On-Site Containment of PCB-Contaminated Soils at Aerovox Inc. New Bedford, Massachusetts

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Introduction

This paper summarizes the results of a remedial investigation and design project completed for the rovox Inc. plant site in New Bedford, Massachusetts. e evaluation was prepared for Aerovox by GHR Engineering Corp. in accordance with consent agreements entered into by Aerovox in May 1982 with the U.S. Environmental Protection Agency (EPA) and the Massachusetts Department of Environmental Quality Engineering (DEQE). In October 1982 the results of soil and ground water sampling and analysis conducted at the Aerovox site were provided to EPA and DEQE. An evaluation of remedial alternatives for the site, based on the previous sampling and analysis program, was completed in February 1983. In September 1983 the necessary governmental approvals for on-site containment by means of a steel sheet piling cutoff wall/hydraulic asphalt concrete cap system were obtained. Construction of the containment system began in October 1983 and was be completed in June 1984.

Background: New Bedford Superfund Site

The Aerovox property, as illustrated in Figure 1, is situated at the northern end of the Acushnet River estuary and is one of five primary sites in the New Bedford Superfund site. In all, there are more than 35 suspected locations of polychlorinated biphenyl (PCB) contamination in the Greater New Bedford area, including local landfills, industrial sites, dredged material osal sites and scrap metal dealers. The widespread contamination in the area is the result of industrial use and disposal of PCBs for several decades until the late 1970s.

PCBs are known to be present throughout the bottom sediments of the Acushnet River estuary and New Bedford Harbor. The distribution of PBCs in bottom sediments (up to 6.5 inches in depth) is shown in Figures 2 and 3. The highest concentrations reported occur in the upper (northern) end of the estuary, to the north of Interstate Route 195. The PCB "hot spots" of the upper estuary, where concentrations are generally in the 1,000

