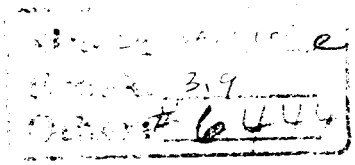
Health Assessment for



SULLIVAN'S LEDGE

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Agency for Toxic Substances and Disease Registry
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Health Assessment

Sullivan's Ledge

New Bedford, Massachusetts

Prepared by:
Division of Environmental Epidemiology and Toxicology
Massachusetts Department of Public Health (MDPH)
Boston, Massachusetts

Prepared for:
Office of Health Assessment
Agency for Toxic Substances and Disease Registry (ATSDR)

I. Summary

The Sullivan's Ledge National Priorities List (NPL) Site is a former granite quarry used as an industrial landfill from around 1940 until the 1970's. The site is located within the City of New Bedford in Bristol County, Massachusetts, and has been owned by the City of New Bedford since 1935. As many as four quarry pits are located on-site.

Due in part to concerns about adverse human health impacts from drilling and/or excavations of the quarry pits, the wastes within the quarry pits were not directly sampled. However, groundwater sampling was conducted immediately adjacent to the quarry pits in order to assist in the characterization of the contents of the pits. The migration of contaminants to off-site locations has been documented. Polychlorinated biphenyls (PCBs) were the most prevalent contaminants detected and were found in surface soils and sediments both on-site and off-site, and as airborne contaminants above the site. Soil and sediment contamination by polycyclic aromatic hydrocarbons (PAHs) also occurs. Volatile organic compounds (VOCs: benzene, vinyl chloride, trichloroethylene, and trans-1,2-dichloroethylene) present in ground water have contaminated surface water through seepage to a stream along the eastern border of the site; from where, surface water contaminant levels diminish rapidly just downstream of the site. Also, ground water contaminants travel as a narrow plume northward under a golf course.

Extensive residential development exists south and east of the site. Three residences and several businesses including an inn, a car wash and a golf course are located near the site. Human exposure to contaminated fugitive dusts may occur throughout the area. At the car wash, human exposure by inhalation of VOC vapors from a ground water seep may occur. At the heavily-used golf course, human exposure to contaminants in soil and in sediments, particularly from dry intermittent stream beds, and to contaminated fish may occur.

Many of the contaminants detected are carcinogens including two known human carcinogens, benzene, and vinyl chloride. PCBs tend to bioaccumulate and biomagnify through the food chain, and are probable human carcinogens. This site is of public health concern because of the potential for exposure to site-related contaminants by a variety of exposure pathways.

II. Background

A. Site Description

Sullivan's Ledge Site is a landfill situated on about 12 acres of land. The location is in the northwestern section of New Bedford near the border of North Dartmouth in Bristol County, Massachusetts. The site isbounded by the Interstate I-195 and Massachusetts Route 140 Interchange to the south, Hathaway Road to the north, and commercial properties to the east and west.

The Sullivan's Ledge Site is a former granite quarry with as many as four pits. Quarry operations were begun before 1846. Other pits were opened between 1848 and 1882. The exact location, size, and depth of the pits are unknown. However, the pits are thought to be about 150 feet deep, but may be as much as 300 feet deep. Quarry operations terminated in 1932. In 1935 the City of New Bedford took ownership of the property through tax title foreclosure.

Two pits were used for disposal of junk cars during the 1930's. The remaining pits were used for waste disposal by local industries, beginning in the mid-1940's until disposal activities were terminated in the 1970's. At the time of closing, the pits were nearly completely filled. The exact nature and amounts of wastes disposed at the site are unknown, but are known to include automobiles, tires, scrap rubber, fuel oils, volatile liquids, smoke stack soot, demolition materials, brush, trees, large timbers, and electrical capacitors and transformers. In the early 1970's, a large number of tires disposed in one of the pits caught fire, resulting in thick, black smoke. The fire took a long time to control. To keep a fire from reoccurring, the pit was completely backfilled and the site regraded to cover exposed waste materials. However, surface disposal of waste of unknown composition may to have occurred following regrading of the site.

In 1982 the Massachusetts Department of Public Works discovered electrical capacitors in test borings on the property. The Environmental Protection Agency (EPA) monitored air quality in the New Bedford area, including locations near Sullivan's Ledge in 1984, and monitored ground water quality around the site in 1983. Sullivan's Ledge was listed as a NPL site in September 1984. The City of New Bedford fenced the site in late 1984 per an EPA Administrative Order. Monitoring for the Phase I Remedial Investigation (RI) was performed by Ebasco Services Inc. and NUS Corporation during the period January 1985 to September 1986. From the draft Phase II RI and Feasibility Study (FS), additional monitoring was performed by Ebasco Services Inc. and E.C. Jordan Company from October 1987 until March 1988.

The RI study area lies within a valley and is over 400 acres in size, including the 12-acre site. The study area is bounded by Interstate I-195 to the south and west, beyond the Conrail rail line to the north to include a portion of the Apponagansett Swamp, and Massachusetts Route 140 to the east. Hathaway Road extends east to west through the study area. Within the study area and north of Hathaway Road is the 250-acre Whaling City Country Club golf course. Also within the study area are commercial properties east and west of the site, including the Days Inn and the Scrub-a-Dub car wash, and three private residences to the west. The closest residence is located 200 feet from the western site boundary. Extensive residential development exists to the south, east, and northeast of the Sullivan's Ledge Site outside the study area.

Immediately north of the Conrail rail line (0.6 miles from the site) are the Apponagansett Swamp and the New Bedford Municipal Landfill and Incinerator. The incinerator has been closed since January 1, 1974

according to the Commissioner of the Department of Public Works for the City of New Bedford, but did burn PCB-contaminated sewage sludge. The municipal landfill has been in operation since 1921, and contains PCB waste. The Apponagansett Swamp is located west of the incinerator and landfill. Refer to Appendix A for a map of the study area.

B. Site Visit

A site visit was performed on August 31, 1988 by Eileen Furlong of the Massachusetts Department of Public Health (DPH), Louise House - a Region I Representative of the Agency for Toxic Substances and Disease Registry (ATSDR), and Jane Downing - the Sullivan's Ledge Site Manager from the EPA. Information obtained from the site visit is incorporated throughout the Health Assessment as appropriate, and includes information on land use, physical hazards, and environmental transport of contaminants. However, important observations made during the site visit are: (1) a strong rubber-like odor is discernible at the site, (2) an organic chemical odor originates from the ground water seep near the car wash, (3) soil is washed from the site and across Hathaway Road to the golf course during rainfall, (4) children were observed fishing in the golf course's water hazards and claim to sled at the golf course during the winter, (5) a municipal water supply tank is present within the study area just west of the golf course, and (6) shooting of birds has occurred in the Apponagansett Swamp.

III. Environmental Contamination and Physical Hazards

A. Environmental Contamination

Environmental monitoring of the study area was done in 9 sampling rounds during the Phase I RI (January 1985 - September 1986). Both field monitoring and the EPA Contract Laboratory Program (CLP) monitoring were performed. Full CLP monitoring (inorganic compounds, VOCs, acid/base/neutral extractable compounds, PCBs, and pesticides) was done for 291 samples of soil, surface water, ground water, and sediments. In addition, 9 surface water, 8 sediment, and 47 test pit soil samples were analyzed for 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). On-site air monitoring for VOCs, PCBs, and total particulates was done to a limited extent during test pit excavations. Surface water and sediment sampling was performed on: (1) a stream which runs along the eastern border of the site and through the golf course to the Conrail rail line, (2) intermittent streams located just north and south of the site, and (3) the middle marsh and water hazards located on the golf course. Most soil sampling was done on 26 on-site test pits to monitor contaminant concentrations in soils overlying the quarry pits and adjacent on-site areas. Samples were obtained to depths of 11 feet as composites of every few feet. Only five subsurface and four surface samples were obtained for the entire study area other than the test pit composites. Extensive bedrock and overburden ground water monitoring was done throughout the study area. Only CLP data, not field data, were considered during this Health Assessment.

