

Figure 1. Site Diagram and Soil Boring Location Map[1, 9]



A total of 40 injection well points were installed along the embankment using a Geoprobe Systems Model 540M direct push unit mounted on a platform. The wells were installed 10 ft apart to allow for a 5-ft radial distribution of reagent from each well (the radius of influence estimated by USACE). Wells were installed to depths ranging from 5 to 25 feet. In situ treatment was performed first in the western portion of the embankment area, then in the eastern portion. A total of 56,800 gallons of calcium polysulfide reagent (18% solution) were injected into the wells. An additional area (4 injection points) on the western embankment was added to the in situ treatment area, as shown on Figure 1, based on conditions observed at the 4-foot maximum excavation limit, accounting for the difference between estimated and actual injection volumes. In situ treatment was completed for the western portion of the embankment on approximately October 6, 2001 and for the eastern portion of the embankment on October 17, 2001.

Post-treatment soil borings were collected from the locations of the pre-treatment borings and analyzed for total chromium and lead (off-site laboratory) and field screened for hexavalent chromium (using HACH test kits).

Following in situ treatment, the soils from the embankment were excavated to a depth of 4 ft, with the deeper soils left in place to maintain the structural integrity of the embankment. Excavation of soils greater than 4 ft deep was performed after in situ treatment of soils because excavating first would have exposed solid paint pigment waste material which would have posed an additional contact threat to site workers. A low permeability cap was installed at the site over the western and eastern portions of the embankment area.

Operating Parameters [1, 2]

Listed below are the key operating parameters for this technology and the values measured for each.

Operating Parameter	Value
Reagent	Calcium polysulfide (18% solution)
Pore volume	50.5 gal/cubic yard (assuming an average porosity of 0.25)
Injection rate	Information not provided

Performance Information [1, 2, 9]

The purpose of the time critical removal action was to address imminent direct contact threats that the site posed to human health and the environment. Treatment of the soils at depth was not required to accomplish the immediate goals of the removal action. However, to attempt to reduce the long-term mobility of the residual contamination at depth, in situ treatment was added on to the project. The non-binding goals of the treatment effort for hexavalent chromium were <200 mg/kg (total) and <1 mg/kg using the Toxicity Characteristic Leaching Procedure (TCLP).

Table 2 shows the sample results for the pre-treatment and post-treatment soil borings. Samples were analyzed for hexavalent chromium, total chromium, and lead. Post-treatment contaminant concentrations in the western portion of the embankment ranged from zero to 5,600 mg/kg for hexavalent chromium (with pre-treatment concentrations as high as 11,400 mg/kg); 140 mg/kg to 67,000 mg/kg for total chromium (with pre-treatment concentrations as high as 97,000 mg/kg); and 24 mg/kg to 11,000 mg/kg for total lead (with pre-treatment concentrations as high as 32,300 mg/kg). Post-treatment contaminant concentrations in the eastern portion of the embankment ranged from zero to 5,000 mg/kg for hexavalent chromium (with pre-treatment concentrations as high as 11,700 mg/kg); 92 mg/kg to 35,000 mg/kg for total chromium (with pre-treatment concentrations as high as 59,000 mg/kg); and 23 mg/kg to 220 mg/kg for total lead (with pre-treatment concentrations as high as 440 mg/kg).

Cost Information [1, 6, 7, 9]

A total of approximately $119,719 was expended by EPA for activities related to in situ treatment performed by the ERRS contractors at the site. EPA noted that the cost for calcium polysulfide injection was $69,296, plus about $13,900 for ERRS contractor labor (injecting reagent), in addition to $36,523 paid to GZA Geoenvironmental, Inc. GZA's costs addressed installing the injection wells and collecting pre- and post-treatment soil borings.

A total of approximately 1,025 cubic yards of soil were treated at the site, corresponding to a unit cost of $117/cubic yard of soil treated.

Table 2: Pre-Treatment and Post-Treatment Soil Boring Results (mg/kg) [1]

Sample Location	Depth	Hexavalent Chromium		Total Chromium		Total Lead	
		Pre-treat	Post-treat	Pre-treat	Post-treat	Pre-treat	Post-treat
Western Treatment Area							
SB-01	0-4 ft	8,000	3,800	97,000	50,000	330	160
	4-8 ft	11,400	5,600	48,700	67,000	32,300	11,000
	8-12 ft	3,700	1,040	21,000	5,000	1,280	110
	12-15 ft	660	5.8	10,500	140	110	24
SB-02	0-4 ft	5,100	2,300	82,300	46,000	97	160
	4-8 ft	800	4,100	8,110	49,000	51	160
	8-12 ft	1,260	750	9,140	39,000	36	51
SB-03	0-4 ft	1,840	500	25,700	16,000	470	500
	4-8 ft	1,840	3,500	56,300	64,000	2,560	1,300
	8-12 ft	980	3,900	23,600	38,000	300	600
	12-16 ft	260	1,540	10,100	23,000	190	260
SB-04	0-4 ft	640	240	42,200	17,000	150	240
	4-8 ft	5.7	33	41,500	50,000	120	78
	8-12 ft	71	0	18,800	9,200	100	51
	12-16 ft	13.2	0	4,530	810	42	24
Eastern Treatment Area							
SB-05	0-4 ft	0	0	170	210	200	120
	4-8 ft	0	0	340	310	81	62
	8-12 ft	0	0	130	92	30	30
	12-16 ft	0	0	43	140	20	44
SB-06	0-4 ft	11,200	50	52,900	14,000	150	220
	4-8 ft	11,700	5,000	59,000	35,000	440	94
	8-12 ft	138	485	950	1,950	22	29
	12-16 ft	5.7	0	480	220	23	23
SB-07	4-8 ft	34	3,900	3,670	9,900	42	110
	8-9 ft	8.9	0	12,200	19,000	24	49
SB-08	4-8 ft	1,640	NA	38,200	NA	220	NA
	8-9 ft	1,360	NA	28,000	NA	100	NA

NA - post treatment sample was not collected

Observations and Lessons Learned [1,2]

In situ chemical reduction was used to treat soil contaminated with hexavalent chromium that could not be excavated from a steep embankment area because of slope stability, structural and safety concerns. Calcium polysulfide was used to convert hexavalent chromium to less toxic and mobile trivalent chromium with the treated soil left in place and capped.

According to the work plan for the site, calcium polysulfide was selected over ferrous sulfate for this application for several reasons including that less calcium polysufide would be needed compared to ferrous sulfate; unlike ferrous sulfate, the use of calcium polysulfide would not require pH adjustment to off-set the basic conditions of the site soils; and with less reagent required, treatment cost would be lower and the amount of hazardous material that needed to be brought onsite would be reduced.

Contact Information

EPA OSC:
Frank Gardner
One Congress Street, Suite 1100 (HBR)
Boston, MA 02114-2023
Telephone: (617) 918-1278
E-mail: gardner.frank@epa.gov

USACE:
Laureen Borochaner
USACE
696 Virginia Road
Concord, MA 01742
Telephone: (978) 318-8220

EPA Contractors:
Mandy Butterworth
Weston Solutions, Inc.
START Contractor
37 Upton Dr.
Wilmington, MA 01887
Telephone: (978) 657-5400
E-mail: mandy.butterworth@westonsolutions.com

Jim White
GZA GeoEnvironmental Inc
27 Nack Road
Vernon, CT 06066
Telephone: (860) 858-3111
E-mail: jwhite@gza.com

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Acknowledgments

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