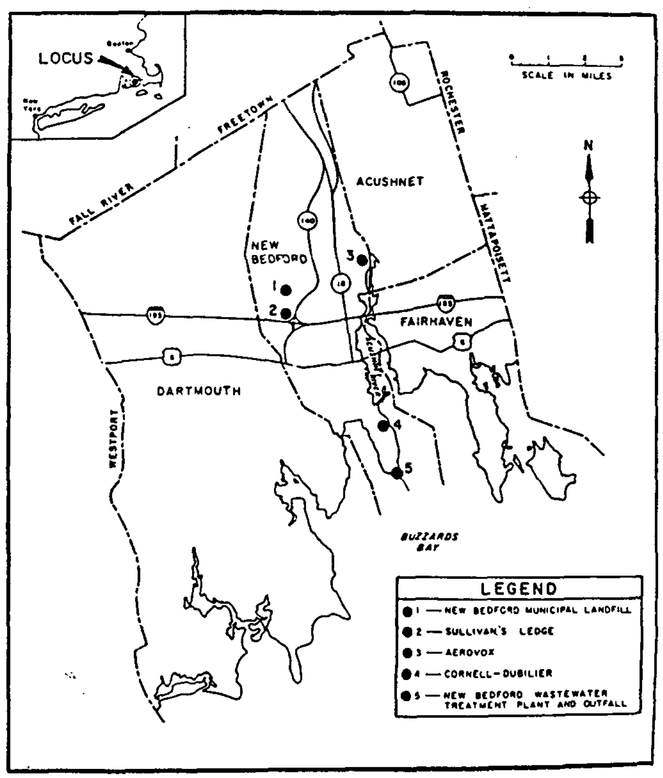

Figure 1. New Bedford, Massachusetts, Superfund site

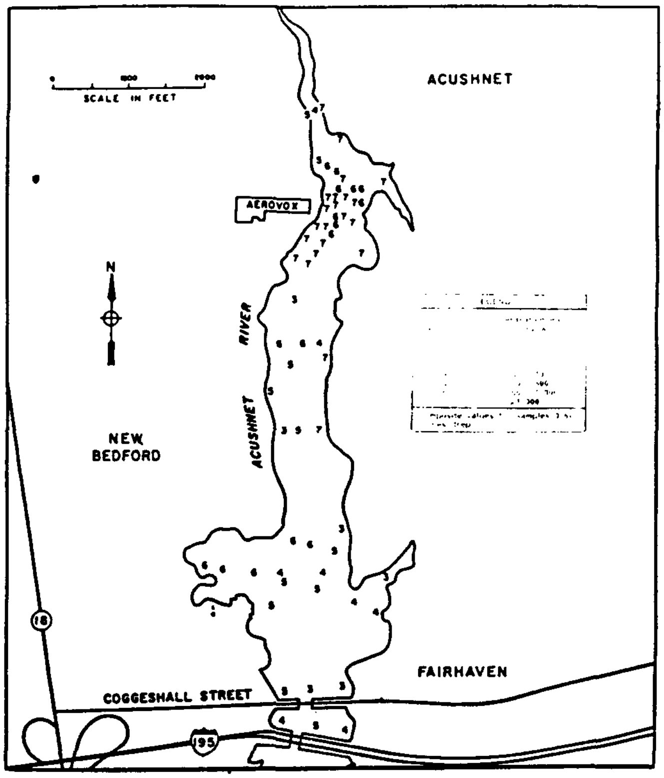

Figure 2. PCBs in bottom sediments, upper Acushnet River estuary

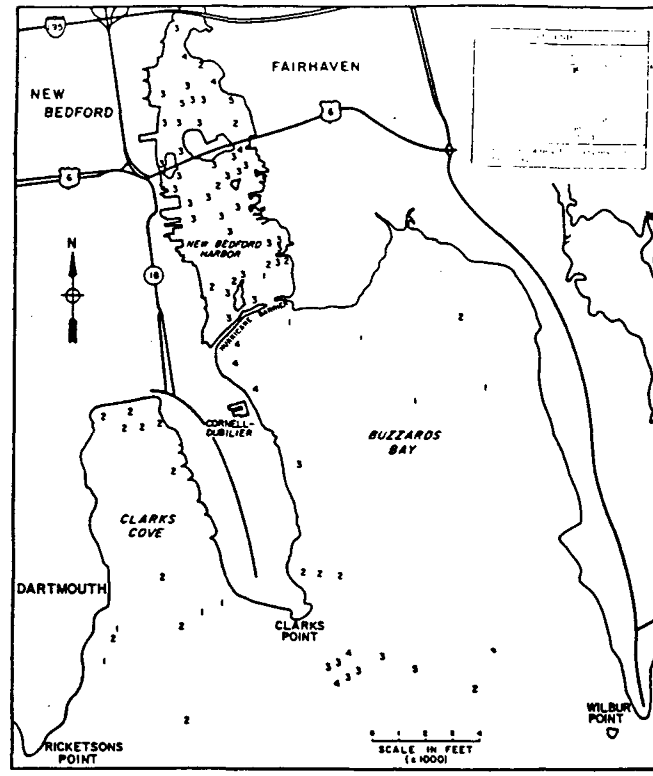

Figure 3. PCBs in bottom sediments, lower Acushnet River estuary

to 5,000 parts per million (ppm) range, are currently receiving priority attention in the ongoing EPA remedial investigation/feasibility study (RI/FS) of the New Bedford Superfund site.

Aerovox Site Description

While there are more than 300 acres of bottomland within the upper Acushnet River estuary, the Aerovox property itself encompasses approximately 10 acres of upland. Of this 10 acres, the current remedial project involved about 1/2 acre of upland, including: 1) the unpaved area at the eastern end of the site bordering on the Acushnet River, and 2) an unpaved strip of land running along the northern side of the Aerovox building. Figure 4 is a schematic diagram of the Aerovox study area.

Purpose of Aerovox Study

The purpose of this project was to develop the information needed to determine the most appropriate method of remedial action for the Aerovox property. The specific objectives of the field investigation program were to:

- Determine the extent of surface and subsurface soil contamination.
- Define ground water characteristics in the study area.
- Determine whether ground water discharged through the subject property represents a continuing source of PCB contamination to the estuary.

A principal goal of the field study was to define the distribution of PCB contamination in subsurface soils in relation to the ground water system, taking into account the potential complications introduced by tidal action.

In evaluating alternative remedial actions for the Aerovox property, the overall methodology used by the EPA for selecting remedial responses for Superfund sites was employed. Alternative remedial actions for the Aerovox site were identified and evaluated on the basis of engineering/technical feasibility, environmental effects and costs. For legal reasons the area of investigation under the EPA and DEQE consent agreements extended only to the mean high water line at the site, or about to the existing rock wall along the edge of the Acushnet River. Thus, remedial alternatives for the Aerovox property were viewed independently of ongoing remedial studies for the upper estuary as a whole.

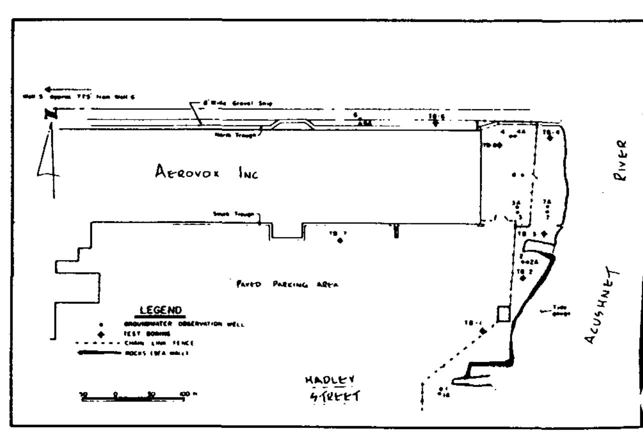

Figure 4. Schematic site plan of Aerovox property

Summary of Field Investigations and Results

The field investigation of the Aerovox site was conducted in two phases designed to cost-effectively characterize the surface and subsurface conditions of the site. Phase 1 consisted of an evaluation of PCB levels in soils at the surface and to depths of up to 2 feet below the surface throughout the approximately 1/2-acre study area. Based on the Phase 1 test results, locations for Phase 2 soil sampling at depth via borings were selected. The Phase 2 investigation included the installation of ground water monitoring wells in eight on-site locations and an evaluation of tidal influences on ground water. Supplemental boring and sampling was done during the design stage.

Phase 1 Results: PCB Distribution in Surface Soils

For Phase 1 sampling, the study area was divided into four major sampling zones corresponding to the four natural subareas created by the actual features of the site. In each sampling zone, composite soil samples were prepared from several individual grab samples collected at the surface and at 1-foot and 2-foot depths. The data obtained during Phase 1 soil sampling are presented in Table 1.

The Phase 1 test results confirmed the presence of PCBs dispersed throughout the top 2 feet of material examined. In many locations sampled, order of magnitude decreases in PCB levels were found at the 2-foot depth relative to the surface, while in other sampling locations PCB levels were as high or higher at the 2-foot level than at the surface. Examination of shallow test pits revealed the top several feet at the site consisted of various sand and gravel fill materials and debris, including cinders, pieces of masonry and concrete, wood scraps and miscellaneous plastic, rubber and metal items.

Phase 2 Results

The second phase of the field study was conducted to examine subsurface conditions at depth in terms of both the types of materials present and the distribution of PCBs within those materials. Phase 2 also included an assessment of the ground water system in terms of water quality as well as tidal influences on ground water levels within the study area.