Table I: On-site Contamination at Sullivan's Ledge

Analyte	Ground Water (ug/l)[f] Overburden range	n[b]	Bedrock range	n	Surface Water[a] (ug/l) range	n[b]	Soils[e] Pit range	n	Subsurface range	n	Sediment[a,e] range	n
benzene	1-580	21	12-1200	31	8-160	10	23-650	6	20	1	340	1
vinyl chloride	64-1800	4	30-6900	19	8-196	3	310	1				
TCE[c]	4.4	1	1.1-180000	47	2-53	5	9.5-28000	5				
trans-1,2-DCE	24-2300	4	3.7-53000	32	5-2340	4			5.4-4700	5		
benzo(a) anthracene	1.0	1	10	1			54-23000	43	2400-5200	2	58-960	6
benzo(b) fluoranthene							130-28000	44	1800-5500	2	64-1300	6
benzo(k) fluoranthene							130-20000	37	1100-2400	2	64-1300	6
benzo(a)pyrene							59-28000	44	1400-5600	2	45-790	6
dibenzo(a,h) anthracene							53-6100	21	250-960	2	120	1
indeno(1,2,3-cd)pyrene							56-12000	37	780-2400	2	45-510	4
Aroclor-1242[g]			7.1-25	4			1200-33000	8				
Aroclor-1248	1.3-65	2	1.3	1			1300-110000	3				
Aroclor-1254	1.0-150	12	92-933	23			1.5-2200000	51	950-31000	2	270-341481	10
dibenzofuran							38-6200	26	350	1		
2,3,7,8-TCDD							0.99-1.00	2				
lead	2.2-23	12	4.2-7.3	2	61-109	2	3.5-4650	59	331-2330	2	218-239	2
mercury	0.22	1	0.70	1	0.11-15.2	4	0.02-1.30	36	0.13-0.37	2	0.27-0.37	2

a. surface water and sediment samples obtained from unnamed stream located on the eastern boundary and an intermittent stream on the southern boundary of the site.

b. the number of samples containing detectable levels of analyte.

c. TCE is trichloroethylene; trans-1,2-DCE is trans-1,2-dichloroethylene; 2,3,7,8-TCDD is 2,3,7,8-tetrachlorodibenzo-p-dioxin.

d. pit soil-composites every 3 to 4 feet to 11 feet; a few representative horizontal samples.

e. organics (ug/kg); inorganics (mg/kg)

f. ug/l is microgram per liter; ug/kg is microgram per kilogram; mg/kg is milligram per kilogram

g. Aroclors are polychlorinated biphenyls (PCBs).

The Phase II RI was initiated to supplement the Phase I RI. Environmental samples monitored were: (1) soils from four new on-site test pits (one at the large quarry and three near the unnamed stream), (2) ground water throughout the study area including four new bedrock monitoring wells capable of accessing ground water at several depths, (3) thirteen surface water locations along the unnamed stream and several seeps, and (4) sediments at Middle Marsh, Apponagansett Swamp, intermittent streams, the unnamed stream, and water hazards. Results of on-site and off-site environmental monitoring are given in Tables I and II, respectively.

For the clarity of discussion, the portion of the unnamed stream located on the car wash property just east of the car wash facility is considered part of the site although it is not located within the fenced boundaries of the site.

1. On-site Contamination

a. Soil

Both Phase I and Phase II RIs contained test pit soil monitoring data. Test pit soil obtained from quarry pits backfilled with waste and refuse contained high levels of PAHs, particularly benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene, PCBs especially Aroclor-1254, and lead. Generally, low concentrations of VOCs were detected in composites obtained from test pit soil. Near the large quarry, high levels of trichloroethylene (9,400 - 28,000 micrograms per kilogram (ug/kg)) and benzene (none detected - 270 ug/kg) were detected in surface composites zero to three feet deep in two test pits. VOCs of particular interest were benzene, trichloroethylene and trans-1,2-dichloroethylene.

Because of the occurrence of a major fire at the site, and since PCBs can be oxidized to dioxins and dibenzofurans during combustion processes, 2,3,7,8-TCDD and the specific chemical dibenzofuran (not the general class of chlorinated dibenzofurans) were monitored for in test pit soil samples. Two out of 47 soil samples contained 2,3,7,8-TCDD at 0.99 and 1.00 ug/kg. These two samples were obtained from 0-6 foot vertical composites. Although 2,3,7,8-TCDD was not detected above the detection limit of 1 ug/kg in any of the pit soil samples, dibenzofuran was detected at levels up to 6,200 ug/kg. The most prevalent contamination by dibenzofuran (45 - 1,500 ug/kg in 10 out of 12 samples) was detected in samples obtained from the small southern quarry pit possibly where the most extensive fire occurred. The large quarry pit also had dibenzofuran present (40 - 370 ug/kg in 9 of 13 samples). One test pit, located along the eastern boundary of the site and not within a quarry, contained the highest levels of dibenzofuran detected (4,900 and 6,200 ug/kg). Dibenzofuran was detected less frequently elsewhere at the site.

b. Ground water

Results of both RIs indicated that ground water beneath the 12-acre site was contaminated with high levels of VOCs such as benzene, vinyl chloride, trichloroethylene, and trans-1,2-dichloroethylene. In addition, the PCBs Aroclor-1254 and Aroclor-1242 were detected in ground water. The bedrock aquifer showed higher levels of contamination than the overburden

Table II: Off-site Contamination at Sullivan's Ledge

Analyte	Ground water (ug/l)[d] Overburden range	n[b]	Bedrock range	n	Surface Water[a] (ug/l) range	n
north-downgradient:						
benzene	1.2-81	6	20-77	10	1.2-18	19
vinyl chloride	2.1-200	3	54-1000	11	4-106	11
TCE[c]	2.2-52	6	8.2-270000	18	1-13	10
trans-1,2-DCE	4.8-360	7	5-13000	16	2.1-153	20
Aroclor-1254[e]	1-5	4			1.7	1
lead	5.3-32	3	5-17	7	5.5-112	20
mercury	0.24	1			0.13-3.6	13
south and east-upgradient:						
benzene			2.1-3.0	2	8-17	2
vinyl chloride			6.3-23	2	8	1
TCE	1.3-61	2	180-240	3	2	1
trans-1,2-DCE	26	1	49-110	3	5-11	2
Aroclor-1254	1	1				
lead	5.7-53	1	6-15	3	8.4-18	2
mercury			1.9	1	0.11-0.11	2

	Soils-North Surface range	n	Subsurface range	n	Sediment[a] Downstream range	n	Upstream range	n
benzene (ug/kg)					16-19	2		
vinyl chloride					14-94	2		
trans-1,2-DCE					130-170	2		
benzo(a) anthracene	390	1			79-860	16	140-540	2
benzo(b) fluoranthene	450	1			100-1900	19	410-530	2
benzo(k) fluoranthene	450	1			100-730	16	410	1
benzo(a)pyrene					62-960	15	530	1
indeno (1,2,3-cd)pyrene					56-430	6		
Aroclor-1248					1300-33000	8		
Aroclor-1254	260-880	3	120	1	210-60000	71	83-1718	3
dibenzofuran	230	1						
2,3,7,8-TCDD					0.99	1		
lead (mg/kg)	43-117	3	9-29	2	15-418	22	25-122	2
mercury	0.15-0.25	3			0.13-1.2	10	0.26	1

a. surface water and sediment samples obtained from streams, water hazards, Middle Marsh and Apponogansett Swamp located throughout the study area, except not at the site.
b,c. see Table I
d. see Table I footnote f
e. see Table I footnote g

aquifer. Ground water contamination was highest in the northeastern section of the site.

c. Surface Water

Surface water samples were obtained from an unnamed stream on the eastern boundary and an intermittent stream on the southern boundary of the site during the Phase I RI. Surface water was contaminated with lower levels of the same VOCs of concern as ground water and also with elevated levels of lead and mercury. Surface water samples showed higher contamination when obtained from a point of shallow ground water seepage.

During the Phase II RI, CLP organics were monitored in samples from the three on-site seeps from the same two streams as above. Of the compounds of interest, only trichloroethylene and benzene were detected, and at lower levels than detected during the Phase I study. Inorganic compounds were monitored for in all 5 on-site surface water samples. Lead and mercury levels were below or at detection limits (5 an 0.2 ug/l, respectively) for all on-site samples.

d. Sediment

Sediment samples were obtained at the same locations as surface water samples during the Phase I RI. Sediment was contaminated mostly by PCBs and various PAHs. Analysis of two on-site samples collected during the Phase II RI indicated the presence of PCBs.

e. Ambient Air

On-site air monitoring was performed during two surveys. The first survey done by GCA Corporation (GCA) during April 1984 was performed using the more sensitive monitoring technique of the two surveys. GCA surveyed contamination by PCBs, PAHs, and select VOCs in air samples obtained throughout the greater New Bedford area. One of twenty-one sampling locations was at Sullivan's Ledge. PCB levels detected at Sullivan's Ledge (Aroclor-1242/1016: 140-180 nanograms per meter cubed (ng/m^3) and Aroclor-1254: 94-110 ng/m^3) were higher than at any other sampling location in the survey. Presumed background levels were 4.9-15 ng/m^3 for Aroclor-1242/1016 and <2 ng/m^3 for Aroclor-1254 based on sampling at local areas thought to have no PCB contamination (Dartmouth Town Hall, New Bedford Fire Station Number Two, Guy's Pharmacy in Fairhaven, and Tripp School in Fairhaven). The second survey was done by Ebasco Services Inc. during the Phase I RI in March 1986. Twelve locations were sampled during the test pit excavations including locations within six inches of freshly unearthed, contaminated soils, and analyzed in the field for select VOCs. Contaminants analyzed for by a CLP laboratory were PCBs (vaporous and particulate-bound), total particulate matter and select VOCs. No appreciable contamination was detected; however, according to the Phase I RI, the strategy and technique used were more appropriate to occupational hygiene measurements rather than environmental ambient air measurements.

2. Off-site Contamination

a. Soil

The only off-site soil monitoring was done during the Phase I RI. Surface soil samples were obtained using a trowel and were composited by mixing in a glass bowl. The sampling depth is unknown, but is described as "shallow" in the Phase I RI. Subsurface soil samples are vertical composites from unknown depths. The one surface soil sample obtained south of the site contained 1,400 ug/kg of Aroclor-1254. Three surface soil and three subsurface soil samples were obtained from the golf course located north of the site. All three surface soil samples and one subsurface soil sample contained Aroclor-1254. One surface soil sample also contained PAHs.

b. Ground water

Both bedrock and overburden ground water contamination was significant north of the site as determined during both RIs. A plume of contamination in the overburden and shallow bedrock ground water exists from the northeast corner of the site and travels north-northwest to the Middle Marsh. Contaminant levels east, west, and beyond the marsh to the north are much lower. In addition, very high levels of VOCs, especially trichloroethylene (270,000 micrograms per liter (ug/l)), were detected in deep bedrock (>200 feet) beneath the site and golf course. The predominant contaminants of concern detected were vinyl chloride, benzene, trichloroethylene, and trans-1,2-dichloroethylene. However, PCBs were detected just north of the site in non-filtered ground water samples. Filtering of samples prior to analysis resulted in PCB levels below detection limits in all samples filtered. VOCs and PCBs were detected at higher levels in bedrock than in overburden ground water.

c. Surface Water

During the Phase I RI, low levels of VOCs were detected in surface water upstream of the site. Higher levels of VOCs, lead, and mercury were detected north of the site, especially at or near ground water seeps. Contaminant levels were much lower in samples obtained from the area ranging from the Middle Marsh to north near the Conrail rail line.

No VOCs of interest were detected in the one upstream and one downstream samples monitored during the Phase II RI. Of the three upstream samples monitored for inorganic compounds, one contained 18 ug/l of lead, and of the five downstream samples, four contained measurable levels of lead (7 - 71 ug/l). The highest level was in a sample obtained from a seep just north of Hathaway Road and the site. No mercury was detected above the detection limit of 0.2 ug/l.

d. Sediment

Combining the results of the two RIs, an extensive amount of sediment contamination data is available. Sediment contamination, especially by PCBs and PAHs north of the site is extensive throughout the golf course and past the Conrail rail line (in the water hazards, Middle Marsh, streams, and Apponagansett Swamp). South of the site, PCBs and PAHs were also detected, but at much lower levels.

Apponogansett Swamp sediments were analyzed during the Phase II RI. Vertical surficial sediment composites (18 samples at depths of 0 - 4 to 0 - 12 inches) contained PCBs (Aroclor-1254: 4,000 - 22,000 ug/kg).

Sediments from the water hazards were monitored once or twice per RI. The predominant contaminants detected were PCBs (Aroclor-1254: 1,500 - 7,000 ug/kg in 4 out of 7 samples; Aroclor-1248: 1,800 - 14,000 ug/kg in 2 of 7 samples), PAHs in 2 out of 4 samples, and lead (15 - 267 mg/kg in 4 out of 4 samples). In the Middle Marsh, thirty of thirty-one samples contained Aroclor-1254 (<1,000 - 60,000 ug/kg). North of the site, the unnamed stream running through the golf course and other streams within the study area--some intermittent--were monitored. These streams, especially the unnamed stream and the intermittent stream paralleling Hathaway Road just north of the site, contained mostly PCBs and PAHs.

B. Physical Hazards

During the site visit, rusted 55-gallon drums, and piles of pipes and concrete pilings were observed at the Sullivan's Ledge Site, and may constitute a risk of physical injury should children or other individuals access the site.

IV. Demographics of Population at Risk

Information on demographics was obtained from the Phase I RI, and was supplemented following the site visit (8/31/88) and from personal communications with various public officials of the City of New Bedford.

A. Populations at risk

According to the 1985 City of New Bedford Census, 1,170 people live within a 1/2-mile radius of the Sullivan's Ledge Site. Fifty percent of this area is populated, mostly to the south and east of the site. Within a one-mile radius there are two nursing homes with a total of 216 beds and three schools. According to the Superintendent of Schools for the City of New Bedford, the three schools and student body and staff size are: (1) Elizabeth C. Brooks School with 313 students and 33 staff, (2) Mt. Pleasant School with 376 students and 38 staff, and (3) New Bedford High School with 3,220 students and 358 staff. There are no schools within a one-half mile radius of the site. State Route 140 and Interstate 195 highways separate the site from most residential developments. The closest residence is across Hathaway Road and is located about 200 feet west of the site. Located just west of the site is the Days Inn and two other residences. Businesses located to the east are a car wash, cafe, cinema, car leasing company, and seafood market (presented from closest to furthest facility). Across Hathaway Road to the north is the city-owned Whaling City Country Club Golf Course.

B. Land Use

Currently, the Sullivan's Ledge Site is fenced to limit human access. However, the site is zoned for planned business use. Therefore,

development of the land in the future may occur. In addition, the aquifer beneath this study area is designated as class II ground water, meaning the aquifer could be used as a future source of drinking water.

The surrounding area is zoned for mixed business use, which means all types of housing in addition to business can occur. The 1.1-square miles surrounding the site (729 acres) are comprised of residences (31%), Whaling City Country Club golf course (23%), Apponagansett Swamp (15%), highways and interchanges (11%), New Bedford Municipal Landfill (6%), woodland (5%), scrubland (4%), industry (3%), commercial properties (1%), and the site area (1%). The Apponagansett Swamp and the New Bedford Municipal Landfill and Incinerator are located north of the golf course just beyond the Conrail rail line.

During the site visit, specific recreational use of the golf course was identified. The golf course is heavily utilized by golfers. In addition, two children from a neighboring housing project located south of Sullivan's Ledge were observed using a butterfly net to capture fish, tadpoles and crayfish in one of the water hazards. They place these aquatic organisms in aquariums at home. These same boys also reported that another youth caught a 'large' catfish from another water hazard, but then released the fish. Further questioning of the boys revealed that the golf course is used for sledding, but these boys did not avail themselves of the blackberries growing on the golf course. The boys arrived at the golf course by bikes.

From a discussion with the owner of the Scrub-a-Dub car wash, the following observations were noted: (1) children used to traverse the site to reach a housing project located to the south, but since the site has been fenced, they no longer travel near or through the site, and (2) children and other individuals look through the fence at the site and at the unnamed stream located on the car wash property, but do not access the site or stream. In addition, shooting at seagulls at the Apponagansett Swamp has been observed in the past by the EPA Site Manager. Just west of the study area, a commercial nursery with greenhouses is present north of Hathaway Road, and a day care center is located in a church south of Hathaway Road.

A New Bedford Municipal water supply tank is present within the study area just west of the golf course. According to an official at the City of New Bedford Water Department, the water supplying the tank originates from Lake Quattacus where it is treated, then is transported to the High Hill Reservoir (holding area) in Dartmouth ten miles north of the city prior to pumping to the water tank. The water is used to supply drinking water to residences located in an elevated region of New Bedford. According to the Director of the City of New Bedford Department of Health, twenty-two private residential water supply wells exist in the vicinity of Sullivan's Ledge; however, the actual well locations are scattered throughout New Bedford, although more tend to be located north of the site near the town of Freetown. Whether the wells were installed in the bedrock or overburden aquifers is unknown.

V. Evaluation

A. Data Needs and Evaluation

1. Environmental Media

Environmental media were analyzed for contamination in 9 rounds of sampling during the Phase I RI (January 1985 - September 1986). Media examined were ground water, surface water, sediments, soil and air. A limited amount of information was presented in the Phase I RI explaining sampling strategy.