Borings and Monitoring Well Installation

To obtain subsurface stratigraphic data and collect samples at depth for PCB analysis, a series of 15 test borings were executed. In each boring location, soil samples were collected at 2-foot intervals. Ground water monitoring wells were installed in eight locations (Figure 4). All test borings were advanced by a standard truck-mounted hollow stem auger rig. Subsurface soil samples were collected by a standard penetration test procedure yielding split spoon samples. In the deeper borings, after fully penetrating a contiguous zone of natural soil, the sampling interval was increased to 5-foot intervals.

Conventional standpipe observation wells were installed at eight test boring locations during Phase 2. The wells consisted of 20-slot 2-inch PVC screens, flush threaded to 2-inch PVC riser pipes. As indicated on Figure 4, in six downgradient boring locations dual or "tandem" wells were installed. An upgradient background well was installed to the west of the Aerovox buildings, some 1,100 feet from the river.

The presence of a 2- to 4-foot thick peat layer at depths of approximately 6 to 8 feet throughout the eastern portion of the study area was anticipated from prior experience in the area. Natural organic peat can be a relatively low permeability material that can serve as an effective barrier to ground water flow. In this study, it was hypothesized that the existence of the peat layer may have resulted in differences in the quality of the ground water found above and below the peat.

TABLE 1

PCB Levels in Soils from Surface to 2-Foot Depth

Sampling zone description	PCBs in composite samples (ppm) Surface	1 Foot	2 Foot
Gravel strip along north side of building	4,940-6,870	270-500	75-345
Area directly behind building to the river's edge	1,335-4,565	2,025-10,560	175-7,095
Shoreline area north of old pump house	1,995-4,835	no data	3,770
Shoreline area south of old pump house	365-3,030	no data	<2 - 13

Thus, tandem wells were installed to allow sampling of ground water from each level.

The test borings were executed in two steps: 1) the initial boring was advanced to a depth of from 20 to 25 feet and the well screen was set to intercept the ground water zone beneath the peat layer, which was typically encountered at depths of from 6 to 8 feet; 2) the second boring, adjacent to the first, was advanced only to the peat layer and the well screen was set to intercept the ground water zone above the peat. The screens for both levels were backfilled with #2 sand and bentonite seals were placed at the peat layer and at the surface as the auger was withdrawn. To protect the wells from vandalism and the elements, protective steel covers with locking caps were cemented in place.

PCB Distribution in Subsurface Soils

Twenty-six subsurface samples obtained during Phase 2 drilling were analyzed for PCBs. A summary tabulation of the results obtained is given in Table 2. A generalized interpretation of the three dimensional distribution of PCBs in the soils behind the Aerovox plant can be developed by considering the Phase 1 and Phase 2 results together (Tables 1 and 2).

Generally, the soil test results showed that reductions in PCB levels of one to two orders of magnitude occur within 4 to 6 feet of the surface throughout the study area. None of the soil samples collected from below a depth of 6 feet were found to exceed 50 ppm PCBs. Figure 5 is a sample data sheet for Boring No. 3.

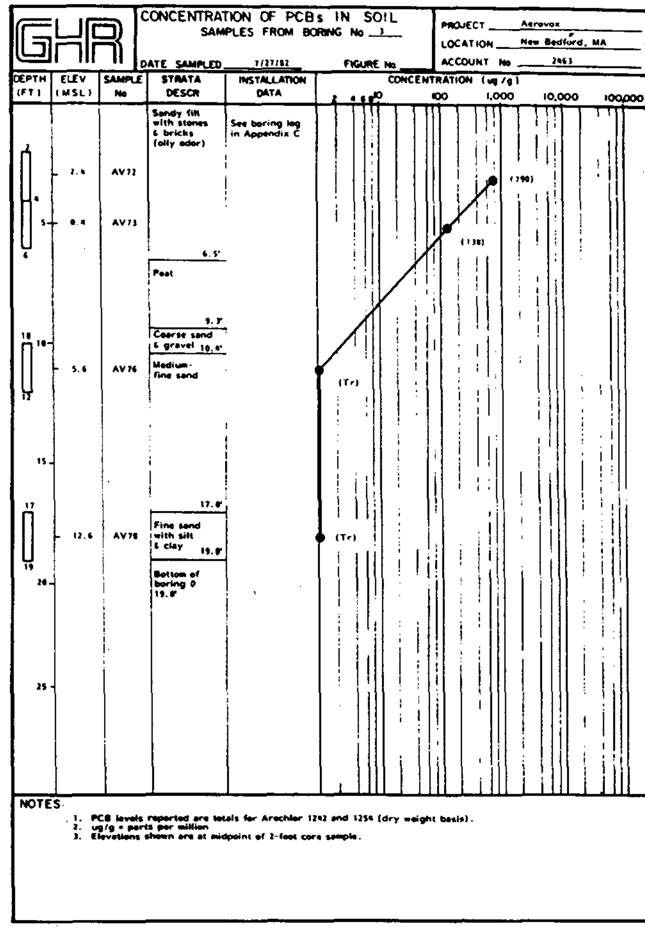

Figure 5. PCBs in soil samples from Boring No. 3

TABLE 2

PCB Levels in Subsurface Soil Core Samples

Sampling zone/ well no.	PCBs in core samples (ppm) 2-4 feet	4-8 feet	Below 8 feet
Gravel strip along north side of building			
— Well no. 6	23	—	<2
Area directly behind building to the river's edge			
— Well no. 3	790	138	<1
— Well no. 4	—	72	23
— Well no. 7	158	1,790	7
— Well no. 8	986	—	32
Shoreline area north of old pump house			
— Well no. 2	90	1,385	<2
Shoreline area south of old pump house			
— Well no. 1	160	<2	<1

In addition to PCB analyses, soil samples from the site were also tested for pH and oil and grease content. These test results pointed out the variability of the materials that form that top 4 to 6 feet of the study area. The pH of the soils varied from 3.4 to 8.4 over the site. The variation was less at different depths at the same boring location than at different locations. The highest oil and grease concentrations were seen in the surface soils in the areas adjacent to the north side of the building and directly behind the building.