The Phase II RI (October 1987 - March 1988) was initiated to supplement the available environmental data. Additional monitoring of ground water, surface water, sediments and test pit soils were performed. The Phase II RI reviewed was a draft.

a. Ground Water

Extensive ground water monitoring of both the bedrock and overburden aquifers was accomplished throughout the study area. A total of 123 samples underwent full CLP analysis for inorganic compounds, VOCs, acid/base/neutral extractable organic compounds, and pesticides/PCBs during the Phase I RI. Monitoring well installation locations were selected over a period of time as information became available on: (1) ground water flow direction as determined from water table levels in various wells in the area, (2) the location of the quarry pits, (3) results of fracture trace analyses for bedrock aquifer screening, and (4) results of VOC field screening of nearby wells. In addition, a packer test from a well just downgradient and north of the largest quarry pit was performed to determine the vertical distribution of contaminants in bedrock ground water.

During the Phase II RI, four new wells and 33 existing wells were monitored for CLP inorganic compounds and organic compounds. The four new wells, two on-site and two off-site wells, were installed to depths of 300 feet, and were monitored at multiple levels at positions of bedrock fractures. These wells were installed to enable analysis of bedrock ground water migration of contaminants both vertically and horizontally. The 33 existing wells were monitored to compare VOC levels obtained in 1985 and 1986 to levels present in 1987 and 1988. Ground water has been adequately monitored for the purpose of the Health Assessment.

b. Surface Water

During the Phase I RI, seventy surface water samples received full CLP analysis and 9 samples were analyzed for 2,3,7,8-TCDD. Surface water contamination was analyzed during seven sampling tours. Six rounds were performed during the winter and spring; the remaining round was performed in the fall, when contamination levels might be highest because surface water flow was low. An unnamed stream runs along the eastern border of the site to the north and into the golf course passing through water hazards and a marsh before emptying into the Apponagansett Swamp. Intermittent streams exist both north and south of the site. Sampling was done in all these water bodies except the Apponagansett Swamp. Locations were chosen both upstream and downstream of the site, following field screening for either VOCs or chlorides and nitrates, and at points of shallow ground water seeps/discolored water.

Surface water was monitored at 13 locations during the Phase II RI.

Full CLP analyses for inorganic and organic compounds were performed on samples obtained from four seeps and from one previously unsampled stream. The remaining eight samples were monitored for CLP inorganic compounds because during the Phase I RI much of the lead data were rejected during validation. These samples were obtained upstream of the site, just downstream of the seeps to determine the impact of on-site ground water on surface water quality, and along the unnamed stream to north of the Middle Marsh. Surface water has been adequately monitored for the purpose of this Health Assessment. However, contamination of fish in the water hazards and unnamed stream, especially by PCBs, PAHs, and mercury, has not been monitored.

c. Sediment

During the Phase I RI, sediment sampling was performed on the same water bodies as for surface water. Full CLP analysis was performed on 48 samples and 2,3,7,8-TCDD analyses on 8 samples during 5 sampling rounds. Sampling locations were often the same as surface water sampling locations, and also were chosen based on field screening for VOCs and pesticides/PCB's and locations of low flow velocity such as pools within the stream, water hazards, and marsh. Sediment sampling was usually conducted in the stream channel where sedimentation would occur most frequently since overlying water is present most often.

During the Phase II RI, additional sediment monitoring was performed in four off-site areas: (1) five upstream locations, (2) 26 Middle Marsh locations, (3) 23 Apponagansett Swamp locations, and (4) four water hazard locations. Samples were obtained as vertical composites to depths of 12 inches using an auger or spoon. Most samples were monitored for total organic carbon and PCBs, and a few samples were analyzed for CLP VOCs and/or semi-volatile organic compounds.

d. Soil

During the Phase I RI, most soil samples (47 for full CLP and 47 for 2,3,7,8-TCDD analyses) were obtained from the 26 test pits excavated at the suspected locations of the quarry pits on-site. Samples were composites of soil obtained every few feet. Hence, the extent of soil contamination within one or two inches of the surface is unknown. Using composites from the first two or three feet of soil to estimate surface soil contaminant levels may lead to extreme underestimation or overestimation of actual contamination present. In the mid-1970's, following a fire at the site, fill from an unknown origin was used to complete the backfilling and grading of the site. The quality of this fill and the extent of erosion in the interim are unknown. Using contaminant levels obtained from the test pit composites may result in overestimation of surface soil contamination at this site. However, during the site visit, the EPA Site Manager reported that surface disposal of waste may have occurred following the backfilling and grading of the site.

The deepest test pit was only 11 feet deep, even though the quarry pits may be 150 feet deep. Difficulty was encountered bypassing refuse (old cars, tires, timber, etc.) in the pits to obtain deeper soil samples. The exact locations, sizes, depths, and extent of contamination of the quarry pits are unknown. A limited amount of surface soil

contamination information exists for both the study area and the Sullivan's Ledge Site. Although only a few surface soil samples were analyzed, all of these samples contained substantial levels of PCBs and some samples contained PAHs.

The occurrence of fire and PCBs at the site indicate that there is a potential for both chlorinated dibenzo-p-dioxins and chlorinated dibenzofurans to be present both on-site and off-site. During the Phase I RI, 2,3,7,8-TCDD was the only dioxin analyzed for in the environmental media. Other dioxins are also formed during combustion processes and may be present here. Dibenzofuran was analyzed as it is a CLP chemical; however, monitoring of its chlorinated analogs was not done. Chlorinated dibenzofurans at times contaminate PCB mixtures, and like the dioxins, various chlorinated congeners of dibenzofuran are formed during combustion processes. The particular chlorinated dibenzo-p-dioxin and chlorinated dibenzofuran congeners present, and the actual and relative amounts of each congener are unknown, although the potency of each congener with regards to toxicity varies.

During the Phase II RI, soil samples were monitored from four additional test pits located along the eastern portion of the site, an area previously determined to contain substantial contamination. Samples were obtained as composites or at representative depths to depths of 10 feet. No additional surface soil samples or composites were obtained. Both CLP organic and inorganic compounds were monitored.

e. Ambient Air

Air contamination at the site was assessed during two separate surveys described in Section III.A.1. Only the more sensitive survey done by GCA in 1984 detected elevated levels of PCBs in the air above the site. Whether detectable levels of VOCs are present in the ambient air of the site or near the seeps is unknown, but a rubber-like odor and an organic chemical odor, respectively, were discernible during the site visit.

Modeling was done during the Phase I RI to predict potential airborne transport of contaminants from the site. The input data used with this model was obtained from test pit composites. As mentioned previously, using data from composites to estimate surface soil contamination levels can lead to erroneous results. At this site, the quarries were completely backfilled and graded; therefore, results of soil composite monitoring may overestimate the actual surface soil contamination present, although surface disposal of waste may have occurred following grading of the site. Hence, the results of this model may represent a worst case scenario.

2. Land Use and Demographics

Substantial land use and demographic information for the region around the Sullivan's Ledge Site was available from the Phase I RI, and was supplemented with information obtained during the site visit and from communications with public officials from the City of New Bedford. However, a discrepency exists between the text (page 2-3) and figure 2-2 which shows quarter-, half- and one-mile zones surrounding the Sullivan's Ledge Site. Based on the text, 5 schools exist within a 1/2-mile radius of the site. Communication with the City of New Bedford's Superintendent of Schools indicated three schools were within a one-mile radius of the

site, and no schools are located within one-half mile of the site.

Because the following individuals are particularly sensitive to the toxic effects of PCBs, information is needed on: the number of nursing infants in the surrounding area, the number of individuals present having an altered hepatic glucuronide conjugation system (important in the detoxification of PCBs), pregnant individuals, neonates, children receiving the antibiotic novobiocin, and individuals with such anomalies as hepatic infections, Gilbert's syndrome, and Crigler and Najjar syndrome. The transient (worker) and permanent population size within the study area is needed, as is the population size of elderly individuals living within the study area, and one-quarter, one-half and one mile from the site.

Recreational use of land around the site, especially at the city-owned golf course, has been partially characterized. Although fishing has been observed within the study area, human consumption of fish or game has not been documented. Blackberries are present on the golf course and may also grow near or at the site. Consumption of blackberries has not been documented. In addition, the extent of livestock or agricultural activities nearby is unknown (particularly dairy or poultry and egg production).

During the site visit, a water supply tank was observed within the study area; however, from communication with an official at the City of New Bedford's Water Department, (1) the water supplying the tank is obtained ten miles north of the city from the High Hill Reservoir in Dartmouth, (2) the water is pumped to the tank and is used to supply residences located in upland areas of New Bedford, and (3) the water is not contaminated with VOCs or other contaminants based on periodic monitoring of the water throughout the public water supply distribution system. Whether the pipes used to transport water to the tank pass through the overburden contaminant plume and are cracked enough to allow contaminated ground water to enter the pipes are unknown. However, based on the fact that the water from the reservoir is pumped to the tank (therefore, the water inside the pipe exerts pressure outward against the wall of the pipe, thus, lowers the chance of infiltration of contaminated ground water even through cracked pipes), the municipal drinking water is probably not impacted by the ground water contaminant plume. From a discussion with an individual at the Division of Water Supply, Massachusetts Department of Environmental Quality Engineering, monitoring data for VOC levels in this water are not available, except for trihalomethane levels which are chlorination products occurring during drinking water treatment. VOC levels are measured prior to pumping water to the tank, and are not elevated. If the pipes pass through the ground water contaminant plume, VOC monitoring data should be obtained for the water in this tank.

Twenty-two private residential water supply wells are located throughout New Bedford; however, the closest wells appear to be located north of the site near the New Bedford Airport and south of the site on Summit St. and Rockdale Ave. Whether these wells were installed in overburden or bedrock is unknown. Also unknown is whether any of these wells are located in the pathway of the ground water bedrock or overburden contaminant plumes. This additional information is necessary to fully assess possible threats to public health.

The site itself is surrounded by a steel mesh fence, but no barbed wire or guard is present to further discourage trespassers. The area is

adequately posted to warn the public of the presence of hazardous waste.

3. Quality Control and Quality Assurance

During the Phase I RI, CLP protocols for media sample handling and analysis were followed. The data presented had yet to be reviewed by the EPA at the time of release of the document (September 1987). However, the data were verified through level one validation by NUS (REMPO). How this validation process compares to EPA's CLP is not known. In particular, the validity of the TCDD data is of concern as great difficulty exists in analyzing TCDD at low levels, and TCDD is very toxic. No quality assurance and quality control information is available for GCA's greater New Bedford air contamination survey. With the exception of most of the sediment data, all of the draft Phase II RI data were validated by the EPA. The conclusions reached in this Health Assessment are based on the data supplied, and therefore, depend on the validity of the data.

B. Environmental Pathways

Sullivan's Ledge is a landfill site. As many as 4 pits exist on-site. The perimeter location and size of the pits are unknown. The pits' depths are unknown, but are probably about 150 feet deep but may be as much as 300 feet deep. Also unknown are the nature and extent of the contamination in the pits. However, enough information exists to determine migration routes of contaminants from the site.

This section is divided into two parts. The first part describes the hydrogeology and general characteristics of the study area. The second section defines the contaminated media within the study area.

1. Hydrogeology and General Characteristics

The Sullivan's Ledge Site is located within a shallow glacial valley. The valley floor lies beneath the unnamed stream and runs from the south-southeast to the north-northwest. The unnamed stream originates just south of the site, is highly channeled at the eastern edge of the site, then passes through conduits at the car wash and beneath Hathaway Road, and enters the golf course. At the golf course, the unnamed stream is joined by various intermittent streams. In particular, an intermittent stream parallels Hathaway Road just to the north and discharges into the unnamed stream northeast of the site. The unnamed stream travels north through the golf course where it intercepts the Middle Marsh and spreads laterally, then passes through water hazards before passing through a conduit beneath the Conrail rail line and into the Apponogansett Swamp.

The shallow bedrock in the study area is highly fractured in various orientations, but becomes less fractured with depth, having a regional north/northwest lineament trend. Ground water flow in the deep bedrock follows the fracture planes and, overall, may be northwest trending. However, the pathway of water in a particular fracture plane may be difficult to predict as the pathway may be quite convoluted. Deep bedrock ground water flow tends not to be impacted by local topography. As the shallow bedrock is highly fractured, water flow is not restricted, and ground water flow direction would tend to be the same as for overburden ground water. This ground water follows the slope of the topography in the study area.

At the site, ground water flows from the southwest to the northeast. Near the unnamed stream, a steep gradient exists such that ground water flow becomes more easterly. From the site, ground water flows north towards the golf course and the Middle Marsh. Ground water tends to enter the quarry pits from the bedrock (sides or floor) from where: (1) a portion of the ground water enters the bedrock fracture planes and travels horizontally from the site, and (2) another portion flows up out of the pit and into the overburden.

Water from the site, both as surface runoff following precipitation and as ground water seeps, discharge into the unnamed stream to the east and the intermittent stream to the north. At least four seeps have been located in these two streams. On-site ground water levels vary from 17 feet below ground in the southwest section of the site to 5 feet in the northeast section. North of Hathaway Road, ground water levels vary from 5 feet below ground to surface level at the Middle Marsh and Apponagansett Swamp. Ground water infiltrates the unnamed stream throughout the course of the stream as indicated by a continual increase in stream discharge volume downstream of the site.

The Phase I RI calculated that an estimated 8 to 81 tons of soil per year erode from the site. The site is sparsely vegetated, and, during storm events, soil travels off-site with the runoff across Hathaway Road to the golf course. The woodlot and intermittent stream across and paralleling the road would intercept most of this soil. Also, because of the sparse vegetation, airborne fugitive dusts probably originate at the site.

Flooding of the unnamed stream south of Hathaway Road has not been documented, although the car wash owner has observed the stream bed filled to the top of its banks. Whether the unnamed stream or intermittent streams north of Hathaway Road ever flood onto the golf course is unknown; however, this is likely to occur as the stream banks are shallow.

2. Contaminated Media

a. Ground water

Contamination from the pits enter ground water either by direct contact with pit water or by infiltration following solubilization in rainwater percolating into the pit. Deep bedrock ground water within certain fracture planes is more contaminated than overburden or shallow bedrock ground water, as water from the quarry pits enters the bedrock aquifer directly. The contamination may then follow ground water flow off-site through the fracture planes, and may travel an unknown but substantial distance before it dissipates. A narrow overburden/shallow bedrock contaminant plume originates from the quarry pit and runs north-northwest to the Middle Marsh where it tends to be diminished. Shallow bedrock ground water tends to be more contaminated than the overlying overburden ground water.

VOCs are the major ground water contaminants present. Benzene, trans-1,2-dichloroethylene, trichloroethylene, and vinyl chloride are expected to persist in ground water. Under certain conditions, trichloroethylene can be degraded to trans-1,2-dichloroethylene then to vinyl chloride. PCBs are present in ground water even though they tend to bind to soils. In particular, Aroclor-1254 is present (933 ug/l) at concentrations exceeding water solubility (24 ug/l at 20^{o}C) limits.

Leaching of PCBs from soils and into water can be significantly increased in the presence of organic solvents. Filtering of water samples prior to analysis (using a .45 micrometer filter of unknown matrix composition) removed all detectable PCBs, even in the control sample containing PCB in solution. Therefore, whether the PCBs in ground water are bound to particulates or in solution is unknown, but filtering does remove PCBs from water at least under these unknown conditions. Because PCBs in solution adsorbed onto the filter as determined from the control sample, a better way to determine whether PCBs are in solution or bound to particulates would be to centrifuge the water sample prior to analysis. This information is important, especially if filtering of water under drinking water treatment conditions prior to distribution removed particulate-bound PCBs, but not PCBs in solution.

At the site, ground water east and north of the quarry pits is more contaminated than to the west and south. Although ground water flow tends to be toward the north, shallow ground water is diverted to the east towards the unnamed stream where contaminated ground water discharges into the stream as evidenced by the presence of seeps. These seeps contain elevated levels of VOCs.

b. Surface Water

VOCs were the predominant contaminants in the surface water of the unnamed stream, with elevated lead and mercury levels also present. The level of contamination originating from the seeps rapidly decreases downstream, either by volatilization of contaminants, dilution by uncontaminated water, or adsorption to sediments. Atmospheric levels of VOCs were not measured at the seeps; however, a strong organic smell was noted at the only seep observed during the site visit. This seep is located adjacent to the car wash. Whether an organic chemical odor is discernible at the other seeps is unknown; however, similar levels of VOCs have been detected in water samples from these seeps. The contaminants of concern (benzene, vinyl chloride, trichloroethylene, and trans-1,2-dichloroethylene) have short half-lives in air, with 6 days for benzene being the longest half-life. The remaining low contaminant levels diminish gradually from the site to the northern end of the study area at the Conrail rail line, probably because contaminated ground water continually infiltrates the stream throughout the golf course. Low levels of VOCs are also present in the intermittent streams, water hazards and marsh.

c. Sediments

A substantial amount of contaminated soil is probably transported to the unnamed stream located on the eastern boundary of the site and to the intermittent stream north of Hathaway Road. Sediments in these streams are highly contaminated with PCBs and PAHs.