Site Stratigraphy

Site stratigraphy was determined through the examination of split spoon samples extracted during test boring operations. These samples were logged by a geologist and representative samples of each strata were analyzed for grain size determination. The stratigraphic units were determined on the basis of physical characteristics such as grain size, texture and morphology, and on their relative stratigraphic positioning.

Fill Materials. In general, the fill materials are granular backfill that consists mostly of medium to coarse sand and fine to medium gravel. This fill varied in the amount and composition of construction debris and refuse mixed in with the granular matrix. Materials such as concrete, steel, wood, paper, rubber, brick and general manufacturing refuse were encountered. The depth of this unit ranged from 2 to 6 feet. The maximum depth of fill material encountered was 6 feet in the area of Wells 3 and 8.

Sand and Gravel. Light brown to gray, fine- to coarse-grained sand and fine- to medium-grained gravel deposits were found mostly in the area of Well 6 and between Wells 1 and 2. The sand and gravel were non-sorted and had minor graded sequences.

Peat. The nature of the peat in the study area was somewhat variable. The peat ranged in degree of decomposition from intact brown root masses to highly decomposed black organic-rich layers. The matrix materials also varied from a dense clay to a medium sand. The peat layer is continuous throughout most of the study area, is variable in thickness and is randomly interlayered with sand. The peat was absent along the area from Well 5 to TB-6, probably due to excavation for the building foundation.

Fine to Medium Sand. This unit consisted of well-sorted and graded sequences of light brown to yellow, fine to medium sand with some coarse-grained beds approximately 2 inches thick. This unit is found primarily beneath the peat layer. The sand contains small layers of gravel material and pebbles. The regional ground water system is contained within the sands underlying the peat deposit.

Surface Water Hydrology

The Aerovox property, most of which is paved, drains in an easterly to southeasterly direction toward the Acushnet River estuary. The estuary at this point is approximately 500 feet wide and the mean tidal range is about 3.7 feet with a spring tidal range of 4.6 feet. During the current water level monitoring program, the mean tidal range observed was 4.25 feet. A maximum high tide elevation of 4.24 feet (mean sea level) was observed on November 4, 1982 (full moon), while an extreme low tide elevation of -2.10 was observed on November 16, 1982 (new moon). The means of the observed high and low tide elevations were 2.92 and -1.57, respectively.

The average annual precipitation for this area is approximately 44 inches. Of this amount, approximately 12 inches per year of precipitation can be expected to infiltrate the ground surface in areas with non-impervious ground cover and enter the underlying ground water system. The remainder of the precipitation either enters surface water as runoff or returns to the atmosphere via evapotranspiration.

Ground Water Levels and Flow Directions

The current investigations revealed the existence of two ground water systems at the Aerovox site. A shallow or "perched" water table exists above the underlying peat layer within the contaminated soils and fill. The saturated thickness of the perched system is a function of the elevation of the peat layer as well as the fluctuation of the tidal level. The peat layer supporting the perched system acts as a confining layer for the deeper confined aquifer. The deep system is defined by the fine to coarse sands and gravels underlying the peat layer. This deeper system runs from west to east throughout the site and appears to extend beneath the Acushnet River.

The direction of the deeper, regional ground water flow is to the east and southeast. Recharge to the system occurs in areas north and west of the site, while discharge of ground water occurs along the edge of the Acushnet River.

Monitoring of ground water levels along with tidal levels was conducted during the study to assess the effects of tidal cycles on ground water flow. It was found that the ground water levels in the shallow wells completed in the fill materials directly behind the Aerovox plant (Wells 3A, 4A and 7A) were not influenced by **normal** tidal fluctuations in the river, but were influenced by **extreme** tidal events. This confirmed that tidal recharge to the contaminated soils above the peat was occurring. At extreme high tides, the saturated thickness of the perched system was observed to be as much as 4 feet in the area of Well 3A (70 feet from the river).

The maximum observed tidal fluctuation of 5.48 feet recorded in this study was illustrative of the influence of the full moon on the tidal range and is representative of a monthly occurrence. During a full moon high tide, the perched ground water system demonstrates a hydraulic connection with the river water by developing a hydraulic gradient with a negative slope in an inland direction from the river. At low tide, the gradient reverses in the perched areas along the edge of the site such that flow is toward the river in the portions of the perched zone located east of an approximate line running from Well 7A to Well 4A. To the west of this line, the gradient in the perched system is in a southeasterly direction, leading to Slip #2 (Figure 4).

TABLE 3

Estimated Ground Water Flows

Portions of site	Infiltration	Gallons per day tidal discharge	Total
Areas directly behind building that are not subject to daily tidal inflow	205	1,900	2,105
Areas directly behind building that are subject to daily tidal inflow	160	78,800	78,960
Shoreline area north of old pump house	100	112,000	112,100
Shoreline area south of old pump house	115	128,000	128,115
		Total daily discharge	321,280

The flow in the perched system at low tide is dependent on the configuration of the surface of the peat layer, which in the area immediately behind the Aerovox plant is concave in shape. The upper edge of the peat layer behind the plant follows the approximate line referred to previously (from Well 7A to Well 4A). Tidal recharge to this portion of the perched system is controlled by the elevation of the upper edge of the "bowl" formed by the peat. Unless the tide level was above 2.5 feet, the perched system behind the edge of the "bowl" received no recharge directly from the river. The bowl-shaped area discharges in a southeasterly direction to the general area of Slip #2.

The lack of measurable water level fluctuation in Wells 3A, 4A and 7A for normal high to low tide indicates that the perched system is not hydraulically connected with the deeper system, which in turn indicates continuity of the peat layer. The perched system in the eastern portions of the site within 25 to 30 feet of the river exhibited a direct hydraulic connection with the estuary for every tidal condition. The tidal water introduced into the shoreline areas during high tide discharges, in about the same manner that it entered, at low tide.

The water levels in the deeper wells, which were completed in the stratified sands and gravels underlying the peat deposit, were found to be subject to a reversal of hydraulic gradient with the changing of the tide. The water level readings for the deeper wells indicated a net ground water flow from the estuary into the deeper aquifer system during high tide conditions. At low tide this gradient is reversed and the net ground water flow is from the deeper system to the estuary. The effects of tidal action were barely distinguishable at Well 6, located about 300 feet from the river.

Ground Water Flow Volumes

To assess the potential for the release of PCBs into the estuary from the site, the ground water discharge from the study area was estimated using a mass balance approach. As discussed previously, recharge to the perched system occurs as infiltration of direct precipitation and as recharge from the estuary. Ground water recharge from areas westerly of the site enters the deeper system and does not encounter the contaminated soils in the perched system. The ground water flow volumes calculated for the site are summarized in Table 3.

Water Quality Testing Results

Water quality data for the project area were used to assess contaminant distribution in both the perched and deeper ground water systems at the site and to estimate water soluble PCB concentrations in the ground water. These estimates provided the basis for evaluating the potential for various remedial action alternatives to reduce off-site migration of PCBs found in the subsurface soils at the Aerovox site.

Summary of PCB Data

PCB testing results of ground water and river water samples in the study area are summarized in Tables 4 and 5. All results are for water soluble PCBs detected after filtering the samples through 0.5-micron glass fiber filters to remove suspended particulates and associated adsorbed PCBs.

Perched Ground Water System

The chemical characteristics of the perched ground water system reflect brackish water recharge received from the Acushnet River. Ground water samples collected from shallow wells within 25 feet of the shoreline were found to be composed primarily of brackish water, which had entered the site as a result of tidal action. Specific conductance values in shallow wells (Wells 1A, 4A, 7A) located within 25 feet of the sea wall were in the same range as the conductance observed in the Acushnet River at the time of sampling (i.e. 10,000 to 20,000 umhos/cm).

The brackish water influence in the perched system diminishes with distance from the sea wall. Conductance levels in Well 3A, located 70 feet from the shoreline, were consistently in the range of 1,000 to 2,000 umhos/cm. Conductance levels in Well 4A, located 75 feet from the shore, were generally from 400 to 500 umhos/cm, only slightly higher than the upgradient background ground water levels of 250 to 350 umhos/cm. The conductance data support the conclusion drawn earlier — that the penetration of river water into the perched ground water system directly behind the Aerovox plant is limited by the configuration of the peat zone. During this study, the total PCB concentrations (unfiltered samples) in the perched ground water system ranged from approximately 2 to 216 parts per billion (ppb), while water soluble PCB concentrations (filtered samples) in the perched system ranged from 3 to 5 ppb. The concentrations of dissolved PCBs found in the perched ground water system are extremely low considering the PCB levels in the soils in the study area. This is consistent with the fact that PCBs exhibit a high affinity for adsorption onto soils and that PCB migration in ground water is not typically a major pathway for off-site movement of PCBs.

Deep Ground Water System

The deep ground water system at the site is also influenced by intrusion of brackish water from the Acushnet River. Brackish water entering into the deeper system, however, is subject to considerable dilution by fresh ground water flowing to the estuary within the aquifer. In the deeper wells at the site, specific conductances ranged from approximately 500 to 2,000 umhos/cm. The brackish condition was observed further inland in the deep system than in the perched system. The existence of different brackish water intrusion gradients in the deep and perched water systems adds support to the conclusion that the two systems are effectively isolated from one another by the intervening peat materials.

Water samples from the deep ground water system were also analyzed for both total (unfiltered samples) and water soluble (filtered samples) PCBs. Total PCB concentrations measured in samples from the lower system ranged from approximately 1.5 to less than 20 ppb of total PCBs. The total PCB values for Well 5, the background observation well, were in the 5 ppb range. In the only filtered sample analyzed for Well 5, no water soluble PCBs were detected (the detection limit was 0.5 ppb).

Water soluble PCB concentrations in ground water samples from the lower system ranged from less than 0.5 to 7.5, with only one sample from the deeper wells exceeding 5 ppb during this study.

TABLE 4

Results of Ground Water Testing for Dissolved PCBs

Well number	Dissolved PCBs (ppb)
Background station near Belleville Avenue	
Well no. 5	< 0.5 (=not detected)
Shallow wells between plant and river	
Well no. 3A	< 4.0
Well no. 4A	< 5.0
Well no. 7A	< 3.0
Deeper wells between plant and river	
Well no. 3	< 1.8 to 5.0
Well no. 4	< 0.5 to 7.5
Well no. 7	< 1.8 to 4.4

TABLE 5

Results of River Water Testing for Dissolved PCBs

Sampling location	Dissolved PCBs (ppb)
Acushnet River 1,500′ upstream of Aerovox at Wood Street bridge	2.8
Acushnet River directly behind Aerovox plant	3.9
Acushnet River at old pump house on Aerovox property	2.2

Acushnet River

The Acushnet River in the vicinity of the Aerovox site can be described as a brackish estuarine environment. This area serves as a mixing zone where fresh water from the river mixes with salt water that enters the estuary from Buzzards Bay. Specific conductance values in the river near the site ranged from 12,000 to 16,000 umhos/cm at high tide.

Water soluble PCB concentrations in river water samples ranged from about 2.2 ppb to less than 4 ppb. Thus, river water entering either the deep or perched water systems at the site enters with water soluble PCB concentrations in the same range as those observed in samples collected from the two ground water systems.