Sediment contamination is extensive and widespread throughout the study area, even in areas upstream of the site and in areas not usually associated with surface water. Contamination may have been transported to these areas by surface runoff, streams either intermittent or continual, airborne transport of contaminated fugitive dusts, or, perhaps, flooding of surface water. Areas containing substantial contamination include the unnamed stream, the intermittent stream located just north of Hathaway

Road and the site, the Middle Marsh, the water hazards, and the Apponagansett Swamp. Sediment contaminants are predominantly PCBs and PAHs. VOCs, lead, and mercury are also present, but at low levels and can become redissolved in overlying surface water. Although mercury may be present on-site in the inorganic form, under certain conditions it can be methylated in sediments by anaerobic microbial detoxification processes. PCBs and PAHs tend to stay bound to sediment and to persist. PCBs tend to bioaccumulate and biomagnify through the food chain. PAHs tend not to bioaccumulate as they can be metabolized; however, PAHs do concentrate in the liver of fish. Fish located in the water hazards have not been analyzed for PCBs, PAHs, or mercury (particularly methyl mercury) levels. Sediments can be resuspended and transported downstream following storm events. Contaminated intermittent streams exist at the golf course; therefore, contaminated sediments from dry streambeds can become airborne and transported to other areas as fugitive dusts.

d. Soils

The actual extent of on-site surface soil contamination is unknown. However, vertical composites of surface soils from test pits indicate high levels of PCBs, lead, PAHs, and dibenzofuran are present. PAHs, chlorinated dibenzofurans, and chlorinated dibenzo-p-dioxins may have been generated during an on-site fire in the early 1970's, and chlorinated dibenzofurans are known to contaminate commercial mixtures (Aroclors) of PCBs. Whether chlorinated dibenzofuran and chlorinated benzo-p-dioxin congeners are present has not been determined, but, is possible. Besides surface water runoff, these contaminants can be transported airborne and bound to fugitive dusts to other places, such as school yards, playgrounds, and residential yards and gardens. In fact, airborne PCBs have been detected above the site. The prevailing wind direction is southwest in the summer and northwest in the winter. PCBs are slightly volatile and may also be transported off-site as vapor, especially during a fire. VOCs are present in deeper soils and, thus, would not appreciably volatilize unless soil is moved as during remediation. Although the level of VOCs in the ambient air above the site is unknown, a distinct rubber-like odor was noted during the site visit. Transport of contaminants off-site by surface runoff, fugitive dust generation, and volatilization would vary with time, depending on rainfall, windspeed, seasonal changes in vegetative groundcover, and whether the ground is frozen or not. Transportation of soil off-site across Hathaway Road occurs during storm events. The extent of contamination of these soils is unknown, but is probably significant.

Little information is available for off-site surface soil contamination. In the golf course, PCBs, PAHs, and dibenzofuran have been transported to these areas by surface runoff of contaminated soil from the site, by contaminated fugitive dusts, and possibly by flooding of the streams and water hazards located on the golf course. Off-site soil may become locally airborne during such human activities as golfing, biking, and sledding as at the golf course and motor vehicles traversing over soil present on Hathaway Road. Soils may be transported off-site during remediation activities and from the golf course by clinging to the clothing or shoes of people accessing these properties and subsequently being deposited on the floors of their homes.

The impact of the Sullivan's Ledge Site on the area is further complicated by the existence of a municipal landfill and incinerator

located just north (downgradient and downstream) of the study area, adjacent to the Apponagansett Swamp. The incinerator was used to burn PCB-contaminated sewage sludge, but has not been operated since 1974. In addition, PCB-contaminated waste was disposed in the municipal landfill. Whether or not the landfill (PCBs) or the incinerator (PCBs, PAHs, and dibenzofuran) has contributed to the surface soil or sediment contamination in the study area is unknown, but is highly possible. Contribution by the landfill or incinerator to the contamination in the study area would probably be by an airborne mechanism, and also by leaching or surface runoff from the landfill into the Apponogansett Swamp.

e. Ambient Air

As little ambient air data is available for this site, the discussion for this environmental pathway is incorporated into the texts of the other media. However, three observations should be noted: (1) PCBs were detected in ambient air above the site, (2) a rubber-like odor is present at the site, and (3) a strong organic chemical odor is present at the seep located near the car wash.

C. Human Exposure Pathways

Due to the contamination of environmental media as described above, there is a potential for human exposure to contaminants in the soil, fugitive dusts, ground water, surface water, and sediments at the Sullivan's Ledge Site and surrounding area. The site itself is fenced to limit access, but exposure to contaminants outside the site probably occurs. Human exposure pathways of concern are -

1) Exposure by dermal contact of contaminated soil especially to PAHs, and by inhalation and ingestion of all soil contaminants (especially PCBs, PAHs, dibenzofuran, and lead) is possible at the golf course, at the site, and possibly along Hathaway Road. Populations potentially exposed are golfers, children, and, particularly, maintenance workers at the golf course, remedial workers at the site, and families of these individuals (particularly very young children who play on the floors of their homes).
2) Inhalation, dermal adsorption, and especially ingestion of contaminants present on fugitive dusts may occur to: (1) on-site workers present during remediation of the site, (2) individuals located downwind of the site during remediation, and (3) individuals located at the site, golf course, and, perhaps, downwind of the site prior to remediation. Exposure to contaminants are most likely the same as the soil and sediment contaminants, specifically PCBs, then PAHs, lead, and dibenzofuran.
3) Inhalation of VOC vapor near surface water is possible, and at seeps is probable. In particular, workers and customers at the car wash located next to a seep with a discernible organic odor are potentially exposed. Human exposure to other contaminated seeps, located immediately south of the site and especially to the north in the golf course, is also possible, but the number of people nearby are fewer. Dermal adsorption and ingestion of all surface water contaminants could occur, especially at seeps. However, ingestion is unlikely as the stream water in these areas are aesthetically unappealing.
4) Dermal exposure to sediment contaminants is an exposure route of

concern. Children were observed catching aquatic organisms in a water hazard using a butterfly net. Sediments were observed on their hands, net, and in the bucket containing their catch. Exposure to contaminants present in dry sediments can occur by direct dermal contact, ingestion, and inhalation from intermittent streams present at the golf course.

5) Fishing occurs in the golf course water hazards, but whether these fish are consumed is unknown. In particular, a consumable fish, catfish, has reportedly been caught in one of the water hazards. Therefore, ingestion of contaminated fish is another potential exposure pathway of concern.
6) Consumption of contaminated wildlife, poultry and dairy products, and vegetables may occur but has not been documented. A greenhouse/nursery is present just west of the study area. The domestic raising of farm animals and vegetables may occur as this area of New Bedford has a somewhat rural character.
7) No water well is known to intercept the contamination originating from the Sullivan's Ledge Site, because the City of New Bedford's municipal water supply originates from a reservoir 10 miles north of the city. However, the locations of twenty-two private residential water supply wells are scattered throughout New Bedford. Because the overburden contaminant plume extends only into the golf course, the interception of this plume by any of these wells is unlikely at this time, but may occur in the future in the three or four private wells located north of the site near the airport. The exact pathway of the bedrock ground water contamination is unknown and whether any of the private wells are installed in the bedrock aquifer is also unknown; therefore, the possibility exists that one of these wells may intercept the bedrock contaminant plume either currently or in the future. Future well development is possible, as the ground water beneath the study area is designated class II ground water, meaning it could potentially be used for drinking water. Therefore, future exposure to ground water contaminants by ingestion, inhalation following volatilization as during showering, and dermal adsorption could occur.
8) Inhalation of volatile contaminants by remedial workers and individuals downwind of the site could occur during ground water remediation activities.

VI. Public Health Implications

The Public Health Implications Section of this Health Assessment is presented in two parts. Part A defines the contaminants of concern that are present on-site and off-site at concentration levels sufficient to impact human health, and what those impacts might be. Part B reviews the available epidemiological information for the area of New Bedford surrounding the Sullivan's Ledge Site.

A. Potential Toxic Effects of Contaminants

Because more contaminants are present on-site than off-site and because the media contaminated differs somewhat on-site and off-site, the

potential health impact following on-site exposure shall be reviewed separately from the potential off-site health impact.

1. On-Site

The Sullivan's Ledge Site is fenced to limit access to the property. However, should individuals, especially children, access the site prior to remediation, exposure to soil contaminants (PAHs, PCBs, dibenzofurans, lead, and mercury) by ingestion and perhaps dermal adsorption, and to PCB-contaminated fugitive dusts by inhalation would constitute a threat to human health. Soil contaminants of greatest concern are PCBs and PAHs because of the high levels present. PCBs tend to bioaccumulate and are probable human carcinogens. Inhalation or ingestion of high levels of PCBs and related compounds can result in chloracne, porphyria, and menstrual disorders. Ingestion of cooking oil containing PCBs, as in the Yusho incident occurring in Japan and a similar incident in Taiwan, has resulted in delayed development, deformed nails, and discolored skin in infants born to exposed mothers. However in these incidents, the PCB levels were high and the carrier was cooking oil; therefore, higher human exposure occurred than would be expected at the Sullivan's Ledge Site. Individuals having an altered hepatic glucuronide conjugation system are particularly vulnerable to PCB toxicities, as this system is important in the detoxification of PCBs.