Summary of Volatile Organics Data

Volatile organics tests were also conducted on ground water and river water samples. In the perched water system, total volatile organic concentrations were less than 0.5 ppm in all wells sampled. The compounds identified included the solvents ethylbenzene, chlorobenzene and trichloroethylene, compounds commonly associated with industrial processes.

In the deeper water system, total volatile organic concentrations ranged from 0.4 ppm to 7.65 ppm. The volatile compounds identified in the deep system included vinyl chloride, trichloroethylene, 1, 2-trans dichloroethylene and chlorobenzene. The fact that the volatile levels in the deep system were higher than in the perched system suggests an off-site, upgradient source.

In the Acushnet River samples, total volatile organic concentrations ranged from less than 10 ppb at the Wood Street bridge to approximately 100 ppb at the shoreline adjacent to the site.

The principal concern with respect to the volatile organics present in the study area was whether they might affect the solubility of PCBs in the ground water. This concern has merit considering the fact that PCBs are highly soluble in pure solvents. At this site, however, solvents were detected only at trace and low ppm levels in ground water and no increases in water soluble PCBs were observed in ground water samples that contained up to 7 ppm of volatile organic compounds. It was concluded that PCB solubility would not be increased to any measurable degree as a result of the low levels of volatile organics present in the ground water in the area.

Subsurface PCB Migration Assessment

PCBs have been shown by numerous studies to be strongly adsorbed by soils and, because of this, have a very low probability of transport by leaching through subsurface materials. At the Aerovox site, it was found that the geohydrologic characteristics of the site would also serve to minimize off-site migration of PCBs via ground water transport. The site features combine to naturally minimize the volumes of water that pass through PCB-contaminated soil and to reduce the potential for migration of PCBs as a result of adsorption on organic soil particles. The organic peat materials isolate the PCB-contaminated soils in the perched system from the deep ground water system. This physical isolation prevents the ground water flowing beneath the site from encountering PCB-contaminated soil.

The potential rate of release of PCBs from the study area via ground water was estimated by combining ground water flow estimates with analytical data on water soluble PCB concentrations. The daily ground water discharge from the perched system was calculated to be approximately 321,280 gallons per day. However, more than 99 percent of this discharge is due to the release of tidal recharge that enters the system as the tide rises. The water soluble PCB concentrations in the shallow wells at the site were found to range from 3 to 5 ppb and the dissolved PCB levels in the river were found to be in the range of 2 to 4 ppb. Based on these values, it was estimated that the net rate of release of PCBs from the site via ground water discharge would be less than 3 pounds per year.

Evaluation of Remedial Measures

The specific remedial goals set for the Aerovox site in this study and the criteria by which the various engineering measures were evaluated are outlined as follows.

Remedial Objectives and Evaluation Criteria
Remedial Objectives

The basic remedial objective for the Aerovox site, consistent with the National Contingency Plan, was to minimize the potential for PCBs in the upland soils to move off the site. Three potential environmental transport mechanisms or pathways by which PCBs might be released from the site were to be controlled:

1. Subsurface movement with ground water
2. Erosion of surface soils by rainfall runoff and tidal fluctuations along the shoreline
3. Evaporation or volatilization into the atmosphere from surface soils.

The approach to evaluating remedial solutions was based on the rationale that any releases of PCBs from the site would be further minimized by controlling or eliminating contact between ground water or surface water and PCB-contaminated soils. Potential releases of PCBs from the site as a result of surface erosion or volatilization were not documented in this study. It had been conceded at the onset that any remedial plan proposed for the site would be designed to eliminate all potential for surface runoff and air transport of PCBs.

The remedial objectives for the Aerovox site can be summarized as:

- Elimination of potential surface erosion of soils containing PCBs
- Elimination of potential air transport of PCBs from the surface of the study area
- Elimination of rainfall infiltration through contaminated soils
- Minimization of ground water contact with and ground water discharges from the contaminated soils.

The first three listed objectives would be achieved by installing a permanent low permeability cover or cap over the contaminated soils. The fourth objective would be achieved by minimizing the flow of estuarine water into the perched water system by installing a vertical barrier along the edge of the river.

Evaluation Criteria

The remedial alternatives identified in this study for the Aerovox site were evaluated according to the following set of criteria:

- Remedial benefits—expected performance in terms of minimizing PCB releases from the site
- Technical feasibility—applicability to the site location and conditions; engineering constructibility; reliability in meeting objectives
- Environmental effects—adverse effects of implementation
- Costs—installed capital cost; monitoring and maintenance costs.

These criteria provided the framework for comparing the remedial options in a two-step approach. In Step 1, an initial screening of the various options was carried out primarily on the basis of preliminary concepts and associated general cost estimates. Other factors were also considered during screening, including possible environmental effects during construction and estimated environmental benefits (qualitative). Based on the initial screening, the following alternatives were eliminated from further consideration for the reasons listed:

- No action—this alternative was rejected at the outset by Aerovox
- Complete excavation of contaminated soils (for out-of-state secure landfill disposal)—other source control alternatives would provide adequate remedial benefits at less than 1/10th the cost; estimated cost to excavate, transport and dispose of all materials containing greater than 50 ppm PCB is more than $1,000,000.
- Bentonite slurry trench cutoff wall along shoreline to prevent tidal flux into contaminated soils—construction technique not applicable to the Aerovox site; other vertical barriers could achieve equivalent results with similar or lower costs and much less site disturbance and adverse impact during construction.

After the initial screening, the following remedial measures were analyzed in more detail in Step 2:

- Capping contaminated areas with asphaltic material
- Installation of a vertical barrier to impede flows across the boundary defined by the existing sea wall
- Limited excavation of contaminated soils for replacement on-site beneath areas to be capped
- Combinations of the above.

This analysis involved preparing preliminary designs for the options under study, developing engineering cost estimates, and evaluating technical feasibility and environmental effects of each option, including effects during construction as well as estimated remedial benefits. Long-term monitoring and maintenance requirements were included in the detailed engineering analysis of options.

Two types of asphaltic paving materials were considered in this study: 1) hydraulic asphalt concrete, and 2) standard roadway paving material.

Three alternative types of subsurface cutoff walls were considered: 1) a barrier trench backfilled with silt washings, 2) a barrier trench backfilled with a bentonite/soil mixture, and 3) a steel sheet pile cutoff wall.

As an alternative to these barriers, all of which would be installed behind the existing sea wall, the option of rebuilding and sealing the sea wall was also examined.

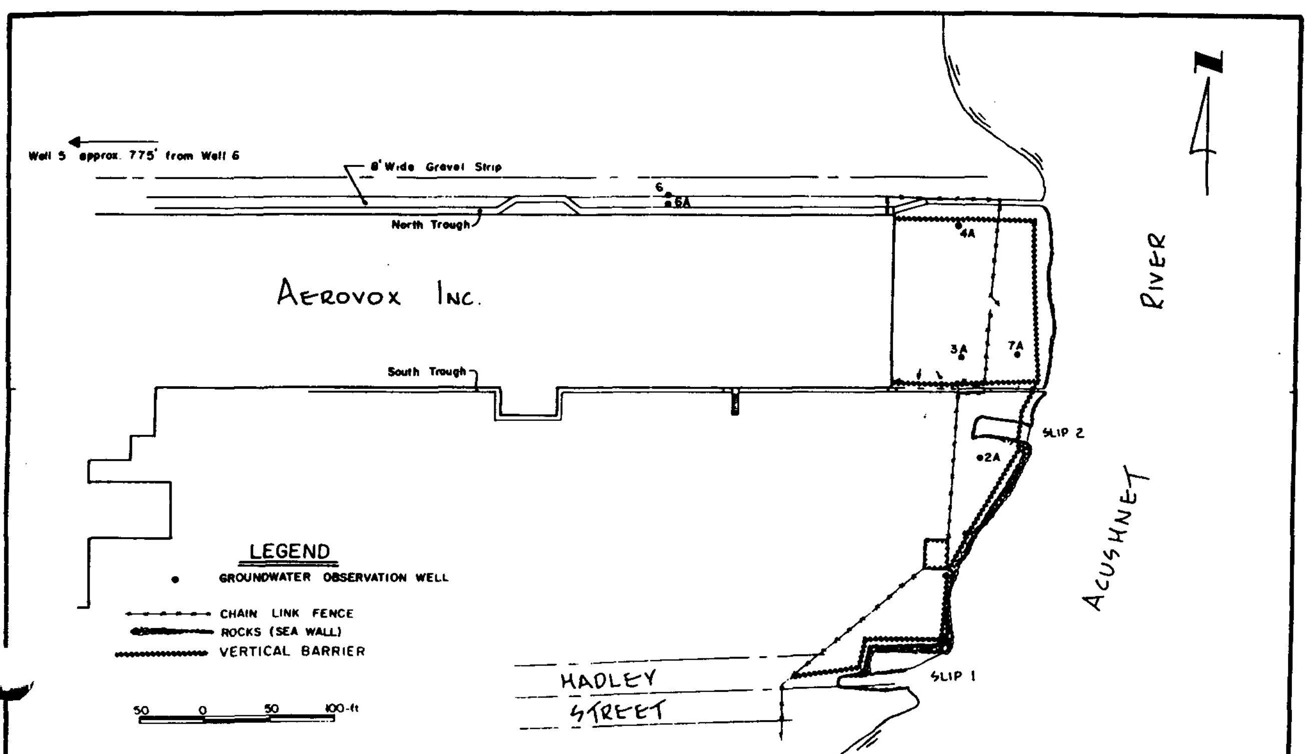

Figure 6. Location of steel sheet piling cutoff wall

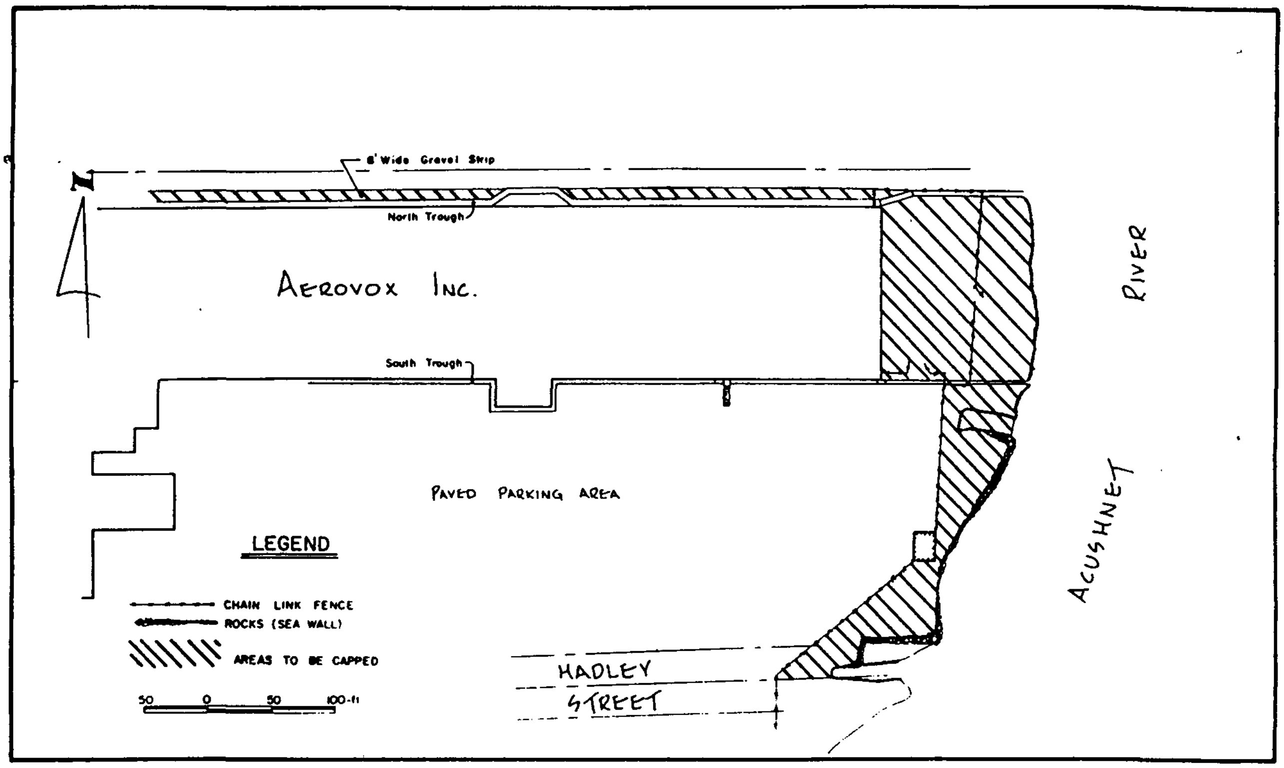

Figure 7. Areas capped at Aerovox

Recommended Remedial Plan

On the basis of the technical, economic and environmental considerations discussed in the preceding sections, the final remedial action plan for the Aerovox property included both:

- Capping of the contaminated soil areas by paving with hydraulic asphalt concrete (HAC)
- Installation of steel sheet piling cutoff wall to serve as a vertical barrier to ground water and tidal flow into and out of the contaminated soils.

Description of Selected Plan

The selected remedial action plan for the Aerovox site is shown graphically in Figures 6, 7 and 8. The HAC surface cap has a thickness of 2.5 inches and the sheet piling cutoff wall is from 9 to 13 feet in depth. The actual depth of the wall is controlled by the depth of the peat layer into which the wall is keyed.

Sheet Piling Cutoff

The location of the sheet piling cutoff wall is shown on Figure 6. The cutoff wall has been installed along the entire eastern boundary of the property within 3 to 4 feet of the existing sea wall to minimize tidal recharge to the perched ground water system and subsequent discharges through the contaminated soils. In the area directly behind the plant the cutoff wall extends on both sides up to the Aerovox plant, forming a containment cell for the most contaminated soils (the building foundation itself serving as the fourth side of the cell).