PAHs are present as a mix of related compounds including the probable human carcinogens: benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. Carcinogenic PAHs cause contact point cancers (eg. skin and lung cancers) as well as systemic cancers following exposure by inhalation, dermal adsorption, and ingestion.

Little information is available on dibenzofuran's toxicity, and the presence of chlorinated dibenzofurans and chlorinated dibenzo-p-dioxins has not been tested. Chlorinated dibenzofurans, especially the 2,3,7,8 congeners, appear to elicit a dioxin-like toxicity and to be nearly as potent carcinogens as dioxins. However, the relative toxicities of the chlorinated dibenzo-p-dioxins and chlorinated dibenzofurans varies for each congener.

Lead and mercury are also present in on-site soils. Certain lead salts appear to be carcinogenic in experimental animals, and lead can also cause anemia and altered learning abilities in children. Mercury in its organic form is toxic to the nervous system and kidney, and can cause brain damage following prenatal exposure to methyl mercury. Inorganic mercury is less toxic than organic mercury but can cause central nervous system toxicity.

From remedial activities, a greater risk of adverse health effects could occur to workers at the site from the above-mentioned soil contaminants as well as the anticipated higher levels of PCB-contaminated fugitive dusts generated during pit excavation activities. As other soil contaminants present in fugitive dusts have not been determined, the toxic effects from this exposure route cannot be assessed. During ground water remediation, a risk of adverse health effects may occur following worker exposure to ground water contaminants by dermal adsorption (vinyl chloride, benzene, trichloroethylene, trans-1,2-dichloroethylene, and PCBs) or inhalation of VOC vapors.

Benzene is a known human carcinogen causing leukemia as well as noncarcinogenic hematopoietic toxicity. Vinyl chloride also is a known

human carcinogen, and occupational exposure has resulted in angiosarcoma of the liver, tumors of the brain, lung, and hemolymphopoietic system, genotoxicity (chromosomal aberrations of peripheral lymphocytes), developmental toxicity in both sexes, and many other systemic toxicities. Both trichloroethylene and trans-1,2-dichloroethylene are probable human carcinogens. Occupational exposure to trichloroethylene has been reported to result in hepatotoxicity.

During remediation activities, individuals downwind of the site may be impacted adversely by contaminated fugitive dusts and VOC vapors.

2. Off-Site

At the golf course north of the site, soil, surface water, sediments, and, perhaps, fish are contaminated with some of the same contaminants as on-site, but at lower levels. Golfers and children playing on this property could be adversely affected following exposure to these contaminants, many of which are carcinogenic. The toxic effects of these chemicals were discussed in the 'On-Site' portion of this section.

Because little monitoring information is available, difficulty exists in interpreting the human health implication of contaminated soil at the golf course. However, contaminated soils from the golf course could pose a human health threat following ingestion and dermal exposure due to the presence of PAHs, dibenzofuran, and especially PCBs. Similarly, contaminated sediments contain PCBs and PAHs which could pose a human health threat, particularly sediments from dry intermittent stream beds.

Although fishing occurs in contaminated bodies of water within the golf course, consumption of fish and levels of contamination in the fish has not been documented. However, fish obtained from nearby surface waters could contain elevated levels of PCBs which are biomagnified through the food chain, PAHs which concentrate in the liver of fish, and perhaps methyl mercury which is difficult to eliminate from the body. A substantial risk to human health would occur if contaminated fish were consumed.

Ground water seeps at the unnamed stream near the car wash and at the intermittent stream in the golf course contain benzene, vinyl chloride, trichloroethylene, trans-1,2-dichloroethylene, lead, and, at times, mercury at levels sufficient to threaten human health should ingestion or perhaps dermal adsorption occur. However, ingestion is unlikely as the stream water in these areas are aesthetically unappealing (due to an organic chemical odor and discolored water and sediments), and surface water just downstream of the seeps contain much lower levels of contaminants.

A strong odor emanates from the seep near the car wash. Although workers and customers at the car wash are probably exposed to organic vapors, the contaminants and levels present are unknown; therefore, the human health impact cannot be assessed. Similarly, PCB-contaminated fugitive dusts may occur throughout the study area and downwind of the site outside the study area; however, the potential health impact following exposure to contaminated fugitive dusts cannot be addressed as no monitoring data are available.

No information on the presence of or contamination of wildlife, livestock, and agricultural products are available. Therefore, the potential effect on human health following their consumption cannot be assessed. The future use of contaminated ground water within the study area for municipal drinking water and the potential present or future

contamination of private residential water supply wells, especially bedrock wells, outside the study area would be of health concern because of the presence of benzene, vinyl chloride, trichloroethylene, and trans-1,2-dichloroethylene in the ground water.

B. Epidemiology

A review of New Bedford's 1982-1985 cancer incidence data for the 12 major cancer sites revealed statistically significant excesses (PIR's) for the following cancers: cervical cancer and bladder, liver, and hematopoietic and reticuloendothelial cancers in females. Of these cancers, both liver cancer and leukemias have been associated with exposure to PCBs in some animal bioassays and in some occupational studies (Tsongas, 1985; NCI, 1977; Ward, 1985; Ikedo et al., 1986; Brown and Jones, 1981; Kimbrough et al., 1975; Norback and Weltman, 1985; and Kimbrough and Linder, 1974). However, a relationship between cancer occurrence and exposure to PCBs cannot be ascertained from the available epidemiologic studies.

Since leukemias are potentially associated with exposure to PCBs in the literature, the leukemia cases were separated from the other hematopoietic/reticuloendothelial cancers and plotted on a map to assess their proximity to the Sullivan's Ledge Site. One case of 33 was located within a half-mile radius of the site. Standardized incidence ratios (SIR's) for leukemias were calculated for both males and females. Male leukemias occurred almost as often as expected (19 observed, 20.5 expected; SIR = 93). Female leukemias occurred at a higher rate than expected (24 observed, 18.6 expected; SIR = 129). This elevation is not statistically significant; therefore, the observed incidence could be due to random variation in the pattern of cancer incidence.

Liver cancer cases (1982-1985) were also plotted to assess their proximity to the site. Again, one case was within a half-mile radius of the site. Overall, liver cancer occurred about as often as would be expected (8.3 expected, 9 observed; SIR = 108). Female liver cancers accounted for the majority of the cases (6 observed, 2.8 expected; SIR = 213). The elevation observed in female liver cancers is of borderline statistical significance (p = .056). Liver cancer cases do not appear more prevalent in any one area of the city.

During 1984-1987, the DPH, in collaboration with the Centers for Disease Control (CDC) and the Massachusetts Health Research Institute, conducted the Greater New Bedford Health Effects Study. This study was comprised of 840 randomly selected 18-64 year old individuals, stratified by age and sex, designed to determine the prevalence of elevated (>30 ug/l) serum PCB levels among the Greater New Bedford population (Acushnet, Dartmouth, Fairhaven and New Bedford). The study also included a separate enrichment group of local seafood consumers (n = 110). Information on past occupations, residence, and local and general seafood consumption as well as various physical measurements and biological specimens (blood and urine) were collected from all study participants. From this information, outside of occupational exposures, individuals who consumed contaminated local seafood were determined to be at the greatest risk of having elevated serum PCB levels. Only eleven individuals or 1.3% of the study population of 840 had serum PCB levels >30 ug/l (mean serum PCB level of 5.84 ug/l). Of the enrichment group, seven people or 6.4% had serum PCB levels greater than 30 ug/l (mean serum PCB level = 13.34 ug/l).

The main route of exposure to PCBs at Sullivan's Ledge is contact with contaminated soils. This route of exposure was examined in a 1984 study in Norwood, MA, conducted by the DPH in collaboration with CDC. Some of the highest levels of PCBs in soil were observed in Norwood (220,000 mg/kg). Human blood serum was collected from 90 individuals aged 11 to 66 years suspected to be at greatest risk of exposure and analyzed for PCBs. The mean serum PCB level was 4.9 ug/l. This study provided data which seems to indicate that exposure to PCBs in soil does not increase PCB body burdens as much as occupational exposure to PCB oils.

VII. Conclusions and Recommendations

(1) Based upon information reviewed, ATSDR has concluded that this site is of public health concern because of the risk to human health resulting from probable exposure to hazardous substances at concentrations that may result in adverse health effects. As noted in Sections V and VI above, low-level human exposure to PCBs and PAHs is probably occurring (and has occurred in the past) via inhalation and ingestion of contaminated soils, sediments and fugitive dusts.

In accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended, the Sullivan's Ledge NPL Site, New Bedford, MA has been evaluated for appropriate follow-up with respect to health effects studies. Since human exposure to on-site/off-site contaminants (PAHs, PCBs, dibenzofurans, lead and mercury) may currently be occurring, may have occurred in the past, and may occur in the future pending remediation efforts this site is being considered for follow-up health effects studies. After consultation with Regional EPA staff and State and local health and environmental officials, the Epidemiology and Medicine Branch, Office of Health Assessment, ATSDR, will determine if follow-up public health actions or studies are appropriate for this site.

(2) To enable a more accurate assessment of public health implication, additional surface soil monitoring should be done as the few available data indicate contamination by PCBs may be extensive both on-site and in the study area. In particular, surface soil at the golf course and at the woodlot between Hathaway Road and the intermittent stream should be more rigorously monitored. In addition, since airborne transport may be or have been a significant contaminant dispersal process, surface soil in neighboring areas, especially those most often downwind of the site, should be monitored. Special emphasis on school yards, playgrounds, and residential yards is appropriate. Fire occurrence at the site would be an important contaminant dispersal process; therefore, the record of fire occurrence at the site is important.

(3) A municipal landfill and incinerator located just downgradient and north of the study area may impact contaminant levels in the surrounding area. To assess the human health impact because of this source, additional monitoring data are needed for both the landfill and the area surrounding the landfill and incinerator, hence, outside the currently defined study area.

(4) Fishing occurs at the golf course. The consumption of fish is unknown. However, PCB, PAH, and methyl mercury contaminants in fish

would be a risk to human health; therefore, fish should be monitored to determine contaminant levels present. Consumption of fish from the area should be discouraged until further information is available.

(5) Signs should be posted at the golf course warning people away from the contaminated wetlands (Middle Marsh, streams, and water hazards) of the golf course as well as at the Apponagansett Swamp boundaries.

(6) As high levels of PCBs are present and a large fire occurred on-site, the existence of chlorinated dibenzo-p-dioxins and chlorinated dibenzofurans on-site and off-site is possible. In addition, chlorinated dibenzofurans often contaminate commercial mixtures of PCBs. More information is needed on the specific concentration of each of these compounds and the relative proportions of their congeners (specifically the 2,3,7,8 congeners) present in soils and sediments to enable a more accurate assessment of the potential human health impact.

(7) a. The City of New Bedford's municipal drinking water is probably not impacted by the ground water contaminant plumes originating at this site, because the water supply is a reservoir located ten miles north of the city in Dartmouth, MA. The water tank located within the study area obtains its water by pumping from this reservoir, and supplies drinking water to upland areas of New Bedford.
b. Twenty-two private residential water supply wells are scattered throughout New Bedford. Whether any of these wells are impacted by ground water contaminants originating from this site is uncertain, but seems unlikely given the distances these wells are from the site and the ground water flow direction; however, because the pathway of contaminant migration in the bedrock ground water is unknown and may meander, and because it is unknown whether any of these wells were installed in bedrock, these private wells should be monitored periodically to ensure the contamination is not intercepted now or in the future.

(8) Based on existing epidemiological studies, the incidences of leukemias and liver cancers appear not to be elevated near the Sullivan's Ledge Site.

(9) The draft Feasibility Study for the Sullivan's Ledge Site was reviewed. The remedial alternative requiring no action for source control or for management of contaminant migration does not adequately protect human health. The remaining remedial alternatives may result in temporary elevations in airborne contaminated fugitive dusts and VOCs at levels sufficient to impact transient populations and perhaps permanent populations should significant airborne transport to other areas occur, as would occur during pit excavation, ground water treatment, or the occurrence of a fire. Ambient air monitoring concurrent with remediation is recommended. Finally, no remedial alternative would decrease the potential adverse health impact of contaminated water found in deep bedrock (greater than 150 foot depths on-site and 100 foot depths off-site). As the actual transport pathway for this contaminated water is not known, the future interception of contaminated water by a bedrock well cannot be dismissed.

(10) This Health Assessment will be updated by amendment whenever any additional pertinent information becomes available.

VIII. Preparers of the Report

Environmental Reviewer: Eileen A. Furlong, Division of Environmental Epidemiology and Toxicology, Massachusetts Department of Public Health

Health Effects Reviewer: Suzanne K. Condon, Division of Environmental Epidemiology and Toxicology, Massachusetts Department of Public Health

Regional Representatives: Marilyn DiSirio and Louise House, Region I, Agency for Toxic Substances and Disease Registry

Typist: Su Ling Wong and Maryette Guerra (Massachusetts ATSDR Administrative Assistant), Division of Environmental Epidemiology and Toxicology, Massachusetts Department of Public Health

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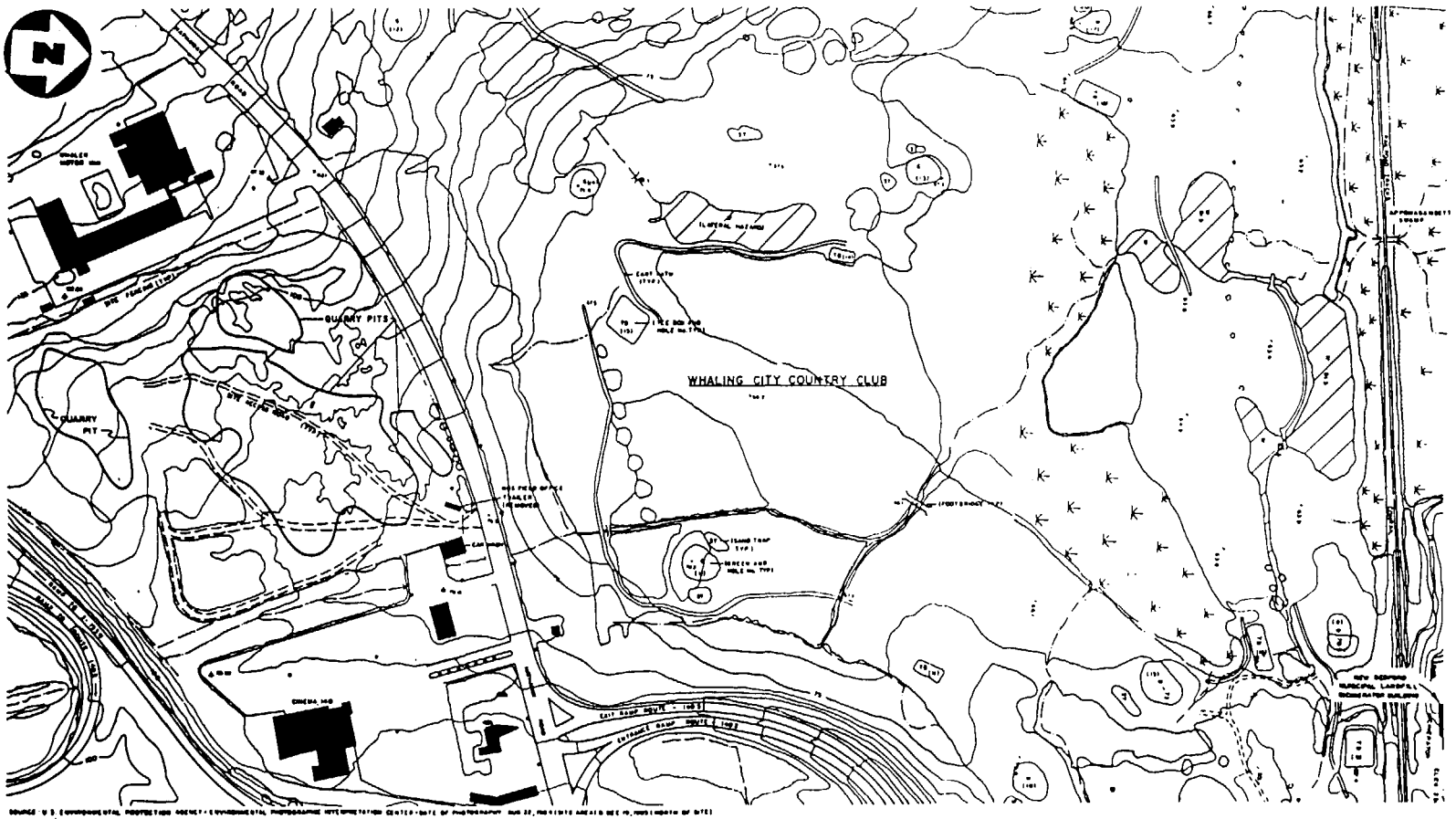
APPENDIX A

APPENDIX A



From: Remedial Investigation (Sept., 1987

SCALE IN FEET

FIGURE 1-2

SITE PLAN
SULLIVAN'S LEDGE SITE, NEW BEDFORD, MA

NUS CORPORATION
A Halliburton Company