Contaminated soils within the 3- to 4-foot space between the steel wall and the existing sea wall were excavated and placed behind the steel. The excavation was then backfilled with stone and chipping to stabilize and protect the steel cutoff wall (Figure 8).

HAC Surface Cap

Hydraulic asphalt concrete (HAC) is a hot mixture of asphalt cement and a high quality mineral aggregate. The aggregate used for this type of mix is a dense-graded aggregate with a maximum particle size of approximately 1/4 inch. The HAC was specially prepared at a hot-mix plant and trucked to the site for spreading and compaction. Delivery temperatures of between 300 to 400 F are required for ease in spreading and compaction. Permeability tests on HAC have yielded permeabilities in the 10^{-8} to 10^{-9} cm/second range. Base preparation for use of this material consists of the spreading and compacting of a 6-inch gravel base.

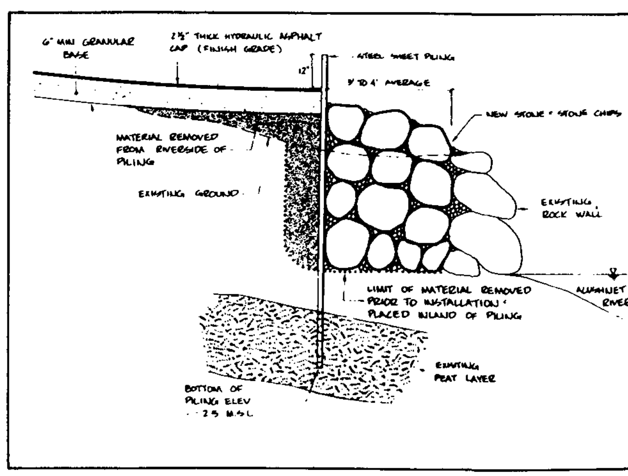

Figure 8. Sheet piling cutoff wall installation detail

The HAC surface cap was designed to cover all the presently unpaved areas on the Aerovox property along the river's edge. In addition, the 8-foot wide gravel strip adjacent to the north trough on the north side of the building has been paved. These areas are shown in Figure 7. In total, approximately 33,000 square feet were capped. The HAC cap extends to the new steel cutoff wall.

Maintenance and Monitoring

The primary maintenance requirements for the surface cap are to: 1) minimize vehicular traffic on the area, and 2) apply a seal coating if needed to revitalize the surface and fill any cracks that may have formed. Access to the area will be controlled by a locked chain link perimeter fence. Periodic inspection of the surface will reveal the need for surface sealing or any other measures to maintain the integrity of the cap.

In terms of site monitoring requirements, the water table elevation within the perched ground water system will be monitored to determine the effectiveness of the vertical cutoff wall and surface cap. Initially, water level monitoring over an extended period, as done during this study, will be used to evaluate ground water levels under normal and extreme tidal conditions. Subsequently, water level readings will be taken only periodically (quarterly) to maintain a continuous review of system performance.

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Biographical Sketches

Biographical information for John J. Gushue and Robert S. Cummings was not available at time of printing.

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